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Edited by Patrick Petitjean, Catherine Jami and Anne Marie Moulin

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SCIENCE AND EMPIRES

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SCIENCE AND EMPIRES

Historical Studies about Scientific Development and European Expansion

Edited by

PATRICK PETITJEAN
Centre National de la Recherche Scientifique, REHSEIS, Paris et CRN, Strasbourg

CATHERINE JAMI
Centre National de la Recherche Scientifique, REHSEIS, Paris

and

ANNE MARIE MOULIN
Centre National de la Recherche Scientifique et Institut National de la Santé et de la Recherche Médicale, U138, Paris

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Foreword

SCIENCE AND EMPIRES: FROM THE INTERNATIONAL COLLOQUIUM TO THE BOOK

Patrick PETITJEAN, Catherine JAMI and Anne Marie MOULIN

The International Colloquium

"Science and Empires - Historical Studies about Scientific Development and European Expansion" is the product of an International Colloquium, **"Sciences and Empires - A Comparative History of Scientific Exchanges: European Expansion and Scientific Development in Asian, African, American and Oceanian Countries"**. Organized by the REHSEIS group (Research on Epistemology and History of Exact Sciences and Scientific Institutions) of CNRS (National Center for Scientific Research), the colloquium was held from 3 to 6 April 1990 in the UNESCO building in Paris.

This colloquium was an idea of Professor Roshdi Rashed who initiated this field of studies in France some years ago, and proposed "Sciences and Empires" as one of the main research programmes for the REHSEIS group. The project to organize such a colloquium was a bit of a gamble. Its subject, reflected in the title "Sciences and Empires", is not a currently-accepted *sub-discipline* of the history of science; rather, it refers to a *set of questions* which found autonomy only recently.

The terminology was strongly debated by the participants and, as is frequently suggested in this book, awaits fuller clarification. Moreover, the very consideration of "sciences and empires" as an autonomous problem in the history of science, suggests an approach divorced from the two traditional perspectives of analysis: the "geographical" ("science IN the empires" viewed as a value-free activity) and the utilitarian-political ("science FOR the empire" or "the tools of empire", where science is considered as a mere instrument for colonial and imperial domination).

But the importance - the necessity even - of treating this topic autonomously is not dictated only by the logic of the history of science.

P. Petitjean et al. (eds.), Science and Empires, ix–xiii.

Epistemology also plays a role. The many questions raised in the discussions were sometimes epistemological and other times historical. **Epistemological questions** such as the definition of "European science"; the generic links between classical science and modern science; the integration of various forms of scientific knowledge; the crossing of cultural borders by science; and the influence of the worldwide expansion of science on cognitive processes are presented and discussed at length, particularly in the opening conference by Professor Roshdi Rashed. **History,** on the other hand, is primarily concerned by questions bearing on the formation of national scientific communities; the creation of indigenous institutes and the emergence of national scientific traditions; the role of ancient traditions; and the various modalities of scientific development (disciplinary distribution; "pure" science versus "applied" science; the role of the State; ...). These questions in turn generate new, and more controversial, questions concerning the choice of models and cultural allegeance to foreign countries, and meet **contemporary political issues.** If one hopes to understand the difficulties encountered by scientific development, these are the questions one must address. In many Third World countries, science is in a marginal position in relation to both international "mainstream science" and the indigenous socioeconomic system. This is the widely discussed problem of science and development.

These discussions encompass diverse cultural contexts and historical periods for the origins of modern science in Third World countries. The contextual diversity offered by the comparative approach is an unvaluable source of information and provokes reflection. This was the guideline for setting up the sessions of the colloquium. Yet it also complicates the task of unravelling the associated trends and homogenous treatment of available material. This work seeks to develop a novel perspective on "sciences and empires" which is simultaneously holistic and militant; which might in turn guide new policies for scientific development.

In addition to our specifically scientific objectives, we envisioned this international colloquium to be a means of assembling an international body of scholars and researchers representative of the very diversity we were to study. The meeting was a great **"première".**

One hundred twenty scientists of more than twenty nationalities attended. Many were from India, China, Japan and Latin America (mainly Brazil), though France and Spain were also represented.

To encourage cross-cultural comparisons, only two of the nine sessions were limited to distinct cultural areas: Brazil and the Far East. The other sessions focussed instead on a theme intrinsic to a particular discipline (botany, medicine, technology, science policies, and scientific institutions) or dissected various aspects of European scientific expansion (missions and expeditions, policies for colonial and imperial science, and institutions of colonial and imperial science. Panellists animated two round table discussions on the general problems of "integration" (classical science versus modern science) and the expansion strategies of the European powers for "exact" sciences. The final session, which aimed at coordinating conclusions and organizing the future, focussed on the question: "what can the history of science bring to help the "policy-makers".

A rapid survey of topics shows that the communications distributed themselves between the two poles of interest represented by the round tables. They reflected a complete spectrum of methodology and content. Some invoked a traditional approach and operated with the classical "diffusionist" hypothesis (travellers and botanists, the reception of mathematics, etc.). A similar approach analyzed the transformation of modern science in different cultural, social or ideological contexts. Others turned to controversial political questions such as creole science versus metropolitan science, science and the birth of nationalism, and science and discrimination. Some participants drew parallels between two periods (for the same country and discipline), or between two culturally-similar countries. Still others compared the models provided by the leading European countries for scientific institutions and policies. A final group worked on the import-export strategies from metropolis to periphery.

A few general models were suggested, either for the European strategies to export "exact" sciences outside Europe, or for the conditions of the scientific development in Third World countries. The predictions from these models were submitted to strong critics. The integration of both classical science and modern science was put into sharp focus.

From these studies, it became evident that integration is indeed a complex process that cannot be understood simply by looking into the "internal" logic of scientific knowledge. Science is never isolated: it is always part of a process that is at once political, economic, social and ideological. The era of political independence is crucial in that respect, whether or not the attempt to construct a national scientific tradition is successful.

The publication of the colloquium proceedings is a step towards the elaboration of further analyses of "sciences and empires" and to the extension of controversies beyond the circle of experts. An international network of historians of science working on this subject is being formed and will publish a Newsletter. This network is being coordinating both by REHSEIS in Paris and NISTADS (National Institute of Science, Technology And Development Studies) in New Delhi.

The book "Science and Empires - Historical Studies about Scientific Development and European Expansion"

Although this book is rooted in the colloquium, it is not drawn from the proceedings in the usual way. Unable to publish all the communications, we have chosen two main directions: first, the problems about the integration of classical science and modern science; second, the overlap between political strategies and European scientific expansion. Consequently, we have not included communications on scientific expeditions, the Enlightment period or even contemporary cases. We tried to balance contributions from different countries. We hope the contributors will forgive this selection. We have listed at the end of this book all the colloquium's contributors whose work did not find space in its pages.

While French, English and Spanish were used during the colloquium, we have translated the Spanish papers. The book is thus bilingual, French and English. We thank the publisher for tolerating this unusual format. Furthermore, we did not impose a particular style upon the vernacular forms of the American or Indian English, or the Canadian French. We trust that the reader will enjoy this additional proof of diversity.

Aknowledgements

Our thanks go in the first place to the International Scientific Committee that supported this international colloquium and allowed us to benefit from an unusually broad international audience. This committee was composed by Professors Ubiratán d'Ambrosio, Ruy Gama, José Goldenberg, Christian Houzel, Ekmeleddin Ihsanoglu, Iyanaga Shokichi, José Leite Lopes, Nakayama Shigeru, José-Luis Peset, Lewis Pyenson, Abdur Rahman, Roshdi Rashed, Nathan Reingold, Alain Ruellan, Ignacy Sachs, Juan-José Saldanña, Claire

Salomon Bayet, Brigitte Schroeder Gudehus, Darwin Stapleton, Arnold Thackray, G. Thyagarajan, José Israël Vargas and Peter Weingart. The Director of our group, Professor Roshdi Rashed, has initiated and personally encouraged this research trend; his involment and his advice have been invaluable to the preparation of both colloquium and book.

Many thanks also to all those who assisted with the colloquium's organization: above all, Annick Horiuchi whose contributions have been indispensable, and Catherine Harcour whose help has been constant all the way from the colloquium preparation to the edition of this book; and also, Marie-Noëlle Bourguet, Maria Amelia M. Dantes, Inés Harding, Ilana Lowy, Denise Ogilvie, Michel Paty, Xavier Polanco and Jean-Jacques Salomon.

This colloquium had the High Patronage of the President of the French Republic. It was sponsored by UNESCO. It was funded by several institutions: UNESCO, *Centre National de la Recherche Scientifique, Ministère de la Coopération et du Développement, Ministère de l'Education Nationale, Ministère des Affaires Etrangères, Fondation de France, Fondation du Japon, Université Paris XIII, équipe REHSEIS du CNRS, Centre de Recherches Nucléaires de Strasbourg (CNRS),* the Commonwealth Science Council, the Council for Scientific and Industrial Research (India). Additionally, many scientific institutions gave financial aid to their researchers. These resources allowed us to finance, in part or fully, many participants from countries outside Europe.

The publication of this book was made possible by the financial support from the *Ministère de la Recherche et de la Technologie* and by the technical (and computer) assistance from the *Centre de Recherches Nucléaires de Strasbourg.* Kim Pelis, Jim Ritter and Maria Luisa Ortun assisted us with the translations from Spanish or the editing of English texts.

Finally, we are grateful to Professor Robert Cohen, who accepted this book into his well-known series, *Boston Studies in the Philosophy of Science.* In this, Professor Cohen has again demonstrated his commitment to the themes of the colloquium. Thanks to him, we hope to reach a wide audience that extends beyond professional historians and philosophers of science to all readers interested in the many provocative issues raised by past and present scientific development around the world.

PART I

OPENING SESSION

Présentation

SCIENCES ET EMPIRES : UN THÈME PROMETTEUR, DES ENJEUX CRUCIAUX

Patrick PETITJEAN

Introduction du colloque

Avant de présenter le thème "Sciences et Empires" qui nous rassemble ici, et de donner quelques hypothèses sur ce sujet, je voudrais commencer par souhaiter la bienvenue à tous les participants à ce colloque international, et saluer particulièrement ceux qui nous ont fait l'honneur d'être à cette tribune pour la séance inaugurale : le Pr. Adnan Badran, Sous-Directeur Général de l'Unesco, chargé des sciences, qui est notre hôte dans cette maison; le Pr. Ubiratán d'Ambrosio, Président de la Société Latino-américaine d'histoire des sciences et des techniques; le Pr. Roshdi Rashed, Directeur de l'équipe REHSEIS organisatrice de ce colloque, qui prononcera le discours inaugural.

Objectifs du colloque

En ouverture de ce colloque, je voudrais préciser rapidement les objectifs de nos travaux. Le titre général "Sciences et Empires" est complété par un très long sous-titre : *"Histoire comparative des échanges scientifiques - Expansion européenne et développement scientifique des pays d'Asie, d'Afrique, d'Amérique et d'Océanie".* Ce qui est un vaste programme de travail.

A ma connaissance, il y a deux précédents colloques dont les thèmes se rapprochent du nôtre : en premier lieu, un séminaire tenu à Melbourne en 1978, comparant l'implantation de la science moderne aux Etats-Unis, en Australie et au Canada : les travaux ont été publiés par Nathan Reingold[1] et Marc Rothenberg sous le titre *Scientific Colonialism: a Cross-Cultural Comparison.* Ensuite, un séminaire[2] tenu à New Delhi en janvier 1985 sous le même titre *"Science and Empire".* Dans les deux cas, les travaux présentés concernaient des pays de l'ancien empire britanique.

P. Petitjean et al. (eds.), Science and Empires, 3–12.

Mais les travaux sur le problème qui nous préoccupe portent sur beaucoup plus de pays, et se sont multipliés ces dernières années. Ils se réfèrent souvent à une première étude générale publiée par George Basalla en 1967 sur l'expansion de la science occidentale[3]. Basalla avait proposé un schéma "diffusionniste" d'expansion dans un "vide scientifique", identifiant des étapes que tout pays devait nécessairement parcourir avant de rattraper les Etats-Unis, pris comme modèle de référence pour la science. La multiplication des études sociales sur les sciences dans les années 1970, l'attention portée à l'histoire nationale des sciences dans des pays d'Amérique latine, en Inde, au Japon et dans d'autres encore, ont mis en question tant l'existence des étapes définies dans ce modèle, que ses fondements conceptuels : une vision purement "diffusioniste" de la mondialisation de la science. Nous sommes passés de l'étude de la "diffusion" à travers des frontières culturelles à celle de la "réception", puis à celle des "conditions de production" de la science moderne, et finalement à l'étude des "problèmes d'intégration" entre la science moderne et les traditions scientifiques classiques.

Il s'agit d'une part d'essayer de comprendre comment, pourquoi, éventuellement selon quelles stratégies conscientes, les métropoles européennes ont développé des activités scientifiques dans leurs empires, mais aussi comment cela s'est articulé avec la construction des empires. Dans cette optique, il faut signaler particulièrement les travaux de Roy MacLeod[4] sur l'Empire britanique, ainsi que ceux de ses élèves. Ou encore le vaste travail de comparaison entre le France, l'Allemagne et les Pays-Bas entrepris par Lewis Pyenson[5] et qui a débouché sur une typologie des stratégies d'expansion pour les sciences exactes.

Il s'agit d'autre part de ce que j'ai appelé des travaux "d'histoire nationale" des sciences. Une vision ancienne de l'histoire des sciences dépréciait souvent les apports des pays non-européens; en réaction, les historiens de nombreux pays ont cherché à mieux évaluer leur propres traditions scientifiques, et à affirmer leur identité. Ils ont été amenés à se poser le problème de la rencontre entre science moderne et science classique, et, par là même ont rejoint les préoccupations de politologues des sciences, d'universitaires et de responsables politiques concernant les difficultés rencontrées par le développement scientifique dans certains pays, les racines historiques du problème science/développement ou science/dépendance. Avec le développement de nouvelles formes d'empires, et certains parlent déjà d'un processus de re-colonisation, ces problèmes sont d'une actualité brûlante.

Les sociologues des sciences quant à eux ont proposé différents modèles du type ″centre/périphérie″, ou ″sciences-monde″ pour expliquer les localisations des activités de recherche dans un système scientifique pris comme un tout, le déplacement des centres scientifiques à différentes périodes historiques, etc. En France, il existe une tradition importante d'histoire coloniale, où parfois l'attention s'est portée sur le rôle joué par la science dans la colonisation. mais, pour les historiens ou sociologues des sciences, cette tradition est peu connue. Et les études autour de ″science et colonisation″ n'ont pas connu une vogue aussi importante, ces dernières années, que dans le cas des autres puissances coloniales comme l'Angleterre, l'Espagne, voire les Pays-Bas (les études concernant des empires plus récents, américain et russe entre autres, souffrent aussi d'un certain manque d'intérêt). L'équipe REHSEIS[6], qui a pris l'initiative d'organiser ce colloque, travaille sur ce sujet depuis sa constitution. Proposé par le Professeur Roshdi Rashed, le thème ″Sciences et Empires″ était un des trois programmes de recherche motivant la création de notre équipe au CNRS[7] en 1984. Si le programme de recherches de REHSEIS ne se limite pas l'Empire français, ce colloque se propose d'inciter au développement d'études sur le cas français.

L'idée de réunir un colloque international sur ce sujet date de la participation de chercheurs de REHSEIS au séminaire de 1985 à New Delhi. Autour des Professeurs Rashed et Rahman, a commencé à se constituer un réseau d'historiens travaillant autour de ce problème, réseau qui a servi de base pour l'organisation de notre colloque. L'idée était d'organiser quelque chose de plus complet et de plus original que les deux séminaires précédents : réaliser des études comparatives, sur une base plus large que l'Empire britanique, entre des régions de traditions culturelles et de civilisations différentes; entre des pays qui ont des traditions scientifiques anciennes et fortes, et d'autres où elles ont été détruites par la brutalité de la colonisation; entre différentes puissances coloniales dans leur empire. Pour cela, il fallait réunir de nombreux participants à ce colloque, représentatifs de la diversité des travaux existants, notamment de la variété des approches méthodologiques et des démarches scientifiques qui existent, aussi bien pour des études de cas, que pour les généralisations et les tentatives de modèles théoriques. Représentatifs aussi de la diversité des civilisations et des cultures. Ce domaine de l'histoire des sciences reste encore largement à construire, et l'histoire comparative y est plus une perspective de travail qu'un état actuel. Nous avons donc choisi d'avoir une participation hétérogène, de caractère un peu disparate, et de tenir des séances diversifiées. Le foisonnement des études et des réflexions est un moment toujours indispensable dans la construction théorique d'un domaine.

Orientations de travail

Si nous revendiquons l'hétérogénéité de nos travaux, cela veut pas dire que nous nous satisferons de discours parallèles, situés sur des plans trop différents pour pouvoir se rencontrer. Pour tenter de structurer un peu plus nos travaux et notre réflexion, je voudrais profiter de cette introduction pour vous soumettre quelques suggestions et hypothèses de travail.

1- La première concerne **l'intérêt, mais aussi les limites, des modèles, des théories, ou des concepts importés des autres sciences sociales.**

L'intérêt des modèles n'est pas contestable : ils sont le plus souvent très stimulants pour la réflexion, ils fournissent des hypothèses à tester. Mais il faut se poser la question des connaissances supplémentaires réelles que tel ou tel modèle apporte pour les phénomènes étudiés. Un certain degré de généralisation, en voulant faire entrer dans un même cadre très structuré, une série de phénomènes historiques, localisés, peut oublier en chemin la richesse et la complexité du réel, ou alors, obliger à multiplier les exceptions qui s'écartent du modèle proposé. Cela peut être très réducteur : dans un même mouvement, un modèle peut enrichir et appauvrir notre connaissance des phénomènes étudiés.

Malgré les précautions prises lors de sa présentation, le modèle proposé par Basalla[8] a été perçu comme devant être valide en tout lieu et en tout temps : c'est le travail le plus cité, et le plus réfuté aussi, par tous les historiens des sciences ayant travaillé sur le problème qui nous réunit. Basalla avait proposé trois étapes "obligatoires" pour le développement de la science moderne : la science "exploratoire" (où le pays est un objet de voyages, d'explorations et de collectes pour les européens), la science "coloniale" (où la science commence à se faire sur place, de plus en plus par des scientifiques locaux, mais de manière totalement dépendante pour la formation comme pour la formulation des questions scientifiques, d'une métropole européenne), et la science "autonome" (celle des pays européens, des Etats-Unis et de l'URSS en 1967, mais qui restait un objectif encore à atteindre pour les autres). En se penchant sur le cas de leur pays, les chercheurs ont essayé de retrouver ces étapes ainsi que les figures "typiques" des scientifiques qui s'y rapportent. Dans beaucoup de pays, la première étape correspond à l'activité scientifique des européens (mais ils n'ont pas toujours été les seuls à avoir des activités scientifiques, classiques ou modernes); mais les autres étapes ne se retrouvent que rarement sous la forme identifiée par Basalla. Les chercheurs ont donc analysé les différences de leur pays avec le modèle de Basalla, ce qui a constitué une incitation précieuse à l'accumulation de nouvelles connaissances. En proposant le développement de la science moderne aux Etats-Unis comme paradigme historique pour les pays hors d'Europe, Basalla a fourni des critères pour mesurer *l'écart* et étudier *les différences* dans ce domaine entre les Etats-Unis et le reste du monde, ainsi que pour *hiérarchiser* les pays selon ces critères. Mais a t-il fourni des éléments permettant d'analyser les modes historiques de développement de la science dans des sociétés de cultures différentes? Pour comprendre les phénomènes à l'oeuvre dans la traversée des frontières culturelles par la science moderne? La problématique "diffusionniste" du travail de Basalla ne permettait sans doute pas de poser ce type de questions.

Un autre modèle, proposé par Lewis Pyenson[9], pose des questions assez différentes. Tout d'abord, il est volontairement, et heureusement, beaucoup moins général. Son propos est beaucoup plus délimité : il ne s'intéresse pas à l'aspect "construction de traditions scientifiques nationales", ou à l'aspect "intégration", ni même au problème de la "réception" de la science moderne, mais à l'utilisation de la science dans la développement des empires; il utilise comme "sonde" pour ce faire les sciences exactes (se référant à l'impérialisme culturel), laissant de côté les sciences humaines ou sociales (trop dépendantes des questions idéologiques) et les sciences appliquées (dont l'expansion est déterminée par leur utilité directe dans la colonisation); et il étudie la transplantation des scientifiques européens à la périphérie, leurs pratiques, leurs résultats, et les stratégies dont ils sont porteurs. En étudiant les corrélations de cet impérialisme culturel avec le niveau économique, politique, militaire ou idéologique, par un travail comparatif entre la France, l'Allemagne et les Pays-Bas, il aboutit à une typologie des stratégies d'expansion scientifique selon trois axes "paradigmatiques" : * **"fonctionnaire"**, marqué par une union étroite entre les intérêts académiques, militaires et religieux, où la volonté de faire des recherches originales est faible, voire inexistante, et où un scientifique à l'étranger reste entièrement subordonné aux directives métropolitaines; * **"scientifique"**, marqué par une union lâche entre les intérêts académiques, militaires et affairistes, où l'éthique de la recherche reste prédominante; * **"commerçant"**, une stratégie où les scientifiques sont au service des grandes compagnies, et où la recherche se voit assigner le but de résoudre divers problèmes techniques. Les différents cas "typiques" sont, respectivement, la France, l'Allemagne et le Canada (ou la Belgique). Le Royaume-Uni est une combinaison entre les axes "scientifique" et "commerçant". Les Pays-Bas sont une combinaison entre les 3 axes. Le classement des différentes métropoles selon ces axes auquel Pyenson parvient, me parait bien refléter les idées généralement admises, ou les préjugés, sur les spécificités de chacun de ces pays en tant que puissance colonisatrice, ni plus, ni moins. Mais sans doute est-ce là un apport de ce modèle : rien ne différencie l'expansion scientifique (l'impérialisme culturel selon les termes de Lewis Pyenson) de l'impérialisme dans son ensemble.

Deux autres modèles ont été proposés dans des publications récentes. Ils sont un peu différents, en ce sens qu'ils "importent" en histoire des sciences des concepts élaborés dans d'autres domaines de la science. Dans le cas de Susantha Goonatilake[10], il s'agit d'appliquer au développement scientifique la théorie d'évolution des systèmes thermodynamiques, en particulier celle formulée par Ilya Prigogine. Pour ce qui concerne ses activités scientifiques,, chaque civilisation est analysée comme un système ouvert, interactif, et l'ensemble des civilisations forme un système "multilinéaire évoluant selon un processus entropique". C'est une approche nouvelle dont il est encore trop tôt pour dire si elle sera utile pour mieux comprendre les modalités historiques du développement de la science, ou s'il s'agit d'un discours clos, auto-suffisant. Dans le cas de Xavier Polanco[11], les concepts qu'il importe sont plus familiers aux historiens, puisqu'il s'agit des "économies-monde", de concepts pris dans l'oeuvre de Fernand Braudel. Pour rendre compte à la fois de la mondialisation de la science européenne et de la construction de traditions scientifiques nationales, sans réduire un phénomène à l'autre, il propose de recourir au concept de "science-monde", comme réunion "d'espaces et de sciences", et d'étudier les règles d'évolution et de transformation des sciences-monde comme Braudel a étudié celles des économies-monde. C'est donc une incitation à repenser différentes études d'histoire nationale des sciences dans ce nouveau cadre, et il s'agit moins d'un nouveau modèle que d'une nouvelle méthodologie.

Il me semble qu'il faut retenir de ces tentatives de réflexions d'ensemble un encouragement à multiplier les études de cas, en utilisant plusieurs grilles d'analyse, plus que l'imposition d'un cadre obligatoire.

Et en cela, notre connaisance des phénomènes concrets s'enrichira. Cela conduit à ma remarque suivante :

2- En deuxième lieu, il parait **indispensable de comprendre l'ampleur de la complexité des phénomènes étudiés.**

Aller au fond de la complexité est sans doute mieux adapté au stade où nous en sommes, et potentiellement plus fructueux, que de vouloir tout faire rentrer dans un même cadre. La naissance et les premiers développements de la science moderne sont le produit d'un mouvement social historiquement daté et localisé dans certaines régions d'Europe. Ce n'est pas reproductible. Analyser très en détail les relations entre les activités scientifiques et les espaces qu'elles occupent (ce qui est une des directions du travail proposé par Polanco) peut aider à rendre compte de la diversité des situations, des traditions scientifiques, des représentations de la science, et de leur richesse. Il y a sans doute nécessité de décomposer ces relations selon les contextes, selon différents plans (culturel, économique, social, idéologique, politique, etc), selon différentes stratégies d'expansion ou, inversement, selon différents types de "demande" de science. Ce qui permettra, ensuite, de mettre en évidence des régularités et des constances dans les phénomènes, ainsi que des corrélations, passées inaperçues, entre certains niveaux. Il faut donc multiplier les études de cas, mais aussi reprendre avec ces nouvelles perspectives des études antérieures plus classiques. Par exemple, il serait intéressant de reprendre l'histoire du Muséum d'Histoire naturelle de Paris, faite par Camille Limoges[12], et qui n'aborde que brièvement les relations entre le Muséum et la colonisation, en y voyant une tentative avortée des professeurs "ancien style" de retrouver pour eux-mêmes et pour leur institution une place dominante dans la science française à la fin du XIXe siècle.

3- Une troisième orientation de travail, c'est **l'utilité de conserver une double mise en perspective dans ce domaine de recherches,** si l'on veut pousser les analyses le plus loin possible.

La première perspective est ce que j'ai déjà appelé schématiquement le modèle "diffusionniste". On s'intéresse à la diffusion d'un savoir constitué, la science européenne moderne, à l'extérieur des pays et en dehors des conditions qui lui ont donné naissance. Et donc à l'émission de connaissances à partir d'un centre, à leur réception dans d'autres pays, ainsi qu'aux "vecteurs" de cette transmission. Les pays d'accueil étant souvent considérés comme passifs, et dépourvus au départ de toute science. Cette perspective peut être étoffée par des apports de l'histoire sociale des sciences, en étudiant les stratégies mises en oeuvres pour l'exportation de cette science d'un côté, et les conditions économiques, sociales, culturelles et politiques de sa réception, ce que Basalla[13] appelle les "niches", permettant d'accueillir cette science. L'histoire des sciences dans les pays non-européens devient alors l'étude de ces niches, de leur mûrissement, et de leur adaptation progressive pour accueillir et faire fructifier la science moderne. La deuxième perspective est inverse, elle ne part plus des anciennes puissances coloniales, des métropoles, mais elle part des différents pays eux-mêmes, et s'intéresse avant tout à l'émergence (mot-clé de cette deuxième perspective, comme "diffusion" était celui de la première) des traditions scientifiques nationales, avec toutes les racines historiques, parfois lointaines, de ces traditions, avec le système de valeurs qui les accompagne, et avec le volontarisme (politique, idéologique) partout présent dans le lancement d'activités scientifiques. C'est une mise en perspective qui permet de recadrer la question de l'influence des pays européens, de prendre en compte le cadre colonial et post-colonial, et qui se situe plus probablement sur la longue durée. Ces deux mises en perspective peuvent être également fructueuses et permettent l'une et l'autre d'étudier la place et le rôle de la science aussi bien dans la mise en place d'un système de domination, que dans la construction d'Etats nationaux ou le développement d'une identité et d'une conscience nationales.

4- Dernière hypothèse, comme étape indispensable avant d'arriver à des modèles, c'est la nécessité **de rechercher les corrélations pouvant exister entre les phénomènes étudiés.**

Après avoir décomposé et déconstruit, il faut malgré tout s'essayer à élaborer des idées plus générales, voire un point de vue d'ensemble. On peut déjà tenter d'identifier plusieurs corrélations importantes. La première, entre science et "politique", si l'on prend le terme "politique" au sens le plus large, et non pas au sens de politique scientifique. Sauf quelques cas ponctuels et isolés, les tentatives un peu systématiques et durables d'impulser des activités scientifiques sont toujours le fait des pouvoirs politiques, en place, ou candidats à le devenir. Par exemple, elles sont venues d'Etats essayant de résister à la poussée expansionniste européenne, en particulier au XIXe siècle, dans l'Empire Ottoman, ou en Amérique latine[14]. Ou encore, elles ont été le fait des mouvements pour l'indépendance, aussi bien en Amérique espagnole au tournant du XIXe siècle qu'en Inde à partir de la seconde moitié du XIXe siècle. L'étude des contradictions entre la science "créole" et la science espagnole par Luis Carlos Arboleda[15], ou celle de des différents types de scientifiques "coloniaux" en Inde par V. V. Krishna[16], mettent en évidence une telle corrélation. C'est enfin le cas aussi des autorités coloniales qui tentent de développer certaines activités scientifiques dans les empires à partir de la fin du XIXe siècle, quand apparaissent les doctrines de "l'impérialisme constructif", de la "mise en valeur" des colonies, de la science pour le développement. Ce recours à la science moderne peut parfois être très velléitaire, et se limiter à une rhétorique ou à des invocations épisodiques, il n'en reste pas moins qu'il s'agit d'un élément constitutif de l'identité d'une partie des mouvements nationalistes ou des Etats nationaux constitués après les indépendances. Une telle corrélation peut être à l'origine des contradictions, encore actuelles, des modes d'enracinement de la science dans les systèmes sociaux. Il s'agit, en particulier, de la marginalité de la science, ainsi renforcée par la marginalité de certaines de ces élites nationales. En second lieu, et ce n'est pas indépendant de ce qui précède, il faut remarquer la place prise par la demande de savoir pratique (la formation, les résultats de la science), au détriment de la recherche elle-même. Par exemple, la deuxième moitié du 19ème est marquée par l'ouverture d'un certain type d'écoles d'ingénieurs, avec importation de livres et d'enseignants européens. Il ne faut pas oublier non plus que si l'appel à la science européenne va de pair avec une volonté nationaliste de "modernisation" générale (avec toutes les ambigüités de cette volonté), le développement scientifique qui en résulte parfois est, en même temps, un moyen d'intégration sous une forme dépendante, au marché mondial[17]. Autre corrélation enfin qui apparaît dans plusieurs situations : la liaison entre science et expansion politique n'est ni marginale, ni limitée au rôle joué par les techniques pour permettre l'occupation militaire de la planète. Il est insuffisant de parler de "science dans l'empire", sans interactions. Il est peut-être aussi insuffisant de parler de "science pour l'empire", même si cela prend en compte le rôle des techniques et "l'impérialisme constructif". Faut-il parler de "science comme empire" pour mettre en valeur l'interrelation entre l'expansion scientifique européenne et la mise en place du système de domination impériale moderne? C'est un problème qui est posé par plusieurs historiens, et qui demande une confrontation plus poussée entre historiens de la colonisation et de l'impérialisme, et historiens des sciences.

Pour importantes qu'elles soient, ces corrélations n'épuisent pas le problème posé par "sciences et empires". Mais elles seront à prendre en compte, notamment quand nous discuterons des problèmes d'intégration entre science moderne et science classique, qui sont au centre des préoccupations de ce colloque. Mais ces quelques suggestions et hypothèses auront atteint leur but si elles ont lancé la discussion, et provoqué la rencontre des analyses. Les travaux du colloque donneront un début de réponse.

Centre National de la Recherche Scientifique, Paris (REHSEIS) et Strasbourg (Centre de Recherches Nucléaires)

Notes

[1] N. Reingold et M. Rothenberg (eds): *Scientific Colonialism: a Cross-Cultural Comparison,* (Smithsonian Institution Press, Washington, 1987).
[2] D. Kumar (ed): *Science and Empire,* NISTADS, New Delhi, 1990.
[3] G. Basalla, "The Spread of Western Science", in *Science,* **vol. 156,** n°3775, 1967, p.611-622.
[4] Roy MacLeod, "Visiting the Moving Metropolis: Reflections on the Architecture of Imperial Science", in Reingold and Rothenberg, *op. cit.* Voir aussi Michael Worboys, *Science and British Colonial Imperialism,* Ph. D. thesis, 1979, University of Sussex.
[5] Lewis Pyenson, "Fonctionaries and Seekers in Latin America: Missionary Diffusion of the Exact Sciences, 1850-1930", *Quipu, Revista Latinoamericana de Historia de las Ciencias y la Tecnologia,* 2, 3, 1985, p.387-422. Lewis Pyenson, *Cultural Imperialism and Exact Sciences. German Expansion Overseas, 1900-1930,* New York, 1985, Peter Lang. Lewis Pyenson, *Empire of Reason -Exact Sciences in Indonesia, 1840-1940,* E. J. Brill, Leiden, 1989. Lewis Pyenson, "Pure Learning and Political Economy: Science and European Expansion", in R. P. W. Visser, H. J. M. Bos, L. C. Palm, H. A. M. Snelders (eds.), Proceedings of the Utrecht Conference, *New Trends in the History of science,* Amsterdam, 1989, Rodopi.
[6] REHSEIS : Recherches Epistémologiques et Historiques sur les Sciences Exactes et les Institutions Scientifiques.
[7] CNRS : Centre National de la Recherche Scientifique.
[8] G. Basalla, *op. cit.*
[9] Lewis Pyenson, "Pure Learning, ...", *op. cit.,* note 5.
[10] Susantha Goonatilake *Multilinear evolution of science as an entropic process,* unpublished (see this volume, p.400).
[11] Xavier Polanco, *this volume,* p.231-248.
[12] Camille Limoges, "The development of the Muséum d'Histoire Naturelle of Paris, 1800-1914", in Fox and Weisz (eds.), *The Organization of Science and Technology in France 1808-1914,* Cambridge University Press, 1980, p.211-240.
[13] G. Basalla, *op. cit.,* note 3.
[14] Jean Batou, *Cent ans de résistance au sous-développement, 1770-1870 - L'industrialisation de l'Amérique latine et du Moyen-Orient face au défi européen,* Centre d'histoire économique internationale de l'Université de Genève, Droz, 1990.
[15] Luis Carlos Arboleda, communication au colloque international "Sciences et Empires", Paris, Unesco, avril 1990, reproduite dans cet ouvrage.
[16] V. V. Krishna, communication au colloque international "Sciences et Empires", Paris, Unesco, avril 1990, reproduite dans cet ouvrage.
[17] Jean Batou, *op. cit.,* note 14.

Opening Addresses

WELCOME ADDRESS

Adnan BADRAN - UNESCO

On behalf of the Director General of UNESCO, it gives me great pleasure to welcome you all to this International Symposium on "Science and Empires". UNESCO, which is an international home for science, education and culture, indeed provides the proper setting for your exchange of views and your deliberations, and this is why we are glad to participate in this gathering.

I should like, first, to commend the organizers, Mr Petitjean, Mr Rashed and their team at the CNRS, for having taken this initiative, which is most timely in this age of technological globalization and instant international communications. Indeed, as we look back over different horizons or historical time perspectives, we discover with awe that man has learned over the past ten years nearly how to fabricate a human being; over the past fifty years how to destroy the planet instantly; and over the past two centuries how to free the individual from daily chores by having machines do them in his stead.

Consequently, that potentialities for mastering our environment seem to be boundless, limited only by the pace of progress in our understanding of this environment. Strangely however the world seems to be in a state of crisis, owing precisely, one senses, to such understanding. Perhaps some of the scholars meeting here would raise the question of the so-called "universality of science". At least, considering the theme of this meeting, "Science and Empires", one infers that a brand of knowledge was developed at some place and transferred to some other places and the question is: what is it that makes certain areas of knowledge prevail over borders and cultures? Is universality a quintessential characteristic of this or that manifestation revealed by scientific endeavour (such as the earth's being round instead of flat), which would make the characteristic enter the realm of evidence, for all to see and adhere to?

P. Petitjean et al. (eds.), Science and Empires, 13–15.

This, in turn, leads us to ask what is scientific truth, and what is its status? Relative, or absolute? There, philosophical debate seems to be inextricably linked to the history of ideas in general, and to science in particular. Certainly, one of the reasons is that science has proved to be a powerful tool to understand our environment, and to act effectively on it, bringing into perspective the problem of power-sharing among peoples of the world.

A fundamental mission of UNESCO is to spread knowledge and thereby facilitate the harmonious and sound development of its member states. UNESCO seeks to effect this mission through progressive mastery of scientific advances and technological capability, which requires a massive educational effort; a carefully-designed programme of technical-expertise acquisition through knowledge-transfer; and a build-up of institutional infrastructure.

The past forty years demonstrate that this has generally been a slow process but that, in certain cases, national capabilities can be drastically changed within a single generation. These exceptions raise important questions. Can such instances of rapid transformation be generalized? How fast, within a given developmental context, might their pace be? Alternatively, if we assume that this pace is set by some internal dynamics of knowledge, what should we, what should statesmen responsible for their people, foresee in terms of education, research infrastructure, and measures to integrate the scientific and technological revolution, as it unfolds?

This meeting seeks to shed some light by examining how and in which cultural, institutional and political conditions certain patterns of thinking and acting, were transmitted in the past. Current thinking at UNESCO, reflected in its current six-year programme, is that science cannot be developed independently of the cultural and social context. Hence, we are committed to promote scientific and technological culture, to look at social conditions favouring research, and to investigate the applications (social, ethical, and otherwise) of advances in science and technology.

In this enterprise, we are faced with enormous worldwide disparities in our ability to integrate, let alone to generate modern advanced science and technology. If one is deliberately to promote certain courses of action, for example policies and strategies in science and technology, in developing countries, one must learn lessons from the past. For this, we are dependent on the outcome of your scholarly work. The final round table of this meeting addresses precisely that question which is far from being an academic one, but constitutes a very crucial issue of our modern development predicament.

Assistant Director-General for Science, UNESCO, Paris

FOR A NEW HISTORIOGRAPHICAL APPROACH OF THE SO-CALLED "TRADITIONAL KNOWLEDGE"

Ubiratán D'AMBROSIO - SLAHCT

It is impossible to look at the theme of this colloquium and disregard the fact that it demands we go back over 500 years to unrevel its history. In 1434, Gil Eanes went beyond the Cape of Bajador, which opened up the Atlantic. Subsequently, an increasing interchange opened between Portugal and Africa, which culminated with Vasco de Gama reaching Calicut in 1498. Had it been delayed for only a few years, the Indians would have reached Portugal via the same route, circumnavigating Africa as claimed by Afonso de Albuquerque.

An enormous exchange of what we now call "knowledge" began after 1434. Curiously enough, the Atlantic resisted communication and interchange until the 15th century. The land routes between Europe and Asia were well known since Antiquity and the transpacific navigation was also well recognized. The only gap that remained was the Atlantic. This was done in 1492. Since then, the world has changed.

New forms of explanation as a result of exchange of scientific information, of observations and of organized knowledge, mainly in astronomy, geography, zoology, mineralogy, agriculture, were produced. Rationalism laid roots in the history of ideas. New forms

P. Petitjean et al. (eds.), Science and Empires, 15–17.

of consumption, of exchange, of production and of property took place. The following four steps laid the ground for progress:

1) Consumption of raw materials and consequent mercantilist expansion.

2) Reconceptualization of geopolitics, of national interest, of defense and of strategy.

3) New concepts of property: expropriated land - to which no one could claim ownership - was given to individuals and families, at the discretion of the Monarch.

4) New concepts of production, with the use of immigrant labor (free or slave), expansion of monoculture and planification of output, the development of industrial management in mining and agro-industry, then laying the ground for mercantilist capitalism in the Renaissance and in the 18th and 19th centuries, and for the Industrial Revolution.

A programme in the history of science has to take into account all these steps. Surely, from an eurocentric viewpoint focussed on the winning ideas of the cultural exchange during the entire history of mankind, and particularly in these last 500 years, it is natural to place emphasis on the emission and reception of the mode of thought labelled as science. But from a broader historical perspective, it might be more appropriate to expand our concerns to: 1 - the generation; 2 - the transmission; 3 - the institutionalization; 4 - the diffusion of knowledge. An historiographical framework based on these four steps necessarily takes strongly into account the cultural dynamics which brings together the "winners" and the "losers" in the development of ideas. The available explanation for cultural dynamics, and even for the cognitive processes, involved in the generation and transmission of knowledge, is strongly biased towards the eurocentric perception of "winning ideas", and leaves much to be explained. Even modern cognitive theories, resulting from a darwinian-haeckelian model and the recent cultural socio-biology approach, all reveal a eurocentric bias. Comparative studies of civilizations also carry, at their first onset, these biases. Take, for example, the importance given to Pythagorean-like theorems when studying other civilizations, or to the existence of a zero. Generally, in these other civilizations, such concepts belong to an entirely different context than their supposed mathematical meaning, and reveal practically nothing about a supposed degree of mathematical knowledge. The existence of a zero would not automatically lead to logarithmic tables and calculators a few hundred years later! The direction taken by the progress of knowledge is intrinsic to the cultural texture, as are the results themselves. The quest for a common evolution of knowledge (called progress) through ages and centuries, is necessarily biased by observer's standards or patrons .

In the future, the concept of a Third World will disappear. This is a further reason to use a broader historiographical approach for history, and particularly history of science and technology. For example, most of the original sources of western scientific knowledge become easily accessible in Latin-America, through fac-simile edition or faxed documents and it might be a lure to believe that we would understand better our current thought by penetrating the thought of less than 1% of our ascendents. In other words, when building up our options for the future, we cannot forget that throughout our history and even today the large majority of our population survives, produces, and reproduces, explains its reality within a different structure of knowledge. What is called scientific development in the western sense is obviously affected by this immense mass of accumulated knowledge - even if many people prefer to talk about superstition, tradition or popular wisdom - through processes of cultural dynamics. Historians of science cannot ignore this process. Obvioulsly, they evenless cannot forget the strong part played by the mental attitude of these 99% or more of our people.

Their thought has contributed to the development of our knowledge, and this is the reason why it should not be looked at with such common and unsustainable biases as - ″this is ad-hoc knowledge″, ″this is superstition″, ″this is folklore″. History of science should be accompanied by the search for new alternative and broader epistemologies, and by the development of new methodologies. The programme ″Ethnomathematics″ is an example of such an attempt.

Loosing ideas are an integral part of our concern for the past: without moving into such a new historiographical context, a further ″Science and Empire″ conference would still have to consider Empires not only as History, but as present systems.

Universidade de Campinas, President of the Latin American Society for the History of Science and Technology (SLAHCT)

Opening Conference

SCIENCE CLASSIQUE ET SCIENCE MODERNE A L'ÉPOQUE DE L'EXPANSION DE LA SCIENCE EUROPÉENNE

Roshdi RASHED

First, let me thank my colleagues of REHSEIS who organized this International Colloquium, Patrick Petitjean, Annick Horiuchi, Catherine Jami and Anne Marie Moulin, and the scientific committee which helped them. Second, I would like to thank UNESCO, and particularly Professor Badran for all their help and all their support for the organization of this colloquium.

My paper will be concerned mainly with the reaction of an historian of science to this question of transfer. I will present two case studies, one from Egypt and the other from Iran, to illustrate exactly what I mean. The title of my paper is "Classical Science, Modern Science and the Contribution of the European Expansion", or the "Contribution of the Expansion of European Science".

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Il y a un siècle, on aurait confié le problème qui nous préoccupe ici - le transfert de la science européenne en dehors des frontières de l'Europe - aux anthropologues et, selon le cas, aux orientalistes, sans penser faire appel aux historiens des sciences. Plus récemment, dans les années cinquante, les économistes, ceux qui s'intéressaient à la célèbre question du développement économique, ont réactivé cette problématique sans recourir à l'histoire des sciences. Mais les historiens des sciences eux-mêmes sont restés dans une parfaite indifférence à ce sujet qui pourtant relève de leur discipline. Quelles sont donc les raisons de cette indifférence? Quels services peut rendre l'histoire des sciences à l'examen d'une problématique de notre temps? Est-il possible de parler d'histoire des sciences appliquée? Je ne pourrai sans doute pas

P. Petitjean et al. (eds.), Science and Empires, 19–30.

répondre à toutes ces questions, mais je tenterai d'en élucider quelques-unes.

Notons pour commencer que, si notre problème fut d'abord renvoyé aux anthropologues et aux orientalistes, c'est en raison d'une situation objective de la science elle-même, d'une conception alors dominante de son histoire, et d'une idéologie admise par la quasi-totalité des historiens. C'est un tel contexte qui, en partie tout au moins, permet de comprendre la position du problème aujourd'hui.

La situation objective touche à la constitution de la science moderne à partir de Newton et de ses successeurs. Cette science est *européenne* en ce sens qu'elle s'est élaborée et développée en Europe de l'Ouest et nulle part ailleurs. D'autre part, par ses intentions unitaires, ses visées d'application, son organisation institutionnelle et la philosophie qu'elle a pu susciter, cette science moderne, ou européenne, se distingue très nettement de la science classique qui fut cultivée entre le IXe et le XVIIe siècles : on comprend immédiatement que le terme "transfert" ne s'applique pas dans le même sens à ces deux périodes de la science. Si maintenant on en vient à l'histoire des sciences telle qu'on la conçut à l'époque, elle oscille entre deux pôles : l'histoire des successions des savants et des résultats accumulés - comme en témoigne l'exemple de Montucla en histoire des mathématiques - et une philosophie du progrès, comme celle de Condorcet, ou du développement, comme chez Auguste Comte plus tard. Selon la première perspective, le transfert de la science européenne n'apporte rien à l'histoire des disciplines, et selon la seconde, il se trouve simplement en dehors de l'histoire, puisque l'humanité est considérée comme un tout en fait représenté par le peuple le plus avancé, c'est-à-dire les états modernes d'Europe; ou parce que les autres peuples n'ont pas encore connu "l'état positif". Quant à l'idéologie, enfin, nous voulons parler de l'idéologie de l'occidentalité de la science en général, tant classique que moderne. Elle a abouti à l'unification sous le vocable *"occidental"* des différentes étapes historiques de la science. Comme démarche théorique, démonstrative et expérimentale, la science serait le fait de l'humanité européenne; bien plus, c'est elle qui, aux dires de Husserl par exemple, définit cette humanité du point de vue spirituel. Toutes les autres positivités historiques seraient alors également étrangères à la science, et la marginalité de leur contribution n'est nullement contingente, mais bien essentielle. Or tous ces éléments ont contribué à détourner l'historien du problème du transfert de la science européenne, mais aussi à surdéterminer en quelque sorte le sens de ce transfert chez les anthropologues et les orientalistes. Il fut alors conçu comme un déplacement valorisé d'un produit occidental, étranger par sa nature aussi bien que par son histoire à ses destinataires. Le second postulat admis par les auteurs est que ce transfert s'opérait sur un terrain vierge, dans un vide scientifique, grâce aux différents vecteurs des Empires, missions, commerçants, armées, etc. Ce serait alors, selon un terme célèbre, un élément de "l'acculturation".

Ce sont de telles idées, qui, me semble-t-il, ont fait germer chez certains auteurs l'ambition de forger un modèle universel pour représenter ce phénomène de transfert. Rien n'empêcherait en effet, dans un tel esprit, de mettre au pied d'égalité les différentes périodes et les divers pays, puisque l'élément unificateur est essentiellement négatif. Nous allons nous arrêter à ces idées qui dominent la représentation du phénomène du transfert de la science moderne, à la lumière d'autres exemples et d'autres résultats de l'histoire des sciences. Nous verrons se dessiner une variété de situations qu'il serait trompeur de confondre en une vision unique. Je m'en tiendrai ici à deux situations exemplaires, représentées respectivement par l'Iran et l'Egypte - en insistant sur le cas égyptien - deux pays de l'ancien monde, et qui appartiennent au vaste ensemble que l'on sait.

L'exemple iranien

Le postulat du vide non seulement est inexact, mais il interdit une vision claire et juste de l'introduction et de la diffusion de la science européenne, notamment dans les pays qui avaient le plus contribué à la constitution et au développement de la science classique. Ce postulat occulte en effet un aspect important mais nullement étudié : la survivance et la continuité d'un enseignement, parfois même d'une recherche, d'origine traditionnelle. La question se formule alors en ces termes: comment s'est faite la rencontre entre une science encore dans l'état où elle était quelques siècles auparavant, et la science moderne? Le savant traditionnel était-il le mieux équipé pour épouser la science moderne? C'est là, de toute évidence, la question de la structure d'accueil de la nouvelle science. Pour éviter les généralités, venons-en tout de suite à l'exemple iranien, pour nous limiter successivement à l'un des foyers culturels du XIXe siècle, la ville d'Ispahan, et à l'un des savants de ce foyer, Mîrzâ 'Alî Muhammad al-Asfahânî (1800-1876). Celui-ci a composé en arabe, en 1824, c'est-à-dire dans la langue de la science traditionnelle, un livre de mathématiques. Ce livre est présenté par l'auteur lui-même comme le complément d'un autre traité rédigé

par un mathématicien du début du XVIIe siècle - al-Yazdî. Or, pour compléter ce livre du XVIIe siècle, al-Asfahânî poursuit les recherches des mathématiciens des XIe et XIIe siècles en algèbre, comme al-Khayyâm et Sharaf al-Dîn al-Tûsî, sur les vingt-cinq équations algébriques des trois premiers degrés. Al-Asfahânî n'était manifestement pas au courant de la résolution par radicaux de l'équation cubique, et sa connaissance en ce domaine ne dépassait pas celle de ses prédécesseurs du XIIe siècle. C'est donc sur la base de ce savoir mathématique qu'il avait rédigé ses propres recherches. Il commence par exposer une méthode de résolution numérique des équations algébriques, qui dépend explicitement de la propriété importante du point fixe. Al-Asfahânî considère d'abord la fonction $f(x) = x$. L'idée importante qu'il a conçue est la suivante : il existe un algorithme simple qui permet de calculer une valeur approchée de la racine, avec le degré de précision voulu. Il démontre alors deux propositions :
(1) La fonction $y = f(x) = x^{1/3}$ est contractante sur un intervalle fermé borné $[a, b] \subset \mathbf{R}$ si $a > 1$;
(2) si l est une fonction croissante contractante de coefficient h, et g une fonction affine croissante, $g(x) = cx + d$,
alors si $hc < 1$, $f = l \circ g$ est croissante contractante de coefficient h.

Mais ce procédé, fondé sur le point fixe, et ces propositions, ne sont pas les seuls résultats que l'on trouve dans le livre d'al-Asfahânî. On y rencontre également une application de la méthode dite de Ruffini-Horner, pour la résolution numérique des équations algébriques. Il réintroduit les fractions décimales, avec le signe décimal, pour poursuivre l'approximation par cette méthode. Il obtient encore d'autres résultats, tels que le recours aux nombres négatifs, les relations entre les coefficients et les racines. A l'exemple de son prédécesseur du XIIe siècle, al-Tûsî, il étudie la séparation des racines des équations algébriques. Mais au lieu de développer les moyens analytiques enfouis dans l'oeuvre de son prédécesseur, al-Asfahânî étudie arithmétiquement la variation des fonctions polynômes et s'efforce de déterminer les intervalles où se trouvent les racines. Il applique, en fait, implicitement, le célèbre théorème des valeurs intermédiaires.

Sans insister davantage sur les résultats obtenus par al-Asfahânî, relevons le fait épistémologique le plus intéressant qui se dégage de cette oeuvre : ce mathématicien est parvenu, en partant de ses prédécesseurs du XIIe siècle, à quelques résultats analogues à ceux que démontrèrent les mathématiciens des XVIIe-XVIIIe siècles non point, comme eux, grâce à l'analyse, mais au moyen de l'étude arithmétique des fonctions polynômes. Tout se passe comme si son intention était de dégager une théorie arithmétique pour ces fonctions.

Al-Asfahânî n'était ni le seul savant, ni un mathématicien isolé; il appartenait bien à une école où oeuvraient d'autres savants, comme al-Birjandî. Les chercheurs de cette école écrivaient ou bien dans la langue de la science traditionnelle, l'arabe, ou en persan. Al-Asfahânî a lui-même écrit deux autres livres en persan : l'un sur la division de la sphère par des plans, l'autre en théorie des nombres.

On voit donc par cet exemple iranien qu'au début du XIXe siècle, il existait bien une activité scientifique indépendante de la science européenne. Et ce cas de l'école d'Ispahan n'est pas unique : on en rencontre de semblables en Turquie aussi bien qu'en Inde, en Tunisie ou en Egypte. Il va sans dire que cette recherche ne représentait pas une partie à la pointe de la science du XIXe siècle, mais qu'elle se situait bien en retrait, condamnée à disparaître à brève échéance pour céder la place à la science victorieuse. Mais la fameuse "décadence" scientifique qu'il est de coutume d'évoquer à propos de l'un ou l'autre des pays de civilisation islamique n'est nullement synonyme de néant; elle ne peut en tout cas signifier l'absence de toute recherche ou l'anéantissement de cet esprit de recherche : elle reflète le recul à un rang subalterne, par rapport à la science en marche, d'une recherche paresseuse dont les produits étaient réduits à un phénomène "provincial", en marge et sans impact sur la vie de la science du temps, recherche isolée tant sur le plan paradigmatique que sur le plan linguistique. Tel est donc le statut de la production scientifique de l'école d'Ispahan et de ses analogues. Mais, en dépit de ce "provincialisme", une telle école aurait pu jouer, dans un transfert réfléchi sinon planifié, le rôle d'un cadre d'accueil et non point de simple déplacement de la science moderne. Elle aurait pu agir dans le sens de la "naturalisation" de la nouvelle science, ou tout au moins des sciences mathématiques, dans la société iranienne et dans la langue nationale. Un mathématicien comme al-Asfahânî était des mieux placés pour accueillir cette nouvelle science, non seulement à partir de ses applications, mais de son point de vue le plus fondateur, c'est-à-dire la recherche théorique et fondamentale. On observe du reste chez des savants comme ce dernier un vif penchant à acquérir, dès que l'occasion le permettait, quelques résultats de la nouvelle science, les plus directement liés à leurs propres recherches. C'est ainsi qu'al-Asfahânî a lui-même rédigé un livre sur "les logarithmes des sinus".

Le postulat du vide n'est pas seulement inexact; bien plus, la "science moderne", ce produit européen, n'était point si étrangère, ni par sa nature, ni par ses origines qui s'enracinent dans la science classique, aux savants de bien des pays - lorsqu'il s'agit des sciences mathématiques, notamment. La vraie question pour qui s'interroge sur le transfert de la science européenne n'est plus celle de son déplacement dans un vide; elle est de savoir si cette structure d'accueil de la nouvelle science avait été pensée comme telle et utilisée, ou si elle avait été écartée, en raison d'une idéologie de la modernité par exemple. Nous allons considérer la réponse apportée à ces questions dans l'Egypte du début du XIXe siècle.

L'exemple égyptien.

Commençons par noter que la situation de l'Egypte sur ce plan - comme c'était le cas pour les autres pays de domination ottomane - était bien moins florissante que celle de l'Iran. On observe, certes, que certains esprits curieux poursuivaient l'étude des mathématiques et de l'astronomie, telles qu'elles se présentaient dans les contributions anciennes, ou plutôt dans leurs commentaires tardifs. Mais l'existence de l'Université d'al-Azhar au Caire a permis d'assurer l'enseignement et la recherche dans les disciplines linguistiques, juridiques et théologiques. Nous verrons bientôt que les membres de cet enseignement traditionnel vont fournir l'essentiel du corps des enseignants, qui servira à superposer à cet enseignement un autre, moderne et concurrent. C'est dire que les tenants de la science classique, même sous sa forme dégradée, loin de s'opposer à ce nouvel enseignement, seront les médiateurs de son introduction, et, en quelque sorte, du transfert. A ce phénomène à première vue paradoxal s'en ajoute un autre : ce n'est pas avec les armées impériales que la science moderne est parvenue en Egypte, mais lors de la création de l'Etat moderne et national. Autant d'éléments qui contredisent les schémas proposés pour le transfert et la diffusion de la science européenne.

Le cas de l'Egypte au début du XIXe siècle est exemplaire, en raison de la succession, à quelques années d'intervalle, de deux événements capitaux : l'expédition française de Bonaparte, et la fondation de l'Etat moderne par Muhammad ʻAlî. Je rappellerai simplement ici que Bonaparte a associé à l'expédition militaire une expédition scientifique, qu'il a fondé, une fois achevée sa campagne d'Egypte, l'Institut d'Egypte qui comprenait parmi ses membres Monge, Fourier, Berthollet, Geoffroy Saint-Hilaire, ...; que cet Institut se composait de quatre sections : mathématiques, physique (au sens du

XVIIIe siècle), économie politique, littérature et arts. Dans l'arrêté de sa fondation, on lit que[1]

"cet établissement aura principalement pour objet : 1° le progrès et la propagation des Lumières en Egypte; 2° la recherche, l'étude et la publication des faits naturels, industriels et historiques de l'Egypte; 3° de donner son avis sur les différentes questions pour lesquelles il sera consulté par le gouvernement".

L'Institut possédait une bibliothèque, fréquentée par certains notables égyptiens. Mais, la grande majorité de ces derniers, selon les témoignages de l'époque, restaient indifférents à la nouvelle science, si ce n'est peut-être qu'ils prenaient une certaine conscience du retard scientifique et technique déjà accumulé, en proportion avec le retard militaire dont ils venaient de mesurer les conséquences. Quant à Bonaparte[2], il

"proposa à l'Institut l'étude de questions qui presque toutes appartenaient à l'ordre des sciences appliquées. Il considérait l'Institut comme un conseil technique ayant pour mission de renseigner le gouvernement, c'est-à-dire lui-même".

Les sources multiples dont nous disposons - dont le monumental *La Description d'Egypte* - montrent que les travaux de cet Institut, importants pour l'histoire, la géographie, l'archéologie..., n'ont aucunement contribué au transfert de la science moderne en Egypte. Autrement dit, les retombées scientifiques de l'expédition, en Egypte même - qui se résument peut-être dans la prise de conscience du retard scientifique, par certains intellectuels comme Hasan al-'Attâr et al-Jabartî - sont incomparablement plus minces que ses conséquences sociales. Mais cette expédition a eu un résultat indirect important : populariser en France, chez les Saint-Simoniens notamment, l'attrait de l'Egypte. En un mot, pour l'expédition l'Egypte représentait un terrain de fouille, et il n'y a pas lieu de parler de transfert là où il n'y avait ni offre, ni demande, de science. Et du reste, le cas de l'Egypte à cet égard ne semble pas être unique. La lecture des *Archives de la Commission Scientifique du Mexique* suggère bien qu'il n'y avait pas davantage de transfert, mais que le Mexique représentait un champ de recherche géologique, minéralogique, géographique, anthropologique et atmosphérique. Quoi qu'il en soit, dans le cas de l'Egypte le transfert n'a commencé qu'avec le premier Etat national et moderne.

En effet, quelques années après l'évacuation de l'armée française, on assiste, avec la formation de l'Etat de Muhammad 'Alî, à la première tentative de modernisation économique et scientifique. C'est à ce moment seulement que s'est créée la demande de la technologie européenne, et, par voie de conséquence, de la science européenne. Nous ne pourrions ici reprendre l'histoire de ce mouvement, encore moins celle de l'Egypte pour un peu plus de trois quarts de siècle; nous voulons seulement souligner quelques-uns des principaux traits.

En premier lieu, ce transfert, nécessité par une politique de développement économique et militaire, a exigé une réforme radicale du système éducatif. C'est ainsi qu'au système traditionnel alors en vigueur, on a superposé un système moderne, qui déclassait inévitablement le précédent, sans le supprimer, mais, au contraire, en en tirant profit. Ce nouveau système, qui devait fournir à l'armée et à l'Etat le cadre technique et administratif dont ils avaient besoin, recrutait le gros de ses sujets parmi ceux qui avaient déjà été éduqués dans le système traditionnel. Le transfert n'était donc pas un acte, ni une suite d'actes ponctuels, mais concernait le système éducatif dans sa totalité.

En effet, le nouvel Etat qui avait le monopole de l'activité économique recherchait la formation d'une puissance militaire substantielle et d'une administration efficace. Muhammad 'Alî, avec l'aide des militaires, des ingénieurs, des médecins..., et même des ouvriers européens, et notamment des Saint-Simoniens, a créé les écoles spécialisées: écoles militaires, navales, vétérinaires; écoles de médecine, d'administration, de comptabilité, etc., c'est-à-dire celles qui étaient liées directement à l'armée et à l'administration. Il a également créé des écoles importantes pour l'armée et l'industrie militaire et civile : Ecole Polytechnique avec ses diverses sections - mines, ponts et chaussées, centrale - Ecole de Chimie, Ecole des Arts Industriels, Ecole Agronomique, etc. Il a en outre créé un observatoire et une bibliothèque. Lorsque par exemple on s'arrête aux matières enseignées à l'Ecole Polytechnique après sa fondation définitive en 1836, on y trouve les disciplines de l'époque : géométrie supérieure, algèbre supérieure, trigonométrie, géométrie descriptive, géométrie analytique, calcul différentiel et intégral, mécanique, physique, géodésie, statistique, astronomie, etc. Mais, pour fournir à ces écoles des élèves capables de suivre un tel enseignement, l'Etat a dû alors créer deux types d'écoles, primaires et préparatoires, et enfin un Conseil de l'Instruction Publique, qui contrôlait et orientait ce nouveau système éducatif, conçu pour "naturaliser" la technologie et la science modernes. Mais, lorsqu'on y regarde de plus près, on constate que les écoles primaires étaient en fait une version renouvelée des écoles primaires du système traditionnel; on y rencontre les mêmes disciplines linguistiques et religieuses que celles enseignées à l'université traditionnelle d'al-Azhar, en plus de l'arithmétique, de la géométrie, et de la géographie. A ce degré, le système traditionnel était présent dans le nouveau non seulement par ses disciplines et ses livres, mais aussi par son personnel : les instituteurs étaient choisis parmi ceux qui avaient achevé leurs études dans le système traditionnel. Dans les écoles préparatoires, on enseignait en plus des langues, la géométrie - le livre de Legendre - l'arithmétique, l'algèbre, la géographie, l'histoire et le dessin. En 1841 on ajoute l'enseignement du français, qui devenait de ce fait la première langue européenne enseignée dans les écoles secondaires. Il est clair que ce programme des écoles primaires et préparatoires est un programme de transition entre le système traditionnel et un enseignement moderne. Le recrutement des élèves - tout au moins au début -, et l'organisation des écoles, se modelaient sur les pratiques alors en usage dans l'armée. L'ensemble du système était très lourd et bureaucratique.

Quoi qu'il en soit, on voit bien que le système traditionnel non seulement a survécu au système moderne, mais lui a servi de support : disciplines, livres, personnel enseignant, et, plus encore, quelques figures importantes du mouvement de transfert au sens étroit. Plusieurs membres de ce système traditionnel se sont en effet employés à la correction et à la traduction de livres européens, et ont composé des lexiques techniques à l'aide de la terminologie de la science classique; ils furent élèves des grandes écoles - médecine, polytechnique - et d'autres furent envoyés en mission à l'étranger. En bref, le transfert a exigé l'élaboration d'un nouveau système éducatif, qui a trouvé ses assises dans l'ancien, lequel s'est trouvé déclassé scientifiquement, mais aussi socialement, par lui.

Second trait de ce transfert : il s'est effectué d'emblée dans la langue nationale. On n'a pas, comme dans la tradition coloniale, imposé une langue européenne pour l'enseignement scientifique, mais on a commencé par introduire un système de traduction orale avant la formation du cadre local. Ce parti pris a provoqué dès le départ un mouvement d'arabisation des traités et des manuels, ainsi que l'édition de lexiques et de dictionnaires. Pour assurer cette arabisation, on a eu recours à deux moyens : la fondation d'une école destinée à former les traducteurs, et les missions d'étudiants à l'étranger. L'école de traduction, dite "école des langues", a été fondée en 1835. La doctrine qui présidait à sa création est ainsi formulée par le chef de l'Etat lui-même : "tout ce qui est utile dans les systèmes occidentaux a été écrit par leurs auteurs; si on le traduit, on peut le suivre". Cette école s'organisait alors en quatre sections, qui désignent bien les buts visés : mathématiques; médecine et physique; littérature, histoire et géographie; et, finalement, turc. Le programme ne comportait pas seulement les langues - notamment l'arabe et le français - mais aussi des éléments de mathématiques, d'histoire, de géographie. Plusieurs membres de cette école (professeurs et étudiants) étaient issus du système traditionnel, et plusieurs de ses anciens élèves seront de grands traducteurs, voire de grandes figures intellectuelles de la génération suivante - comme Rifâʿa al-Tahtâwî.

Les missions étaient multiples, mais essentiellement dans les domaines scientifiques et techniques. On peut recenser une mission en Italie en 1813, sept missions en France, en 1818, 1826, 1832, 1844, 1845, 1847, 1848; on a même fondé à Paris une école égyptienne pour former ces missionnaires. On a envoyé des missions en Angleterre et en Autriche - 1829, 1845, 1847, 1848 - et même une mission au Mexique. La coutume voulait que chaque élève, à son retour, rendit en arabe un livre étranger dans sa spécialité. La totalité des livres scientifiques traduits étaient destinés à l'enseignement des futurs ingénieurs, médecins, chimistes... Ainsi, pour les livres mathématiques, on trouve *La Géométrie descriptive* de Monge, la *Géométrie* de Legendre, *l'Algèbre* de Mayer, la *Géométrie descriptive* de Duschenes.

Un troisième trait de ce transfert est le choix pragmatique et appliqué qui y présidait. L'examen des disciplines enseignées, des livres traduits, des objets des missions, montre assez que l'on avait délibérément opté pour les disciplines appliquées, ou pour celles qui leur sont étroitement liées. Même lorsque l'on introduisait l'enseignement d'autres disciplines, c'était en rapport avec les disciplines appliquées, selon leurs besoins de formation. De sorte que le transfert vise bien davantage les techniques industrielles et militaires, la santé ..., que les sciences elles-mêmes. Ainsi, parmi les livres traduits, plusieurs traitent de géométrie descriptive, mais aucun de théorie des nombres, pour ne citer qu'un exemple. Bien des ouvrages touchent directement aux applications industrielles.

Le quatrième trait remarquable de ce transfert est qu'il s'est effectué sans la recherche; c'est-à-dire qu'on visait les effets de cette science plus que les moyens de la produire. Sur le plan institutionnel d'abord, alors qu'on a fondé, selon le modèle français, dans les premières décennies du XIXe siècle, différentes écoles d'ingénieurs, de médecine, de pharmacie, etc., on n'a pas songé à créer une seule institution académique consacrée à la recherche. Cet état de choses a eu plusieurs conséquences qui toutes mènent à l'absence de traditions scientifiques nationales et à l'instauration d'une certaine dépendance scientifique permanente à l'égard des pays d'Europe. La traduction concrète d'un tel état de choses était qu'un jeune savant, productif au cours de son séjour de formation en Europe, réduisait ou, en fait, arrêtait, toute recherche, à son retour. Ce même savant, toujours faute d'institutions de recherche, n'avait pas de successeur. Donnons un exemple, parmi tant d'autres, celui de la biographie d'un astronome, égyptien, Mahmûd al-Falakî. Professeur à l'école polytechnique au Caire à partir de 1834, il a été envoyé en mission en Europe. Pendant son séjour, il a publié dans les *Mémoires* des différentes Académies - belge, française, ... - plusieurs recherches sur le calendrier et le champ magnétique de la terre. Durant les quelques années qui ont suivi son retour en Egypte, il a poursuivi ses recherches dans le prolongement de celles qu'il avait engagées en Europe, tracé la première carte astronomique et topographique d'Egypte, observé l'éclipse du 18 juillet 1860. Il s'est intéressé ensuite aux études qui n'avaient pas de rapport avec l'astronomie - géographie et météorologie. Devenu deux fois ministre, il n'a pas laissé d'élèves.

Mais, en dépit de cet obstacle majeur et qui a contribué à empêcher la fondation d'une véritable cité scientifique, on assiste à un début de "naturalisation" de la science : l'organisation militaire de l'enseignement cède la place à une organisation civile, le corps enseignant est constitué en majorité de nationaux, l'arabisation progresse et se perfectionne. Telle est la situation à la veille de l'occupation par les Britanniques, en 1882, qui donne un brutal coup d'arrêt à ce mouvement; mais ceci est une autre question[3].

En dépit des différences, les deux exemples évoqués ici montrent bien que, pour comprendre l'introduction de la science européenne et les problèmes soulevés par son transfert et son intégration, il semble nécessaire de connaître la science traditionnelle, qui était encore en vigueur au XIXe siècle, ses idéaux, ses paradigmes, ses écoles et ses institutions, ainsi que le système d'enseignement traditionnel qui avait formé l'élite. On est alors en mesure de repenser non seulement le transfert de la science européenne, mais également un débat idéologique qui lui était lié, connu sous les termes de *modernisme et tradition.*

Enfin l'exemple égyptien a montré que le transfert n'était pas l'oeuvre des empires coloniaux, mais qu'il a eu lieu, en quelque sorte, contre eux : c'était l'oeuvre de l'Etat national, dans la langue nationale.

Les obstacles étaient en partie imputables à une conception pragmatique de la science et ont sans doute affaibli sa "naturalisation", en rendant le destin du transfert incertain.

Centre National de la Recherche Scientifique (REHSEIS), Paris

Notes

[1] Henri Dehérain, "L'Egypte turque - Pachas et mameluks du XVIe au XVIIIe siècle - L'expédition du Général Bonaparte", in Gabriel Hanotaux, *Histoire de la nation égyptienne,* Paris, 1934, Tome V, p.533.
[2] *Ibid.,* p.536.
[3] La plupart des écoles ont été fermées, l'enseignement est devenu rare et payant, et le programme des écoles visait à former des fonctionnaires du gouvernement (voir séance du 24 décembre 1894 de l'Assemblée Nationale).

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PART II

PROBLEMS ABOUT THE INTEGRATION OF CLASSICAL AND MODERN SCIENCE

Round Table

INTEGRATION PROBLEMS: INTRODUCTORY REPORT

Francis ZIMMERMANN

In selecting the word **integration** as a title for this session, the organizers have invited contributions that would question the possibility and conditions of a synthesis between modern Western science and the local scientific traditions. Issues to be addressed are of the following type: - How do local researches and native scientists find their way through the international scientific community? - Through which mechanisms of reception are scientific ideas transferred to a foreign culture? - In countries like British India, the cultivation of science was promoted both by colonial state institutions and by the rising native elite; was there, as a result of this double process of science cultivation, an integrated system of scientific knowledge?

The answer seems to be: No. Our contributors seem to agree on the absence of any true example of integration. On the contrary, they all describe aspects of a fundamental misunderstanding between, so to speak, the donors and the receivers of scientific ideas. E. Ihsanoglu shows how the Ottomans followed a consistent policy of "selective transfer" of Western techniques, chosen for military and sanitary purposes, while they ignored scientific ideas in themselves. A. Vasantha evokes the grand controversy between "Anglicists" and "Orientalists" in British India, and eventually the failure of the "Orientalists" model of integration. V. Krishna shows that "colonial science" began to recede as soon as a national scientific tradition began to emerge in India; colonial science and national tradition seem to have been antithetic.

To initiate a discussion around the theme of integration, three issues may be set out, that arise from the papers contributed to this session: (I) a critique of the integrated or integrating concept of "colonial science"; (II) a distinction to be made between science proper and the teaching of science, or else, between research and education; (III)

P. Petitjean et al. (eds.), Science and Empires, 33–35.

the choice of a language as medium, and the place of the vernaculars in the process of integration.

(I) One of the first issues at stake in our debates is that of the colonial model of science, and its role in the integration of national research into the international academic arena. The Diffusionists, attacked in V. Krishna's paper, have resorted to a biological metaphor to describe, so to speak, the congenital integration of national science into colonial science. Krishna quotes George Basalla : *"Colonial science contains in an embryonic form some of the essential features of the next stage"*, i. e. of the emerging national science. On the contrary, Krishna shows that the most innovative scientists in colonial India were neither the "gate keepers" nor the "soldiers" of colonial science, but a third category of science personnel who were nationalists in the cultivation of science, and promoted technology, engineering, and the use of vernaculars, against the declared policies of the colonial power.

(II) Throughout a number of papers, there is a recurring ambiguity on "colonial science", "the institutionalization of modern science", and the idea itself of an integration, be it the integration of local traditions into modern science, or conversely, that of Western knowledge into an emerging national science. Do we mean research or education? One wonders if the scientific institutions created in the dominions were anything more than educational bodies, although in that respect the colonial history of technology (e. g., irrigation and sewerage) was quite different from that of science (e.g., mathematics).

All papers given in this session are focussing on scientific **education** and the question of scientific research in the strict sense is being left aside. Then, a series of convergent remarks in E. Ihsanoglu and A. Vasantha illuminate a most interesting ambiguity in the relationships between the Western personnel and the "native scientists" teaching in the scientific schools of the British or the Ottoman empire, as well as the links between their respective ideological claims for integration.

Ihsanoglu remarks that in the new-type educational institutions established at the end of the 18th century in the Ottoman empire, theoretical science courses were taught by *ulemas* coming from *medreses* (schools of classical learning), while applied sciences were taught by Europeans. Vasantha notes that, while some enlightened Indians were crying for instruction in European knowledge, it was a body of Englishmen who insisted on the retention of "Oriental" learning. I would like to summarize these polarities in the following table as a point of departure for discussion:

	the personnel	the ideology
	practizing and teaching (a) or (b) was mainly composed of:	advocating and promoting (a) or (b) was mainly propounded by:
(a) technology, engineering, laboratory training	Westerners	Natives
(b) theoretical science	Ulemas, Natives (e. g., Ramchundra)	Westerners ("Orientalists")

(III) Last but not least, we have to assess the role of textbook translations into vernacular languages. The promoters of integration, that is, both the "Orientalists" and the rising native elite, thought that the new ideas in Western science would be more easily taught in the mother tongue of each student. V. Krishna shows that the main thrust of the activities of scientific societies in India at the turn of this century was concentrated on creating a base for modern science in vernacular language (Urdu, Bengali, etc...). The question was complicated by the competition between the vernaculars and Sanskrit. A. Vasantha shows that there were actually two issues, a first one between English and Sanskrit, and another one between English and the vernaculars. This triangular contest, is, so to speak, the modern, colonial version of the competition between Latin and the Romance languages in Galileo's times.

Ecole des Hautes Etudes en Sciences Sociales (Centre d'Etudes de l'Inde et de l'Asie du Sud), Paris

OTTOMANS AND EUROPEAN SCIENCE

Ekmeleddin IHSANOGLU

It may be said that the environment with which Western science first came into contact, outside its milieu, was the Ottoman world. The close interaction, geographical proximity and active relations of the Ottomans with Europe, made the Ottomans aware of the novelties and discoveries in Europe. Throughout the history of the Ottoman State which lasted 600 years, the Ottomans naturally took an interest in the developments of Western science and technology. To understand the context and nature of this interest, we have to go back to the 15th century when the features were different from what happened in the 20th century. This would clarify an important subject of Ottoman history; at the same time, it would add a new dimension to the theories put forward about the spread of Western science.

Evidently, the theories of Basalla[1] and Pyenson[2] about the spread of Western science, which cite various examples, are not valid for the Ottoman case, since there is no center-periphery and colonial power-recipient pattern. The matter discussed here is the attitude of a powerful empire towards the occurring developments outside its domain. That is to say, with the exception of the missionary activities of the French and American schools which were founded in Beirut in the second half of the 19th century, the matter is not a question of the influence of the West on the Ottoman State, but rather the interest of Ottomans in the West. For these reasons, construction of the theoretical model for the relationship of Ottomans with Western science would mean to construct a sui generis model or a paradigm.

In order to understand the attitude of the Ottomans towards Western science and technology, we have to bear in mind the Ottomans' general outlook towards the West as well as the state of their own scientific institutions when they faced the necessity to answer new needs.

Their attitude was not any different from their outlook on the Western world. During the first centuries of their history, the Ottomans considered themselves to be morally and materially superior to the Europeans. This consciousness was due to the fact that their economy and finances were sound, they had rich mining sources and military power and were victorious in warfare. Moreover, being heirs of the rich

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Islamic civilization of the middle ages and their belief in Islam, as the last and truest faith, were among underlying reasons for this feeling of superiority. In our opinion, while examining Ottoman-Western relationship, the factor of superiority may give us better understanding of the Ottomans' attitude towards Western science.

Moreover, in that period, the cultural and scientific autarchy of the Ottoman State must be considered when evaluating its attitude towards Western science. The *medreses* which were the most important educational and scientific institutions in the Ottoman State were organized to meet the social and cultural needs of people and solve the various problems which they faced. Their own sciences were adequate for the Ottomans in that they were able to find the basic solutions regarding the matters which they needed and their educational system was organized to fulfill this aim. For this reason, they did not need the science of contemporary European countries and did not consider it indispensable. Likewise, the fact that the Ottomans were economically more advanced than the contemporary European and other muslim states, shows that the Ottomans also had a self-sufficient economic system. This self-sufficiency, however, did not prevent the Ottomans from receiving the novelties from the West which they did not possess but considered necessary.

Contacts with the West in the 15th and 16th Centuries

The feeling of superiority and autarchy in the Ottoman State prevented the Ottomans from realizing the importance of the newly developing intellectual and scientific trends of the Renaissance and Scientific Revolution. They did not realize the consequences that would arise from these new developments either. But this did not mean that they were not aware of the technical developments and geographical discoveries of the 15th and 16th centuries. These developments were followed in the Ottoman State in different ways and means, selectively in the fields of warfare, mining technology, geography and medicine.

Direct geographical contact with Europe was an important factor in following the Western developments. Ottoman lands stretched from Rumelia to the middle of the Continent, reaching to the borders of European countries and they also reigned in North Africa and the Mediterranean. Their close geographical proximity with European countries enabled the Ottomans to obtain information about the developments in Europe. At the same time, the Ottoman State had an attraction for Europeans who, one way or another, found a means of arriving in the country. Other means of contact with the West were provided by the diplomats, Europeans who accepted Islam *(muhtedis)*, travellers, merchants, sailors and war prisoners, immigrants, especially the Jews and Morisques who ran away from the religious oppression in Europe. These people were instrumental in transferring a lot of scientific and technical information to the Ottoman State as well as new skills and knowledge.

Geography: In examining maps used by the Ottomans[3] of the 15th century and the geography books such as *Kitab-i Bahriye* (1521)[4] and *Tarih-i Hind-i Garbî* (1580)[5] of the 16th century, European influence is easily recognized. These works show that new elements were transferred from European geography sources in addition to the classic Islamic knowledge of geography. As well as mentioning new geographical discoveries, they gave information gained as a result of these discoveries. It is evident that Ottoman seamen were aware of the developments in cartography and followed the geographical discoveries of this period. An examination of *Kitab-i Bahriye* by Pirî Reis indicates vividly that he supplemented his own observations and findings with information from the West. *Tarih-i Hind-i Garbî* which was prepared around 1580 was based on Spanish and Italian geographical references[6]. It mentions the discovery voyages made to America from 1492 through 1552, giving information backdated thirty years, thus is a measure of the interval with which the Ottomans followed some of the developments in the West.

War technology: Developments regarding the use of firearms and gunpowder in the West were also followed in a similar manner. Ottomans gradually started using firearms at the end of the 14th century, fifty years after the firearms were first used in Europe. Towards the middle of the 15th century, great progress was seen in the Ottoman artillery. Gunsmiths from Italy, Germany and Hungary worked together with the local masters in casting guns. When Bosnia and Serbia were annexed to the Ottoman State, many munition factories and a large number of guns were taken over[7].

Mining: In the 16th century, Ottomans used the same techniques as the Europeans. They were aware of the techniques explained in Agricola's book *De Re Metallica* printed in 1556. Mehmet Ashik, an Ottoman traveller who visited one of the big Ottoman mines of Siderokastron, in the Thrace region, wrote about the equipment and techniques used in the mine which were similar to those defined by Agricola.

Medicine: The Renaissance medical science was brought to the Ottoman State by Spanish, Portugese and Italian physicians of Jewish origin who took refuge in the Ottoman State after 1492[8]. As these physicians were familiar with the new developments in Europe as well as the classic Islamic medicine, they offered their services to the Court and were able to distinguish themselves. Some even became personal physicians of the Sultan. It is interesting to note that besides religious tolerance, the Ottomans also expressed their appreciation for this group, in other ways. Jewish physicians were exempt from some taxes and certain privileges were given to them.

Ottomans' first contact with the Renaissance medicine started with physician Jacopo of Gaeta, a Jew of Italian origin, who entered the service of Murad II (1421-1451). He became personal physician to Sultan Mehmed II and later was favoured with the rank of Chief Physician and Minister. Starting with this Italian physician at the end of the 15th century, the Ottoman State was able to follow the Renaissance medicine in the 16th century, through the Jewish physicians.

Contacts with Western Sciences in the 17th, 18th, and 19th Centuries

As a result of our studies to this day, it appears that from the 17th century to the beginning of the 19th century, Ottoman contacts with the West were realized through three main channels. Firstly through translations made from European languages, secondly via personal observations of Ottoman ambassadors who paid official visits to Europe, and thirdly through modern educational institutions which were established in the Ottoman State at the end of the 18th and at the beginning of the 19th century. From the third decade of the 19th century Ottoman State initiated a new mechanism of acquaintance with Western science by sending students to study in Europe. In the beginning of the 20th century, a Faculty of Science was established within the University of Istanbul *(Dârü'l-fünûn)*, hence a new mechanism of scientific transfer started in Ottoman educational institutions. This was different from the scientific transfer applied in institutions established in the 18th and 19th centuries in the Ottoman history of science. In this paper, we shall try to clarify the nature of the Ottoman attitude toward Western sciences, as a result of our researches on these channels of transfer.

Translations: Though we have many examples of translations in different branches of Western sciences from 17th century onwards, we shall confine ourselves to translations on astronomy which we think will more effectively illustrate the Ottoman attitude to science.

As far as we could establish, the first work of astronomy translated from European languages is astronomical tables entitled *Ephemerides Motuum Celestium Richelianae ex Lansbergii Tabulis* (Paris, 1651) by the French astronomer Noël Duret (d.1650). The translation was made by the Ottoman astronomer Tezkereci Kose Ibrahim Efendi *(Zigetvarli)* in the year 1660 under the title of *Sajanjal al-Aflak fi Ghayat al-Idrak.* Examination of this work shows that within the psychology of Ottoman superiority, the first reaction of the *müneccimbashi* (chief astronomer of the Sultan) was to declare the book to be a "European vanity", but after learning its application and checking with Ulug Bey's *Zij,* he realized its practical use and value and rewarded the translator. This was an indication of the fact that Ottomans were not yet ready to accept the superiority of the West in the field of science. On the other hand, it shows that they were capable of following the developments in the West without a great time lapse.

This translation is also the first book in Ottoman literature which mentions Copernicus. Copernicus' heliocentric theory which caused a controversy in Europe, was taken as an alternative technical detail by the Ottoman astronomers and it was not made a subject for polemics. One probable reason may be that there were no religious dogmas concerning the system of the cosmos.

Other astronomy books translated from European languages, which followed this book, were mostly astronomical tables. Whereas many important works of this period, written by Copernicus, Tycho Brahe, Kepler, and Newton which changed the main principles of the science of astronomy did not interest the Ottoman astronomers.

Translation of the necessary astronomical tables, which were the focus of interest in Ottoman astronomy, instead of the major works of above-mentioned pioneers of modern science, characterize the practical aspect which dominated the Ottoman science. Hence, the Ottomans' interest was not in the science of astronomy, but in the developments concerning calendar making and timekeeping which were necessary for the State and religious affairs and daily life. Ottomans were only interested in and used the things they needed. In other words, theirs was a selective transfer. Their approach to astronomy was an example of what they expected from the West[9].

In examining the scientific literature in Turkish, the astronomical tables in particular, one can easily see that after overcoming their feeling of superiority, new concepts and information and techniques were readily accepted by the Ottoman scientists. The State had a positive outlook and the *"ulema"* (religious circles) did not display a negative attitude. There was no conflict of science and religion at this stage.

Publication of science books began with the establishment of the first official printing house in 1727. Bibliometric studies of these books and the analysis of the contents showed that the objectives of transferring Western sciences changed according to political developments. Books which were printed before 1839, date of the proclamation of the reformation movement known in the Ottoman history as the *Tanzimat,* mostly aimed at realizing military objectives. Books printed after this date generally aimed at developing the civil and social life and other areas of modern science which took up the public interest. There was an increase in the number of books on medicine and mathematics while the number of publications on geography, military art and sciences and astronomy decreased relatively[10].

Ambassadors' Reports *(Sefaretnames):* These reports are exclusive sources that indicate what was most interesting to the Ottoman ambassadors in Europe and what they sought, as well as expressing the Ottoman psychology towards Europe.

Ambassadors, who were very protocol-conscious, concentrated their attention on sites of military significance on their route, the organization of the armies and firearms. The first contact between the ambassadors and European science began with their visits to scientific institutions.

In the 18th century, Ambassador Shehdi Osman Efendi went to the Russian Academy of Sciences in Petersbourg, where he visited the museum of natural history which he called *"acayiphane"* (house of wonders), the library and the printing house. Of these three, he was most interested in the printing house. As to research orientated activities of the Academy of Sciences, he did not report on this as he apparently did not find it worth mentioning. This was not only important in reflecting the subjects in which the ambassador took an interest, but also a conspicuous example that the Ottomans did not take into account the "research-oriented" aspect of Western science which would play an important role in the transfer and establishment of science.

Most notable visits were made to the observatories. We know that two ambassadors paid visits to Paris and Vienna Observatories in the first half of the 18th century. In 1721, Yirmisekiz Mehmed Chelebi visited the Observatory and the Botanical Gardens *(Le Jardin du Roi)* in Paris, while in 1748 Hattî Mustafa Efendi visited Vienna Observatory. Mehmed Chelebi's visit was a significant event for Ottoman science in that besides his personal interest in astronomy, he brought back to Istanbul the astronomical tables presented to him by the director of the Observatory, J. D. Cassini, and gave them to the Ottoman astronomers[11].

Educational Institutions: The main channel through which modern science was introduced to the Ottoman Empire was the new type of educational institutions established at the end of the 18th and the beginning of the 19th century. These institutions were established for more practical reasons such as organizing and making reforms in the army and to provide technically educated officers *(mütefennin zabit)*, in order to hold their own against the European armies equipped with the latest techniques. *Hendesehane* (School of Mathematics) which was opened in 1733 was followed by the *Mühendishane-i Bahri-i Hümayun* (Imperial School of Naval Engineering) in 1773. The *Mühendishane-i Berri-i Hümayun* (Imperial School for Military Engineering) which started functioning in 1795, provided to a certain degree, a systematic scientific education[12].

The Ottoman *ulema,* together with foreign experts and engineers, taught lessons in these institutions of modern science. Theoretical science courses were taught by the teachers from the *medreses* while applied sciences were taught by Europeans, mainly French. Thus teachers from these classical educational institutions supported this new movement of modernization in education. After the *Tanzimat* period in the middle of the 19th century, the number of *ulema* teaching in modern schools gradually decreased and they were replaced by engineers and officers who had graduated from these new institutions.

Mühendishane was the first example of the Western-Ottoman synthesis in the framework of institutions. The synthesis is seen in the educational organization such as the formation of classes, system of grading and graduation as well as in the educational staff, curriculum and textbooks. Translation of science books of Western origin gained momentum in the time of Chief Instructor Ishak Efendi. Books compiled by him from the French sources[13] were used as basic educational books in the *Mühendishane.*

In the 19th century, in addition to the *Mühendishanes,* two other modern schools were founded. These were *Mekteb-i Harbiye-i Shahane* (Imperial Military School) founded in 1834[14] and the *Mekteb-i Tibbiye-i Adliye-i Shahane* (Imperial School of Medicine) founded in 1839.

Mahmud II of this period emphasized the importance of these schools by visiting them and favouring the staff.

With the proclamation of the *Tanzimat* reformation movement in 1839, the foundations of radical changes were laid. Though the *Tanzimat Firman* did not include an article on education, the educational policy of the Ottoman State, which was directed at military objectives underwent a transformation and was replaced by public education with a view to raise the educational and cultural level of the people and establish Western style modern educational institutions. Within this understanding, three unsuccessful attempts to open an institution of higher learning namely the *"Dârü'l-fünûn"* (University) were made until the end of the century.

Within the *Tanzimat* period, the educational policy was run by the Council of Public Instruction *(Meclis-i Maarif-i Umumiye)* and the Ministry of Public Instruction *(Maarif Nezareti)*. In 1869, a commission which was entrusted with the task of studying the French educational system[15] prepared the general educational regulations[16] called the *Maarif-i Umumiye Nizamnamesi.* However, they were not completely successful in implementing many of the articles, especially those regarding the *Dârü'l-fünûn.*

Europeans in Ottoman Lands, Ottomans in Europe

When one considers the role of the Europeans in the transfer of sciences to the Ottoman world, a similar paradigm comes to surface. The influence of the Europeans who were employed by the State from the 16th to 19th centuries may be summarized as follows.

There was a group of Europeans called *Taife-i Efrenciyan* who were employed in the Ottoman Palace to help transfer European war techniques[17]. In the 18th century, we find European experts employed in the Ottoman army who were instrumental in introducing some elements of modernization in the first half of the century. In the second half of the 18th century, foreign teachers, especially French engineers, were employed in the new type of educational institutions founded in this period. These teachers wrote books concerning their subjects and were also employed actively in the fields of gunnery, naval and military engineering.

In the 19th century, physicians were called from Europe to teach in the modern medical schools which were opened in addition to the engineering schools. The French surgeon Sat de Gallière (in 1832)[18] then the Austrian physician C. Ambroise Bernard in 1839 , contributed to the modernization of the medical school in Istanbul. Modern medical education was carried out more systematically in Bernard's time. However, in the trials to establish the *Dârü'l fünûn,* no attempt was made to bring teachers or scientists from Europe.

Apart from those who were employed in State services, there is no evidence that European scholars who applied for entry to the Ottoman State, mostly for archaeological studies or scientific field researches, were functional in the transfer of Western sciences into the Ottoman world. We may briefly say that the role of the Europeans was to fulfill the services required by the State and was subject to the initiative of the statesmen. Naturally, the situation of Western teachers who worked in the French and American educational institutions, established in the second half of the 19th century as part of the missionary activities in Beirut, constitute a separate subject outside the above generalization.

A new episode in the introduction and transfer of Western sciences started in the 19th century with the influx of students who were sent to Europe for training. This practice which started in the period of Mahmud II (1808-1839) was confined to military education. After the proclamation of the *Tanzimat* in 1839, students also received training in other disciplines in Europe. Between the years 1864-1876, 93 students were sent to France, of these 42 were officers and military physicians. The rest received their training in different professions, such as lathe operators, carpenters, upholstery workers, etc[19]. Here we also observe that the *Tanzimat* movement caused a shift in the transfer of Western sciences from military to civilian ends and also in the objectives of science and learning.

Conclusion

Following is the general conviction which we deduce from an examination of the contacts and attempts related to Ottoman-European relationship in the field of science.

The Ottomans did not consider it necessary to deal with the process of the transfer of Western science as a whole. At the beginning, the Ottomans' feeling of superiority and the autarchy of the Ottoman State led them to implement this transfer process only in the necessary fields. One can say that this process, which can be called a functional transfer, was carried out in two categories as before and after the *Tanzimat,* both categories having the same characteristics.

Before the *Tanzimat* period, the State had need of the army and military techniques, while medicine, astronomy and others were necessary for the administration and the needs of the public. The Ottomans required the immediate transfer of science and techniques concerning the former subjects while this movement did not extend beyond practical purposes. After the *Tanzimat,* this transfer was made with the objective of serving the public needs. The change in the objectives of the State was also reflected in the field of science, and the transformation from military to civilian objectives is observed in what was expected from science.

In conclusion we may say that the Ottomans did not consider the Western science as a whole. The new concepts and mentality arising from the scientific revolution, that is, research of matter, space, time, movement and nature, as well as the essence of research and detailed study, escaped their attention.

Perhaps, it would not be an exaggeration to say that Ottomans' principal interest was oriented towards practical ends and the application of scientific discoveries while the three main aspects of science, namely theory, experiment and research were not taken into consideration. This understanding was reflected in the educational and "scientific" policy of the Ottoman State before and during the *Tanzimat* period and no attempt was made to include scientific research per se in the curriculum of the educational institutions. For this reason, institutions established for the transfer of Western sciences were not as successful as their counterparts in Russia and Japan.

Naturally the determination of every aspect of Ottoman-Western science relationship depends on new researches. As stated above, however, the feeling of superiority and autarchy which was dominant among the Ottomans, explains one aspect of this relationship until the middle of the 18th century.

The paradigm of "Ottoman-European Science" relationship which we examined in a broad sense from its beginning to the middle of the 19th century, continued after the middle of the century without changing its main traits. The greatest exception in the 20th century was that the Faculty of Science established in 1900 in the University of Istanbul aimed to teach science itself instead of the previous practice where science was taught as an auxiliary course for civilian and military professions. Meanwhile, we may say that the subsequent increase in scientific activities created some new factors and developments which had controversial effects, especially from intellectual and social viewpoints. An analysis of these developments could be the subject of another study.

Research Center for Islamic History, Art and Culture (ICIRCA), Istanbul

Notes

* The well known works (Bernard Lewis, *The Emergence of Modern Turkey*, 2nd ed. London 1968; Sherif Mardin, *The Genesis of Young Ottoman Thought*, Princeton 1962; Niyazi Berkes, *The Development of Secularism in Turkey*, Montreal 1964; Roderic H. Davison, *Reform in the Ottoman Empire,1856-1876*, New York 1973), which treat the relation of the Ottomans with the West, have dealt more with the political and cultural aspect of the subject. Lewis has treated the subject as a separate chapter in his work entitled *The Muslim Discovery of Europe* (1982). His evaluations are based on the studies on History of Science up to that point and on the widespread opinions about the subject. The most important opinion among them is the one which states that the *ulema* are opposed to European science and technology. As a result of the studies conducted in the last ten years, this opinion is now changed (See E. Ihsanoglu, *Annotated Bibliography of Turkish Literature of Chemistry: Printed Works 1830-1928*, Istanbul 1985, in Turkish; *The Ottoman Scientific and Professional Associations* (ed. Ihsanoglu), Istanbul 1987, in Turkish; "Some critical notes on the Introduction of Modern Sciences to the Ottoman State and the Relation Between Science and Religion up to the End of the 19th Century", *Varia Turcica IV*, Comité international d'études pré-ottomanes et ottomanes, VIth Symposium, Cambridge, 1-4 July 1984, Proceedings, Istanbul-Paris-Leiden 1987, p.235-251.

In the current paper, some results deduced from our studies on Ottoman understanding of science are presented in short notes. It may not be possible to give the whole picture here due to lack of space, but we tried to delineate the main lines of the subject. Our study, which treats the relations of Ottomans with Western science, more extensively, is in press (See. E.Ihsanoglu, "Tanzimat Oncesi ve Tanzimat Donemi Osmanli Bilim ve Egitim Anlayisi", *Tanzimat II*, Türk Tarih Kurumu, Ankara 1991, in press).

1 G. Basalla, "The Spread of Western Science", in *Science*, **vol.156**, n°3775, 1967, p.611-622.

2 Lewis Pyenson, "Pure Learning and Political Economy: Science and European Expansion", in R. P. W. Visser, H. J. M. Bos, L. C. Palm, H. A. M. Snelders (eds.), Proceedings of the Utrecht Conference, *New Trends in the History of Science*, Amsterdam, 1989, Rodopi.

3 Maps prepared by Ibrahim Kâtibî in 1416; by Mürsiyeli Ibrahim in 1461; and map made by Pirî Reis, drawn on Colombus' map dated 1489 and presented by Pirî Reis to Yavuz Sultan Selim in 1513.

4 Pirî Reis, *Kitab-i Bahriye*, facsimile edition published by Türk Tarihi Arashtirma Kurumu, Istanbul 1935.

5 *Tarih-i Hind-i Garbi ve Hadis-i Nev*, facsimile edition published by T. C. Kültür ve Turizm Bakanligi, Istanbul 1987.

6 Thomas D. Goodrich, *The Ottoman Turks and the New World, A Study of Tarih-i Hind-i Garbî and 16th Century Ottoman Americana*, Wiesbaden 1990.

7 V. J. Parry, "Barud", *Encyclopaedia of Islam* (EI2), **vol.I**, Leiden-Brill 1979, p.1060-66; Djurdjica Petrovic, "Firearms in the Balkans on the Eve of and After the Ottoman

Conquests of the 14th and 15th Centuries", *War, Technology and Society in the Middle East,* ed. V. J. Parry and M. E. Yapp, London 1975, p.164-194.

[8] Avram Galante, *Türkler ve Yahudiler,* 2nd ed., Istanbul, 1947, p.101-102; A. Galante, "Médecins Juifs au Service de la Turquie", *Histoire des Juifs de Turquie,* **vol.IX,** n.d., ed. ISIS, p.71-117.

[9] E. Ihsanoglu, "Introduction of Modern Astronomy to the Ottoman State: 1660-1860", 1st International Symposium on Modern Science and the Muslim World, Istanbul, Sept.1987, *Proceedings* (ed. E. Ihsanoglu), in press.

[10] Feza Günergun, "A General Survey on Turkish Books of Science Printed During the Last Two Centuries of the Ottoman State", paper presented at the XVIIIth International Congress of History of Science, Hamburg-Munich, 1-9 August 1989, (unpublished paper).

[11] E. Ihsanoglu, "Tanzimat Oncesi ve Tanzimat Donemi Osmanli Bilim ve Egitim Anlayishi", *Tanzimat II,* Türk Tarih Kurumu, Ankara 1991, in press; for the French edition of Mehmed Chelebi's report see *Le paradis des Infidèles, un ambassadeur ottoman en France sous la Régence,* éd. Gilles Veinstein, Paris 1981.

[12] Cavid Baysun, "Eski Mühendishanelerin Kurulushuna Ve Bazi Hocalara Dair", Istanbul Teknik Okulu Yilligi, Istanbul (1952), p.52-54.

[13] E. Ihsanoglu, *Bashhoca Ishak Efendi, Türkiye'de Modern Bilimin Oncüsü (Chief Instructor Ishak Efendi, Pioneer of Modern Science in Turkey),* Kültür Bakanligi Kaynak Eserler Dizisi, Ankara 1989, (with a summary in English).

[14] Osman Nuri Ergin, *Türkiye Maarif Tarihi,* **vols.1-2,** Istanbul 1977, p.354-368.

[15] Mehmed Galip Bey, *Sadullah Pasha Yahud Mezardan Nida,* 1909, Ebüzziya Press, p.26-28.

[16] E. Ihsanoglu, "Dârü'l-fünûn Tarihçesine Girish: Ilk Iki Teshebbüs", *Belleten,* **vol.LIV,** n°210, 1990, p.699-738.

[17] Rhoads Murphey, "The Ottoman Attitude Towards the Adoption of Western Technology: the Role of the Efrenci Technicians in Civil and Military Applications", *Contributions à l'Histoire Economique et Sociale de l'Empire Ottoman,* Collection Turcica III, Editions Peeters, Louvain (Belgique), 1983, p.287-298.

[18] *Takvim-i Vakayi,* n°11, 11 Shaban 1247 (15 January 1832), p.2, col. 3; No information was available about the identity of Sat de Gallière who is said to be a French surgeon.

[19] Adnan Shishman, *Tanzimat Doneminde Fransa'ya Gonderilen Osmanli Ogrencileri,* Ph. D. diss., Istanbul University, 1983.

THE "ORIENTAL-OCCIDENTAL CONTROVERSY" OF 1839 AND ITS IMPACT ON INDIAN SCIENCE

A. VASANTHA

India owes its introduction to modern science to the early European (Portuguese, Dutch, French and English) explorers, traders and missionaries. Through these contacts dating back to 16th century, the elements of civilization of the West and the spirit of rationalism began to produce an impact on the Indian mind. But when the English, who became the rulers, attempted to introduce English literature and Western science in the educational system, a bitter controversy erupted. After twelve years the controversy was finally settled by Macaulay in 1835. Popularly known as the "Oriental-Occidental controversy", it had several dimensions and it was more than a linguistic battle[1].

The present paper is concerned with the debates relating to the introduction of Western science only. Though it is very difficult to capture the fury and vehemence of both sides within a few pages of this paper, an attempt has been made to set forth these arguments centering around the following questions: How did the two groups perceive Indian science? What was the status of indigenous science at that time? How did the two groups propose to diffuse Western science and in what language? It is for this reason chronological framework has been set aside and the events described refer to the twenty-two years between the Charter Act of 1813 which merely compelled the East India Company to accept the responsibility for education of the people of India, and Macaulay's Minute of 1835 which sealed the controversy once and for all.

Science vs Religion: The reason for the introduction of Western science in India is strange indeed! It was not the intention of the British East India Company to enter the educational arena at all. The Government, which had ignored and even opposed English education of natives, was forced by Parliament to patronize it. In British Parliament it was felt, mainly by the evangelists, that little was being done for the education, particularly the moral and religious instruction, of the natives in India. When the Charter Act of the Company was to be renewed in 1793, the missionaries had begun an agitation in Parliament for the encouragement of their activities.

P. Petitjean et al. (eds.), Science and Empires, 49–56.

The opponents of the missionaries felt an urgent need to set up a strong rival agency in Indian education to counteract missionary enterprise. They therefore introduced a clause which became the controversial 43rd Section in the Charter Act of 1813 of the E.I.C. They believed[2] *"that by fostering both Oriental and Occidental science a reliable counterpoise, a protecting breakwater against the deluge of missionaries, could be created"*.

The Controversial Clause:

"... A sum of not less than one lakh of rupees in each year shall be set apart and applied to the revival and improvement of literature and the encouragement of the learned natives of India, and for the introduction and promotion of a knowledge of the science among the inhabitants of the British territories in India ...[3].

Not clear as to how the money was to be spent, the Court of Directors, while communicating this provision to the India Government, pointed out that the clause presented two distinct propositions for consideration: - the encouragement of the learned natives of India, and the revival and improvement of literature; - the promotion of a knowledge of science amongst the natives of the country.

The Rival Groups: Prior to the advent of the Moghuls and the Europeans, India had a well developed scientific tradition, an elaborate and firmly established theory of life and a rich tradition of education which drew the admiration of many Westerners, popularly known as the Orientalists. However, the native education, in the beginning of the 19th century, was at its low ebb. The Orientalists took up the cause of indigenous education and culture which brought them into confrontation with the changing mood of 19th century India; and the Anglicists who felt that Oriental education was far less developed, if not absurd altogether, argued that English education alone could help in the dissemination of Western knowledge.

Perception of Science: The Orientalists found in Eastern sciences the roots of modern science. As Prinsep observed, the *"philosophy of Bacon, Locke and Newton had grown out of that very philosophy of schools which had also been the highest point of knowledge reached in Sanskrit and Arabic"*. In a similar vein Johnston asserted that the Hindus possessed early knowledge of the numeral system which had proved essential for achievements of Kepler, Newton, Laplace and Napier. Comparing Hindu science to Greek science, he contended that the Hindus made the same progress in logic and metaphysics by 1500 B.C. as the Greeks during most enlightened period of its history. He considered the astronomical tables devised by the Hindus around 3000 B.C. a great scientific work[4]. Hence the Orientalists, argument was that the Arithmetic and Algebra of the Hindus were grounded on the same principle as those of Europe, and they insisted that the metaphysical sciences in Sanskrit and Arabic writings were fully as worthy of being studied in the languages as in others.

On the contrary the Anglicists view of Oriental science was an arrogant and prejudiced if not distorted one, and their pronouncements on the same were harsh and scathing. They considered it worse than a waste of time to teach or learn the sciences, in the state they were found in the Oriental books, and it was futile to study a science which knew nothing about Galileo, Copernicus and Bacon. The stipends offered to Oriental scholars was termed as bribe *"to imbibe systems of error which ... have been exploded and their falsehood demonstrated years ago"*.

Trevelyan and later Macaulay, both staunch Anglicists, termed Oriental sciences as most absurd. Trevelyan found its medicine quackery, its geography and astronomy monstrous absurdity, and its science as unchangeable as its divinity. Macaulay later accused the Committee of Public Instruction of giving artificial encouragement to absurd metaphysics, absurd physics...[5].

So on and on the arguments went. The main thread in these arguments was that Western science was superior to Eastern and that the latter was outdated. They wanted a clean break from the system of education which tried *"to arrest the progress of the human mind"*.

Diffusion of Science: As stated earlier, the Orientalists were not against Western science and literature and agreed that Oriental science needed updating. They wanted the introduction of the science and literature of Europe as an improvement to be "engrafted" upon the existing one. Lamenting the low status to which the native education had fallen, they believed it was their first duty *"to revive and extend the cultivation of the literature of the country"*. This, they argued could be brought about in two ways : - by seeking the cooperation of the native learned, who might not like the discipline and subordination of Western institutions of learning; - by fostering Oriental languages.

Consequently, the officers of the East India Company were encouraged to cultivate the native and learn Sanskrit. Sanskrit tracts dealing with plants and drugs were recommended to European medical men for study. Tracts on astronomy and algebra, it was observed, *"might be made to form links of communication between the natives and the gentlemen in our service, who are attached to the observatory and the de-*

partment of engineers". This kind of intercourse it was felt might lead to adoption of improvements in those other sciences. This was their idea of "engrafting" Western knowledge and innovation upon Indian cultural traditions by means of Sanskrit and Arabic.

The acquisition of Sanskrit was considered indispensable by the Orientalists, not only for the study of classical books composed in that language but principally as the mother language of a great number of Indian dialects. Thus, the educational grant was spent on the teaching of Sanskrit and Arabic, and in providing for the translation of English books into these languages. Such translations, the Orientalists contended, would enable the students to enjoy the benefit of improved doctrines without being strangers to their national science.

It should be clarified at this juncture that the Orientalists were only concerned with the education of elite class - a class of diffusionists - who would spread education to the masses. They were fully aware of the fact that education of the masses was a formidable task for the British in terms of resources, personnel and geographical coverage. They urged a vernacular education for the masses. Prinsep wrote, *"the instruction, the business, and eventually the literature of India must be in vernacular".* John Tytler urged[6], *"Science is to be diffused generally by means of the languages of the country and these, it is the Natives duty to cultivate, and ours to learn".* But the vernaculars had to be rendered, precise and elegant, to convey scientific ideas. The Anglicists assault on the Orientalists was multipronged. Not only the aim and method of education but also the class of diffusionists came under heavy attack. About the aim of education, they argued *"while Wellesley's aim has been to educate Europeans in the languages of the East our object is to educate the Asiatics in the sciences of the West".* Also, *"the great end should not have been to teach Hindu learning but useful learning".* The Orientalists were accused of trying to raise the reputation of Calcutta as a seat of Oriental literature through their academic Orientalism. They were criticized for translating English works into Sanskrit, Arabic and Persian instead of the popular languages of the country. *"What was required was not a Babel of dead languages but rather living languages as English and Indian vernaculars".* In their view, the Pandits and Maulvis whom the Orientalists wanted to be the diffusionists, would not consider the literature and science of the West worth the labour of learning.

Indian Aspirations: The necessities of intercourse with the natives had early created a class of intermediaries and assistants between the English and the people of the country. Interpreters, clerks, copyists and agents of the respectable class were in demand alike by the Government and the great mercantile houses. Cultural fascination for Western learning independently of monetary gains was also attracting in that direction. Knowledge of English had become a hallmark of social status. The desire for English education, wrote Raja Ram Mohan Roy, was found even in the lowest classes. In 1823 he pleaded for introduction of English literature and Western science in his famous letter to Lord Amherst[7]. It is interesting to note that while some enlightened Indians were crying for instruction in Western knowledge, a body of Englishmen were insisting upon retention of Oriental learning.

Revival of Vernaculars - a Major Issue: Reverting back to the controversy, it can be seen that both groups agreed upon the superiority of Western literature and sciences to Eastern learning. There was also a general agreement about the vernacular education for the masses based on vernacular literature *"infused to some extent with Western ideas and values"*. Both agreed that something had to be done to revive vernaculars. What then were the matters at issue, one may ask? Primarily it was about the means to be employed for revitalizing vernaculars and about the scope of educational system to be instituted.

The Orientalists felt that the only way of breathing new life into vernaculars was through Indian classical languages. Wilson maintained that the Indian vernacular literature had to be constructed out of a mixture of European and home spun ideas[8]. In Sanskrit they found a highly refined language, fixed by the most accurate rules and taught with most ingenious methods:[9] *"Hence, it was absolutely essential to cultivate Sanskrit and Arabic if Indian people are to have a literature of their own. No man ignorant of Sanskrit or Arabic could write Hindustani with elegance and purity"*. The Anglicists contested this point arguing that Indian vernaculars were "harmfully" tied to Sanskrit and Arabic, whose professors they regarded as religious obscurantists:[10] *"The Indian mind had walled itself up inside such a prison that only a new language could give it a ladder of escape"*. That new language had to be English.

Thus the Orientalists wanted the creators of new vernacular literature to learn Sanskrit or Persian, whereas the Anglicists wanted the language to be English. Mention should also be made here of a fanciful idea that emerged from the Anglicists' side. Trevelyan suggested[11] the application of the Roman alphabet to all the Oriental languages to help the gradual formation in India of *"a national literature embodying in itself the selected knowledge of the whole civilized world"*.

Role of English Language: The briefs reporting the controversy do not present the conflict in the committee between English and the Indian Classical languages as an either-or question but as a debate over priorities[12]. The Orientalists' position about English was that it should be studied extensively, no doubt, but that the improvement of the native dialects depended upon Sanskrit. Thus both languages were to be cultivated[13] *"but it was a visionary absurdity to think of making English the language of India"*. What they objected to was the promotion of English rather than encouragement of it. John Clive in his book on Macaulay observed[14], *"the cause advocated by Orientalists was really not that of science and literature, but rather that of rudimentary English as means of eventually pursuing the course of literature and science"*. It was in this, rather than in the ostensible conflict, that battle lines were drawn. The Orientalists disagreed with their opponents: they explained that the Indians craved on English education and were indifferent to Oriental languages. Certain classes of Indians were surely learning English with an ulterior motive of public employment but not out of love. Hence they would learn a minimun English - *"no literature and no principles"*, the Orientalists argued, and termed this spelling-book education. They urged that the Government's main aim must be to encourage study of English as a classical language, and vehemently opposed English instruction at the cost of native instruction lest the Indian learned class became jealous and hostile. Public money, they insisted, must be only for encouraging qualified teachers for higher branches of English education.

The Anglicists' petitions for English were often brisk and stressed the utilitarian aspects of learning English. Their main appeal was that a knowledge of English would produce more intimate connections between the governor and governed; corruption and intermediate agents be checked; and that natives had a wonderful aptitude for language as everyone above the cultivator spoke at least two. They argued that it was only those who had mastered English who would be able to translate European Science into vernaculars.

Macaulay's Verdict: In 1835 Lord Macaulay as a legal member of the council wrote his famous minute and gave his verdict when the papers dealing with the dispute were placed before the Executive Council. A cleavage arose over the interpretation of certain words of Clause 43 of the Charter Act of 1813. The Orientalists argued that the word "literature" contained in the clause stood only for Arabic and Sanskrit literature and a "learned native" meant an Indian scholar proficient in either of these two languages. To the Anglicists these expressions were not to be interpreted in the restricted sense and English was entitled to take its place in literature. Macaulay argued that the word "literature" could mean English literature as well and the phrase a "learned native of India" could also be applied to Indian familiar with the poetry of Milton and the metaphysics of Locke. Macaulay considered English to be better than Sanskrit or Arabic as a medium of instruction. He observed[15], *"a single shelf of a good European library was worth the whole native literature of India and Arabia"*. He also felt that it was possible through Indian education to bring about[16] *"a class of persons Indian in blood and colour but English in taste, in opinion, in morals or intellect"*. and that education was to filter down from them to the masses. Lord Bentick, the Governor General in Council, agreed with Macaulay and passed a resolution the same year and declared that henceforward the object of the Government should be the promotion of European literature and science among the natives of India.

Epilogue: Opposition to Macaulay's verdict came from different quarters. The Asiatic Society protested vigorously against it, observed that English could never become the language of the masses, and appealed for the encouragement of Sanskrit. Needless to say, the appeal was turned down. Brian Hodgson, a profound Orientalist, maintained that the real issue was not as Macaulay, with a debater's instinct, had insisted, between English and sacred languages of India, but between English and vernacular languages. If any scheme of public instruction were really to teach the Indian people, it must, he insisted, take as its basis their mother tongues[17].

Though the Government admitted that it looked forward to the time when Western knowledge would be widely diffused through vernaculars, the subsequent measure adopted dealt a severe blow to vernacular education. In spite of the Wood's Despatch's (1854) reversal of policy to the principles and methods of Hodgson, Lord Hardinge had in the meantime made the significant announcement that an English education must be regarded as the exclusive avenue to public employment. The Universities in the three Presidencies of Calcutta, Bombay and Madras established in 1857, instead of promoting the cause of vernaculars, further weakened its claims. In 1863 Bombay drove away vernaculars from its college course of studies. Calcutta followed suit.

Impact on Indian Science: Western learning was the instrument the British rulers used in their attempt to mould the life of the Indian people. The two major objectives of education were to effect moral and material improvement and to promote rationality through sound scientific knowledge. But the downward filtration theory of Macaulay did not facilitate these objectives. Modern science introduced from the top in an alien language could not find a social base to grow, as that science was not an organic extension of the earlier tradition.

As English education became a passport to public employment, a wide gulf was created between the educated and the masses. Thus the products of educational institutions were immune to the problem of the society like illiteracy, poverty, disease, etc. The literary character of education was adding thousands to the crowded professions of law, journalism and Government service in contrast to Medicine, engineering and sciences. The society of 19th century India was not in a mood to assimilate science and take advantage of the opportunities for progress offered to it by science; hence the transformation of society that occurred in England during this period could not be possible for the above historical conditions.

Jawaharlal Nehru University (Centre for Studies in Science Policy), New Delhi

Notes

[1] Clive, John, *Thomas Babington Macaulay. The Shaping of the Historian,* London, Secker and Warburg, 1973, p.342.
[2] Richter, J. A., *History of Missions in India,* London, 1908, p.152.
[3] Sharp, W. H., *Selections from Educational Records: 1781-1839,* Calcutta, 1920, p.22.
[4] Clive, John, *op. cit.,* p.398.
[5] Macaulay, Thomas Babington "Indian Education", in Clive, John, and Pinney, Thomas *Macaulay,* Chicago, Chicago University Press, 1972, p.250.
[6] Letter of Tytler to Thomas Babington Macaulay, in Sirkin, Gerald, and Sirkin, Natalie Robinson, "Macaulay", *Victorian Studies,* Jan. 26, 1835, p.421-26.
[7] Letter of R. Roy to Amherst, Dec. 11, 1823, in Sharp, *op. cit.,* p.100.
[8] Wilson, H. H. "Education of the Natives of India", *Asiatic Journal,* n.s. XIX, 1836, 14-15.
[9] *Ibid.*
[10] Kiermam, V. G., *The Lords of Human Kind: European Attitudes Towards the Outside World in the Imperial Age,* London, 1969, p.41.
[11] Trevelyan, Charles, Prinsep, J. et al. *The Application of the Roman Alphabets to All the Oriental Languages,* Serampore, 1834, p.21.
[12] Clive, John, *op. cit.,* p.366-367.
[13] Letter of Wilson to Sen, Aug 20, 1834 in Kopf, David. *British Orientalism and the Bengal Renaissance,* Berkeley, California, 1969.
[14] Clive John, *op. cit.,* p.367.
[15] Clive and Pinney, *op. cit.,* p.241.
[16] *Ibid.,* p.249.
[17] Hodgson, B. H. "Two Letters on the Education of People of India, in Hunter, H., *Life of Hodgson,* London, John Murray, p.311.

THE COLONIAL "MODEL" AND THE EMERGENCE OF NATIONAL SCIENCE IN INDIA: 1876-1920

V. V. KRISHNA

Basalla's three stages "model" for the spread of modern, Western science has in recent years come under serious criticism[1]. The inadequacy of this diffusionist "model" to reflect sufficiently upon the socio-cultural and politico-economic relations of Western science with recipient cultures continues to draw the attention of scholars. In doing so, the analysis of individual scientists, scientific institutions and the practice of science is increasingly brought within the ambit of sociology of knowledge in a historical mould[2]. Such an approach enables us to penetrate beneath the contours of the colonial science "model" of Basalla to enquire how recipient cultures perceive and respond to Western science and how the experience of one society varies across other cultural contexts. Recognizing that a justification for such an exercise requires a larger work than the present paper, an attempt is made here to focus on the scientific enterprise in India during 1876-1920. It focuses largely on the period prominently categorized as colonial science by Basalla. Further, this paper attempts to examine Basalla's inescapable conclusion that *"colonial science contains in an embryonic form, some of the essential features of the next stage"* through the definition of colonial scientist.

Who is a "Colonial Scientist"

Basalla's "model" has been critically examined for its conceptual clarity by a number of scholars. One feature of the "model" considered here as fundamental to the understanding of independent scientific tradition is the definition of a colonial scientist. Basalla, and for that matter the writings on colonial science, make no distinction between native and transplanted scientists or settler scientists. In the Indian context, the latter category calls for a further distinction between committed missionaries, who participated in the promotion of modern science, and government scientists, who merely executed the policies coming from above. Such a distinction, which in fact is empirically valid in the Indian case, is indeed an important basis upon which to understand the dynamics of colonial science and therefore its continuity and change.

P. Petitjean et al. (eds.), Science and Empires, 57–72.

Without such distinctions the understanding of phase transition becomes problematic, particularly when we compare the emergence of national scientific communities across cultural contexts. Inkster[3] who draws attention to the spread of modern science to Japan and Australia, meant for the former *"the penetration of indigenous science and culture by Western science, culture and technique"* and for the latter, *"the spread of science in the Western scientific community"*. In contrast to the settler societies such as Australia or Canada, a closer examination of the composition of scientists in late 19th century India shows broadly three categories of scientists.

First, the practice of research activity in a large measure was limited in about a dozen survey research organizations under the control of colonial administration. The image of science in the periphery, categorized by historians as colonial or "low science", identified with fact gathering was a division of labour[4]. This image of science in fact was kept intact by the colonial administration by blocking the advancement of scientific research. These features could not have been possible without institutions and persons who were basically the **"gate keepers"** of colonial science. Native Indian Scientists were highly discriminated against in the colonial scientific enterprises[5]. In 1920, P. C. Ray, father of the Indian School of Chemistry, could count only 18 Indians out of 213 scientific personnel in eleven colonial scientific enterprises, including the Indian Educational Service[6]. H. B. Medlicott, Head of Geological Survey, held that Indians were incapable of any original work in natural science. Medlicott[7] wanted to wait till the *"scientific chord among the natives"* was touched and added that *"if indeed it exists as yet in this variety of human race so let us exercise a little discretion with our weaker brethren, and not expect them to run before they can walk"*. Supercession of P. N. Bose by a junior scientist, T. Holland, for the position of Director, Geological Survey of India, and the negative attitude of Alfred Croft, Director of Public Instruction, Bengal, towards J. C. Bose and P. C. Ray - are a representative sample of the gate keepers of colonial science. "Gate keepers" operated on several fronts including education, industry, finance and science departments.

In the second category, both within and outside the colonial administration there were professionals who did their best in the given circumstances. These professionals came to India either through government channels or commerce. They were **"scientific soldiers"** both of Indian and European origin for whom the work ethic was of paramount importance and who would not normally dabble in the "gate keeping" business. William Brook O'Shaughnessy, who was instrumental in laying about 12,000 miles of telegraphy between 1857 and 1860 (period noted for the first war of Indian independence) is a good example of this category[8]. The bulk of the scientific personnel in this category were of European origin. Even though these scientists spent long periods of time in India they were psychologically tuned to their mother country and lived in a world of isolation among native Indians. When these European scientists attained the age limit, they returned to their country, taking in their baggage a vast treasure of experience which was simply lost to India for ever. William Pole (1814-1900), who taught engineering at the Elphinstone College, Bombay, helped in the "Survey of Great Indian Railway". On his return to England he was employed in railway engineering and consulted by de Lesseps on the proposal to dig a canal through Suez. Pole went on to become consulting engineer to the Japanese Government and hold a chair of engineering at University College, London. Colonel Alexander Strange (1818-76) returning to England from the Trignometrical Survey of India in 1861, established a large department on scientific instruments inspection. Strange was elected as a F.R.S. in 1864. *Nature* in March 1876 observed that *"to him belongs the credit of appointing Royal Commission in Scientific Institution and the Advancement of Science"*. Strange was also instrumental in the establishment of the Ministry of Science[9].

The third category of scientific personnel was native Indians in majority and a small number of Western settlers, mostly missionaries and Jesuits. David Hare, Father Eugene Lafont, William Carey and Marshman of Serampore missionaries, P. C. Ray, J. C. Bose, C. V. Raman, M. N. Saha, Ashutosh Mukherjee, M. L. Sircar, Visvesvaraya and many others may be included in the third category[10].

Basalla, and many other scholars, do not distinguish the roles performed by Meldicott, O'Shaughnesy and M. L. Sircar or P. C. Ray. They are lumped together to define a colonial scientist. In actual terms, the three categories of scientists had their respective constituencies of operation with their respective goals, purposes and network of relationship. What role did the third category of scientists play? What kind of institutions did they established? And what were their ideological and intellectual objectives?

These scientists were basically part of the emerging nationalism and were as much partners in the freedom movement as Gokhlae, Ranade, Joshi, Dutt and others. Even though most of the scientists did not directly participate in the political struggle, ideological underpinnings to their scientific pursuits reflected a definite form of "struggle". Their struggle meant to accord an international status to science in India and thereby reassert their national scientific identity. J. C. Bose, India's eminent scientist held that[11] the *"highest expression in the life of a nation must be its intellectual eminence and its power of enriching the world by advancing the frontiers of knowledge"*. His mission, as he often said, was not to introduce science to India, but to revive Indian science. There were others such as P.C. Ray who declared[12], in the midst of his scientific career, that *"science can afford to wait, but Swaraj cannot"*. In concrete terms what this struggle sought was to transform the structures of colonial science in the national interest. More importantly, the struggle was directed to create alternative support structures towards the establishment of independent national science as pursued by J. C. Bose and others referred to earlier. What I mean by support structures are: institutions for the dissemination of scientific and technical knowledge; national views on science and technology; institutions and research programmes geared to the advancement of scientific knowledge; and the constitution of specialist or scientific communities. It is to these support structures, in which the third category of scientists was involved, that the rest of the paper will be devoted.

Early Institutional Efforts

If the establishment of the Asiatic Society of Bengal in 1784 is considered as the landmark for the institutionalization of Western science in India, the inauguration of the Indian Association of Cultivation of Science (IACS) on 15 January, 1876, inaugurated the national science. The man behind this institution was Mahender Lal Sircar (1833-1904), an allopathic doctor by training but a strong advocate of homoeopathy. The uniqueness of this institution was the vision of its national objective in science and autonomy from government laid down as early as in 1875. Sircar[13] stated that

> "the object of the Association is to enable natives of India to cultivate science in all its departments with a view to its advancement by original research, and (as it will necessarily follow) with a view to its varied applications to the arts and comforts of life".

Despite a modest collection of Rs. 61,000 for the establishment of IACS, in 1875, Sircar[14] pleaded that *"we should endeavour to carry on the work with our own efforts, unaided by the government. I want it to be solely native and purely national"*. Sircar envisaged the combination of the character, scope and objectives of Royal Institution of London and British Association for the Advancement of Science (BAAS) in the IACS. Seven sections were organized within few years after IACS establishment. These were general physics, chemistry, astronomy, systematic botany, systematic zoology, physiology and geology. Sircar, Lafont, Tara Prasanna Roy, Nilratan Sarkar, Chunnilal Bose, J. C. Bose, Ashutosh Mukherjee and P. N. Bose were some of the Indian scientists who delivered lectures at the IACS. Even though the efforts of these people went a long way to generate mass interest in science in Bengal, original investigations in science had to wait till C. V. Raman's association with the IACS in 1907.

Above all, the greatest contribution of IACS during this period (1876-1901) was its development of the idea of nationalism in the cultivation of science. A direct spin-off from the IACS was the emergence of at least four institutions to promote the cause of national technical education. Paramnath Bose, a member of IACS, established Indian Industrial Association in 1891. The Association arranged popular lectures on coal and fibres. Its members experimented with indigenous raw materials. The Association for the Advancement of Scientific and Industrial Education (AASIE) was founded in 1904 by Jogendranath Ghosh. This Association played an important role in sending Indian students abroad in the Swadeshi movement. Satishchandra Mukherjee, a leading educationist of Bengal, launched the Dawn Society, in 1902 to promote the idea of national education. The Society's magazine, *The Dawn,* provided an important platform for promoting applied science literature and popularization of science[15].

In 1904 and 1905 Lord Curzon's attempts to invoke government control over education followed by the Bengal partition brought the question of technical education into sharp focus. The Dawn Society became the National Council of Education (NCE) in 1906 to organize parallel structures of education[16] on *"national lines under national control"*. But crises struck the NCE. As a direct fallout of the splits in NCE over the question of higher technical education, two institutions were established. Tarak Nath Palit and Nilratan Sarkar launched the Society for the Promotion of Technical Education in 1906, which established the Bengal Technical Institute[17]. The other group of NCE, involving Satish Mukherjee, Goorudas Banerjee and Aurobindo Ghosh, established the Bengal National College and School in the same year to promote science along with literary courses in the universities[18]. The split of NCE lasted only four years and in 1910 both the rival camps merged. What survived out of this national movement in education was the nucleus of the present day Jadavpur University and the establishment of the University College of Science, Calcutta University, which received rupees 2.4 million rupees from Taraknath Palit and Rash Behari Ghosh along with the assets of the Bengal Technical Institute in 1914[19]. As a part of the national education movement, P. K. Roy and M. L. Sircar were demanding separate science courses in physics, chemistry, botany and math at the Calcutta University in the 1890's. Through the efforts of Nitraian Sircar, J. C. Bose and M. L. Sircar, the Science Degree Commission was set up in 1898 and recommended it. Ashutosh Mukherjee, taking over as the Vice-Chancellor of Calcutta University in 1912, further boosted science by starting post graduate research and teaching at the Calcutta University. This development, in a way, weakened the NCE split. The colonial government opposed the department and refused to finance it for advanced training. It was at this stage that the donation of Palit and Ghosh made it possible the organization of advanced scientific research at the Calcutta University.

The efforts of the national education movement in the promotion of science education and research was, however, not confined to Bengal. Poona Sarvajenik Sabha's demand of 1882 to strengthen technical education was later taken up by the Indian National Congress after 1885[20]. About two decades before the idea of the Bengal Technical Institute, the princely states of Baroda and Travancore established technical institutes in the 1880s, of which Baroda's Kala Bhavan Technical Institute was the first and biggest institute established by the native Indian states[21]. The roots of the present day Faculty of Technology and Engineering, M. S. University, Baroda, goes back to Kala Bhavan. The phenomenal growth of Baroda as a manufacturing and industrial centre between 1890 and 1910 is related to the engineering schools of Kala Bhavan[22]. Taking the lead from Baroda, 57 "industrial and arts schools" or "technical institutes" were established by native Indians and missionaries in the states of Baroda, Mysore and Travancore[23].

Between 1880 and 1919 the native Indian and missionary contribution for the establishment of colleges and the initiation of science teaching in them was at par with British contribution. But for the universities established at Bombay (1857), Madras (1857), Calcutta (1857), Allahabad (1887), Banaras (1916), Mysore (1916), Patna (1917), Hyderabad (1918), non-governmental contribution was substantial. In the three presidency regions and Punjab, 45 affiliated colleges were established where 91 lecturers, mostly of Indian origin, were teaching graduate and post-graduate subjects in science and engineering[24].

To counter the literary bias of the British educational policy and to motivate Indian students to science and engineering, wealthy Indian elites instituted a number of scholarships and endowments. The famous Premchand Roychand offered 5 scholarships of Rs. 1400 per year from the endowment of Rs. 200,000 in 1879 to the Calcutta University[25]. The Rajabhai Tower and Library at Bombay University were established by the generous grant of Rs. 400,000 given by Roychand. Dadabhai Naroaji offered Rs. 50,000 and collected Rs. 175,000 for Canning fellowships at the Bombay University[26]. J. N. Tata's contribution of Rs. 3.0 million and the donation of Rs. 500,000 by Sheshadri Iyer, Dewan of Mysore Maharaja, along with the offer of 300 acres of land for the establishment of Indian Institute of Science had no parallel in 1910. The AASIE founded in 1904 by J. Ghosh was to raise Rs. 100,000 per year to provide scholarships for Indian youth going abroad for technical training. From 1905 to 1908 the Association offered 236 scholarships for study abroad[27]. In Bengal, private aid to education from 1878 exceeded the government aid by a considerable margin[28].

Scientific Societies and Vernacular Literature in Science

Between the University Departments in Science and Engineering and specialized institutions such as IACS and Kala Bhavan, there were half a dozen societies whose main objective was to popularize science and create a base for modern science among Indians. Besides the Dawn Society (1904) and AASIE (1904), the Aligarh Scientific Society founded by Syed Ahmad in 1864, the Bihar Scientific Society, Muzaffarpur, founded by Syed Imdad Ali in 1868 and Punjab Science Institute, Lahore established in 1886, were the main societies[29]. The main thrust of these societies was activities to create a base for modern science in vernacular language. Translation of science books and launching of newspapers were therefore undertaken by these societies[30]. Aligarh Society translated 40 books dealing with electricity, algebra, arithmetic, agriculture and social sciences. It launched the *Aligarh Institute Gazette* to promote Western arts and science. Bihar Society started a fortnightly *Akhbar-ul-Akhyar* and established five schools in 1870s to popularize Western science[31]. The Punjab Society's lectures were organized by Lala Ruchi Ram Sahni.

The Anglicist-Orientalist debate of the 1830's in Bengal had a definite influence on the national education movement, particularly on science education. Ram Mohan Roy relegated classical languages to the pre-Baconian form in favour of English education in English medium[32] *"to instruct the natives of India in mathematics, natural philosophy, chemistry, anatomy and other useful sciences".* On the other hand, Debendranath Tagore established Tattwabodhini Patnashala (school) in 1840 for imparting education in vernacular language. This was supported by Rabindranath Tagore in the late 19th century[33]. Compromise between the two positions and yet, not snapped link with our own culture through the use of vernacular was the only way out. P. C. Ray realized this problem and pleaded[34] that

"although there is a diversity of language among the European nations, there is uniformity in the use of technical terms. The Japanese have fully realized and have thus adopted the middle course. We should also follow in their footsteps".

Others, like Gurudas Bandopadhyaya, the first Indian Vice Chancellor of Calcutta University, and J. C. Bose, supported the middle course. Serampore missionaries like William Carey and Marshman are to be credited with the first introduction of science into Bengali literature. Bengal had given the lead in the late 19th century for science magazines and books in the vernacular. Between 1868 and 1900, 10 journals and magazines in science alone and 47 in technology were reported from Bengal[35]. *Vigyan Rahasya* (1871), *Vigyan Vikas* (1873), *Vigyan Darpan* (1876), *Sachitra Vigyan Darpan* (-1882), *Chikitsa Darshan* (1887), *Tatvabodhini Patrika* and *Bengal Spectator* were some of the important periodicals in Bengali dealing with science and technology[36].

TABLE 1
Publications on Science in Indian Vernacular Languages in the Indian Provinces between 1875 and 1896

Provinces	Medicine	Maths	Natural Sciences	Total
Bengal	472	180	124	776
Madras	83	35	43	161
Bombay	210	101	102	413
Punjab	264	183	17	464
NWP Oudh	116	174	20	310
Total	1145	673	306	2124

Efforts invested in creating a base for modern science in Indian languages were however not confined to Bengal. These activities stretched to other parts of India, as is evident from table 1[37]. Of the 2124 publications, 306 are in Bengali languages. Whilst these publication were concerned with the graduate and under graduate level, the

Calcutta School Book Society in 1875 published a catalogue of Bengali titles. Of the 1544 titles, 333 were on science and technology[38].

Individuals, Institutions and Programmes to Advance Science

When J. C. Bose and P. C. Ray joined the Presidency College in 1885, and C. V. Raman the IACS in 1907, the "cultivation of science" was extended to mean the contribution to the advancement of sciences. Father Lafont at St. Xavier College established an excellent observatory for meteorological and spectrotelescopic investigations[39]. The Indian Institute of Science came into existence by 1909, and before the close of 1920, the University College of Science, Calcutta University (1914) and Bose Research Institute (1917) were established. In effect, these institutions gave a new "identity" to Indian science. Even though the scientific elite of this era were the product of the Western education, advancing science did not mean aping the West passively. As J. C. Bose observed[40],

> "impulse from outside reacts on impressionable bodies in two different ways. So the first impetus of Western education impressed itself on some in a dead monotony of imitation of things Western while in others it awakened all that was greatest in the national memory".

J. C. Bose often said that his purpose was not to merely introduce science, but to revive Indian science. By this he meant to revive the experimental tradition and not the speculative tradition. The assertion that the method of science was Western, and hence alien to national culture, was rejected as groundless by J. C. Bose[41]. Thus advancing science also meant achieving a new status for the self and for national prestige. Eminent Indian scientists of J. C. Bose's era widely shared this view.

The constitution of research activity to advance science in the above institutions enabled the leading scientists to make a significant departure from the era of colonial science. For instance, Indians could only publish 18 papers in the *Journal of Asiatic Society* for the sixty year period from 1836 to 1895. The European settlers in contrast accounted for 1021 papers[42]. In the next quarter century (up to 1920) research output from the above five institutions alone accounted for 304 papers, the bulk of it concerning original investigations[43]. In every branch of science Indians contributed to the advancement of knowledge and earned professional recognition from the world bodies.

J. C. Bose's work on micro-wave (1895) and plant physiology (1900) earned him world recognition: he was elected to the Royal Society in 1920[44]. On Radio receivers, Patrick Geddes, biographer of J. C. Bose, accords him priority over Marconi who patented it[45]. P. C. Ray discovered Mercurous nitrite in 1896. No branch of chemistry was left untouched with his original papers. He published about 107 papers by 1920 and was elected vice-president of the Edinburgh University Chemical Society as early as 1888. C. V. Raman entered IACS in 1907 and published about 35 papers by 1920. The areas of research covered by Raman and his colleagues included sound and vibration, theory of musical instruments, viscosity, colloid studies, wave optics and molecular scattering of light[46]. Basic research in these areas which were further developed earned Raman the Nobel Prize after fifteen years and the fellowship of the Royal Society in four years. Another genius was S. Ramanujan, a Port-Trust clerk at Madras who never entered the University. His theory of numbers earned him the Fellowship of the Royal Society in 1918. Ashutosh Mukherjee, a lawyer by training, contributed 16 original papers on differential equations. Similarly Dr. Ganesh Prasad, Hardinge Professor at Calcutta University, contributed to applied mathematics in the theory of potentials[47]. Satyendranath Bose joined Calcutta University in 1916 along with M. N. Saha. Bose was the first to translate Einstein's original German paper on the generalized theory of relativity into English in 1915; it was published as book by Calcutta University in 1920. S. N. Bose's interest in Einstein's work led him to the famous Bose-Einstein statistics of 1924 paper wherein he gave a logical derivation of Planck's law of blackbody radiation.

While Indian scientists achieved world recognition in many scientific fields, technologists made their presence felt at the national level[48]. P. C. Ray's Bengal Chemicals and Pharmaceutical Works (BCPW), established in 1892 with the assistance of S. C. Sinha, is a direct example of his economic nationalism. There were a number of independent innovators in Bengal[49]. However, J. C. Bose, C. V. Raman, P. C. Ray and others were not isolated individuals. They constituted the embryoes of what is known as the Indian scientific community for the first time. The Indian School of Chemistry under P. C. Ray encouraged and trained a generation of students, who immensely contributed to the development of chemistry departments in the universities and gave at least four generations of chemists[50]. The base for the Indian Chemical Society (1924) was in fact provided by the students of P. C. Ray and its genesis goes back to the dream P. C. Ray shared with J. C. Ghosh, J. N. Mukherjee and S. S. Bhatnagar in London. The second school was the School of Physics which emerged at Calcutta. C. V. Raman, J. C. Bose and M. N. Saha constituted this school but until 1920, C. V. Raman was its leader. The Centenary Volume of IACS identified the school as "School of Raman"[51].

Another group which became active during 1900 and 1920 was the group on plant physiology under J. C. Bose. Following his paper in 1900 on the generality of molecular phenomena produced electrically in living and non-living matter, J. C. Bose published four monographs through Orient Longmans, which contained the details of 650 experiments in plant physiology[52]. With this base, J. C. Bose organized a research group at his Bose Research Institute from 1917. N. N. Neogi, S. C. Das, Gurupudaswamy Das, Jyotiprakash Sircar, S. C. Guha and Lalit Mohan Mukherji worked with J. C. Bose and published about 20 papers on life movements in plants, which received world recognition.

Reviving the Indian tradition of mathematics, the Calcutta Mathematical Society was established in 1908 with Ashutosh Mukherjee as president. Ashutosh Mukherjee, known for his legal profession and the vice-chancellorship of the Calcutta University, contributed 16 original papers on differential equations. Through the efforts of V. Ramaswami Iyer, the "Analytical Club" at Fergusson College, Poona was upgraded to the Indian Mathematical Society in 1911. Dr. Ganesh Prasad founded the Banaras Mathematical Society in 1918. Other societies which were established by 1920 are the Bihar and Orissa Research Society (1915) and lastly the Institution of Engineers (India) in 1920. There were however other researchers with small teams and scientific societies spread all over India which needed the common platform provided by the launching of the Indian Science Congress Association in 1914. As Rutherford[53] observed,

"the congress was founded at a time when the universities were becoming the centres of original research, it afforded to a widely scattered scientific community a much needed common meeting ground".

Concluding Remarks

An attempt has been made in this paper to critically examine a part of Basalla's colonial "model" in the context of scientific enterprise in India for the period 1876-1920. It is erroneous to construct the definition of colonial science delinked from its social context - namely colonialism and rising nationalism - to extract its "regenerative" features by grossly undermining the "exploitative" features. The colonial science used by Basalla reflects its political unreality in the Indian context.

A closer examination of the institutions and scientists between 1876 and 1920 begs a finer definition of a colonial scientist. I have argued that three categories of scientific personnel and institutions make sense for the period after the 1870s, if one is to understand the constitution of (Basalla's Third Phase) what I term as national, independent science. The first category is the "gate keepers" of colonial science who helped to keep science dependent and practiced discrimination against the native Indian scientists. Second, there were "scientific soldiers" who merely executed their occupational and professional roles. The third category consisted of scientists who struggled to create support structures for the cultivation of modern science and its advancement in the framework of emerging nationalism. The term "national" is interpretatively derived which manifests widely in the writings and views of the third category scientists. This categorization is put forward as an alternative to the homogeneous colonial scientist used by Basalla and others for the period after the 1870s. Explicit to stratification is also the recognition that scientists in each stratum had different constituencies of operation with respective goals and purposes. It is held that the third category was responsible for the emergence of national science or a "independent" scientific phase and that the other two categories were not. The empirical support which is brought to bear on this argument is that scientists and institutions established by the third category neither had any intellectual collaboration with nor received the barest minimum economic support from the other two categories in the constitution of national science.

The research groups constituted by the third category of scientists may be accredited with this historic role in that they established for the first time schools in physics and chemistry, "specialized groups" and professional bodies in plant physiology and mathematics. To this category may be added the group on spectra-telescopic investigations at Saint-Xavier's College, organized by Father Lafont. All these groups constituted the genesis of the Indian scientific community formalized by the establishment of the Indian Science Congress in 1914, which created a common platform for scientists from different parts of India.

The role of Indian scientists in the constitution of national science began with the creation of support structures from 1876. This effort of creating support structures was however not confined to Bengal: within the constraints of limited sources and time, I have shown the spread of support structures in various other parts of India. Technical institutions such as Kala Bhavan, college departments in science subjects, scholarships and endowments for science subjects, popularization of science and the creation of base for modern science in vernacular language - all institutionalized by native Indian scientists, constitute the support structures. In the midst of colonial economic exploitation technical training centres in minor trades have played a very important role without which thousands of artisans might have been converted into landless labourers.

By the 1890s, Indian scientists first achieved world recognition in modern science from the Indian soil. An altogether different view, which follows from the stratification of scientists, is that the constitution of national or independent science was outside the structures of the colonial scientific enterprise. Basalla's hypothesis that phase III in its embryonic form is contained in colonial science is questionable. Further, the paper suggests that national science was not constituted just because it is financed by natives of the country. It needed a "calling" by which it was intellectually integrated into the national interests aided by political and economic efforts. Emerging nationalism after the 1870s and the ideological role of scientists in it is in no small measure unconnected to the struggle of Indian scientists to achieve international recognition. Limited to their sphere of influence, they believed that advancing the frontiers of knowledge also meant giving a distinct national identity to their intellectual production. This "cultural nationalism" in science was however not completely devoid of economic relevance. The generation of skilled persons, chemists and technologists who managed swadeshi based industries (such as - The Bengal Chemicals and Pharmaceutical Works of P. C. Ray, - Calcutta Chemicals, - Duck-Back Waterproof, - Bengal Potteries), received their training in the Bengal Technical College, a product of the national education movement. What happened in Bengal also happened elsewhere. Kala Bhavan Technical Institute is the best example of the development of Baroda as a manufacturing town. By 1920, although some infrastructure was laid down, the forging of structural connections between science, technical education and production was greatly constrained by colonial policies. Scientific excellence on the other hand did not require such an elaborate umbrella of connections. With an optimum support structure, scientific excellence could be developed at the laboratory level with brains, so Indians could contribute.

By all means the national science was "stemming" out of its embryonic form by 1920. The support structures created up to this period were to prove to be a great boon for science in India in the next

15 years and enabled further consolidation of the base of national science. C. V. Raman won the coveted Nobel prize and two more fellowships of the Royal Society were added to the Indian list. S. N. Bose, M. N. Saha and S. K. Mitra were making original contributions. Twelve professional societies such as the Indian Chemical Society, the Society of Biological Chemists, the National Institute of Science, and the Indian Academy of Sciences were established in this period. All these accomplishments by the mid 1930s were the result of the support structures created before 1920. The continuity and change in the national science tradition calls for further research.

National Institute of Science, Technology and Development Studies, New Delhi

Notes

[1] G. Basalla, "The Spread of Western Science", in *Science*, **vol.156**, n°3775, 1967, p.611-622; for critical examination of Basalla's "model" see Ian Inkster," Scientific Enterprise in Historical Context", *Social Studies of Science*, **Vol.15**, 1985, p.677-706; and Roy MacLeod, "On Visiting the Moving Metropolis: Reflections on the Architecture of Imperial 'Science'", *Historical Records of Australian Science*, **vol.5**, n° 3, 1982, p.1-16.

[2] See D. Raina and I. Habib, "Cultural Foundations of a 19th century Mathematical Project" *Economic and Political Weekly*, 16 Sept., 1989; R. M. Young, "The Historiographic and Ideological Context of the 19th Century Debate on Man's Place in Nature", in M. Teich and R. M. Young (eds), *Changing Perspectives in the History of Science*, London: Heinman, 1972.

[3] *Op. cit.*, note 1.

[4] See MacLeod, *op. cit.*, note 1

[5] Deepak Kumar, "Racial Discrimination and Science in 19th century India", *Indian Economic and Social History Review*, 1983, **vol.xix**, **n°** 1, p.63-82.

[6] P. C. Ray's Presidential address to the seventh Indian Science Congress (ISC), see *Proceedings of the 7th ISC*, Calcutta: Royal Asiatic Society of Bengal, 1920.

[7] Review of agriculture, *surveys*, n°25, September, 188O.

[8] Sarjoj Ghose, "William O'Shaughnessy - an Innovator and Entrepreneur", paper presented at a seminar on "Calcutta and Science", December 21-23, 1989, Birla Industrial & Technological Museum (BITM), Calcutta.

[9] These examples are taken from an excellent study by W. H. G. Armytage, *A Social History of Engineering*, London: Faber and Faber, 1961, p.164-167.

[10] In contrast to "scientific soldiers", some foreign scientists and missionaries were attached to India. Father Lafont joined St. Xavier College in 1865 and died in Calcutta in 1908. He was in fact one of the founders of the IACS. David Hare, a watch maker, came to Calcutta in 1800 at 25, later founded the Great Hindu College in 1817 with R. M. Roy and died in Calcutta in 1842.

[11] Dibakar Sen and A. K. Chakrabarty (eds), *J. C. Bose Speaks*, Calcutta: Puthipatra, 1986, p.97-105.

[12] S. Chatterjee and A. Sen, *A. P. C. Roy - Some Aspects of his Life and Work*, (125th Birth Anniversary volume) Calcutta: Indian Science News Association, 1986, p.105.

[13] *A Century: IACS*, (centenary volume of IACS), Calcutta; IACS, 1976, p.9.

[14] *Ibid.*

[15] For little more details of the associations, see Sumit Sarkar, *The Swadeshi Movement in Bengal 1903-1908*, New Delhi: People's Publishing House, 1977.
[16] *Ibid.*
[17] The staff included N. Sircar, M. Nandi, P. C. Ray, B. N. Seal and J. C. Basu. The emphasis was laid on promoting swadeshi products. It had 124 students in 1909.
[18] NCE drew curriculum of 3 years of primary, 7 years of secondary and 4 years of collegiate course. Many eminent persons taught at the college including Dharmanand Kosambi, father of D. D. Kosambi. In 1908 there were 450 students.
[19] Shiv Visvanathan, *Organizing for Science: The Making of an Industrial Research Laboratory*, Delhi: Oxford University Press, 1985.
[20] At its third session in 1887 the Indian National Congress demanded that the government "*elaborates a system of technical education*". Later in 1888 it demanded the constitution of a commission to enquire into the state of technical education. See Congress Resolutions VII, X, XII & XV for the years 1887, 1888, 1891 to 1893 respectively.
[21] *The Dawn Magazine*, Calcutta, from September 1910 to February 1911 traced a detailed history of the Kala Bhavan. Material used here is drawn from these sources.
[22] *Ibid.* See also Dhruv Raina and S. Irfan Habib's paper, *this volume.*
[23] *Ibid.*
[24] K. R. Kirtikar, "The Study of Natural Sciences in the Indian Universities", Part I to V, *The Modern Review*, Calcutta, 1909. Kirtikar studied the native Indian contribution to the development of science education in affiliated colleges.
[25] *Ibid.*
[26] *Ibid.*
[27] See Sumit Sarkar, *op. cit.*, note 15.
[28] In 1879-80, private aid was 54% of the total expenditure on education in Bengal which was increased to 56%. Bengal Administration Report, 1880-81 p.53 quoted in D. Kumar, *Science Policy of the Raj*, 1857-1905, Ph. D. thesis, Delhi University, 1986.
[29] *Report on Industrial Education*, Part II, National Archives of India, New Delhi, 1903. This report covers Punjab Science Institute, Lahore. For detailed studies on Aligarh and Bihar Scientific Societies, see Irfan Habib, "Institutional Efforts: Popularization of Science in the mid-19th Century", *Fundamenta scientiae*, **vol.6** n° 4, 1985, p.299-312.
[30] 17 Books on pure mathematics by Tod Hanler, Bernard Smith, Galbraith and Haughton were translated. A model farm of agriculture to cultivate modern methods was created by Aligarh Society. Foreign varieties of wheat, cotton and vegetables were imported. Bihar Society established five schools in which Western sciences were taught.
[31] Deepak Kumar, *op. cit.*, note 28.
[32] Address from R. M. Roy to the Governor General protesting against the establishment of the Calcutta Sanskrit College, Dec. 1823, see J. K. Majumdar (ed), *Raja R. M. Roy and Progressive Movements in India: A selection from Records (1775-1845)*, Calcutta: Art Press, 1941.
[33] Sumit Sarkar gives an excellent exposition of this debate in his book swadeshi movement, *op. cit.*, note 15. See also J. F. Hilliker, "The Creation of a Middle Class as a Goal of Educational Policy in Bengal 1853-54, in C. H. Phillips, M. D. Waivwright (Eds), *Indian Society and the Beginnings of Modernization: 1800-1850*, School of Indian and African Studies, University of London, 1970.
[34] P. C. Ray, "The Place of Science in the Vernacular Literature", in P. C. Ray (ed), *Essays and Discourses*, Madras: G .A. Natesan & Co. 191 8, p.136-137.
[35] D. P. Bhattacharya, R. Chakravarty and R. D. Roy, "A Survey of Bengali writings on Science and Technology", *Indian Journal of History of Science*, 24 (1) p.8-66, 1989.
[36] *Ibid.*
[37] Selected from excellent survey conducted by D. P. Bhattacharya et al., *ibid.* Delhi.

[38] *Ibid.*

[39] A. K. Biswas, "Eugene Lafont and the Scientific Activity of Saint Xavier College, Calcutta (1860-1910)", paper presented at a seminar on "Calcutta and Science", December 21-23, 1989, BITM, Calcutta.

[40] J. C. Bose, "The History of a Failure that was Great", in Dibakar Sen and A. K. Chakrabarty, *op. cit.*, note 11.

[41] See D. Bose's article on "J. C. Bose and the Indian Tradition of Science" in D. Sen and A. K. Chakrabarty, *op. cit.*, note 11. Pr. Sathianadhan interviewed J. C. Bose in 1896, J. C. Bose who mentionned two assistants: "My young assistant not a graduate has within a short time developed great originality and has rendered me very efficient help in the construction of my apparatus. Lastly, a bearer, employed as a menial servant, now arranges for me the most difficult experiments, manages the Dynamics-Machine and is a good photographer", reported in *The Dawn*, October, 1902, p.115. C. V. Raman shared many of J. C. Bose and M. L. Sircar's views. See, G. Venkataraman, *Journey into Light: Life and Science of C. V. Raman*, Bangalore: Indian Academy of Sciences, 1988.

[42] See Shiv Visvanathan, *op. cit.*, note 19, p.27.

[43] The 261 papers are from J. C. Bose and co-authors 87; P. C. Ray and co-authors, 107; C. V. Raman and co-authors 46; S. N. Bose, 5; and A. Mukherjee, 16 from IACS, Presidency College, University College of Science, Bose Research Institute and St. Xavier College only. Remaining papers are from the Indian School of Chemistry.

[44] Lord Kelvin, commenting on the papers of J. C. Bose on polarization of the Electric ray, observed "I have found time to look all through the pamphlet although not to learn all its contents but I have seen enough to fill me literally with wonder and admiration", reported in *The Dawn*, under J. C. Bose interviewed in 1896, November 1902, p.113.

[45] Bose gave an experimental demonstration at a public function Calcutta town hall in 1894-95 in the presence of Lieutenant-Governor of Bengal. Marconi patented his discovery in England in 1896. The improved version of coherer, the electric wave receiver was patented by Sister Nivedita and Mrs. Ole Bull in USA on behalf of Bose. Unwilling to use his rights the patent lapsed.

[46] See G. Venkataraman, *op. cit.*, note 41.

[47] S. N. Prasad, *Progress of Science in Indian during the Past 25 Years*, Calcutta: Indian Science Congress Association, 1938.

[48] M. Visvesvaraya, *Memoirs of my Working Life*, Delhi: The Publication Division (NBT), 1951.

[49] See Sidharth Ghosh, "Some Eminent Bengali Pioneers in the Field of Technology", paper presented at a seminar on "Calcutta and science", BITM, Calcutta, 21-23, Dec. 1989.

[50] Rasiklal Datta, Nilratan Dhar, Jitendranath Rakshit, J. C. Ghosh, J. N. Sen, Jnanendranath Roy, Pulin Bihari Sarkar, A. C. Ghosh, P. C. Bose and G. C. Chakravorti are few of those chemists who achieved national recognition. For further details see P. C. Ray, "Essays and Discourses", *op. cit.*, note 34.

[51] A. Dey, S. K. Banerjee, S. Appasamyar, S. K. Mitra, D. N. Ghosh, D. Banerjee, T. J. Chinmayanandan K. S. Rao are some of the scientists who constituted the "Raman's School of Physics" up to 1920. See, A Century: IACS, *op. cit.*, note 13.

[52] These four monographs are: *Response in the Living and Non-Living (1902)*, *Plant Response as a Means of Physiological Investigation (1906)* with 315 experiments, *Comparative Electro-Physiology (1907)* with 321 experiments, *Researches on Irritability of Plants (1913)*. See, Dibakar Sen and A. K. Chakrabarty, *op. cit.*, note, 11.

[53] Rutherford's presidential address to the silver jubilee session of the Indian Science Congress. See, *Proceedings of the 25th Indian Science Congress*, 1938, Part II, Calcutta: Royal Asiatic Society of Bengal, 1939.

INTEGRATION PROBLEMS: DISCUSSION

IYANAGA Shokichi (Chairman)

First, one should raise the problem of the relationship between the old tradition of science and the new one. Was there any conflict between these two traditions? Were there any common elements?

Roshdi RASHED

Pr. Zimmermann has explained the problem of integration in a detail. Is it in fact the "integration" or the "disintegration" of modern science in underdeveloped countries that we are talking of? One must differentiate some specific cases: a colonial situation, and a national-state situation; the period before the expansion of colonial powers, such as the case of Egypt or Turkey; or after colonization, in the late 19th century, with a dominated state which was not very active in science or in industry.

Could we speak about the integration of science, or its disintegration, in the same way, for these three or four situations? Could we really speak about the integration of science in the underdeveloped countries, or is it a distinction to be made between 19th century science and the new science after 1905, or 1920?

Ekmeleddin IHSANOGLU

The case of Ottoman Turkey and Ottoman Egypt raisesa very difficult question. The Ottomans' contacts with European science took place since the 15th century. They were selective: they used certain things but did not need others. They had their own institutions for architecture, engineering, medicine, etc. But, when it came to the power balance between them and Europe, they had to introduce new elements, they went after them, and tried to produce them. So, they were teaching medicine, mathematics, and astronomy, which were highly developped by the 16th century.

We come across some statements in the Ottoman books, with complaints about the theoretical aspects of this science, and with critiques about its inactivity or its lack of sophistication. Some of these statements come from the fact that, in the old days, emphasis is only given to the theoretical aspect, whereas the Europeans are doing science both with theoretical and practical aims. When the systematic introduction (or transfer) of science from Europe to Ottoman Turkey started in the 18th and 19th centuries, one could not speak of a nation-state and colonial power, in the case of Ottoman Turkey and of Mehmed

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Ali Pasha's Egypt. Mehmed Ali himself was the ruler of Egypt. He was trying to establish his authority, and Egypt was not under colonial occupation, as were India and other countries. He had a kind of autonomous status within the framework of the Ottoman Empire, though he felt the challenge of European powers, and reacted to it. We have to distinguish between cases like Ottoman Turkey, Ottoman Egypt, and British India.

V. V. KRISHNA

The reality of the Colonial science in India can be understood from the experience of the integration of Western science, within the Indian culture and tradition. There was a vast infrastructure of colonial science organizations and, from the late 19th century onwards; there were groups of scientists in physiology, chemistry and physics. But these groups had no kind of intellectual cooperation with scientific organizations like those for geological, meteorological or botanical surveys. They did interact with the metropolis outside India. It is problematic to talk about integration at that level: for integration, some collaboration is needed and some kind of institutional linkages should take place. This was not the case. Unless, or until, some comparative case studies are made, for example about British colonial expansion in Asia and Africa, French expansion in Africa, and Spanish expansion in Latin America, it would be difficult to use such problematics. More comparative studies after the 19th century, up to at least 1920s and '30s, are needed for answering such a question.

IYANAGA Shokichi (Chairman)

Another aspect is now to be investigated about the nation-states. Besides the model of nation-state and colonial power, one should study the presence (or absence) of philosophical or conceptual differences in the basis of the old and the coming traditions. It might help to better understand the relation between the coming and the existing science.

NAKAYAMA Shigeru

When the French Jesuits' influence came to China in the 17th or 18th centuries, Chinese astronomers never changed their own paradigm, but just tried to borrow the Western astronomy simply as data for information. They never thought of getting interested in the planetary promotion since they had a paradigm for their own astronomy. So these two were never integrated, but coexisted side by side and were happy not being integrated.

In the case of contemporary Japanese science, more than 50% of Japanese science is not yet integrated. That means that, in the exact sciences (mathematics and theoretical), most people try to write their works in English, but still just think and discuss physics in Japanese. In a way, they are bilingual. In the case of exact sciences, 80% of their work may be in English, 50% for chemistry, and may be 10% to 20% in geology. I am a rather exceptional English writer among the history of science community in Japan, and maybe 10% of my writing is in English. They write for Japanese colleagues, and their reference bodies are always Japanese. This sort of tradition has already been going on for the last 50 years. They have their own paradigm, and the Japanese read English which is the most common Western language; they can borrow the data, even the paradigms too. But Japanese have their own way of evaluation and that aspect can never be integrated into it. Some new paradigm will emerge out of that. But in History, when Greek science moved to the Islamic world, what happened there? Perhaps it might also have happened; and again from the Islamic world to the Latin world. What happens when the centre of scientific activity moves from one place to another? Perhaps in the early part of Islamic science there might have been local peripheral paradigm of Islamic science in chemistry, or something else. To study how paradigms can come from the periphery to the centre is mostly a social programme rather than an intellectual programme.

Ekmeleddin IHSANOGLU

In the Islamic world, there are one or two parallels to be drawn; and such a comparative study brings new elements to the discussion. Pr. Nakayama drew a parallel between the Islamic world as a receptor of the Greek, and then as a donor to the Latin world. Different periods should be compared. When Muslims first came in contact with the sciences of their predecessors, the result was a brilliant scientific activity, and a strong scientific tradition, which then went to the Latin world. But when the Muslim world had a similar experience with the new European Western science which they tried to transfer (and to translate), it was unsuccessful. In the 2nd and 3rd centuries of Islam there are examples of a great Islamic scientific tradition in mathematics and astronomy. But in the 18th and 19th centuries, when the Muslims were again trying to learn a new science which they did not have, it was unsuccessful. Why were theye successful in integrating Greek science and Indian science, and why were they not as successful in integrating European science?

Roshdi RASHED

Concerning Pr. Ihsanoglu's question, some remarks should be made about this parallel between the passage (the word "introduction" is irrelevant) from Greek to Arabic, and the modern period. A unique term, "transfer", cannot be used for both phenomena whose differences could be very significant.

The first science, called Greek science, was in the same land, and with the same people; they only changed religion, and some of them changed its language. At the same time, they knew Syriac, Greek and Arabic. Then a kind of religious and cultural conversion took place, but not from a scientific point of view. The second important difference is the fact that translation did not precede research. In the most important cases, research precedes translation:

** For instance, before translating the *Arithmetica* of Diophante, there was a lot of research on indeterminate analysis;

** Again, before translating all the books about burning mirrors in optics, there was already research on this subject. For this research, they translated the Greek and the Byzantine books.

This point needs to be clear, in order to understand the phenomenal development of science in the 9th, 10th and 11th centuries. There is an accelerated formation in Arabic itself of a new scientific language. Then the problem is completely different.

It is possible to go further, even with a schematic analysis: the society which is militarily and economically the most powerful - even at the mere mercantilist level - can be expected to push further than the others from the scientific point of view. The meaning of transfer in the 19th century procedes from a dominated point of view. The science is not on the place, it comes from outside. Translation is the way to gain this science.

The problem of language has not been discussed yet, and has to be solved: in the modern period, research has **NOT** preceded translation, which was made in order to assimilate the technical and industrial procedures, even more than science. In the 19th century, societies were not looking for science. First, they were looking for a strong army; second, for industry; and then for health and agriculture. Science really just came along as a sub-product, and it was not actual research or theoretical science.

This is a completely different point of view: two terms have to be used, and "transfer" cannot be used both in the case of the 9th and 10th centuries, AND in the case of the 19th century. In this last period, one could call it a "trial transfer", which is not really achieved, or only more or less achieved; and in this sense, one could speak of "disintegration," not of "integration". Some colleagues use the word "appropriation", which is a very strong term. Appropriation means that you can produce people who can produce science. In India itself, where there is a scientific tradition, one cannot speak of the tradition of the Indian school in physics, separately from, for instance, the English or French schools of physics at the turning of the 20th century, including the conflicts between these traditions. There is no such kind of Indian tradition yet.

Another important point to stress is the language problem, the domination of one single language. It is very curious that, in every period of history, only one language is dominant. It was Arabic; then it became French; now it is English. Furthermore, the problem of social sciences has not been discussed. "Science" has been taken as "exact sciences". But social sciences are a very particular and very important problem, with connections to ideologies (national ideology, modernist ideology, etc). The integration of science is surely connected, in one way or another, with social sciences, or rather with the Humanities. Archeology, which is not a social science, was very important in the national consciousness in certain countries, and in the nationalist movement, for instance in Egypt, in India, in Mexico, etc. History and similar disciplines were also important and worth discussing in another debate.

Anne Marie MOULIN

The Ottomans did not miss science, even if they mainly favoured technology. They thought that they already had science. They had the Islamic tradition and were probably concerned by the fact that the adoption of foreign knowledge would impair their identity. One should analyse also the fact that, in the case of Turkey, modern science really came with secularization.

Ekmeleddin IHSANOGLU

The Ottomans had their own tradition of science, with their institutions, even until the middle of the 19th century. But they did not miss European science, and they understood it. Their attitude towards it was selective in the earlier stages, during the 15th and 16th centuries; and then, from the 17th to the 19th century, there was extensive access or orientation towards this science at different levels. They had their own understanding, and they preferred certain things. They did not see the scientific activities taking place and taking shape in Europe in its generality, its wholeness, its integrity, and they emphasized one aspect. Whether this science came with secularization depends on what is called "science"; there were translations and transfers, and attempts to build institutions, teaching, etc, from rather early centuries, whereas we tend to consider that secularization starts with the *Tanzimat* period (1839). There were things before that, despite the fact that the transformation of the *Tanzimat* period changed the pattern of the state, the pattern of the objective of the state, and also the emphasis of the state on service and their more Western ways.

As science or building institutions themselves are concerned, there is a quantitative change, but there is no qualitative change with respect to built-up science through its research, its teaching, on a high level. When studying, for instance, the first attempt to build the *Dârü'l fünûn,* the house of sciences, as a university, in the 1840s, and the second attempt in the 1860s-1870s, no change appears in their attitude towards European science. It is on the same pattern: continuing the utilitarian, practical and pragmatic aspects of European science.

IYANAGA Shokichi, *Japanese Academy of Science, Tokyo*
Roshdi RASHED, *Centre National de la Recherche Scientifique (REHSEIS), Paris*
Ekmeleddin IHSANOGLU, *Research Center for Islamic History, Art and Culture (IRCICA), Istanbul*
V. V. KRISHNA, *National Institute of Science, Technology and Development Studies, New Delhi*
NAKAYAMA Shigeru, *Kanagawa University*
Anne Marie MOULIN, *Centre National de la Recherche Scientifique et Institut National pour la Santé et la Recherche Médicale (U138), Paris*

Asian Countries

WESTERN MATHEMATICS IN CHINA, SEVENTEENTH CENTURY AND NINETEENTH CENTURY

Catherine JAMI

Historians of Chinese science have proposed that the introduction of Western[1] mathematics into China took place in two waves[2]. Both of these waves may be regarded as side effects of European expansion. The first introduction of Western mathematics was due to Jesuit missionaries who entered China at the end of the 16th century and stayed there for two centuries. The second introduction took place in the second half of the 19th century, after the Opium War (1839-1842); it initiated the process of alignment of Chinese mathematical practice on Western disciplinary standards.

The purpose of this paper is to compare several aspects of these two periods: the motivations of both sides; the means of transmission of science; the institutional framework in which this transmission took place; its reception among Chinese scholars; and how the new knowledge stood in relation to previous mathematical traditions. In order to assess what was at stake in these importations of mathematical knowledge, I will give a general outline of these two waves and point to some similarities and contrasts between them.

The Jesuits

It is usually considered that at the time of the arrival of the first Jesuit missionaries, Chinese science in general and mathematics in particular were in a state of decline: the great achievements of 13th century algebrists had fallen into oblivion[3]. However, from the turn of the 17th century on there was a significant renewal of interest in "concrete studies" *(shixue)* among scholars[4]. The Jesuit missionaries who came to China at the end of the 16th century sought to arouse scholars' interest in the Christian religion by introducing some elements of European scientific knowledge, mainly in astronomy and

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mathematics[5]. Their aim was to be introduced at court and convert the emperor (the conversion of Constantine and the evangelization of the Roman empire were explicitly taken as a model). Their strategy was to illustrate the excellence of the Christian religion by the scientific and technical achievements of its representatives.

For their first Chinese protectors and converts, admiration for the Jesuits' scientific knowledge went together with the adoption of the Christian faith[6]. It was these converts who collaborated with the Jesuits in the translation of scientific works published at the beginning of the 17th century. The method of translation then employed was used again in the 19th century: the missionary gave an oral translation of the text, which the Chinese scholar then transcribed in classical Chinese. The translation that has attracted most attention, both among Chinese scholars of the time and among historians, is that of the first six books of Euclid's *Elements of Geometry* (1607), from Clavius' Latin version (1574), under the title[7] *Jihe Yuanben.* It was done by Matteo Ricci (1552-1610), the founder of the mission, and Xu Guangqi (1665-1633), the most famous of the Chinese converts. It is indeed very tempting to make a symbol of this translation, given that the *Elements of Geometry* were a founding text of the Western tradition. But it was rather as a book of the Renaissance and as a Jesuit textbook that it came to China: Matteo Ricci had studied with Clavius in Rome; and Clavius' works were the source of some of the first mathematical works published by the Jesuits in China. A century later, Euclid's *Elements,* which had aroused much interest and criticism among Chinese scholars, was supplanted by another book of *Elements,* written by the French Jesuit Pardiès (1671) and used as a textbook in the Jesuit colleges in France[8].

Ricci's collaborator in the translation of the *Elements,* Xu Guangqi, was a high official of the Ming court. Around 1630 he introduced the Jesuits into the Imperial Board of Astronomy to reform the Chinese calendar (which was indeed in bad need of revision[9]); they did this according to Tycho Brahe's astronomical system. In China, calendrical astronomy had always been loaded with heavy political and symbolic significance: the Board of Astronomy was subordinated to the Board of Rites. From that time on, the Jesuits were increasingly in contact with civil servants who were professional astronomers and people around the emperor, and less associated with scholars who took a "private" interest in scientific matters. They became court savants in the emperor's service. Kangxi (1662-1722), the second emperor of the Manchu dynasty (1644-1911), had a high regard for Western science and took lessons with the Jesuits; he acted as patron and arbiter of scientific knowledge[10]. It was during his reign that the French king Louis XIV attempted to break the Portuguese monopoly on the sponsorship of the Jesuit missions in the Far East[11] by sending some French Jesuits as his envoys to the Emperor with the title of "the King's Mathematicians". They were correspondents of the French *Académie Royale des Sciences* and the innovations that they tried to introduce at the Chinese court were often based on works of French Academicians. This was a source of conflict among the Jesuits of China, perceived as opposing to "French science" the scientific practice of "Portuguese" Jesuits working at the Board of Astronomy[12].

The elements of mathematics introduced into China by the Jesuits in the 17th century were mostly those necessary for the computation of the calendar according to Tycho Brahe's model[13]. These elements belong to the fields of Euclidian geometry, practical geometry, written arithmetic, and plane and spherical trigonometry. On the whole, the mathematics then spread among Chinese scholars is more reminiscent of the Renaissance than of the 17th and 18th centuries: it ignored Viète and Descartes, to say nothing about Newton and Leibniz (although the latter was very much interested in China and was in correspondence with one of the French Jesuits[14]).

The success of the scientific knowledge introduced by the Jesuits among Chinese scholars was mainly due to the latter's renewed interest in "concrete studies" *(shixue)* at the time: "Western studies" and their applications (excluding religious writings) dealt with disciplines in which more and more Chinese scholars specialized, such as mathematics, astronomy and geography. This change in Chinese scholarship was one aspect of the criticism of Neo-Confucianism that prevailed at the time. Scholars claimed that their aim was to return to "genuine Confucianism", and to its emphasis on the social concerns apparent in ancient Chinese texts[15]. Thus it was the social usefulness of mathematics and of its applications that justified its study. This argument was put forward by Ricci in his preface to the translation of Euclid's *Elements.* He mentioned the usefulness of mathematics for (among other things) state management and military art, trade and astronomy, the latter in turn being of use to agriculture and medicine[16]. This was akin to the justification of the study of mathematics (including both local and imported elements) put forward by Chinese scholars of the time[17] and fell within preoccupations that are recurrent in Chinese history. It is worth noting that Chinese scholars discriminated between what they found interesting and useful (scientific and technical writings) and what they considered dangerous as a potential factor of social disorder (religious writings) among the Jesuits' Chinese writings[18]. Chinese scholars were interested in European mathematics because it was relevant to fields of study that were considered important according to criteria pertaining to Chinese intellectual tradition.

Chinese scholars of the time looked for a language common to Chinese tradition and Western contributions in the field of mathematics. This led them to the rediscovery of their own mathematical tradition. The famous mathematician and astronomer Mei Wending (1633-1721)[19] who was one of the initiators of the rediscovery of the Chinese mathematical tradition also was one of the first advocates of the thesis of the Chinese origin of Western knowledge *(Xi xue Zhong yuan),* which played an important role in mathematics. This thesis was not merely a chauvinistic reaction; it legitimated Western science by rooting it in Chinese antiquity. Its study was thus made part of the return to original Confucianism. The Kangxi emperor himself supported this idea. It was important for the Manchu emperor to appear as the champion of Chinese orthodoxy, and not as the upholder of "Barbarian" knowledge[20]. Kangxi, a keen student of Western mathematics and astronomy, set up new institutions and encouraged the appropriation of European scientific knowledge by Chinese scholars. It was during his reign that they started developing a creative mathematical activity, which can be characterized as a synthesis between Western knowledge and the local tradition; this activity was continued until the 19th century. At the same time the proscription of the Jesuits by the Chinese emperor in 1723 put an end to any significant Western innovation in mathematics until the middle of the 19th century.

The limits of this first transmission of European scientific knowledge in China are often emphasized, the blame being laid either on the Jesuits for not having said enough, or on Chinese scholars for not having understood the "essence" of Western science[21]. However it seems that the most important limiting factor was institutional. Chinese intellectual life of the 17th and 18th centuries was not centered at the Peking court but in the Lower Yangtze academies[22]. When they were introduced at court, the Jesuits gave up direct dialogue with the scholars that were active in the academic community, and who were less dependent on ritual and imperial sanction than court savants. However, the academics did study Western mathematics, and applied them to various fields that were of importance in the intellectual issues of the time[23].

The analysis of this transmission of Western science to China as a failure relies on the implicit assumption that what China then needed or should then have been inclined to achieve was the reproduction of the European pattern of scientific development. This assumption, which is questionable, actually stems from the interpretation of 19th century history in terms of the Chinese incapacity to face Western intrusion for lack of appropriate military technology.

The Colonial Powers

When the second wave of translation of mathematical books occurred in the later half of the 19th century, the balance of power between China and the countries from which science was imported had changed drastically. Moreover the internal situation of the Chinese empire had severely deteriorated. The Taiping rebellion (1850-1864), both a symptom of the dynastic crisis and a factor of aggravation of this crisis, had caused at least 30 million deaths and much destruction. In particular it sounded the knell of the network of academies of the Lower Yangzi area[24].

One of the first texts published then was a continuation of Ricci and Xu Guangqi's translation of Euclid's *Elements*. The remaining books, published in 1859, were translated from English by the protestant missionary Alexander Wylie (1815-1887) and the Chinese mathematician Li Shanlan (1811-1882), under the patronage of Zeng Guofan (1811-1872), the main architect of the suppression of the Taiping rebellion[25]. This translation clearly referred to the knowledge introduced in the 17th century. It opened a new era of introduction of Western mathematical works.

In the following years the translation of European and American scientific and technical works was undertaken on a much larger scale than two centuries earlier. Once again it was missionaries who together with Chinese scholars initiated the first translations. Most of these missionaries were protestants (often British); the first of them entered China following the first Opium War (1839-1842). The works they translated were often English textbooks; a number of articles of the *Encyclopedia Britannica* also served as sources for short treatises on subjects such as algebra, calculus and probability, which were new in China. These works were not systematically selected among the whole mathematical production in European languages: they were usually the books, primarily in English, that happened to come into the missionaries' possession.

Most of the Chinese institutions in which this mathematical knowledge was taught and applied were created especially for that purpose. The motive behind the acquisition of that knowledge was quite different from the issue of Western studies at the time of the Jesuits. The Chinese needed to master Western science in order to defend themselves against aggressive Western Barbarians. The core of this science was military technology. The need to train savants and engineers capable, for example, of building warships, became more and more obvious to many scholars following the defeats suffered from the Opium War on. The debate then focused on how to spread the necessary knowledge, and on how far Western science could be adopted without threatening Chinese civilisation. The creation of specialized institutions was suggested very early, and they were progressively implemented. Thus Feng Guifen (1809-1874), one of the first advocates of "self-strengthening"[26] *(ziqiang)*, wrote:[27]

> "If today we wish to select and use Western knowledge, we should establish official translation offices at Canton and Shanghai. Brilliant students up to 15 years of age should be selected from these areas to live and study in these schools on double rations. Westerners should be invited to teach them the spoken and written languages of the various nations and famous Chinese teachers should also be engaged to teach them classics, history and other subjects. At the same time they should learn mathematics (Note: all Western knowledge is derived from mathematics. Every Westerner of 10 years of age or more studies mathematics. If we now wish to adopt Western knowledge, naturally we cannot but learn mathematics ...)".

This program of study was remarkably syncretic. Feng Guifen also argued that people competent in technical fields should be given the same titles and offices as those who succeeded in the traditional examination system. It was their technical competence that was vital for the defence of China, rather than knowledge of the classics and mastery of the "eight-legged essay" which were the key to official appointments[28]. This was a serious challenge to the bureaucracy, since it meant changing the content of the knowledge that legitimized their power. The response to this threat was to point to the adoption of Western science itself as the main danger for the foundation of Chinese civilization and Confucian morality. But it was also argued that coexistence between this morality and Western knowledge was possible, keeping a strict hierarchy between the two: this was epitomized by the slogan "Chinese learning for the base, Western studies for use" *(Zhong xue wei ti, Xi xue wei yong)* which Feng Guifen anticipated[29].

Despite the strong opposition of some scholars and bureaucrats, a few schools were created. In 1866, a mathematics department was added to the *Tongwenguan* (College of Interpreters), created in 1862 in Peking, which was attached to the *Zongli Yamen* (Bureau of Foreign Affairs, created in 1861)[30]. This institutional affiliation reflects the fact that mathematics and its applications were needed for reasons that had to do with foreign affairs. Later, mathematics was taught in military academies in Shanghai, Canton and Fuzhou; this teaching was always connected to that of foreign languages. In 1887 mathematics was introduced into the examination system[31].

Mathematics taught in these institutions mainly relied on recent translations. In some of the first colleges *the Nine Chapters on the Mathematical Art, Jiu zhang suan shu,* (1st century A. D., the Chinese mathematical classic[32] *par excellence)* were still taught. But by the turn of the 20th century this classic was abandoned; Euclid's *Elements* (that had played a central role in Chinese mathematics for two centuries) were hardly more favoured. On the whole the mathematics that had prevailed up to the middle of the 19th century, which was perceived as pertaining to Chinese scholarship, was replaced by "modern" mathematics that was more adapted to the main technological applications for which mathematics was then needed.

Similarities and Contrasts Between the Two Periods

The two waves of introduction of European mathematics present both striking similarities and contrasts. First, although China never was colonized in the strict sense, both waves were linked to European colonial expansion. The development of Jesuit missions in East Asia from the 16th century on relied on the Portuguese overseas expansion: the Jesuits who went to East Asia called at Goa on their way; Macao was their gateway to China where they prepared for their entry to China by learning Chinese and improving their knowledge of the sciences. The king of Portugal was the patron of all the Chinese missions. In the nineteenth century Britain was the leading colonial power in the opening of China to international trade. The books translated into Chinese reflect Jesuit teaching in the first case (including that of the University of Coimbra, but also that of other Jesuit colleges and universities of Europe[33]); in the second case, they were mostly British (and sometimes American) textbooks.

Another similarity between the two periods is that in both cases the missionaries' role was crucial in making Western mathematical knowledge available in Chinese. To these missionaries science and religion were the ways to salvation and progress, the benefits of which they sought to bestow upon China. On the other hand if the Chinese needed these intermediaries, it was because they did not see the point of learning foreign languages until compelled to do so. When they finally did, it was out of political necessity, not out of scientific curiosity[34].

In 17th century China, the interest in Western mathematics was linked to the renewal of "concrete studies"; the main application of mathematics was to astronomy. This interest was then legitimated by the claim that this knowledge belonged to Chinese tradition. The framework of reception was determined by the internal dynamics of Chinese history. Western mathematics was interesting for its content, in other words because it was mathematics. The slogan "Chinese learning for the base, Western studies for use" then went without saying: Western studies did not appear as a threat to Chinese learning, but as part of it. When the slogan was stated in the 19th century, it was crucial to make it explicit that the foundations of learning lay in the Confucian tradition. This became even truer as Confucian learning was threatened as a source of legitimacy of power, because of the need to appropriate Western knowledge. By then the interest in Western mathematics was linked to the "self-strengthening" movement: the Chinese were compelled to study it in order to turn the Westerners' weapons against them. Western mathematics was then included in the learning of imported technology because it was regarded as a key to military power. This learning was linked to Western intrusion, not to "internal" Chinese factors. Western mathematics was vital because it was Western. It was regarded as part of a corpus of knowledge that was essentially foreign. At the same time, the Chinese mathematical tradition was depreciated and gradually abandoned, being regarded as one of the causes of Chinese military inferiority. This marked the end of a specific mathematical tradition in China, in contrast with the first wave of introduction of Western mathematics which had nurtured and renewed this tradition.

Centre National de la Recherche Scientifique (REHSEIS), Paris

Notes

[1] The term "Western" used in this paper corresponds to the Chinese category of *Xixue*, "Western learning", a term that was used from the 17th century on to refer to all the knowledge brought in by the Europeans.

[2] Li Yan and Du Shiran, *Chinese Mathematics. A Concise History.* Oxford, Clarendon Press, 1988; p.190-266; Wang Ping, *Xifan lisuanxue zhi shuru* (The Introduction of Western Mathematics and Astronomy). Taipei, 1966.

[3] On 13th century mathematics, cf. Li and Du, *op. cit.*, p.109-174.

[4] Concrete studies *(shixue)* were opposed to the emphasis on self-cultivation that prevailed in Neo-Confucianism. They included fields such as mathematics, astronomy, water control and land reclamation. Up to then such "technical fields" were hardly regarded as suitable concerns for a scholar. Cf Benjamin A. Elman, *From Philosophy to Philology. Intellectual and Social Aspects of Change in Late Imperial China.* Cambridge, Mass., Harvard University Press, 1984, p.46.

[5] Jacques Gernet, *Chine et christianisme. Action et réaction.* Paris, Gallimard, 1982; p.32-35.

[6] Two of the most famous converts, Xu Guangqi and Li Zhizao, contributed to the translations of mathematical works. Li an Du, *op. cit.*, p.191-201.

[7] Pasquale D'Elia, "Presentazione della prima traduzione cinese di Euclide", *Monumenta Serica* XV-1: 161-202 (1956).

[8] A Chinese adaptation of I.G. Pardiès' *Elémens de Géométrie* (Paris, 1671) was published in 1723 in the famous imperial mathematical encyclopedia *Yu zhi shu li jing yun* (Imperially commissioned collected basic principles of mathematics). Li and Du, *op. cit.*, p.219.

[9] There had already been several attempts to reform it in the late Ming; Willard Peterson, "Calendar Reform Prior to the Arrival of Missionaries at Ming Court", *Ming Studies* 21: 45-61 (1986).

[10] Rita H. Peng, "The Kangxi Emperor's Absorption in Western Mathematics and Astronomy and His Extensive Application of Scientific Knowledge", *Lishih Hsüehpao* 3: 349-422 (1975).

[11] This Portuguese monopoly was a consequence of the treaty of Tordesillas (1494) between Spain and Portugal which divided the world in two zones, the East being allotted to the Portuguese.

[12] Catherine Jami, "The French Mission and Verbiest's Scientific Legacy", forthcoming in *Proceedings of the Ferdinand Verbiest Conference*, Louvain, 1988.

[13] Henri Bernard-Maître, "Les adaptations chinoises d'ouvrages européens: bibliographie chronologique", *Monumenta Serica* X: 1-57 et 309-388 (1945) et XXV: 349-383 (1960).

[14] Etiemble, *L'Europe chinoise.* Paris, Gallimard, 1988-89 (2 vol); **vol.1,** p.370-436.

[15] Elman, *op. cit.*

[16] D'Elia, *op. cit.*, p.179-185.

[17] Catherine Jami "Learning the Mathematical Sciences in the Early and Mid-Ch'ing" in *Education and Society in Late Imperial China*, B. Elman and A. Woodside eds, forthcoming, University of California Press.

[18] Gernet, *op. cit.*, p.85.

[19] Li and Du, *op. cit.*, p.212-216.

[20] Lawrence Kessler, *K'ang-hsi and the Consolidation of Ch'ing Rule. 1661-1684.* Chicago, Chicago University Press, 1976; pp 137-166.

[21] Joseph Needham, *Science and Civilisation in China.* Cambridge, Cambridge University Press, 1954-, 7 vol.; **vol.III,** p.442-447; Jean-Claude Martzloff, *Histoire des mathématiques chinoises.* Paris, Masson, 1987; p.100-108.

[22] Elman, *op. cit.*, p.7-13

[23] For an example of problems of chronology raised by the development of rigorous methods in history and philology, which was the main trend of Chinese scholarship at the time, see, Elman, *op. cit.*
[24] Frederic Wakeman, *The Fall of Imperial China.* New York, The Free Press, 1975; p.143-156.
[25] Li and Du, *op. cit.*, p.257.
[26] On the theory of self-strengthening, cf. Ssu-yü Teng and John K. Fairbank, *China's Response to the West. A Documentary Survey.* Cambridge, Mass., Harvard University Press, 1954; 2nd ed. 1979; p.46-59.
[27] Teng and Fairbank, *op. cit.*, p.51. This was written in 1860.
[28] Teng and Fairbank, *op. cit.*, p.52.
[29] This was the slogan of the Chinese reformers of the last decade of the 19th century. Ssu-yü Teng and John K. Fairbank, *op. cit.*, p.169.
[30] Li Shanlan, the translator of the last books of Euclid's *Elements,* was the first Chinese to teach mathematics there.
[31] Frank J. Swetz, "The Introduction of Mathematics in Higher Education in China, 1857-1887", *Historia Mathematica* 1: 167-179 (1974).
[32] Li and Du *op. cit.*, p.33-56.
[33] Ricci and other Italian Jesuits transmitted the teaching of the Collegium Romanum, where Clavius' influence had been predominant.
[34] This was in strong contrast to the Japanese situation: the first Japanese interested in Western medicine in the 18th century learned Dutch and made adaptations of Western works themselves. cf. Donald Keene, *The Japanese Discovery of Europe. 1720-1830.* Stanford, Stanford University Press, 1969; p.17-30.

THE RECEPTION OF WESTERN MEDICINE IN CHINA: EXAMPLES FROM YUNNAN

Elisabeth HSÜ

Introduction

Much has been written on the European and later mainly American activities that introduced Western medicine into China[1]. How this foreign practice was perceived and eventually accepted by the Chinese and how these forms of knowledge, grounded in Western science, were transformed by folk belief and practices of traditional professionals, is only mentioned briefly in the available literature. Chinese were probably not interested pointing out how Western medicine was modified, because they wished to stress progress and possibly foreign advocates of development were likewise not inclined to draw attention to the adulteration of cosmopolitan medicine with local practice.

This paper focuses on the perception and integration of the foreign medicine into the existing body of traditional knowledge by presenting snap-shots from Yunnan province in Southwest China. They were taken during three different periods of modern Chinese history: the period of colonial dominance at the end of the Qing dynasty (1840-1911), the nationalist Republican Period (1911-1949) and the period of the socialist PRC, People's Republic of China (after 1949). For reporting on "first encounters" with Western medicine in the first section, passages of missionaries' diaries and surveys after the Communist revolution give valuable, though biased information. The research of the anthropologist F. L. K. Hsü[2] has been summarized in the second section, and in the third my own observations are presented which were made during fieldwork in Kunming 1988/89.

China was never completely colonized, therefore missionaries remained the main vector of transmission. The missionaries were a most heterogeneous group of individuals. All they had in common was the backing through the foreigners' overwhelming military, economic and political power. Due to military interventions (1839-42; 1856-60), concessions from the imperial court were obtained which allowed for the penetration of China's hinterland and the propagation of the Christian religion[3]. Catholic missionaries had been establishing the church in China's mainland long before official sanctioning, but Western medicine was disseminated throughout China mainly by the Protestants[4]. For

P. Petitjean et al. (eds.), Science and Empires, 89–101.

the Protestants, as for the Jesuits of the Peking mission in the 17th century, conversion could also be achieved by means other than preaching[5] : the tools of Protestant conversion which endured in modern China, ironically only after secularization, were institutions of higher education and Western medicine[6].

The Protestant home churches were from the very start critical of missionaries engaging in anything other than pastoral work. They often refused to finance supplementary expenditures for educational or medical enterprises as they saw the duties of teachers and doctors as limiting their time for being good evangelists[7]. The more progressive went as far as to suggest a division of labour between pastor and doctor[8]. Only at the end of the century was medical aid accepted as a principal missionary strategy in addition to the five standard ones set up by Ziegenbalg in 1706. It is noteworthy that the medical mission was more successful in China than in India; possibly the Han-Chinese were more responsive to the Protestants' zeal of individual salvation[9].

Yunnan province was, as its Chinese name "south of the clouds" suggests, remote from the imperial court and almost inaccessible to the colonialists on the coast, but close to the French in Vietnam and the British in Burma who showed much interest in the "five treasures" *(wu bao)* of the province, the gold, silver, copper, lead and zinc mines[10]. In the middle of the 19th century the province was however in upheaval: while the Taiping revolt raged in the lower Yangzi basin (1850-64) and Miao people struggled in Guizhou (1855-72), the Muslims revolted in Yunnan (1856-73). The weak and corrupt dynasty was at its centre supported by the British who helped to crush the Taiping revolt. At its borders, however, in Yunnan, the Muslims found support in the British who were particularly interested in this region between India and the Yangzi for geopolitical reason. After the Sino-French war (1883-85), the court was obliged to recognize the treaty of 1874 which had made the tributary state of Annam (Vietnam) a French protectorate. Burma was annexed by the British in the same year, 1885. When the Russians, Germans and British got their share of China in 1897, the French established a sphere of influence in Eastern Guangdong, Guangxi and Yunnan[11]. In 1895 the French were given a concession for extending the Annam-Railway to Yunnan and in 1897 the British were given the same for the Burma-Railway[12].

With the building of the French railway, completed in 1910, Yunnan was taken out of its inland isolation and further removed from imperial control. It was during that period that vaccination started to be promoted by consular administration. In order to prevent the spread of epidemics into the Tonkin protectorate, the French military had earlier organized vaccination of the population in the border areas of southern Yunnan[13]. Schools and hospitals as well as mail services were increasingly established with the explicitly stated goal of reinforcing the French influence in Yunnan[14]. Growing nationalism in the 1920's, however, the retreat of the Guomindang into the Southwest after the Japanese invasion (1937-45) and Communist control since 1950 have reinforced its bonds with the Chinese state.

Snap-Shots of "First Encounters" with Western Medicine

Western practices of hygiene and medicine may have appeared, first of all, just strange and exotic, as the following passage with reference to children suggests.

"The leader of this afternoon's party wants a piece of soap. Now a piece of soap means, of course, one for each and all, so I suggested that she might wash her hands with my soap and basin, both on the low shelf behind us. The desire to be clean is such a laudable one that we must not discourage it, must we? So she prepares to start in, but her hands being innocent of previous washings, she is a little in doubt of the *modus operandi,* and looks at me inquiringly. There is some lather in the soap-dish and I tell her to use that first, whereupon she scraps some up gingerly and spreads it on the back of her left hand - just as you would spread butter on a piece of bread. No, I tell her, she must *rub* it in, not just spread it on, so she tries again. However, it soon seems evident that a practical demonstration is necessary, so after washing my own hands to show her the approved method, she starts in again. She warms to her work this time, and washes both hands and face with rather more vigour, more splashing, and more blowing than I thought I had included in my demonstration. However, there is nothing like erring on the right side, is there?

Of course by this time all the others have discovered that the thing they desire more than anything else in the world is to wash *their* hands too. ... Of course, they all succeed in getting their sleeves wet up to the elbows, and part of their tunics and dresses too. Moreover, they do not seem as anxious to remove the soap from their hands and faces as they were to put it on. ... They finish their hand-washing, as you might guess, by spilling all the water on the floor - a touch of nature! But we will not blame them" (quoted in Taylor, 1944:200-201).

J. O. Fraser, a missionary of the China Inland Mission (1886-1938), wrote the above passage in a letter from his converts among the Lisu in Western Yunnan[15] to his prayer circle in England. The reason for citing it is not to maintain that the Lisu were unhygienic, but to show that at first encounter the meaning of this activity, developed on grounds of scientific discoveries in 19th century Europe, was not recognized by those children. They were curious towards the exotic of the white man and made out of it a game with its own rules.

The passage also throws light on the missionary's perception of the setting.

"He was eminently concerned with the souls of the Chinese and in many cases grew to love the Chinese as people. But this very concern and affection reinforced in him the driving urge to bring light and remove darkness. And this impelled him, almost of necessity, to adopt a critical and intolerant posture toward much of Chinese culture".

Fraser fits Cohen's description[16] of the missionary among the Chinese. He was loving while he felt superior, if only because he thought he was more knowledgeable.

As will be shown below, the attitudes between the intruders and the residents were not always as affectionate as presented above. In view of their unequal power relations, the interpretation of the foreigner's activities was prone to be marked by suspicion. The foreigner, his political power and his medicines were seen in close association.

S. Pollard (1866-1915) from the Wesleyan Methodist church used medicine for providing humanitarian aid on the one hand and generating converts on the other. He preached in the markets, in contrast to the Catholic priests; mostly near Zhaotong in the northeast of Yunnan (between 1887-1915). Unlike Fraser, who was *"in the first, second and third instance"* a preacher[17], he inclined to the missionary strategy of medical intervention during the crisis of an illness:[18] *"It came naturally to help"* and *"to care for the uncared"*, with the result that his therapeutic aid was often more sociomedical than medical. It is not co-incidental that the first "medical case" for which his aid was sought was a "social case", a woman who attempted suicide by consuming large doses of opium. His medicine was not what Western medicine is nowadays - *"a bottle of mustard, another of sulphate of zinc and a few feathers"*, but he managed to make her vomit and she recuperated[19].

Missionaries like Pollard dealt mainly with socio-medical problems which would presumably fall nowadays into the sector of primary health care. Traditionnally the gentry had undertaken welfare activities during epidemics, famines and floods; by providing relief work during such crises, the missionaries were challenging their position of prestige and power[20].

In Yunnan, opium was not only used for consumption by suicidal women, its cultivation for provincial export and the increasing number of addicts had far reaching socio-economic impacts. The poppy field thrust aside the rice paddy; only the well-to-do could eat rice, common people ate maize, and famines were frequent. Moreover, epidemics frequently swept across the province, even more after the severe Muslim uprisings in 1835-40 and 1856-73. On the basis of reports in various annals, 25300 deaths between 1772 and 1855 were attributed to *shuyi,* the plague, and almost three times as many, 73300 between 1856-1902[21].

Pollard became well known for his socio-medical interventions. While Fraser was only suspected of being a secret agent of British imperialism, Pollard was held in awe as a powerful medicine man. If he had good medicines, he also had bad ones; such rumours became more prevalent with his growing influence in and around Zhaotong, after mass conversions of Miao people.

The story goes that a small group of Miao had approached him and thereafter small groups of Miao came continuously from the hills to seek him in town[22]; eager to learn to read in the script Pollard had invented for them, as his biographer puts it[23].. Upon returning to their villages, many were tortured and put into jail. They were accused of learning black magic from a powerful medicine man and urged to hand over the drugs with which they were believed to poison the wells. Metaphorically speaking, the accusation made by the landlords of the Miao, who were themselves mostly sinicized Yi (Nosu) people, was probably correct. The mass conversions of the Miao were undermining existent power structures[24].

It was not only the Miao and Yi who attributed magical power to the foreigner and his practice of medicine. The Han Chinese also had suspicions that the foreigner practized black magic and rumours circulated that he was therefore hunting for *"hearts and eyes"*. There had been rumours, as early as during the 18th and possibly even the 17th century that Christians could make silver out of Chinese eyes by means of alchemy. Zhang Zhentao (1713-80) expressed the following suspicions:[25]

"When a Chinese convert was on the verge of death, the Catholic priest came and, covering the convert's head with a piece of cloth, pretended to pronounce the absolution. In reality, however, he secretly made off with the eyes of the dying man. These were then mixed with lead and mercury to create silver, ...".

Zhang offered this as partial explanation for the seemingly unlimited amounts of money which the catholics had and saw this as a motive for seducing the Chinese into Christianity. The suspicions about the foreigner gouging out eyes must have been reinforced by the widely practized cataract operations in missionary hospitals during the 19th century[26]. After photography had been invented, rumours started to circulate that Chinese eyes were used for producing photographs[27].

In Africa human blood was said to be used for improving the quality of copper coins[28], in South America human fat for fuelling airplanes[29]. The white man suspected "the other" to be a non-human who practiced cannibalism; likewise, he was viewed as "the other" and suspected of cannibalism. The fact that he was believed to make profits from his cannibalism may be understood as an expression of imperialist exploitation and accumulation of power in the colonized world.

Snap-Shots from the Nationalist Republican Period

Informal interviews during fieldwork in 1988-89, with about a dozen of aged inhabitants of Kunming threw some light on the situation of their youth before and during the Second World War. They indicated that Western medicine was practized in Kunming, by foreigners and Chinese doctors, but that it was generally ignored.

When talking about Western medical services they often referred to missionaries. This might indicate that during the time of the Republic missionaries offered more medical care in Kunming at the grass-roots level than the government did. The first hospitals had been built at the beginning of the 20th century, but they were in the first instance installed for professional groups; the first one, built by the French in 1901, was mainly for the French railway builders, the one installed in 1908 by the Qing court was for the military and in 1914 the head of police funded a third one for the police (installed in a temple)[30].

Few of the people I talked to remembered visits to the missionaries' clinics, except in cases of very specific diseases such as tuberculosis. They remembered that resorting to Western medicine had been too expensive and they were under the impression that only converts had been exempted from fees. Some remarks[31] even suggested that in certain families there was no such condition as *"sick enough even to try **papalangi** medicine"*. It seems that Western medicine was offered, but hardly used by the Chinese in Kunming.

In his thesis *Magic and Science in Western Yunnan,* (1943), F. L. K. Hsü came to similar conclusions after investigating how a community dealt with a cholera epidemic. He described the locality, Westtown, as a *"small village or town"* with a population of about 8000 people in 1000 households (p.3). It seems that, apart from a *"few native dispensaries"*, there were two major stations of Western medical health care in town. One was the *"infirmary of the missionary college"* with a foreign doctor in charge, an American surgeon who had graduated from the Harvard Medical School and who was a medical missionary of the American Episcopal church; the other was the government *"local hospital"* with a Chinese M.D. who had graduated in a provincial medical college and a nurse trained in the Peiping Union Medical College (p.29).

Once the first two cholera cases had been hospitalized, the missionary college authorities urged their students and faculty members to take anti-cholera injections[32], but the general populace took little notice of these precautions. After a certain delay, prayer meetings where Daoist and Buddhist adepts read scriptures and recited incantations were held at various localities, almost daily in town and in the surrounding villages. Their purpose was, as a priest explained: *"... to invoke the mercy of the superior deities who would require the Wen god (god of epidemics) to retract the Wen spirits which he had let loose earlier on"* (p.15).

These meetings were conscientiously attended and financed by the community members, but in contrast to the priest, most did not have a clear explanation for their actions. Some knew that they were expelling spirits while many simply commented that they were doing a good deed and that it had always been done in this way. Simultaneously, they resorted to other traditional methods for overcoming the epidemic, such as drinking "fairy water" *(fangshui?)*, taking additional drugs etc., with the result that some who had observed the varying efficacy of those drugs, came to the conclusion that survival was a matter of fate, and not of medical treatment.

The attitude of the community members as detailed above, suggests that there was little incentive to search for new measures to combat the epidemic. The government poster pleading for hygienic behaviour and assuring people of the absolute efficacy of the anti-cholera injections was one option among many others, with the disadvantage of being new and foreign, propagated by outsiders. Only few, mainly children and a very small number of women, took the injection and those who took it had also taken part in the prayer meetings. It was permissible to worship many gods and there was a saying *"the more, the better"*.

The Western doctors condemned the activities of the community as superstition (p.29) while their own precautions appeared just as nonsensical and superstitious to many Chinese[33]. Hsü was, nevertheless, convinced that eventually the modern injection would

"... in the minds of the local people, be ranked side by side with the prayer meeetings, the many native prescriptions, the food taboos etc. and that (it would) be carried out and received in the additional manner and not in that of the modern ways of science" (p.39).

Snap-Shots from the PRC

Tian (1987) claims that since the Communist revolution, cholera epidemics have not occurred in Yunnan province; the exception in 1964 was kept under control (no deaths). *Shuyi,* the plague, is said to have occurred for the last time in 1956, and malaria was allegedly also brought under control in the fifties. Western medicine, in combination with socialist control, is believed to have proved its efficacy. The foreigners were expelled in the fifties while the medicine they had earlier introduced to the country was promoted by the Chinese themselves. This certainly facilitated the acceptance of Western medicine which is nowadays widely practized and taught by the Chinese themselves. Speaking in friendly terms, hospitals are reasonably clean. The medical treatment has a Chinese touch but generally does not differ much from that in Western countries.

There are, however, a few examples of Western medical care in China where the foreign practice has been significantly modified by the matrix of folk belief and the practices of additional professionals into which it was implanted. In the rural areas and to a lesser extent in the cities, it is a widespread practice to give intravenous infusions of glucose to patients who suffer from complaints of general weakness and fatigue. A peasant, for instance, may go once or twice a week in the evening to the village hospital to receive an intravenous infusion and continue to work in the fields on subsequent days. A European who expects only to find patients with metabolic deficiencies or those in intensive care attached to a drip, is slightly surprised to see that intravenous infusions belong to the repertoire of outpatient health care in China.

The patient's condition is labelled *pi xu* and indicates weakness and fatigue, often associated with poor blood conditions. In literal translation it means *"emptiness of the spleen"*. As an expression of additional Chinese medicine it offers a standardized description of the patient's condition by referring to physiological processes in the body: the spleen *(pi)* is one of the five visceral organs *(wuzang)* located in the centre of them; the stomach *(wei)* is one of the six bowels *(liufu)* and functions as part of the digestive system. Spleen and stomach are closely allied to each other in an "inner-outer" relation *(biaoli guanxi)*. The ingestion of food is a function of the bowels, but the transformation of the nutrients into blood is controlled by the spleen. Just as the earth may be understood as the mother of life in the macrocosm, the spleen and blood nurtures the microcosm of the human body. The general well-being of a person depends very much on the condition of the spleen. General weakness and fatigue are symptoms, then, of insufficient nutrition. How clever to take the shortcut of nourishing the blood - not by oral intake, but by intravenous infusion!

A doctor at a hospital in Kunming city suffered from chronic stomach ulcers. In view of her occupational and domestic responsibilities there was little doubt that they were stress-induced. At the outpatient acupuncture clinic she was the right hand of the clinic director who treated 50 to 70 patients on every other day. She was in charge of an untrained group of students and responsible for an accurate record of the patients' treatment. She was also expected to have an ear for their complaints. At home, she was mother and housewife. She was completely overworked, had bags under her eyes and announced once in a while that she had found blood in her stool. The stomach ulcer had induced symptoms which were in terms of Chinese medicine typical for a *"deficient and cold spleen and stomach"* ***(pi wei xu han).*** To me, her health was in an alarming state and I urged her to ask for sick leave. She acknowledged my concern with a sad smile. She was not very explicit about her motives for continuing work, but her sparse comments indicated that the time of the iron rice bowl belonged to the past. In striving for the economic reform of the eighties, the acupuncture department had signed a contract with the hospital authorities which allowed for more self-determination but less social security *(chengbao).*

She used to be attached to the drip during lunch time. In response to my question why she preferred the drip to other therapies, she said: *"The drip has rapid effects". "Western medicine has rapid effects"* ***(xiyi liaoxiao kuai),*** I echoed, reminded of the widespread opinion about modern Western medicine. She nodded. The modern medicine is believed to effect rapid changes. It is ascribed the characteristics of technological inventions which speed up the pace of life. Since modern (Western) medicine and traditional (Chinese) medicine are both considered scientific, she was simultaneously taking Chinese medical drugs for invigorating the *"deficient spleen". "Western medicine cures the symptoms, but Chinese medicine cures the underlying cause of illness* ***(Xiyi zhi biao, zhongyi zhi ben):*** the above phrases[34] of folk belief about Western and Chinese medicine show that one admits the efficacy of modern science and technology without ascribing to it the capacity of solving the underlying problems. Intravenous infusions are of symptomatic use while the drug therapy is effective in the long-term because it focuses on the underlying "cause".

Nutritional aspects of well-being are central to Chinese culture. In Chinese medicine, for instance, the school based on principles of Li Dongyuan's *Discussion of the Spleen and Stomach (piweilun),* 1249 A. D., which stresses the spleen and its nutritional functions, has remained one of the most influential ones since its formation in the Song dynasty (960-1297). It may therefore not be astonishing to find practices of Western medicine modified in favour of nutritional considerations. For treating diarrhoea, for instance, all kinds of contradictory biomedical therapies have been in fashion in the West. A symptom like diarrhoea for which Western biomedicine does not provide standard treatments, is more susceptible to be treated by grandma's home recipe or, in China, to be modified by the principles of the additional medicine.

Almost every tourist in China experiences diarrhoea. A doctor of traditional Chinese medicine writes a recipe for him which consists of many different herbs; a doctor of Western medicine, prescriptions of many different kinds of pills. The tourist, somewhat perplexed, asks for an explanation. First, so he is told, there are sulfonamids - they kill off the bacteria. Then, other pills such as painkillers or antihelminthica may be added, according to the particular condition of the patient. Finally, vitamins are included, usually vitamin B and C. Vitamin B (B1 or B6), a doctor at Yunnan's first provincial hospital once explained, because it had neutralizing effects on the stomach; its main function was to restore the intestinal flora of bacteria. At other instances, *"vitamin B nurtures the nerves"* was the answer. *"Didn't you just say you felt quite weak and tired?"* This attention given to the condition of the patient in its entirety, suggests to be influenced by Chinese patterns of thought.

On closer inspection the prescription of these Western drugs seems to be guided by a principle of Chinese medicine: *"attack and build up simultaneously"* ***(gong-bu-lian-shi).*** Common knowledge of Western medicine is familiar with the idea of killing bacteria, but the emphasis on nurture is particular to the Western medical cure in China.

Summary

The examples presented above are snap-shots from different periods and various regions of Yunnan province. Exemplary as they are, they show different kinds of attitudes to the foreigner's medicine; whether they are exemplary for their historical period still needs further research. In other words, no claim to have described stages of a historical process is made, rather, important factors which modified a practice grounded in Western science, are highlighted.

In the 19th century, the missionaries who introduced the foreign medicine into Yunnan were all backed by colonialist power and wealth. The medical knowledge they brought was not always acknowledged for its therapeutic effects. Their hygienic habits were utterly strange and as the stranger, "the other", they were suspected of cannibalism. Frequently, the political power as an attribute to the person, was extended by attributing magical power to his medicines.

In Westtown of the 1940's, Western medicine had been practiced for several decades. It was, however, generally ignored during the cholera epidemic. Belief in traditional customs did not require it while belief in the government, the foreigner and Westernized Chinese did. *"It is too painful"*, the frequent excuse for refusing to take the anti-cholera injections, expressed distrust and appealed to one's own sovereignty. Factors which allowed for acceptance of the foreign practices may be found in the tolerance of worshipping many gods in Chinese society and the folk belief of *"the more, the better"*. During this period of nationalism, Western medicine was not recognized as a scientific, but as the foreigner's medicine.

In the People's Republic of the eighties, Western medicine is more widely practized and the belief in its efficacy is well-established in the cities. Chinese and Western medicine are both considered scientific; in contrast to the traditional Chinese medicine, modern Western medicine is ascribed the characteristics of modern technology and believed to cause rapid changes. The examples from the Western medical clinic concern reasoning on physiological processes and illustrate how the imported practice of medicine can be modified by indigenous patterns of thought.

Cambridge University

Notes

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[2] Hsü F. L. K., *Magic and Science in Western Yunnan*, Ph. D. thesis. London, 1943.

[3] Furthermore, the "Toleration Clause" in the treaty of Tianjin (1858) enabled Christian converts by implication to be exempted from Chinese jurisdiction.

[4] The Catholics prospered in Sichuan (Société des missions étrangères) with estimates of up to 40.000 Catholic converts in 1801 and 80.000 converts in 1870 (Latourette K. S., *A history of Christian Missions in China,* London, 1929). In the 1880's, Yunnan's Catholic community was said to comprise one bishop, eight French priests, and 9.000 converts (Clark G. W., *Kwiechow and Yunnan Provinces,* Shanghai, 1894; p.63). The Catholic missionary methods of the 19th century, however, were not as diverse and flexible as those of the Protestants and they did not expand as rapidly as the protestants did (Latourette K. S., *Christianity in a Revolutionary Age: a History of Christianity in the 19th and 20th Centuries,* **Vol.5,** New York, 1963).
[5] The mathematical and astronomical teachings of the Jesuits were a means for proving the existence of God as well as for encouraging conversion to Christianity. In 1692, the Emperor Kangxi (1662-1722) was cured by a Jesuit from malaria by application of cinchona bark, but the Jesuits'medical endeavours were not carried on; the breakthrough in modern medicine was still to occur in Europe. (Hume E. H. *Doctors Courageous,* New York,1950, p.218).
[6] Lutz G. W., *China and the Christian Colleges 1850-1950,* Ithaka and London, 1971.
[7] Lowe J., *Medical Missions, their Place and Power,* London, 1886.
[8] Lockhart W., *The Medical Missionary in China,* London, 1861.
[9] Lowe, *op. cit.,* 1886, p.121.
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[11] Fairbank J. K. and Liu K. C., *The Cambridge History of China, Late Ch'ing 1800-1911,* **Vol.11,** Part 2, Cambridge, 1980.
[12] *Comparative Chronology of Protestantism in Asia, 1792-1945,* By the Institute of Asian Cultural Studies, International Christian University, Tokyo, 1984.
[13] Marianne Bastid, personal communication during the conference. See also: "Variole et vaccin en Indochine", *Revue Indochinoise,* n°91-92, 1908, p.479-492.
[14] Doumer P., *Situation de l'Indochine 1897-1901,* Hanoi, 1902.
[15] The Lisu inhabit mountainous regions of Western Yunnan (ca. 0.5m pers.), Thailand and Burma.
[16] Cohen P. A., *China and Christianity.* The Missionary Movement and the Growth of Chinese Antiforeignism 1860-70, Cambridge Massachusetts, 1963, p.265.
[17] Taylor, *op. cit.,* 1944, p.228.
[18] Kendall R. E., *Beyond the Clouds,* Holborn Hall, 1948.
[19] Kendall, *op. cit.,* 1948, p.30.
[20] Cohen, *op. cit.,* 1963, p.84.
[21] Tian J. G., *Yunnan Yiyao Weisheng Jianshi,* Yunnan Keji Chubanshe, 1987, p.159.
[22] Clarke S. R., *Among the Tribes in Southwest China,* London 1910. 'Miao' refers to many related ethnic groups, mainly in and around Guizhou province (ca. 4m pers.).
[23] Kendall, *op. cit.,* 1948, p.48.
[24] Christians fell under Western jurisdiction (cf. introduction).
[25] Cohen, *op. cit.,* 1963, p.31.
[26] The first clinic in China was an eye clinic, P. Parker's ophthalmic clinic in Canton. The cataract operation is still nowadays a strategy for advertizing the benefits of Western medicine in virgin regions (e.g. job advertisement for Nepal of the International Red Cross in 1985).
[27] According to (Lutz 1971), eyes were allegedly used for the producing the silver salts for photography. To link organs of vision with the preservation of vision reminds of sympathetic magic.
[28] Owen Sichone, personal communication, February 1990. See also Gann L. H., *A History of Northern Rhodesia,* London, 1964; Banyama myth is labelled an "anti-colonial doctrine", p.231.

[29] Gilbert Lewis and Françoise Barbera-Friedman, personal communication, March 1990. See also: Taussig, M., *Shamanism, Colonialism and the Wild Man*, Chicago & London, 1986, p.238.
[30] Tian, *op. cit.*, 1987, p.116.
[31] Hsü, *op. cit.*, 1943, p.42; *Papalangi* medicine refers to the white man's medicine.
[32] R. Koch discovered vibrio cholerae in 1883. In 1943 the cholera toxin was still to be discovered (1947) and only in the 1960's were further factors causing diarrhoea better understood (Van Heyningen, W. E. and Seal, J. R., *Cholera: the American Scientific Experience 1947-80*, Boulder, 1983).
[33] "Les Européens rapidement alertés, prirent les précautions d'usage et surveillèrent de près leur personnel... : eau bouillante en permanence dans la cuisine, ordre d'échauder les bols, les assiettes, les couverts, défense de toucher les aliments, de servir ou de manger des crudités, lavage obligatoire des mains toutes les heures. Son cuisinier, ..., manifesta une répugnance invincible à se soumettre à ce traitement barbare. Il méprisait les manifestations facheuses des **superstitions étrangères...**" (Gervais A., *Aesculape en Chine*, Paris, 1933, p.190, in a description of a cholera epidemic in Chengdu).
[34] Martin K. G., "Medical Systems in a Taiwan Village: Ong-ia-Kong, the Plague God as Modern Physician" in Kleinman A. et al., *Medicine in Chinese Cultures*, Washington D. C., 1975, p.115-141.

DU "ZIRA" AU "MÈTRE" : UNE TRANSFORMATION MÉTROLOGIQUE DANS L'EMPIRE OTTOMAN

Feza GÜNERGUN

Les défaites devant les forces militaires européennes ont poussé les Ottomans à prendre au début du XVIIIe siècle, des mesures pour réorganiser leur armée. La réforme militaire qui commença sous le règne du Sultan Ahmed III fut suivie par l'établissement de l'Ecole des Mathématiques *(Hendesehane)* en 1733 sur l'initiative du Comte de Bonneval et de l'Ecole Impériale du Génie Maritime *(Mühendishane-i Bahri-i Hümayun)* en 1773 sur la recommandation et l'initiative du Baron de Tott. Par la suite, avec la fondation de l'Ecole Impériale de Génie *(Mühendishane-i Berrî-i Hümayun)* en 1795 sous le règne du Sultan Selim III, les efforts de modernisation déployés tout au long du XVIIIe siècle prirent un caractère régulier.

Au début du XIXe siècle, marqué par les réformes du Sultan Mahmud II, la première école de médecine moderne *Tiphane* fut ouverte en 1827 pour pourvoir aux besoins de l'armée en médecins et en chirurgiens; la réorganisation de cette école en 1839 donna naissance à l'Ecole Impériale de Médecine *(Mekteb-i Tibbiye-i Adliye-i Sahane)* qui fut l'une des institutions principales à travers lesquelles les sciences médicales européennes furent introduites dans le pays. Enfin, l'Ecole Impériale Militaire *(Mekteb-i Harbiye)* fut fondée en 1834 dans le but d'éduquer les cadres dirigeants de l'armée ottomane[1].

Aux réformes militaires du XVIIIe siècle succédèrent au siècle suivant une série d'autres réformes. Des innovations transférées de l'Occident furent introduites dans plusieurs domaines et les efforts de modernisation se multiplièrent. Ainsi l'on pourrait dire que le XIXe siècle fut pour les Ottomans, une période de changements et de renouvellements continus. Les réformes réalisées à l'exemple de l'Occident dans l'administration, l'éducation, la justice, les finances, les transports et les communications ont influencé profondément la société ottomane.

Des réformes furent aussi entreprises dans le domaine de la métrologie. L'accroissement des relations commerciales, culturelles et scientifiques avec les pays européens mit l'Etat ottoman en contact direct avec le système métrique décimal dès le milieu du XIXe siècle.

P. Petitjean et al. (eds.), Science and Empires, 103–110.

Dans le cadre des mouvements de transfert des sciences et technologies occidentales, mouvements qui caractérisent la "Période des Réformes" *(Tanzimat Devri)* dans l'histoire de l'Empire ottoman, les réformateurs n'hésitèrent point à accepter ce nouveau système décimal et à le déclarer en 1869 système officiel de l'Etat. D'autre part, on observe que le nouveau système avait été introduit dans le pays par des voies diverses et mis en usage avant même son adoption officielle par l'Etat, parmi les milieux en relations intenses avec les pays de l'Europe.

L'introduction du système métrique dans l'Empire ottoman

Les écoles déjà citées constituèrent l'une des voies principales par lesquelles le système métrique décimal s'introduisit dans l'Empire. Les manuels utilisés dans l'enseignement des sciences étaient des traductions directes ou des adaptations basées sur des livres scientifiques européens, français pour la plupart. Ceux-ci ont assuré l'introduction des premières informations sur le système métrique.

La première référence au système métrique dans la littérature scientifique ottomane se trouve dans la traduction en turc du livre intitulé *Eléments de géométrie* du mathématicien français Legendre (1752-1833), faite par Ibrahim Edhem Pasa (1785-1865), ingénieur et mathématicien ottoman, qui à la traduction ajouta aussi des notes personnelles. Le livre fut imprimé à Boulaq (Egypte) en 1836 sous le titre[2] *Kitab-i Usul-i Hendese.* Dans ce traité, Ibrahim Edhem Pasa non seulement traduit les données fournies par Legendre mais expose les équivalents métriques des poids et mesures ottomanes qu'il a lui-même calculés[3]. Il développe aussi pour les multiples et sous multiples des unités de poids et mesures une nomenclature en langue ottomane en se servant des mots arabes. Il ajoute cependant qu'il serait plus commode d'adopter la nomenclature française, la terminologie dérivée de l'arabe étant plus difficile à utiliser.

Après cette première citation ottomane datant de 1836, le système métrique figura fréquemment dans les livres scientifiques publiés à Istanbul et à Boulaq pendant tout le XIXe siècle. D'autre part, les jeunes Ottomans qui poursuivirent leurs études en Europe et qui à leur retour au pays prirent place dans l'enseignement scientifique ont contribué eux aussi à la connaissance et à l'application du système métrique. Les relations commerciales avec les pays européens ont mené à l'adoption des nouveaux poids et mesures surtout dans les régions du pays engagées dans le commerce d'outre-mer. Au début de la seconde moitié du XIXe siècle, les grands ports par où filtrait le commerce européen furent parmi les premiers centres[4] où le système s'instaura. De son côté, l'Etat ottoman jugeait nécessaire d'unifier les poids et mesures dont les unités différaient de valeur d'une région à l'autre. Les diverses entreprises[5] d'unification prouvent cette intention. On peut admettre que le désir d'instituer un système totalement nouveau au lieu de réformer l'ancien a par lui-même contribué à l'adoption du système métrique décimal[6].

L'adoption officielle du système métrique par l'Etat ottoman et sa mise en application

Les travaux préparatoires à l'introduction du système métrique dans l'Empire ottoman furent assurés par le Département des Travaux Publics du Conseil d'Etat, sous l'initiative et la responsabilité d'Ibrahim Edhem Pasa (1818-1893)[7], directeur du département entre 1868 et 1870[8]. Le système métrique fut admis comme système officiel des poids et mesures de l'Empire par la loi promulguée le 27 Septembre 1869, à savoir la "Loi concernant les nouveaux poids et mesures"[9].

Les travaux préparatoires concernant la mise en application du système métrique furent entrepris sans délais. Le règlement[10] qui suivit cette loi déterminait les responsabilités des fonctionnaires devant faire connaitre le système métrique au peuple, les dimensions à respecter et le matériel à employer dans la fabrication des nouveaux poids et mesures, les questions relatives au scellage, etc. Des tables d'équivalence furent imprimées. Ces tables contenaient, outre les noms français, une nomenclature en langue ottomane spécialement conçue pour désigner les unités du système métrique. D'autre part, les reproductions d'une gravure qu'on avait fait venir de Paris, illustrant les poids et mesures métriques furent distribuées aux écoles secondaires; un guide expliquant le nouveau système à l'usage de ces mêmes écoles fut imprimé. Des programmes instructifs furent organisés, un règlement concernant l'utilisation des poids et mesures métriques dans les officines fut distribué aux pharmaciens.

Quant à la fabrication des poids et mesures, les premiers modèles furent importés de France en 1870. Par la suite, ceux-ci furent fabriqués à l'Ecole des Arts et Métiers à Istanbul.

La "Loi concernant les nouveaux poids et mesures" promulguée en 1869 rendait obligatoire l'utilisation des poids et mesures métriques dans les administrations publiques à partir de 1871 et dans l'ensemble du pays à partir de 1874. Il était donc prévu que la conversion au système métrique serait effective cinq ans après la promulgation de la loi. Mais les nouveaux poids et mesures ne furent pas aussi largement utilisés qu'on l'avait espéré. En 1873, la question fut soulevée auprès du Conseil des Ministres soulignant que le peuple ne s'était pas encore habitué au nouveau système, qu'il se plaignait et avait tendance à l'abandonner, qu'on ne devrait pas le forcer à l'utiliser, d'autant plus que ce système n'était pas encore pleinement établi même dans les services du gouvernement. En conséquence, l'obligation de se servir du système métrique fut reporté à cinq ans plus tard. Cet ajournement fut suivi par d'autres, de nouvelles mesures furent prises par le décret publié en 1881[11]. Mais les nouveaux poids et mesures métriques ne purent totalement remplacer les traditionnels et tous les deux furent utilisés en commun jusqu'à la fin de la période ottomane.

Attitude des Ottomans vis-à-vis du système métrique

L'attitude de la société ottomane devant l'adoption du système métrique différait d'un milieu à l'autre. Nous tâcherons ici de déterminer ce qu'a été celle de différents groupes professionnels, des administrateurs, des autorités religieuses *(ulema)* et du peuple.

Les médecins, pharmaciens et chimistes ont été les premiers à utiliser le nouveau système et à l'assimiler. On observe que le système métrique fut utilisé dans les analyses chimiques effectuées à l'Ecole Impériale de Médecine dès le milieu du XIXe siècle, avant l'adoption de celui-ci par l'Etat ottoman. L'emploi des poids et mesures métriques, d'une part par les Ottomans qui avaient étudié en Europe la médecine et les sciences qui s'y rapportent, et d'autre part par les médecins, chimistes et pharmaciens étrangers qui travaillaient à Istanbul, facilita doublement leur adoption surtout dans les milieux médicaux.

En 1880, les pharmaciens qui étaient membres de la Société de Pharmacie de Constantinople exprimèrent le désir que le système métrique fût utilisé dans les officines et même ont proposé qu'un article imposant cette pratique fût ajouté au règlement qui régissait l'exercice de la pharmacie civile. Cependant, les médecins et pharmaciens continuèrent à utiliser un système mixte composé d'anciens poids français et des poids décimaux et ceci, jusqu'à la mise en application générale du système métrique dans les officines dans les années 1890[12].

L'unité de mesure de longueur utilisé par les ingénieurs et architectes se nommait *zira-i mimari* (coudée des architectes) ou *zira-i osmani* (coudée ottomane) et dépassait à peine la coudée française. Nous n'avons pas pu obtenir des renseignements suffisants pour pouvoir décider dans quelle mesure le système métrique était appliqué par des ingénieurs et des architectes.

Selon Ibrahim Edhem Pasa, qui a été le premier ingénieur à mentionner le système métrique dans la littérature scientifique ottomane, l'utilisation de ce nouveau système dans les milieux techniques et scientifiques serait favorable. Il explique que le caractère décimal du système faciliterait les calculs et déclare que son utilisation dans les pays musulmans serait "convenable et digne". Elle éviterait les erreurs dans la conversion des unités et rendrait ainsi plus aisée la traduction des livres occidentaux sur les sciences, les arts et les techniques[13]. Le fait qu'en 1871 dans un livre[14] traitant des techniques de construction routière l'échelle des dessins techniques est indiquée en mètres, nous mène à penser que le processus de passage au système métrique avait déjà commencé. D'autre part, comme des tables de conversion des mesures traditionnelles de longueur et de superficie - telles que *parmak, mimar arsini, evlek* et *donüm* - en unités métriques ont été publiées indépendamment dès 1889[15], on peut affirmer que les unités de longueur du système métrique étaient utilisées à cette époque.

Quant à l'attitude des cercles religieux *(ulema)* à l'égard du système métrique, nous n'avons pas rencontré parmi les documents consultés, une mention qui indique leur opposition. La seule critique à l'égard de l'adoption du système métrique venait de l'historiographe officiel Ahmed Lûtfi Efendi (1817-1907). Celui-ci blâmait le directeur du Département des Travaux Publics Ibrahim Edhem Pasa (1818-1893), pour avoir introduit le système métrique par curiosité personnelle et de ce fait entraîné des dépenses pour la trésorerie et des pertes pour les pauvres. Il critiquait de même l'esprit d'imitation de l'Europe dans tous les domaines en disant[16] que *"l'on avait tout pris de l'Europe et qu'il ne restait plus que les mesures à changer"*. Cette expression indique qu'il existait à cette période des intellectuels qui n'étaient pas satisfaits de l'insuccès de certaines démarches de modernisation entreprises par les hommes d'Etat et inspirées de l'Occident. La tendance de certains réformateurs ottomans à abandonner le système traditionnel au lieu de l'améliorer et à le remplacer par des modèles entièrement nouveaux, a suscité la réaction d'Ottomans attachés à la tradition dont Lûtfi Efendi faisait partie.

L'attitude des commerçants en gros devant le nouveau système était tout à fait différente de celle des boutiquiers. Dans les années 1880 où les deux systèmes étaient en rigueur, les commerçants en gros ne touchaient pas à la question de la métrologie parmi les demandes qu'ils adressaient au gouvernement ottoman au sujet des mesures à prendre pour le développement du commerce et de l'industrie. Ce qui montre que, dans le commerce en gros, la dualité des mesures ne posait pas trop de problèmes. Mais, les marchands et les boutiquiers étaient fort contents et profitaient de l'usage simultané des deux systèmes. Ils ne manquaient pas d'exploiter le peuple mal renseigné, peu expérimenté dans les calculs de conversion et mis dans la confusion par une terminologie nouvelle. Le peuple était fréquemment victime des fraudes et à peu près partout où des transactions d'après le nouveau système avaient lieu, c'était souvent lui qui était lésé[17]. Cependant, certains boutiquiers, soucieux de garder leur clientèle avaient continué à utiliser en cachette les anciens poids et mesures. La méfiance du peuple exploité fût d'ailleurs, avec son attachement aux mesures traditionnelles, un des principaux facteurs qui ont empêché l'adoption et la généralisation des nouveaux poids et mesures.

Le gouvernement ottoman, quant à lui, a appliqué le nouveau système dans les administrations publiques avec fermeté. Toutefois les protestations du peuple l'ont contraint à reporter à plusieurs reprises l'obligation de se servir des poids et mesures métriques. Ces ajournements, et les dispositions visant à faciliter l'assimilation du système au niveau du peuple, témoignent de la détermination de l'Etat ainsi que de sa tolérance.

Si l'on compare l'introduction du système métrique dans l'Empire ottoman et en France, le pays où il fut créé, on remarque que la différence la plus importante, c'est qu'en France, le désir de modifier les mesures est venu du peuple lui-même (surtout de la part des paysans) avec le mouvement antiseigneurial en réaction au régime féodal[18]. Tandis que dans le cas ottoman, l'établissement d'un nouveau système de mesures était le désir de l'Etat. On remarque tout de même que, dans le processus de transition, les deux pays ont connu des difficultés semblables. En France, une cinquantaine d'années a dû s'écouler avant que le système métrique ne soit pleinement adopté. Le processus, déclenché dans la Turquie ottomane en 1869, a été complété soixante ans plus tard en 1931 dans la Turquie républicaine.

Le système métrique fut introduit, comme nous l'avons mentionné plus haut, dans le mouvement de transfert des sciences et techniques occidentales, mouvement qui faisait partie d'une plus vaste réforme visant à la modernisation de l'Empire ottoman dans plusieurs domaines. L'application et la propagation du système métrique se sont développées parallèlement à l'extension progressive des relations politiques, commerciales et scientifiques de l'Empire avec les pays de l'Europe.

Université d'Istanbul

Notes

[1] Ekmeleddin Ihsanoglu, "Tanzimat Oncesi ve Tanzimat Donemi Osmanli Bilim ve Egitim Anlayisi", *Tanzimat II*, Türk Tarih Kurumu, Ankara 1991, sous presse.
[2] Semuhi Sonar, "Ibrahim Pasa'nin Kitabu Usûli'l Hendese'si Hakkinda", *Arastirma (DTCF)*, II(1964), p.145-178.
[3] Il connaissait, d'après les mesures réalisées à l'Ecole Impériale de Génie à Istanbul sous le règne du Sultan Selim III (1789-1807), le rapport entre les mesures ottomanes et les anciennes mesures françaises. D'autre part, il savait, d'après les informations fournies par Legendre, les équivalents métriques des anciennes mesures françaises. Ainsi, avec de simples opérations arithmétiques, il a déduit les équivalents métriques des poids et mesures ottomanes.
[4] Zafer Toprak, "Onemli Bir Yasa, Olçüler Kanunu (1931)", *Yapit*, n°2, (1983-84), p.37-43.
[5] Halil Inalcik, "Introduction to Ottoman Metrology", *Turcica*, XV (1983), p.311-348.
[6] Feza Günergun, "Introduction of the Metric System into the Ottoman State", 1st International Symposium on Modern Science and the Muslim World (Thema : Science and Technology Transfer from the West to the Muslim World from the Renaissance to the Beginning of the Twentieth Century), Istanbul, Sept. 1987, Proceedings (édité par E. Ihsanoglu), sous presse.
[7] Homme d'Etat et de science ottoman qui fut Ministre des Travaux Publics, Ambassadeur et Grand Vizir à diverses reprises. Il introduit la géologie dans l'Empire ottoman. Il ne doit pas être confondu avec Ibrahim Edhem Pasa (1785-1865) ingénieur et mathématicien. Pour sa biographie, voir Ercümend Kuran, "Ibrahim Edhem Pasa", *Encyclopedia of Islam*, New Edition, **vol.III,** Leiden-Brill, 1979, p.993.
[8] *Vak'a nüvis Ahmed Lûtfi Efendi Tarihi* (Ed. M.Münir Aktepe), **vol.XII** (Ankara 1989), p.60-61, et **vol.XIII** (Ankara 1990), p.7-8.
[9] "Mesahat ve Evzan ve Ekyâl-i Cedideye Dair Kanunname" (20 Cemaziyelahir 1286), *Düstur* (I. Tertip), **vol.I,** Dersaadet 1289 (1872), p.744-46.
[10] Cedid Mikyaslarin Tatbik ve Muayenesine Dair Nizamname, *Düstur* (I. Tertip), **vol.I,** Dersaadet 1289 (1872), p.747-64.
[11] *Fi 29 Sevval sene 1298 ve fi 11 Eylül sene 1297 tarihiyle seref müteallik buyrulan irade-i seniyye-i hazret-i Padisahi mucibince yeni olçülerin tanzim ve tensikiyle suver-i icraiyesi hakkinda kararnamedir*, Istanbul, Imprimerie du Tophane-i Amire, 7 Rebiülevvel 1299/15 Kanun-i sani 1297 (12 January 1882).
[12] Feza Günergun, "Desimal Metrik sistemin Osmanli Eczahanelerine Girisi (Introduction du système métrique décimal dans les officines ottomanes)", *Tubitak Türk Eczacilik Dergisi*, sous presse.
[13] Ibrahim Edhem Pasa, *Kitab-i Usul-i Hendese* (traduit de Legendre), Le Caire, L'Imprimerie Boulaq 1252 (1836), p.360.
[14] Hüseyin Rifki (Elhac, Miralay), *Usul-i Insa-i Tarik*, Istanbul, Imprimerie de l'Ecole Impériale de Génie, 1288 (1871).
[15] *Eski olçülerden parmak, arsin ve evlek ve donümün yeni olçülere tahvil ve icrai hakkinda tarifnamedir*, Istanbul Matbaa-i Osmaniye, 1306 (1889); *Atik mimar arsininin yeni arsina ve atik donümün yeni donüme tahvili cedvelleri*, Istanbul, Matbaa-i Osmaniye, 1306 (1889).

16 *Ahmed Lûtfi Efendi Tarihi,* **vol.XIII,** p.7-8.
17 *Journal de la Chambre de Commerce de Constantinople,* 2ème Année, n°46, 15 Novembre 1886.
18 Witold Kula, *Les mesures et les hommes,* Editions de la Maison des Sciences de l'Homme, Paris 1984.

MODELS OF EUROPEAN SCIENTIFIC EXPANSION: A COMPARATIVE DESCRIPTION OF "CLASSICAL" MEDICAL SCIENCE AT THE TIME OF INTRODUCTION OF EUROPEAN MEDICAL SCIENCE TO SRI LANKA, AND SUBSEQUENT DEVELOPMENT TO PRESENT

A. DE ZOYSA and C. D. PALITHARATNA

Early Historical Period

A generally accepted chronological framework for study of Srilankan history recognizes several distinct periods[1]. Starting from prehistoric times (circa 125,000 B.C.) to a proto-historic era when settled agriculture and iron age technology was begun. A historical period as such begins with the growth of advanced irrigation systems for food production, and with the surplus created by this, one sees the emergence of a flourishing civilization centered on cities such as Anuradhapura, Sigiriya and Pollonnaruwa. These city-centered civilizations were equal to any that existed at the time and spanned a period of one and a half millenary, from around 300 B.C. to 1250 A.D.

From 1250 A.D. onwards one sees a number of "centrifugal" tendencies, with fragmentation of centralized power to the periphery. With the arrival of the Portuguese (16th century) a period of colonization by European powers followed and ended only after the second world war. Modern Sri Lanka was given birth to and heavily influenced by this colonial period.

Living evidence of conditions in the pre- and proto-historic periods exists amongst the Veddha community, an indigenous people who retain most of their hunter-gatherer past even today[2]. The Veddhas possessed sufficient medical knowledge for their survival needs. They had knowledge of medicinal plants to treat wounds, and used python fat for fractures. Exorcism, still practiced today and reputed to have great psychosomatic value in an appropriate socio-cultural context, was probably introduced by them. There is however no evidence of any attempts to build a connected knowledge system out of these curative practices.

With the coming of the city civilizations (circa 300 B.C.), one sees rapid developments in all fields of knowledge. Medical science was

P. Petitjean et al. (eds.), Science and Empires, 111–120.

no exception. Historical information of this period is derived from several sources[1,3]:
(a) Written material, which was on ola leaves. The *Mahavamsa* a massive collection of historical information is such an example;
(b) Rock inscriptions at religious and archaeological sites;
(c) Artifacts and buildings from archaelogical sites.

A reasonable picture of what constituted medical knowledge in Sri Lanka during this time could be derived from these sources. By the end of the proto-historic period, curative medicines and practices were locally found and available, but it was probably not until the early historic period that Indian (Ayurveda and Siddhi) and Unani (Muslim) systems were introduced and integrated with local regional (Deshiya Chikitsa) practices. Ayurveda, which when translated literally means the "science of life", forms the major science underlying the practice of indigenous medicine in Sri Lanka. The well known texts on Ayurveda such as the *Charaka Samhita* and the *Susrutha* were known and read in Sri Lanka from the historical period onwards. Ayurveda, originating from ancient Vedic insights and practices, was well developed[4] and had the character of a well-connected knowledge system, just as much as modern medical science is, and some of this knowledge has parallels with modern allopathic medicine. There were for instance sections describing fields similar to surgery, toxicology and ENT diseases. The *Susrutha Samhita,* an Ayurvedic book on surgery from India describes 121 surgical instruments[5] including many surgical practices using these, and dissections on dead bodies. Surgical procedures show a knowledge of the infective power of micro-organisms too small to be seen by the human eye. The underlying paradigms of Ayurveda were however very different from the atomistic science known today and forms a powerful alternative to it. During the city-centered historic period, extensive state sponsorship was given for medical practice and science. Some kings such as Buddhadasa (4th century), Aggabodhi (8th century) and Parakrama Bahu (12th century) were actual practitioners and scholars of Ayurveda. The *Mahavamsa* records the existence of hospitals, dispensaries and medical halls during this period and archaeological excavations are supportive of these claims. Medical practice at this time, in keeping with Ayurveda, would have been comprehensive covering both preventive and curative measures, and was extended even to the of care of animals.

With the decline of the city-centered civilizations one sees the emergence of a number of regional centers of administration around port cities such as Kotte, Jaffna, and in the hill country Kandy. Although a large body of medical knowledge was preserved and passed down through generations, no notable achievements were recorded during this period.

The Colonial Period to Modern Times

Colonial conquests of territory started with the Portuguese in 1505 and continued for nearly four and a half centuries. This period saw also the rapid growth of modern science in Western Europe and its introduction to Sri Lanka by the colonial powers, in particular the British.

Both the Portuguese and Dutch had a great respect for local medical knowledge and used it at times to treat even their own sick and wounded[3]. The Portuguese are reputed to have used local knowledge to cure dysentery and snake poisoning amongst soldiers. They could not, however, understand practices which were heavily culture bound such as exorcisms and discouraged them on religious grounds. The Dutch who captured the coastal towns from the Portuguese in the 17th century are credited with building many hospitals in Sri Lanka[3] where herbal medicines were used along side drugs imported from Europe. Towards the latter part of the 18th century they appointed "native" physicians proficient in Ayurveda in all their hospitals. During the Dutch period there was a brief renaissance in the study of traditional medicine. King Narendrasinghe (1707) translated a 13th century palm leaf manuscript, the *Bhesajja Manjusa,* on medicine and was also responsible for compiling a *Vattoru Vedapotha,* a book of indigenous medicinal prescriptions. Paul Hermann, a famous surgeon attached to the Colombo hospital, was interested in botany; he was at that time in contact with Linnaeus, and sent collections of local plants to him. It is said that these were used by Linnaeus for his famous plant classification[6].

The British colonial period in Sri Lanka started from 1796 and lasted 150 years. During this period one saw the rapid industrialization of Europe and North America and its domination of the rest of the world. Not surprisingly, Western medical science was introduced and it established a dominant position in Sri Lanka. Ayurveda and indigenous medicines were generally discouraged under British rule and they learnt little from it. There were however notable exceptions. Sir Henry Blake, a British Governor in Sri Lanka, translated parts of the *Susrutha* using Buddhist scholars; he claimed in a lecture delivered to the Royal Asiatic Society in 1905 that malaria was recognized as a mosquito borne disease, and thereby foreshadowed the work of Manson and Ross[3]. This was never accepted in Europe, but it is difficult to envisage how an irrigation-based civilization flourished if it did not understand even the causative mechanisms of such a devasting disease like malaria. Another notable exception was the establishment of a College of Indigenous Medicines in 1929 with state sponsorship. These instances of support were however very much the exception, not the rule.

In spite of heavy state support for Western allopathic medicines and the marginalization of indigenous practices, the latter survived and were used by a majority of people: even the urbanized middle classes, who were heavily "Westernized" in outlook, continued to use them often. It is not unusual to find an individual with an "incurable" disease, who has resorted to almost all these systems. The choice offered in the pursuit of a healthy life is quite remarkable and the openness shown by a majority of recipients in exploration of these systems is unusual, and not found in modern developed nations. What were the reasons which made these indigenous systems of medical knowledge so resilient? We will in the following text investigate the "world views" behind the two knowledge systems of Ayurveda and Allopathy and, despite differences, their potential for cross-fertilization. To do this, we will first touch on some developments in the philosophy of modern science.

Incommensurability Between Two Knowledge Systems

The term *incommensurable,* first introduced by Kuhn[7] and later developed by Feyerabend[8], refers to the impossibility of comprehending a theory "A", based on a paradigm "A", by using concepts and terminology of a theory "B" based on a different paradigm "B". By paradigm we mean, as Kuhn expressed by the following:[7]

> "On the one hand it stands for the entire constellation of beliefs, values, techniques, and so on shared by the members of a given community. On the other, it denotes one sort of element in that constellation, the concrete puzzle-solutions which, employed as models or examples, can replace explicit rules as a basis for the solution of the remaining puzzles of normal science".

Numerous examples can be taken from the history of science itself as evidence for incommensurability between theories. Relativistic and Newtonian physics form one of the best known examples. In Newtonian physics, mass, time and energy are observer-independent entities, existing out there in absolute space. In relativistic physics, they depend on the relationship between the observer and observed, have no fixed value and lose all absolute meaning. In fact the concepts are so radically different, that the use of the same word "mass", "time", etc, leads to confusion. A student used to years of reference to "Newtonian mass" finds it difficult to comprehend and adjust to "relativistic mass". Perhaps, it would be easier to make the *gestalt switch* if different terminology were used. A rather striking, but less well known example of incommensurability is detailed by Werner Heisenberg[9]. Again taken from physics, here, one is shown the almost total incommensurability between Newton's and Goethe's theories of colour. Newton's theory of colour was mechanistic, precise and with later modifications proved to be useful for all kinds of practical purposes. Goethe's theory of colour was based on symmetry and complementarity. Its purpose was very different from Newton's, it described a sensory world of colour which was relevent and proved usefull for artistic and aesthetic purposes.

The world views or broad paradigms on which the two knowledge systems are based, are different and incommensurable. The ontology of classical Western science takes for granted the existence of subatomic particles which form atoms, and these arrange themselves into chemical compounds growing in complexity to form organic molecules and hence life (although recent quantum phenomena have somewhat altered this ontology, it does not in any way effect the practice of medical science). Ayurveda is in essence an outgrowth from ancient Vedic philosophy[4]. The world is postulated to be made of five factors, the *Pancha Mahabuta.* They are described as the factors of earth *(Prithvi),* liquid *(Apo),* fire or energy *(Theja),* gas *(Vayu)* and ether *(Akasa).* In understanding these concepts, language itself is an impediment, as they are difficult to translate exactly. A proper understanding can only be derived by an appropriate *gestalt switch* from knowledge system "A" to knowledge system "B". It is incorrect to view these five factors as some form of atomistic elements. Instead we should view them from an ecological perspective: if the world is thought of as the ecosphere, consisting of the lithosphere *(Prithvi),* hydrosphere *(Apo),* atmosphere *(Vayu)* driven by energy flows *(Theja)* and existing in empty space *(Akasa),* it begins to make sense. Ancient Vedic philosophers viewed the biosphere and hence the human body as a manifestation of these five factors.

Let us examine the paradigms underlying the theory of disease causation in the two systems. In Ayurveda, reasons for disease are four fold: *Aganthuka* (external factors such as injuries), *Sharirika* (physical), *Manasika* (mental), and *Swabhavika* (natural, such as old age, hunger, thirst). Disease[5] itself is defined as contact with *Dukkha*. *Dukkha* is very comprehensive and includes unsatisfactory physical as well as mental states, both temporary and permanent. Negative emotions such as anger and jealousy are considered to be disease states. We can at once see why such a system has to deal with both physical and spiritual treatments.

In Ayurveda the human body is described by using three principles, *Dosha, Dhatu* and *Mala*. The *Doshas* are again divided into three:[10] *Vata, Pitta* and *Kapha*. *Vata* (or gaseousness) for instance has more of the *Vayu* of the *Pancha Mahabuta* than the other factors, while *Pitta* would have a preponderance of the factor of *Theja* (energy), and *Kapha* a preponderance of *Apo* (liquidity). When an imbalance amongst these three *doshas* is present, the body becomes susceptible to disease, particularly of the *Sharirika* category (physical). When healthy, they exist in a state of dynamic equilibrium. Hence, although Ayurveda recognizes the existence of micro-organisms, the main causative factor lies in an imbalance within the human body. Using such a theory it would be easy to explain the occurence of influenza and to adopt preventive measures against it[10]. Cold temperatures, moisture, food described as cooling, all enhance *kapha* leading to an imbalance, which makes the body susceptible to the ″flu virus″. Although in Ayurveda the virus as a causative factor is not recognized, the cause and effect relations are explained by the theory of imbalances. The ″flu virus″ aetiology by itself does not explain why person ″A″ contracts it while ″B″ doesn't or why ″A″ contracts it in autumn and not in summer and so forth. The virus after all presents itself constantly, but it is only sometimes and only some people who are affected. The *three-dosha-vade* of balance and imbalance can be thought of as a comprehensive theory of resistance and susceptibility to disease. Its real benefits lie in disease prevention.

The broad paradigms which underlie theory strongly influence observation, or, following Kuhn and Feyerabend, the theory-ladenness of observation. It becomes therefore extremely difficult to frame an observation test which would be fair by both Ayurveda and Allopathy. An observation test which is framed from the perspective of knowledge system ″A″ will strongly carry its hallmarks, and be unfair or irrelevant to knowledge system ″B″. Let us consider an example. In Western science we have the control experiment, which is designed to exclude ″unwanted″ effects from an observation, and consider the effects of the sole phenomena under study. The phenomena under study is usually physical and "unwanted" effects psychological. Such a test cannot account for interaction between the "wanted" effects and the "unwanted". The double-blind test for the efficacy of drugs is a special case of a control widely used to determine the solely physical effects of drugs. In Ayurveda we find a category of herbal medicine known as *Khema,* in which "wanted" physical component interacts with the "unwanted" psychological action. A *Khema* is always accompanied by an intricate story of its origin, and ritualistic preparations are used before administration. The patient is made to believe in these and although the herbal medicine has a physical effect, its value is substantially enhanced by psychosomatic interactions. Further the two effects may not be separated out and studied, because in general their interaction is non-linear, effecting the whole human body rather than the merely diseased parts of it. A double-blind test would be irrelevant for such a case.

Theory And Practice - Their Unconnectedness

Both Ayurvedic and Western medical practices claim to rest on a firm "scientific" basis. These claims are only partly true. The practice in a number of cases does not flow naturally from a theory, based within a broad paradigm. In a Kuhnian sense, we cannot say that both are fully "mature sciences" flowing from broad generally accepted paradigms of theory to practice. This would be the case in say physics. There are many practices and medicines, in both Western and Ayurvedic systems, which are used simply because they work. Sometimes ad-hoc theories are used to describe how they work, but these theories do not deeply penetrate the respective knowledge systems. Vaccinations for instance were used in Europe for smallpox, long before any theory of immunity had been developed, and it is only recently that immunology has been accepted as a specialist discipline. Inoculations against smallpox had been practiced in India long before Jenner introduced vaccination to Europe. It is mentioned in the ancient Indian text *Atharva Veda,* and was practiced in Ancient India by introducing "inoculated pustules of the previous year" to healthy persons[5]. Again it is unlikely that Ayurvedic theory prompted such treatments. Treatment of many common ailments, such as back pain in all its manifestations, is treated on a "try and see" basis in Allopathy, and often the patient knows what course of action would be best for him. Many other examples can be taken to show this disjointedness between theory and practice in both systems.

Possibilities For Cross-Fertilization

We have earlier pointed out that the broad paradigms on which the two systems of knowledge are based, are different and incommensurable. These paradigms were established in Ayurveda a few thousand years ago and have remained relatively unchanged. Western medical practice falls within the world view of Descartes and Newton, which has guided its development since the 17th century. Under such circumstances, can these two systems benefit from each other? We have in an earlier section pointed to the disjointedness of theory and practice between the two systems. This disjointedness with mutually incommensurable theories allows for cross fertilization at a practical level, when one can ignore theory without any loss. The broader question of cross fertilization towards growth of the respective knowledge systems can only happen in an atmosphere of openness and equality. The theory-ladenness of observation excludes certain observations from each knowledge system. A sense of openness would allow practitioners in each science to take each others' observations seriously and thus perhaps initiate major theory change. One of the earliest Western scientists to do so was Carl Jung with his theory of the collective Unconscious[11]. He accepted freely his indebtedness to eastern philosophy and observations on the mind. Professor Patwall's "gate-control theory" of pain is a more recent example[12]. The earlier simple view of pain was Cartesian and could not account for psychosomatic effects in pain control, or the phenomena of Acupuncture, which are true observation data usually ignored by Western science. Professor Patwall's theories do at least partially explain these effects and have broken the Cartesian wall obstructing a new vision. Paul Feyerabend[8,13] has repeatedly taken examples from the history of Western science to illustrate that observation is theory-dependent and that anomalous observations are not legitimized until a change has occurred. And Kuhn[7] has shown how anomalous observation unexplained within existing paradigms persist and new ones appear to add up to force a scientific revolution. We believe that the most fertile grounds for cross-fertilization lie in taking note of each others' observations. Ayurvedic doctors in Sri Lanka accept and study aspects of Western medical knowledge. Basic Western sciences, such as anatomy and modern diagnostics, are increasingly being used in Ayurvedic practices. For example, earlier, a fractured bone would be detected and set by sheer skill and practice passed down from father to son through generations, while with the breakdown of such systems in recent times, increasing use is being made of X-ray photography.

Unfortunately Western medical practitioners in Sri Lanka with a few exceptions, do not consider Ayurveda to be a useful knowledge system and often dismiss it without study. As a result they learn nothing from it, and the creative contribution from these "native" practitioners of Western medical science even in their own fields is poor. The reasons for this are numerous. Principle among these is simply prejudice, a result of a neocolonialism which overshadows most of the third world. Even the few who have a genuine interest in imaginative research are not backed by national governments or by international agencies. "Aid" for research is given to accepted areas, usually falling well within the most conservative branches of Western science. The result is a science which mimics the activity at the centers of "excellence" in industrially developed countries. Some may point to examples of successfully marketed drugs being produced from "Active ingredients" extracted from herbal medicines. This however is an act of foraging of a limited value. One often finds an expensive drug perhaps more dramatic in its effect, but with side effects which were absent in the original herbal medicine. These ingredients in pure form pose an easier adaptation problem for the micro-organism it attacks than the confusing signals from an herbal mixture. Invariably the chief beneficiary of such a process happens to be a multi-national drug company who will have the investment potential to switch to another drug, when nature adapts. If real progress is to be made, it is necessary to redress the political and economic imbalance between the treatment of Western and indigenous medical knowledge systems. A beginning was made in 1961 in Sri Lanka with the parliamentary act on Ayurveda. Some political and economic backing has resulted following this act, but is insufficient and has not been sustained.

Western medical scientists interested in creative work have a fertile observation field in indigenous systems of medical knowledge. They can, we feel also, learn much from the history of Western science itself, in particular from its major creative periods, to develop an openness and methodology for fruitful cross-fertilization of knowledge with indigenous knowledge systems. At present however, they work within the confines of narrow paradigms, often reductionist in nature, solving puzzles and sub-puzzles and generating for themselves even more intricate puzzles. As Newton once said, they behave like children playing with pebbles by the seashore discovering interesting shapes, sizes and colours. Expertise derived from such intensive puzzle-solving activity within reductionist paradigms leads to an unwarranted self-confidence and a blindness to wider horizons. A healthy respect for alternative knowledge systems would be a liberating force for science and hence, finally, for humanity.

Arjuna DE ZOYSA, *Open University of Sri Lanka*
C. D. PALITHARATNA, *Colombo Municipal Council*

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TECHNICAL CONTENT AND SOCIAL CONTEXT: LOCATING TECHNICAL INSTITUTES. THE FIRST TWO DECADES IN THE HISTORY OF THE KALA BHAVAN, BARODA (1890-1910)

Dhruv RAINA and S. Irfan HABIB

Introduction

The three jewels in the imperial crown, Bombay, Calcutta and Madras, had acquired universities by the 1870s[1]. By 1887, Punjab and Allahabad had also acquired university status. In the Native Indian States the project of modernization had to be undertaken, not through imperial structures in alliance with local elites, but at the initiative of the native elites and ruling classes themselves. The process was in turn catalyzed, among other factors, by the demand for an emerging class of literates and professionals. Thus it is of interest to investigate the founding of a technical institute in the Native State of Baroda in 1890. This interest does not merely rest in commemorating the centenary of the event as institutional history, but in identifying one more modality for the introduction of modern sciences to 19th century India.

During the initial stages the technical institutes in the Native Indian States such as those at Travancore, Cochin, Bhavnagar, the Nizam's Dominions, Gwalior, Kolhapur, Baroda, etc, did not offer degrees in engineering, as did the universities, but turned out a generation of middle and lower rung technicians; some of whom, as the laws of chance and the additional virtue of professionalization would have it, did rise to positions of importance. What is being suggested here is the existence of a metropolis-province structure. For within the framework of colonial India, the Presidency towns came to serve as metropolises, while the Native States became the provinces: in effect there was a hierarchization in the distribution of power, and quite naturally, knowledge. The study of such technical institutes opens up the possibility of fathoming the dissemination of natural knowledge, and more importantly technology, by its carriers, viz. artisans and technicians, not by its purveyors (*)[2].

To study the introduction of the modern and exact sciences in 19th century India is to assess the conventional institutional histories' evaluating in the process the content of science in educational

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programmes across a sequence: primary education ---> secondary and higher secondary education ---> graduate and post-graduate studies ---> doctoral efforts. Students who traversed the third and fourth stages of this sequence went on to constitute the early generation of Indian professionals. But the technical institutes in the 19th century, on the other hand, sought to transform the traditional Indian artisan into a modern technician. What did this entail in traditional terms as apprenticeship, and in modern terms as scientific education?

Founding the Kala Bhavan

To begin with, a candidate seeking admission to an engineering degree would have had to have completed his secondary education, while a candidate who had completed only six years of schooling in the vernacular was eligible to sit for the entrance examination[3] to the Kala Bhavan; of course, a *"... knowledge of English is considered an additional qualification"*. We shall as far as possible restrict ourselves to the realm wherein modern science mediated the programmes of technical education.

Pyenson has developed a "Euclidean" model for the introduction of the exact sciences into the colonies[4]. He locates the British efforts along a plane defined by the mercantilist axis and the research axis. On examining the indigenous efforts in the area, the mercantilist interest stands out markedly in the 1880s and early years of the 1890s. In the process, call them spin-offs if you will, a fillip was also given to research and technical innovation. The then-ruler of the Native State of Baroda, Sayyaji Rao Gaekwar, an enlightened despot (the daily papers of 1900s preferred the more neutral "enlightened ruler"), realized the importance of a scientific and technical education[5] in breaking the *"iron chains of intellectual bondage"* and that *"merely elementary education could not do this adequately"*. One of the first steps in this direction was the founding of the department of agriculture in 1887, to stimulate agricultural activity on modern scientific lines[6]. The Baroda College was set up in 1881 and offered a bachelor's degree in science. The Principal was the Englishman T. S. Tait. In this space surfaced a series of intersections of economic interests that in turn led to the founding of the Kala Bhavan.

The Kala Bhavan was founded to train technical manpower, whose skills could then be harnessed to *"develop the existing industries of the State as well as to* **help in introducing new industries** *calculated to improve the economic condition of his Highness' (Sayyaji Rao of*

Baroda) numerous subjects" (emphasis added)[7]. But the driving force behind this project, imbued with Baconian optimism, was a chemist, T. K. Gajjar[8]. Professor Tribhuvandas Kalyandas Gajjar was descended from the suthar or carpenter caste of Surat in Gujarat. The caste enjoyed considerable social status among the artisanal classes. His father was a noted civil engineer and timber merchant, who had authored a book on architecture, *Shilpashastra* in Gujarati[9]. Gajjar discontinued his efforts towards acquiring a Master's Degree in Sanskrit, and went on to graduate in chemistry from Elphinstone College, Bombay, in 1879. In passing it may be remarked that classical education was already making way for more pragmatic knowledge systems, which were ironically beginning to be considered prestigious (**)[10]. At the Kala Bhavan, the licentiate of art[11], awarded at the end of a three year course, was the least rigorous and developed of the courses.

In 1886, Gajjar had put forward a proposal to found a Polytechnic at the important port town of Surat[12]. However, he went on to found the Kala Bhavan at Baroda, in June 1890[13]. Gajjar visualized an additional role for the Kala Bhavan, viz. that of serving the cause of the artisans and the weaker sections[14]. In 1896, about 83 of the 204 students came from artisan castes and families of farmers and cultivators[15]. The location of the Kala Bhavan was quite apt, since it lay along the industrializing axis of Western India: Bombay, Surat, Ahmedabad. By the first decade of the 20th century Baroda had itself become a highly industrialized city[16].

The Kala Bhavan was fitted with the latest machinery from Britain and Germany, although some of it was manufactured indigenously. The foreign companies from which some of these machines were bought included Liebold of Germany, Mathison from Glasgow, and Windsor and Norton, as well as Burshiani from England[17]. The initial intent was to fabricate articles for the departments of the State of Baroda, such as those of medicine, revenue, engineering and the department of water works. The students were also exposed to the repair and maintenance of engines, boilers and machines for departments in other Indian Native states[18]. Despite the focus on his Highness' subjects and the state of Baroda, of the 570 students on the rolls in 1908-1909, 399 were from Baroda itself, and as many as 102 came from the Bombay Presidency; the remaining came from the other Native Indian States[19].

By 1909, Kala Bhavan was offering licentiates in six schools, that included mechanical technology, dyeing and chemical technology, weaving technology, architecture and civil engineering, commercial technology, and finally the School of Art[20]. A School of Pedagogy was also part of the Kala Bhavan, but was closed in 1908 and an independent training college opened in Baroda[21]. The above six departments were conceived of as "school and workshop"[22]. The curriculum involved both training and manufacturing operations[23], so that the students could compete[24] *"on equal terms with outside manufactures doing business on commercial lines"*. Only a third of the total period spent at the Institute was dedicated to "theoretical" studies which included the study of modern science, and the relevant technology[25]. Appendix 1 summarizes the training schedules and the auxiliary subjects for each of the disciplines.

Gearing Up for the Mechanical World

The schools of mechanical and chemical technology, architecture and civil works, had training schedules that involved very fundamental contributions from modern science. Stepping into the context of contemporaneous Western Europe, it is known that scientific and technological development in the 18th and 19th centuries necessitated the forging of linkages with the trades. By the 1850s, a firm linkage was irretrievably established between the sciences and innovation in the technical and manual trades. Towards the beginning of the 19th century, Bernal points out, the interaction between scientists and engineers was the greatest, since more often than not, they were one and the same person. However, towards the close of the century they had grown apart[26], but by *"then the advance of science had made its intervention into techniques possible and indeed necessary over a large part of the field"*. Pages 3 to 10 of Appendix A of Gajjar's book *Kala Bhavan* contains a reasonably detailed syllabus of the auxiliary subjects, or what was termed[27] *"Syllabus of the scientific and realistic side at Kala Bhavan"*.

The syllabus in turn, it may be inferred, offers a perspective of the technologies entering the Indian subcontinent at the time. Nevertheless, from the point of view of the pedagogy of modern science teaching and its place in a technical institute such as the Kala Bhavan, it is noteworthy that space had been accorded[28] to the *"principal propositions of statics, kinetics, hydrostatics and heat"*, and what was called "chemical philosophy", that sketched the history of chemistry and the developments thereof in the 18th and 19th centuries[29]. This chemistry included some synthetic, and the elements of organic, chemistry, and discussed *"the regulation of the best defined groups of organic bodies and the laws* *regulating their formation"*. In the schema adopted at the Kala Bhavan, which aimed to produce technicians out of artisans and aspiring professionals, was the interjection, as in the other schools of the manual trades, not only of modern science, but of a new theory of knowledge, whose epistemological edge was the mechanistic programme underlying 19th century physics, and to an extent chemistry. At its core resided the Baconian programme, wherein practice and skills were closely wedded to theoretical development in the sciences and innovation in technology.

It is not our purpose here to explore the contours of this mechanistic programme, but how it was reflected in the training schedule, and what steps were taken to disseminate this new knowledge. As mentioned earlier, during the early years of the Kala Bhavan, the medium of instruction was Gujarati. The principal task of the Sayyaji Gyana Manjusha project was to translate scientific works from English into Gujarati, and by 1892 books on physics, chemistry and "linear perspectives" were ready for publication[30]. The Sayyaji Gyana Manjusha series of scientific and technical books was in fact founded by Gajjar[31], who undertook the study of philology to familiarize himself with the specificity of the task at hand, and went on to appoint a number of Sanskrit scholars[32] to bring their erudition to bear upon the choice of a modern technical lexicon. It is important to note that some of the technical books used by the students of the Kala Bhavan were specifically written in Gujarati: students of mechanical technology were recommended A. V. Ghaskadavi's *Notes on Steam and Steam Engine,* Part. 1 in Gujarati (the author was also a faculty member at the Kala Bhavan); in addition they were recommended Bharuch's *Mill Engine Boiler and Gearing*. Similarly the Manjusha series had published a book on the chemistry of dyeing for students of chemical technology, while students of weaving technology[33] used Brahmabhatt's *Weaving Calculations*. By 1894, textbooks on agriculture, heat, arithmetic, practical chemistry, mechanics, and steam power had been published; in addition, a journal of chemistry in the vernacular, *Rasayana Rahasya,* appeared[34]. Most of the other texts used at the Kala Bhavan were in English and authored by Englishmen. Appendix 2 gives a list of textbooks used at three of the schools of the Institute.

The list of textbooks used at the schools of the Kala Bhavan reflects the degree of formalization of the disciplines, and that of mechanical engineering most significantly. By the middle of the 19th century, mathematics was enshrined as an *"indispensable element of* *secondary and post-secondary education"*. The Clarendon Commission's recommendations of 1881 required that advanced students be *"exposed to applied mathematics, especially mechanics"*. Ambirajan points out that *"educational planners in India had already moved in that direction"*. The list of textbooks prescribed at the School of Mechanical Technology, Kala Bhavan, reveals the emphasis given to applied mechanics[35]. The books prescribed for the disciplines of chemical technology and mechanical technology reveal the emphasis accorded to the theoretical and practical content of the programmes of these schools. Further, the emphasis of the courses also offers us insight into the nature of industrialization on the subcontinent.

It has been pointed out that a specific and inalienable relation between science and modern industry comes into existence when the production process is *"broken down into a series of separately analysable steps..."*, and that the historical importance resided in that it was now possible to incorporate[36] *"... these separate steps into machine processes to which scientific knowledge and principles could be routinely applied"*. The final accomplishment of this process was not merely the application of mechanics to the entire ensemble of emerging technologies, but its final absorption in the factory system. In real terms these were gears, mills and steam related technologies. The case with the chemical industry was still quite different. Chemistry till late into the 19th century remained a discipline awaiting formalization - a programme that commenced with Mendeleev's periodic table. While by the mid-19th century, fundamental advances in the synthesis of organic compounds had provided a new fillip to the chemical industry, resulting in a novel laboratory-industry engagement, it was still early for the formalization of the discipline, as had happened with chemical engineering.

By 1900, the School of Mechanical Technology, at the Kala Bhavan, had acquired a great deal of prestige, given the fact that there was a demand for their students in the growing sphere of Indian industry[37]. In 1900, the School of Mechanical Technology was recognized by the Government of Bombay: students from the discipline of mechanical technology were eligible to appear for the engineer's certificate examination of the Poona College of Science and the Victoria Jubilee Technical Institute, Bombay[38]; as a result, the number of students seeking admission to the School of Mechanical Technology, Kala Bhavan, increased rapidly[39]. The teachers at the School were all Indians, who had graduated in engineering, though there were a few licentiates too. However, there were no doctorates[40]. Under the guidance of one of the faculty members, Vithal Hemchandra, lathes, drilling machines, and other essential equipment were fabricated at the workshops of the Kala Bhavan[41].

Further, an inventory of products produced for the market and for the state departments reveals a degree of specialization in the discipline of mechanical technologies, that could in turn also have been stimulated by local demand: some of these products included oil engine valves, hand looms, dobby and beaming machines, and a whole range of products for the state departments. During the early years the state was still dependent on the workshops of the Kala Bhavan. Actually, between 1904 and 1908, about fifty percent of the products fabricated by the workshops of the Kala Bhavan were for the state departments; of these, about seventy five percent required inputs from the School of Mechanical Technology only. In 1904, K. B. Jadav, a faculty member at the same School, patented[42] *"sewage destroyer and discharge pipes"*. From 1907 onwards, it appears that the demand for auxiliary components from local mills and factories increased[43], and the Kala Bhavan obliged, taking the opportunity as one of enriching the training schedule of their students. Students from the School of Mechanical Technology easily found openings in the industrial cities of Calcutta, Bombay, Karachi, Kanpur, Allahabad, and Amritsar[44]. At the trade exhibitions organized at the industrial towns of Gujarat and the city of Bombay, the products of the Kala Bhavan, received acclaim (***) (bagging in the process a couple of medals at each of the exhibitions)[45]. A significant number of awards went to artefacts, the fabrication of which required expertise in carpentry, metal-casting, metal-work, engraving, and clockwork mechanisms[46]. Even so, these artefacts qualified more for the appellation "exotica" rather than as consumer goods meant for the indigenous market. Apparently conditions were not yet ripe enough for the entry of indigenous products, since the market was probably flooded with goods from Europe.

On the other hand, by the turn of the century, the modernization of the traditional textile industry of Gujarat was underway, and a Bombay-Baroda-Ahmedabad axis was becoming visible. This further found its reflection in an updated programme in chemical technology at the Kala Bhavan. Before discussing the discipline of chemical technology at the Kala Bhavan, and its special focus, it must be reiterated that while a whole range of professions was opening up to trainees in mechanical engineering, technological innovation was not yet at a premium.

Chemistry for the Textile Industry

The chemistry syllabus drawn up in the 1890s creates a space for the chemistry of alizarines, and a course was being offered on *"Calico Printers, Dyers and Colour Manufacturies"* [47]. The growing importance of textiles, in the textile heartland of India, is reflected in the fact that the acreage of land in Baroda state under Dhollera cotton cultivation was 168,000 acres in 1885-86, and by 1888-89 had increased to 227,000 acres[48]. The total cotton production in the Native States of Baroda, Surat and Broach was 525,000 cwt, only 25% of which was transferred to Bombay for export, the rest being processed locally.

T. K. Gajjar was a chemist who was quick to see the importance of development in synthetic organic chemistry, and what these developments entailed in the long run for the textile economy. Ray the father of modern chemistry in India, was among the first to visualize this development in terms of a connection between the laboratory and industry, but for him these issues were also becoming closely tied up with that of self-sufficiency. For Gajjar the programme of self-sufficiency, while obvious, was not vocally stated as one. The preparation of dyes like alizarine had marginalized the demand for indigo and the cultivation of the same had caused acute distress to the Indian farmer. By the 1890s India was importing alizarine worth Rs. 3.1 million (1890 rupees) annually; further, the import of dyeing and tanning materials together amounted to Rs. 7.3 million for the financial year 1896-7[49]. The new generation of Indian chemists and manufacturers felt the need to manufacture and prepare the dye in India, to ensure the growth and survival of the indigenous textile industry. The clamour for self sufficiency on the industrial front was becoming quite clear and audible as much in Bengal as in Baroda. Jeremiah W. Jenks, Professor of political science, Cornell University, and special commissioner, War Department, U.S.A., visited the Kala Bhavan, in 1902, and was to write after his visit:[50]

"I find a new industry brought into the state which may well in a few years become of great economic importance, making Baroda independent of Europe in one class of goods. The experiments in dyeing and testing of dyes may well prove of great financial advantage to the state. The work in engineering and the manual trades will serve to mark the inhabitants of Baroda more independent of foreign workmen".

The building of facilities to train technicians in chemical technology meant commencing *de novo,* since a new generation of technologies was being introduced. In the 19th century the chemical industry grew up *"in the shadow of the textile industry"*, and the gas technologies used in mills provided the material for the coal tar dyes[51]. Gajjar was able to call Professor Hugo Schumacker, from the giant dye manufacturing concern Farben Fabriken, as well as Dr. Erbehardt from Germany, to join the School of Chemical Technology of the Kala Bhavan[52]. The German university and the German chemical industry was to serve as the example for building a science-industry connection, for the early generation of Indian scientists[53]. Schumacker joined as a Professor of chemistry and chemical technology[54], and he was aided in his efforts by the chemist Maganlal Chotalal Desai from Baroda College. That The link between the Kala Bhavan and German chemical industries is not merely reflected in the equipment entering the workshops, but also in the fact that the Bombay branch of the German firm, Messrs. Leopold Cassela & Co., instituted scholarships for study at the School of Chemical Technology, Kala Bhavan[55]. In terms of patents, however, during the period 1890-1911, there is no mention of any being registered; even though products of the Kala Bhavan did win awards at some of the trade exhibitions mentioned earlier, students were proficient at producing a Turkish red dye[56], the composition of which was considered a trade secret. Though there was no dyeing industry in Baroda when the Kala Bhavan was founded, by 1911 it was turning out dye-chemists for most textile industries springing up all over India[57].

The most noteworthy feature of the syllabus and the focus of the training programme is the lack of emphasis on the pharmaceutical industry. P. C. Ray had founded the Bengal Chemical and Pharmaceutical Works by 1900[58], but at Baroda, even by 1908, there is no move towards establishing the facility for this area of the chemical industry. One can only conjecture as to why this could have been the case.

Firstly, the pharmaceutical industry was still highly dependent on the research laboratory, and not the workshop, which effectively meant relying on the skills of highly qualified chemists and pharmacologists. This was well beyond the charter of the Kala Bhavan. The Kala Bhavan, it should be realized, was not the Indian equivalent of the English or Irish manual training school that turned out[59] *"highly skilled workmen"*. It was felt at the time, that contrary to the opinion of Thomas Alexander, M. C. E., Professor of Engineering, Trinity College, Dublin, a pupil passing out of manual training school was bereft of prospects in India, since neither a trade school nor a factory would have him as an apprentice. Consequently, the Kala Bhavan and other technical institutes[60] *"must combine the functions of both a school* *and a factory"*. Thus the charter of the Kala Bhavan was quite clear. Secondly, and as a consequence of the above, the demand for qualified workmen created by an up and coming textile industry, both demanded specialization and focussed attention of the Institute.

Concluding Two Decades of the Kala Bhavan

Despite the brave efforts of *"The biggest technical institution in the Native Indian States"*, the Kala Bhavan till 1911 did not become the fount of new technologies or technological innovation. The training schedule of the Kala Bhavan, while giving attention to the process of adapting technologies from Europe to the Indian environment, did allow in a sense for Rosenbergian innovation. The movement away from the traditional artisan to the modern technician by the early decades of the 20th century was probably precipitated by a shift from the artisanal work site to the workshop. In addition, the laboratory was to prove fundamental. On examining the specificity of the chemical industry in Europe in the 19th century, it is seen that the heavy chemical industry drew largely upon academic science. This affected improvements in technique[61] and *"large scale processes derived from laboratory experiments"*. The laboratory was to become important for the Kala Bhavan much later.

The overwhelming impact of the colonial industrial system cannot be underestimated. Further, resources were a constraint in the way of infrastructural expansion of the Institute, the munificent support of the state and the resources generated by the Kala Bhavan's own factory notwithstanding. Towards the end of his report on the Kala Bhavan, the earlier mentioned Jeremiah Jenks remarks that[62]: *"India needs such trained men... and the State could not spend to better advantage than in the development of education along these practical lines"* In 1938 W. A. Jenkins prepared a report[63] on the *"Progress of Scientific Education in India During the Past Twenty Five Years"*, for the Indian Association for the Cultivation of Science. Jenkins noted that while considerable efforts had gone into research in the physical sciences, and some of it had been acclaimed abroad, a lot was desired on the industrial front. He writes:[64]

"It is the business of the commercial and industrial firms, which stand to gain by the result of research work, to make possible the building and equipping of research laboratories and the carrying out of work upon problems, the solution to which is to their advantage"

He goes on to recommend the cooperation of commercial and industrial firms for research activity. In other words, Duruy's Baconian optimism[65] that had held that the: *"wealth of industry flows like a river from its source, out of the chemists laboratory and the physicists and naturalists study"*, had grounded itself in the Indian soil as an ideological fetish *à la* Ray. In fact, Ray in unequivocal terms subscribed to the vision of wealth flowing out of the laboratory. Falling back on the success of the German chemical industry, he writes:[66]

"The history of the supremacy of the Germans in the industrial world is the history of the triumphs achieved by successive generations of silent and patient workers in the laboratory".

Yet it remained a fetish gratuitously seeking realization in the colonial environment characterized by an adverse science technology engagement.

What general and specific conclusions can be drawn about the spread of scientific knowledge, through technical institutes such as the Kala Bhavan, and what does this reflect of the social and economic history of the time? Just as the urban centers of Europe served as the metropolises for the provinces in the colonies, there appeared other metropolises and provinces in Colonial India, the former located in the Presidency towns of British India, and the latter in the Native Indian States. While the former became the focus of metropolitan science (****)[67] in India with universities, engineering and medical colleges, the Native Indian States began at the other end; viz. with technical institutes, both as part of a process of revitalizing economic activity and that of upgrading technical skills. The Kala Bhavan became the conduit, seen now as school and workshop, now as school and factory, for the transformation of the traditional Indian artisan into a modern technician, with a grounding in modern science completing and legitimizing this process of transformation.

The schools of mechanical, civil and chemical technologies offered the heaviest and most formalized courses; imparting to the students a strong grounding in most aspects of mechanics and modern chemistry. During the early years of the Kala Bhavan, mechanical technology was a course that had a high demand, given the large space created for newly skilled workers by the introduction of the boiler and gear technology. With the growth of the Bombay-Baroda-Ahmedabad textile axis, and the economic infeasibility of using natural dye-stuffs following the synthesis of alizarine, courses in chemical technology were upgraded to meet the requirements for small dye industries being set up in India, and to furnish skilled professionals for the textile industries. Though the adaptive skills of the faculty and students at Kala Bhavan, in conjunction with the Swadeshi (home made) impulse(*****)[68], catalyzed the processes for the acculturation of modern technology in the Indian environment, the process of innovating with these technologies had not yet been unleashed, at least during the first two decades of the history of the Kala Bhavan. What was accomplished was the transition from the traditional apprenticeship into the factory system, a process stamped in turn by natural knowledge of the post-Galileo era.

Dhruv RAINA, *National Institute of Science, Technology and Development Studies, New Delhi*
S. Irfan HAHIB, *National Institute of Science, Technology and Development Studies New Delhi*

Notes

* Rothblatt differentiates between the doers of science and the purveyors of science. The latter include popular science lecturers, instrument makers, writers of best selling texts, compilers of almanacs, and provincial literary and philosophical societies; cf note 2.
** A case in point is the chemist P. C. Ray's address to the Bengal Literary Society, *The Place of Science in the Vernacular Literature,* that offers a critique of Bengali classicism from the standpoint of modern science[10]. Ray prefaces his argument with a quotation from Buckle: "... during the thirty years preceding the Revolution the spread of the physical sciences was so rapid that in its favour the old classical studies were despised". *Ibid,* p.132.
*** A detailed investigation of these trade exhibitions would in turn reveal, in the Indian context, less studied aspects of science, technology and culture. Plum has pointed out that industrial exhibitions in a way[45] "anticipated modern ideas of cultural history as an interdisciplinary study of society ...".
**** According to MacLeod, science as practiced in the metropolis was based on the activities of learned societies, small groups of cultivators and certain conventions of discourse[67].
***** At an industrial exhibition organized at Baroda in 1917, Ray called[68] upon *"enterprising organizers"* to undertake the setting up of pharmaceutical works, and install facilities for producing organic dye stuffs, to off set the shortage in supply during the war years, "this cause aided by our Swadeshi awakening, that has made us feel the necessity for developing our chemical industry".

[1] B. Parshad (ed.), *The Progress of Science in India During the Last Twenty Five Years,* Indian Association for the Cultivation of Science, 1938, p.38.
[2] Sheldon Rothblatt, "The Notion of an Open Scientific Community", in Michael Gibbons, Bjorn Wittrock (eds.), *Science as a Commodity,* Longman, 1985, 21-75.
[3] *The Dawn and the Dawn Society Magazine,* Feb. 1911, p.34. This magazine will hereafter be referred to as *The Dawn.*
[4] Lewis Pyenson, "Pure Learning and Political Economy: Science and European Expansion", in R. P. W. Visser, H. J. M. Bos, L. C. Palm, H. A. M. Snelders (eds.), Pro-

ceedings of the Utrecht Conference, *New Trends in the History of Science*, Amsterdam, 1985, p.277.
[5] V. K. Chavda, "Development of Science Education and Growth of Scientific Institutions in the Native State of Baroda in the 19th and 20th Centuries", *NISTADS Seminar on Science and Empire*, New Delhi, 1985, p.4.
[6] *Ibid*, p.1.
[7] *The Dawn*, Jan. 1911, p.11.
[8] *The Dawn*, June 1911, p.97.
[9] Makrand Mehta, "Institution Building in Princely India: a Case Study of the Polytechnic Institute Baroda, 1890-96" in *Proceedings of the Indian History Congress*, Fifth Session, 1984, p.670.
[10] P. C. Ray, *Essays and Discourses*, Madras, 1918, p.122-137.
[11] *The Dawn*, Feb. 1911, p.30.
[12] Mehta, *op. cit.*, p.671.
[13] *The Dawn*, June 1911, p.97.
[14] Mehta, *op. cit.*, p.670.
[15] *Ibid*, p.674.
[16] *The Dawn*, Feb. 1911.
[17] Chavda, *op. cit.*, p.7.
[18] *The Dawn*, April 1911, p.63.
[19] *The Dawn*, Jan. 1911, p.12.
[20] *Ibid*, p.12.
[21] *Ibid*, p.12.
[22] *The Dawn*, March 1911, p.12.
[23] *Ibid*, p.12.
[24] *Ibid*, p.12.
[25] *The Dawn*, Jan. 1911, p.12-13.
[26] J. D. Bernal, *Science and Industry in the 19th Century*, Routledge and Kegan Paul, 1953, p.10. See also Michael J. Moravcsik, *Minerva*, xxvii, 1, 1989, 20-32.
[27] Chavda, *op. cit.*, p.14.
[28] *Ibid*, p.14.
[29] *Ibid*, p.15.
[30] Mehta, *op. cit.*, p.674.
[31] *The Dawn*, June 1911, p.97.
[32] Mehta, *op. cit.*, p.674.
[33] *The Dawn*, May 1911, p.88.
[34] Mehta, *op. cit.*, p.674.
[35] S. Ambirajan, "The Content of Science and Technology: Education in South India During the Colonial Period", *Indo-Australian Seminar on Science Under the Raj*, New Delhi, 1988, p.17.
[36] N. Rosenberg, "Marx as a Student of Technology" in L. Lavidow, Bob Young (eds.), *Science, Technology in the Labour Process*, London, p.16.
[37] *The Dawn*, Jan. 1911, p.12.
[38] *The Dawn*, Feb. 1911, p.30.
[39] *Ibid.*, p.34.
[40] *Ibid.*, p.30.
[41] Chavda, *op. cit.*, p.7.
[42] *The Dawn*, March 1911, p.55.
[43] *Ibid.*, p.56.
[44] Mehta, *op. cit.*, p.675.
[45] Werner Plum, *World Exhibitions in the 19th Century: Pageants of Social and Cultural Change*, Federal Republic of Germany, 1977, p.154.

[46] *The Dawn*, May 1911, p.88.
[47] Chavda, *op. cit.*, p.16.
[48] George Watt, *A Dictionary of the Economic products of India*, **vol.4**, 1890, p.G.453.
[49] Annual Statement of the Trade and Navigation of British India with Foreign Countries, quoted in P. C. Ray, "Scientific Education in India" (1899), in Ray, *op. cit.*, Madras, 1918, p.6.
[50] *The Dawn*, June 1911, p.98.
[51] Bernal, *op. cit.*, p.27.
[52] *Ibid.*, p.97
[53] S. Irfan Habib, Dhruv Raina, "Copernicus, Columbus, Colonialism and the Role of Science in 19th Century India", *Social Scientist*, 190-191, 1989.
[54] Chadva, *op. cit.*, p.7.
[55] *The Dawn*, Feb. 1911, p.97.
[56] Mehta, *op. cit.*, p.674.
[57] *The Dawn*, June 1911, p.97.
[58] Manoranjan Gupta, *Prafulla Chandra Ray: A Biography*, Bombay, 1971, p.105.
[59] *The Dawn*, March 1911, p.54.
[60] *Ibid.*, p.55.
[61] Bernal, *op. cit.*, p.33.
[62] *The Dawn*, June 1911, p.98.
[63] W. A. Jenkins, "Progress of Scientific Education in India During the Past Twenty Five Years", in B. Parshad (ed.), *op. cit.*
[64] Jenkins, *op. cit.*, p.16.
[65] H. W. Paul, *From Knowledge to Power: The Rise of the Science Empire in France, 1860-1939*, Cambridge University Press, 1985.
[66] Ray, *op. cit.*, p.4.
[67] Roy MacLeod, "On Visiting the 'Moving Metropolis': Reflections on the Architecture of Imperial Science", *Historical Records of Australian Science*, Camberra, **vol.5**, n°3, 1982.
[68] P. C. Ray, "Possibilities of Chemical Industries in India", *op. cit.*, p.64.

APPENDIX 1

Discipline	Training Schedule	Auxiliary Subjects	Job Openings	Diploma Awarded
mechanical technology	-pattern making -casting -smithery -fitting -turning on lathes and machine tools	-heat -electricity -magnetism -steam engines -applied mechanics -machine drawing -mechanical technology	-qualified foremen -managing mills and factories -maintenance of engines and boilers of different descriptions	Licenciate of Mechanical Technology(LMT)

APPENDIX 1 (continued)

Discipline	Training Schedule	Auxiliary Subjects	Job Openings	Diploma Awarded
chemical technology	-dyeing and bleaching -calico printing to Egyptian style	-organic and inorganic chemistry (practical and theoretical) -chemistry of coal tar and technology	-efficient dyers -chemists -other areas of chemical industry	Licenciate of Chemical Technology(LCT)
architecture	-building materials -building construction -earth work -road making -surveying	-general physics -heat -magnetism -carpentry -drawing	-draftsmen -surveyors -oversears in PWD and municipalities -independent architects and contractors	Licenciate of Architecture (LCA)
weaving technology	-theoretical and practical training in handloom and power loom weaving -finishing textile fabrics -preparation of looms		-managers and weaving masters in cotton mills and factories	Licentiate Weaving Technology (LWT)
commercial technology	-book keeping -accounting -banking and currency - machinery of business	-commercial history and geography -commercial law -elementary economics	-employment in business concerns	Licentiate of Commercial Technology (LCT)
art	-drawing, photography, modelling -architecture, engraving -photo-mech-anical pro-cess work		drawing teachers -draftsmen -artists for arts manu-facturers	Licentiate of Arts (LA)

APPENDIX 2

MECHANICAL TECHNOLOGY	DYEING AND CHEMICAL TECHNOLOGY	WEAVING TECHNOLOGY
LAW, Applied Mechanics JORDAN, Applied Mechanics. GOODEVE, Elementary Mechanics GOODEVE, Mechanisms DUCAN, Applied Mechanics DUNCAN, Steam Engine GOTTERIL and SLADE, Applied Mechanics RIPPER, Steam Engine GHASKADAVI, Notes on Steam and Steam Engines SHELLEY, Machine Drawing JONE, Machine Drawing BHARUCH, Mill Engine Boiler and Gearing REED, Handbook for Engineers CASTLE, Machine Construction	BENEDICT-KNECHT, Chemistry of Coal Tar MANJUSHA SERIES Chemistry of Dyeing HUMMEL, Dyeing of Textiles Fabrics KNECHT and RAWSON, Systematic Colouring of Organic Colouring Matters GEORGIVCS, Chemistry of Dye-Stuffs CAIN and THORPE, Synthetic Dye-Stuffs ANTONIO, Dyeing ANTONIO and SAUSONNE, Calico Printing DUERR, Calico Printing	FOX, Mechanics of Weaving TAYLOR, Cotton Weaving and Dyeing BRAHMABHAT, Weaving Calculations FRAP, Manual of Dyeing

Latin American Countries

THE FIRST CHAIR OF CHEMISTRY IN MEXICO (1796-1810)

Patricia ACEVES

In this paper we shall analyze the principal features of the chair of chemistry in the Royal School of Mining *(Real Seminario de Minería)* during the period 1796 to 1810. To this end we shall discuss those aspects related to theoretical and methodological concept of the chair and references to its functioning. Other points which will be emphasized are the economic, political and ideological factors which intervene in the events included in this study. In our analysis we shall try to articulate an integrated vision of this particular case of the complex process of diffusion-reception of European science.

The documentation we present in what follows comes, for the greater part, from the historical Archives of the *Palacio de Minería* (Mexico City), from sources hitherto unexploited by 20th century historians.

The Royal School of Mining

The diffusion of "modern" science within New Spanish society in the last third of the 18th century occurred in a context of economic and cultural renewal, to which contributed a series of political, economic, social and cultural factors stemming from the local situation as well as from the Spanish Crown.

As part of the former, we note that the reigning dynasty in Spain had implemented a set of reforms with the aim of strengthening the state, replying to the disquieting situation of the metropolises, and protecting its colonies from the interests of other European nations.

Within this body of policies aimed at the transformation of various sectors (administration, economy, hygiene, military, scientific and technological education) mining, as the principal source of income for the Crown, received special attention[1]. To understand the interest for

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this branch, it is sufficient to remark that New Spain was the major producer of silver in the world, providing 66% of total production[2].

These actions took place in an enlightened atmosphere. Throughout the entire territory, the local creole *élites* took an interest in scientific and technical progress, which they tried to defend and to apply not only in the solution of problems of their society, but also in the revaluation of the natural environment, the inhabitants and the production of Latin America.

The New Spain creoles, inheritors and renovators of a rich scientific-cultural tradition, took an active part in colonial life, though one not always free from conflicts since often the defense of their interests did not coincide with the projects of the metropolises[3].

In the case of the foundation of the Royal School of Mining, the interests of the mining *élites* coincided with those of the Crown[4]. Both parties recognized that the lack of organization and of scientific boundaries in the area of mining demanded a solution. In 1774 Joaquín Velázquez Cárdenas de Léon and Lucas de Lassaga sent a Petition *(Representación)* to Carlos III in the name of the New Spanish miners, asking for the creation of a Mining Tribunal, a Loaning Bank and a College of Mines to educate their children. In response to the demands of the petition new Mining Ordinances were approved in 1783.

On the deaths of Joaquín Velázquez Cárdenas de Léon and of Lucas de Lassaga in 1786, the Spanish Crown unilaterally decided to send Fausto de Elhuyar to substitute for the former as Director of the Mining Tribunal[5]. Elhuyar landed, along with eleven German technicians[6], in 1788, with the mission of setting up the College, of evaluating the works in the mines, and of investigating the possible application of Born's method[7].

The Royal School of Mining opened its doors on January 1st, 1792, with the intention of preparing individuals to direct the work of the mines as well as the exploitation of metals in those metal-poor minerals normally thrown away.

The studies to be undertaken by the future experts during their four years at the School included courses in mathematics, physics, theoretical and practical chemistry and mineralogy. Besides these subjects the students studied French, drawing, Latin and grammar[8].

At the end of these studies there followed two years of practical experience in the real principles of mines and the submission of a thesis. After these conditions were met came the professional examination before the professors of the School and in the presence of the Royal Crown.

The courses in the School were free for the twenty boarding students foreseen in the statutes, but paying for the external students. This establishment, independent of the Royal and Pontifical University, depended on the King and the Royal Mining Tribunal. The Chairs were occupied by lay professors and the courses were theoretical and practical in accordance with the most modern theories and textbooks.

Jointly with their scientific education, the students were obliged to follow a rigorous religious course of study and to learn the manners, forms of thought, fashions and customs of the Court. In short, it was a question of an integrated education, directed to the formation of true academic and technical functionaries at the service of the Court.

Another important feature of the science practiced in this institution was the marked State character. The State intervened in a decisive manner in the diffusion and institutionalization of new knowledge and practice. To ensure these ends it allotted economic resources, created an institutional and juridical framework, and chose the professors, the curriculum, the pedagogical methods, the textbooks and the social space within which knowledge was to be applied[9].

The Chair of Chemistry

The first course of chemistry was given in 1797 by Fausto de Elhuyar, assisted by Franz Fischer and the pharmaceutical officer, Juan Garcia. The contents were restricted to the mineral kingdom and in accord with the principles of modern chemistry.

The invitation to the end-of-year ceremony announced that the three most outstanding students would speak on the particular properties *"of the various substances that nowadays are considered simple as well as those which are called composite"*, and that these matters would be treated according to the new theory of Lavoisier *"founded on the most rigorous and suitable analytic demonstrations"*. The public was also informed that there was now to be found on sale, in the house of the Royal Tribunal agent, a subscription for the Spanish translation of the first volume of Lavoisier's *Traité élémentaire de chimie,* - the *Tratado elemental de química* -, pending the publication of the second volume[10].

The name of the translator does not appear on the title page of the first volume of the *Tratado.* He has remained anonymous for nearly two hundred years. Recently, however, we had the opportunity to unveil his identity[11] on the basis of data found in the *Monthly Account Books of the School of Mining (Libros de Cuentas Mensuales del Colegio de Minería)* for the years 1796 and 1797[12]. In them is registered the fact that it was Vicente Cervantes, professor of botany in the Royal Botanical Garden of Mexico City, who first translated the new chemistry into Spanish. The copyist who helped him was José Rojas, the plates were made by Manuel López and the book was prepared for printing by Manuel Valdéz[13].

It should be mentioned that this find is of major interest for the history of chemistry. On the one hand, it permits the establishment of new connections between the Royal School of Mining and the Royal Botanical Gardens of Mexico City and, on the other, it sheds a new light on the role played by Cervantes in the diffusion of Lavoisier's chemistry[14].

As for the second volume of the translation of the *Tratado elemental de química,* we do not know if it was ever printed, despite the fact that Andrés del Río, in the Introduction to his edition of Karsten's *Tablas mineralógicas,* published in 1804, claimed that it was to appear imminently. Until now, the only clue we have found of the existence of the second volume of the *Tratado* is in the Monthly Account Book for 1804. There is recorded a payment of a small sum of money to Nicolás Irigoyen[15] (the same who, in that year, was copyist for the second part of Rio's *Elementos de Oritognosía), "for the copy of the second volume of Lavoisier's chemistry".*

Concerning the diligence of the students who took his course, Elhuyar informed the Viceroy that only thirteen of the twenty students registered revealed themselves apt to continue the study of metallurgy and ultimately to practice it in the royal mines[16].

The chemistry course of 1798 was directed by Ludwig Lindner - who had been named temporary professor, pending the arrival of the professor from Spain -, assisted by José Rojas. On this occasion, the subject matter was at a level equivalent to that of the previous year[17].

The contents of the course for 1799 reached a higher level. This is shown by the information given in the invitation to that year's final ceremony, during which the students spoke of caloric, following the demonstrations of Seguin and Laplace; of substances in the gaseous state; of combustion, oxidization and detonation of inflammable and metallic substances; of acids of the first, second and third degree of oxygenation; of the separation of gold and silver in nitric acid; and of the theory of affinities[18].

In 1800 there were no students since in 1798 the duration of the mathematics course had been extended from one year to two. In 1801, Ludwig Lindner taught, assisted by the substitutes Manuel Ruiz de Tejada and Manuel Cotero. There was no course in 1802. In 1803, Ludwig Lindner gave the complete course for the last time since he fell ill in 1804 and the responsibility passed to Manuel Cotero who continued in the following years. The final ceremonies of 1810 were canceled on account of the disorders provoked by the insurgency movement. In 1811, the lectures were interrupted by the removal of the School to its new building in which the laboratories were not yet finished.

Concerning the textbooks used in the course, the consultation of the *Inventory Lists of the School (Libros del almacén del Colegio)* allow us to compose a list of the chemical texts which the students could acquire (see Table 1).

Of the 15 titles in Table 1, only four are not by French authors. It should be noted that both Lavoisier's *Tratado elemental de química* and the *Elementos de química* by Chaptal were used simultaneously as textbooks and that their demand was minimal between 1808 and 1810. During those thirteen years, books arrived on only four occasions, and between 1804 and 1810 no new texts came in.

During these years, the diffusion of scientific works was blocked by the wars among the European powers; a situation which led to delays and even the total loss of shipments of books and scientific instruments, when the ship in which they were transported fell into the hands of the enemy. This last was the fate that befell 30 copies of the Spanish translation of the *Traité* ordered in 1798. Because of this, it was not until 1803 that a second shipment safely arrived at its destination[19].

The *Inventory Lists of the School* also give an account of the chemical reagents used in the period under study. It will be observed that the new chemical nomenclature was not used in the registry of substances (see Table 2).

In addition to chemicals mentioned in Table 2, the following were regularly purchased for laboratory work: snow, *tequesquite,* ether, vinegar, mercury, iron and copper filings, nitric acid, charcoal of oak and torch pine, quicklime, muriatic acid, frogs and chickens.

For the instruments and apparatus necessary for the chemical laboratory, Ludwig Lindner, in 1799, sent to Elhuyar the following list of materials, lacking in his course[20]:

1. A machine for the constitution of water.
2. Bell jars and beakers with stopcocks.

TABLE 1
Stocks of Chemistry Textbooks Inventoried in the School
Period 1797-1801

Year	1797	1798	1799-1801
Química by Duhamel	1	1	
Diccionario by Bomare	6	6	
Química by Baumé	3	3	
Diccionario de química by Macquer	4	4	
Ensayos sobre el aire puro	1	1	
Opúsculos químicos by Bergman	2	2	
Aguas minerales by Duchanoi	1	1	

Period 1802-1810

Year	1802	1803	1804	1805	1806	1807	1808	1809	1810
Elementos de química by Chaptal	45	39	34	31	31	20	13	13	12
Elementos de historia natural by Fourcroy	6	5	4	4	4	1	1		
Nuevo beneficio de los metales by Garcés (Mexico)	24	18	14	10	10	23	19	21	20
Método de nomenclatura química by Morveau, Lavoisier, ...		1							
Tratado de afinidades químicas by Bergman		1							
Memorias y observaciones de química by Fourcroy		1							
Ensayo sobre el flogisto by Kirwan		1							
Tratado elemental de química by Lavoisier, en 2 tomos (Madrid)			24	21	21	10	3	3	1

Source: APM, "Libros del almacén del Colegio de Minería", 1797-1810.

TABLE 2
Reagents consigned to the stockroom of the School (1804-1810)

White Vitriol	Verdigris	Sheet Zinc
Manganese	Ammoniacal Salt	Blue Vitriol
Yellow Sheet Brass	Borax	Iron Blue
Iron Wire	Putty Powder	Hematite Stone
Ammonium Bitartre	Emery	Oil of Alavandine
Crude Tartar	Potash	Oil of Vitriol
Gall	White Arsenic	Tripoli
Calamine Stone	Red Arsenic	Bismuth
Tincal	Yellow Arsenic	Alum
Zaffer	Sugar of Lead	

Source: APM, "Libros del almacén del Colegio de Minería, 1804-1810.

3. Tubular bell jars and beaker with their leather cases.
4. A beaker with an electrical apparatus for combining gases.
5. A gasometer.
6. Apparatus or bellows for melting by means of oxygen.
7. A eudiometer.
8. A Voltaic pile.
9. Trial balances.
10. A blowpipe for assaying mineral samples.

The preceding eliminates the hypothesis made by some authors that, prior to 1799, the chemical laboratory was equipped with the apparatus that appear in the Lindner petition[21].

As for the applications of the knowledge acquired in the classroom, it has already been mentioned that the students were supposed to work in the country's mines the for two years. During this period, 35 graduates lent their services to the mines of Guanajuato, Zacatecas, Catorce, Taxco, Sombrete, Surango, Real del Monte and Mina de Jesús.

It must be said that this number concerns only the boarding and scholarship students. However, the number of students who graduated from the School was much greater.

It is not surprising that many abandoned their studies for a variety of reasons: some because of sickness, others due to lack of support, or because they had to go to work in the family mines; it even occurred that some simply fled.

Boarding students paid an annual tuition of two hundred pesos and, in certain years, exceeded the regulatory number of 20 scholarship students. For the years from 1806 to 1810, the former reached the totals of 20, 22, 28, 12, and 13 and the latter, 21, 19, 22, 27 and 19.

To these students must be added the amateurs who regularly attended classes in chemistry and professionals from other areas, like surgeons and pharmacists. Thus the total level of attendance was really much higher.

Final Commentary

In the period under study, the chair of chemistry showed a marked French influence and, internally, adopted and diffused the new theories.

We would like to emphasize that, as a result of the degree of development of the society of New Spain, particularly in the mining sector, the necessity arose for a reorganization of mining as a whole, at a date much earlier than the founding of the Royal School of Mining. Moreover, the concept of such an establishment had its origin in a local initiative to achieve a major advance in the institutionalization of mining.

In this way, once the School was established, the level of development permitted and assured the permanence of the institution until the end of the colonial period - and even into independence.

An analysis of the chair of chemistry shows that there was no lack of situations in which functional obstacles arose: the lack of a professor, books, instruments and a budget. However, teaching continued, as in the other cases of chairs in the Royal School of Mining; alternate solutions were found thanks to the combined efforts of Spaniards and New Spaniards.

Thus, Elhuyar was obliged to teach the first course of chemistry in the absence of the Spanish professor who never arrived; he, in his turn, was replaced by Ludwig Lindner. Finally, on the death of the German, the teaching post fell to the New Spaniard, Manuel Cotero. It should be pointed out that in the other departments as well, teaching was assumed by people of New Spain.

In the face of the lack of books coming from Spain, the translation of foreign works and the elaboration of national texts were undertaken. Although this work consumed important resources and a good deal of time, the Mining Tribunal granted the funds necessary for their completion.

Moreover, the chair could count on the support of officials external to the School, such as Cervantes, Humboldt, Sessé, Sonneschmidt and others who contributed by making available books, instruments, reagents, collections and, as was the case for Cervantes, translations.

One must not lose sight of the fact that instruction in the School was integrated into a powerful and numerous community; there thus was no lack of young candidates with the preparation necessary to be accepted, nor of subsidies to permit the School to continue functioning. We might mention in this respect that the annual budget for the years 1800-1808 held constant at about thirty thousand pesos.

The foregoing allows one to understand why the School of Mining was able to continue and to give birth to other institutions, which have lasted until today.

Finally, although the School formed young men with a program guided by the designs of the Crown, this did not prevent five graduates from fighting and dying in the cause of independence in 1810 and 1811. It is worth mentioning the curious fact that all of them had been chosen to participate in the graduation exercises of the chair of chemistry[22].

Universidad Autónoma Metropolitana (Xochimilco), Mexico

Notes

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[1] Saldaña, Juan-José,"The Failed Search for Useful Knowledge: Enlightened Scientific and Technological Policies in New Spain" in Saldaña, J. J. (ed.), *Cross Cultural Diffusion of Science: Latin America* (Cuadernos de Quipu 2), SHLCT, Mexico City, 1988.

[2] Florescano, Enrique & Gil, Isabel, "La época del crecimiento económico y las reformas borbónicas 1750-1808" in *Historia general de México,* El Colegio de México, Mexico City, 1976.

[3] Aceves, Patricia, "La difusión de la ciencia en la Nueva España en el siglo XVIII: la polémica en torno a la nomenclatura de Linneo y Lavoisier", *Quipu: Revista Latinoamericana de História de las Ciências y Tecnologia* **vol.4,** n°3, 1987, p.357-385.

[4] Brading, David, *Mineros y Comerciantes en el México Borbónico 1763-1810,* Fondo de Cultura Económica, Mexico City, 1975.

[5] Fausto de Elhuyar and his brother Juan-José were known in the principal centers of Europe for their studies in metallurgy. To finish their studies they undertook in Spain a series of works which led them to the discovery of tungsten. Fausto de Elhuyar remained as Director of the Royal School of Mining until 1821 when the personnel of the establishment took the Oath of Independence.

[6] Among the eleven German technicians were the mineralogists Frederick Sonneschmidt, Franz Fischer, Ludwig Lindner and the mine engineer Karl Gotlieb.

[7] The history of the Royal School of Mining can be found in: Izquierdo, José-Joaquín, *La primera casa de las ciencias en México,* Ediciones Ciencia, Mexico City, 1958.

[8] The first professors were: Andrés José Rodríguez (mathematics), Francisco Bataller (physics), Andrés Manuel del Río (mineralogy), and Ludwig Lindner (chemistry).

[9] A case study on the State character of metropolitan science is presented in: Aceves, Patricia, "La difusión de la química moderna en el Real Jardín Botánico de México", Master's thesis, UNAM, Mexico City, 1989.

[10] Archives of the Palacio de Minería (APM): "Oficios, informes y consultas relativas al Seminario Nacional de Minería de Nueva España", 1798, f°154.

[11] Aceves, Patricia, "La introducción y difusión de la química de Lavoisier en México (1788-1800)", (lecture given before the Mexican Society for the History of Science and Technology, November 15, 1989 at Mexico City), *Actas de la Sociedad Mexicana de Historia de la Ciencia y de la Tecnología,* **vol.1,** 1989.

[12] APM: "Libros de cuentas mensuales del Colegio de Minería", 1796 and 1797.

[13] The dates for the editions published in Mexico City and Madrid are: - Lavoisier, A. L., *Tratado elemental de chimica,* translated into Spanish for the use of of the Royal School of Mining of México, volume I, Mexico City, Mariano Zuñiga y Ontiveros, 1797. - Lavoisier, A. L., *Tratado elemental de química,* translated into Spanish by Juan Manuel Muñariz, volumes I & II, Madrid, Imprenta Real, 1798.

[14] Vicente Cervantes arrived in México in 1787 with the Royal Botanical Expedition. In 1793 and 1794 he published, in the *Gacetas de literatura,* the first two research articles in Mexico in which Lavoisier's chemistry was applied. He died in Mexico City in 1839.

[15] APM: "Libros de cuentas mensuales del Colegio de Minería", September 10, 1804. The payment received by Irigoyen on this date was 10 pesos, one and one-half reales.

Such a sum appears negligible compared to the 311 pesos, 44 reales received by José Rojas for the first volume.
[16] APM: "Oficios, informes y consultas relativas al Seminario Nacional de Minería de Nueva España", 1798, f°163.
[17] *Op. cit.*, f°188-189.
[18] *Op. cit.*, f°222-223.
[19] APM: Documento 41,1802.3
[20] APM: "Oficios, informes y consultas relativas al Seminario Nacional de Minería de Nueva España", 1799, f°218.
[21] Among the historians who support this point of view is José-Joaquín Izquierdo. See *La primera casa de las ciencias en México...*, p.116.
[22] Their names are: Casimiro Chovell, Mariano Jiménez, Rafael Dávalos, Ramón Fabié and Isidoro Vicente Valencia.

TRADE AND THE NATURAL SCIENCES IN THE UNITED STATES OF COLOMBIA

Diana OBREGÓN

In the United States of Colombia between 1863 and 1886 - when an enlightened *élite,* belonging to the radical wing of Liberalism, held power - there was a great interest in the study of science and technology. Several scientific institutions were created. We shall see how this was possible and in what way socially justified.

Participation in the World Market

During the second half of the 19th century, and well into the 20th, the doctrine of free trade was dominant within the *élite* of Colombia. But it was the Radical period more than any other which took this theory for an unquestionable truth. It was considered a certainty that the only way of joining the general current of civilization was to fully participate in world trade. It was a question of benefitting from comparative international advantages; hence the febrile search for export products. The Colombian economy at the end of the century was an essentially agricultural and autarchic one, and its level of technical development was very low. Despite this precarious situation, this period was characterized by the entry of the country into world trade through its exports of raw material[1].

Scholars of the natural sciences found an ample justification for their activities in the free trade ideology: the study of Nature continuously offered new resources for commerce. Of course, the discourse of free trade was not exclusively created to this end, but rather, as members of the *élite,* natural science enthusiasts shared this ideology; one which dominated the cultural, political and economic panorama of the period and, as such, possessed a high social status. Those interested by the sciences used, with relative success, the argument of foreign trade to try and legitimate their scientific activity. Given the circumstances, this justification showed itself to be very appropriate.

Indeed, the search for products for export is shown very clearly in the scientific literature. The "doctor-naturalists" of this period did not limit themselves to investigations only of quinines, tanin and other export products, but also elaborated a discourse which contributed to the legitimation of the agro-export model - seemingly the only valid one for

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the time, given the conditions in the country. Actually, towards the end of the century when this model had already entered into crisis, allusions to the necessity of studying natural products in order to provide the trade of the Republic with new export items had become less and less frequent in the scientific journals. On the other hand, the "doctor-naturalists" personally took on tasks sponsored by the Ministry of the interior and related to foreign trade, such as classifying, for purposes of import duty, medicinal and chemical products coming from abroad[2].

Economic historians have recorded how, despite the relative boom in exports between 1850 and 1882, Colombian foreign trade was very weak compared to that of other countries in Latin America. This fact lent even greater importance to the ideological aspects of the export mentality and to the great value placed on the outside world that went along with it, insofar as exporting also meant importing luxury items to be consumed by the *élite*. This ideology continued independently of the cycles of rise and fall of the foreign sector of the economy.

Nevertheless, the agro-export economy, due to its particular characteristics of "speculative production" gave rise neither to a developed technology nor to scientific advance. In fact, merchants limited themselves to profiting from comparative advantages and conjunctural situations at the international level. This produced a cycle of exceptional prices accompanied by a sudden expansion, then followed by a definitive paralysis of the production in question. The successive cycles for quinine, indigo, tobacco and rubber, among others, have been studied in detail and it has been found that all of them obeyed these movements of momentary expansion, followed by decline. Businessmen simply exploited forest products (dividivi, ivory, nut palm, precious woods), without cultivation or technological innovations, and, above all, without worrying about resource preservation. For example, forests of quinine were pitilessly pillaged[3]. Thus, agro-export trade did not give rise to a permanent interest in scientific research. This is confirmed by an examination of the articles on natural resources in the scientific journals. These limited themselves to describing their basic characteristics, the areas in which they could be found and, in some cases, the best means of harvesting and transporting them; there was no continuity in the subjects nor accumulation of knowledge[4]. The result was a superficial interest in a science of classification and description, and a total neglect of any techniques more directly aimed at transformation. A permanent search for new natural products became indispensable since the commercial success of each product was only temporary. But, despite the interest of a few, it was impossible during this period to set up schools of agriculture or to diffuse technical knowledge since the characteristics of the agro-export firms did not stimulate the application of scientific knowledge to production[5].

Trade and participation in the world market were seen as privileged means for the development of the country at all levels. An opening toward, and contact with, the outside world was synonymous with progress and civilization. For the *élite,* the image that the "civilized world" had of Colombia was a question of prestige; even the desire to imitate modern bourgeois institutions obeyed the need to appear an enlightened country. Therefore, the only escape from isolation lay in the reinforcement of the links connecting the country to the wheels of international trade. However, this integration into the world economy, which appeared equally to be the destiny to which the nation was called, was not exempt from risks. There was the fear of contagious illnesses arriving by sea, a fear of contamination which was not due exclusively to a knowledge of pathogenic agents but which carried a symbolic charge as well. It was linked to fear of the unknown, anxiety in the face of ongoing social transformations. To participate in a world market was to confront threats of a cultural nature. For the intellectual and political *élite,* "contact" with the outside world produced a certain ambiguity since it could also be a source of "contagion".

The Scientistic Movement

The passion displayed for science by political leaders had all the characteristics of a "scientistic" movement[6]. Science, it was claimed, had produced a *"revolution in the nature of all human societies"* and they ardently desired to participate in it. They claimed implicitly to be extending the norms of science, its universality in particular, to areas of culture, such as politics, religion and ethics; in scientific knowledge and in its applications to different areas of social life, they saw a solution to all problems. In fact, they were bent on seizing the monopoly on education from the Church and believed that social transformations would follow educational reforms.

The National University of the United States of Colombia was created in 1867, where a great importance was laid on studies applicable to agriculture, mining and industry. In 1871, the Academy of Natural Sciences was founded, with the object of increasing and preserving the collections of the Museum of Natural History and promoting research in the physical and natural sciences in Colombia. The University was formed on the basis of four already existing Schools: literature and philosophy, law, engineering and medicine. The contribution of the founders of the University was the creation of a School of Natural Sciences, destined for the study of natural resources, and a proposal for a School of Arts and Crafts which would have as its aim the training of a labour force that would be employed in a future industrial development. This development would sprout up as though by magic once an association for the manufacture of sulfuric acid would be installed[7].

Among Radicals, the language of laissez-faire was not at variance with the idea of protection of industry. They pointed out the benefits which would accrue to manufacturing industry from the improvement in production procedures with the application of chemistry in particular. In the face of financial difficulties in creating the School of Arts and Crafts, the lack of money for the construction of workshops and for the purchase of machinery, the choice was made to give evening lectures to artisans. In fact conditions were not ripe in the country for an industrial revolution. Behind the affirmations on the importance of "improving men" by means of science, there lay hidden the interest of the *élite* to exercise an effective control over the artisans, viewed as a menace since they constituted an important pressure group. Indeed the latter felt threatened by the implantation of the economic model of free trade and opposed it at various times in the 19th century[8].

Science and scientific education were seen as a mean of transcending party political activity; they represented a truly national interest situated above political and regional struggle. Science was a kind of neutral space in which Liberals and Conservatives could meet. Fights in political circles had no influence within the university and professors and directors were drawn from all political parties. The country was very dispersed; the different regions found themselves isolated from each other through lack of communication routes and thus lacked a unified market. Formally the nation existed, but internally it was torn apart by marked local differences encouraged by regional *élites* owing obedience to distinct political and religious loyalties. The enormous fragility of the institutions, the economic and political weakness of its ruling classes, a large scale regional fragmentation, made of Colombia an unstable country in permanent crisis. The four civil wars that took place between 1876 and 1902 are an indication of this situation[9].

The lack of national symbols was clear. The radical *élite* thought of schools and universities as the means of creating civic loyalties and resolving the problems of national unity. Intellectuals linked to power in this period believed that in public education and science they had found a means of national unification. It was indispensable that enlightenment spread to the last inhabitant of each region; in this way a citizenry loyal to the federal union would be created[10].

The Problem of Institutionalization of Science

There was little social differentiation in Colombian society in the second half of the 19th century. The *élite* engaged in multiple activities, among them science. This was just one more luxury - to be exercised by those who had the time for it - beside university or secondary school teaching, professional activities, business, trade, politics, liberal arts and poetry. By the very nature of the society, these businessmen, scientists, doctors, naturalists and teachers were obliged to follow a certain type of unstable and diversified behavior. The adventurous spirit of enterprise, be this economic or cultural, was dominant.

Thus, since the scientific organizations discussed above had no lasting existence; the process of institutionalization of science could not consolidate itself nor could a scientific community form. In twelve years, the school of natural sciences succeeded in graduating only eight students and was reabsorbed into the school of medicine where it occupied an even more secondary place in official preoccupations. The academy of sciences disappeared without a trace and the national university was virtually dismembered. The society for medicine and the natural sciences was converted into an academy of medicine, more concerned with the professionalization of medicine than with scientific research. Science was a marginal activity for the *élite,* whose principal interest was politics; thus the social role of scientist existed only as a part of other social roles: doctor, lawyer, engineer, teacher.

Although commerce and its corollary, the politics of free trade, yielded a justification for science in complete accord with the values and norms in force in society, these same social characteristics prevented this argument from becoming a true legitimation of scientific activity. As we have seen, the progress of the country and the contribution of scientific and technical education to national unity were also used as valid reasons to obtain support for science. But, in reality, the opposite was true; science was used as a political argument, thanks to the prestige this institution had acquired in the 19th century in those societies considered as models by the *élite.* However, their fundamental goal was to legitimate their own power, constantly under attack. In this way the renewed interest in science shown in Colombia at the end of the 19th century had, as its sole result, a scientistic movement which failed to find a way to institutionalize science.

Universidad Nacional de Colombia, Bogotá

Notes

[1] On the integration into the world economy see: Ocampo, J. A., *Colombia y la economia mundial 1830-1910,* Siglo XXI, Bogotá, 1984, p.19-77; Palacios, M., *El café en Colombia (1850-1970): una historia económica, social y política,* Editorial Prescencia, Bogotá, 1979, p. 177 ff.; Palacios, M., *Estado y classes sociales en Colombia,* Procultura S. A., Bogotá, 1986, p.111-122; Sandoval, Y. & Echandia, C., "La historia de la quina desde una perspectiva regional: Colombia, 1850-1882", *Anuario Colombiano de Historia Social y de la Cultura,* n°13-14, Bogotá, 1985-1986, p.153-187; Alarcón, F. J. & Arias B., G., "La producción y comercialización del anil en Colombia 1850-1880", *Anuario Colombiano de Historia Social y de la Cultura,* n°15, Bogotá, 1987; Safford, F., *Aspectos del siglo XIX en Colombia,* Ediciones Hombre Nuevo, Medellín, 1977; Sierra, L. F., *El tabaco en la economia colombiana del siglo XIX,* Universidad Nacional, Bogotá, 1971; Rodríguez, O. (ed.), *Estado y Economia en la Constitución de 1886,* Controlaría General de la República, Bogotá, 1986.

[2] *Revista Médica,* Series I, n°4, Sept. 1873, p.26-27; Series IV, n°47, May 1878, p.388-389; Year XVIII, n°198, July 1894, p.67-68; Series X, n°111, Feb. 1887, p.484.

[3] Ocampo, *op. cit.,* p.61-71; Sandoval & Echandía, *op. cit.,* p.176; *Anales de la Universidad,* **vol. XIII,** n°90, Sept. 1879, p.120.

[4] *Revista Científica e Industrial,* Year I, n°4, Bogotá, Aug. 1870, p.59. Published in this review are the current prices on the European and New York markets of the principal Colombian export items: cotton, indigo, coffee, leather, quinine and tobacco.

[5] Bejarano, J.A., "Notas para una historia de las ciencias agropecuarias en Colombia", *Ciencia, Tecnologia y Desarrollo,* **vol.10,** N°1-2, 1986; Ocampo, *op. cit.,* p.369.

[6] Ben-David, Joseph, *El papel de los científicos en la sociedad,* Trillas, Mexico City, 1974, p.102-103 and 115-119.

[7] Law 22 of September 1867: *Anales de la Universidad,* **Vol I,** n°1, 1868, p.3-6; **vol.X,** N°77-78, 1876, p.29.

[8] Ospina Vásquez, Luis, *Industria y protección en Colombia 1810-1930,* Editorial Santa Fe, Medellin, 1955; Nieto Arteta, Luis Eduardo, *Economía y cultura en la historia de Colombia,* Editora Viento del Pueblo, Bogotá, 1975 (5th edition); Colmenares, Germán, *Partidos políticos y clases Sociales,* Ediciones Universidad de los Andes, Bogotá, 1968.

[9] *Aspectos polémicos de la historia colombiana del siglo XIX,* Fondo Cultural Cafetero, Bogotá, 1983; Orlando Melo, Jorge, "La evolución económica de Colombia 1830-1900", in *Manual de Historia de Colombia,* **vol.II,** Procultura, Bogotá, 1984 (3rd edition), p.135-207; Tirado Mejía, Alvaro, "El estado y la política en el Siglo XIX", in il. Mejía, Alvaro *Manual de Historia de Colombia, op. cit.,* p.327-384.

[10] Loy, Jane M., "Los ignorantistas y las escuelas: oposición a la reforma educativa durante el federalismo", *Revista Colombiana de Educación* (Bogotá), n°9, 1982, p.9-24; Helg, Aline, *La Educación en Colombia: 1918-1957,* Fondo Editorial CEREC, Bogotá, 1987; Jaramillo Uribe, Jaime, "El proceso de la educación, del virreinato a la época contemporánea", in *Manual de Historia de Columbia,* **vol.III,** Instituto Colombiano de Cultura, Bogotá, 1980, p.264-277 and 309-325; Fresneda, Oscar & Duarte, Jairo, *Elementos para la historia de la educación en colombia: alfabetización y educación primaria* (Monograficas Sociológicas N°12 -2nd series-), Universidad Nacional, Bogotá, 1984; *Anales de la Universidad,* **vol.I,** n°3, 1868, p.379-380 and p.368.

SCIENCE ET POUVOIR AU XIXe SIÈCLE. LA FRANCE ET LE MEXIQUE EN PERSPECTIVE

Juan-José SALDAÑA

"La science et le pouvoir" est un sujet qui peut donner matière à étude comparative entre la France et le Mexique et qui intéresse donc ce colloque. Les relations entre la France et le Mexique (y compris les relations scientifiques) ont existé très tôt au XIXe siècle. Sur les plans idéologique et scientifique, elles sont même apparues plus tôt car l'influence française était importante dès le siècle précédent. L'idéologie indépendantiste au Mexique doit beaucoup aux Lumières, et, sur le plan scientifique, des contacts existaient également : J. A. Alzate, par exemple, était devenu correspondant de l'Académie des Sciences en 1771, et des publications scientifiques françaises se trouvaient sans trop de difficulté dans les bibliothèques néo-hispaniques (Osorio, 1986).

On pourrait même parler d'un certain parallélisme entre les deux pays : d'une part, la science a joué un rôle important dans la conception de l'Etat, jusqu'à devenir une "technique de gouvernement" aussi bien en France qu'au Mexique; d'autre part, dans les deux pays, l'Etat eut généralement une attitude favorable à l'égard de l'activité scientifique, favorisant la prise en compte de la science dans les politiques gouvernementales (Saldaña, 1985 et 1989a; Rouban, 1988).

L'Etat scientifique

Le développement de la science française au XIXe siècle vient des réalisations des différents gouvernements de cette époque (Hahn, 1971; Paul, 1985; Rouban, 1988). Cela faisait partie d'un phénomène complexe avec plusieurs origines : une philosophie politique, née au siècle des lumières, qui donna une justification rationnelle à la suprématie de l'Etat; une industralisation qui se sert de plus en plus de la science; des initiatives des scientifiques eux-mêmes pour arriver "au pouvoir", etc. En fait, les politiques scientifiques existaient en France depuis le XVIIe siècle, et les membres de l'Académie des Sciences avaient bien compris que leur intérêt était de garder de bonnes relations avec l'Etat (Hahn, 1971). A la veille du XIXe siècle les choses se sont modifiées : d'une part il y a alors un Etat issu d'une révolution sociale, responsable d'assurer le bien-être populaire et la défense du pays; d'autre part, existent les connaissances scientifiques et techniques qui

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vont être utilisées pour atteindre ces objectifs. Les sciences seront en plus organisées dans des institutions nouvelles, avec une stratégie bien définie. Les initiatives de la Révolution de 1789 dans le domaine de l'institutionnalisation des sciences et de leur enseignement, ont laissé un exemple permanent pour la politique scientifique française depuis lors (Fayet, 1960). La politique et la science sont devenues dépendantes l'une de l'autre, et cette sorte de mariage a conduit aussi bien à "l'âge d'or" de la période 1799-1830 qu'aux difficultés de la science française avant 1870 et à son renouvellement postérieur (Ben-David, 1971; Fox, 1974; Paul, 1985). L'idéal des Lumières devait se transformer suivant les différentes conceptions politiques dominantes au cours de ce siècle, et selon les progrès scientifiques. Mais le rôle actif de l'Etat vis-à-vis de la science, et celui de la science comme cadre de référence pour l'organisation de la société, sont des acquis définitifs. Et c'est l'origine de l'Etat scientifique et de la science politisée des temps modernes.

De la même façon, l'entrée du Mexique dans la vie républicaine en 1824, après une guerre d'indépendance et un empire éphémère, fût caractérisée par un enthousiasme pour la science et la technique. La Constitution fédérale laissait dans les mains de l'Etat l'enseignement public, trouvant dans les sciences et les "Lumières" une finalité pour le bien-être populaire. L'exposé des motifs de la Constitution mentionne la révolution scientifique et ses héros pour, est-il dit, produire sur le plan politique un changement analogue à celui que les sciences ont produit sur le plan des connaissances. Dans le texte constitutionnel plusieurs articles y font une référence explicite, et imposent, tant au Gouvernement fédéral qu'aux Etats fédérés, des obligations précises au sujet des sciences. En conséquence de nombreuses actions pour le développement et l'utilisation sociale des sciences ont été mises en pratique selon ces dispositions entre 1824 et 1833 (Saldaña, 1989a). Du point de vue des résultats, ceux-ci ne furent pas aussi importants que souhaités, car la situation économique et l'instabilité des gouvernements ont toujours empêché d'y parvenir. En fait les savants mexicains se sont trouvés isolés et sans information, ce qui contraste avec le niveau atteint trente ans auparavant (Trabulse, 1983). A cause de cela, la Constitution de 1857 et les lois de réforme reviennent sur le rôle de l'Etat en matière scientifique et éducative, et décrètent la séparation de l'Eglise et de l'Etat, entre autres réformes sociales. Or, il a fallu attendre jusqu'au 1867 pour que ces réformes deviennent une réalité. La guerre avec la France d'abord, et l'empire étranger ensuite, y firent obstacle.

Les luttes pour former un Etat national mexicain, en l'absence d'une classe dominante unifiée, caractérisent les cinquante ans qui suivirent l'Indépendance. Le triomphe militaire et politique définitif des libéraux, et le rétablissement de la République en 1867, ont conduit à la formation d'un Etat avec une structure autoritaire, basé sur l'accord conclu entre l'oligarchie et la classe politique libérale. Comme dans d'autres domaines de la vie publique, une réforme scientifique basée sur une politique volontariste à long terme, fût engagée à ce moment.

L'influence française

Une influence française est évidente dans la politique scientifique de la deuxième moitié du XIXe siècle et dans les précédents au début de la période républicaine (Saldaña, 1989b). Plusieurs faits peuvent être mentionnés à l'appui de cette interprétation : l'adoption du modèle de l'Institut de France pour l'organisation de l'Institut scientifique et littéraire de 1825; ou, plus tard, l'expédition scientifique française au Mexique (1864-1869) qui se déroule en même temps que l'aventure colonialiste de Napoléon III; les institutions scientifiques créées par le Gouvernement de Maximilien d'après le modèle français, dont certaines survivèrent après sa défaite; l'influence du positivisme comtien et toute la francisation effectuée au Mexique pendant le dernier tiers de ce siècle.

En France les scientifiques avaient exercé une influence sur la vie publique depuis la Convention et leur "pouvoir" devint important durant la République et le premier Empire (Fayet, 1960, Crosland, 1967; Fox, 1974). Durant le Deuxième Empire et la Troisième République, les scientifiques se sont graduellement "emparé" du pouvoir économique, politique et militaire (Paul, 1985). En même temps, un contexte favorable a permis la décentralisation de l'enseignement et de la recherche appliquée dans plusieurs régions, en fonction de la demande économique locale, et avec son soutien. Les exemples de la recherche agronomique et industrielle et de la recherche militaire montrent un aspect fondamental de l'organisation de la science à l'époque. En effet l'Etat, sans abandonner la mission scientifique qui est la sienne, a vu son rôle se transformer : il fût, à l'époque du premier Empire, et jusqu'au années soixante, le moteur unique du développement scientifique, et est devenu un lieu de negociations entre des groupes d'intérêts, en vue de définir une politique scientifique et technique acceptable pour différents groupes, y compris, de scientifiques. Même le coût économique a été partagé entre les différentes parties intéressées. L'organisation de la science qui en résulta, c'est-à-dire les institutions publiques et privées d'enseignement scientifique et de recherche, les sociétés savantes, les journaux et les livres, les prix, la vulgarisation des sciences, le système de diffusion vers les colonies et d'autres zones d'influence, etc., fût une conséquence de cette politisation de la science et du scientisme dans la société. Par la suite, cette organisation des sciences devait amener l'Etat à avoir le rôle dirigeant en matière scientifique, avec la création au XXe siècle du CNRS et d'autres institutions étatiques consacrées aux sciences.

Au Mexique, on rêvait pareillement d'un Etat capable de jouer le rôle dirigeant pour les sciences, comme le prévoyaient d'ailleurs les lois, et la philosophie politique de la République depuis sa fondation. Le moment opportun est finalement arrivé vers 1874, avec la paix sociale et un gouvernement fort, sur une base politique nouvelle, qui s'est installé pour plus de trente ans. Cette période est connue comme le *"Porfiriato"* du nom de Porfirio Díaz qui fut Président de la République jusqu'à 1910, sauf pour une courte période de quatre ans où il n'a pas été directement lié aux affaires. Comme nous l'avons déjà dit, une politique scientifique efficace et de longue haleine prenait forme à cette époque. A ce moment-là, bien qu'il y eût, au Mexique, une vieille tradition scientifique, et que quelques institutions subsistaient, il a fallu construire presque tout. Cinquante ans s'étaient écoulés depuis la séparation d'avec l'empire espagnol, avec des guerres civiles, des interventions étrangères, l'amputation du territoire et même une intervention militaire de Napoléon III pour faire couronner Maximilien d'Habsbourg empereur du Mexique. Avec la chute de Maximilien et le triomphe des libéraux avec Benito Juárez en tête, le pays était exténué. Du point de vue économique il a fallu imaginer un programme en faisant appel à l'investissement étranger pour stimuler l'industrialisation et la modernisation du pays. La population était peu nombreuse (environ 12 millions) sur un grand territoire potentiellement riche. L'activité productive principale était l'agriculture, suivie par l'exploitation minière. La population urbaine se trouvait concentrée en deux ou trois villes, dont Mexico était la plus importante du point de vue économique, culturel et politique. Le niveau général de l'éducation était très réduit et l'analphabétisme très repandu. Ainsi, l'orientation de l'action du nouveau régime s'est basée sur trois axes : l'industrialisation, l'éducation et la construction d'infrastructures, comme le réseau de communications nécessaire pour développer le commerce, surtout international. En ce qui concerne l'industrialisation et les voies de communication, des résultats importants ont été atteints mais avec une domination économique étrangère. Les conséquences ont été importantes, aussi bien pour les sciences que pour les scientifiques mexicains, car ceux-ci n'ont pas été partie prenante dans ce processus.

Sur le plan éducatif un effort considérable fut réalisé depuis 1867 pour développer l'éducation publique. Au départ est né, dans cet esprit, un système d'éducation supérieure en sciences, et se sont développées les institutions déjà existantes (en médecine, génie, agriculture, etc). Dans les annés 1880, d'autres ministères, notamment celui de "Fomento", vont aussi s'intéresser à la promotion des sciences. De ces initiatives viennent la création de plusieurs institutions comme *l'Observatorio Central* (1877), la *Comisión Geográfico-Exploradora* (1877), *l'Instituto Médico Nacional* (1888) ou d'autres, ainsi que le soutien aux activités de recherche et de diffusion.

A cette période de nombreuses sociétés savantes et des journaux scientifiques ont été créés; il y eut également des congrès et le nombre de publications s'est sensiblement accru (Carpy, 1989); des expéditions scientifiques ont été organisées pour connaître les ressources du pays (Gortari, 1963) et même une expédition astronomique fut envoyée au Japon en 1874 (Moreno, 1986); des laboratoires de recherche et des observatoires astronomiques et météorologiques furent installés (Moreno, 1989; Taboada, 1965; Domínguez, 1965); nombreux furent les Mexicains envoyés à l'étranger pour faire des études et des savants étrangers sont venus s'installer au Mexique; des écoles professionnelles furent créées ou réorganisées comme *l'Escuela Nacional de Ingeniería* (1867), *l'Escuela Nacional de Agricultura* (1867), et la très célèbre *Escuela Nacional Preparatoria* (1867) dont l'importance pour la vie scientifique du pays fut capitale, et d'autres (Lemoine, 1970; Arce *et al.,* 1982).

Avec cette politique, la recherche s'est orientée vers la botanique et la zoologie (cythologie végétale et animale, parasitologie et microbiologie, physiologie, morphologie, embryologie, bactériologie, biochimie), la chimie analytique, la médecine, la géologie et la minéralogie, la géographie, la cartographie et la statistique, l'astronomie, l'ethnologie, la linguistique descriptive, etc. Un trait caractéristique de la recherche a été l'intérêt plutôt pragmatique dominant, ainsi que la place réduite de la recherche théorique dans ces institutions (Gortari, 1963; Trabulse, 1983). Une autre caractéristique de cet ensemble d'actions et des institutions créées est la suivante : le "tout puissant" Etat s'est trouvé toujours présent et les initiatives souvent lui appartenaient et, dans la presque totalité des cas, son soutien était fondamental

(Saldaña, 1989b). Les liens personnels existants entre les scientifiques et la classe politique sont un autre trait marquant de la science à ce moment là, sur lequel nous reviendrons.

La science et son contexte

Le modèle diffusioniste de la science a souligné le caractère dépendant de la science périphérique et le cas mexicain du XIXe siècle semblerait s'y accorder. En effet, dans cette interprétation, la subordination de l'activité scientifique mexicaine à la science européenne (française notamment) se traduit par : les textes scientifiques utilisés, les expéditionnaires et les savants qui se sont déplacés dans le pays, l'équipement et les théories importés, la formation des scientifiques mexicains en Europe, l'emploi de la langue française à la place de la langue nationale dans les ouvrages, la publication des articles et des livres en Europe, les institutions conçues d'après le modèle européen, etc. On peut même parler de l'assujettissement de la science périphérique aux desseins impérialistes, soit dans le sens de son exploitation économique, soit dans le sens de sa domination culturelle (Pyenson 1985a, 1987).

Du point de vue du diffusioniste le contexte local est une espèce de scénario dans lequel se joue une pièce de théâtre. Le scénario n'est pas considéré comme la condition de possibilité de la pièce elle-même, ni même comme la source des modalités adoptées par le processus. Les études sur l'impérialisme culturel et les sciences nous ont fait voir que l'activité scientifique européenne réalisée dans la périphérie faisait partie plus fréquemment qu'on y pense d'une politique consciente (Schroeder, 1966; Pyenson, 1984, 1985a et b, 1987; MacLeod, 1987). Il est sûr que le phénomène impérialiste en sciences a effectivement existé, et en ce qui concerne la France par rapport au Mexique, de nombreux faits pourraient être cités en appui de ces conclusions[1].

Mais l'étude des facteurs locaux qui agissaient sur le processus scientifique endogène, dont **seule une de ses composantes** est de nature externe, ne devrait pas être oubliée dans une histoire comparative des sciences. Le modèle diffusioniste, tout en regardant un fait important, celui de la présence ou même de la domination de la science européenne dans la périphérie, a fait seulement une analyse à sens unique sans s'interroger par les facteurs locaux[2]. Or, ces facteurs sont finalement responsables des spécificités de la science périphérique et l'absence d'une telle analyse limite notre compréhension de l'expansion de la science européenne.

Si on regarde du côté du contexte, le processus de diffusion ainsi que les politiques impérialistes des sciences prennent une autre allure. D'abord parce qu'il n'y a pas eu dans les pays récepteurs une attitude seulement passive, et la pratique de leurs scientifiques n'a pas été uniquement répétitive ou imitative. En fait, ce qui s'est passé est une dialectique entre créativité et dépendance où, parfois la périphérie est devenue aussi centre (MacLeod, 1987; Cueto, 1990; Díaz et al., 1983), ou bien, où on a adapté la science importée aux conditions locales. Deuxièmement, l'activité scientifique de la périphérie n'obéit pas dans tous les cas aux mêmes exigences, ni théoriques ni pratiques, que la science métropolitaine, car elle suit sa propre dynamique, comme dans le cas du Mexique, du fait de son passé culturel. Souvent même les motivations de la science exogène sont complètement indifférentes ou inconnues pour les scientifiques des pays périphériques (Ruíz, 1987; Aceves, 1987; Saldaña, 1987; Trabulse, 1989). Or, quand les programmes de recherche ont uniquement de l'intérêt pour le centre, les scientifiques locaux se trouvent dans la position de simple "main d'oeuvre". Des cas pareils ont effectivement existé[3], mais ils n'expliquent pas à eux seuls, une pratique sociale des sciences comme celle qui a existé au Mexique au XIXe siècle.

Troisièmement, les conditions socio-politiques du travail scientifique (politique scientifique, culture, formes d'organisation, financement, demande sociale, etc.) s'avèrent décisives pour mettre en route des innovations et pour obtenir les résultats attendus. La méconnaissance de ce fait a produit toute sorte d'incohérences entre les initiatives prises et le contexte dans lequel on devait agir. Dans les cas de la France et du Mexique, il existait, au XIXe siècle, un cadre politique qui, sous une apparence d'uniformité qui a beaucoup enthousiasmé à l'époque, joua très différemment son rôle vis-à-vis de la science.

L'esprit et la lettre

Le *"Porfiriato"* fut un régime qui avait fait de la paix sociale son point fort. Une idéologie du progrès était en conséquence à la base de l'action gouvernementale. Le progrès matériel était devenu évident avec l'industrialisation, la croissance démographique, l'introduction des chemins de fer et de l'électricité dans les usines et dans les villes, etc. Sur le plan de la culture, le progrès se manifestait dans le niveau de civilisation de la société mexicaine (Cosío Villegas, 1955). Dans cet esprit l'éducation fut privilégiée et l'enseignement scientifique fut orienté par la philosophie positiviste. Une génération de Mexicains fut formée d'après les idéaux de modernisation, dont on a crédité des pays avancés comme la France. Au paradigme européen de la révolution scientifique et technique, il fallait ajouter l'état subjectif nécessaire pour que le transfert au Mexique de celle-ci eut lieu. Ce fut la tâche du programme éducatif. En plus il fallait créer une organisation des sciences correspondant au niveau voulu de civilisation. Des sociétés savantes, des revues, des instituts de recherche, etc., furent ainsi formés. Bien évidement l'enthousiasme pour ce projet n'a pas manqué parmi les scientifiques, pour qui cela représentait la modernisation du pays.

L'Etat poussa le développement scientifique dans tous les domaines de l'action gouvernementale et avec son concours. Mais à la fin de cette période, vers 1910, malgré les réalisations de la politique scientifique du *"Porfiriato"* elle rencontra une opposition. Cette politique n'ayant pas eu une base sociale elle produisait des connaissances socialement inutiles (Saldaña, 1985). En effet, le secteur industriel n'avait pas besoin des sciences car il était en majorité étranger et il importait tout. Arriéré, le secteur agricole produisait pour une économie de subsistance régionale qui pouvait se passer des sciences. L'armée, avec le pays en paix et sans conflits externes, n'en avait pas besoin non plus pour remplir sa fonction de gardienne de la paix. A ce moment les scientifiques issus du scientisme[4] *"porfirista"* vont reconsidérer leur rôle social et professionnel et en 1910 (Saldaña, 1985) la Révolution allait commencer.

Mais quels étaient les points d'appui de l'activité scientifique développée au Mexique entre 1850 et 1912? Quelle était la base de la politique scientifique de l'Etat? Au départ l'orientation avait un but pédagogique et les travaux de divulgation et d'enseignement des sciences furent fermement soutenus. Dans ce sens, la science devenait une arme idéologique contre l'obscurantisme et un instrument politique pour former la nouvelle nation, c'est-à-dire une technique de gouvernement. Plus tard, la recherche commença au moment où le nombre des scientifiques s'était accru, et que leur niveau de compétence et d'information était devenu acceptable. Cette recherche fut orientée vers la connaissance des ressources du pays. En particulier les études botaniques, zoologiques, médicales, géologiques et géographiques furent importantes. Sous l'influence du darwinisme il y eu également un intérêt pour les études paléontologiques et ethnologiques. La recherche sociale, surtout les études statistiques et historiques, furent développées aussi. Dans les sciences exactes l'intérêt se tournait surtout vers l'astronomie.

Or, à la différence d'autres pays comme les Etats Unis (Hunter Dupree, 1986), ou la France de l'époque, au Mexique, la recherche était réalisée en dehors des activités industrielles, agricoles ou militaires et l'Etat en tirait seulement profit pour des buts politiques et de prestige. D'une part le *"Porfiriato"* pouvait montrer au monde un pays civilisé et d'autre part, l'élite "éclairée" qu'il avait formée, devenait son allié. Les liens personnels qui se sont établis entre la classe politique et les savants mettaient la science dans une position de dépendance du pouvoir central. Les écoles et les institutions de recherche comme *l'Instituto Médico Nacional,* la *Comisión Geográfico-Exploradora* ou *l'Observatorio Astronómico* étaient des institutions étatiques. Même les sociétés savantes comme la *Sociedad de Historia Natural* ou la *Sociedad de Geografía y Estadística* étaient aussi dépendantes de l'Etat du point de vue économique (pour ses publications, expéditions, etc.). Plusieurs de leurs membres et de leurs dirigeants appartenaient au Gouvernement, et une pratique usuelle consistait à nommer le Président de la République comme protecteur de la corporation. Ainsi, le rôle déterminant de l'Etat mexicain sur la science s'explique par l'absence d'indépendance vis-à-vis du pouvoir de la part de la communauté scientifique, des institutions d'enseignement et de recherche, et par l'incidence peu importante de l'activité scientifique sur les activités économiques. Or, ici le contraste est net avec ce qui s'est passé en France, et la raison en est que les conditions locales existantes au Mexique n'ont jamais été prises en considération.

Mais le rôle de l'Etat mexicain vis-à-vis de la science doit être examiné également sous une autre optique. Au XIXe siècle il y eut une **fonction structurante** de l'activité scientifique de la part de l'Etat, fondée sur la philosophie politique de la République. Cette philosophie fut exprimée pour la première fois dans la Constitution d'Apatzingan de 1814 (inspirée de la Constitution française de 1792) et répétée dans celles de 1824, 1857 et 1917. Cet aspect politico-juridique doit être pris en compte, car il nous fait comprendre le contexte social et idéologique qui a transformé les sciences en affaire publique. Sur ce point il y eut un parallélisme, mentionné plus haut, entre le Mexique et la France. Dans l'histoire contemporaine ces deux pays sont issus de révolutions sociales qui ont complètement transformés l'Etat, c'est-à-dire qu'elles ont créé un Etat avec des responsabilités sociales.

Au Mexique comme en France les initiatives étatiques ont permis la formation de l'infrastructure scientifique. A la différence de la France, au Mexique, c'est la seule action de l'Etat qui ait compté, car il n'y eut pratiquement pas d'autres secteurs intéressés par les sciences. Dans ce sens, l'action gouvernementale s'est avérée décisive. Grâce à cela, en plus des institutions et de l'éducation scientifique d'une partie significative de la population, le pays tira du XIXe siècle une expérience en matière scientifique qui s'est ajoutée à la tradition déjà existante. Cette expérience allait jouer un rôle important plus tard, puisque la Constitution de 1917 était inspirée d'un programme social exigeant un appel aux sciences.

Finalement, l'effort scientifique du XIXe siècle eut aussi un effet dans l'intégration du pays, ce qui était un but politique important au moment où le territoire était amputé par les Etats Unis (1847) ou convoité par la France (1864-1867). Depuis la période coloniale, le centre de toute l'activité scientifique avait été la capitale, mais la politique scientifique de l'Etat national était alors orientée vers la diffusion scientifique et la formation d'infrastructure dans tout le pays. Les expéditions scientifiques qui ont parcouru le territoire pour le connaître du point de vue physique et social (Sánchez, 1990) agirent dans le même sens.

Ainsi, la science mexicaine du XIXe siècle s'est trouvée passablement loin du modèle français au point de vue des actions et des résultats, même si leurs motivations étaient assez proches les unes des autres d'après les textes. Cela nous oblige à considérer qu'en histoire comparative des sciences comme dans un texte, il sera toujours nécessaire de faire référence au contexte pour distinguer l'esprit et la lettre.

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Notes

[1] Voir, par exemple, (Archives Nationales (Paris) F17 2910) le *"Questionnaire de M. Ed. Dalloz, Député, ayant pour objet de favoriser le mouvement industriel et commercial de l'Empire"*, du 20 novembre, 1864, où l'intérêt français de tirer un profit de l'expédition scientifique au Mexique est manifeste. A ce questionnaire le Ministre plénipotentiaire du Mexique à Paris répond (26 nov., 1864) que l'expédition devrait servir "à vulgariser les notions indipensables à la science, au commerce et à l'industrie. en un mot ce serait le moyen le meilleur et le plus efficace d'attirer et de faciliter au Mexique avec connaissance de cause, l'émigration européenne". Ce sentiment n'était pas partagé par tous comme il deviendra évident par la suite, avec l'opposition que rencontra ce projet imperialiste, car il méprisait la longue tradition scientifique mexicaine.

[2] A ce propos, un important débat eut lieu en 1984 dans le symposium *"New Directions in the History of Science in Latin America"* (Chicago, December 1984, Annual Meeting, History of Science Society), organisé par *la Sociedad Latinoamericana de Historia de las Ciencias y la Tecnologia* et publié dans son périodique *Quipu, Revista Latinoamericana*

de Historia de las Ciencias y la Tecnologia, 2 (1985), 3. Cette question est également abordée dans les travaux réunis dans : J. J. Saldaña (éd.), *El perfil de la ciencia en América,* Coll. Cuadernos de Quipu 1, México, SLHCT, 1986; et J. J. Saldaña (éd.), *Cross Cultural Diffusion of Science: Latin America,* **vol. V** , Acts of the XVIIth International Congress of History of Science, Coll. Cuadernos de Quipu 2, México, SLHCT, 1987.

[3] Pyenson a utilisé ces cas pour définir les scientifiques "fonctionnaires" par opposition aux "missionnaires" (L. Pyenson, 1985). Dans un sens analogue A. Lafuente et J. Sala ont analysé le cas des scientifiques "métropolitains" qui ont agi au Mexique à la fin de la période coloniale, "Ciencia colonial y roles profesionales en la América española del siglo XVIII", *Quipu, Revista Latinoamericana de Historia de las Ciencias y la Tecnologia,* (Mexico) 6 (1989), 3, p.387-403.

[4] Le groupe politique le plus influent pendant le *"Porfiriato"* s'appelait lui-même *"partido de los cientificos"*.

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LE POSITIVISME ET LA SCIENCE AU BRÉSIL

Maria Amelia M. DANTES

Introduction

L'idée que le Brésil est le pays qui a le mieux accueilli le positivisme d'Auguste Comte est très répandue[1].

On ne peut pas nier cette relation entre la doctrine et le pays. La doctrine positiviste a diffusé au Brésil au XIXe siècle, et ses sympathisants ont été actifs, surtout dans la vie politique du pays, lors des dernières années de l'Empire, et du début de la République. Un signe de cette présence est l'existence sur le drapeau national républicain du message positiviste "ordre et progrès".

C'est, en vérité, surtout cette image qui nous accompagne : la relation entre la République brésilienne, instituée en 1889, et le positivisme[2]. Une image, à notre avis, due à l'action de l'Apostolat positiviste, créé en 1882, qui fut très actif jusqu'au début du XXe siècle, et qui existe encore de nos jours[3].

Mais il y a, nous semble-t-il, une exagération quant à l'influence du positivisme au Brésil. L'historiographie sur le pays est, elle aussi, marquée par cette distorsion. Par exemple, le livre de João Cruz Costa,[4] *Contribução a história das idéias no Brasil,* une référence classique, réserve une attention toute particulière au rôle du positivisme dans la pensée philosophique brésilienne, sans l'intégrer à un ensemble plus vastes de doctrines progressistes. L'oeuvre de Cruz Costa a influencé la production historique qui l'a suivi et, même aujourdhui, la responsabilité de quelques traits peu louables du caractère national est attribuée au positivisme[5].

L'historiographie des sciences au Brésil transmet, elle aussi, une image dépréciative, où la présence du positivisme est vue comme un obstacle au développement des sciences dans le pays. Le but de cet article est d'éclairer cette question.

La diffusion du positivisme au Brésil

La doctrine positiviste est arrivée au Brésil dans la première moitié du XIXe siècle. Au début, ses adeptes étaient des éléments des classes moyennes urbaines, surtout liés aux écoles professionnelles. Il y avait alors dans le pays une Ecole d'Ingénierie Militaire, à Rio de Janeiro, et deux Ecoles de Médecine, à Rio de Janeiro et Salvador de

P. Petitjean et al. (eds.), Science and Empires, 165–172.

Bahia. Avec une moindre intensité, le positivisme est parvenu également à la ville de Recife, dans l'Etat de Pernambouc, un autre centre culturel du pays avec sa Faculté de Droit.

Un premier texte de caractère positiviste fut écrit en 1844 par un auteur brésilien : la thèse de concours du Dr Justiniano da Silva Gomes *Plano e método de um curso de Fisiologia,* présentée à la Faculté de Médecine de Bahia[6]. Nous trouvons dans cette thèse, le positivisme considéré comme une philosophie des sciences, ce qui caractérise la première phase de sa diffusion dans le pays. Silva Gomes[7] écrit :

"par la méthode positive, utilisée aujourdhui dans toutes les branches de la science, nous devons analyser pleinement les phénomènes (...), sans chercher les causes qui les produisent".

Cette attirance pour l'aspect philosophique du positivisme se justifie, selon Roque S. M. Barros[8] par la clarté du système philosophique d'Auguste Comte, accessible même aux esprits peu familiarisés avec la philosophie. Les professionnels brésiliens des écoles disposaient ainsi d'une pensée philosophique pour orienter l'organisation de leur savoir.

La recherche que nous avons faite sur les thèses scientifiques (en Mathématiques, Physique, Chimie ou Médecine) nous a montré que celles-ci étaient en minorité par rapport à l'ensemble des thèses présentées dans les écoles professionnelles. Mais leur présence persista au moins jusqu'à la fin du XIXe siècle.

Vers 1870, la diffusion des idées positivistes commence à changer de sens. C'est alors la philosophie politique et historique de Comte qui commence à attirer les intellectuels brésiliens. Ils essaient d'étudier, à travers le prisme du positivisme, le passé du pays, et les perspectives futures, vues comme relevant de l'histoire de la civilisation occidentale[9].

Une troisième phase de la diffusion du positivisme commence avec la création, en 1881, à Rio de Janeiro, de l'Eglise positiviste du Brésil, sous la direction de Miguel Lemos et de Teixeira Mendes. Dès lors, l'histoire du positivisme brésilien va être caractérisé par une dualité entre orthodoxie et hétérodoxie.

L'Apostolat, dédié au culte de la Religion de l'Humanité, revêtit le rôle de représentant officiel du positivisme au Brésil[10] et, par l'attitude très rigide de ses directeurs, éloigna plusieurs positivistes brésiliens historiques, liés à une conception plus "littréiste" de la doctrine de Comte[11]. Les adeptes de l'Apostolat furent très actifs, et ont participé au mouvement pour l'implantation de la République dans le pays, et aux débats publics sur l'éducation, l'université, l'esclavage, ainsi que, au début du XXe siècle, sur la vaccination.

Les thèses positivistes présentées à la Faculté de Médecine de Rio de Janeiro

Nous avons commencé par utiliser les informations contenues dans le livre *O Positivismo no Brasil* d'Ivan Lins[11], où l'auteur présente une liste des oeuvres positivistes, ou sur le positivisme, éditées au Brésil de 1844 à 1967.

De 1844 à 1900, près de trente textes ont été écrits par des auteurs positivistes, sur des thèmes scientifiques. Il s'agit, pour la plupart, de thèses de conclusion de cours : mais ce sont également des livres et de véritables thèses présentés dans les écoles professionnelles d'ingénierie et de médecine.

L'analyse qui suit concerne les thèses de caractère positiviste soutenues à la Faculté de Médecine de Rio de Janeiro.

Les thèse sont des thèses de conclusion de cours[12], c'est-à-dire que ce sont des travaux de jeunes gens qui s'initient aux sciences médicales. Cette documentation peut nous renseigner surtout sur les conceptions médicales diffusées dans cette institution d'enseignement professionnel.

Nous avons travaillé sur la période qui va de 1850 à 1900, pour laquelle nous avons trouvé 19 thèses de caractère positiviste pour un total de 2904 thèses[13]. Un petit pourcentage, mais qui nous montre que, jusqu'en 1900, les idées d'Auguste Comte étaient considérées comme "scientifiques" selon les normes des professeurs de l'Ecole.

Notre analyse portera sur les thèmes choisis par les jeunes positivistes, leur façon de développer le thème, et sur les caractéristiques de leur positivisme.

1°) Les thèmes des thèses

Les thèmes des thèses des auteurs positivistes ne diffèrent pas totalement de l'ensemble des thèmes choisis par les élèves de la Faculté de Médecine dans leurs travaux de conclusion de cours. Ce qui les distingue est leur façon de développer leur étude. Nous trouvons donc surtout des thèses sur des maladies (névroses, maladies épidémiques), sur leur naissance, leur guérison. Ou encore, sur la science médicale (sur les concepts de médecine, de pathologie, de physiologie, etc). Mais on trouve aussi des thèmes propres aux théories positivistes, comme les "nerfs trophiques" ou "nutritifs", introduits par Auguste Comte. Et des thèmes polémiques, comme la pratique de la crémation, que rendraient possible la diffusion des valeurs positivistes.

2°) Le développement du thème

Sous cet aspect, les oeuvres des auteurs positivistes brésiliens diffèrent peu des autres : ce sont, en général, des textes théoriques qui présentent une rétrospective historique des diverses conceptions sur le thème. Ces textes témoignent d'une façon de voir la formation scientifique des jeunes, très répandue dans les écoles professionnelles brésiliennes du XIXe siècle, comme une introduction à la connaissance scientifique déjà établie, ou considérée comme telle. En général, ces textes sont peu créatifs, mais manifestent une certaine érudition, et utilisent systématiquement des textes originaux.

3°) Le caractère positiviste des thèses

Ces thèses positivistes ont en commun la citation directe des oeuvres de Comte. Mais elles montrent des différences.

Nous trouvons tout d'abord quelques textes moins orthodoxes qui utilisent aussi les contributions d'auteurs bien connus, comme Claude Bernard ou Virchow, que l'on ne saurait qualifier de positivistes. Mais les thèses sont, en général, de caractère orthodoxe, présentant les conceptions du philosophe et de ses disciples, comme Audiffrent, et d'auteurs reconnus par Comte, comme Broussais, Gall, etc. L'oeuvre de Comte et de ses disciples est présentée comme la vraie connaissance positive ou scientifique de la médecine, et les auteurs ont une vision critique de la médecine expérimentale, fondée sur l'expérimentation en laboratoire et sur l'utilisation intensive de la vivisection, et dépourvue d'une éthique[14].

Mais il y a au moins une thèse qui utilise d'une autre façon la doctrine positiviste. C'est la thèse d'Eustachio G. Stockler, sur la fièvre jaune, de 1881[15]. L'auteur met en oeuvre dans son travail un critère "comtien" pour le choix de la théorie scientifique de cette maladie. Il analyse tout d'abord la théorie des états de l'atmosphère, théorie qui est, pour lui, métaphysique, dans la mesure où elle contient des entités abstraites. Puis la théorie des miasmes qui est, à ses yeux, une hypothèse non vérifiable. Enfin, la théorie parasitologique, la seule accessible à la connaissance en ce moment de l'histoire de la médecine. Cette thèse, qui utilise le positivisme comme une méthode plutôt que comme une théorie scientifique établie, amène l'auteur à des conclusions qui l'opposent, en conséquence, à certaines positions défendues par les positivistes orthodoxes, telles que la critique de la théorie pasteurienne.

Positivisme et science au Brésil

Cette étude sur la présence du positivisme d'Auguste Comte à la Faculté de Médecine de Rio de Janeiro a montré, en premier lieu, que cette présence n'était pas si significative qu'on le pensait. Nous pouvons généraliser, en nous appuyant sur d'autres études récentes sur l'action des positivistes brésiliens[16], et dire que le positivisme n'a attiré qu'une minorité parmi les intellectuels du pays. Une minorité, sous certains aspects progressiste, si l'on pense au caractère traditionnel de la société brésilienne. Ce progressisme, on le voit à l'action politique de ses adeptes qui ont lutté, par exemple, pour la laïcisation de l'Etat brésilien, ce qui les a opposés aux catholiques. Un autre aspect de ce progressisme apparait dans les discours pour la modernisation du pays. Tels les discours des ingénieurs de l'Institut polytechnique brésilien, créé en 1865, sous l'inspiration du positivisme diffus, où les ingénieurs demandent une participation plus grande des professionnels scientifiques dans l'administration impériale[17]. Les médecins avaient également un rôle important à jouer dans le modèle de société proposé par les positivistes.

Mais le positivisme brésilien comportait aussi des aspects rétrogrades. Le modèle politique des positivistes pour le pays était, par exemple, la dictature républicaine. C'est précisément cet aspect qui devait être dominant dans leur image future.

Une image négative du positivisme est présente également dans l'historiographie des sciences au Brésil, où les positivistes brésiliens sont vus comme des défenseurs d'une conception dépassée de la science.

L'analyse des thèses présentées à la Faculté de Médecine de Rio de Janeiro, a montré qu'en un sens, cette image se justifie, dès lors que leurs auteurs, pour la plupart, présentaient l'oeuvre de Comte comme une science définitive des êtres vivants. Ils avaient en outre une attitude critique envers le développement de la biologie et de la médecine expérimentales.

Prenons comme référence l'histoire des sciences biologiques en France. Robert Fox[18], étudiant le rôle du positivisme dans ce pays, observe que les biologistes français de la fin du XIXe siècle ne s'intéressaient pas au positivisme. Il comprend d'abord ce fait comme une conséquence de la la séparation existant alors entre la pratique scientifique et la philosophie. Mais, il observe aussi, en suivant Georges Canguilhem[19], que l'oeuvre de Comte, établie sur les conceptions de la science du XVIIIe siècle, était alors déjà éloignée de la science expérimentale, qui gagnait du prestige. En France, les conceptions positivistes en biologie, à la fin du XIXe siècle, n'appartenaient plus au monde de la science.

Au Brésil, la situation était différente. Les oeuvres des auteurs positivistes étaient acceptées à la Faculté de Médecine de Rio de Janeiro, comme des travaux scientifiques légitimes. De telle sorte qu'il n'y avait pas alors de résistance épistémologique au positivisme. Les résistances observées étaient dues à l'athéisme de certaines oeuvres positivistes et étaient le fait des catholiques[20].

On peut comprendre cet état de choses dans la mesure où l'activité scientifique était encore limitée au Brésil. Les institutions de recherche comme le Muséum d'Histoire Naturelle, le Jardin Botanique, ou l'Observatoire, tous situés à Rio de Janeiro, développaient leurs activités dans les branches les plus traditionnelles de la science du XIXe siècle. Le premier Laboratoire de Physiologie, par exemple, fut créé, en 1881, au Muséum de Rio de Janeiro.

Il existait aussi des écoles professionnelles destinées à l'enseignement scientifique, et qui diffusaient un concept de science établi selon des références externes, à savoir la prestigieuse Europe. D'où l'existence, à côté de Comte, de Claude Bernard ou de Pasteur.

Vers 1900, à l'Ecole Polytechnique de Rio de Janeiro, Oto de Alencar détruisait le prestige scientifique de Comte par une critique de son oeuvre mathématique[21]. La science plus moderne commençait à arriver au Brésil. Mais l'oeuvre philosophique d'Auguste Comte restait encore présente dans le pays.

C'est précisément la critique portée par les scientifiques brésiliens à l'encontre du positivisme qui a été poursuivie par les historiens des sciences, montrant la doctrine de Comte comme un obstacle au développement des sciences dans le pays. C'est ainsi que, en astronomie, Ronaldo Mourão souligne l'influence négative des positivistes sur le développement de l'astrophysique au Brésil[22]. Mais cette explication est faible, dans la mesure où elle ne prend pas en compte la complexité des facteurs qui peuvent expliquer le chemin parcouru par les sciences dans le pays. Et, quant au positivisme, on ne peut oublier son rôle comme philosophie scientifique dans la valorisation des sciences au Brésil, ni sa contribution à la diffusion de l'enseignement scientifique.

Ce que nous voulons dire par là, c'est qu'il faut comprendre le rôle du positivisme dans l'histoire des sciences au Brésil à partir de ce qu'a été réellement la science dans le pays. Et, dans ce cadre, nous pouvons conclure avec L. O. Ferreira[23] que le positivisme a été une part vivante de l'histoire des sciences au Brésil.

Universidade de São Paulo

Notes

* Recherche réalisée dans le cadre du programme de coopération internationale CNPq-CNRS, sur le thème "Histoire du rôle de la science dans les relations entre le Brésil et la France, 1808-1960". Participent à ce programme, des chercheurs de l'Université de São Paulo (Brésil) et de l'équipe REHSEIS du CNRS (France). L'auteur exprime sa reconnaissance pour l'appui reçu de la part des chercheurs de l'équipe REHSEIS et de la part de la Maison d'Auguste Comte de Paris.

1 Paulo E. Arantes, "O Positivismo no Brasil - Breve apresentação do problema para um leitor europeu", *Novos Estudos*, n°21, CEBRAP, São Paulo, julho de 1988, pp.185-194. L'auteur, p.188, écrit que Paul Arbousse-Bastide considérait le Brésil comme la vraie patrie du positivisme.

2 Les positivistes du monde entier ont célébré la République brésilienne, pour eux la première République positiviste. Des études récentes comme le livre de José Murilo de Carvalho, *A Formação das Almas - O imaginário da República no Brasil*, São Paulo, Ed. Companhia das Letras, 1990, montrent pourtant que les positivistes étaient en minorité relativement à d'autres groupes républicains.

3 Significative est l'inauguration le 5 avril 1990 à Paris, d'une statue de Clothilde de Vaux, offerte par les positivistes de l'Apostolat positiviste du Brésil à la Ville de Paris, en commémoration du bicentenaire de la République française.

4 João Cruz Costa, *Contribução a História das Idéias no Brasil*, 2a edição, São Paulo, Ed. Civilização Brasileira, 1967.

5 Par exemple, il est courant de rendre le positivisme responsable de l'autoritarisme des relations sociales au Brésil.

6 Justiniano da Silva Gomes, *Plano e Método de um curso de Fisiologia*, Thèse de concours présentée à la Faculté de Médecine de Bahia, 1844.

7 *Id., ibid.*, p.25.

8 Roque S. M. Barros, *A Illustração Brasileira e a idéia de Universidade*, São Paulo, EDUSP/Ed. Convivio, 1986.

9 Voir sur ce thème, Roque S. M. Barros, *A evolução do pensamento de Pereira Barreto*, São Paulo, Ed. Grijalbo, 1967.

10 Les positivistes brésiliens de l'Eglise positiviste étaient plus orthodoxes, relativement à divers aspects de la pratique positiviste, que Lafitte. C'est pour cette raison qu'ils se sont éloignés et qu'ils ont créé l'Apostolat positiviste du Brésil.

11 Par "littréiste", on entend qui suit l'interprétation par Littré de l'oeuvre d'Auguste Comte, c'est-à-dire plus scientiste, et plus accordée à la première phase de sa pensée. La vie de Luis Pereira Barreto et de Benjamin Constant, deux positivistes historiques, sont de bons exemples de ce moment de l'histoire du positivisme au Brésil.

12 Nous n'avons pas trouvé, à la Faculté de Médecine de Rio de Janeiro, de thèses de concours, c'est-à-dire de travaux de professeurs de l'Ecole, de caractère positiviste.

13 Nous avons analysé : a- Luis Pereira Barreto *Theoria das Gastralgias e das Nevroses em geral*, 1865. b- Joaquim R. Souza Mendonça, *Da Nutrição*, 1876. c- José Teixeira de Souza, *Da Influência que têm exercido as experiências fisiológicas no progresso da Medicina prática*, 1878. d- Eustachio G. Stockler, *Quais as causas que favorecem o desenvolvimento da febre amarela no Rio de Janeiro? Quais as medidas higiênicas que se devem adotar para fazer desaparecer este flagelo?*, 1881. e- Raymundo Belfort Texeira,

Medicação revulsiva, 1881. f- Joaquim Bagueira C. Leal, *Theoria positiva das epidemias segundo Augusto Comte e Audiffrent,* 1881. g- Rodolfo Paula Lopes, *Importância da Fisiologia experimental,* 1882. h- Carlos A. Oliveira Duarte, *Vantagens e inconvenientes da cremação dos cadáveres,* 1882. i- Francisco R.B. Figueiredo, *Dos nervos tróficos,* 1883. j- João F. Almeida Fagundes, *Do estado patológico em geral,* 1883. k- Gabriel B. Campos, *Da medicação antiflogística,* 1884. l- Antonio J. Souza Aguiar, *Clorose,* 1886. m- Graciano S. Neves, *Dos nervos tróficos,* 1889. n- Verissimo D. Castro, *Das Emoções,* 1890. o- Javert Madureira, *Da unidade cerebral e da loucura,* 1895. p- Vicente Licínio Cardoso, *Concepção da medicina,* 1899.

[14] Voir, par exemple, les thèses de R. Belford Teixeira, L. Pereira Barreto, J. Bagueira Leal, R. Paula Lopes, qui présentent le concept comtien de médecine. Paula Lopes fait aussi une critique de la vivisection.

[15] Voir Eustachio G. Stockler, *op. cit.*

[16] Voir, par exemple, José Murilo Carvalho, *op. cit.*

[17] Luis Otávio Ferreira, *Os politécnicos : ciência e organização social segundo o pensamento positivista da Escola Politécnica do Rio de Janeiro (1862-1922),* Rio de Janeiro, Tese de Mestrado, UFRJ, 1988. L'auteur étudie l'action des ingénieurs de l'Institut polytechnique du Brésil qui, s'appuyant sur les idées positivistes, luttèrent pour une plus grande participation à l'appareil d'Etat de la part des scientifiques professionnels.

[18] H. W. Paul, *From Knowledge to Power: the Rise of the Science Empire in France, 1860-1939,* Cambridge, Cambridge University Press, 1985.

[19] Georges Canguilhem, *Etudes d'histoire et de philosophie des sciences,* Paris, J. Vrin, 1975.

[20] Je remercie Silvia F. M. Figueirôa de l'information qu'elle m'a donnée sur l'interdiction faite à Miguel Lemos de l'Apostolat positiviste, de donner un cours à l'Ecole Polytechnique de Rio de Janeiro en 1882, pour ne pas faire une *"dissémination de l'erreur".* Le Directeur de l'Ecole fait référence à l'athéisme des positivistes. Document des Archives nationales, Rio - réf. IE^3 84.

[21] Oto de Alencar, Professeur à l'Ecole Polytechnique de Rio de Janeiro, critique la Synthèse subjective d'Auguste Comte, où le philosophe, à son avis, ignorait l'oeuvre mathématique du XIXe siècle.

[22] L'auteur, dans son article "A Astronomia no Brasil" in M. G. Ferri et S. Motoyama, *História das ciências no Brasil,* São Paulo, EDUSP/EPU, 1979/1981, 3 vols, **vol.2,** p.411-441, écrit (p.428) "F. Behring qualifiait les nouvelles études sur la formation de l'univers et la connaissance physico-chimique des planètes, de conjectures immorales". Pour R. Mourão c'est à cause de positivistes comme Behring que l'Astrophysique ne s'est développée au Brésil qu'à partir des années 50 de notre siècle.

[23] L. O. Ferreira, *op. cit.,* p.141.

LES DÉBUTS DE LA PHYSIQUE MATHÉMATIQUE ET THÉORIQUE AU BRÉSIL ET L'INFLUENCE DE LA TRADITION FRANÇAISE

Michel PATY

Introduction

La formation, tardive, d'une véritable communauté scientifique au Brésil s'est effectuée selon des modalités très différentes d'une discipline à une autre. Le développement de la physique théorique a été plus long à se réaliser que celui d'autres secteurs de la connaissance scientifique, et peut être daté pour l'essentiel des années trente de ce siècle, bien que l'on compte, dans les périodes antérieures, quelques noms importants et des contributions non négligeables. Il est intéressant de s'interroger sur les divers facteurs qui ont influé sur cette discipline et sur les circonstances qui ont précédé et préparé son émergence, aboutissant à déterminer une voie propre et originale, une véritable "tradition" (ou école) nationale. Ces facteurs tiennent, considérant la spécificité de ce champ scientifique, pour une part au contexte local, aux structures mentales et institutionnelles, pour une autre aux influences culturelles et intellectuelles. Si l'on peut caractériser de façon relativement aisée ces deux groupes de facteurs conjoncturels, il est plus difficile d'évaluer exactement la part de chacun d'eux et les effets de leurs inter-relations. L'approche historique tend souvent, par la nature même de ses objets et de ses méthodes, à dissocier le contexte, qu'il est difficile de ne pas ramener à ses seuls aspects sociaux ou culturels au sens large, et le contenu, considéré sous des formes "standardisées", en raison de l'objectivité de la science à laquelle on le rapporte. Le présent travail voudrait contribuer, à partir d'un cas d'espèce et bien délimité, à éclairer cette question délicate en essayant d'échapper à cette réduction.

Les circonstances de la formation d'une "science brésilienne", tant au niveau d'une organisation systématique de l'enseignement supérieur dans toutes les disciplines qu'à celui d'une contribution significative à la recherche, ont été étudiées par divers auteurs[1], qui ont insisté à juste titre sur les aspects institutionnels, et montré comment c'est la fondation, relativement récente, des Universités (et notamment celle de São Paulo en 1934) qui a donné l'impulsion déterminante. Les structures de formation et les quelques institutions de recherche qui

P. Petitjean et al. (eds.), Science and Empires, 173–191.

existaient auparavant avaient été conçues dans un but pragmatique. L'enseignement supérieur se réduisait à des écoles techniques (Ecoles de Droit, de Médecine, des Mines[2], d'Ingénierie, ces dernières au début militaires[3]), dont la création remonte pour l'essentiel à la fin du XIXe siècle, et qui visaient à former des spécialistes directement utilisables pour répondre aux besoins de la société (ceux du Brésil lui-même, et aussi sans doute ceux des Puissances intéressées à certaines activités[4]). Quant à la recherche institutionnalisée, elle visait également l'utilité, et était cantonnée à certains domaines: les historiens font généralement débuter l'institutionnalisation de la science au Brésil avec la fondation de l'Institut sérothérapique de Manguinhos, à Rio, en 1900, voué à la recherche microbiologique et parasitologique, parce que son rôle et sa renommée furent considérables. Le retard au développement scientifique peut se mesurer par la distance qui sépare les années 1880-1890, où a lieu la création des premiers instituts techniques, et 1934[5], date de la fondation de la première université moderne (l'USP, Université de l'Etat de São Paulo, bientôt suivie d'autres Universités fédérales et d'Etats).

C'est dans les années trente que se constitue, en même temps que d'autres disciplines, et à la faveur de la création et du développement de l'Université, la physique théorique brésilienne. Elle bénéficie, certes, de l'appui indispensable de l'Institution; et il n'est pas indifférent que ce soit sous l'impulsion de Teodoro Ramos, mathématicien et physicien théoricien qui occupe une position charnière, que la physique, théorique aussi bien qu'expérimentale (et plus généralement les sciences exactes) aît été développée à l'Université de São Paulo[6]. Dans cette réalisation, on ne saurait surestimer le soutien et le rôle actif de savants étrangers de grande envergure, fixés au Brésil pendant des années[7], tel Gleb Wataghin (venu du laboratoire de Fermi en Italie) pour la physique. Mais si la "greffe" a pris, de telle sorte que la physique (ainsi que d'autres branches, comme les mathématiques, la chimie, la biologie, pour s'en tenir aux sciences exactes ou naturelles), s'est développée d'une manière assez remarquable, par l'apparition de scientifiques de premier plan et de recherches originales du meilleur niveau, dès la fin des années trente et jusqu'aujourd'hui, le "terrain" n'est évidemment pas indifférent : certaines conditions indispensables étaient présentes. C'est, précisément, sur ces conditions locales, que nous pouvons dire "de préparation" d'un terrain favorable, mais peut-être en même temps porteuses de certaines limitations, que nous voudrions porter notre attention dans ce qui suit. Nous l'examinerons sous l'angle de l'interaction entre des éléments de connaissance, empruntés pour une grande part à une tradition-mère, et des facteurs contingents qui tiennent aux circonstances locales, donnant lieu à une assimilation originale que nous essaierons de caractériser.

Nous insisterons, dans ce travail, sur la période préliminaire, avant que ne commence de s'affirmer un courant à proprement parler de physique mathématique et théorique : cette période comprend le XIXe siècle et les premières années du XXe[8], se concluant, en un certain sens, avec la création, à Rio de Janeiro en 1916, de la Société Brésilienne des Sciences, qui devint plus tard l'Académie. L'exhaustivité est ici bien entendu impossible, et nous nous en tiendrons à l'examen de quelques uns des traits les plus significatifs pour notre propos.

Constitution d'une tradition scientifique et influences

Facteurs institutionnels et idéologiques

La constitution progressive d'une science brésilienne fait partie d'un ensemble de modifications survenues dans le pays depuis la moitié du XIXe siècle. Le Brésil colonial se transforme peu à peu, socialement et culturellement, et cette période est celle d'un essai d'adaptation progressive des structures de la société brésilienne aux exigences d'une nation moderne, promise à l'autonomie depuis l'Indépendance (1822), préoccupée de définir et d'affirmer son identité, ouverte au développement agricole, industriel et urbain et au peuplement de son espace (d'ailleurs sur l'arrière-fond d'une immigration massive). Des institutions se créent et une idéologie se forme, qui mènera à celle affirmée par la République, en 1889. Mais cette société est marquée en même temps par la persistance de structures archaïques, et même féodales, et l'avènement de sa République sera en vérité surtout une victoire de l'oligarchie. Son passé de colonie vouée à l'enrichissement de la Métropole la marquera longtemps (l'absence d'Université en est un exemple, lié d'ailleurs à la spécificité de la colonisation par le Portugal). D'autre part, s'il s'est détaché économiquement et politiquement du Portugal, le Brésil dépend depuis lors - et pratiquement jusqu'à la seconde guerre mondiale -, de l'Angleterre du point de vue économique. Quand à la "dépendance culturelle", elle est plus complexe, autant et peut-être davantage choisie qu'imposée, mais elle n'en est pas moins présente, car les élites sociales brésiliennes garderont longtemps les yeux tournés vers l'Europe. Parmi les pays européens, c'est à la France que va très largement la préférence, pour des raisons qui ne sont pas propres au Brésil seul, puisque c'est le cas de la plupart des autres pays d'Amérique latine, voire d'autres pays dans le monde qui s'ouvrent à la modernité, et ces raisons tiennent à l'histoire autant à la culture[9].

Dans ce contexte se situe l'influence du positivisme de Comte. Cette philosophie correspondait à des conceptions et à une attitude qui présentaient cet intérêt, pour les élites sociales brésiliennes, d'être attentives aux idées de progrès et, en même temps, fondamentalement conservatrices[10]. Ce n'est pas notre propos ici d'analyser les modifications subies par la doctrine de Comte dans son adaptation au contexte intellectuel et social brésilien[11] : nous nous contenterons d'indiquer que la philosophie positiviste a pu stimuler, pour ce qui concerne notre sujet, la création d'Ecoles supérieures et d'Instituts de recherche appliquée, voire susciter un intérêt pour les sciences physiques et naturelles. Mais la "synthèse subjective" du Maître, reprise par ses disciples en France et au Brésil[12], en proclamant que la connaissance est unilatéralement ordonnée à l'homme, dépréciait en même temps son aspect objectif. Elle constituait un handicap face au caractère fondamental de la connaissance scientifique et de la recherche, et même un blocage à l'égard de bien des conceptions modernes. Cependant, cet aspect d'une influence culturelle d'ordre général, dont il faut voir à quel niveau exactement elle s'exerce, ne doit pas masquer d'autres facteurs, qui pourront être éventuellement plus importants. Nous y reviendrons.

Influences culturelles et scientifiques

La question des influences scientifiques soulève le problème de l'évaluation de l'état de développement de la science dans les centres ou métropoles, notamment dans le cas de la France, qui fut la source étrangère principale d'influence culturelle et scientifique au Brésil dans la période considérée. Les historiens qui se sont intéressés à l'histoire sociale des sciences ont parfois opposé l'ancienne splendeur de la période classique, c'est-à-dire le XVIIe et le XVIIIe siècles, où la culture et la science française excellaient, et le XIXe qui, passé le premier tiers du siècle serait, avec le XXe, le temps de sa décadence[13]. Dans ces conditions, la considération privilégiée encore répandue de par le monde au début du XXe pour cette culture et surtout pour cette science serait totalement injustifiée, celle-ci ne devant son reste de réputation qu'au prestige de son passé; et l'on fait éventuellement valoir que la persistance de cette influence aurait été franchement négative, lui attribuant bien de des facteurs du retard dans les pays qui l'on subie. Il pourrait être tentant, dans ce sens, d'imputer à l'excès d'influence française les retards de la science brésilienne, du moins en ce qui concerne la physique, invoquant un effet du positivisme en matière de sciences théoriques, ou la situation dans laquelle se trouvait, en France, au tournant du siècle, la physique théorique, alors qu'apparaissaient deux directions de nouveautés qui allaient la modifier radicalement, la Relativité, la Physique des Quanta, auxquelles elle serait restée largement étrangère.

Mais ce serait évidemment simplifier à l'extrême les situations en les schématisant, et ce serait surtout les déformer. En premier lieu en raison du caractère excessif de la thèse du déclin, qui résiste difficilement à l'examen. Sans exclure l'effet de facteurs institutionnels importants, comme l'organisation de la science française et son lien aux structures de l'Etat - en particulier à travers les Grandes Ecoles - qui a pu porter préjudice au dynamisme de la recherche, il s'agit là de tendances, non d'un état de chose de portée absolue. D'autres auteurs ont fait valoir, avec plus de vraisemblance, le caractère *relatif* de la prépondérance, à partir du moment où d'autres centres se sont développés, comme, au cours du XIXe siècle, les pays de langue allemande et, plus généralement, d'Europe du Nord. Sans être le déclin de la science française, c'était du moins la fin d'une certaine hégémonie. Le grand physicien autrichien Ludwig Boltzmann témoignait[14] en 1905, dans son *Voyage d'un professeur allemand en Eldorado,* de la concurrence entre les grands centres scientifiques européens de l'époque - et par là-même de leur qualité - en se plaignant de ce que, dans les congrès scientifiques qui se tenaient en Amérique (du Nord, en l'occurrence), *"parmi les foreigners*-(les non-anglais) *c'étaient toujours et partout les Français qui étaient les meilleurs"*. Et il regrettait l'absentéisme de ses collègues de l'Académie de Berlin, en s'écriant : *"Nous, les Allemands, n'avons aucune raison de ne pas les égaler"*.

En second lieu, un schéma généralisant d'explication *a priori,* d'ailleurs idéologique, s'avère insuffisant en face de la réalité historique qui se présente d'abord de manière différentielle, et pour laquelle on ne saurait faire l'économie d'une étude spécifique, pour chaque domaine et chaque discipline, des différents facteurs qui marquent tant les traditions-mères dont l'influence se fait sentir, que les traditions locales sur lesquelles cette influence s'exerce. Un tel examen sera propre à faire voir les mécanismes exacts de constitution de traditions et du rôle des influences. Ces traditions privilégient de fait certains domaines, certains types d'approches et de problèmes, sans qu'il soit possible de les réduire à un jugement de valeur global. Par exemple, d'être demeurées délibérément à l'écart de certaines orientations, comme l'intérêt pour les fondements et l'axiomatisation, n'a pas empêché les mathématiques françaises au tournant du siècle d'être d'une qualité incontestable. De même, si la physique théorique proprement dite trouve peu de praticiens en France à la fin du XIXe, la physique mathématique et la physique expérimentale n'ont pas cessé d'y connaître un riche développement.

Comme c'est précisément cette particularité disciplinaire que nous voudrions éclairer dans le cas de la science brésilienne aussi, disons en quelques mots quelle est cette distinction.

Physique mathématique, physique théorique

La physique mathématique et la physique théorique, confondues jusqu'alors sous le signe de la mécanique rationnelle, et qui le demeurent pour l'astronomie mathématique (de Laplace à Poincaré), se séparent au début du dix-neuvième siècle avec la théorisation de domaines de la physique pour lesquels les principes et les concepts fondamentaux doivent faire l'objet d'une élaboration particulière. Les noms de Laplace, Fourier, Poisson évoquent bien ce qu'est la physique mathématique, par leur approche analytique (d'ailleurs féconde) des phénomènes de l'optique physique, de l'électricité, de la mécanique des fluides ou de la chaleur. L'utilisation du formalisme mathématique l'emporte sur l'élaboration physique proprement dite, laquelle est souvent ramenée à la seule considération d'un modèle général, tel le modèle moléculaire, permettant l'interprétation du formalisme.

La physique théorique, au contraire, met l'accent sur les caractères spécifiques des phénomènes considérés et formule des énoncés de nature physique avant toute mathématisation, énoncés qui d'ailleurs conditionnent cette dernière, comme on le voit par exemple dans les travaux de Fresnel en Optique, d'Ampère (puis de Faraday et Maxwell) en Electrodynamique, plus tard de Maxwell, Clausius, Boltzmann, en Thermodynamique (sur la base des deux principes de cette science), puis de Planck et d'Einstein.

Si la physique mathématique s'est instituée en une tradition riche et vivace en France, on ne peut dire qu'il en soit allé de même avec la physique théorique, dont les initiateurs n'ont pas eu d'héritiers directs dans leur pays, et qui fleurit très vite au contraire en Grande Bretagne et en Europe du Nord, sur les traces mêmes de Fresnel et Ampère. A vrai dire, la physique théorique qui se développa dans ces régions fut également héritière des Lagrange, Laplace, Poisson, Fourier, comme en témoignent ses représentants que furent, notamment, von Helmholtz, Kirchhoff, Hertz, Boltzmann, Lorentz... Il faudra attendre, pour qu'elle se voie cultivée de façon systématique en France, les années vingt du présent siècle, à l'occasion du développement de la théorie de la Relativité puis de la physique quantique.

Les premiers éléments constitutifs au XIXe siècle

Les étapes de la constitution de la physique comme discipline au Brésil

On rencontre, au Brésil, une situation un peu semblable, toutes proportions gardées puisqu'il s'agit d'une communauté scientifique naissante, et avec un certain décalage. Pour l'étudier à travers les scientifiques qui se sont intéressés à la physique (qu'elle soit mathématique, théorique ou expérimentale), il convient de distinguer diverses phases dans la constitution de la physique comme discipline au Brésil. La première est celle des tout premiers commencements, et comprend le XIXe siècle et les premières années du XXe : elle est marquée par quelques individualités remarquables, du mathématicien Joaquim Gomes de Souza à l'ingénieur et astronome Oto de Alencar (sans oublier Henrique Morizé pour la recherche expérimentale), et par le contexte d'un enseignement scientifique et technique qui connaît une forte influence du positivisme. C'est de cette période que nous esquisserons dans ce qui suit l'analyse : on y verra comment, localement, une situation se forme en empruntant des éléments dans deux directions fort diverses à une même source d'influence, qu'elle transforme selon des modalités déterminées par les particularités du contexte local.

La seconde phase, directement issue de la première en continuité comme en opposition, est celle d'une tradition en voie de constitution, qui s'affirme dans la direction de la physique mathématique mais s'ouvrant à la physique théorique proprement dite. Cette époque est marquée par des scientifiques de qualité, comme Amoroso Costa, Teodoro Ramos, Luis Freire et d'autres, qui se révèlent et font école, modifient les structures de l'institution, modernisent autant qu'ils le peuvent le contenu des enseignements[15]. Il est utile de remarquer que ce courant de physique mathématique, à travers lequel la physique théorique s'imposera peu à peu, est très influencé par la tradition des physico-mathématiciens français, de Henri Poincaré à Paul Painlevé, Emile Picard et Emile Borel. La troisième phase commence avec la création des Universités et voit toute une génération de jeunes chercheurs, formés par les précédents, développer une physique théorique, une physique mathématique et une physique expérimentale, tant dans un enseignement systématique que dans des recherches originales qui rejoignent le concert international, et contribuent à faire de la science brésilienne l'une des plus avancées des nations neuves. Ces développements, qui se font à travers une diversification, voire un changement des influences, restent cependant tributaires des premiers inspirateurs.

Ayant ainsi situé les grandes lignes de l'évolution de la physique au Brésil, revenons à la première phase, dont les "lignes de champ" marqueront les développements ultérieurs.

Deux directions d accès aux mathématiques

L'histoire de l'implantation des mathématiques et de la physique au Brésil porte dès son origine la marque d'une influence française privilégiée. Sur l'ancienneté de cette influence, on évoquera tout d'abord le fait que les Universités d'Europe où des brésiliens allaient de préférence se former au temps de la colonie étaient non seulement celle de Coimbra, mais aussi celles de Montpellier et de Paris[16]. Ensuite, la pénétration dans le pays des mathématiques françaises, par des ouvrages dans l'édition originale ou traduits, dès 1800, donc avant même l'arrivée de João VI à l'occasion de l'invasion du Portugal par les troupes napoléoniennes - arrivée qui, paradoxalement, eût pour effet d'amplifier l'influence culturelle en général de la France. Les premières traductions en portugais de Lazare Carnot ou de Lagrange à parvenir au Brésil furent publiées à Lisbonne en 1798, mais sont l'oeuvre d'un brésilien : elles suivirent de près les parutions à Paris[17]. Puis c'est au Brésil même que les traductions s'effectuèrent, à partir de 1809, concernant surtout des livres de caractère didactique, ceux entre autres de Legendre et de Lacroix, qu'allait adopter l'Académie Militaire Royale[18].

Nous savons que les mathématiques et la physique théorique étaient alors très étroitement liées; mais c'est vers cette époque qu'elles se différencient dans la pratique des savants, et cette différence, prolongée dans celle entre la physique mathématique et la physique théorique, permet de comprendre un caractère très spécifique des débuts de la tradition brésilienne en physique. Tout au long du XIXe siècle, les mathématiques et la physique seront cultivées au Brésil par une petite élite formée dans les Ecoles techniques, mais ne seront pas l'objet de contributions originales, à une exception près, d'ailleurs assez considérable pour qu'on s'y arrête. Nous reviendrons plus loin sur certains traits de cette "assimilation" à partir des ouvrages importés d'Europe, qui a fourni, en tout état de cause, les moyens de dépasser les limitations qui tenaient à l'enseignement figé des Ecoles.

Deux éléments d'influence, tous deux originaires de France, ont en effet marqué, dans des directions en partie contraires, l'accès aux mathématiques et à la physique. Le premier vient d'être mentionné : il concerne la "réception" des connaissances dans ces disciplines, à partir des publications disponibles, et la figure de Joaquim Gomes de Souza, bien qu'elle sorte du commun, constitue un exemple significatif, révélateur des dimensions de cette assimilation qui peut aller jusqu'à la création. Le second est celui d'une adaptation locale particulière du positivisme, dont les effets ont marqué de manière importante la formation d'enseignants et de techniciens au long de plusieurs décennies.

Le "premier physico-mathématicien brésilien"

Joaquim Gomes de Souza[19], que l'on a pu qualifier de *"premier physico-mathématicien brésilien"*, et que sa mort précoce (à l'âge de 34 ans) empêcha, dit-on, de réaliser une oeuvre plus considérable. Cependant, il donna en mathématiques et en physique mathématique des contributions originales. Cet autodidacte de génie, qui prépara seul et très jeune encore les examens de mathématiques et de physique de l'Ecole Militaire, était au fait des connaissances les plus récentes dans ce domaine. Sa "thèse" d'astronomie théorique, soutenue à 19 ans et qui lui valut d'enseigner dans cette Ecole, reflétait la découverte, survenue deux ans auparavant, de la planète Neptune prédite par Le Verrier : le jeune savant posait le problème de savoir si, connaissant la perturbation d'une planète, il est possible de décider par l'analyse s'il existe plus d'une solution, c'est-à-dire une ou plusieurs planètes perturbatrices[20]. Il le résolvait dans la lignée des méthodes laplaciennes en mécanique céleste.

Ses contributions originales portent sur le calcul intégral et sur des applications à des problèmes de physique : théorie du son, détermination des fonctions inconnues d'intégrale définie, méthodes générales d'intégration considérant les conditions aux limites auxquelles doivent être soumises les solutions, énoncés et démonstrations de théorèmes d'analyse mathématique. Ces travaux, qui témoignent d'une connaissance approfondie de l'oeuvre des grands mathématiciens et physico-mathématiciens Euler, Lagrange, Laplace, Liouville, Abel, et manifestent[21] *"une grande intuition et un admirable talent d'analyste"*, firent l'objet de communications à l'Académie des Sciences de Paris en 1855. Le physicien anglais Stokes en estima certains résultats assez importants pour qu'il les présentât devant la *Royal Society* de Londres, l'année suivante[22].

Plus tard, son "disciple" Oto de Alencar prendra certains de ces travaux pour base des siens propres, marquant la continuité de la physique mathématique brésilienne en voie de constitution. Que l'Académie de Paris n'aît pas jugé bon de les publier est peut-être dû à ce qui pouvait alors apparaître comme manque de rigueur, mais qui était en fait la marque d'un esprit plus intuitif et créateur que formaliste : Gomes de Souza n'hésitait pas à envisager l'utilisation des séries divergentes, qu'il regardait comme *"une espèce de symbole qui remplace la fonction génératrice"*, et sur lequel on peut effectuer des opérations, anticipant par là sur des idées qui s'avèreraient fécondes[23].

Outre l'analyse, il s'intéressa aux équations algébriques, voyant dans ces dernières une analogie avec les équations différentielles linéaires et formulant l'espoir qu'il serait possible[24] de *"traiter au moyen des mêmes principes l'analyse algébrique et l'analyse différentielle"*. Ce qui a pu faire dire que Gomes de Souza avait pressenti des développements que l'oeuvre de Galois rendrait possible, voire en suggérant un parallèle entre Evariste Galois et Gomes de Souza, tous deux génies précoces et trop tôt fauchés[25].

Mathématiques et positivisme

Gomes de Souza représente une brillante exception dans le Brésil du XIXe siècle, celle d'un physico-mathématicien qui fut peut-être de génie. Il faudra attendre les premières années du XXe siècle pour voir apparaître à nouveau une pensée originale en mathématiques et en physique mathématique. Entretemps, ces disciplines sont enseignées dans les Ecoles d'ingénieurs en fonction de leur utilité et suivant une présentation peu propice à susciter l'innovation. De plus, cet enseignement même est menacé après l'abdication de l'Empereur et l'avènement de la République sous la bannière des idées "positivistes", et sera d'ailleurs pendant un temps supprimé[26]. C'est ici que se place l'"intermède positiviste".

Si la Société pour l'étude du positivisme fut fondée à Rio par Benjamin Constant[27], en 1870, dans l'intention de propager l'"Apostolat positiviste", c'est à bien des années auparavant que remonte l'influence de la doctrine d'Auguste Comte au Brésil. Les premiers disciples brésiliens de Comte furent des ingénieurs formés à Paris - notament à l'Ecole Polytechnique comme élèves étrangers -, qui avaient suivi ses cours dès les années 1830[28]. L'influence du positivisme s'exerça ainsi de manière privilégiée au Brésil par le canal des enseignants des Ecoles[29] d'ingénieurs : il n'y eût pas, dit-on, un ingénieur civil ou militaire qui n'aît été à cette époque enrôlé dans la doctrine[30]. Nul doute que le prestige de Comte auprès d'eux ne fût dû à sa qualité de mathématicien.

La première mention du positivisme au Brésil figure (par une citation de Comte) dans une thèse de dissertation sur les principes de la Statique, soutenue en 1850 à l'Ecole Militaire. C'est dans cette même Ecole, ainsi qu'à l'Ecole Polytechnique de Rio, qu'enseignèrent plus tard Benjamin Constant et ses disciples Miguel Lemos et Raimundo Teixeira Mendes : peu à peu, sous leur influence et celle d'autres professeurs également convertis à la doctrine[31], l'enseignement supérieur des mathématiques et de la physique s'orienta délibérément dans la direction "positiviste", telle que Comte la présentait[32] dans sa *Géométrie analytique* et dans sa *Synthèse subjective*. Dans ce dernier ouvrage, Comte rejetait les constructions abstraites des nouvelles mathématiques (représentées notamment par Cauchy) et enseignait que les mathématiques étaient achevées avec la Mécanique céleste, la seule tâche dans ce domaine étant, désormais, une systématisation finale subordonnée à l'ensemble des connaissances humaines.

Par son caractère unilatéral, le "positivisme mathématique" (d'ailleurs prolongé dans l'oeuvre de Pierre Lafitte, auquel les positivistes brésiliens étaient liés[33]) orientait au Brésil une direction bien différente de celle des traditions-mères : la physique mathématique et les mathématiques s'arrêtaient à celles des Laplace, Monge, Fourier, Poinsot, et se poursuivaient indifférentes à toutes les transformations qui, de Cauchy à Poincaré et Hilbert, s'opéraient au même moment en Europe, et en particulier en France même, où d'ailleurs se répandaient des manuels traitant des nouvelles conceptions et méthodes, comme le *Cours d'Analyse de l'Ecole Polytechnique* de Cauchy ou, plus tard, le *Cours d'Analyse* de Camille Jordan[34].

Cet effet du positivisme d'Auguste Comte et ses disciples sur les mathématiques constitue un avatar spécifiquement brésilien : on ne constate pas de situation semblable dans l'enseignement des mathématiques en France. D'ailleurs l'"Apostolat positiviste" brésilien reprenait un flambeau déjà bien chancelant en Europe. Il éditait et diffusait à Paris, Londres et Rio les oeuvres de Comte, ainsi que les livres d'une collection à l'usage des professeurs et des élèves des Ecoles Militaires, Navales et Polytechniques[35]. On trouvera un indice de la perte de vitesse du positivisme - voire d'un désintérêt pour la conception comtienne des mathématiques - dans la patrie d'origine de la doctrine à considérer les circonstances de la ré-édition de la *Géométrie analytique* de Comte par les soins de Miguel Lemos. Ce dernier avait déjà traduit l'ouvrage en portugais, avec Teixeira Mendes, mais se ravisa et le fit paraître dans la langue originale pour lui assurer une diffusion plus large - donc, internationale -, selon ce qu'il annonce dans une lettre à Pierre Lafitte[36].

La figure et l'oeuvre du Maréchal Trompowski fournissent la meilleure illustration possible du positivisme mathématique et de son influence. Elève de Benjamin Constant à l'Ecole Militaire, puis son successeur, il publia entre 1903 et 1905 quatre épais volumes[37], totalisant 4000 pages, de *Leçons de géométrie algébrique* de *Géométrie différentielle,* de *Géométrie intégrale* et d' *Algèbre supérieure.* Luiz Freire, qui prononça son hommage pour le centenaire de sa naissance[38], voit dans cette oeuvre *"le plus grand effort didactique à ce jour au Brésil en mathématiques",* loue la clarté de l'exposé, et dit avoir lui-même appris *"les classiques de la pensée mathématique"* dans les ouvrages du Maréchal, qu'il qualifie d'ailleurs de *"meilleur des maîtres dans les limites de l'orientation suivie, qui était l'orientation positiviste".* Mais l'éloge est mitigé, venant après une longue analyse, qui occupe plus de la moitié du discours, des méfaits du positivisme au Brésil en matière de sciences, et singulièrement en mathématiques; et la critique qui le suit n'en est que plus vive, soulignant l'ignorance et le rejet, dans les ouvrages du militaire et mathématicien positiviste, des oeuvres, qui lui étaient contemporaines, des *"Cauchy, Weierstrass, Poincaré, Painlevé, Borel, Lebesgue, qui furent les Maîtres des mathématiques de son temps".* En déplorant la stérilisation des esprits qui en est résultée, et qui a pu empêcher l'épanouissement de grands talents, Luiz Freire ne fait qu'exprimer le sentiment général des scientifiques des générations suivantes.

L'influence des positivistes en matière d'enseignement perdurera dans les premières décennies du XXe siècle, et c'est en réaction contre elle que l'Université sera instituée[39]. Elle retarda probablement l'instauration d'une recherche originale - elle tendait à en dissuader, plutôt qu'à y inciter -, du moins en ce qui concerne les mathématiques et la physique. Mais les connaissances les plus contemporaines étaient malgré tout présentes par les livres et les revues, dans les bibliothèques mêmes des Ecoles, et ceux qui les cherchaient avaient la possibilité de les trouver. Tel fut le cas de Oto de Alencar, pourtant éduqué dans les conceptions positivistes, et qui sut se défaire de ce "moule rigide", de cette "carapace"[40].

La Physique au Brésil dans les premières années du XXe siècle : contributions critiques et compréhension originale

Contributions critiques en physique mathématique : la stabilisation d'une tradition

Oto de Alencar Silva[41], mathématicien et astronome, appartint en effet un temps au courant positiviste alors dominant dans la discipline, avant de s'élever contre la rigidité et la fermeture de cette doctrine. L'article dans lequel il relevait[42] *"des erreurs de mathématiques dans la synthèse subjective d'Auguste Comte"* causa quelque sensation au-delà même du cercle des professeurs-ingénieurs de l'Ecole Polytechnique de Rio. Formé dans cette Ecole, il y enseigna, et publia dans la *Revue* qui y fut fondée, dès 1897, la plupart de ses travaux. Il publia aussi plusieurs articles dans des revues de mathématiques au Portugal et en France. C'est par lui que la recherche originale mathématique et physico-mathématique fit au Brésil sa réapparition, dans la lignée de Gomes de Souza[43] et en relation aux développements récents. Il a ainsi permis, par ses travaux originaux et surtout par son enseignement, de dépasser les limitations de l'imprégnation positiviste. Les travaux de l'école française, en particulier, trouvaient en lui un connaisseur averti. Son travail sur les surfaces minimales de Riemann, par exemple, fait référence aux considérations de Darboux et Poincaré sur le sujet, notamment aux travaux de Poincaré sur la capillarité, phénomène où l'on a affaire à de telles surfaces[44].

Oto de Alencar s'intéressa à des problèmes de physique mathématique, comme ceux de l'astronomie théorique (théorie de la Lune, etc.), mais également à la théorie physique elle-même, jusque dans sa relation à l'expérience. Son article sur "la théorie de Maxwell et les oscillations hertziennes", paru en 1899, présente et analyse l'opuscule publié peu d'années auparavant sous ce titre par Poincaré[45]. Il écrit sur tels problème d'électrostatique, sur l'effet Zeeman, propose une nouvelle démonstration de la formule de Stokes, présente, en 1906, un recueil de notes et de mémoires sur la physique et l'électrotechnique, et un autre sur la théorie des erreurs.

Les résultats réellement inédits concernent surtout quelques problèmes mathématiques (comme les applications géométriques des équations de Ricatti), et la plupart de ses mémoires, articles et notes de cours sont de caractère didactique, menées par un vif sens critique, exercices de réflexion plutôt que recherches originales. C'est là un trait général de la plupart des contributions de la génération de mathématiciens et physiciens théoriciens qui va le suivre immédiatement; on n'en sous-estimera pas le rôle formateur, ces exposés critiques s'avérant propres à aiguiser la compréhension profonde et, par là, à stimuler des pensées originales. Oto de Alencar disparut trop jeune[46] pour mesurer le fruit de son enseignement, et c'est à son disciple Manoel Amoroso Costa qu'il venait de reprendre le flambeau dans la même direction. Mais nous sortons, avec ce dernier, de la période stricte à laquelle nous voulions nous cantonner.

Faute de place, nous laisserons de coté ce qui a trait à la physique expérimentale, dont les premiers linéaments furent posé par Henrique Morizé, d'origine française, et dont le rôle fut également important à la direction de l'Observatoire National et à la Chaire de physique expérimentale de l'Ecole Polytechnique de Rio[47].

Voies et vecteurs de la communication

Si les scientifiques brésiliens cultivent les mathématiques avancées et la physique fondamentale, c'est, dans toute la période étudiée, à titre purement individuel. Le rôle que les métropoles ont joué dans la formation et dans la circulation des débats sur les nouvelles idées scientifiques, pour indirect qu'il aît été, n'en fut pas moins essentiel. Cette influence s'est effectuée par les livres et les revues publiés en Europe, présents pour bon nombre d'entre eux dans les bibliothèques des institutions brésiliennes, ou acquis individuellement par abonnements et commandes, notamment par l'intermédiaire des actives librairies de Rio. A quoi s'ajoute la répercussion immédiate et importante, dans la presse brésilienne, des informations scientifiques données dans les périodiques d'Europe.

Plusieurs traits caractérisent ce mode spécifique de communication et d'influence, dans ses effets sur le "milieu" récepteur. L'un est relatif à la langue, et renforce une influence par ailleurs dominante en ce qui concerne la culture et les idées : les publications en langue française sont privilégiées, la France, outre son influence culturelle en général, étant alors celui des grands pays européens scientifiquement développés dont la langue était lue couramment par les élites sociales qui avaient accès à l'enseignement. Rappelons d'ailleurs que le commerce des livres au Brésil, au XIXe siècle comme au début du XXe, était presque un apanage de français installés au pays, et cela vaut aussi bien pour les ouvrages généraux que pour les publications scientifiques[48].

D'un autre coté, que le vecteur de la communication des connaissances nouvelles fût exclusivement l'écrit imprimé et publié, y compris en ce qui concerne les débats d'idées, entraîne une différence avec ce que serait un enseignement oral et une participation directe à des discussions. Cette différence est de deux ordres : le délai d"une communication différée, et l'espèce d'autorité particulière que donne la chose écrite par les Maîtres, dans sa présentation formelle, comme un produit achevé. Telle avait été, certes, la voie naturelle de la communication dans le passé : mais elle n'était plus la seule désormais, les conditions de la production scientifique ayant changé. Etant donné ce qu'est désormais le système des connaissances, cette voie, tout en rendant la communication possible, ne facilite pas la participation : elle favorise l'assimilation plutôt que la création. De fait, les contributions des physico-mathématiciens brésiliens, jusqu'aux années trente de ce siècle - sauf exceptions marquantes -, ne constituent pas tant des recherches originales que des commentaires et présentations critiques des idées scientifiques nouvelles en provenance des métropoles. Ce qui ne préjuge pas de la qualité de ces contributions, souvent très pertinentes et manifestant une pénétration profonde des problèmes, révélatrices de la qualité exceptionnelle de professeurs qui auraient de toute évidence pu, dans un contexte favorable, réaliser des recherches de premier plan. D'un autre coté, le caractère différé de la participation aux connaissances nouvelles et de leur assimilation favorise sans doute la prise de recul, lisible dans l'intérêt marqué pour l'aspect philosophique des problèmes. Ce dernier est d'ailleurs cultivé, dans toute cette période, par la fréquentation d'ouvrages de philosophie des sciences comme ceux de Poincaré ou d'autres savants et philosophes, notamment les auteurs de la *Bibliothèque de philosophie contemporaine,* dont les titres furent largement diffusé voire réimprimés par les libraires[49].

Centre National de la Recherche Scientifique (REHSEIS), Paris

Notes

[1] Cf. Azevedo (1955), Ferri, Motoyama (1979-1981), Schwartzmann (1979).

[2] L'école des Mines d'Ouropreto fut fondée en 1875; elle eût pour premier directeur Henri Gorceix (1842-1920), appelé de France par l'empereur don Pedro II.

[3] L'Académie Militaire Royale, qui fut longtemps le seul lieu d'enseignement supérieur des mathématiques et des sciences physiques, fut fondée du temps de la Couronne

portugaise, en 1810. Elle s'appela plus tard Ecole Militaire, et donna lieu ultérieurement à l'Ecole Centrale (1858) et à l'Ecole Polytechnique de Rio (1874).

[4] Par exemple, et ceci vaut pour l'enseignement comme pour la recherche, la connaissance des maladies tropicales, ou celle des ressources minières et leur exploitation.

[5] Cf. p. ex. Mathias (1982).

[6] Sur la constitution de l'Université de São Paulo, et le recrutement de professeurs européens en sciences exactes (par Teodoro Ramos) et en sciences humaines (par Georges Dumas), cf., p. ex., Petitjean (1988, 1991).

[7] Notamment les années de guerre. La science brésilienne a bénéficié de l'émigration européenne de savants fuyant le nazisme, mais à un degré bien moindre que les Etats-Unis.

[8] Ce travail s'inscrit dans une recherche (cf. Paty, Petitjean (1985)), qui porte également sur les physico-mathématiciens brésiliens du premier tiers du XXe siècle (Paty (1987, et en prép. 1)) et sur la réception de la théorie de la Relativité au Brésil (Paty (en prép. 2)).

[9] L'image de la France des Lumières tient un rôle considérable dans cet éveil à la modernité, et la Révolution n'en est pas séparée, qui assure la rupture avec l'ordre ancien - et qui d'ailleurs eût une influence sur les mouvements d'indépendance des pays latino-américains au début du XIXe siècle. Voir, en particulier, Coggiola (1990), Petitjean (1989), ainsi que Dantes (1987).

[10] On sait que la devise de la République brésilienne, qui figure sur le drapeau national, est celle-là même d'Auguste Comte, "*Ordem e progresso*", "Ordre et progrès".

[11] Cf., p. ex., Arantes (1988).

[12] Cf. Comte (1856) et, p. ex., Lafitte (1875). Sur l'histoire du positivisme au Brésil, voir Lins (1964), Arbousse-Bastide (1956).

[13] Voir, p. ex., Ben David (1970), Gilpin (1968).

[14] Boltzmann (1905).

[15] Pour une étude de leurs "profils" dans le prolongement du présent travail, voir Paty (en prép. 1).

[16] Azevedo (1947), vol.1.

[17] Il s'agit des *Réflexions sur la métaphysique du calcul infinitésimal* (1797) de L. Carnot et de la *Théorie des fonctions analytiques* (1797) de Lagrange, traduites par Manuel Jacinto Nogueira da Gama.

[18] L'Académie Militaire Royale avait au programme l'étude des oeuvres de Euler, Bezout, Monge, Legendre, Lacroix, Laplace, Prony, Delambre, La Caille, Delandre, Haüy, Brisson, etc : cf. Oliveira Castro (1955).

[19] Costa Ribeiro (1955), p.167. Sur Joaquim Gomes de Souza (1829-1863), voir également Amoroso Costa (1929), p.75-76, Freire (1931), Henry (1882), Oliveira Castro (1955), p.56-61, Ramos (1929).

[20] Gomes de Souza (1848). Voir Morais (1955).

[21] Ramos (1929).

[22] Ces mémoires furent réunis avec d'autres dans une publication posthume, préfacée par le français Charles Henry, à l'initiative du gouvernement brésilien : *Mélanges de Calcul intégral,* Leipzig, 1882 : Gomes de Souza (1882).

[23] Gomes de Souza (1882).

[24] *Ibid.*

[25] Freire (1931). Gomes de Souza ne connaissait pas l'oeuvre de Galois. Freire évoque l'extension de la théorie de Galois aux équations différentielles, qui fut l'oeuvre d'Emile Picard.

[26] A partir de 1896 à l'Ecole Polytechnique de Rio : Oliveira de Castro (1955), p.62.

[27] Benjamin Constant Botelho de Magalhães (1836-1891) fut adepte de la doctrine de Comte dès 1857.

[28] Lins (1964), éd. 1967, p.13 et suiv.
[29] Ceci dit sans oublier que le positivisme fut enseigné et divulgué de manière systématique dans les Ecoles de Droit - notamment pour la première fois à Recife, où l'Ecole de Droit et de Philosophie fut fondée par Tobias Barreto - et fut également très répandu dans les Ecoles de Médecine.
[30] Freire (1953).
[31] Lins (1964), p.289 et suiv. Les mathématiciens positivistes les plus notoires étaient, selon Luiz Freire (1953), Benjamin Constant, les frères Morais Rêgo, Samuel de Oliveira, José Eulálio, Ferreira Braga, Roberto Trompowski, etc.
[32] Comte (1843, 1856).
[33] Cf. en part. Lafitte (1875).
[34] Freire (1953) le souligne et oppose Cauchy à Poinsot en ces termes : "deux enseignements, deux écoles, l'une qui mourait, l'autre qui surgissait avec Cauchy". Pour Freire, le positivisme au Brésil reprenait, figeait et prolongeait la résistance des conceptions anciennes aux idées nouvelles. On voit combien, dans sa critique des "mathématiques positivistes" brésiliennes, la référence de Luiz Freire va encore préférentiellement aux mathématiciens français.
[35] Cette collection fut lancée en 1893.
[36] Miguel Lemos, lettre à Pierre Lafitte du 7.8.1879, in Lins (1964), éd. 1967, p.595. Cf. Comte (1894) : l'ouvrage est co-édité à Paris et à Rio.
[37] Les *Leçons de géométrie algébrique de* Trompowski (1903), par exemple, sont dédiées à la mémoire d'Auguste Comte, et portent en exergue une citation du Maître. Elles sont marqués par un souci de classification, pour une science achevée, très comtien. Le Maréchal publia également dans la *Revista Maritima* et dans la *Revista dos docentes militares,* un autre essai systématique d'étude, par la géométrie algébrique, du plus grand nombre de courbes possibles. Les quatre volumes des *Leçons* furent les manuels utilisés au cours des vingt premières années du siècle, dans les Ecoles d'ingénieurs et les Ecoles militaires.
[38] Freire (1953).
[39] Cf. Paim (1977).
[40] Selon les expressions de Luiz Freire (1953).
[41] Sur Oto de Alencar Silva (1874-1912), cf. Amoroso Costa (1929 (éd. 1981)), p.67-86, Costa Ribeiro (1955), p.168-170, Morais (1955), p.147-148, Oliveira Castro (1955), p.65-67.
[42] Alencar Silva (1898). Les erreurs qu'il relève ont trait à certains énoncés géométriques de Comte.
[43] En particulier par un travail de 1901, publié en français dans une revue portugaise, sur la propagation du son, qui prolonge un des mémoires de Gomes de Souza (Alencar (1901)).
[44] Ainsi qu'à des études parues dans les *Annales de l'Ecole Normale Supérieure* de Paris.
[45] En 1894.
[46] En 1912, dans la trentaine. Amoroso Costa devait également disparaître jeune, accidentellement, en 1928.
[47] Cf., en part., Rocha e Silva (1976).
[48] Par ex., les librairies Garnier, Briguiet, etc., à Rio, Garraux à São Paulo. Cf. Hallewell 1985.
[49] On en trouve aujourd'hui encore de nombreux exemplaires dans les boutiques de livres d'occasion.

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BRAZILIAN MUSEUMS OF NATURAL HISTORY AND INTERNATIONAL EXCHANGES IN THE TRANSITION TO THE 20th CENTURY

Maria Margaret LOPES

Introduction

The institutionalization of Natural History Museums all over Europe was a characteristic phenomenon of the second half of the 18th century up to the middle of 19th century. The consolidation of Natural History as science forced old cabinets to substitute their displays for catalogued and ordered exhibitions. 19th century European museums, testimonies up to now of colonialism, gathered fabulous collections around the world and outlined museums main features, which survived almost everywhere.

In this context, Latin-American natural history museums were founded: Rio de Janeiro, 1818; Buenos Aires and Bogota, 1823; Santiago do Chile, 1830; Belém, 1871; La Plata, 1880; San José da Costa Rica, 1887; São Paulo, 1894, among others. Our first thoughts about international relationships of Brazilian museums in the turn to the 20th century, are presented here, as part of a main research on experiences undergone in the history of natural sciences museums in Brazil, due to the necessity of understanding the role they played as mechanisms of propagation of science in peripheral countries.

Some Aspects Related to Brazilian Museums of Natural History

The origin of the oldest Brazilian and Latin American museum, the nowadays National Museum of Rio de Janeiro derived from the *"Casa de História Natural"*, best known as *"Casa dos Pássaros"*, created during the colonial period, which stored the collections to be sent to Lisbon. Having worked under poor conditions during some 30 years, it was extinguished in 1813 by the Royal Court and five years late later, the Viceroy João VI founded the Rio de Janeiro Royal Museum.

During last decades of 19th century, museums were very important to the process of institutionalization of science in Brazil, as research bodies, which despite all their weakness, anticipated in many decades our first universities.

Museu Nacional, surviving with huge difficulties, as keeper of modest collections, sometimes providing informations needed by gov-

P. Petitjean et al. (eds.), Science and Empires, 193–200.

ernmental bodies on natural resources of the country, and sometimes sharing the physical space with other institutions[1] was the sole reference during many years to those concerned with natural science. Renewed in 1876, under the direction of Ladislau Neto (1870-1892), a botanist of French education, *Museu Nacional* lived its days of glory, concerning scientific production, with the consolidation of its library, the publication of the *"Archivos"* and the foundation of the first laboratory of Experimental Physiology in Brazil.

Two other museums, the nowadays *Museu Paraense Emilio Goeldi* and the *Museu Paulista,* also will be responsible for great advancements in natural sciences, in the end of last century. The *"Sociedade Philomática"* created in 1866 was the initial nucleus of the *Museu Paraense* founded in 1871. Overcoming a period of neglect, which almost led to its closure, the Museum was reopened in 1891 directed by a Swiss zoologist Emilio Goeldi (1894-1907). Goeldi organized it and transformed it in the first scientific institution in the Amazon. The *Museu Paulista,* known as *Museu do Ipiranga,* was created in 1894 by Orville Derby, an American geologist, Director of the Geological and Geographical Commission, and its first director was a German zoologist Hermann von Ihering (1894-1916).

Brazilian Museums in the International Context

Working with or under European naturalists, these museums were linked to federal or provincial government. They kept different levels of scientific exchange with several countries and followed attentively the international debates in their respective fields of research, and tried to follow European standards.

Since the middle of the 1820's, first exchanges of collections are recorded. Thanks to the naturalist Frederic Sellow, guest at the *Museu Nacional,* the *Berlin Royal Museum* sent an ornithological collection, and proposed a regular interchange, while the *Museu Nacional* would send[2] *"duplicated collection of products of the three natural kingdoms"*. In 1829, by order of the Emperor, a duplicate collection of minerals from Brazil would be sent to the Mineral Cabinet of the Royal Prince of Denmark, in exchange with other products[3]. In 1843, the direction of *Museu Nacional* asked permission to the Ministry of State to deal directly with European museums, to exchange materials and to award the title of "Corresponding Member" to all institutions and personalities who the Museum considered worthy by their scientific merits.

The long list of exchanges and gifts donated by *Museu Nacional* ranges from Melbourne Museum to European ones, especially Berlin and Paris, to National History Museums of New York and Washington. As an example, the envoy of 3,500 Amazon fishes to the *Muséum d'Histoire Naturelle* in Paris for taxonomical studies, (since the Museu Nacional did not have a specialist of that field)[4].

Ihering[5] stated in his first year of work that had been *"very useful and encouraging"* the help and support that his Museum received from other museums and scientific societies. He says that relations were *"intimate and extremely worthy"* with the United States National Museum and with the British Museum. The latter offered to classify and revise the snake collection of Goeldi's Museum[6]. Ihering[7] also reported on donations received, in 1895, from museum directors: Dr. Kraeplin, Hamburg; Dr. A. B. Meyer, Zoological Garden, Dresden and Dr. K. Lampert, Stuttgart.

The same year, the *Museu Paraense* received a valuable gift donated by the British Museum Trustees Board - nearly 500 stuffed birds from Mexico, Central America and neighbor areas of the Amazon[8].

Museu Paulista exchanged in 1899 and 1900 with Museum de la Plata, Montevideo and the British Museum Ihering reports that *"in reward to the valuable support the Museum has received"* he tries hard to respond *"in the most satisfactory manner to countless demands from all over the world, either by institutions, or by fellows specialists"*. Ihering classified shells, eggs and birds collections to several Latin-American museums, to the Basel Museum and to the University of Tokyo[9].

The *Museu Paraense* received, around 1901, help from the British Museum to classify bats and from the Bern University to study dogs and foxes. Goeldi decided from his eight years old experience[10] that

"to guarantee the salvation of intellectual work represented by the determination and elaboration of collections of fragile objects, perishable due to climate conditions, copies of collections should be trusted to overseas museums with better climatic conditions (...). So we choose for objects related to zoological matters, the Museum of Natural History in Bern, directed by Theophil Studer".

Publications, during this period, were exchanged with some 300 to 400 institutions, all over the world. Exchanges also included journeys to Europe, for research and congresses, such those made by Ladislau Neto to France in 1888 and latter to Berlin where he took part in an Americanist Congress; *Museu Goeldi's* botanist in chief, to Europe in 1901; Ihering in 1907, and de Lacerda[11] visited several European museums, to study their organization.

Besides their scientific work, directors of Brazilian museums were fairly acquainted with museological ideas of William H. Flower, director of the British Museum, and George B. Goode, the organizer of the U.S National Museum in Washington (Smithsonian Institution). Ihering[12] makes explicit references in his proposals about the organization of the *Museu Paulista* to the well-known *Principles of Museum Administration* by George B. Goode[13]. He mentions that collection's displays at his museum follow the *"reasonable and practical"* separation between public and scientific collections, according to the great Museums in Europe and United States, which choose carefully the collections for exhibition and store the study collection what, besides, saves more space[14]. In 1919, Roquete Pinto[15], an educator at the *Museu Nacional,* again quotes Flower, hoping that *"museums could be treated as living beings, cared for thoroughly to keep its balance and to grow better."*

If in 1860, Ladislau Neto[16] acknowledges that, in Europe, Brazilian natural resources were already known, but *Museu Nacional* was unheard of, this situation has changed in the 1900's. William J. Holland, president of the American Association of Museums (AAM) from 1907 to 1909, in a short reference to *"other American countries"* included under the reference Science Museum in the 11th edition of the Encyclopaedia Britannica, edited in 1911, mentions that most Central and South American countries already have museums in their capitals, although the majority was in *"a somewhat languishing condition"*. Among the *"worthy exceptions"* were: *Museus Nacional, Paraense* and *Paulista,* along with the Buenos Aires, the Valparaiso and the Mexico Museums. Brazilian museums were also mentioned by the British Museum Association and by the AAM, especially the *Museu Paraense* and the *Museu Paulista,* from 1903 to 1906, either in full page articles or in brief notes[17]. The Proceeding of the AAM, in its inaugural meeting in 1906 registered among those who replied to its original invitation, and thus signified their adhesion by letter, the names of Emil Goeldi and Hermann von Ihering[18].

The international exchange was not the only thoughtful concern of directors of Brazilian museums. Their references as center of excellence in museological and scientific matters were their motherlands, where they had studied and worked, or the museological centers of excellence at that time. Ladislau Neto chose Paris Museum as the ideal one. He establishes comparison between the budget of Rio de Janeiro and Paris museums, to show how the former is *"far from having funds to support the real costs of a scientific institution"*, even if he attenuates the comparison, taking into account the difference between the two countries. He states that any person who has visited the main museums in Europe could not fail to note how inadequate the building of *Museu Nacional* was. His remarks were not just architectural, but rather reflected his view on Natural History:[19]

"A botanical garden and a zoological garden are acknowledgedly indispensable dependencies to a museum of natural science all over the world, because they make possible verify the taxologic laws that were discovered based on dead and sometimes badly kept collections".

A botanical garden would only be created at *Museu Nacional* following its transfer to its present site, in 1892. But in 1879, under the support of Pedro II, a Claude Bernard admirer, a laboratory of Experimental Physiology was founded, and was headed by Louis Couty, a French physiologist, and by João Batista de Lacerda, latter director of the Museum, (1895-1915) who, always determined to give the Museum a practical and utilitarian goal, opened new laboratories, an evident indication of transformations operated in these scientific fields.

Sheets-Pyenson comments[20] that images of the palaces of Victorian science swung on heads of men of museums in British colonies; these images also dwelled in Goeldi's mind, as if he had his museum well fitted with indispensable botanical and zoological gardens, when he decided to restore the aquatic birds lake, he gave it the shape of the Lake Maggiore, in Italy. He purchased, in Paris, iron net for the birds cage like those at the St. Germain Parc and to shelter aquatic plants he built a lake shaped as the Black Sea[21].

Ihering since his investiture speech expressed the importance of *Museu Paulista* to overcome the delay in natural sciences in Brazil, due to the lack of universities or schools *"almost comparable to European one"*. He considers[22] the *Museu Paulista "a scientific establishment that tries and manages to match those Institutes in North America and Europe"*. Ihering had been educated in Germany, when field zoology started to give way to laboratory work and where since 18th century started strong reactions against a purely taxonomical zoology. At first, he did not claim for botanical and zoological gardens, but he did fight later to have a biological station to study animals in their own environment, and acquired a reputation of a pioneer in ecological studies in Brazil[23].

Signs of the time and marks of transformation and of different influences undergone in Brazilian museums can be noted by minor details in their rules and regulations: while the *Museu Nacional* in 1876 rules stated that for job qualifications, French was mandatory, this does not hold to *Museu Paraense* rules or to *Museu Paulista* 1894 ones, which stressed the necessity of a scientific education in university dedicated to natural history, and in the case of the *Museu Paulista* establishing as part of the practical examination, a microscopic analysis[24].

Final Considerations

In this short overview, we focused only to a narrow aspect - international relationships - of the intricate web of relations that characterized the development of Brazilian museums.

Museums in Brazil have not yet been the focus of works dealing with the institutionalization of science. The origins and progress of collections of different museums and of several subjects in other countries were treated in various works in Europe[25]. Some works especially those dealing with North American Natural History museums[26], English colonies and countries under British influence[27] take the diffusion of museums as a specific fact of a wider historical phenomenon - the development of sciences in countries under European imperialism.

Under this perspective, Lacerda, in 1905, had a clear vision of museums's role when he said that their function was not to be repositories of objects, but rather it was scientific production, experimental research, cataloguing, classifying and exhibitions of collections.

Directors of Brazilian museums were proud of their *"the web of tight relations which maintained with almost all establishment of the same kind in the world, as well the multitude of naturalists demanding counselling on expeditions and scientific journeys"*.

The international exchanges occupied each year more pages and gained relevance in the annual reports. This fact leads us to a working hypothesis: not only did the directors see these mechanisms as shelters in search of support and acknowledgment from their peers, but they used it to put internal pressure on government to support their own interests, in order to help them to overcome their permanent problems of proper funds, suitable materials and qualified personnel.

If these international relations had been so *"advantageous"*, this might be due to the methods used in acquiring the collections, which were quite different from other museums. Our museums hardly bought any collections; sometimes they were exchanged, but most of the time they were just the result of field collecting by museum personnel hired as explorer naturalists. These methods might have projected our directors in the international museologic scene: more collections were sent than kept.Collections resulting from field excursions, exchanges, or donations, were used as study material and hardly returned or safeguarded.

The directors had their references either in the Museum de Paris, the British Museum or the Smithsonian, aiming to accompany from Brazil the development of their sciences, and their interest included the creation of institutional spaces, where to, new ideas and social movements have transferred the international prestige[28]. But they armed themselves with patience and preached, as Goeldi:[29] *"Wait ! A natural history museum on the Amazon mouth, cannot be made in one day ! Let our seeds grow and bear fruits !"*

This bore fruits, no doubt, since those institutions survived up to now, as significant centers of scientific production, although one must say, without illusions, in the context of peripherical science.

Universidade de Campinas (Instituto de Geociências)

Notes

[1] Among them: a Academia de Belas Artes, a Sociedade Auxiliadora da Indústria Nacional, o Instituto Historico e Geográfico do Brasil, a Sociedade de Instrução Elementar.

[2] Cf. Notice of "Secretaria de Estado de Negócios do Império", dated August 30, 1827 and signed by the Viscount de São Leopoldo, Arquivo Museu Nacional, Pasta 1, documento 79.

[3] See by Law of the "Secretaria do Estado dos Negócios do Império", dated January 15, 1829, and signed by José Clemente Pereira. Arquivo Museu Nacional, Pasta 1, documento 108.

[4] Neto, L., *Le Muséum National de Rio de Janeiro et son influence sur les sciences naturelles au Brésil,* Paris. Librairie Ch. Delagrave. 1899, 83 p.

[5] Ihering, H. von, *Relatório apresentado ao digno secretário do interior Dr. Cesario Motta Junior,* Museu Paulista, São Paulo, Typ. do Diario Official, 1894.

[6] Goeldi, E. A., "Relatório sobre o estado do Museu Paraense", *Boletim do Museu Paraense de História Natural e Ethnographia,* Pará, Typ. A. Silva. Tomo 1. Fasc. 1 -4., 1894-1896. 1896.

[7] Ihering, H. von, *Relatório apresentado ao digno Secretário do Interior Dr. Alfred Pujol,* Museu Paulista, São Paulo. Typ. do Diario Official, 1896, 16 p.

[8] Goeldi, E. A., "Relatório apresentado pelo diretor do Museu Paraense ao Sr. Lauro Sodré, governador do Estado do Pará", *Boletim do Museu Paraense de História Natural e Ethnographyia,* Pará, Typ. A. Silva, Fasc.1, **vol.3,** 1896, 26 p.

[9] Ihering, H. von, "O Museu Paulista nos anos de 1899 e 1900", *Revista do Museu Paulista,* 1902.

[10] Goeldi, E. A., " Relatório sobre o museu relativo ao ano de 1901", *Boletim do Museu Paraense de História Natural e Ethnographyia,* Pará, Typ. A. Silva, Tomo 111, fasc.1-4, 29 p.

[11] João Batista de Lacerda was director of the Museu Nacional from 1895 to 1915. See Lacerda, J. B. de, *Os Museus de História Natural e os Jardins Zoológicos de Paris e de Londres. O Kew Garden*, Rio de Janeiro, Papelaria Macedo, 1912, 70 p.
[12] Ihering, H. von., "O Museu Paulista no ano de 1896", *Revista do Museu Paulista*, São Paulo, 1897, v. 2: 1-6.
[13] Goode, G. B., "The principles of Museum administration", *Reports of Proceedings* with the paper read at the Sixth Annual General Meeting held in New Castle Upon-Tyne. 23-26 July 1895, London, Dulan and co, 1895, p 69-148.
[14] Ihering, H. von, "História do Monumento do Ipiranga e do Museu Paulista", *Revista do Museu Paulista*, São Paulo, Typ. Hennies Irmaos, 1895, v. 1: 9-31.
[15] Pinto, R., Centenario do Museu Nacional, *Archivos do Museu Nacional do Rio de Janeiro*, Rio de Janeiro, Imprensa Nacional, vol XXII, p 29-30, 1919.
[16] Neto, L., *Investigações históricas e Científicas sobre o Museu Imperial e Nacional do Rio de Janeiro*, Rio de Janeiro,. 1870, 310 p.
[17] See: *The Museums Journal*, **vol.11,** n°12, June 1903, p.374-375; *The Museum Paulista*, São Paulo, Brazil, **vol.IV,** n°11, May 1905, p.388-389; *Boletim do Museu Goeldi de História Natural e ethnographia (Museu Paraense)*, **vol.4,** parts 1-3, 488 p., illustrated, and **vol.V,** n°7, Jan. 1906, p.227; *Memórias do Museu Goeldi*, p.679; *Revista do Museu Paulista*, **vol.6,** 1904.
[18] Dorsey, A., "Minutes of the first meeting of the American Association of Museums", held in New York City, May 15-16. 1906", *Proceedings of the American Association of Museums*, Pittsburgh, **vol.1,** 1907-1908, p.4-14.
[19] See footnote 16.
[20] Sheets-Pyenson, S., "How to 'grow' a natural history museum: the building of colonial collections, 1850-1900, *Archives of Natural History*, 15(2): 121-147, 1988.
[21] See footnote 8.
[22] See footnote 5.
[23] Sawaya, P., "O primeiro centenário do nascimento de Herman von Ihering (1850-1950)", *Ciência e Cultura*, **vol.111,** n°1, March 1951, p.52-61.
[24] See: "Regulations referred by decree 6/16, Re-organization of Museu Nacional, (9/2/1976)", *Archivos do Museu Nacional do Rio de Janeiro*, Rio de Janeiro, Imp. Industrial, **vol.1,** 1876, p.X-XII. Regulations of Museu Paulista do Estado de São Paulo, São Paulo. Typ. do Diario Official. 1984. 10 p. Decree 249 (26/July/1894). "Regulations of Museu Paraense, (2/7/1894)", *Boletim do Museu Paraense de História Natural e Ethnographyia*, Tomo 1, fasc. 1-4, 1874-1896, Pará, Typ. A. Silva, 1896, p.22-27.
[25] Impey & MacGregor, *The origins of Museums*, Oxford, Clarendon Press, 1985.
[26] Kohlstedt, S. G., "International Exchange and National Style: A view of Natural History Museums in the United States, 1850-1900", in: *Scientific Colonialism: a Cross-Cultural Comparison*, Reingold. N. and Rothenberg, M., (eds), Washington, Smithsonian Institution Press, 1987, p.167-190.
[27] Sheets-Pyenson, S., *Cathedrals of Science. The development of Colonial Natural History Museums during the late 19th century*, McGill-Queen's University Press, 1988, 144 p.
[28] Kohlstedt, *op. cit.*, comments the transfer of the main museological axis from Europe to the United States by the end of last century. Limoges, C., "The development of the Muséum d'Histoire Naturelle of Paris, 1800-1914", in Fox & Weisz, (eds.), *The Organization of Science and Technology in France 1808-1914*, Cambridge University Press, 1980, p.211-240, points to the decline of this institution at the end of 19th century.
[29] See footnote 10.

THE PAN AMERICAN EXPERIMENT IN EUGENICS

Nancy Leys STEPAN

Introduction

Eugenics, the science and social movement of "better breeding", has in recent years attracted considerable attention from historians. But the way eugenics became part of the political relations between nations, whether as a deliberate strategy of foreign or colonial policy, or as a more diffuse discourse structuring debates about nationality and the flow of peoples across national boundaries, has been rarely studied. This aspect of eugenics is explored in an account of the Pan American effort in eugenics in the 1920s and 1930s.

The goal of the Pan American Office of Eugenics established in Havana in 1923 was to represent, stimulate and cooordinate eugenic efforts in the American hemisphere. From the beginning, such Pan American coordination was problematic. Indeed, the story of Pan American eugenics was one of failure; rather than bringing about agreement on a Pan American "Code of Eugenics" that would regulate immigration policies and human reproduction according to eugenic principles, as the organizers hoped, only watered down, compromise resolutions emerged from the two Pan American Conferences held in 1927 (Havana) and 1934 (Buenos Aires). The story of this failure is nevertheless of historical interest because it reveals that eugenics was not unitary in its scientific and political meanings; eugenics was, rather, a contested field of knowledge and social action. It is this contestation that concerns me here.

North American and Latin American Eugenics

Until recently, North American eugenics has often been taken as normative for eugenics as whole. Yet histories of eugenics are increasingly revealing the complexities of the eugenics movements. Though all of them were based on new ideas in genetics and an assumption that public policies should be derived from science, genetic theory was not monolithic between 1900 and 1940, and the public policies endorsed as "natural" or logical derivations from scientific knowledge also varied considerably from place to place. In many respects, in fact, North American eugenics and Latin American eugenics stood at opposite ends

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on a spectrum of eugenic possibilities. From the earliest days, eugenists in the United States had taken a strongly reductionist, Mendelian line on the science of racial improvement. On matters of eugenic policy, the United States had taken the lead on eugenic sterilization laws, twenty-four states passing such laws by the late 1920s. Many North American eugenists also gave an extreme racist cast to their movement; racial hybridization was presented as a physiological and psychological threat to North American identity, and an Immigration Restriction Act (the Johnson Act), setting new racial quotas for entry into the United States, was actively promoted by eugenists in the years leading up to its passage in 1924, just at the time the Pan American Eugenics Office was being organized[1].

Latin American eugenics was in several respects oriented in different directions[2]. There was in the region a selective appropriation and re-elaboration of eugenical notions. Though the eugenists had many of the professional, class and technocratic characteristics of eugenists elsewhere in the world, many of them interpreted genetics in a "soft", neo-Lamarckian fashion instead of the "hard" Mendelian fashion typical of eugenics in North America. This emphasis often led to a blurring of the "nature nurture" dichotomy and a belief that certain sanitary reforms of the milieu were themselves "eugenic". In the area of reproduction, the Latins also favored a "soft" eugenic approach, via such things as prenuptial counselling, tests, or certificates, instead of the extreme interventionism of sterilization. Then there was the question of race. While many of the Latin American eugenists shared the racist attitudes of the North Americans, the sheer varieties and ambiguities of the racial issue within the different Latin American countries contrasted with the emphasis on racial purity and Saxon superiority characteristic of some of the most outspoken North American eugenists like Davenport.

The reasons for these different inflections of eugenics within the larger international parameters of the eugenic movement cannot be examined in the short space of this paper. They involved social-cultural processes of scientific appropriation; the ideological weight of the sanitary sciences; scientific nationalism; the burdens of racial identity politics; and the cultural (mainly Catholic) constraints on introducing new reproductive policies that challenged traditional norms in too violent a fashion (in Latin America, only the single state of Vera Cruz, Mexico, and Puerto Rico, passed eugenic sterilization laws in the 1930s). From the Latin Americans' viewpoint, there existed a stream of eugenic interpretation and activity that was altogether milder and more practicable than the eugenics the "Anglo-Saxons" stood for, a stream that linked them to "Latin" movements in certain countries of Europe, such as France. The chief result of the Pan American conferences on eugenics was to make these contrasts in the politics of eugenic interpretation plain.

The Cubans and the Pan American Conference of 1927

The Pan American initiatives in eugenics were not an exclusively North American effort, imposed on unwilling, un-cooperative partners. The story is more complex than that and involved the desire on the part of some Latin Americans to participate in what was viewed in medical circles as a modern, scientific, secular approach to problems of "racial" health. In 1921 the North American eugenists hosted the first international congress in eugenics to be held since before the first world war. Invitations to the congress were sent to several Latin American nations; of those responding Cuba was the most important because of the heavy involvement of the North Americans in Cuba's economy and political life. The U.S. had twice occupied the island since Cuban independence; North American intervention in health in the island was almost a tradition[3]. The moment, then, to involve the Cubans in their own "eugenization" seemed opportune.

The Cuban delegate, Dr. Domingo y Ramos, had a long standing interest in "homiculture" and following the congress began to see the possibility of creating a new Pan American organization within which Ramos would play a prominent role. Precedents existed for using the Pan American organizational umbrella to foster cooperation in the Americas over such things as the control of infectious diseases. In 1923 Domingo y Ramos won approval to create a permanent Pan American Office of Eugenics, to be based in Havana. In 1927 the first of what was expected to be a regular series of Pan American Conferences of Eugenics and Homiculture was held.

Though the conference was relatively small (with only 28 official delegates), Davenport himself attended from the United States, and the "Code of Eugenics", drawn up by Domingo y Ramos and presented for debate, was a significant document for which the Cuban organizers had high expectations, hoping it would establish inter-American norms and policies for eugenics[4]. The Code had been worked out with considerable input from Davenport and Laughlin, with questions of race and immigration occupying a central place. Reproductive issues were also emphasized. The Code, for example, called for all individuals in each of the American countries represented at the conference to be registered for their biological eugenic condition. Those classified as "bad" or "doubtful" from a eugenic point of view would come under the supervision of the relevant eugenic authorities, and in cases of eugenic "irresponsibility", would have to submit themselves to isolation, segregation or sterilization. On immigration, the Code stipulated the free flow throughout the Americas only of individuals officially classified as eugenically or germinally "good". The eugenically unfit would therefore be excluded from contributing their heredity to the social body. Racially, too, the Code proposed that each country would be able to exclude specific types as a whole, according to self-defined racial goals.

The Code was an effort to bring to Latin America as a region a North American form of eugenics. Perhaps not surprisingly, this form was resisted. Eugenics was still a new scientific social idea, and the delegates were under considerable constraints about what they could endorse publicly, whatever they thought privately. As official delegates of their governments, they wished to be cautious, especially when it came to resolutions that carried with them expenditures of government money.

The resistance to the Code was most clear-cut on the issue of reproduction and sterilization. The stipulation that the population of each country be eugenically classified, and the rights of individuals to reproduction be decided on eugenical criteria of fitness, shocked many of the delegates. Eugenic sterilization, as a government policy, was rejected as completely premature. Debate produced only an agreement to put aside further discussion of the matter. In its place, the milder (in the sense, at least, of being non-surgical) prenuptial examinations were recommended, as an acceptable but nonetheless non-voluntary alternative social approach to the control of "unfit" reproduction.

Reactions to the chapters of the Code on race and immigration were even more ambivalent. They reflected the complexities of the racial ideologies within Latin American eugenics, especially in the face of the stridency of the North Americans. While the Cuban Secretary of State praised the "Saxon" race in his opening remarks to the Conference, many delegates were aware that this supposedly superior race was often in short supply in their own countries, and that the North American immigration selection laws were often applied to Latin Americans in humiliating fashion. Dr. Paz Soldan, one of the pioneers of social or "preventive" medicine in Peru, condemned the racial propositions of the Code as a "fantasy" that would *"resuscitate the racial spirit, and would* *bring the gravest consequence of all --imperialism, political conflict and inflammatory struggles"*. The outcome of the debate was therefore a compromise. As a report on the conference said, the Code proposed originally[5] *"was too mandatory and all mandatory statements were changed to recommendations or invitations"*. There was no rejection of eugenics; a place was kept for racial controls over immigration. But references to eugenic classifications and sterilizations of individuals were eliminated.

The "Latinization" of Pan American Eugenics

Despite the disagreements that marked the first Pan American Conference of Eugenics and Homiculture, plans went forward for the next one, to be held in Argentina. Various factors delayed the meeting from 1930 to 1934; this delay was significant, because in the intervening period, the international situation in eugenics changed considerably. In many places there was a growing dissatisfaction expressed by the more liberal eugenists with the extreme racism of the eugenics movements, an extremism manifested at the Third International Congress of Eugenics held, again in New York, in 1932. The next year, the Nazis took power in Germany and very quickly introduced the most sweeping eugenic sterilization law in existence in the west[6]. As news of human rights abuses began to be received, there was need for a certain re-assessment of eugenics among its more progressive and liberal proponents. In Latin America, interest in eugenics had meanwhile grown considerably since 1927. Many of the more significant eugenic societies were formed in the early 1930s, and political discussion of eugenics had widened[7]. But the Catholic Church's condemnation (in the Papal Encyclical of December 1930) of any eugenic policies that led to direct intervention in the reproductive life of individuals had its effect in Catholic countries. The Encyclical did not rule out eugenics altogether as a general aid to reproduction and the family, but it did greatly restrict the scope of eugenic policies in the area of reproduction (if not in race). These possibilities and constraints set the scene for the Pan American Congress of Eugenics and Homiculture that met in Buenos Aires in 1934.

As before, the North Americans and Cubans found themselves in opposition to what was increasingly being seen as a "Latin" point of view in eugenics[8]. The "problem" of the Congress was established when the Latin American delegates insisted on placing eugenics within the broad spectrum of preventive medicine and public health, and resisted the extreme proposals put forward by Domingo y Ramos. In this respect, the Uruguayans' position can be taken as exemplary. The Uruguayan delegates opened the discussions armed with a new piece of social legislation, a "Children's Code", which was very different from the "Eugenic Code" debated seven years previously. The Code was presented as a broad, non-coercive, public health and social welfare program directed towards the child. Though the Code was largely symbolic and rhetorical, and though it kept a space for hereditary issues and the "right of the child to be well born", it was predicated on the assumption that in eugenics not everything was hereditary.

The majority of the delegates at the Pan American conference warmly followed the Uruguayan lead. Agreeing to protect children was politically easy; taking a strong or extremist position on eugenics was not. To many delegates, eugenic sterilization was a zoological mutilation that lacked scientific rationale or moral credentials. So cautious had the Latin Americans become on the issue of eugenics and reproduction in the wake of the Papal Encyclical of 1930, at least in public, that even prenuptial certificates were reexamined as eugenic measures[9].

The disagreement over the very definition of eugenics within the ecology of medicine was also interesting. Whereas the North Americans deliberately excluded from eugenics issues of public health and social welfare, the Latin Americans could not, or would not, refrain from linking their eugenics to themes of the social environment or "homiculture" in its broadest sense, meaning by the latter the study and control of all the factors in the milieu and heredity that affected the individual from before conception to adulthood. So persistent was the wider definition of eugenics that Domingo y Ramos himself, acting as the spokesman for the narrower, North American view, finally conceded the point. He acknowledged that though he had planned the Conference around eugenic themes only, he accepted that the Argentinian and Uruguayans would not confine themselves in this way. Far from failing, then, one could perhaps claim that the Pan American Congress of Eugenics and Homiculture succeeded in living up to its name.

The Latin International Federation of Eugenic Societies

Even before the Second Pan American Conference of Eugenics and Homiculture took place, the "Latins" had begun to reach out for a new international organization that would express better than existing ones their special sense of "Latinity" and "eugenics". This was the *"Federación Internacional Latina de Sociedades de Eugenesia"*, an organization founded in Mexico in 1935 in imitation of the already existing International Federation, but whose goal was to represent the particular concerns of eugenists from the "Latin" areas of the world such as France, Italy, Rumania, as well as Latin America.

The interest of the Latin Federation for the historian lies not in its concrete results, which were nil, but in its role in representation. Within the Latin Federation, "Latinity" was constructed as an oppositional identity to "Anglo-Saxonism". The latter was taken to stand for dogmatic interpretation, hasty action in application, and too rigid an identification of eugenics with narrow hereditarianism. The former was taken to mean moderation in interpretation, caution in application, and a more ample sense of the sphere of social action. According to Italian eugenist and first President, Corrado Gini, the Anglo-Saxons had a one-sided, excessively biological view of eugenics which made the Saxon the exemplar of racial superiority; the Latin view, he claimed, was by contrast "multiple", reflecting the diversities of the Latin American racial situation, and "spiritual" or "philosophical", the result of a more tolerant view of race. Of course, such notions of Latinity and race, many of them reflecting Italian and fascist ideas hardly compatible with the mestizo and mulatto character of the Latin American countries, incorporated their own forms of racialism, whatever the languages used to express them. Nevertheless, the Latin American Federation of Eugenic Societies, in setting itself up in contra-distinction to other international eugenic identities, tried to draw upon a particular tradition in eugenics, based on the feeling that the variety of different populations that made up the Latin countries, the "moderation" of Latin culture, even, they said, its "detachment", rendered a Latin perspective on eugenics distinctive. The time to express that sense of Latinity in eugenics was, however, fast disappearing. When the Latin Federation held its first (and only) meeting in Paris in 1937, support for even a "mild" eugenics had evaporated[10].

Columbia University

Notes

[1] The best account of North American eugenics is given by Daniel J. Kevles in *In the Name of Eugenics: Genetics and the Uses of Human Heredity*, New York, Knopf, 1985. By North American, I mean eugenics in the United States.

[2] Eugenic movements in Latin America have been almost entirely left out of history. The Brazilian story is told in Nancy Leys Stepan, "Eugenesia, Genética y Salud Pública: El Movimiento Eugenesico Brasileño y Mundial," *Quipu: Revista Latinamericana de História de las Ciencias y Tecnología* 2(3), 1985, p.351-384; and "Eugenics in Brazil, 1917-1940", in *The Wellborn Science: Eugenics in Germany, France, Brazil, and Russia* ed. Mark B. Adams, New York, Oxford University Press, 1990, p.110-152. This paper is part of my larger comparative work on Latin American eugenics movements, called *"The Hour of Eugenics": Race, Gender and Nation in Latin America*, Ithaca & London, Cornell University Press, 1991.
[3] Nancy Stepan, "The Interplay Between Socio Economic Factors and Medical Science: Yellow Fever Research, Cuba and the United States," *Social Studies of Science* 8, 1978, p.397-423.
[4] See *Actas de la Primera Conferencia Panamericana de Eugenesia y Homicultura de las Republicas Americanas*, Habana, El Gobierno de la Republica de Cuba, 1928.
[5] *Eugenical News* 13, n°2, Feb. 1928, p.17-19.
[6] For details, see Robert N. Proctor, *Racial Hygiene: Medicine Under the Nazis*, Cambridge, Mass., Harvard University Press, 1988, ch.4.
[7] The Argentine Association of Biotypology, Eugenics and Social Medicine was established in 1932. This was not the first eugenic society in Argentina, but it was the largest. In Brazil, the First Brazilian Eugenics Congress of 1929 was followed by the creation in 1931 of the Central Brazilian Committee of Eugenics. In Mexico, eugenic interest crystallized around the Mexican Eugenics Society founded in 1931.
[8] See *Actas de la Segunda Conferencia Panamericana de Eugenesia y Homicultura de las Republicas Americanas*, Buenos Aires, Imprensa Frascoli y Bindi, 1934.
[9] The delegates reversed their position of 1927, and agrees only to the endorsement of voluntary prenuptial measures.
[10] A report of this congress appeared as Fédération Internationale Latine des Sociétés d'Eugénique, *1er Congrès Latin d'Eugénique, Rapport*, Paris, 1937.

PART III

EUROPEAN SCIENTIFIC EXPANSION AND POLITICAL STRATEGIES

Table Ronde

TYPOLOGIE DES STRATÉGIES D'EXPANSION EN SCIENCES EXACTES

Lewis PYENSON

A la mémoire de Christa Jungnickel

On m'a prié de prononcer quelques mots d'introduction à cette table ronde consacrée à une discussion libre sur la typologie des stratégies d'expansion en sciences exactes. Après avoir précisé le champ d'intérêt, je vous proposerai une orientation particulière pour aller plus loin. Cette orientation entraîne un paradoxe fondamental qui, d'ailleurs, n'est pas insoluble.

Il ne m'incombe pas de définir ce qu'est une science exacte. Dans la perspective actuelle, j'entends par là tout exposé savant qui recourt à une formalisation mathématique d'une part, ou qui, d'autre part, produit comme résultat provisoire une série de chiffres précis. La précision numérique qui sert à une synthèse mathématique éventuelle me semble se trouver au coeur des sciences exactes où l'on est à la recherche des lois universelles. Sans doute cette quête se prête à des applications pratiques, telles les raffinage, affinage et épuration de divers produits naturels et aussi les caractéristiques sinon les cahiers des charges de grands mécanismes et constructions, mais le but des sciences exactes ne réside pas dans le domaine technologique, c'est-à-dire pratique.

Ce caractère fondamental de mathématisation des sciences exactes ne les privilégie nullement dans l'univers humain de l'activité scientifique. En effet le savoir scientifique dont on a toujours besoin est un savoir d'ordre inexact - les soins médicaux et les réparations, réfections et radoubs d'invention mécanique. Mais puisque les chiffres et les équations se prêtent à tout lecteur sans traducteur, on voit surtout dans les sciences exactes un outil adapté pour sonder avec une certaine précision ce qui se passe quand le discours scientifique traverse des frontières linguistiques et culturelles.

P. Petitjean et al. (eds.), Science and Empires, 211–217.

Je dis "sonder" dans un double sens: d'abord au sens de cerner des modifications et transformations produites normalement dans le discours lui-même et les publications scientifiques; et deuxièmement au sens de véhiculer des connotations de prestige et de pouvoir. Ainsi l'outil ne peut se passer d'une enquête auto-réflexive, dans laquelle seraient exposées les souches culturelles du discours. Mais je vous dirai d'abord que vingt ans de recherche intensive pour éclaircir ces souches nous fournissent des résultats qui se résument de la façon suivante : les orientations générales, voire les normes disciplinaires, issues d'un contexte social bien précis, portent un caractère culturel spécifique; l'innovation discursive demande que ces spécificités soient respectées, mais elle est ouverte à tout chercheur intéressé.

Cela ne veut nullement dire que tout chercheur est en mesure d'engager ou d'apporter des modifications au discours scientifique. Des contraintes d'ordre institutionnel et de caractère personnel, dont il est à peine capable de s'évader, le lient par contrat à son environnement local. L'histoire sociale des sciences depuis vingt ans reste en effet le récit de luttes contre ces contraintes et en même temps elle précise telle ou telle contrainte particulière. Ces précisions sont passionnantes puisqu'elles reflètent tout le champ des interactions entre le savant et ses maîtres politico-économiques.

Un fait nous frappe à la lecture de plusieurs de ces contrats sociaux en sciences exactes, contrats dans des domaines divers tels le monde de la physique à haute énergie, l'astronomie à grand format, la physique des basses températures. C'est que le scientifique cherche à séduire son maître par des concessions aux intérêts réels de celui-ci, mais sans compromettre pour autant l'intégrité de sa quête fondamentale. Il est vrai que cette démarche n'est pas un *sine qua non* pour effectuer des recherches en sciences fondamentales; il y a en effet des programmes de recherche qui ont des implications immédiatement pratiques, en météorologie par exemple. Mais à défaut de synthétiser ses résultats, sans les relier à un contexte plus vaste que celui de son bâtiment ou de son bureau, on ne s'engage dans une démarche scientifique qu'au titre de commis ou, à la limite, de greffier municipal.

Les caractères de précision et de généralité nous suggèrent ainsi que c'est surtout à travers les sciences exactes que l'on a l'occasion de voir ce qui se passe au niveau du savoir - à la différence du niveau aléatoire de l'idéologie - quand le discours scientifique franchit une frontière culturelle ou linguistique. Et je vous dirai que l'on ne verra pas grand chose quant au discours codifié - ou texte publié - sauf bien sûr des échecs d'assimilation. Lorsque l'on parle de la physique, et quand on prononce ces mots en France à la fin du XXe siècle, on n'a pas besoin de chercher longtemps où en trouver des exemples concrets[1].

Cette conclusion nous recommande la recherche en sciences exactes comme champ particulièrement bien choisi pour étudier l'interaction entre savoir scientifique et l'étendue du pouvoir politique. Et si ce que je viens de dire se trouve *grosso modo* dans la bonne voie, une telle étude nous renseignera surtout sur les orientations idéologiques qui se trouvent derrière l'expansion politico-économique.

Afin de souligner l'idée centrale, je me permets de présenter l'état de la question dans un autre sens. On va sûrement trouver ces orientations idéologiques dans des sciences comme la santé publique et la psychologie. Mais dans ces dernières sciences, là où l'idéologie se trouve à tous les niveaux et là où les scientifiques sont souvent à la fois commerçant, entrepreneur professionel et savant, il nous semble plus difficile d'identifier des idéologies qui se relient dans la première instance à l'expansion impérialiste proprement dite.

Il est opportun enfin, dans ce préambule, d'invoquer explicitement le deuxième grand mot de ce congrès - "empires". Le choix de ce mot signifie une idée assez vaste, et les sens du mot évoqués par la conférence inaugurale de notre illustre collègue M. Rashed vont vraiment au-delà de mes compétences. Il est néanmoins vrai, si l'on étudie le programme d'activités de ces quatre jours, que l'on est prié de se concentrer sur l'époque moderne et même sur les derniers 150 ans. Dans l'intérêt d'une discussion fructueuse lors de notre courte table ronde, je vous prie de respecter l'esprit de cette contrainte. L'avantage d'une telle délimitation est de cerner un des phénomènes les plus intéressants qui se relie aux "empires" de l'époque contemporaine - l'impérialisme. Et l'on verra sous peu que ce phénomène n'est pas étranger à la question des stratégies d'expansion dans les sciences exactes.

*

We have arrived, by a perhaps circuitous path, at the central question of this session: how to understand strategies of expansion in the exact sciences. The first words in the announced title of the session shall serve as a referent for the remainder of my remarks. The term "typology of expansion" is redolent of Weberian overtones, especially the notion of ideal types. The choice of terms is felicitous in a discipline such as the history of science, which has been dominated, I believe to its detriment, by Durkheimian and Mertonian structures and forms. Weber promises liberty, choice, and a dynamic ebb and flow - that which constitute essential parts of history, elevating historical discourse from the "all too human" level of personal action and motivation.

One must be clear at the onset that strategies are by no means identical with plots or conspiracies - at least in the sense that it is fruitful to entertain them here. It is certainly true, as I have noted above, that scientists frequently affirm the utility of their endeavours in an attempt to attract funding from patrons. They say: I promise to cure cancer, predict tomorrow's weather, or build a thermonuclear power source, but I will do these things on my own terms, which include much attention given over to the claims of pure research. Smart patrons are not deaf to the logic of such forms of reasoning, knowing as they do that the republic of science is regulated by traditions unlike those that govern the political empires of mankind. But state functionaries and foundation officers alike sometimes find it convenient to hedge their bets, and practicality is not a notion foreign to those who assume responsibility for disbursing funds. This much is true for science in general. Even in the cases where pure science is used as a Trojan horse, as a part of a dark conspiracy - one thinks of Milan Stefánik in Ecuador at the beginning of the 20th century - the practical overlay is entirely visible[2]. Strategies of expansion in the exact sciences, predicated on funding from the source of expansion, are forms of negotiation. And the most interesting part of this negotiation concerns the claim of the prestige of pure learning.

Now in the country that invented the *mission civilisatrice,* this notion of the prestige attached to pure learning may seem entirely natural. It is sufficient to invoke the hoary prestige of national French institutions of pure learning - an ideal type so foreign to other countries before the 20th century and so dear to them since 1900. That prestige, leading in France and elsewhere to abuse and inertia, crossed all disciplines and specialties. Its reflections are found in the great centers of archaeology and linguistics which France financed in Egypt, Greece, and Indochina, and it provided the justification for enormous projects that ultimately sapped the spirit of science itself, such as the late 19th century photographic *carte du ciel,* the remeasuring of the fundamental arc of longitude in Ecuador, and the great Bellevue magnetical laboratory[3].

If prestige radiates isotropically, its full effect is nonetheless felt selectively. And certain institutions by their very nature - in spite of their own volition - collimate the incoming signal and record it. Principal among these institutions are Government Ministries of Foreign Affairs. The incoming picture is sharp and focussed when such ministries are concerned with precisely the inverse form of radiation - as they are when they seek to sustain and to expand an overseas empire. Prestige is and has been an essential feature of interimperialist rivalry. It defines spheres of influence and obviates the necessity of armed intervention. Indeed, it may be that the most striking instance of interimperialist war over an overseas empire - that between the United States and Japan - occurred because the belligerents lacked the prestige, in the contentious areas, of the older, European powers.

The prestige ascribed to pure learning and the practical results reputed to stem from it are essential elements of strategies of expansion in the exact sciences. If strategies of expansion followed directly from those elements, one might be led to conclude that pure science expands in one basic fashion - that physics travels overseas much as a navy does, conforming to universal needs and constraints and without much variation as to where the chain of command originates - whether in Paris, in The Hague, or in Berlin. But it seems to me remarkable that whereas discourse in exact sciences reveals national traits only with great difficulty, the expansionary strategy exhibits a certain variation from one country to another. Four years ago I indicated how the variation could be resolved according to three orthogonal axes, which I called "functionary," "mercantile," and "research" axes[4]. The axes were intended to reflect scientific practice on the periphery and the political uses to which that practice was put. The model did not argue for a grand scheme on the part of metropolitan politicians and civil servants[5].

Now the variation in using pure science for imperialist ends, which I have discussed elsewhere, cannot be the simple result of general socio-economic circumstances at the seat of the various empires, as has been suggested by the distinguished Dutch historian H. W. von der Dunk[6]. If it were as Prof. dr von der Dunk suggests, then one would expect to find an identical strategy of expansion for all sciences in each national sector. One instance, which has been discussed at this congress, shall suffice as a counterexample. It is that of the *Instituts Pasteur*. Here one finds a history of private initiative and intense devotion to research which contrasts in an astonishing way to the servility to metropolitan masters on the part of French physicists and astronomers who worked overseas. That is to say, Alexandre Yersin and Charles Nicolle find no counterparts at all among physicists or astronomers at Tunis and Hanoi! The finest French physicists who worked overseas - Jean Coulomb at Algiers and Pierre Lejay at Shanghai - were extraordinarily well supported in the metropolis by the physics hierarchy[7]. Physicists and astronomers found it unusually difficult to formulate original and independent research programs on the periphery of the French empire.

It is nevertheless true, as Prof. dr von der Dunk observes, that strategies of imperialist expansion in the exact sciences, during the 19th and early 20th centuries, fit well with general socio-economic imperatives at the time of the Second Industrial Revolution. Here is a striking illustration of just how strongly physics and related sciences were implicated in that revolution - and inversely (in view of the comments above) how the revolution skirted the biomedical sciences. 20th century physics derived from the practical needs of the nation state to an extent greater than we are accustomed to admit. This is the reason why the nation state and its appurtenances have merited close scrutiny by historians of the exact sciences[8].

But, too, is the reason why we are invited to look at more than one nation state at a time. National peculiarities stand out in clear relief when nations are stood up side by side. I need hardly underscore, in the country that gave comparative history to the world, the limitations of this way of doing things. It remains, nevertheless, to emphasize the extent to which comparisons are made in one mind, by one intelligence. We think well of a historian who looks at one thing closely. But a collection of specialized studies is simply that - unless one person makes synthetic sense of them. At a certain point the light of synthesis is necessary, and that light is accessible to all enquirers if they will choose their examples carefully.

If it does nothing else, comparison invites us to seek generality - not apodeictically in the manner of normative sociology or academic philosophy - but up from the bottom, so to speak, from what is. I say "what is", because to a historian, existence is a function of the availability of documents - a non-linear function possibly, or an inhomogeneous function, but a function nonetheless. Part of the achievement of the very greatest historians - those who spent their life in this city - concerns the identification of new kinds of document and archive. The generality resulting from comparison has a greater good. It gives us strength to avoid naïve chauvinism - the maelstrom around which all historians, no different from women and men generally, must navigate.

Let us return to the paradox announced at the beginning of my remarks. The apparent paradox is this: For science to generate the prestige that is useful to admirals and councillors of state, science must appear to transcend partisan engagement. Scientists decorated by the state for their scientific work have had to deny that any national character may be ascribed to what they did. Is there such a thing as French astronomy or German physics? Over the past generation, historians of science have found their most difficult task in providing an answer to this question. We have not yet fathomed the bottom of it.

Université de Montréal

Notes

[1] Lewis Pyenson, "La Réception de la relativité généralisée : Disciplinarité et institutionalisation en physique", *Revue d'Histoire des Sciences,* **27** (1975), p.61-73, pour l'échec de la physique théorique en France.

[2] On Stefánik: Lewis Pyenson, "Pure Learning and Political Economy: Science and European Expansion in the Age of Imperialism," Proceedings of the Utrecht Conference, *New Trends in the History of Science,* R. P. W. Visser, H. J. M. Bos, L. C. Palm, and H. A. M. Snelders (eds), Amsterdam, Rodopi, 1989, p.209-278, on p.244-248.

[3] For the *carte du ciel:* John Lankford, "The Impact of Photography on Astronomy", in *The General History of Astronomy, 4: Astrophysics and 20th Century Astronomy to 1950,* Part A, Cambridge, Cambridge University Press, 1984, p.16-39, on p.29-32; Pyenson, "Pure Learning and Political Economy, ...", *op. cit.,* p.241-244, for Ecuador; Terry Shinn is the author of a forthcoming study about the Bellevue laboratory.

[4] Pyenson, "Pure Learning and Political Economy, ...", *op. cit.,* p.274-278, which was presented at Utrecht in 1986.

[5] Recognition of this limitation resolves the objections raised against my model by John Jenkin, "British Influence on Australian Physics, 1788-1988, *Berichte zur Wissenschaftsgeschichte,* **13,** (1990), p.93-100, on p.98. My model, where British cultural imperialism rates high on "research" and "mercantilist" axes, provides a reasonable description of exact sciences in Australia.

[6] Von der Dunk, "Commentary," in *New Trends, ..., op. cit.,* p.279-282.

[7] Lewis Pyenson, "Why Science May Serve Political Ends: Cultural Imperialism and the Mission to Civilize", *Berichte zur Wissenschaftsgeschichte,* **13,** (1990), p.69-81, for Coulomb and Lejay.

[8] In their classic study of physics at the beginning of the 20th century, Paul Forman, John Heilbron, and Spencer Weart document the enormous role of the state in supporting the discipline: "Physics *circa* 1900: Personnel, Funding,and Productivity of the Academic Establishments", appearing as *Historical Studies in the Physical Sciences,* **5,** Princeton, Princeton University Press, 1975.

SCIENCES EXACTES ET POLITIQUE EXTÉRIEURE

Brigitte SCHROEDER-GUDEHUS

Le terme "Empire", tel qu'il est employé dans ce colloque, renvoie certes d'abord aux Empires coloniaux -- métropoles et territoires dépendants. Mais il gagne à ce qu'y soient aussi incluses les "zones d'influence" de toutes nuances, ces empires qui s'étendent à des pays nominalement souverains. Les actions scientifiques qui traversent des frontières politiques se positionnent, par conséquent -- peu importe l'attention qu'y prêtent les acteurs -- par rapport à la politique extérieure des États dont ces derniers sont les ressortissants.

Il ne s'agit certes pas là d'un aspect central du thème débattu dans ce colloque, mais il mérite quand même qu'à l'occasion on en précise les implications, qu'on en déduise des éléments d'analyse et d'interprétation. La prise en compte des politiques étrangères nous conduit à enrichir la typologie des stratégies d'expansion en distinguant, par exemple, des actions scientifiques hors-frontières

- qui procèdent dans un vacuum de politique extérieure,
- qui se placent à contre-courant de la politique extérieure
- et celles qui se poursuivent en accord avec la politique extérieure, en connivence, en collusion avec elle ou même en exerçant sur elle un effet d'entraînement.

Quand il est question d'empires, c'est bien sûr la troisième hypothèse qui est le plus fréquemment évoquée : on souligne la concordance entre la politique impérialiste des grandes puissances et l'expansion de la science européenne, on démasque la science comme instrument de l'impérialisme ... L'élan dénonciateur a parfois tendance à ne pas s'embarrasser de questions qui méritent néanmoins d'être posées. On ne doit pas renoncer à s'interroger, par exemple, sur les termes exacts de cette instrumentalisation : qui est l'instrument de qui? *Who is using whom?*

Est-ce le pouvoir politique qui utilise la science à l'appui d'une politique impérialiste? Ou est-ce que les hommes de science utilisent l'autorité de l'Etat, les gouvernements et les administrations au profit de leurs projets -- pour avancer les connaissances, le statut de leurs disciplines, le prestige de leurs institutions, leurs carrières personnelles?

P. Petitjean et al. (eds.), Science and Empires, 219–223.

Il convient, bien entendu, de désagréger la notion "d'Etat", de ne pas parler de la France, de la Grande Bretagne, de l'Empire allemand -- comme s'il s'agissait d'entités compactes, homogènes, dotées d'une volonté, au lieu de structures complexes; comme si une politique n'était pas avant tout la résultante de négociations, de compromis et d'arbitrages entre les divers détenteurs de l'autorité publique dont l'unité de propos n'existe que sur un plan très élevé. Distinguons donc, quand nous parlons de mobilisation de la science par la politique ou de l'autorité politique, au profit de la science, entre les composantes de l'appareil étatique : le Quai d'Orsay, le Ministère des Colonies, le *Foreign Office,* le Ministère de l'Instruction Publique, les militaires ...

Il est vrai que parmi les vecteurs de l'influence européenne sur le développement scientifique des pays non-européens dominent d'abord, et pendant longtemps, les acteurs privés. Ils sont d'ailleurs toujours là -- une continuité qui doit beaucoup à l'avantage qu'ont les politiques officielles de conserver aux actions culturelles à l'étranger (donc aussi dans le domaine scientifique) une apparence apolitique. Dans les continents dans lesquels les grandes puissances allaient se tailler leurs empires, les frontières n'étaient d'ailleurs pas toujours nettes entre les explorateurs, les géographes et les militaires, la recherche médicale et les services de santé publique, etc. Les missions diplomatiques étaient généralement intéressées à être informées de la présence de ressortissants nationaux sur le territoire de leur pays d'accréditation. Pour pouvoir les protéger, le cas échéant, mais aussi pour prévenir leurs maladresses. Les scientifiques en déplacement -- des séjours de recherche aux tournées de conférences en passant par les affectations temporaires à l'enseignement -- n'étaient donc pas sans rapport avec la politique extérieure. Le fait que dans de nombreux cas, des activités scientifiques hors-frontières étaient encouragées, couvertes ou financées par d'autres administrations nationales -- de l'Instruction publique à la Guerre -- pouvait d'ailleurs poser des problèmes : les frictions étaient fréquentes, dans la capitale aussi bien que sur place.

Ce qui m'intéresse, c'est l'interface entre les activités scientifiques hors-frontières et les politiques extérieures, dans le sens très précis de la pratique des administrations qui en portent la responsabilité. Je porte une attention particulière à la phase de transition entre l'époque où les Ministères des Affaires Etrangères se bornaient à intervenir plus ou moins régulièrement pour subventionner une présence scientifique et culturelle à l'étranger (une école, une série de conférences, un poste de professeur) et celle que nous connaissons aujourd'hui, celles des politiques culturelles extérieures, politiques scientifiques internationales, explicites et plus ou moins structurées.

Quels sont les indicateurs qui permettent de repérer les étapes de cette transition? Quelles sont nos sources? Quels sont les pays qui sont les plus intéressants à étudier? La France et l'Allemagne, sans doute en premier lieu -- qui s'accusaient l'une et l'autre d'avoir inventé l'impérialisme culturel tout en prétendant, chacune pour elle-même, d'être dépourvue de tout talent pour la propagande.

Nous examinons les budgets, les structures. Ce n'est que relativement tardivement que les Ministères des Affaire Etrangères accordent une certaine attention à l'activité culturelle et scientifique. C'est d'abord, et pratiquement partout, dans le domaine des écoles qu'ils interviennent, poussés par un désir de maintenir près de la patrie les populations émigrées. Vient ensuite, et encore très proche de cette première préoccupation, le soutien de l'enseignement de la langue et la promotion de son usage par des populations étrangères. En comparaison, les actions hors-frontière dans le domaine scientifique ne sont guère envisagées dans le cadre d'une politique systématique d'expansion ou d'influence.

Les sources qui sont à notre disposition doivent être utilisées avec beaucoup de précaution. Les plus convaincus de l'importance de l'action culturelle ou scientifique à l'étranger sont généralement les personnes qui l'assurent et les instances qui les gèrent, comme -- dans certains pays et dans un premier temps -- les Ministères de l'Education.

Ce n'est que progressivement que la pratique de la politique extérieure -- et ses structures -- intègrent de façon systématique les actions scientifiques et culturelles. Cette intégration s'accomplit généralement au cours de réorganisations administratives comme les Affaires Etrangères et leurs services extérieurs les ont connues dans plusieurs pays dès le début du siècle, -- réorganisations provoquées avant tout par la nécessité d'assurer une gestion compétente des secteurs économique et commercial grâce à une plus grande spécialisation des services. C'est en 1907 et 1920 qu'est mis en place au Quai d'Orsay, le Service des Oeuvres à l'étranger. En Allemagne, au début des années vingt, *l'Auswärtiges Amt* se dote, à l'intérieur de la section des affaires politiques, d'un département pour les relations humanitaires et scientifiques avec l'étranger; le Service des Ecoles allemandes à l'étranger faisait partie jusque-là du département juridique... La situation en Allemagne était particulière en raison de sa structure fédérative et de l'absence de compétence au niveau central en matière de culture et d'éducation. C'est alors le Ministère de l'Education de Prusse qui s'était trouvé en charge de la plupart des activités scientifiques internationales, et non pas la *Wilhelmstrasse*.

L'Angleterre qui, déjà, ne sentait pas le besoin de défendre sa langue, attendit encore plus longtemps avant d'instituer un service de politique culturelle extérieure : la création du *British Council* ne survient qu'en 1934. A partir de ce moment cependant, les choses allaient vite, aussi dans le sens d'une certaine spécialisation des postes à l'étranger. N'oublions pas que Joseph Needham était en Chine, à la fin de la deuxième guerre mondiale, au titre de conseiller culturel à l'Ambassade britannique!

Malgré cette place que les relations scientifiques trouvent progressivement dans les structures des politiques extérieures, elles n'y jouissent pas d'un prestige considérable. La direction des Affaires politiques demeure la voie royale de la Carrière. Il est toujours courant d'entendre -- comme au siècle dernier -- les scientifiques décrire aux diplomates l'importance de leurs contributions à la puissance, ou au prestige, du pays. et les diplomates faire l'éloge des services que les scientifiques rendent à la politique extérieure, -- la relation demeure néanmoins délicate.

Les sciences exactes présentent à cet égard une spécificité, spécificité qui est fondée sur des considérations de deux ordres : premièrement, le fait que l'avancement des connaissances scientifiques est une oeuvre essentiellement coopérative donne à la science une connotation d'ouverture et de solidarité; la coopération scientifique est par conséquent aisément mobilisée sur le plan de la politique extérieure pour témoigner d'un esprit coopératif, pour signaler des dispositions amicales. Deuxièmement : le rapport qui, sans être linéaire, existe néanmoins entre la recherche et les applications, entre science, technique, industrie et puissance économique (et militaire), fait de la performance scientifique d'un pays à la fois un élément de compétition et un facteur de prestige. Il confère ainsi aux actions scientifiques une position plus "musclée" dans le jeu diplomatique, supérieure à celle des relations artistiques et littéraires, par exemple.

La prise en compte, en politique extérieure, de l'activité scientifique -- notamment sous l'angle de son potentiel économique -- pose cependant d'épineux problèmes de spécialisation. Les personnels des Ministères des Affaires Etrangères et des missions diplomatiques sont rarement en mesure de maîtriser le contenu des dossiers scientifiques et techniques qu'ils sont censés suivre ou qui font l'objet de négociations internationales. La politique extérieure est par conséquent exposée, ici plus que dans tout autre secteur, à la concurrence des ministères dits techniques. Dans beaucoup de pays, ces ministères ont développé leurs propres services de relations internationales. Les problèmes de coordination qui en résultent ne sont pas près d'être résolus. L'imbrication des bureaucraties publiques avec les systèmes de recherche a brouillé, depuis longtemps, la frontière entre "l'Etat" et la "science", entre politique publique et activités privées. La science au service de l'Etat? L'Etat mobilisé au service de la science ? Depuis belle lurette, les choses ne sont plus si simples.

Cité des Sciences et de l'Industrie (Centre de Recherches en Histoire des Sciences et des Techniques), Paris

Note

* Contribution orale à la table-ronde "stratégies d'expansion scientifique".

WORLD-SCIENCE: HOW IS THE HISTORY OF WORLD-SCIENCE TO BE WRITTEN?

Xavier POLANCO

Perhaps the most striking feature of the problems we have just encountered about world science is how modern European science has developed within European geographical boundaries, and expanded outside its geographical area towards others continents. Our problem is therefore to explain this expansion and importation process (export and import problem). It also seems important to consider the double-sided nature of the process; that is to say, the dissemination mechanisms, the second aspect being the local emergence of the national scientific traditions in non-European areas within the standards of Western science.

With regard to this question I suggest putting forward ***world-science*** as a "research device" which should be useful[1] *"by the difficulties it highlights as well as by the solutions it brings"*. It is not a new label to stick onto old methods of analysis. The hypothesis taken in this essay is that the modern scientific world system took form from a world-science that had its genesis in Europe in the 16th and 17th centuries.

World-Science Is Not World Science

Translating Fernand Braudel's ***world-economy*** into the social study of science, we obtain this new concept: ***world-science.*** Its meaning is not the same as "world science" or "international science".

World-science is a sociological and historical concept, and I propose using it in analogy with Braudel's world-economy. Every world-science concerns a fragment of the world, it is an autonomous knowledge section of the planet capable of providing for most of its own needs, it is a section to which its internal links and exchanges give a certain epistemological unity. It follows that we need to consider, as Braudel says, *"geographical space as source of explanation"* in the history and sociology of science.

In fact, geographical space is rarely considered "a source of explanation" in the model of the history of ideas. As Braudel's world-economy, a world-science is *"a sum of individualized areas which it brings together", "it generally represents a very large surface area, in theory the largest coherent zone at a given period, in a given part of the*

P. Petitjean et al. (eds.), Science and Empires, 225–242.

globe", and furthermore *"it usually goes beyond the boundaries of other great historical divisions".* World-sciences have always existed. There is not a world-science without its own area, for example, Babylonian science, Chinese science, Indian science, Greek science, European science, Pre-columbian sciences. The expansion and hegemony of European world-science is a recent fact.

"World science" is an expression applied to the whole world, and ordinary speech very often masks its domination effects: there are powerful and better placed scientific communities, and weaker and badly placed scientific communities. The expression "world science" also masks its genesis, an important historical fact, because it is "taken-for-granted". The epistemological claim of the "universality of science" (which was first European and then became world science) covers what is an empirical fact, the material and intellectual construction of this "universal science" and its "international character". The "universality of science" does not appear to be the cause but the effect of a process that we cannot explain or understand merely by concentrating our attention on epistemological claims[2]. It is an empirical process, and it would therefore seem worthwhile to consider it as the subject of sociological and historical research.

Inequalities, dominations, and "Saint-Matthew Effects"[3] are found in all national scientific communities, the ***"international scientific community"*** being no exception. There is a lot of reliable evidence to show that world science is very highly stratified. All this is very often obliterated, or at best explained from a functionalist viewpoint. Furthermore, the "international scientific community", as a sociological corollary of "world science", is often identified in a bibliometric analysis with the authors of scientific "mainstream" literature[4]. Thus, "world science" seems to be a well localized and highly stratified science from the point of view of language, journals, institutions, countries, scientific groups and individuals. I think that the concept of world-science can help us explain all this, but we must be careful not to reproduce a sort of macro-functionalist interpretation such as I perceived in Braudel's history of world-economies.

In what follows, I shall show that world-science has its boundaries, it invariably has a centre, it is marked by a hierarchy, and it has a network structure.

Some Ground Rules or Tendencies

As in Braudel's world-economies, some rules or tendencies may define the relationship between world-sciences and geographical space.

According to the sociologist Georges Gurvitch, Braudel (1984, 3, p.634 note 9) used the expression ***rules or tendencies*** (in French: ***règles tendancielles)*** in order to avoid using the stronger word ***laws.*** Braudel (1984, 3, p.26) presents these rules as *"three sets of conditions, each with general implications".*

Here I will try to apply these rules to my concept of world-science. But we must also consider the emergence of a scientific world-system from a European world-science, and the formation of local scientific traditions within the limits and norms of the so-called Western world-science[5].

Rule One: *"the boundaries only change slowly".* In fact, the frontiers of a world-economy are not imagery lines. Braudel produces a variety of evidence to demonstrate that

"they are quiet zones, the scene of little activity. They are like thick shells, hard to penetrate; they are often natural barriers **no-man's-lands, no-man's-seas.** The Sahara, despite its caravans, would have been one such barrier, separating Black Africa from White Africa. The Atlantic was another, an empty expanse to the south and west of Africa, and for long centuries a barrier compared to the Indian Ocean, which was from early days the scene of much trade, at least in the north. Equally formidable was the Pacific, which European explorers had only half-opened to traffic: Magellan's voyage only unlocked one way into the southern seas, not a gateway for return journeys" (Braudel 1984, 3, p.26).

And he writes further on:

"It is worth taking the measure once again of these hostile expanses. For it was within the limits imposed by such difficulties that world-economies became established, grew, survived and develop" (p.27).

In this respect, the role of technology and science was always to move back those frontiers, those borderlines. European technoscience did this during the colonial expansion, and it was a powerful operator in the physical and intellectual organization of the world from the European metropolis.

As Braudel (1984, 3, p.27) writes:

"Europe miraculously extended her frontiers at a stroke, or very nearly so, with the great discoveries at the end of the 15th century. But once this space had been opened up, it had to be controlled, whether the waters of the Atlantic or the wastes of America. Controlling the empty expanse of the Atlantic and the near-empty expanse of America was not easy".

These are historical facts in which science, technology and policy were intimally imbricated. And as Braudel (1981, **1**, p.402) observes:[6]

"The conquest of the high seas gave Europe a world supremacy that lasted for centuries. The time, technology - ocean navigation - did create 'asymmetry', and advantage on a world scale".

Rule Two: a dominant scientific community always lies at the centre. The World-science always has a scientific pole around which other scientific communities will be found,

"sometimes playing the role of associate or accomplice, but more usually resigned to their second-class role. Their activities are governed by those of the metropolis ... These metropolises came accompanied by a triad of subordinates"

(Braudel 1984, **3**, p.29-30). This is the first issue concerning this rule, the second issue is that scientific primacies succeed, scientific centres take it in turns to lead, they did not dominate for ever; they replaced each other[7]. *"This was as true at the summit as it was at every level of the hierarchy"* says Braudel (1984, **3**, p.32).

Consider, for example, the case of French science. As Charles C. Gillispie (1980, p.74) says:

"During the half-century between the Turgot Ministry and the Revolution of July 1830, or (to embrace the interval in dates with scientific significance) between the last years of d'Alembert and the death of Laplace in 1827, the French community of science predominated in the world to a degree that no other national complex has since done or had ever done. In its eminence, French cultural leadership in Europe reached a climax".

One century later an official document notes[8] *"France is only at third rank in the European scientific production after Germany and England"*. Today, according to economic and bibliometric standard indicators, French science is in fourth place in the scientific production ranking of the most industrialized countries, after the United States, Japan, Germany, side-by-side with, or perhaps slightly higher than England. Finally, the history of French science is, I think[9], that of a strong scientific community that makes great efforts in order to remain in the central zone of world-science after having played an hegemonic role.

The scientific hegemonies are more or less complete, which is the third issue concerning this rule. In their supremacy, scientific communities are *"in the course of their history, better or worse equiped for their tasks"*, they present *"differences or comparative failings"*, not all of them possess the complete arsenal of scientific domination, the whole panoply of means necessary to impose an absolute scientific leadership. Thus, in the history of science, there are oscillations between strong and weak centering. As Braudel (1984, **3**, p.35) writes on world-economies, world-sciences might be more or less firmly controlled, as they oscillated between strong and weak centres of gravity.

According to this rule, the monitoring of research activities by the center (people say also by the North) would be the general tendency. It is also possible that impulsion concerning a particular field of research does not always come from the center, but from a certain specific center localized in semi-peripheral or peripheral zones[10].

Rule Three: a world-science is always marked by a hierarchy of zones, meaning a difference of levels and asymmetries.

The different zones within world-science *"all face towards one point in the center: thus polarized, they combine to form a whole with many relationships"* (Braudel, 1984, **3**, p.35).

One first represention of this pattern is the "Von Thunen's zones"[11], where only distance plays the role of the principle of explanation. According to this model *"a number of concentric rings around the center will take shape";* in consequence distance defines the nature of the activities of the different concentric rings. But what we would criticize is, as Braudel (1984, **3**, p.39) says,

> "the absence from this schema of the very important concept of inequality. The inequality between the different zones described is patent, but it is stated without comment".

David W. Chambers has recently criticized the use of distance as an explanatory concept in the history of science, because distance tells us, he argues[12], *"little about how science works in the periphery",* and he claims that *"The distances that may tyrannize are social, cultural, psychological and finally professional".*

The rule is that all world-science (as all world-economy)

> "is a sort of jigsaw puzzle, a juxtaposition of zones interconnected, but **at different levels.** On the ground, **at least,** three different areas or categories can be distinguished: a narrow **core,** a fairly developed middle zone and vast **periphery"** (Braudel 1984, **3,** p.34)[13].

The existence of this three-part hierarchy is a sort of structural pattern of world-science. And the inequalities between the different zones has, of course, its origins and its genesis.

In a book recently published (Polanco 1990)[14], we can see French science as the central core, whereas Spanish science is a semi-periphery, and in the distance *Nueva Granada* (Colombia) and *Nueva España* (Mexico) are the peripheries of world-science. Lafuente's (1990) and Sala's (1990) studies show Spain, the metropolis of a great colonial empire, as a scientific semi-periphery of the Enlighted and Positivist French science. In the case of Mexico, the problem evoked by Saldaña's (1990) study is whether *Nueva España* was not in the 17th and 18th centuries a scientific semi-periphery of the European centers, and later after a positivist and very difficult 19th century (at least during the first half), Mexico did not become during the 1930's a semi-periphery of the United States as the scientific center.

We need to have recourse to some indicators in order to decide if we are faced with a periphery or a semi-periphery.

We do not discover "backward zones" exclusively in the peripheral areas; they punctuated the central regions too[15]. It is another issue concerning this rule.

The last issue which is addressed is the idea that *"A world-economy is like an enormous envelope"* (Braudel 1984, **3**, p.44). But I think is more accurate than Braudel's "envelope" to say that world-science is a network[16] and to reformulate Braudel's statement in the following way: world-science is a very extensive network that generally displays with relatively limited means and which power may often be weak. I should be inclined to consider this as ***rule four.***

The fact that it is a network excludes that the autonomy of a scientific community means a scientific autarchy. The network structure compels the insertion of national scientific communities in the world-system. Finally, these ground rules do not have as much analytical value if we are unable to give them an empirical (historiographic and sociological) meaning.

Western World-Science System

The modern world-system of scientific knowledge took the form of world-science that had its genesis in Europe during the 16th and 17th centuries. As with Wallerstein's capitalist world-economy (1984, **2**, p.7-8), since that time European world-science has geographically expanded following the ocean roads and fronts of colonization to cover the entire globe, shifting geographical locations of scientific roles, following the rise and fall of hegemonies, the up and down movements of a particular core, peripheral, and semi-peripheral zones.

The distribution throughout the world (in the French language, *"mondialisation")* of European world-science is an empirical process.

Institutional and intellectual forms of knowledge (cognitive norms and institutional organizations) are reaching a world-wide scale, and will hencefoward be imposed and adopted as the legitimate way of performing a "good" science. Many studies exist showing the important and pervasive role of the distribution and importation of scientific disciplines, academies, observatories, botanic gardens, laboratories, engineering schools and science faculties. In addition, the *"mondialisation"* of western science is carried out through the importation and espionage, the journeys and scientific expeditions, the free movement of individuals scientists, the distribution of books and journals, and also of scientific instruments and techniques of observation, measurement and computing.

It is important to note that the global process of the transformation of European world-science into a world-system of knowledge involves three different aspects which are interesting to analyse: firstly the centring, that is to say, the constitution of central zones, secondly the diffusion of forms of knowledge and practice in peripheral zones, and lastly the efforts or strategies in order to create a scientific tradition capable of becoming (or not becoming) a self-governing (or subordinated) scientific centre.

With regard to the formation of local scientific traditions, it is important to observe the scientific and political strategies implicitly or explicitly pursued by the actors during the transition from "colonial science" to "national science"[17]. In Arboleda's study (1990, namely p.115-119), for example, we find the controversy between José Celestino Mutis and his more enlightened disciples Francisco José de Caldas and Jorge Tadeo Lozano, in ***Nueva Granada*** (Colombia), at the end of the colonial period[18]. It is only an example of what seems to be a general pattern, the conflict between two different strategical projects of scientific development. On the one side, are those who want science for the metropolis, and on the other side, are the supporters of a local scientific development.

It is important to stress, once more, the conditions through which a particular scientific enterprise takes place as a central, semi-peripheral or peripheral activity in the world-science network. A great deal of work concerning the transformation of the Western European world-science into a scientific world-system has already shown, from the point of view of the central zones, how central interests of one form or another shape the exportation of science according to a diffusion-reception model of explanation. The other aspect of the process, the importation mechanism of knowledge - experts, institutions and forms of organization of scientific practice - has unfortunately been the subject of a more limited number of studies from the point of view opposite from semi-peripheries and peripheries. And the work which deals with showing the way that scientific traditions are created in semi-peripheries and peripheries in general uses as its main instrument of explanation the centre-periphery dependence model with it corollary of one science without "social function". Let me emphasize that my world-science concept aims at superseding these models of explanation and one-sided views of the process.

The Shifts at the Scientific Centre

One significant aspect in the central zones of a world-science is the shift in the scientific leadership. Of particular interest to us here is the fact that scientific primacies succeed in the history of Western science.

According to Ben-David (1971, p.15),

> "from the beginning, scientific activity tended to be disproportionately centered in one area. Until the middle of the 17th century, the center for all scientific study was Italy, but in the second half of the century, the center shifted and everyone who was interested in science wrote and spoke about its favorable situation in England. However, because developments in France closely followed those in England, Paris became the undisputed center around 1800. No scientist could afford not to read and speak French and all went to Paris to study, to do research, or just to meet the most famous people in their fields. Forty years later, the meeting and training place for the scientists of the world became Germany; that country retained its position until the 1920s. Then the center shifted to the United States, with Britain holding a secondary position".

This is, of course, a summary account, but this quotation enables us at least to form a first idea of the significance of these shifts. In fact, it is the whole system of world-science that is affected by such changes in the scientific center.

For example, the last three changes in the scientific leadership, from France to Germany and then to United States, are visible from and inside the history of Latin American peripheral science. This history shows us how Latin American science has been "polarized" in relatively the same historical sequence of these shifts[19]. It is also the case of Spanish science in its semi-peripheral status[20]. These remarks enable us to say that the different zones within a world-science are always linked and polarized by the more advanced and dynamic centers of the world-science.

It is not possible for me at this moment to judge the actual, as opposed to potential, degree of inter-relations between world-cities' succession as centres of the European world-economy such as Braudel's history sets it out, and the shifts of the scientific centres described by Ben-David. It is a question I can only note here, but we must work on it when the time has come. In any case, a statistical correlation has been found, as we shall see in the next section.

Let me comment very briefly on the idea that, in the explanation of shifts in scientific leadership, science as knowledge must be excluded, and we must only consider science as institution. Such is Ben-David's position (1960, 1969, 1971). It is an externalist approach. In his opinion, the reasons for a shift have to be sought in the *"organization of science"* and not in science *"as a body of ideas"*, or at the level of its *"international system of communication"*. Among these organizational elements concerning the scientific take-off, three of them are quoted by Ben-David, firstly the creation of scientific careers, secondly the development of scientific facilities, and thirdly the training of a larger number of research workers. Ben-David believes that competition within a decentralized system encourages the establishment of these conditions. *"Towards the middle of the 19th century, these conditions of scientific growth and leadership emerged first in Germany and presented a challenge to the older scientific countries such as Britain and France"*, and Ben-David notes: *"It is difficult to understand the relative inability of the French system to respond to this challenge which became increasingly evident in the 1840's"*. According to his answer: *"The explanation is to be sought in the peculiar characteristics of French scientific organization"*, namely, in its *"centralized bureaucratic organization"*. Putting to one side questions about the accuracy of such conclusions, particularly concerning the French system[21], this externalist model of explanation is unsatisfactory today on methodological and conceptual grounds, in light of contributions such as Kuhn's in the history of scientific changes, and new sociology of scientific knowledge. In my opinion, we must consider scientific knowledge when our purpose is to explain the shifts in scientific leadership in the framework of the world-science concept.

Now I shall try to characterize the relation between science and state in a world-science context. In general, a "scientific policy" is the result of the junction between science and state[22]. The state, as Braudel (1984, 3, p.45) says, *"may appear to be divided into three zones: capital, provinces and colonies"*. As a consequence of this, we may suppose that a scientific community may also appear to be divided into these three zones. As Zuckerman (1970, p.237) writes,

"Stratification and ranking are not limited to individual investigators. Disciplines, publications in particular journals, types of research, organizations and rewards are also ranked".

In a national scientific community, its central groups should be those which are localized in the capital, and polarize and rule the members of both groups of scientists, those which are of the semi-periphery or provinces, and furthermore those of the periphery or colonies. It is clear that capital and center, provinces and semi-periphery, colonies and periphery are equivalents and may be applied in the analysis of the variations in the availability of training facilities, research resources, formal and informal access to information, and differences in research productivity, in the context of a country, and in the whole cycle of a world-science.

The Economic Order and the Zones of the World-Science

Let me, in this section, outline the relationship between science and economy. In Braudel's world-economy this link seems to presuppose the intermediate of the cultural order. On the other hand, we can apply to science and technology what Braudel says about culture or civilization (for him the two words are interchangeable in most contexts), *"cultures are ways of ordering space just as economies are"* (Braudel 1984, **3**, p.65). In general any world-economy tends to share one and the same culture, yet *"the cultural and economic maps might differ considerably"*. Thus, cultural centers (for instance Florence and Paris) do not necessarily coincide with the economic centers (Genoa and London), *"the respective gravity centres of economic zones and cultural zones"* are not the same. It is true that science and technology means a great problem for his theory, as Braudel himself recognizes. Indeed, he remains convinced that there is a necessary difference in any world-economy between its economic and cultural centering. In this respect, science and technology means, as I have already said, a serious problem for Braudel's viewpoint. To quote him again:

"Technology (though not necessarily science) has always noticeably developed in the leading zones of the economic world. The Venetian Arsenal was still a centre of technology even in the 16th century. First Holland, then Britain inherited this double privilege in turn. It now lies with the United States. But technology is perhaps the body rather than the soul of a civilization. It is logical that it should be encouraged by the industrial activity and high wages of leading economic regions. Science on the other hand is not the particular privilege of any single nation. Or at least it was not until recently; now I am not so sure" (Braudel 1984, 3, p.65-66).

We can, I think, make this quotation more radical. It is the meaning of the following remarks.

We all know what Galileo wrote at the beginning of his *Discourses on Two New Sciences* (1638) about the meaning of the Venetian Arsenal for these new sciences. What I want to say, and it is my second remark, is that science seems, whatever Braudel says, to have been always a "big science". From its beginning, European science has at all times relatively expected too much from states and economies, laboratories, salaries, libraries, sophisticated equipments, observatories, botanic gardens, journeys and expeditions and so on. Today it is an obvious pattern of science.

These remarks enable us at least, I hope, to consider the significance of the problems that provide this section with its title. In what follows, I shall refer to a more empirical approach to our subject, and I shall presuppose a familiarity with the general pattern of scientometric analysis. Price (1969), using the bibliometric indicator of counts of scientific papers published by countries, has detected a statistical correlation between the gross national product (GNP) on Research and Development (R&D) by countries and their rank as producers of scientific literature (numbers of papers).

A sociological interpretation of this result is provided by Ben-David (1971).

"A comparison of the geographical shifts of scientific activity with historical about wealth of the various countries does not show any indication that scientific growth was the result of economic growth" (Ben-David, 1971, p.15-16).

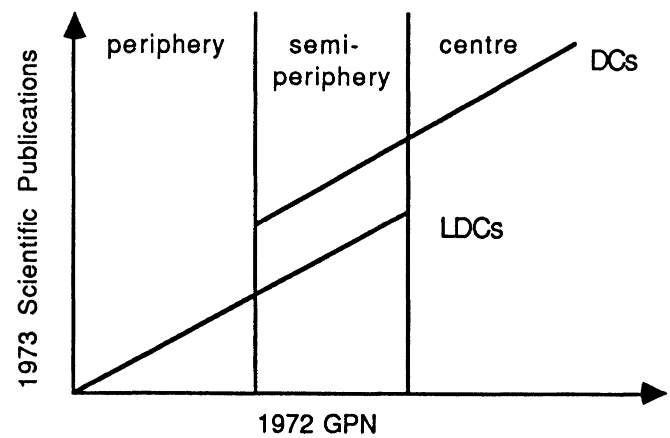
He recognizes that a certain connection has to exist, but it might not be a cause-effect relationship (Ben-David 1971, p.12-13). And his commentary on Price's finding is that these may indicate

"the emergence of such a causal relationship between science and the economy, but they may also be the result of the wider and more efficient diffusion of the patterns prevailing at the center. As a result of social conditions, there emerges in the center a certain level and certain forms of scientific activity. And because the center influences all over the world, they use it as a model for the organization of science in their respective countries. But scientists will be successful in emulating the central model only within the limits determined by the wealth of their countries, because it is difficult to persuade government to spend relatively much more on science than the model country spends on it. Thus the money spent on science in each country will be a fairly uniform percentage of its gross national product, not because economic activity determines or is determined by science, but because of the way all countries imitate one" (Ben-David, 1971, p.12-13 and 16 note 30).

Ten years later, Frame (1979) came again to Price's correlation and confirmed as he says *"the log-linear relationship described by Price"*, in addition he observed that *"total scientific strength is well correlated with the economic wealth for most countries of the world"* (Frame 1979, p.151).

When the publication and GNP link for developed countries (DC's) and underdeveloped countries (LDC's) is analysed separately, the two publication-GNP lines are parallel yet at a higher level for the DC's (see figure below), and the elasticities of publications with respect to GNP indicate that for both groups, increases in GNP size are accompanied by more or less proportional increases in the amount of research published.

The figure below is a symbolic representation of Frame's real statistical findings, publication output and GNP of the two groups of countries, for the 1972-1973 period (see Frame 1979, p.236). Furthermore, I have indicated the three-part hierarchy of world-science that can now be identified statistically.



It is interesting to remark that the relationships between scientific output and GNP as a measurement of the economic size of a country, and "GNP per capita" as a measurement of national affluence, differs substantially:[23]

"in poor countries the production of scientific research does not appear to be very responsive to changes in the level of national affluence, while shifts in affluence may have a substantial impact on the amount of research produced in rich countries".

In DC's, by contrast,

"the national publication output is more responsive to a given percentage change in national affluence than an equal percentage change in economic size".

And this leads to the conclusion that:

"In LDC's, the size of the scientific effort appears to be independent of changes in the relative degree of national affluence. What is important for LDC science is simply the gross economic size of a country, which is a measurement of its economic resource base".

The GNP appears to be of particular importance for LDC's. This means that its limited resources would not allow them to maintain substantial research efforts, and in consequence their scientific efforts will continue to be rather minor. The important exception is India with a low GNP and a significant bibliographic scientific output, number one in the Third World and eighteenth in the World over the 1972-1973 period.

The behavior in relation to affluence (GNP per capita) changes at a certain economic threshold level; below this threshold, the effect of affluence on national scientific size is trivial. This threshold, according to Frame (1979, p.240), is clearly located somewhere in upper per capital GNP levels of the LDC's and the lower levels of the DC's. Within this range, a country stands on the development and underdevelopment borderline. I have designated it a semi-peripheral zone. As Wallerstein writes elsewhere, the semi-peripherical states are usually those who rise or fall.

Short-time and Long-time

I would like to conclude this essay with the following remarks on the world-science and divisions of time. Time can be divided into short-time and long-time. There are short-term and long-term movements in the development of science. Science, like other cultural things, lives in both the long-term and the short-term[24]. Short-term movements constitute the conjunctures. Long-term movements are the secular trends. These two different forms of time, it is true, represent two viewpoints. Of course, conjunctural histories and sociologies are more concerned with short-term oscillations and fluctuations, or events, than with the long-term, slow-moving shifts and cycles. In this respect, as Braudel (1984, **3**, p.85) advises,

> "the conjuncture should be studied in all its richness: it would be regrettable if historians did not seek to locate its boundaries on one side in the history of events and the short-term, and on the other in the long-term and the secular trend. The short and the long-term coexist; they cannot be separated".

Then, we must analyse in scientific development both long-term strategies and short-term strategies.

The short-term ups and downs unable to engage in a long cycle of development and accumulation are often the mark of the peripheral scientific developments.

A world-science involves conjunctures or short-term events and slow-moving shifts and fluctuations. Perhaps we could map it using some indicators, if not necessarily quantitative, at least qualitative, such as, for example, clusters of scientific disciplines and types of research, academic institutions, forms of organization and relationships of scientific activity with the state and industry. There is a natural temptation to use the history of such as issues to measure progress, once it has been laid out.

A view widely held over the past few decades has been that the direction to follow, and the scientific stage to aim for, are necessarily represented by the state of the central scientific communities. Such beliefs have often been proved wrong, and in addition responsible for erroneous strategies of development. Insofar as the world-science network is polarized, scientific communities are broadly oriented to consider and evaluate the state of affairs according to the paradigms in action in the central zones. This is a source of a permanent tension between closed and open strategies, vis-à-vis the attraction and orientation forces that central zones should be able to communicate to the whole cycle of the world-system.

The disorganization of the network, which determines the role and position of differents zones, is, as Braudel (1984, **3**, p.85) says, *"the result of an accumulation of accidents, breakdowns and distortions"*.

This is the crisis of a world-science and it is an other subject. I shall finish here.

Centre National de la Recherche Scientifique (INIST), Nancy

Notes

[1] According to Bourdieu (1984, p.51): "Un problème théorique qui est converti en dispositif de recherche est mis en marche, il devient en quelque sorte automobile, il se propulse lui-même par les difficultés qu'il fait surgir autant que par les solutions qu'il apporte".

[2] "Science is universal", and the role of men of science "is to be cosmopolitan" said Alphonse de Candolle in 1873 (De Candolle 1987, p.159 et 254). In his era, of course, the franco-prussian war woke up nationalist demons (Crosland 1975). For the problem of the "national context" in the history of science, see also Crosland (1979). We found an other formulation of the same idea in Price (1969), he says: "Science has an intrinsic quality of universality and internationality - one might even call it "supranational", in a remarkably strong sense of this word". For a sociogical development of this epistemological claim, within the framework of the Merton school, see Storer (1970).

[3] The "Saint-Matthew Effect" has been proposed by Merton in 1968 in order to explain the cumulative advantage process in the allocation of rewards to scientists, in the system of scientific communication, and in the distribution of resources necessary for research (see Merton 1974, chap.20, p.439-450).

[4] It is the "mainstream" scientific journals that a bibliometric or scientometric analysis uses as an indicator of the scientific research activity. I explain my opinion about this in Polanco 1990, p.29-49.

[5] As Pyenson (1989, p.211) says: "Beyond the North Atlantic world, research and teaching in the exact sciences have for the past 150 years closely followed the pattern set in the principal industrial nations of Europe and North America".

[6] For a reliable analysis of the technical-complex of ocean navigation produced by Portuguese, see Law 1986, 1987.

[7] Braudel put it this way: "When Amsterdam replaced Antwerp, when London took over from Amsterdam, or when in about 1929, New York took over from London, it always meant a massive historical shift of forces, revealing the precariousness of the previous equilibrium and the strengths of the one which was replacing it" (Braudel 1984, **3**, p.32).

[8] It is quoted by A. Ranc in the *Revue Scientifique,* 22 novembre 1930, p.688.

[9] See Polanco 1990, chapter 7; and Polanco 1989.

[10] An example of this, according to an bibliometric study, is the research, to-day, on soils in the tropical agriculture (see Chatelin et Arvanitis, 1988).

[11] Johann Heinrich von Thünen (1780-1851), is the author of this eponomy model, Braudel (1984, **3**, p.38) says "who ranks alongside Marx as the greatest German economist of the 19th century".

[12] I quote his preprint (p.12 and p.13) entitled "Does Distance Tyrannize Science?" to be published in S. Kohlstedt and R. Home (eds), *Nationalistic and Internationalism in Science* (Washington D.C.: Smithsonian Press). In this paper Chambers criticizes "the myth of distance-imposed isolation as a general explanation" of the weaknesses of a peripheral scientific tradition; and Australians have, he thinks, for too long accepted the distance as a general explanation of their own situation.

[13] As Braudel (1984, **3**, p.39) notes: "This is a explanation of very wide application, one on which Immanuel Wallerstein has based his book *The Modern World-System* (1974)".

[14] In this collective book, I have exposed (in chapter 1), for the first time, the world-science notion as a general and introductory framework in which the different studies take a related meaning.
[15] In this respect, see Braudel 1984, **3**, p.42-43.
[16] A network is generally defined as a specific type of relationship linking a defined set of persons, objects, or events. See Mitchell (1969). For the sociological developments of the network analysis, see Collins (1985), cahpa.6; Latour (1987), part III, "from short to longer networks"; Shrum and Mullins (1988); Callon (1989).
[17] For more material relevant to this point, see Inkster's (1985) and Chambers' (1987) studies concerning the historical cases of Australia and Mexico respectively. The authors discuss the current models of explanation.
[18] See also Saldaña (1987), whose study deals with the historical case of Mexico, and he provides (p.43-50) another example of a controversy between opposite views on the scientific development at the time of the foundation of the Royal Seminary of Mining in Mexico City in 1792.
[19] It is only a general conclusion; there are differences between the countries and scientific disciplines or research areas; my sources of information are: Schwartzman (1978); Pyenson (1985), (1987), (1989, mainly p.237-259); Maria Amelia M. Dantes (1988); Cueto (1989).
[20] Lafuente's (1990) and Sala's (1990) studies show these shifts in the polarization of Spanish science.
[21] Historians such as Harry Paul (1972) and Mary-Jo Nye (1984, 1986) have criticized Ben-David's description of the French system and its decline.
[22] One example is the creation of the Académie des Sciences of Paris in 1666. Compare this case as Hahn (1971) describes it with the English case in Shapin and Schaffer's (1985) description. They present different forms of relationship between state or political order and science.
[23] It means that there are two equations linking these variables. Frame calls them the DC research production function and the LDC research production function. Because these equations express publication output (Y) as a function of GNP (X) and GNP per capita (X/P); P represents the country's population, for LDC's and for DC's; see Frame 1979, p.238-239.
[24] Braudel (1984, **3**, p.85) writes: "For we all live in both the long-term and the short-term: the language I speak, the trade I practice, my beliefs, the human landscape surrounding me are all inherited: they existed before me and will go on existing after me".

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SCIENCE AND THE JAPANESE EMPIRE 1868-1945: AN OVERVIEW

SASAKI Chikara

In Memoriam Hirosige Tetu

Japan is sometimes considered to be a miracle of history with regards to its success in westernization or modernization, especially in comparison with other Asian countries. This success is due at least partly to its energetic introduction of modern western science and technology. Recent historians frequently shed light only on the brighter side of this success story. While acknowledging this side, however, we should not forget that before Japan's surrender in World War II, it had darker aspects as well.

In this brief report, I would like to present my general standpoint as to how the problem of the relation between science and imperialism should be treated in the case of modern Japan. It is unfortunate to state at the beginning that the manner in which scientific studies were carried out in the colonial territories of the Japanese Empire before Japan's surrender in 1945 has been largely unexplored because of the destruction of historical materials and the indifference of historians. An outline of this history, however, may be drawn[1].

The year 1881 may be considered to be the beginning of the emergence of Japan as an imperialist country. In 1881, Japan, under the political leadership of Ito Hirobumi, decided to adopt the Prussian model of politics and culture. It was around this year that the absolutism of the Emperor system began to be consolidated and the policy of "rich country and strong soldiers" was introduced. In 1886, the Emperor issued the Imperial University Ordinance, in which scholars were considered to be national servants of the Emperor. Therewith, the research imperative became aggressively pursued by Japanese scientists. They began to make efforts to become scientists who could be evaluated highly by their colleagues in the so-called "first class countries" of Europe and America, first of all for national prestige.

The next crucial stage of the history of the science of Imperial Japan was marked with its colonization of other Asian countries. As a consequence of the Sino-Japanese War, Japan acquired suzerainity over Taiwan as a colonial territory in 1895. In the following years it succes-

P. Petitjean et al. (eds.), Science and Empires, 243–246.

sively colonized or semi-colonized Korea, Manchuria, and South Sea Islands. One of the important characteristics of Japanese science between 1895 and 1945 may be seen in the science in these colonial territories.

Intending their rule to be permanent, the Japanese imperialists established higher educational institutions for scientific, technological, and medical studies. In Manchuria, three technical and medical colleges were opened in 1922. As a part of Japan's Imperial University System, the Keijô (Seoul) Imperial University and the Taihoku (Taipei) Imperial University were established in 1924 and 1928, respectively. Applied disciplines were emphasized there, reflecting the imperialists' interests. The educational system was based on the Japanization policy, in other words, Japanese was adopted as the official language and Japanese culture was forced upon colonial people.

Research institutions were also established. To mention only notable examples, as early as 1907, the Central Laboratory in Manchuria, later connected with the South Manchuria Railway Company, was opened for advancing practical chemistry. In China, against the will of the Chinese government, the Shanghai Science Institute was inaugurated in 1931 as an overall research organization for the natural sciences. The Palau Tropical Biological Station in Koror Island was opened in 1935. These institutions were run principally by Japanese scientists.

With the outbreak of the Pacific War in 1941, the science policy of Imperial Japan displayed its most conspicuously imperialistic aspect. We may witness a telling example of the imperialistic characteristic of Japanese science during this period by looking at a travel report by a Japanese scientist who made a "science trip" to the Malay peninsula, Burma, Indonesia, and the Philippines in the autumn of 1942. The Japanese army had occupied these areas in the spring of that year. The scientist was Tada Reikichi, who was lieutenant general and president of the Board of Technology, but is now little known.

Tada published a book entitled *Science Trip to the South* toward the end of 1943. According to his report, Tada was most impressed by the science in the Dutch East Indies. He states:[2]

"The Dutch East Indies is the country of the most developed science and technology in the South Pacific Area. The Dutch policy in this area attaches importance to science and technology. This is because they intend to exploit natural resources effectively through rationalizing the rule of this area by a few Dutch leaders. They emphasize science as the central organ of their politics intending to govern the Indonesians of three hundred times of their (i. e. the Dutch) population in this area, and as a representation of their political power, showing the superiority of their scientific talent".

This observation is interesting in relation to Lewis Pyenson's description in his *Empire of Reason: Exact Sciences in Indonesia, 1840-1940,* published in 1989, on Dutch science in Indonesia immediately before Japan's military occupation[3]. In Tada's opinion, by emphasizing the policy through science[4], *"the whites made the natives think that the home country of the whites is an unreachable country of God"*. What should the Japanese do in the South Pacific Area? Tada answers: The Japanese, one of the Asian races, must be more familiar to the natives than the whites. But they should learn how the whites govern their colonial people. The aim of the Japanese is to construct the Greater East Asia Co-prosperity Sphere. But "co-" of "co-prosperity" has no relation to "co-" of "communist party"[5]. The co-prosperity of the South Pacific Area means that each nation works according to its ability and receives benefits accordingly:[6] *"the Japanese race must enjoy honor corresponding to the role of leaders, because it is the superior responsible principal post"*. Further he insists: the Japanese must not send themselves to the South Pacific Area as emigrants or settlers. Only leaders, especially scientists of the first class, should be sent. The Japanese must keep their superior blood pure. Tada's ideas seem to have been commonly accepted among Japanese politicians and scientists.

It seems rather natural in such an ideological milieu that there existed a medical laboratory for biological warfare organized in Manchuria by the Japanese army. This laboratory was directed by the army doctor Ishii Shiro, who, it is now known, committed it to human experimentation. It is reported that thousands of Chinese, Koreans, and Russians were killed there in carrying out experiments[7].

It may be concluded that Imperial Japan since the Meiji Restoration of 1868 and before 1945 was energetic in establishing itself as a scientific and technological power of the first class in order to compete with other imperialist countries. By and large, Japanese scientists accepted the imperialist policy, positively or reluctantly, and some cases, as we have seen in the case of Ishii's troop, engaged in a "murderous science", to use the title of Benno Müller-Hill's book on the Nazi medical science[8]. Some formed a group of ideologues who may be labelled "reactionary modernists", to use Jeffrey Herf's term[9].

Following its defeat in World War II, Japan has not been an imperialist country in the literal sense of the word. It would be fortunate if the Japan of today were not an imperialist country in any sense.

The University of Tokyo

Notes

[1] See especially Hirosige Tetu, *Kagaku no Shakaishi* (A Social History of Science: The Institutional Order of Science in Modern Japan), Tokyo: Chuokoron-sha, 1973, p.144-147 and 200-203; The History of Science Society of Japan, *Nippon Kagaku-gijutsu-shi Taikei* (An Outline of the History of Science and Technology in Japan), **vol.7** Tokyo: Daiichi-hoki, 1968.

[2] Tada Reikichi, *Nampo Kagaku Kiko* (Science Trip to the South), Tokyo: Kagakushugi-kogyou-sha, 1942, p.219. Interestingly, the name of the publisher was "Kagakushugi-kogyou-sha", i. e. *Scienticism* Industry Company, and the book was sponsored by the Society for the Science Mobilization, which was organized in Japan during World War II.

[3] Lewis Pyenson, *Empire of Reason: Exact Science in Indonesia, 1840-1940,* Leiden/New York/Copenhagen/Cologne 1989, esp. p.81. See also the same author's "Pure Learning and Political Economy: Science and European Expansion in the Age of Imperialism", in R. P. W. Visser, L. C. Palm, H. J. M. Bos and H. A. M. Snelders (eds), Proceedings of the Utrecht Conference, *New Trends in the History of Science,* Amsterdam, Rodopi, 1989.

[4] Tada, *ibid.*, p.156.

[5] *Ibid.*, p.227.

[6] *Ibid.*

[7] Kei-ichi Tsuneishi, "The Research Guarded by Military Secrecy - The Isolation of the E. H. F. Virus in Japanese Biological Warfare Unit -", *Historia Scientiarum,* N°30, 1986, p.79-92; Peter Williams and David Wallace, *Unit 731: Japan's Secret Biological Warfare in World War II,* New York: The Free Press, 1989.

[8] Benno Müller-Hill, *Murderous Science: Elimination by Scientific Selection of Jews, Gypsies, and Others, Germany 1933-1945,* translated by George R. Fraser, Oxford/New York/Tokyo: Oxford University Press, 1988.

[9] Jeffrey Herf, *Reactionary Modernism: Technology, Culture, and Politics in Weimar and the Third Reich,* Cambridge: Cambridge University Press, 1984.

SCIENCE AND NATIONALISM IN NEW GRANADA ON THE EVE OF THE REVOLUTION OF INDEPENDENCE

Luis Carlos ARBOLEDA

The intellectual activity of the criollo Francisco José de Caldas (1768-1816) has been the subject of many kinds of study, and specifically in connection with the emergence in New Granada, at the beginning of the 19th century, of the native forms of scientific culture. Attention has focussed on two characteristic features of the Colombian society of that time: first, on the transformations of the country's cultural space, a consequence of the impact, over the preceding forty years, of the message of the Enlightenment; and second, on the appearance of the first signs of social and political contradictions which would eventually lead to independence from the Spanish Crown in 1810.

In the vast literature on Caldas, two papers in particular, from my point of view, have brought to light new factors which clarify the origins of Caldas's indigenous forms of scientific thought. Both appeared in 1987 in important journals in Spain and Latin America Both were written by distinguished historians who have spent years studying the life and work of Caldas. Jeanne Chenu has examined the question of the reception in scientific circles in New Granada of Caldas's research on hypsometry and geobotany, and has shown that this research was guided by a mentality that she proposes to call[1] *"criolisme scientifique"*.

Recently, two of my fellow historians of the mathematical sciences, Víctor Albis and Regino Martínez-Chavans, have presented a paper which studies in detail the innovations in Caldas's thermometric methods for the measurement of altitudes in the very special conditions of South-American geography. They extract, from the multitude of factors which determined Caldas's "rediscovery" of this method, the protocol of an experimental formula and the design and construction of a prototype, both being contingent situations. One refers to the random elements involved in Caldas's geophysical experiences and the other to his knowledge of the state of the question in Europe, after his encounter with Humboldt[2].

In what follows, I shall attempt to make use of the elements brought forward by these two papers, my purpose being the analysis of a problem which underlies both of them and which appears to me

P. Petitjean et al. (eds.), Science and Empires, 247–258.

to be the key to the understanding of the dynamics of scientific activity in the peripheral areas toward the end of the colonial regime: the emergence, among the intellectuals with nationalistic views, of a realistic program for specialized training and research in their countries. My sources are Caldas's writings[3] and, above all, his letters between 1795 and 1802 to his friend Santiago Arroyo[4]. Among the features of Caldas's thought which stand out in his letters, the essential link between his nationalistic pride and his will to know deserves to be underscored. Both are present in the origins of his erudite criollo's determination to set up a systematic research program for the study of New Granada's territory and society. This becomes evident from the very first letters he sends, from 1795 on, to his friend and principal partner in his process of scientific self-education, Santiago Arroyo:[5]

"Nature enchants me, and carries me away. I am already a diligent observer: everything attracts my curiosity. This occupation doesn't burden my head with sterile worries; it allows me the time to instruct myself without the least hindrance. If I had only found this means ten years earlier!"

The naive observation of nature's marvels little by little brings Caldas from curiosity to intellectual commitment. He becomes interested in reading[6] *"the authors that have dealt with the matters and things that belong to us in the New Kingdom and in America".* From his reading, and from the confrontation of theory with observation and experience, Caldas soon learns to develop that *philosophical view* which he will later depend upon in his scientific production and in his political activity. The letter of 16 December 1796 to Arroyo shows this new *theoretical sense* of the observation of nature which Caldas acquires from the reading of Buffon and Bouguer:[7]

"What an unexpected and what an astonishing world for me! I, who had gone over these enchanting grounds three times without seeing anything! Here I have discovered what it means to be enlightened and to have a philosophical view of nature. Before, I knew nothing about Count du Buffon's theory of the earth, now everything attracts me, everything engages me".

Subsequently, I shall attempt to discover in Caldas's letters the process that may have taken place in the formation of this philosophical view of nature. We shall also see that it is the same process that gave birth to a new social and political consciousness of the role of the members of the criollo elite at the end of the colonial regime in New Granada. From the very beginning, there was a bond between this consciousness and the understanding of the natural environment. At a certain moment, the scientific culture obtained through reading the most advanced texts of the time, but from within his precise social context, will allow Caldas to transform the enraptured view of his first voyages. As a consequence, he will be able to describe the geophysical characteristics of the territory. At the same time, all this will produce a notable overall effect: the reassertion of his faith in his native soil and, therefore, the emergence of a political foundation for the aims and orientation of his scientific activity.

At the start of his career as a naturalist, Caldas begins his self-education in science by reading descriptions of voyages through the territory of New Granada. On december 9th 1795 he asks Arroyo, well situated in the intellectual circles of the capital, to take out for him, from the Santafé Public Library where he had consulted them during his university days, the following books: Gumilla's *Illustrated Orinoco,* Julian's *Description of the Province of Santa Marta,* Condamine's *Voyage along the Amazon* and this same author's *Description of (his) travels in the Presidency of Quito.* Interested also in the identification and taxonomic analysis of the Andean species of vegetation that he had observed during his travels, Caldas asks his friend for José Quer's *Flora Española* where he thinks he will find the keys to Linnaeus's and Tournefort's nomenclature and classification.

Many of Caldas's dealings with the enlightened criollos, with Arroyo as intermediary, will be restricted to acquiring these works and the much more important one by Linnaeus, *The Philosophy of Botany.* The letter of 20 July 1801 is most revealing in this regard. Caldas congratulates himself on his friend's having finally discovered a copy of the *Philosophy of Botany* in Joaquín Camacho's possession:[8] *"Let us rejoice on having acquired this masterful classic of the northern naturalist, a first necessity for every botanist".* His following commentary testifies to the social prestige, among the enlightened criollos in the principal cities of the Vice-Royality, that accrued to the possessors of scientific books. Caldas warns Santiago Arroyo not to be fooled in these dealings:[9] *"Camacho himself has told me that Manuel del Socorro Rodríguez deceived you when he said he had Bouguer's* ***Figure of the Earth*****".**

In the letter dated 20 March 1797 in Popayán, Caldas speaks of having recently learned of the true origin of the Orinoco river, discovered by the expedition that between 1754 and 1761 had as its task the definition of the boundaries between Spain and Portugal's American possessions. At the same time, he discovers that most authorized previous studies, such as those by Condamine, d'Ambille, Magnin and

Gumilla, placed the birth of the Orinoco at a different spot. His confidence in the results of the explorations of the American territories by metropolitan expeditions begins to waver.

No longer satisfied by the authority of established learning, Caldas desires to describe his native country, fortified by his conviction that it was necessary, at any cost, to dedicate himself to[10] *"reforming the geography of these regions forgotten by scholars and unknown in Europe"*. He settles down to studying the most well-known maps, including Piedrahita's and Maldonado's maps of New Granada. He has Santiago Arroyo send him from Popayán Juan de la Cruz Cano y Olmedilla's map of South America, which had been officially approved by the Spanish Crown in 1775.

Busy at work in 1798 tracing the map of a portion of the Province of Popayán[11], Caldas will have more than one opportunity to discover for himself the insufficiencies in skill and knowledge of the Europeans who had studied the local geography. The paradoxical thing, he says in the 5 December letter mentioned above, is that the map of the Vice-Royalty *("the most important of my intellectual projects")* must take into account the findings of the available books; but these books, *"were they not made in negligence and in ignorance of these matters?"*.

This is precisely the conduct that guided Caldas's scientific and cultural activity and that of the scholarly criollos of the generation of the independence. Formed as thinkers in the school of the Enlightenment, they knew that in last analysis all of reason's ambiguities would be dispelled by *nuda experientia.* On the other hand, the consciousness of their geographical, social and political location with regard to the European centres had shown them the unprecedented role they had to play in the translation and acclimatization of science in the circumstances of the new society to be built[12].

Let us return to Caldas's Letters and to our immediate aim of tracing the formation, among the youth of New Granada, of a scientific spirit through the reading of the representative scientific textbooks of the age, and of its deployment in intellectual and practical endeavours in their country. On January 5th 1799 Caldas deplores the adverse circumstances which impede him from carrying out the astronomical calculations and observations necessary for determining the location of his native city of Popayán. Besides the season's poor atmospherical conditions, the armed conflicts that were disturbing the tranquillity of Spanish society at that time also blocked the sale of books and scientific instruments across the Atlantic.

Having at hand neither up-to-date almanacs nor astronomical tables, Caldas remembers having consulted during his stay in Santafé the two volumes of Lalande's Astronomy. So he puts pressure on Arroyo to use all his means to convince Fernando Vergara to sell him this work. Vergara was Mutis's substitute in the Chair of Mathematics, one of the new institutions which held the highest prestige and academic authority among the members of the elite and cultivated social circles, with the one exception of the Botanical Expedition Establishment where Mutis reigned supreme. As for Caldas, he worked alone and solitary in Popayán, kept afloat by his sheer will to know and by the esteem of his neighborhood of relatives and illustrious friends. Only after having been discovered by Humboldt and having been appointed corresponding member of the Botanical Expedition for the Presidency of Quito, and especially after having been placed at the head of the Astronomical Observatory at Santafé, will he enjoy a unique prestige[13].

His lack of social legitimacy will not stop Caldas from trying to wrest away from almost anyone the scientific instruments he can put to more practical use in his work as an astronomer. He was so convinced of the absolute importance of the work he was carrying out that he could not imagine that anyone else could do the job of cultural enlightenment of disseminating and explicating the world view of a book like Lalandes's. Caldas states unabashedly in his letter of January 5th to Arroyo that the book in Vergara's hands was useless. This bartering for the possession of the sole available copy in the country of a work reputedly paradigmatical for astronomy sheds light on the discrepancies among the members of the elite with regard to the social function of knowledge. These discrepancies were vented openly in the pages of the *Papel Periódico Ilustrado,* the first local journal of scientific popularization, and agent for the social and intellectual cohesion of the studious who were scattered all over the provinces. An aggressive group of scholars, which would play a decisive role in the political events of the Independence, set up, in opposition to the *academic* strategy of the exercise of knowledge, a *pragmatic* strategy for science.

At the end of the century, this last tendency, to which Caldas would be an outspoken adherent, proposed to turn science in New Granada to the exploration of the countryside. Some even began to throw doubt on the pertinence of that most prestigious project, the Botanical Expedition, which in theory was supposed to be in the service of the Crown's policy of colonial science with eventual benefits for national science, but in practice, restricted by Mutis to the function of describing the flora in the neighbouring regions of Santafé, it afforded little scope to the pragmatic intentions of the enlightened criollos. At one point several of Mutis's one-time collaborators on the Expedition, Zea, Pombo and Valenzuela, went so far as to propose a change of course for the institution. In their opinion, it had become urgent to make it itinerant, to abandon the exclusive aim of collecting detailed illustrations of the plants of the central regions, and to move on to the systematic study of the population and of nature (in the amplest sense) in other regions over the whole of the country. In order to reach this goal, they suggested recruiting the circles of amateur naturalists located here and there in all provinces of the Vice-Royalty[14].

Caldas shared these pragmatic and nationalistic ambitions for scientific research. He was the first to demonstrate, through his contributions to astronomy, geography, physics, biology and sociology, the possibility of such an approach to theory and its applications. Throughout his life Caldas was faithful to his nationalistic project whose prefiguration is to be found in the very first of his letters at the end of the 90s. But it is in the pages of *Semanario del Nuevo Reino,* the journal of which he was editor of in the years 1808-1811, where this position is most clearly expressed. Thus, for instance, in the preface to the almanac of 1811, year One of the Independence, Caldas, the astronomer whose merits Humboldt had praised to the skies and who was then the official director of the Observatory at Bogotá, writes:[15]

"To regard the heavens and nothing else is an honest occupation; nevertheless, to do only that would be sterile curiosity suited to satisfy the needs of the idle and well-to-do man. Such an observer would be useless and the Fatherland would consider him an improductive burden from whom nothing could be expected. We do not wish to play that role in our society: we desire, with our astronomical studies, to improve our geography, our roads and our commerce".

A nationalistic aim, the desire to be useful in science and with science to contribute to the social projects of the criollo elite, is what gives to Caldas's way of knowing its special style. In the case of astronomy, the very first letters tell us of a young lawyer who at the start makes a choice of a calling and then pursues this line of research with the idea of putting his forefathers' country on the world's maps, and, more modestly, of helping to settle disputes between landowners in his neighbourhood.

Caldas's astronomical thought was marked from the beginning by practical interest in geography and it was shaped at the same time by the technical activity of building instruments. Due to the penury of books and implements in those years, Caldas was obliged to build himself the quadrant he needed. He built it following the indications given on this subject in Jorge Juan's *Observaciones Astronómicas* with which he was apparently familiar. He tells his friend Arroyo how he managed, in a trial and error procedure subjected to scientific control, to manufacture the required apparatus to identify Saturn's ring and Jupiter's satellites and to determine the position of Popayán[16]. In passing, it should be remembered that Jorge Juan was one of the expeditionaries to Peru in the 1740s who most took advantage of that experience to broaden his scientific training and to develop objective knowledge on how to put theory to use in the concrete conditions of exploration of nature[17]. His treatise was thus a privileged instrument for making known rational mechanics and cosmogony. Written with an understanding of the most advanced newtonian theories of the time, it enabled the interested reader to become familiar with these theories and to put them to practical use. Caldas was one of the fortunate readers to whom this book provided from the very beginning the knowledge in physics and astronomy most suited to the research program he was attempting to draw up for New Granada[18]. In a letter of 1 July 1809 to the Vice-Roy Amar y Borbón, he recalls the circumstances and occasion of his reading of the book that would draw him to his profession as astronomer:[19]

"In 1796 I came to Santafé in search of certain books, instruments and clarification. I realized then that I would have to shut myself up in my projects, as there were neither instruments nor astronomers in the capital or in Popayán. Back in the silence and darkness of my home-town, I attempted to build a quadrant in accordance to the model described by His Excellence Jorge Juan in his *Observaciones Astronómicas.* This Spanish scholar, honor to the Nation and to science was my guide in the utter darkness that surrounded me".

In this quotation one finds once again in Caldas that feeling of loneliness shared by other members of the elite, irredeemably condemned to pursue their studies in complete isolation and marginality. He was obliged to try to gather round him other intelligent young men, to discover the personal, material and technical resources to carry out his research, and at the same time, to consolidate his position in the limited space of the country's academic institutions. This evolution is observable all through his correspondence[20].

As he progressively deploys, in the unfavorable conditions of his surroundings, an autonomous ability to instrument and manipulate a complex mass of knowledge and techniques, Caldas also learns how to bargain for the means of carrying out the research problems dear to his heart. His scientific activity is thus directly dependent on his personal circumstances. In such a context, the intellectual products of his experience bear the stamp of the negociations between him and his interlocutors. This is true both of the problems, ideas and hypotheses which most interested him, as well as of the criteria, norms and significations that he applies for their solution.

Let us take for example the well-known case of Caldas's innovation in the so-called hypsometer method which provides a technique for calculating altitudes using a simple thermometer and a theoretical principle: the boiling point of water remains constant under conditions of constant barometric pressure. Most often, this "discovery" of Caldas's has been explained, as Humboldt was the first to do[21], as being in relation to the state of the question in Europe. The sociological explanation with regard to the originality, simultaneity or repetition of this discovery shares the transcendent idea of the necessary action of a logical principle which produces the same effects (or almost the same) in the same conditions of place and time. Such a conception limits the analysis of historical facts to the proof of similarity and difference (one might even say strangeness) with regard to the norm of European invention. It would be worthwhile to meditate on this affair, not so much with the idea in mind of a novelty which would have to appear ineluctably, but rather as the result of a series of contingent interactions between Caldas's scientific activity and his environment[22].

As he refers it in his letter of 5 June 1801 to his friend Arroyo, Caldas reached this technical innovation and then its mathematical formulation by starting from observations and calculations on the variations of temperature at different barometrical levels of the Andean regions over which he had traveled in his voyages of the years 1796-1800. The thermometrical method for calculating altitudes was thus perfected little by little over the years in a practice of barometric readings in order to determine the longitude and latitude of notable sites in the geophysical space of New Granada. This experience was contrasted with the theory, as can be deduced from the works mentioned by Caldas in his publications on this subject. As well as *Observaciones Astronómicas* and Bouguer's *Figure de la Terre,* he consulted a canonical text[23] of the new physics: Sigaud de la Fond's *Eléments de physique théorique et expérimentale*. In this last-named book he found this observation:[24]

"that if the elevation or the descent of the mercury in the barometer were one inch then the boiling point of water would change in approximately two degrees Fahrenheit".

This provided him with an empirical criterion for solving a directly practical problem: how to rebuild his thermometer, broken in a recent accident[25]. But it also made him realize that a linear relation exists between the boiling point of water and atmospheric pressure, shown by a constant that would later be determined through observation and experience.

Subsequently, Caldas would take advantage of a long voyage to the equatorial Andes, whose objective was almost exclusively restricted by Mutis to botanical exploration, to pursue his experiences on which he counted in order to add the formulas for barometric levelling and in order to determine the constant in the local conditions of the equatorian latitude[26]. In passing, let us call to mind that this research was carried out while simultaneously negotiating his research's strategy in Ecuador with Mutis, and with the Consul in Cartagena and Caldas's benefactor José Ignacio Pombo. The details of this negotiation are to be found in the correspondence among them[27]. It is important to bear in mind that after a certain moment in his process of innovation, Caldas became aware of the originality of his proceeding. He knew, in particular, that Bouguer, Juan and Ulloa were mistaken in supposing that[28] *"the atmosphere is of the same weight in Europe and in America"*, even though the differences were slight. This fact was confirmed in 1805 by Laplace's differential formula which gives the calculation of the barometrical altitude in terms of gravity, variations in latitude, temperature and other factors. Apparently Caldas never learned of this result[29].

In my view, the historical case of Caldas bears witness to the emergence, in the peripheral areas towards the end of the 18th century, of a realistic trend of scientific endeavour among the intellectuals with nationalistic tendencies. This trend would be present in a field of forces constituted by two independent vectors. The first, characterized by an *optimistic faith in the native land,* would show the way to the achievement of knowledge specially in the local geocultural space. The second, founded on a *sense of solitude,* would promote the scholar's consciousness of the peculiar nature of the enterprise of specialized scientific training and research in the peripheral zones far away from international scientific centres.

This realistic trend is present in all those rare moments in the history of the sciences when in the periphery there was the lucidity to put forward projects for the institutionalization of research and training of specialists adapted to local circumstances. Most of the time, this was undertaken in opposition to sweetly simple conceptions of scientific progress that obstinately duplicated in the periphery the models of scientific institutionalization for the central countries[30]. To these conceptions Caldas and the editorial team of *Semanario del Nuevo Reino* replied in the prospectus to the first number of 1809, in words that must be placed in the context of the epoch:[31]

"How could a people that has no roads, whose agriculture, industry and commerce are foundering, concern itself with dazzling and imaginary projects? Horticulture, an easy direct road, the map of a province, the latitude and altitude of a place, the geographical location of a river, these are far more important questions than all those trumpeted matters that afford occasion to genius, erudition and eloquence. The *Semanario* is a serious journal which will publish useful memoirs on the subjects that interest us the most".

Universidad del Valle, Cali

Notes

[1] Chenu, J. (1987): "Du bon usage d'instruments imparfaits : Science et technique dans le Vice-Royaume de Nouvelle Grenade (Deuxième moitié du XVIIIe siècle)", *Asclepio Revista de Historia de la Medicina y de la Ciencia*, **vol.29,** p.255-271. For Caldas's intellectual biography see: Arboleda Llorente, J.-M. (1945): "La plaza de Caldas en Popayán", *Boletín de Historia y Antigüedades*, **vol.32,** p.877-907; Bateman, A. D. (1978): *Francisco José de Caldas, El hombre y el sabio,* Biblioteca Banco Popular, **vol.79,** Cali; Paredes Pardo, J. (1983): "Repaso del sabio Caldas", *Boletín Cultural y Bibliográfico,* Bogotá, **vol.20,** p.98-130; Arias de Greiff, J. (1980): "Aspectos inéditos de la vida y la obra de Caldas", in: *Bases biológicas de la vida y la enfermedad,* Fundación OFA, Bogotá; Arias de Greiff, J. (1985): "La Astronomía", in: *Historia social de las ciencias en Colombia,* **vol.1,** Colciencias, Bogotá (Manuscrito).

[2] Albis, V., Martínez-Chavans, R. (1987): "Las investigaciones meteorológicas de Caldas", *Quipu, Revista Latinoamericana de Historia de las Ciencias y la Tecnología,* México, **vol.4,** p.413-432. Classical, and still useful, historiographic studies on this topic are: Hernández de Alba, G. (1947): *Aspectos de la cultura en Colombia,* Ministerio de Educación, Biblioteca Popular Colombiana, Bogotá; García Bacca, J. D. (1955): García Bacca, J. D. *Antología del pensamiento filosófico en Colombia de 1647 a 1761,* Selección de manuscritos, textos, traducción, introducciones, Imprensa Nacional, Bogotá; Jaramillo Uribe, J. (1977): *La personalidad histórica de Colombia y otros ensayos,* Instituto Colombiano de Cultura, Bogotá; Pachecho, J. M. (1976): *La Ilustración en el Nuevo Reino,* Universidad Católica Andrés Bello, Caracas; y Cristina, M. T. (1982): "La literatura en la conquista y la colonia", in: Jaramillo Uribe, J. (ed.), *Historia social, económica y cultural,* 3 vol., 2nd ed., Procultura, Bogotá, **vol.1,** p.491-592. Other more specialized writings that bring to light new aspects of the reception of the Enlightenment in Colombia are: Chenu, J. (1977): "Littérature scientifique en Nouvelle Grenade à la veille de l'indépendance : du discours à la pratique", *Studies on Voltaire and the 18th century,* **vol.97,** p.313-336; Obregón, D. et al (1986): *Historia social de las ciencias. Sabios, médicos y boticarios,* Colección popular de la Universidad Nacional de Colombia, Bogotá; Restrepo Forero, O. (1985): "La formación del espíritu

científico en el Nuevo Reino de Granada", *Revista Colombiana de Educación*, Bogotá, **vol.16**; Quevedo, E. y Zaldúa, A. (1988): "Institucionalización de la meédicina en Colombia", I, *Ciencia, Tecnología y Desarrollo, Bogotá*, **vol.12**, p.137-221; Arboleda, L. C. (1987): "Acerca del problema de la difusión científica en la periferia: El caso de la física newtoniana en la Nueva Granada (1740-1820)", *Quipu, Revista Latinoamericana de Historia de las Ciencias y la Tecnología*, **vol.4**, p.7-30; y Arboleda, L. C. (1990): *Newton en la Nueva Granada*, Informe de Investigación, Programa F. P. Santander, Colcultura, Bogotá (Manuscrito).

[3] *Obras completas de Francisco José de Caldas*, Imprenta Nacional, Bogotá, 1966. From here on will be cited as *Works*.

[4] *Cartas de Caldas*, Editorial Kelly, Bogotá, 1978. From here on will be cited as *Letters*.

[5] I refer here to the letter dated December 9th 1795, *Letters*, p.25, where Caldas speaks of his travels in commerce and the birth of his spirit of scientific observation. Slipping out of the constraints of the profession of jurist which kept him away from his calling as naturalist, Caldas chose at that time to travel the route of commerce between the seat of the government of the Presidence of Quito and Santafé, the Capital of the Vice-Royalty. He thus found the way of making his living in the lucrative activity of the tradesman and at the same time of responding to his inner calling, the "call of nature", which would lead him to the exploration of the central areas and then of the andean regions of the territory of New Granada. Bateman (1978), *op. cit.*, p.25-31 has some interesting commentaries although from his traditional laudatory point of view. Compare with Arias de Greiff (1985), *op. cit.*, p.24-27.

[6] *Letters*, p.25; see the continuation of this commentary, infra, p.3. Caldas's interest in basing the exploitation of the territory on solid scientific works, principally in physics and the natural sciences, will be reiterated in his correspondance all through the years 1795-1801; *Letters*, p.25, 29, 33, 35, 49, 60-61, 101.

[7] *Letters*, p.29. The perusal of the reports of previous travellers over these routes, like Bouguer, quickened Caldas's sense of observation during his numerous voyages and so he became aware of the details of nature, and the ruins of precolombian constructions that he had passed by without seeing. Scientific curiosity in natural objects led Caldas to an interest in those works, then available to him, which offered an explanation of their characteristics and properties.

[8] *Letters*, p.86. Caldas still expresses here the unlimited confidence (shared by all his generation as a result of Mutis's teachings) in the supposed competence and adequacy of Linnaeus's system for the explanation of equatorial nature. This confidence will begin to shrink as botanical investigations start to appear over the following years. See: Restrepo Forero, O. (1986): "El tránsito de la historia natural a la biología en Colombia 1784-1936", *Ciencia, Tecnología y Desarrollo*, Bogotá, **vol.10**, p.181-275; y Arboleda, L. C. (1990b): "José Celestino Mutis (1732-1808), l'Expédition botanique (1783-1816) et la naissance d'une tradition scientifique à la Nouvelle-Grenade", in: X. Polanco (ed.), *Naissance et développement de la science-monde*, ed. La Découverte-Unesco, Paris.

[9] J. Camacho and C. Torres, Caldas's cousin, were famous jurists and ideologues of the Revolution of Independence. M. del Socorro Rodríguez, of Cuban origin, was contracted by the Vice-Royalty to set up a printing press and the Santafé Public Library.

[10] In this letter of 5 December 1798 the necessity of a project for the mapping of the territory of New Granada, including the Province of Quito, appears for the first time (*Letters*, p.42). Caldas spent a great deal of time and effort in the geographical survey and mapping of the territory in its relation to the economy and commerce. His most important publication on this subject was his report on the "Estado de la geografía del Virreinato de Santa Fe de Bogotá", published in the first numbers of *Semanario del Nuevo Reino de Granada*, corresponding to 1808, See Works, p.183-211.

[11] Boundary disputes between landowners in the Timaná region could not be settled using maps as incomplete as that of Piedrahíta which had been drawn up in the previous century. So Caldas finds his first opportunity to sell his professional services as geographer and is able to determine exactly the latitude and longitude of several sites, with the conscious aim of correcting maps as prestigious as those of Maldonado and La Condamine (*Letters*, p.279).
[12] Compare with notes 15 and 30.
[13] The letters from the end of 1808 and the beginning of 1809 give proof of Caldas's maneuvers, aided by friends and relatives, to obtain from the authorities of the Vice-Royalty his official appointment as Director of the Observatory. See: *Letters*, p.284-286. Finally, July 1st 1809 Caldas thanks the Vice-Roy Amar y Borbón for his appointment to a position which "has bestowed me the most brilliant destiny and the one most consonant to my inclinations " (*Letters*, p.293).
[14] Consult Restrepo Forero, O. (1986), *op. cit.*, y Arboleda, L. C. (1990), *op. cit.*
[15] See *Works*, p.401-404.
[16] *Letters*, p.43-48. When passing through Popayán, Humboldt learned of Caldas's studies and did not hesitate to include them in his *Diary of Astronomical Observations*. He also praised Caldas's skill and talents in such unfavorable circumstances in comparison to international centres (see, for example, Humboldt's letter to Mutis November 10th 1801, in: Hernández de Alba, G. (ed.) (1983): *Archivo epistolar del sabio naturalista José Celestino Mutis*, Instituto de Cultura Hispánica, Bogotá, **vol.IV**, p.12; *Letters*, p.151).
[17] On the geodesic expedition to Peru it is of interest to consult Lafuente, A., Mazuecos, A. (1987): *Los Caballeros del punto fijo*, ed. del Serval, Barcelona.
[18] As well as the instructions for building a quadrant, Caldas founds in *Observaciones* methods of geometrization, astronomical calculations and geodesic techniques used in Peru by Juan and Ulloa. Other sources of Caldas's knowledge of astronomy and meteorology are summarized in Albis, V., Martínez-Chavans (1987), and Chenu, J. (1987).
[19] *Letters*, p.287. Compare with note 16.
[20] See in particular notes 13 and 27.
[21] A typical example of this approach is in Bateman, A. (1978), *op. cit.*, p.101-132.
[22] A careful reading of Letters, from this point of view, would discover other random factors that entered into Caldas's meteorological investigations and not just the famous breaking of this thermometer to which Caldas himself apparently ascribes an exclusive importance. See the reference in note 25.
[23] This text was a privileged instrument for the dissemination of the "new physics" in the country, in: Arboleda (1987), *op. cit.*
[24] Albis, V., Martínez-Chavans, R. (1987), p.442.
[25] In Chenu, J. (1987), *op. cit.*, p.263-264, an account can be found of how this random factor entered into Caldas's innovations in the methods of measuring altitudes.
[26] Caldas's correspondence during his numerous voyages from Popayán to Quito, demonstrate his endeavours to determine the constant basing himself on significant barometrical readings. This interest of his is clearly evident in his posthumous report: "Sobre un nuevo método de medir la altura de las montañas por medio del termómetro y el agua hirviendo", in: *Works*, p.153-173 y 487. Also in *Letters*, p.91, 160, 170.
[27] See the correspondence between Mutis and Pombo in Hernández de Alba, G. (1983).
[28] *Works*, p.156, 395, and *Letters*, p.246.
[29] Albis, V., Martínez-Chavans, R. (1987), p.419-420.
[30] See Arboleda (1990), *op. cit.*
[31] Cited in Pacheco (1976), *op. cit.*

MODELS OF EUROPEAN SCIENTIFIC EXPANSION: THE OTTOMAN EMPIRE AS A SOURCE OF EVIDENCE

Alberto ELENA

As it is well known, the Scientific Revolution was a genuinely European phenomenon (although not all nations contributed equally) in which a great majority of the world's regions were left by the wayside. The powerful West European nations did not take long, however, in displaying a determined desire to expand; they soon try to diffuse *their* science and *their* technology around the world, motivated more by colonial aspirations than philanthropic ones. This important historical process, in which Europe happened to reproduce its scientific-technical patterns in very different locations, continues to be poorly understood, despite recent growing interest.

The reasons for this sudden interest are not easy to determine, although they are undoubtedly related to the numerous recent criticisms of the role which science currently plays within the complex dynamics - by no means balanced- between advanced and less advanced countries. Moreover, if the problem of the relations between scientific centers and peripheries has assumed an important place in the work of some historians, it has also come accompanied by the reappraisal of George Basalla's paper "The Spread of Western Science", which has become, with time, a classic on the subject[1]. In it Basalla offers not only the first attempt at a synthesis of unconnected partial studies but also suggests a model which might permit one to give an account of the significant process of diffusion of Western science (although in fact the term *European* seems more adequate for any period prior to the 20th century). The above mentioned model consists of "three overlapping phases or stages"[2], however sufficiently autonomous and differentiated. The first of these is no more than an extension of geographical exploration characterized by the surveying of new territories in order to study their physical features, including their flora and fauna, then transferring the results thus obtained to the metropolis. In this phase, Europe limits itself in making use of other regions as vast repositories for scientific work, which is why obviously the most affected fields are, above all, natural history and the geographical disciplines. The second phase, which Basalla ambiguously named *colonial* science[3], is characterized by

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the emergence of a certain scientific activity in the *colonies,* although always with a reliance on metropolitan science and its institutions, in which generally the colonial scientist receives his training due to the lack of native institutions. Only when this scientific activity takes on significant dimensions and its agents succeed in freeing themselves from the metropolis - generating a proper scientific tradition endowed with an adequate institutional endorsement - will it enter the third and final phase: the establishment of an *"independent scientific tradition",* to quote Basalla's words[4]. And only then will it be fit to consider Western (or European) science actually assimilated into the receiving nation.

Basalla's model, no doubt very stimulating, has nevertheless been the object of a number of criticism by other scholars (historians, sociologists, economists...), some of whom have offered alternative models with different results[5]. Naturally this is not the place to conduct a systematic and detailed revision of Basalla's model nor of those which followed, primarily because we lack a sufficient number of case studies from which to theorize. However, it is possible to contrast the validity of the different models when applying them to the case of the Ottoman Empire, which is curiously absent from all previous studies (since Basalla's pioneer contribution scholars have almost invariably concentrated on Latin America and the Pacific). The case of the Ottoman Empire is, moreover, particularly interesting in that various characteristics are brought together which *prima facie* seem to make it an important exception in the context of the European scientific expansion[6].

To begin with, it must be noted that the Ottoman Empire, despite its chronic weakness in the 18th and 19th centuries, had known an astonishing golden age and had taken the leading role in world history, which for centuries had been held by the Islamic culture. Differing then from other regions eventually subjected to Western imperialism, the Ottoman Empire constitutes a case of decline rather than an emergence of a new scientific culture[7]. It was not a new world which the colonizers discovered and tried to model after its own image. The numerous travellers who offered descriptions of the Empire invariably emphasized that they were dealing with a different, yet highly sophisticated *civilization,* and in general focussed on disciplines other than natural history. Apart from a few exceptions, the Ottoman Empire was never a stimulus for metropolitan science. This would explain why the first phase of Basalla's model (curiously enough, the least criticized by other scholars, although it is not even a true *stage of expansion)* is scarcely recognizable in the Ottoman case: works such as Luigi

Ferdinando Marsili's *Osservazioni intorno al Bosforo Tracio overo Canale di Constantinopoli* (Rome, 1681) make a clear exception in the context of the sources of inspiration for the European naturalists of the time.

Moreover, the Osmanli case - insofar as the Empire always kept its formal independence - constitutes a peculiar deviant from *peripheral science* since it is not possible to recognize easily a strict metropolitan dependence, nor could it be properly labeled *colonial science*. In effect, the Ottoman Empire does not fit into any of the classical categories - *formal colonies* and *informal empires* under the rule of great powers - as were suggested nearly four decades ago by Gallagher and Robinson[8] in their explanation of the process of European economic expansion. Thus not only did it never lose its independence, but it never even formed a part of the *informal empire* of any specific power (as occurred, for example, in a large part of Latin America during the 19th century). In contrast, Western capitalism penetrated Turkey under conditions of an intense inter-imperialist rivalry. A relatively strong centralized bureaucracy and a small but not negligible military power could offer the necessary resistance to formal colonization as well as prevent the plans of division and redistribution of the Ottoman territories from being carried out. This third category, inter-imperialist rivalry, has recently been proposed by Sevket Pamuk[9] as an explanation for the distinctive features of the incorporation of the Ottoman Empire (and perhaps of others cases such as China or Persia) into the world economic system. This revived exploration of the subject by economic historians has not found, however, any parallel among historians of science interested in European scientific expansion and what has been called, in a vague and inaccurate way, *colonial science*.

Now then, if there is one thing one can be sure about, it is that the introduction of modern science and technology into the Ottoman Empire was carried out parallel to European economic expansion. The sense of economic unreality of Basalla's model, severely criticized by some authors, is revealed in its full dimension. Therefore, to understand the diffusion of European science in the Ottoman Empire, it is important to consider other more realistic patterns such as the one proposed by the Latin American economists Sagasti and Guerrero[10]. According to them, the process would start with a certain stage of clear scientific metropolitan dependence. But far from giving itself an evolution towards a greater autonomy or independence on the receiving nations side, these nations would end up perpetuating themselves, in most cases, submitted to new and more sophisticated forms of dependence (at the same time integration in the world market becomes larger). In this way, the illusion of independence superposes to a much subtler submission of a neocolonial nature. The case of the Ottoman Empire in the 18th and 19th centuries is perfectly illustrative on that score.

From Carlowitz to Küçük Kaynarca the successive military defeats and diplomatic setbacks led the Ottomans, for the first time, to open to the West in pursuit of a knowledge they estimated vital in order to continue vying with European powers. This receptiveness, until then limited practically to war technology (as it is well known, the Turks immediately adopted firearms[11]), meant the triumph of pragmatism over traditional prejudice against the *bid'a* (innovation). However, the main channel for the introduction of modern science and technology into the Ottoman Empire continued to be the army, and in particular, the new military academies, promoted as long ago as the first half of the 18th century (the *Hendesehane of Üsküdar,* founded in 1734; later, during the 1770s, the *Muhendishane-i Bahri;* etc.). The process would gather even greater momentum with the *Nizam i Cedid* promoted by the Sultan Selim III[12], whose programs of reform would be explicitly followed by Mahmud II in the beginning of the 19th century. This particular development of the military institutions was accompanied by the establishment of the first permanent embassies of the Porte abroad (1793-1796), which exemplify another privileged channel to import European science and technology, and the foundation of scientific institutions independent of the military academies (the *Mekteb-i Tibbiye-i Sahane,* opened in 1838, constitutes a real landmark in this process). Undoubtedly, the Porte held scientific and technological modernization in high esteem, even though the circumstances were not as propitious as they should have been and the attempts often failed (sometimes due to virulent reactions).

Far from coinciding with the idealistic estimations of Basalla concerning the takeoff towards the establishment of an independent scientific tradition in response to Western stimulus, the scene the Ottoman Empire furnishes is much more problematic. Its attempts at modernization had borne remarkable costs, since Western powers obviously had not been prompted by philanthropy. Modern science and technology had been sold to the Ottomans as just another commodity and in this way, the counterweight to the reform could not have been other than technological dependence and a systematic debt. The Porte became a very good customer, as Voltaire noted to Frederic the Great in 1771:[13] *"It is now sixty years since they (the Turks) have been importing watches from Geneva, and they are still not able to make one, or even to set it right"*. Therefore, the scientific and technological dependence was only one aspect of a more profound economic crisis of the Empire, and as such has to be contemplated: the perspective of economic history thus reveals itself to be highly enlightening in the study of the introduction of modern science and technology in the Ottoman Empire.

The crisis had certainly been incubating itself since the 16th century, when the effects of the circumnavigation of Africa by Vasco de Gama, the discovery of the New World and the continual setbacks of the Turks in the Indian Ocean were strongly felt in Constantinople. The commercial routes of the Middle East and Central Asia on the one hand, and of the Mediterranean Sea on the other were gradually losing their importance in the face of oceanic navigation, to the detriment of the Ottomans[14]. Convinced that (in trade as well as in diplomacy) it was the responsibility of the one considered inferior to move towards the one considered superior and to negotiate with him, the Porte always maintained a favorable attitude toward the affluence of foreign merchants in Constantinople and never estimated it convenient to launch a real trade offensive outside the frontiers of the Empire. To that was joined a most peculiar Osmanli conception of the *trade balance:* while all kind of imports were encouraged under pretext of satisfying the necessities of the domestic market, exports were strictly disapproved for the opposite reason (being generally liable to heavy taxes if not simply prohibited in some cases[15]). Thus, the imperial debt grew at the same rate: the market was inundated with every type of commodities manufactured in the West, promptly furnished by European merchants. Even merchandise that the Muslims had introduced into Europe, such as coffee, sugar, or spices, already began its importation in the 17th century from France and Holland (since they obtained them at the best prices in their respectives colonies). At the end of the 18th century the trade balance which had traditionally been favorable to the Ottoman Empire (who, as a general rule, had only been interested in war equipment from the West) had reversed itself completely in favor of Europe, this being the first step toward political and military domination of the following century. Therefore, it was not the best time to undertake reforms: the attempts at modernization promoted by Selim III and his successors were to a great extent conditioned by an unattractive economic situation.

The most crucial turning point in the Osmanli economic development during the 19th century was the signing, between 1838 and 1841, of different treaties of free trade with England first, and the remainder of the Western powers afterwards. England, taking advantage of the Porte's conflicts with Muhammad Alî and Russia, obtained then a preferential treatment resulting in an unchallengeable hegemonic position in trade with the Ottoman Empire[16]. Such a trend would strengthen itself as the century progressed, when the foreign - and British in particular - economic penetration was reinforced with the first direct investments and also with loans to the Ottoman state in very diverse sectors. The economic debt and the consequent financial control exercised by the Western powers became so intense that one could well say that, during the reign of Abdülhamid, the finances of the Empire were already found in the hands of European bankers[17], and thus accomplished a complete integration into the world economic system[18].

The incipient Osmanli industry, basically textile and war industry, as inferred from its participation in the Paris Industrial Fair in 1856[19], could not withstand the concurrence and pressures of the European powers, and by mid-century even traditional state monopolies (such as mining and the fabrication of paper money) eventually passed into foreign hands. The last quarter of the 19th century, following the Russian Ottoman war of 1877-1878, produced a substantial alteration in European competition for economic hegemony in the Empire, curbing British investment in favor of France and Germany (then aggressively committed in a *Drang nach Östen* policy), but without the global situation actually being much affected. In this way, on the eve of World War I the concept of an *Ottoman economy* appears to economists and historians alike, devoid of any utility as a significant unit of analysis[20].

The incorporation of the Ottoman Empire into the world economic system in the second half of the 19th century took place under peculiar conditions of rivalry between the European powers, and is thus an interesting case in the context of the process of capitalist penetration into peripheral areas. But however different the mechanisms were, the effects (destruction of the native industry, foreign debt, etc.) did not differ much from what was observed in other cases. The growing scientific and technological dependence of the Ottoman Empire was not an exception on that score and as would be expected, it reached its zenith during the reign of Abdülhamid at the same time that foreign penetration became even more vigorous. The development of railroads and modern telecommunication during this period is exemplary[21] and shows to what extent the *imitation* of Western science had already stopped being intertwined with more or less ambitious plans of national reconstruction and had turned into a mere reflection of European economic domination.

The framework of inter-imperialistic rivalry so characteristic of the Ottoman history in the 18th and 19th centuries thus constitutes an interesting case that would confirm Rothenberg[22] and Reingold's intuition that we need to contemplate the emergence of the international scientific community as a thick polycentrical network of relations at very diverse levels. Furthermore, the Osmanli case, to the extent that the Empire always conserved its formal independence, constitutes a peculiar variant of peripheral science in that it is not possible to recognize a proper colonial dependence: instead, the inter-peripheral relations with Egypt under Muhammad Alî, or even with Russia, necessarily have to be taken into consideration if one wants to explain reasonably their development. As for the rest, the strictly economic motivation of the exportation of science and technology to the Ottoman Empire does not seem to fit any of the philanthropic assumptions of Basalla, nor does the idea of an independent scientific tradition seems to have played a relevant role in the process, whose guiding principle was always that of *imitation* without ever resulting in the emergence of a true national science.

Why some nations succeeded in soaring up after their contact with European science and others, instead, joined what would be later called the Third World is something that the different models have not begun to explain yet. It is certainly not for this paper (whose scope is much more limited) to settle the question, as the problem of European scientific expansion has hardly even begun to be examined by historians. However, objectives will be more than fulfilled if it succeeds in calling attention to the Ottoman case (stressing its interesting distinctive features and its value to testing the different models so far proposed) and looking at the problem from its perspective rather than examining it from the much more familiar view of the European powers. In fact, as Robert Mantran so appropriately wrote in this respect[23],

"it would be unjust to make the Ottoman Empire not only the victim, but also the main responsible. For a long time, the opinion of historians has in no way been favourable to the Ottomans and has magnified, instead, the splendor and might of the Western states. Without wanting now to reverse such judgement, it is doubtless also that neither is it fitting to accept it without qualifications as the internal history of the Ottoman Empire is being shown with greater clarity and new light is shed on the life of a world traditionally little known and frequently misjudged".

Universidad Autónoma, Madrid

Notes

[1] George Basalla, "The Spread of Western Science" *Science*, **vol.CLVI**, n° 277, 5, (1967).
[2] George Basalla, "The Spread of Western Science", *op. cit.*, p.611.
[3] George Basalla, "The Spread of Western Science", *op. cit.*, p.613.
[4] George Basalla, "The Spread of Western Science", *op. cit.*, p.611.
[5] See, for example, David Wade Chambers, "Period and Process in Colonial and National Science"; Roy MacLeod, "On Visiting the Moving Metropolis: Reflections on the Architecture of Imperial Science"; Richard A. Jarrell, "Differential National Development and Science in the 19th Century: The Problems of Quebec and Ireland": all of them in Nathan Reingold and Marc Rothenberg (eds.), *Scientific Colonialism - A Cross Cultural Comparison*, Washington, The Smithsonian Institution, 1987; and Antonio Lafuente and José Sala, "Ciencia colonial y roles profesionales en la América española del siglo XVIII" *Quipu, Revista Latinoamericana de Historia de las Ciencias y la Tecnologia*, **vol.VI**, n°3, 1989.
[6] See Alberto Elena, "El Imperio Otomano y la expansión científica europea, 1699-1908", in Javier Ordoñez and Alberto Elena (eds.), *La ciencia y su público: Perspectivas históricas;* Madrid, Consejo Superior de Investigaciones Científicas, 1990; "La America de Pirî Reis y otras visiones otomanas", in Ubiratán D'Ambrosio (ed.), *Anais do Segundo Congresso Latinoamericano de História da Ciência e da Tecnologia*, São Paulo, Nova Stella, 1989. The standard reference works on the subject are Bernard Lewis, *The Emergence of Modern Turkey*, Oxford, Oxford University Press, 1961; Niyazi Berkes, *The Development of Secularism in Turkey*, Montreal, McGill University Press, 1964; Stanford J. Shaw and Ezel Kural-Shaw, *History of the Ottoman Empire and Modern Turkey*, Cambridge, Cambridge University Press, 1977; Abdulhak Adnan, *La science chez les Turcs ottomans*, Paris, Maisonneuve, 1939.
[7] Alberto Elena, "Westwards or Eastwards? Reconsidering the Decline of Islamic Science", in: *Proceedings of the Fourth International Symposium for the History of Arabic Science*, Aleppo, 21-25 April 1987, in press. See also the interesting contributions by Robert Brunschvig, "Problème de la décadence", in Robert Brunschvig and G.E. von Grunebaum (eds.), *Classicisme et déclin culturel dans l'histoire de l'Islam*, Paris, Editions Besson-Chantemerle, 1957; J.J. Saunders, "The Problem of Islamic Decadence", in *Cahiers d'Histoire Mondiale*, **vol.VII**, n°3 (1962).
[8] John Gallagher and Ronald E. Robinson, "The Imperialism of Free Trade", in *The Economic History Review*, **vol.VIII**, n°1 (1953).
[9] Sevket Pamuk, *The Ottoman Empire and European Capitalism, 1820-1913. Trade, Investment and Production*, Cambridge, Cambridge University Press, 1987, p.4-7 and 130-147.
[10] Francisco R. Sagasti and Mauricio Guerrero, *El desarrollo científico y tecnológico de América Latina*, Buenos Aires, Instituto para la Integración de América Latina - Banco Interamericano de Desarrollo, 1974, p.7-17.
[11] Halil Inalcik, "The Socio Political Effects of the Diffusion of Fire Arms in the Middle East", in V.J.Parry and M. E. Yapp (eds.), *War, Technology and Society in the Middle East*, Oxford, Oxford University Press, 1975, p.210.
[12] Stanford J. Shaw, *Between Old and New. The Ottoman Empire under Sultan Selim III, 1789-1807*, Cambridge (Mass.), Harvard University Press, 1971.

[13] Quoted in Bernard Lewis, *The Muslim Discovery of Europe*, London, Weidenfeld and Nicolson, 1982, p.234.
[14] See Alberto Elena, *La América de Pirî Reis y otras visiones otomanas;* Thomas D. Goodrich, *16th Century Ottoman Americana: A Study of "Tarih-i Hind i Garbi"*, Ph. Diss. Columbia University, 1968; Halil Inalcik, "Osmanli Imparatorlugunun Kurulus ve Inkisafi devrinde Türkiye'nin Iktisadi Vaziyeti üzerinde bir tektik münasebetile" *Belleten*, n°60 (1951); M. Longworth Dames, "The Portuguese and Turks in the Indian Ocean in the 16th Century", *Journal of the Royal Asiatic Society*, 1921.
[15] Halil Inalcik, "The Turkish Impact on the Development of Modern Europe", in Kemal Karpat (ed.), *The Ottoman State and its Place in World History;* Leiden, Brill, 1974, p.57.
[16] See the tables presented by Stanford J. Shaw and Ezel Kural-Shaw, *History of the Ottoman Empire and Modern Turkey*, **Vol.II**, p.122, and Sevket Pamuk, *The Ottoman Empire and European Capitalism, 1820-1913*, p.31-32.
[17] Niyazi Berkes, *The Development of Secularism in Turkey*, p.271.
[18] See Sevket Pamuk, *The Ottoman Empire and European Capitalism, 1820-1913*, and Huri Islamoglu-Inan (ed.) *The Ottoman Empire and the World-Economy*, Cambridge/Paris, Cambridge University Press - Editions de la Maison des Sciences de l'Homme, 1987.
[19] Sadun Aren, "Le problème de l'industrialisation dans l'Empire ottoman au XIXe siècle", in J. L. Bacqué-Grammont and P. Dumont (eds.), *Economies et sociétés dans l'Empire ottoman (Fin du XVIIIe siècle début du XXe siècle)*, Paris, Editions du C.N.R.S., 1983, p.451.
[20] Sevket Pamuk, *The Ottoman Empire and European Capitalism, 1820-1913*, p.17 and 131.
[21] See Stanford J. Shaw and Ezel Kural-Shaw, *History of the Ottoman Empire and Modern Turkey*, **vol.II**, p.120-121 and 226-229; Sevket Pamuk *The Ottoman Empire and European Capitalism, 1820-1913*, p.34-36 and 68-71; and Bernard Lewis, *The Emergence of Modern Turkey*, p.185-187.
[22] Nathan Reingold and Marc Rothenberg, *Introduction to Scientific Colonialism*, p.XII.
[23] Robert Mantran, "La transformation du commerce dans l'Empire ottoman au XVIIIe siècle", in T. Naff and E.R.J. Owen (eds.), *Studies in 18th Century Islamic History*, Carbondale-Edwardsville (Ill.), Southern Illinois University Press, 1977.

Policies for Scientific Expansion

PROBLEMS IN SCIENCE ADMINISTRATION: A STUDY OF THE SCIENTIFIC SURVEYS IN BRITISH INDIA 1757-1900

Deepak KUMAR

Next to the guns and ships, survey operations were the most potent tools in the hands of a colonizing power. Through them it could afford to know unknown people, chart untrodden paths, and estimate local resources. So surveyors marched along with the conquering armies. Topographical surveys had military origins and this relationship was maintained throughout (India gets its first civilian Surveyor-General only in 1991!). Similarly, meteorological observations and data were important for a sea-faring colonizer and an agro-based colony. Geological Surveys came late. They started as a part of topographical explorations but as the British rule stabilized, it acquired its own identity and played a major role in the economic exploitation of the country. How these organizations developed? What were their problems? The East India Company was not oblivious of their importance, but concrete steps were taken only in the later half of the 19th century. So the focus is mostly on this period.

The Beginnings

Rennell stands foremost among early surveyors. Whilst in the navy from 1756-63, he learnt marine surveying. In 1764 he took to land surveying under instruction from Vansittart, then Governor of Fort William. In 1778 he returned to England to organize and publish his labours[1]. His surveys were very important for revenue purposes and later figured in several law-suits[2]. In the South, Colonel Kelly surveyed the Carnatic region and his charts proved of immense value to General Eyre Coote in military operations[3]. The British could succeed against their numerically superior adversaries largely because they usually possessed a thorough and scientific knowledge of the country through which they marched. So survey and expansion were to move side by

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side, hand in hand. The Directors of the Company were quite enthusiastic about these early survey works. In a letter dated December 9, 1784, they reiterated their great interest in securing regularly all maps, charts etc., and gave directions for the use of oil paper for tracing maps. There are interesting details in this letter as to how a surveyor should conduct his work[4].

Towards the close of 1799, Major Lambton drew up a project for a geographical survey from the Coromandel to the Malabar coast based on geodesic principles. In 1800 the most accepted means of determining exact locations was called *"trigonometric surveying"*. It involved a careful measurement of a long base line, one end of which was a point of known location. Latitudes could be calculated from celestial observations, but precise longitudes could only be determined by the actual measurement of distances with a calibrated chain. Once the exact location of the second end of a base line was established, the location of a third point could be calculated by triangulation. In this way a series of triangles could be extended trigonometrically for any distance. Once the exact coordinates of major land marks were determined, more local positions could be calculated directly from them. Colonel Wellesley, fresh from his success against Tipu, quickly grasped the significance of Lambton's proposal, and for this probably also used his influence with his brother, Lord Wellesley, the then Governor-General[5]. And thus was born the Great Trigonometrical Survey of India (G.T.S.I.).

The ideas of a trigonometrical survey was not very old, being first conceived by General Watson at the suppression of the Scot uprising in 1745. The Carnatic and Mysore wars impressed upon its necessity here in India. But there were few sceptics. The Finance Member of Madras Council, for example, felt that such a survey was utterly unnecessary. On being told that many important places were wrongly laid down in all the existing maps, his answer was[6], *"if I wish to proceed to Seringapttam, I have only to tell the* palakeen *bearers, and they will find their way to it just as well if it were ever so accurately placed in the maps"* Fortunately this view went unheeded. Lambton was adequately patronized[7] and later got Warren, Everest and Voysey as his assistants. Warren was the first to strike gold in Mysore. And gradually several incidental notices of topography, climate and geology came out of these operations[8]. They provided the points on which to base topographical, cadastral or fiscal surveys[9].

No less important were the marine surveys, particularly for a maritime power. The Court always showed a keen interest in the improvement of the charts and navigation of the Indian seas. Rennell and Dalrymple gave real encouragement to this subject and in 1770 Ritchie was appointed the first Hydrographical Surveyor to the Company[10]. The Napoleonic wars re-emphasized the importance of hydrography and in 1809 a full-fledged Marine Survey Department was established in Bengal with Captain Wales as the first Surveyor-General[11]. Henceforth a number of hydrographers like Horsburgh, Dominicetti, Ross, and Haines minutely surveyed not only the coasts of peninsular India but also the different coasts and archipelagoes from Malaya to Madagascar.

These survey operations were not without administrative problems. Mr. Laidlow who was deputed for a mineralogical survey of Kumaon in June 1817, was denied allowances in 1818. He was a very able man and said to have been very badly treated[12]. In July 1821, Captain W.S. Webb, another surveyor in Kumaon, tendered resignation on account of his supercession by Herbert[13]. In early 1828, the whole Himalayan survey project was suddenly abandoned as an economy measure, and Herbert was left high and dry[14]. Such irritants were quite possible. Their was no scientific cadre. Few people, too much of work and added to it was an excessive centralisation of power.

Topography vs. Revenue

In 1818 the Great Trigonometrical Survey of India (G.T.S.I.) was formally created to supervise all types of survey operations whether topographical, trigonometrical, or revenue. Lambton, Everest and Waugh enjoyed this centralisation of power. In 1862, after Waugh's retirement, the Surveyor-Generalship was separated from the Superintendency of the Trigonometrical Survey (Colonel Thuillier was appointed to the former, and Colonel Walker to the latter). But the division of labour was not absolutely clear, and the two overlapped quite often. In 1864 Colonel Dickens submitted an elaborate report on the Survey Department. He envisaged the position of the Surveyor-General as that of *"a consulting officer to the Government of India"*, while the trigonometrical and topographical surveys were to be under separate superintendents attached to each local administration[15]. But this scheme of total decentralisation did not find favour.

Between 1861 and 1878, under Thuillier's command, revenue surveys were actively pursued and were given a more professional name - the Cadastral Survey. Henceforth this was to occupy the maximum time and money of the whole survey establishment. In 1891-92, for example, out of 21 survey parties, 12 were engaged on remunerative operations i.e. on work connected with the enhancement of land or forest revenue[16]. It thus had more than 50 per cent of the total workforce of the survey. And the expenditure was even greater. The average cost of revenue survey was more than double of that spent on topographical survey. The following table[17] illustrates the cost and average rate of Survey during 1870-71.

	Square miles covered	Total Cost in rupees	Average rate of survey per square mile
Topographical Survey	14,592	3,24,225	Rs. 22 (about 2.50)
Revenue Survey	16,938	7,64,745	Rs. 45 (about 5)

These survey operations came under severe financial strain during the 1870s. Several survey parties, both topographical and revenue, were broken up; while the Indian subordinates were discharged, several European assistants were asked either to retire on pensions or to go to other departments[18]. The budget was almost static during 1869-76, and savings remained a major concern. The following table[19] bears this out.

Financial Year	Sanctioned Budget Grant in Rs.	Actual Expenditure in Rs.	Savings	Deficit
1869-70	27,08,282	24,58,938	2,49,344	...
1870-71	23,67,273	20,87,103	2,80,170	...
1871-72	24,04,710	22,18,409	1,86,301	...
1872-73	24,56,190	24,10,796	45,394	...
1873-74	24,15,570	24,55,198	...	39,628
1874-75	24,15,930	24,35,124	...	19,194
1875-76	23,81,000	23,38,614	42,386	...

Apart from these administrative and fiscal prunings, need was felt to give the survey works a more compact and cohesive look. So in 1878 the three branches - the trigonometrical, the topographical and the revenue which had up to that time been virtually separate departments, each with its own cadre and establishment, were amalgamated. The post of Superintendent of the G.T.S.I. was abolished, and his duties were undertaken by the Suveyor-General in addition to his topographical work, while a Deputy Surveyor-General was placed in charge of revenue surveys. In 1882 the original programme of the G.T.S.I. was completed;

and as topographical work was regarded rather a luxury than a necessity, it was decided to transfer parties, as far as possible, to cadastral work, or other operations, of which the cost fell on local administrations. The result was that the energies of the surveyors were totally diverted to forest and cadastral work. In 1883-84 there were eight topographical parties, in 1890 only four survived. The Indian Survey Committee, constituted by Curzon in 1904 to enquire into the working of the Survey of India, expressed grave concern over this shift in priorities. The Committee noted[20],

"During the last 17 years topographical work has been almost at a standstill except in Burma, Baluchistan and Sind... We are ourselves very strongly of the opinion that all forest surveys should be brought to a close as soon as possible, in order to admit of the concentration of the full strength of the Survey Department on its topographical programme... The perusal of any of the Survey Reports will afford instances of the diversion of part of the strength of parties for the survey of cities, towns, or cantonments, places often of very little importance. It is most undesirable that work of this description should be allowed to interfere with the continuous execution of the topographical programme, and we think that it should for the present be entirely excluded from the work of the Department".

Geological Explorations

The geological explorations had far more direct economic bearing. The East India Company was aware of its importance but was not willing to sanction a separate full-fledged Geological Department and had lumped it with the topographical surveys. The Company's policy was to have the maximum at the minimum cost. The arrival of Thomas Oldham in March 1851 marked the establishment of the Geological Survey of India (G.S.I.) on a regular basis[21]. He started, so far as the material conditions and opportunities were concerned, literally from scratch - a room, a box and a messenger[22]. His job was a contractual one (for 5 years) and was always renewed until he himself sought retirement in 1876 on account of failing health. During the first phase of his contract, he chose seven geologists with great care (of whom three, H. B. Medlicott, W. T. Blanford and H. F. Blanford, later became Fellows of the Royal Society) and laid a solid foundation for the G.S.I. At this time the nomenclature of the officers was a simple one. Oldham was Geological Surveyor and the other were all Assistants. The Department was treated as a personal affair of its head[23]. The Government of India was satisfied with his labours, but not the Court of the E.I. Company, which passed adverse remarks while granting him in 1856 the second term[24]. Perhaps it wanted him to concentrate more upon the survey of mineral resources than on the study of geological structures. The former, however, defended Oldham and even authorized him, in anticipation of the concurrence o the Court, to recruit 3 or 4 more assistants. In 1850 a permanent office-building and a museum were also given, and publications like the *Memoirs* and the *Annual Reports* were started the same year. Senior assistants like J.G. Medlicott and the two Blanfords were placed in charge of parties, a development in organization that was to lead to the introduction of the term *"deputy superintendent"* in 1862. By 1860 twelve more assistants had been appointed and in 1862 it rose to sixteen[25]. But the staff could never stabilize. Many died due to climatic exposures and a few left because of stagnation in service. In 1862 J. G. Medlicott preferred to become an Inspector of Schools and was lost to science, while H. F. Blanford turned to meteorology. In almost every annual report Oldham alluded to his difficulty in obtaining properly qualified Assistants. To make the service more attractive, in May 1866 the Assistants were divided into three grades. The first grade was to receive up to Rs. 100 per month, second to Rs. 700 and the third to Rs. 500. The new entrant was to get minimum Rs. 300 per month and all were entitled to an annual increment of Rs. 50. Promotion was to depend on merit[26] and on the existence of a vacancy, but in the absence of a vacancy the candidates claim to annual increment was to continue. This was something unusual and different from the practice in other departments. Oldham even wanted to induce a few good students of Calcutta University to join the Survey as apprentices by offering them scholarship[27] but this was vetoed by the Finance Department. Finance officials offered a very funny solution - scholarships involved money, so why not give inducement by allowing special marks in the University examination in the papers concerned![28]. In 1871 Oldham pleaded for a substantial hike in salary (involving an extra-expenditure of Rs. 39,000), and also for a special relaxation of leave rules so that his Assistants could be sent out of India during summer recess on geological missions, of course again at the Government's expense[29]. Such an expedition to Australia, Mauritius, etc. would, Oldham thought, *"stave off many an attack of serious illness, and would also enable the Assistants to acquire information of great service to them in their work"*. On this proposal P. Whalley, an Under-Secretary to the GOI, commented,

" ... to permit him to scatter one-fourth of his Assistants every year to the four quarters of the globe, on a general mission, to pick up such incidental scraps of information as may fall in their path, seems altogether too vague and crude a plan to admit or sanction".

The Government refused to give G.S.I. these special favours[30].

Acceptance of Oldham's proposal would have made other surveys raise similar demands. A comparison of all officers drawing Rs. 400 and more in each survey shows that the GSI was already in a favourable position.

	Number of Officers	Average Salary per month	Average Years of service
Geological Survey	16	Rs. 770	11
Great Trigonometrical Survey	27	Rs. 717	16
Topographical Survey	17	Rs. 583	15

Still Oldham had done so much for the organization. By the time of his retirement in 1874, he had left behind an excellent collection of specimens and books, an impressive array of publications and a dedicated cadre. He was not averse to the natives and had pleaded for science education (especially geology) in the universities. When this did not materialize, he even attempted to remedy by introducing a system of apprenticeship[31]. His successor H. B. Medlicott, however, reversed the trend. He got disillusioned with persons like P. N. Bose and P. N. Datta who had been educated in England and who owed their appointment in the GSI directly to the Secretary of State. Professional jealousy and discrimination on grounds of race harmed not only the Indians but in some cases Europeans also. When Waagen was being tipped for the post of palaeontologist in the GSI after Stoliczka's death in 1874, A.O. Hume, Secretary to the G.O.I, remarked[32], *"though I have the greatest liking for Germans, I do not think that our whole Survey should consist of foreigners"*. Geology had caught the attention of Indian students in the 1890s. Still Holland, who superceded Bose's claims to directorship in 1903, wanted geologists to be trained in Britain itself on a regular basis for employment in the colonies. He would allow the work to suffer but would not settle for anything less[33].

Watching the Sky

Meteorology perhaps received most attention after the G.T.S.I. and the G.S.I. The Company was well aware of the importance of astronomy, geography and navigation in India, and so observatories were established in Madras, Bombay, Calcutta, Trivendrum, Simla, Ootacamund and Karachi in the years 1792, 1823, 1829, 1836, 1841, 1847 and 1852 respectively. But meteorological observations in these places suffered from several types of inaccuracies, divergence, faulty instruments, lack of trained personnel and absence of any standard method of work. The experiences of N. R. Podgson (Government Astronomer and Supintendant, Meteorology in Madras 1861-91) are quite illustrative. He felt that[34]

"Few men in India are placed in so difficult and trying a position as I have been... I left England in January 1861, aged thirty, with a strong sound constitution, delighted with my appointment, devoted to my science and with extensive plans of work, which I then hoped in vain and intended to carry into prompt execution. Upon arriving at Madras I found the observatory in a most miserable state, not an instrument fit for use, fifteen years arrear of hourly magnetical observations, about twelve years of meteorological ditto. The staff consisted of nine natives, only one of whom (a strict Brahman) possessed either knowledge or intellect... For eight years, from 1862-70, I struggled and agitated for an English assistant, and only gained my point last June... "

Earlier in April 1857 the Asiatic Society had appointed a Meteorological Committee. It failed, and in 1862 asked the Government to constitute a committee on the model of the Meteorological Committee of the Board of Trade in London. A storm-warning system was very vital for an empire whose life-line passed through sea. In October 1864 one of the most destructive cyclones on record struck Calcutta (more than 80,000 persons lost their lives). Weather-forecasting was now a matter of the most immediate concern. Next year the Sanitary Commission probed into how far climatic and weather conditions were linked with diseases in India[35] and called for a systematic record of the meteorological phenomena. On its recommendation meteorological reporters were appointed in the provinces. As many as 77 observatories were in operation by the year 1874. But this system of independent reporters proved unsatisfactory. It generated much confusion about methods of observations (there was no coordination and no supervision). So in early 1875 was set up a Meteorological Department on all-India basis with H. F. Blanford as the first Imperial Meteorological Reporter to the Government of India. The existing provincial and local reporters were retained, this was significant because they could draw upon the provincial funds. Blanford himself was placed under the Revenue and Agriculture Department of the G.O.I., but he enjoyed a fairly large amount of autonomy and funds. A central observatory was created for him in 1877 in Calcutta. The Government would accept his plans without any modification, even though it involved a big increase in expenditure. Henceforth he was able to introduce a uniform method of without any modification, even though it involved a big increase in expenditure. Henceforth he was able to introduce a uniform method of observation, train observers, and standardize instruments[36]. Blanford had succeeded in laying a solid foundation for the Department, his successor John Eliot (1889-1903) added to it the prestigious observatories of Madras and Bombay[37]. The latter was not content with works of routine nature like the local time services, tide tables and weather forecasts, etc. Norman Lockyer had for long been pressing for an observatory devoted to solar-physics. He was a British astronomer of great repute and had made a special study of the sun-spots. A tropical country like India offered plenty of "raw-materials" (sun-rays) for solar researches. Apart from scientific, he claimed that his studies had important economic bearings also. Citing data from India's meteorological reports, he showed that rainfall took place at the time either of maximum (solar) heat pulse or minimum heat pulse, thus famines took place only in the time of intervals between these two pulses. He petitioned the Indian Famine Commission of 1881 on this relationship between the sun-spots, and famines, and never lost an opportunity to impress upon the Government the need of an exclusive obsevatory in India to serve as his data-bank[38]. Eliot grabbed the opportunity. In August 1892 a solar-physics observatory was sanctioned under meteorological budget, and Kodaikanal was chosen as the site. Similarly Colaba Observatory was to be the base for magnetic survey.

But both these proposals ran into rough weather because of opposition from the Survey of India which wanted to keep them under its own supervision. In 1898 Norman Lockyer and W. H. M. Christie (the Astronomer Royal) visited India to observe the total solar eclipse, and the Government of India took the opportunity to ask them to make a report on the state of Indian observatories[39]. Christie and the Surveyor General (Strahan) were not very enthusiastic about an exclusive observatory on Solar-physics, preferring instead a general observatory at Kodaikanal devoted to astronomy, magnetic survey as well as solar observation. Lockyer and Eliot dissented. As for magnetic survey, Christie wanted it to be given to the Survey of India, while Lockyer suggested that it should be conducted by a specialist under the general control of the Meteorological Reporter. Eliot's contention was that

"the results of investigations of solar physics and of terrestrial magnetism belong more to the science and sphere of meteorology than to those of the Survey of India".

He almost begged[40],

"The inclusion of the scientific observatories under the control of the Meteorological Reporter will improve his status and increase his prestige. The Survey of India has the prestige natural to its connection with the army, numbers, to its important work, and need no extension of its field of work to increase its value and prestige".

The Government of India agreed to it. He was given a new designation - the Director General of Observatories, and was even acknowledged by the Governor-General-in-Council[41] as *"your principal scientific adviser"*.

To conclude, science administration in Victorian India mirrored colonial administrative policies in general; top-heavy structure, inner-contradictions (for example, imperial vs provincial claims), and professional jealousies were reflected everywhere. The Government of India had its own limitations. Financial demands as those of administrative expediency hindered the growth of a well-knit and integrated scientific department. A few branches which were of military and instant economic significance (e.g. the Survey of India and the G.S.I.), could manage to develop. But, on the whole, the efforts remained ad-hoc, sporadic, and provincialized. The local civilian administrators wanted the scientific staff to be provincial rather than imperial, they wanted practical results rather than research papers[42]. An excessive administrative control exercised at different levels (that too, by more than one centre of power) ensured that the colonial scientist would always dance to the official tune. But at the same time this bred dissatisfaction, often demoralisation, among them. Some found themselves saddled more with administrative responsibilities than research, while others resented their hopeless dependence on bureaucracy for every minor favour. They had little faith in civil administrator and very often felt insecure. The latter, on their part, could seldom understand the complexities of scientific investigations, and, in their zeal for immediate practical returns, bungled with whatever opportunity and funds they had.

National Institute of Science, Technology and Development Studies, New Delhi

Notes

1 His early works are, *A Description of the Roads: in Bengal and Bihar*, 1778; *The Atlas of Bengal and Bihar*, 1779; *Memoir of a Map of Hindustan*, 1788; *Memoir of a Map of Peninsula of India*, 1793. He was interested in politics also and in 1794 wrote a pamphlet entitled, *War With France: The Security of Britain.*

2 Since his surveys were made under the authority of the Government, and the maps were not made for any explicit purpose, a presumption of accuracy got attached to them

under section 83 of the Indian Evidence Act (of 1872). Ascoli, F. D., "The Legal Value of Rennell's Maps", in Hirst, F. C., *A Memoir upon the Map of Bengal,* Calcutta, 1914.
[3] Saletore, B. A. (ed.), *Fort William - India House Correspondence,* 1782-85, IX, Delhi, 1959, p.xxxviii.
[4] *Ibid,* p.xxxix.
[5] *Calcutta Review,* **iv, 7,** 1845, p.77.
[6] *Ibid,* p.80.
[7] In January 1810, Lord Minto transmitted to the Asiatic Society Lambton's "Account of the Measurement of an Arc on the Meridian", *Asiatic Researches,* **xii,** 1816, p.1.
[8] Lambton had high praise for Voysey and felt that their mutual investigations were beneficial for both trigonometrical and geological purposes. Home Public, No. 84, July 6, 1821 (All archival references are from the National Archives of India).
[9] Walker, J. T., *Account of the Operations of GTSI,* **i,** Dehra Dun, 1870, p.xxxv.
[10] Markham, C. R., *A Memoir on the Indian Surveys,* London, 1871, p.4.
[11] *Calcutta Review,* **67, 133,** 1878, p.576.
[12] Markham, C. R., *op. cit.,* (2nd ed.), 1878, p.207. J. A. Hodgson, the then Surveyor-General, was more appreciative of Herbert than Laidlow. This might have led to some bitterness. Home Public, No. 52, October 5, 1821.
[13] Home Public, No. 35, July 13, 1821.
[14] Home Public, No. 20, February 14, 1828.
[15] *Report of the Indian Survey Committee,* Calcutta, 1905, p.8.
[16] *General Report on the Operations of the Survey of India,1891-92,* p.i.

Number of parties for each specific work (total number is 21)	
Trigonometrical	1
Topographical	3
Forest	4
Cadastral	7
Traverse	1
Scientific (tidal, electro-telegraphic, astronomical, etc.	3
Geographical	2

[17] Taken from *General Report of the Topographical Survey of India, 1870-71,* p.7.
[18] Thuillier remonstrated, "the diminution of the trained machinery as recently insisted by the Government... appears to be as much a mistake financially, as it must be injurious to the crying wants and necessities of the Administrations, which must have the survey they ask for, sooner or later". *Ibid,* 1876-1877, p.7.
[19] *Ibid,* p.8.
[20] Report of the Indian Survey Committee, *op. cit.,* p.11-38.
[21] Earlier Dr. J. McClelland, as secretary of the Coal Committee of 1836, had corresponded with noted geologists in Britain (Lyell, Murchison and De la Beche) on he question of employing trained geologists in India. This led to the appointment of D. H. Williams as "Geological Surveyor in Bengal" in 1846. Upon William's untimely death in 1848, McClelland designated himself as "officiating superintendent, Geological Survey". But the GSI proper was yet to be born. Fox, C. S., The Geological Survey of India, *Nature,* **vol.160,** Dec. 1947, p.889-891.
[22] Markham, C. R., *A Memoir on the Indian Surveys,* London, 1871, p.154.
[23] Fermor, L. L., *First Twenty-Five Years of the G.S.I.,* Calcutta, 1976, p.42.
[24] This was unfair. As Oldham pointed out in his reply, "We are working under the same difficulty that would affect a tradesman without his tools or a physician without medicines and under these circumstances it is utterly impossible to attain the same

progress which should be looked for in Europe... Another great drawback to our steady progress arises from difficulty of securing properly qualified assistants... " T. Oldham to C. Beadon, May 31, 1856, *ibid.*, p.157.

[25] This was to be the maximum strength for the next 40 years.

[26] Oldham very clearly warned, "it must be distinctly understood that mere seniority of service, unaccompanied by proved ability, and steady devotion to duty, gives no claim to promotion into the higher grades of the staff of the Survey". Home Public, Nos. 82-84, January 1867.

[27] Home Public Surveys, No. 65, July 10, 1869.

[28] Home Public Surveys, No. 116-117, January 29, 1870.

[29] *Rev. Agri. Surveys*, Nos 1-10, January 1872.

[30] *Ibid.*

[31] Ram Singh was the first Indian to join the GSI as apprentice in March 1873, and was made to attend the elementary science classes at the Shibpur engineering school. Two more apprentices, Kishan Singh and Hira Lal who joined in Jan. 1874, were asked to attend Physical Science lectures at the Presidency College, Calcutta, *Rev. Agri. Surveys*, n°38, June 1874, Pt. B; *Records of GSI*, **Vol.vii,** 1874, p.8.

[32] *Rev. Agri. Surveys*, n°6-11, April 1875.

[33] "We shall have 2 or 3 more vacancies this year. Although I am hard up for men, I would rather do without them in order to show the Government the failings of the present system". From T. Holland (Director G.S.I.), to J. J. H. Teal (Director Geological Survey of Great Britain), dated July 23, 1903, *Mss. GSM.2/284*, Institute of Geological Sciences Library, London.

[34] N. R. Podgson to C. R. Markham, dt. February 22, 1871 (marked private), *Podgson Papers*, IOL, Mss Eur. B 251.

[35] The data of one Dr. Murray Thomson (who in 1868 produced a "Report on Meteorological Observations in NWP") showed an access of cholera on a sudden fall of temperature *The Athenaeum*, n°2143, November 21, 1868, p.683.

[36] An account of the early years is given in *100 Years of Weather Service, 1876-1975*, (The Centenary volume of India Meteorological Department), Poona, 1976, p.8-28.

[37] The Colaba Observatory in Bombay was known for its magnetic survey works while the one in Madras was getting famous for its attention to solar observations.

[38] For details see, Lockyer, W. L., *Life and Work of Sir Norman Lockyer*, London, 1928, and Meadows, A. J., *Science and Controversy: A Biography of Sir Lockyer*, London, 1972.

[39] *Rev. Agri. Meteorology*, n°1-12, March 1899.

[40] J. Eliot to the Secretary to G.O.I., dated November 29, 1898, *ibid.*

[41] Curzon to Hamilton, dated February 2, 1899, *ibid.*

[42] This was true for other British colonies as well. Worboys, M., "Science and Colonial Empire 1895-1940", in Kumar, Deepak (ed.), *Science and Empire*, Delhi, 1991, p.13-30.

NATURAL HISTORY IN COLONIAL CONTEXT: PROFIT OR PURSUIT? BRITISH BOTANICAL ENTERPRISE IN INDIA 1778-1820

Satpal SANGWAN

The overseas expansion of Europe and the exploration of the natural history of their colonial possessions have progressed on a relationship of cause-and-effect. While technological superiority of the Portuguese "caravels" ensured their success against the Eastern "junks"[1], more important was the strong will of the Europeans to control the spice trade hitherto carried by the Arabs that necessitated such a "trial of strength"[2]. The Portuguese were soon joined by the Spaniards, the Dutch, the French and the English in the scramble for colonial possessions. Back in the colonies, apart from the Spanish import of bullion from their South American dominions, the wealth of the colonies lay in their tropical vegetable products - spices, sugar, tobacco, dyes and medicinal drugs, tea, coffee and oils. *"A merchant who trades in spice"*, it was said[3], *"could ship six cargoes, lose five and still make a profit when the sixth was sold"*. The Eastern spices carried so much influence in the economy of the "mercantilist" Europe that in England rents and taxes were often exacted in "peppercorns", the dried berries of the true pepper plant[4]. In return, the Asian countries were enriched by the gold and silver coming from México and Peru via the European trading companies[5]. But how long the Europeans could sustain the drain of bullion? Although by the end of the 17th century the trading companies of Holland, France and Britain had established their own colonial outposts - the Dutch in Java, Ceylon and South Africa; the French in Canada, Mauritius and Reunion and the English in the East and West Indies - the outflow of bullion continued till the English came out with their factory goods at the turn of the 18th century[6].

Apart from the European merchant, colonial natural history also appealed to the European naturalist who had learnt[7] that *"physical universe was to be understood and subdued not through unbridled speculation or mystical contemplation but through a direct, active confrontation of natural phenomena"*. Garcia da Orta[8], the Portuguese naturalist, left for Goa on 12 March 1534 with *"a great desire to know about the medicinal drugs,... as well as all the fruits and pepper... their names in all the different languages, as also the countries where they grow, and the*

P. Petitjean et al. (eds.), Science and Empires, 281–298.

trees or plants which bear them and likewise how the Indian physicians use them". A similar *"desire to see the diversity of plants God has created for the human wealth"*, had brought Cristovão da Costa, another Portuguese in Goa in 1568[9]. This was equally true of the English with whom collecting became fashionable towards the end of the 17th century. So much so that seamen and travellers began to be haunted by the "gentlemen" collectors around the docks who would supply them[10] *"sheets of instruction on how to go about their searches and, even more important, on how to bring back in the best condition possible whatever they might succeed in finding"*.

The growing interest in the colonial flora, in effect resulted as much from the possibilities of trade in "exotic items" as from the changes in the agenda of science of the Baconian era. The great triumph of 17th century science was the rejection of knowledge based on theological or metaphysical explanation. The new science was very near to utilitarian use. Bacon wished scientific activity to work in the direction of recovering dominion over nature and gaining knowledge of natural laws. Though the medical system of the ancient Greeks, Hindus and Muslims depended largely on natural herbs, the growing interest in economic botany and the proposition of a universal system of classification, the *"binomial taxonomic nomenclature"* of Carl Linnaeus, are two important developments ushered in during the post-Baconian years. Another no less significant development was the founding of botanical gardens. Initially botanic gardens rose as a medicinal nucleus, attached to a medical faculty of a university[11]. But with the increasing passion for economic botany their role also changed and towards the end of the 18th century there were quite a few botanical gardens in the metropolis as well as in the colonial peripheries for collecting and rearing plants from different climatic zones[12]. The quest for natural history was thus an outgrowth of the unceremonious marriage between mercantilism and the "gentlemen" amateurs during the age of exploration and scientific revolution. The European trading companies and the "gentlemen" joined hands, albeit for different motives - the former for the economic gains coming out of natural history and the latter, perhaps, for the sake of science itself. The compromise and cooperation reached between the English East India Company (EIC) and the naturalists with respect to the Indian flora, is the subject of this paper. In the process the paper will touch upon some of the features of the first stage of George Basalla's model of what is now conveniently called "colonial science", viz., professional relations at the metropolitan and peripherial levels and the dependency of colonial naturalists on their metropolitan mentors for shaping their results for a wider audience, level of professionalism among the colonial scientific cadre and symptoms of "international idealism".

Beginning of the Plantation Philosophy

The year 1778 represents a water-shed in the history of botany in England and India as well. In 1778, Sir Joseph Banks (1743-1820), a great lover of plants, became President of the Royal Society (of Great Britain) thereby raising "natural history" to the level of first priority in its programme despite strong protest from members interested in "natural philosophy"[13]. In 1778, not necessarily inspired by the development in London, the EIC appointed Dr. Gerhard Koenig (1728-1785), a Dane botanist with the Danish Mission at Tranquebar, as "Professor of Botany and Natural History" at its Madras establishment, with a monthly salary of 40 Pagodas[14]. While Banks's interest in natural history goes back to his early years at Eton and before occupying this coveted post he was associated with a few exploratory voyages across the Pacific, for a trading Company managed[15] *"by groups of individuals who cared not a whit what the balance sheet looked like so long as their private ends were served"*, the spurt for natural history was simply a marriage of convenience. Earlier, only a few of its servants with a medical background would indulge in natural history as a part time hobby[16]. But with changes in the Company's fortunes in India following the territorial acquisition of Bengal in 1757, the EIC had to re-frame its policy with regard to the natural history of India. In 1776, one Mr. M. Francis rose to occasion and in his Minute on the prospects of trade with India he recommended plantations by the "European" in India which, he argued, would not only improve the material conditions of the local people but would also justify and increase the volume of drain from India[17]. Dyes and drugs were his first priority. Francis's *fatwa* was pursued by Dr. James Anderson, a surgeon with the Madras army, who, in 1778, obtained a large piece of wasteland near Fort St. George. Here he experimented with the cultivation of sugar-cane, coffee, American cotton and European apples[18]. From the EIC however, there was no immediate follow-up till January 1788, when Henry Dundas, President of the newly founded Board of Control, had the Treasury draw up a list of dyeing and medicinal drugs suitable for expanded production in India[19]. Similarly, when indigo supplies from the Carolinas were cut off during the American War of Independence, the Bengal government had encouraged some resident Europeans to fill the gap. Charles Grant, a future Chairman of the EIC, started his plantation while a resident at Malda[20]. At the same time in the Northern Circars, Dr. William Roxburgh (1751-1815) was struggling to secure the *zamindari* rights of the Corconda district to start plantation of coffee, indigo and pepper[21]. Such a plantation philosophy arose from the national need to exploit the "wealth of India" that would compensate the loss of New World colonies. That metropolitan science gained was only a by-product.

Colonial Flora for Continental Audience

Dr. Koenig, the first "professional" botanist in India, had assembled, while at Tranquebar, considerable number of specimens of the plants of the Coromandel coast. His first major assignment under the EIC banner was a voyage to the Straits of Malacca and Siam which he undertook in 1780, to study plants yielding gamboge, cardomoms and other commercial products. These discoveries, according to Banks[22], *"would have been essentially advantageous not only to science, but to the investment of the Company"*. Upon his arrival from Siam and Malacca, Koenig was called to Bengal. The EIC, as it claimed, wanted to derive *"real utility from his talents"* by directing him "properly". He was therefore, asked to explore *"Boutan (Bhutan) and other interior parts"*. As for Koenig[23], though he sincerely wished to *"repay his employers a thousand fold by the discoveries of drugs and dyeing materials fit for the European market"*, his first priority was to collect all his papers together, to arrange them into order and to complete fascicules before taking *"so long and dangerous an expedition"*. Koenig was, however, deterred by ill health to complete the fascicule and died on 26 June 1785. But before his death he had sealed up his will, by which he had bequeathed to Banks[24] *"all his MS papers and specimens"*. Besides, he had also desired the Tranquebar Mission to send his MS letters to Banks:[25] *"rarely again will the Company meet"*, Banks exclaimed, *"with a servant so well qualified to do them essential service in the department with which he was entrusted"*.

Dr. Patrick Russell (1727-1805) succeeded Koenig as "Professor of Botany and Natural History". He had been engaged in the prosecution of researches into natural history on the Coromandel "at his own expense", ever since his arrival to India in June 1782. Though more a zoologist, Russell considered his new placement as empowering him to extend[26] his *"pursuits on a more extensive plan"*, by adding *"motive of duty to what was before only a voluntary amusement"*. His immediate concern was to get Koenig's papers and manuscripts published. In fact, it was Russell who had impressed upon Koenig, when the latter had visited him at Vizagapatam in 1784, to place his papers into order before undertaking new pursuits, and also to send[27] a *"specimen of his labours to England to be presented to the Company"*. Russell had also urged Koenig, some time before the latter died[28], *"to give a fascicule containing the descriptions, illustrated with drawings of a score of the most useful plants,... to show how his researches might be more immediately productive of advantages to the European residents in those countries"*. But the Dane, as we have noted, could not complete the job. Thereupon Russell requested Banks to publish Koenig's collections which, he believed[29], *"would be an honourable monument to the memory of the good old man, and prove the means of spreading a species of useful knowledge in this country"*.

Apparently Russell's idea was to publish a fascicule of *"such plants as were of importance, either on account of their medicinal virtues or of properties applicable to economic purposes"*. Besides, he suggested adding an accurate botanical description in Latin and English accompanied with an elegant engraving of each plant, along with observations on its virtues and uses[30]. Russell argued that *"a more general acquaintance with the medicinal simples of this country may prove of essential utility. Many of the Indian plants are very imperfectly described by the elder botanists, and the modern descriptions of others are scattered in a variety books intermingled with subjects foreign to India. The large collections contained in the* ***Hortus Malabaricus*** *and the* ***Herbarium Amboinense*** *of Rumphius are also so voluminous and expensive as to exclude them from the libraries of most of the young medical gentlemen coming from Europe"*. *"These circumstances"*, he stressed[31], *"prove often insurmountable impediments to the attainment of an early knowledge of the indigenous plants and their uses"*. With these views Russell submitted his plan to the consideration of the Madras Medical Board, soliciting their assistance. He also offered his services to send the specimens of such plants to Banks which were not included in Koenig's collections. The collections being limited to plants of established utility *"will not"*, Russell believed, *"swell to a great bulk, perhaps four Fascicules will complete it, or at least will form a respectable Herbarium"*. As for the expense, Russell confessed that a collection principally of Indian plants could not be interesting to the botanists in Europe. It was quite unlikely that any *"private adventurer"* would have been willing to publish it. He therefore, suggested[32] that *"the Honorable*

Company should bear the expense of publication". The EIC however, would not make a commitment unless they know the cost of the project. *"When you recommend such propositions to our protection"*, the Court of Directors had suggested to the Madras Medical Board[33], *"you should at the same time give us some idea of the probable expense, in order to enable us to form an immediate decision"*. Russell suggested that Banks would be the best person to meet the EIC enquiries. On 12 November 1788 the EIC forwarded Russell's proposals to Banks for comment. Sir Joseph Banks, after going through the details of the project, recommended[34] that *"Dr. Russell's project of publishing here, at the expense of the Company, engravings and descriptions of such plants natives of India as are found useful there either in medicine or manufacture be adopted"*. *"That each number instead of fifty, which the Dr. proposes, shall consist of twenty plants"*. *"That 500 copies may be provided elegantly for about £ 23 and decently for about £ 18 a plant, a considerable part of which would be received back by the sale which should not be at less than £ 1.5 each of elegant and £ 1.1 of decent"*. *"That no plant be admitted on account of its supposed medicinal virtues, unless one or both of the Medical Boards now established in India recommend it as actually possessing the qualities ascribed to it, or that it be recommended as a drug in some European materia medica, and the plant producing it be not perfectly described by Botanical Writers"*. *"That no plant be admitted on account of its commercial utility, unless its advantageous properties are well known and generally acknowledged"*.

The EIC was satisfied with Banks's opinion. But by the time their approval could reach Madras, Russell had resigned from the EIC service. Before leaving India he however, saw to it that Dr. William Roxburgh took his place, who, in his opinion[35], was the *"only person on this coast in any degree qualified"*.

Publishing the Fascicules: A Cautious Approach

The responsibility of publishing fascicules of Indian plants devolved on Roxburgh after Russell left India in 1789. Roxburgh began sending his drawings and notes to the EIC headquarters in London in September 1790 who would then pass them on to Banks. Having studied some 500 drawings by July 1794, Banks applauded *"the skill with which the drawings are made, the accuracy with which the parts illustrative of the sexual system are delineated, the intelligence with which interesting views of these parts are selected, and the patience and detail with which the descriptions are drawn up"*. Banks hoped that once published, the fascicule would *"give more satisfaction to the Botanists of Europe than either the **Hortus Malabaricus** or the **Herbarium Amboinense"***. To be on safe side, he suggested that the whole project should be published in instalments[36], *"two of the fascicules in a year, each containing 25 plants". "Instead of waiting till the whole is completed"*, he argued, *"the Company will speedily enjoy the credit due to them as liberal patrons of science. The experiment of the final success of the work will be soon tried and tried at a moderate expense"*. Besides[37], *"if the whole is published together, the loss, in the event of its failure, would be considerable"*. Banks also submitted an estimate of expense for publishing the first fascicule, which he assured, would not be more than £ 351.2.0. If that be acceptable to the EIC, he agreed *"to undertake the General overlooking of the work, to set the engravers their tasks, and to see that they are executed with accuracy"*. As for the publisher, he recommended George Nicol, the King's bookseller, who had earlier published James Cook's *Voyage to the Pacific Ocean.* And to clear the EIC doubts about its benefits, Banks contended that not only the naturalists in India would come to know about the vegetable production, the Company would derive immense benefit[38] from the extension of its commerce and *"improvement of our materia medica"*. In April 1794 the EIC paid £ 300 in advance to George Nicol who did not take more than a year to publish the first fascicule of twenty-five plants[39].

Banks, however, had misjudged its sale prospects. It was on his assurance of the reimbursement of the money through sale that the EIC had pumped some £ 2000 up to 1799. But the luke-warm response it received raised pretentions. Banks informed[40] the worried Roxburgh in 1798 that *"the publication at present goes on but slowly.... just now no books can sell on account of the pressure of taxes and voluntary contributions. I cannot hurry on the bookseller, though I have tried"*. As for the bookseller[41], though *"he had sent the numbers to the most extensive channel of sale"*, the results were altogether disappointing. The Madras agent reported[42] that *"the whole of Dr. Roxburgh's publications on the subject of native plants are still undisposed of, nor is any prospect of their meeting a sale"*. In the Bombay presidency, it is reported, the consignment remained unsold despite its being advertized[43] twice in the *Courier.* The reason was not that the fascicule was unwanted. Rather its publication was mistimed. Expensive books on natural history did not find much favour with the early 19th century[44] *"Englishmen exhausted through taxes laid on them to pay armed men to diffuse rapine, fire and* *murder over civilized Europe"*. It was true of Germany also, *"the great mart for books of Natural History"*, where, as per Nicol's report[45], *"no copies (of Roxburgh **Plants**) had been sold"*. The project, however, lingered on, thanks to the Committee of Warehouses, who wanted it to be completed for the sake[46] of *"its tendency to promote the study of Natural History, and its affording an inducement to the Company's servants to devote a portion of their time and attention to scientific researches"*. Nicol was hopeful that once the whole work was completed[47], it *"would eventually do much more than repay the Directors their original advance for this splendid work"*. The EIC finally relented and the third and final volume of the *Plants of the Coast of Coromandel,* was published in 1820, five years after its author had died.

EIC and the Professional Naturalists: An Uneasy Alliance

When the EIC first appointed a professional naturalist in its Indian establishment (at Madras) in 1778, it had hardly thought in terms of earning an image of a "liberal patron of science". A closer scrutiny of the correspondence of colonial naturalists reveals that the EIC was inspired more by the pecuniary gains attached with natural history than by the scientific ethos of the Banksian era of "discovery and explanation". And it was not unusual either on the part of profit making share-holders to think in such terms[48]. When the EIC finally agreed to publish fascicules of Indian plants, its main worry was whether the money invested would be reimbursed through sale. Discouraging reports had alarmed the Company and the publication was delayed because *"some gentlemen of the Committee who managed that business, frequently threw cold water upon it"*. Nicol was particularly unhappy with one of its Directors, T. T. Metcalf[49], who *"often set his face against it"*. Some other colonial naturalists had also complained of the bussiness-like attitude of the EIC. Francis Buchanan (1762-1829), Superintendent of Calcutta Botanic Garden (CBG) during 1814-15, who had collected plants in Ava, Chittagong, Nepal and the Mysore regions, was not at all happy with the treatment of his collections at the hands of the EIC. *"The Court of Directors has indeed received my collection"*, the Scot once wrote to his successor Dr. N. Wallich[50], *"with such contempt and arrogance that I would neither ask nor receive any favour from so scoundrelly a body. My collection would have been received with the utmost thankfulness by the most learned bodies here (Scotland) and might have gratified several of the most distinguished"*. *"Do not therefore"*, he sought to warn Wallich, *"throw any of your pearls before swine* *but collect largely and keep your collection for the learned of your own country, who I have no doubt will be thankful*".

Buchanan's outburst against the EIC was, however, not unwarranted in the face of the difficulties with which the specimens were assembled, drawings were made and collections were first maintained in India and then transferred to England. Sometimes local informants would not comply with their demands and sometimes the collectors themselves would be suspected. Sharing his Malabar experiences with Roxburgh, Buchanan wrote:[51] "*I found no native who could or rather who would inform me of the names of plants. The obstinacy of the people of Malabar is astonishing and every man you meet suspects you have an evil design in every question you ask*". On another occasion Buchanan expressed his inability to send specimens to Roxburgh because[52] he "*had no authority to call upon any of the natives for information and assistance and without that it is impossible to procure the most trifling thing*". Even if easily procured, it was indeed an uphill task to get the required job completed from the local plant collectors, who would "*by no means take the trouble of recollecting where they get anything and when they are sent to bring the seed of any particular plant to which they got the flower before, they generally wander about a day or two and declare they can not find it*". The colonial naturalists[53] had "*therefore to trust to chance and to take whatever by chance they stumble on*".

Taking clue from this approach of "collection by proxy" some earlier works on the scientific pursuits of the naturalists in EIC service have sought to minimize their contribution[54] for the "*lack of strict professionalism*". It is argued that individual EIC servants in the 18th century were amateur natural historians, who, on their arrival in India, "*found a vast new field in which to pursue their avocation*". Hence their activity was "haphazard"[55]. There can be no denying the fact that "professionalism" in science from the modern standpoint, a research activity carried in universities and research institutes by the "jobers", was not the speciality of the Banksian era[56]. The pursuit of natural science, which even in the metropolis had long been associated with the amateur activities of leasured classes[57], was carried to the colonies by the "transplanted Britons", the "amateur gentlemen" for whom Kargon has coined the term "devotees"[58]. But surely the class of Koenig, Roxburgh, Buchanan and Wallich, the galaxy of naturalists in the service of EIC, can not be placed alongside the amateur Britons - "*explorer, traveller, missionary, diplomat, physician, merchant, military or naval man, artist or adventurer*" - whom Basalla has identified as "carriers" of western science to India[59]. The science done by this team in India was in no way a science of "lesser minds", a connotation used by Roy MacLeod for the scientific activity during the first phase of Basalla's model[60]. Although a full treatment of the subject (the centre-periphery relations in the Indian context) is still awaited, it does not appear, if one bothers to look into the private papers of the metropolitan mentors (Banks, John Lindley, Robert Brown and W. J. Hooker), that they ever under-valued the scientific potentials of their peripherial colleagues (Koenig, Roxburgh, Buchanan, Wallich) in India.

Their scientific genius notwithstanding, the colonial naturalists were indeed not comfortable in places where they had no society, no books and an earliest delivery of a letter taking not less than two years[61]. Collection of specimens by proxy and lack of communication with the professionals sometimes resulted in half-baked information. Recollecting his experiences with local informants, Buchanan confessed in 1828[62] that *"the names of plants collected in Mysore and Nepal were taken entirely by the ear, an intelligent Brahman pronouncing the words. All of the names are however liable to numerous mistakes, among the chief of which is that a native seldom hesitates in giving some name or other to every plant which you meet, although it is probable that with a great many he is quite unacquainted"*. More than the local plant collectors, the EIC and the European naturalists were themselves to be blamed for such lack of authenticity. While the EIC did not have[63] a *"coherent theory of state scientific activity"*, the naturalists too overlapped their scientific pursuits. Patrick Russell, even after being appointed to look after the botanical ventures of the Company, persisted with his work on Indian fishes and snakes. Roxburgh and Buchanan-Hamilton, the two thoroughly "trained" botanists with the EIC, found no difficulty in writing on zoological matters. Benjamin Heyne, to whom Roxburgh had entrusted his plantations at Samalcot before the latter left for Bengal, was more interested in mineralogy. His *Tracts* contain original information concerning rock formation, minerals and the soils of the peninsula[64]. In fact this over-lapping by colonial naturalists has been accounted for the trifling contribution their activities made towards the theoretical understanding of the subject[65].

The Metropolitan Mood

The fact that the metropolitan doyens of natural history were keeping trace of the developments in the colonial outposts is testified by their concern with regard to related matters. We have seen Banks's contribution towards publishing Roxburgh's *Plants.* His interest in the establishment and working of the Calcutta Botanical Garden (CBG) is equally important. Interestingly, the idea of establishing a botanical garden in the Bengal presidency did not come from any professional botanist. Rather, it was the brain-child of a man of rank in the Bengal Infantry, Colonel Robert Kyd (1746-1793). In June 1786, Kyd had approached the Bengal government to open a botanical garden[66] *"not for the purpose of collecting rare plants or furnishing articles for the gratification of luxury, but for establishing a stock for disseminating such articles as may prove beneficial to the local inhabitants as well as natives of Great Britain".* In May 1787, Kyd became Superintendent of CBG, the first botanical garden in the EIC possessions in India. Kyd being more a "gardner" than botanist, his priority was to establish a stock of plants assembled from other regions of India and abroad. Specimens of plants of food and commercial value came from outside. He however, did not do much towards describing his collections[67]. And since other colonial outposts were not aware of the collections at Calcutta, Kyd could not justify his labours in terms of colonial requirements. The EIC requested Banks to report on the viability of their collections at the Calcutta garden. Banks agreed provided its Superintendent sends him *"periodical reports of the plants cultivated"* there along with their specimens[68]. Banks, it appears, did not approve placing so important an establishment like the botanic garden under a person[69] *"whose views have never been directed to that study (botanical knowledge)".* It was therefore, a great relief to Banks when Roxburgh joined the Bengal establishment as Superintendent of CBG in 1793. And Roxburgh's botanical labours as Superintendent show that he did not belie the expectations of his metropolitan mentor. *"By sending home regular supplies of seeds and of living plants to the Royal Botanic Garden at Kew",* Banks complimented Roxburgh's contribution[70] as Superintendent of CBG, *"by receiving from thence and from other places such useful and curious plants as were suited to the climate of Calcutta, by corresponding with a variety of botanists and exchanging plants with them and by sending home a very large collection of drawings made by native artists with descriptions annexed, Dr. Roxburgh has deserved well of his employers".*

Though Banks had all the veneration for Roxburgh[71], *"whose long and faithful services to the Company",* he declared, *"merit no small portion of gratitude",* this certificate, however, did not mean that Sir Joseph Banks would allow Roxburgh to err in his professional duties. He was certainly not happy with the quality of drawings sent by

Roxburgh in his first consignment. Roxburgh[72] wrote back, *"it would have given me much satisfaction if you had mentioned what the defects were that my drawings and descriptions had. I would then, probably, have been able to rectify them in those that are still to finish"*. Similarly when Roxburgh was in England for two years during 1805-1806, leaving the CBG in the hands of his son William Roxburgh, Banks was quite straightforward in his remarks: *"Mr. Roxburgh (Jr.) though a well educated, a well disposed and an amiable young man, is wholly defective in these qualifications which enable a man to become respectable as a naturalist, ... it is a fitting that the Court of Directors should search for a person capable of doing credit to the appointment"*. Such a fitting person in Banks's opinion was Dr. Buchanan who, he noted, *"has the best founded hopes of success, his works as a naturalist, a geographer and a statistical writer bear ample and uncontroversial testimony"*. *"His appointment to succeed Dr. Roxburgh"*, he assured[73], *"will give satisfaction to every naturalist in Europe"*. As for the post of assistant to the Superintendent, a post held by William Roxburgh under his father, Banks[74] opined that *"it will be necessary, in future, that unless a well qualified candidate can be found in India, the place of assistant be filled by a young man regularly educated in Europe to the science of natural history"*.

So far as the selection of plant collectors was concerned, Joseph Banks, and perhaps the EIC too, had no reservations in seeking the support of the continental scientists, cutting across the national whims of war-ridden Englishmen. It is no less significant that the first professional botanist appointed by the EIC in India (Dr. Koenig), was a Dane who had learnt botany at the feet of Carl Linnaeus. After Koenig's death the EIC had turned to Banks to suggest on the best way for continuing the work[75]. To face this difficulty to find a person so well qualified in England, Banks suggested to procure someone from northern Europe[76] *"where young men who show a natural disposition for such studies, are educated principally with a view to Natural History"*. In March 1787, Banks informed the EIC that he had found a suitable man for the mission - Olf Swartz, a Swede pupil of Linnaeus, with considerable knowledge of tropical botany[77]. In 1793, when Roxburgh opted for the Bengal establishment, the EIC invited Dr. Benjamin Heyne, another Dane naturalist at the Tranquebar Mission, to take charge of their botanical enterprise in the Circars. The EIC rose to occasion again in 1815 when, realizing the botanical potential of Dr. Wallich, one of the war-prisoners from the Danish settlement at Serampore, made him Superintendent of CBG after the dimise of Roxburgh.

The metropolitans, however, did not follow this "international idealism" with regard to the sharing of botanical loot from India. The case of the distribution of Wallich's Indian collections sufficiently substantiates the point. Although Wallich was cautioned by Buchanan not to put his collection in the hands of English botanists who would least care to publish them[78], Wallich, it seems, did not take the Scot seriously. But very soon he realized that the English botanists were *"either incapable, or too busy (as Lindley or Hooker), or would accept and do nothing (like Brown)"*. And he did not wish his collections to be made useless[79] *"as it would if entrusted to Brown, or buried in some Museum where it could no longer be consulted"*. Therefore, in 1830 Wallich decided to distribute some *"thirty barrels of dried plants containing everything he (Wallich) has collected in India and the Kingdom of Ava"*, among his fellow friends in Europe and America[80]. This earned him the ire of some English naturalists who would not allow the richess from India to slip from their hands. So much that when Wallich desired to extend his stay in London to *"sort out, classify and supervise his collections"*, the Board of Control, perhaps under duress from the Admiralty and a few of the doyens of English botany, did not agree. Robert Brown went to the extent of declaring[81] that *"he had at last succeeded in putting an end to the scandal of Wallich's distributions"*. The Board of Control, however, relented under the mounting international pressure and Wallich stayed in England until 1833[82].

Conclusion

The foregoing discussion brings to surface a few facets of "scientific" pursuits in a colonial outpost. The fact that Indian example does not fit in Basalla's model is primarily because India was governed by a trading Company whose first and foremost priority was "profit". It was for the sake of this profit-making instinct that the EIC was lured to the Indian flora. It would not mind if some of its medical men or army personnels, in addition to their "official business", infatuated with the local flora. The EIC went to the extent of sponsoring "scientific expeditions" because they would open new channels for investment. The founding of the botanic gardens was again an arrangement to meet the practical requirements: assembling exotic seeds and specimens, experimenting them in the new environs and despatching the seedlings to those parts of their possessions where they could be grown commendably. The propagation of cash-crops like tea, coffee, indigo, hemp, flax, cotton, sugar-cane, etc., and timber plantation, are some of the commercial ventures accomplished through the agency of the botanic gardens. The EIC directors were "so sensible" of the vast importance of Robert Kyd's plan for assembling newer plants in the CBG that they gave him free hand[83] *"in point of expense, in the pursuit of it"*. But was the EIC really so liberal with regard to the scientific pursuits of its naturalists? Perhaps not. It was largely because of its apathy that the publication of the three volumes of Roxburgh's *Plants* took nearly 30 years. The EIC, as Buchanan's correspondence with Wallich testifies, did not know what to do with the thousands of dried specimens collected over the years by its naturalists. When Wallich, disgusted with the treatment of his Indian collections in England, finally decided to distribute them among the continental men of science, the EIC felt much relieved. Then again in 1832 the EIC cleared its docks by donating *"the fruits of the researches of the last half century, comprising about 1300 genera and about 8500 species"* to the Linnaean Society of London[84].

This ad-hoc arrangement on the part of the EIC threatened the seriousness of the business. The EIC civil and military personnels, who had hardly any training in the subject, pretended to be well-informed naturalists. This was the same "leisured" class of "amateur gentlemen" who are quite often mistaken as champion of colonial science. But how could the scientific labours of Linnaeus's disciples like Koenig and Wallich, or those of Roxburgh and Buchanan who had learnt botany under John Hope, could be discarded so cheaply. Whatever priorities their employer might have decided, these "professionals" would never fail to fulfill their commitment to the cause of natural history. The grumblings of Buchanan and Wallich prove their sincerity.

However on the theoretical front the contribution of the colonial naturalists was very negligible. In fact, their primary job was to collect, not to theorise. The theoretical part was accomplished by the metropolitan mentors. This was mainly because of their placement at places devoid of latest scientific information on the subject. The EIC had no concern for importing books unless otherwise pressed by some influential authority[85]. This was also because of the paucity of time and funds. The EIC would prefer its naturalists making exploratory voyages to the unexplored regions rather than theorising the collections sitting in their tents. *"The greatest, if not the only obstacle to the progress of knowledge in these provinces"*, Roxburgh once explained[86], *"is our want of leisure for general researches"*. This arrangement was not an EIC choice only: it suited the metropolitan naturalists who would steal the show at the cost of collections coming from the colonies.

National Institute of Science, Technology and Development Studies, New Delhi

Notes

[1] Cipolla, Carlo M., *Before the Industrial Revolution: European Society and Economy, 1000-1700,* New York, 1976, p.81.

[2] Elaborating on the question why there was an overseas expansion of Europe and not of Asia, a question raised by Joseph Levenson in *European Expansion and the Counter Example of Asia,* New York, 1967, Lucile Brockway concludes that "they (the Asians) had neither the will nor the need to expand overseas. The self-sufficiency of these large, settled agricultural population with their well developed handicrafts in textiles, ceramics and metallurgy discouraged overseas expansion". L. H. Brockway, *Science and Colonial Expansion: the Role of the British Royal Botanic Gardens,* New York, 1979, p.16-18. Angus Calder explains that the overseas expansion of Europe took place when "the landlust of noblemen married with the goldlust of merchants". Angus Calder, *The Colonial Expansion: The Rise of the English Speaking Empires from the 15th Century to the 1780s,* New York, 1981, p.6.

[3] Calder, Angus, *ibid.,* p.8.

[4] Baker, H. G., *Plants and Civilization,* California, 1978, p.31.

[5] Cipolla, C. M., *op.cit.,* p.214; Braudel, Fernand, *The Mediterranean and the Mediterranean World in the Age of Philip II,* **vol.1,** New York, 1966, p.569; Chaudhuri, K. N., "Treasure and Trade Balance: The East India Company's export trade 1660-1720", *The Economic History Review,* Ser.2, **vol.21,** 1968, p.497-98.

[6] In the 1780s, an average of £ 700,000, a year was sent to China by the English East India Company. Harlow, V. T., *The Founding of the Second British Empire 1763-1793,* Longman, 1952-1964, **vol.1,** p.63-67.

[7] Basalla, G., "The Spread of Western Science", in *Science,* **vol.156,** May 1967, p.611-622.

[8] Gaitonde, P. D., *The Portuguese Pioneers in India,* Bombay, 1983, p.120-21.

[9] *Ibid.,* p.140.

[10] Allen, D. E., *The Naturalists in Britain: A Social History,* Penguin, 1976, p.37.

[11] Pisa, Florence and Padua, each had a *hortus medicus* in 1545, Leiden in 1577, Leipzig in 1579, and Montpellier and Heidelberg in 1593, all university centred. The *Jardin des Plantes* in Paris was established in 1635. The Royal Botanic Garden of Edinburgh grew out of a *Physick Garden* started in 1690. Brockway, L. H., *op. cit.,* p.72.

[12] The Dutch started a botanic garden in Capetown in 1694, the French on Mauritius in 1735, and the English on St. Vincent, Jamaica, Calcutta and Penang. Brockway, L. H., *op. cit.,* p.58.

[13] Brockway, L. H., *op. cit.,* p.63-65.

[14] Dr. Gerhard Koenig, a pupil of Carl Linnaeus, had landed in India in 1768 to join the Danish Mission at Tranquebar as surgeon. But finding his means too limited to pursue his investigation, he took employment with the *Nawab* of Arcot. Still unhappy with his allowance, Koenig applied for assistance to the Madras Medical Board, on whose recommendation the EIC granted him a monthly allowance of 40 pagodas. Royle, J. F., *Essay on the Productive Resources of India,* London, 1840, p.49.

[15] Fuber, H., *John Company at Work: A Study of European Expansion in India in the late 18th Century,* New York, 1970, p.269.

[16] Samuel Browne, a Surgeon at Madras, for instance, sent a succession of papers listing the plants to James Petiver, towards the end of the 17th century. Edward Bulkley (1651-1714), who succeeded S. Browne in 1692, sent plants collected from Bengal and Burma to Petiver, L. Plukenet and C. du Bois. Another surgeon in the EIC service who sent plants to Petiver was John Fox. Gyfford sent plants from Madras to Bombat. Benjamin Mewse sent plants to Petiver from Surat. See Desmond, Ray, *Dictionary of British and Irish Botanists and Horticulturalists including Plant Collectors and Botanical Artists,* London, 1977.
[17] M. Francis's Minute on Trade etc., *Home Public Proceedings,* 4 Nov. 1776, No. 1.
[18] Anderson Papers, India Office Library and Records, Photo, Eur.85, quoted in Deepak Kumar,"The Evolution of Colonial Science in India: Natural History and the East India Company", *Imperalism and the Natural World,* ed. J. M. MacKenzie, Manchester, 1990, p.51-66.
[19] Mackay, David, *In the Wake of Cook: Exploration, Science and Empire 1780-1801,* London, 1985, p.170-171.
[20] *Ibid.,* p.172.
[21] Dr. William Roxburgh (1751-1815), who had studied botany at Edinburgh, landed at Madras in 1776 as surgeon in the EIC medical service. In 1782, Roxburgh was transferred to a small place called Samalcot, a hilly area rich in tropical flora in the Northern Circars. There, he developed a small botanical garden. Samalcot, however, fell short of the botanical interests of a person who is said to have desired that "nothing will induce him to make a much longer stay in India, than being possessed of improvable land prosperity which can not be taken from him when it is improved". A. Ross to David Haliburton, Acting President of the Board of Revenue, 20 June 1793, British Museum: Natural History (hereafter cited as BM-NH), MSS-ROX.
[22] There he made some observations on the *Agallochum,* a drug of great value, for which the Chinese annually paid an immense amount to their neighbours in Cochin-China and Siam. J. Banks to T. Norton, 22 Feb. 1787, The Dawson Turner Copies of Sir Joseph Banks's Correspondence in the British Museum (Natural History), (hereafter cited as D.T.C.), **vol.5,** ff.133-137.
[23] *Ibid.*
[24] P. Russell to J. Banks, 9 July 1785, D.T.C., **vol.4,** ff.148-153.
[25] J. Banks to T. Norton, 22 Feb. 1787, D.T.C., **vol.5,** ff.133-137.
[26] P. Russell to J. Banks, 12 March 1786, D.T.C., **vol.5,** ff.21-24.
[27] P. Russell to J. Banks, 9 July 1785, D.T.C., **vol.4,** ff.148-153.
[28] P. Russell to J. Banks, 12 March 1786, D.T.C., **vol.5,** ff.21-24.
[29] *Ibid.*
[30] Memoir from P. Russell to J. Banks, D.T.C., **vol.5,** ff.180-183.
[31] *Ibid.*
[32] *Ibid.*
[33] Court of Directors to Madras Presidency, 31 July 1787, India Office Library, London, General Correspondence (hereafter cited as I.O. Gen. Corr.), E/4/873, ff.730-732.
[34] J. Banks to EIC, 25 Nov. 1788, D.T.C., **vol.6,** ff.91-93.
[35] P. Russell to J. Banks, 21 Dec. 1788, D.T.C., **vol.6,** ff.96-97.
[36] J. Banks to Court of Directors, 4 July 1794, D.T.C., **vol.9,** ff.52-56.
[37] *Ibid.*
[38] *Ibid.*
[39] Desmond, Ray, "William Roxburgh's Plants of the Coast of Coromandel", *Hortulus Aliqaundo,* **vol.11,** 1977, p.23-41.
[40] J. Banks to W. Roxburgh, 9 Aug. 1798, Additional Manuscripts, British Library (hereafter cited as Add. MSS), 33980, ff.159-160.

[41] Minutes of the Committee of Warehouses, 25 Nov. 1799, I.O.R., MSS Eur. F 25, ff.75-97.
[42] Commercial letter to Fort St. George, 29 May 1799, I.O.R. MSS Eur. F 25, ff.20.
[43] Commercial letter from Bombay, 21 January 1800, I.O.R. MSS Eur. F 25, ff.75-97.
[44] Robert Thorton in the Preface of his book, *The Temple of Flora (1799-1807)*, quoted in Desmond, Ray, *op. cit.*, p.34. When Robert Brown published the results of Banks's exploration of New Holland in 1801 - the well known *Investigator* Voyage - entitled *Prodroumus Florae Novae Hollandiae in 1810*, its sale was so small that Brown had to abandon his programme after printing the first volume at his own expense. Arber, Agnes, "Sir Joseph Banks and Botany", (Typescript notes), BM-NH.
[45] Quoted in Desmond, Ray, "William Roxburgh's ...", *op. cit.*, p.34-35.
[46] Minutes of the Committee of Warehouses, 10 June 1801, I.O.R., MSS Eur. F 25, ff.75-97.
[47] G. Nicol to W. Wissett, 31 May 1815, I.O.R., MSS Eur. F 25, ff.107-108.
[48] "The fact that India was ruled by a profit-making body implied that government activity in India proceeded fundamentally along commercial lines". MacLeod, R. and Dionne, Russell, "Science and Policy in British India, 1858-1914: Perspectives on a Persisting Belief", *Proceedings of the 6th European Conference on Modern South Asian Studies*, July 1978, p.55-68.
[49] G. Nicol to S. Davis, 28 Aug. 1816, I.O.R., MSS Eur. F 25, ff.169-171.
[50] F. Buchanan to N. Wallich, 4 Feb. 1817, BM:NH, MSS-BUC, ff.149.
[51] F. Buchanan to W. Roxburgh, 31 January 1801, BM:NH, MSS-BUC.
[52] F. Buchanan to W. Roxburgh, 20 May 1800, BM:NH, MSS-BUC., ff. 39.
[53] F. Buchanan to W. Roxburgh, 10 May 1793, BM:NH, MSS-BUC, ff.75.
[54] Archer, Mildred,"India and Natural History: The Role of the East India Company 1785-1858", *History Today*, **vol.ix**, n°11, 1959, p.736-744; Larwood, H. J. C., "Western Science in India Before 1850", *Journal of the Royal Asiatic Society*, 1962, part.1, p.62-76; MacLeod, Roy and Dionne, R., *op.cit.*
[55] Archer, Mildred, *ibid.*
[56] Allen, D. E., "The Early Professionals in British Natural History", *From Linnaeus to Darwin: Commentaries on the History of Biology and Geology*, London, Society for the History of Natural History, 1985, pp.1-12. For more details on this issue see D. E. Allen, "Naturalists in Britain ...", *op. cit.*
[57] MacLeod, Roy, "The Support of Victorian Science: The Endowment of Research Movement in Great Britain, 1868-1900", *Minerva*, **vol.ix**, n°2, April 1971, pp.197-230.
[58] Quoted in D. E. Allen, "The Early Professionals...", *op. cit.*
[59] Basalla, George, *op. cit.*
[60] MacLeod, Roy, "On Visiting the 'Moving Metropolis': Reflections on the Architecture of Imperial Science", *Historical Records of Australian Science*, **vol.5**, n°3, Canberra 1982.
[61] While stationed at Puttahaut on the Malabar, Buchanan had complained to Roxburgh that "To speak the truth I am not very comfortable here. There is a very poor society or almost I may say none, and there is no books". F. Buchanan to W. Roxburgh, 10 May 1797, BM:NH, MSS-BUC, ff. 16-17.
[62] F. Buchanan (who changed his title to Buchanan-Hamilton in 1818) to N. Wallich, 1 Nov. 1828, BM-NH), MSS-BUC, ff. 165.
[63] MacLeod, Roy and Dionne, R., *op. cit.*
[64] Heyne, B., *Tracts: Historical and Statistical on India*, London, 1814.
[65] Larwood, H. J. C., *op. cit.*
[66] Letter from Lieutenant Colonel R. Kyd to the Governor General of India, 1 June 1786, Home Public Proceedings, 16 June 1786, no. 14.

[67] Elsewhere I have discussed the botanical collections at the Calcutta Botanical Garden. See Sangwan, Satpal, "Plant Colonialism", *Proceedings of the Indian History Congress,* Burdwan, 1983, p.414-424.
[68] J. Banks to T. Norton, 17 January 1791, D.T.C., **vol.7,** ff.303-305.
[69] *Ibid.* Later, reflecting on the success of the Calcutta garden under Robert Kyd, Banks wrote in 1806: "The establishment was originally framed, first for the purpose of conferring on the inhabitants of that circle of the globe who enjoy a climate similar to the climate of Calcutta, an increase of their resources in food, in raw material and in luxuries by receiving from the West such useful plants as the East did not then propose and by sending to the West such as had hitherto exclusively belonged to the East, and secondly, for extending the interesting science of natural history and more particularly that of Botany, by advantageously to the learned world such discoveries in the animal, the vegetable, and the mineral kingdoms, as are made from time to time in the extensive regions of the East.... The whole of this liberal plan could not at first be carried into execution, the worthy proposer of it, Colonel Kyd, ... was not a professional naturalist". J. Banks to the Court of Directors, 4 July 1794, D.T.C., **vol.9,** ff. 52-56.
[70] J. Banks to EIC, 2 August 1806, D.T.C., **vol.16,** ff.299-303.
[71] *Ibid.*
[72] W. Roxburgh to Banks, 17 Aug. 1792, Add. MSS, 33979, ff 171-73.
[73] J. Banks to EIC, 2 Aug. 1806, D.T.C., **vol.16,** ff.299-303.
[74] *Ibid.*
[75] Letter from EIC to J. Banks, 26 January 1787, I.O. Gen. Corr. E/1/80, ff. 103.
[76] J. Banks to T. Norton, 22 Feb. 1787, D.T.C., **vol.5,** ff.133-137.
[77] J. Banks to Hawkesbury, 30 March 1787, D.T.C., **vol.5,** ff.139-142. Swartz, however, did not find the annual salary of £ 400 with travelling allowances sufficient to leave his mother country. Swartz to Banks, 29 Aug. 1787, Add. MSS, 8096, ff. 519-20.
[78] Speaking of his collections from Nepal, Buchanan wrote to Wallich that "A great part of what I have done there has been in a short lost as having been given to Sir J. E. Smith who is rather indolent and not likely to publish any considerable part of what he has". F. Buchanan to N. Wallich, 16 Oct. 1821, BM-NH, MSS-BUC, ff. 157. -
[79] Alphonse de Candolle to his father Augustine Pyramus, 13 May 1830, quoted in Roger de Candolle, "Nathaniel Wallich: How the Largest Botanical Collection yet Brought to Europe by a Single Man Was Distributed", (typescript) BM-NH, MSS-CNN, ff. 3.
[80] de Candolle, Roger, *op. cit,* f. 7.
[81] Alphonse de Candolle wrote to his father Augustine Pyramus, who was among the 40 probable beneficiaries, from London that "English botanists disapprove of Wallich's exotic liberalities", *ibid.*
[82] Augustine Pyramus wrote a letter on behalf of the international scientific community asking that "Wallich be allowed to complete his essential work", *ibid.,* f.7-8.
[83] Quoted by F. Buchanan, HPP, 15 April 1816, no. 94.
[84] Royle, J. F., *op. cit.,* p.180-181. The Linnaean Society was very pleased with such an "example of disinterestedness" exhibited by the Company and expressed "their high sense of the distinguished honour conferred upon the Society for the unexampled act of liberality". Address from the Council of the Linnaean Society to the Court of Directors, 23 June 1832, quoted in Royle, J. F., *op. cit.,* p.183. Interestingly, the specimens transferred to the Linnaean Society were only the duplicates, the original having been placed with Wallich in the Firth Street.
[85] W. Roxburgh would agree that "it would only require a hint from Sir J. Banks to the Directors to induce them to send me all new publications on Natural History". W. Roxburgh to A. R. Lambert, 21 Feb. 18O1, BM Add. MSS 28545, ff.173-174.
[86] Roxburgh Papers, IOL Eur. MSS D. 809, quoted in Deepak Kumar, *op. cit.*

THE SOCIÉTÉ ZOOLOGIQUE D'ACCLIMATATION AND THE NEW FRENCH EMPIRE: SCIENCE AND POLITICAL ECONOMY

Michael A. OSBORNE

The *Société Zoologique d'Acclimatation's* (hereafter Society) present mission belies its imperialistic heritage. It now resembles America's Sierra Club, its National Wildlife Federation, and other groups active in the wildlife protection and conservation movement. In the 19th century the group presented other faces. I wish to focus on just two of its many aspects --these being the transformist zoological theory which informed its manifold biomedical activities, and its role in the construction of the new French Empire.

In terms of size, this was surely one of the largest of the post-Revolutionary scientific societies. Founded in 1854, nearly three thousand people had joined the group by 1871. But this is just the tip of the iceberg, for there were several regional and colonial branches of this Paris-based group. If the membership lists of just two of the major provincial branches are factored in, those of Grenoble and Nancy, founded in 1854 and 1855 respectively, the total quickly rises above 5000[1].

A major impetus for founding the Society had been the desire to rationally exploit faunal resources, both in France and in Algeria. This often took the form of importing exotic domesticated animals and trying to establish them as economically viable crops for industry and agriculture in France and its colonies. At other times, it meant exploiting more fully the animals already common in France. The best example of this was the Society's successful campaign to get the French to eat the flesh of horses no longer fit for labor.

Today one can summarize the Society's concerns as domestication, naturalization, acclimatization and human settlement in the tropics. During the Second Empire, however, science had not yet resolved these problems into distinct units of investigation. Acclimatization was then the term of preference, and it connoted an adaptation --frequently a forced adaptation guided by scientific principles-- to new circumstances of diet, climate and hygiene. Society members deployed the idea in numerous agricultural projects which they

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hoped would provide a rational foundation for French colonial agriculture.

The activities of this band of naturalists, physicians, diplomats and land-owners were guided by a theory which issued from the pen of Isidore Geoffroy Saint-Hilaire (1805-1861), holder of the Chair of Mammals and Birds at the Paris Museum of Natural History. Geoffroy Saint-Hilaire served as president of the Society from 1854 until his death in 1861. His successor as president, Napoleon III's sometime Minister of Foreign Affairs -- Edmond Drouyn de Lhuys-- gave the group an even closer association with the Empire's expansionist politics. Geoffroy Saint-Hilaire constructed the public within which the Society took root. Several Society officers attended his Museum lectures on applied natural history. Indeed, the first complete account of Geoffroy Saint-Hilaire's transformist theory appeared as a hand-out for his Museum course in 1850. The theory, really a collage of concepts enunciated by Buffon, Lamarck, the elder Geoffroy Saint-Hilaire and himself, added up to a weak variety of functional transformism labeled by its author a theory of the limited variability of species[2].

From Buffon, who had revised his thoughts on the nature of species as he worked his way through the *Histoire naturelle,* Geoffroy Saint-Hilaire took what he called the "true doctrine of Buffon," the idea that the principal characters of species persist through time, while accessory characters vary under the effects of climate and diet. Lamarck and Etienne Geoffroy Saint-Hilaire received credit for recognizing the variability of species in response to the local environment. While the two men last named had focused on environmentally produced effects at different stages of animal life --the adult and embryonic stages respectively-- Isidore Geoffroy accepted both accounts. Although Isidore Geoffroy did not specify the rate at which the environment caused changes to occur --perhaps a concession to Etienne Geoffroy's saltationist explanations of mutability -- Lamarck's gradualism is a persistent image in several passages on variation. The theory which resulted accepted the heritability of acquired characters, but rejected many other aspects of Lamarckian thought, notably the hypothesis of spontaneous generation, and of unlimited though directional variability. In the larger historical picture, the stability of species was only a fragile stasis in oscillation[3], a *"stability and permanence equal to that of the present state of the globe"*.

Even if the global environment remained stable, organisms might also experience physiological alterations when they encountered new ambient circumstances. Thousands of Frenchmen were then encountering a new disease ecology in North Africa, and by the theory of acclimatization their hopes for survival rested on proper physiological adaptation. Although the precise effects of the environment on specific characters and other aspects of the human and animal economy were unclear at best, Geoffroy Saint-Hilaire's scientific ideas lent credence to the claim that the French could adapt to the conditions of life in Algeria and other European colonies[4].

The relationship between science and the acquisition of empire is at once subtle, complex, and reflexive. To be sure Geoffroy Saint-Hilaire's transformism and the activities of the Society supported and extended the French colonial mission. Thus the Society constituted an important tool with which metropolitan authorities "developed" Algeria. In the case of French studies of animal, human and plant acclimatization, the acquisition of empire occasioned the opening and re-opening of scientific investigations in this field. France had taken the city of Algiers in the summer of 1830, and according to Isidore Geoffroy Saint-Hilaire this event opened debate over the scientific basis of acclimatization and sparked new consideration of the ability of Europeans to settle in and colonize the warmer regions of the globe. In this instance events on the periphery rather than at the center provoked the intellectual construction of a scientific research program. In large measure, the Society's extraordinary influence in matters colonial in the late 1850s and 1860s is due to its active cultivation of a symbiotic relationship with the politics and growth of a new French Empire.

The basic concept of acclimatization was easily grasped by amateur naturalists of all social levels. Yet the most important element in the growth of the acclimatization movement in France was not a matter of theory, but the direct patronage of the Society by the royal household in the form of gifts of animals, land, and money. No great intellect himself, Napoleon III tended to support the institutions of French science that promised practical results over those which adhered to purer research agendas. His nephew, the Prince Jérôme Napoléon, shared his views on practical science. Jérôme, who briefly headed the Ministry of Algeria, was also honorary president of Society's experimental zoo in Paris, the *Jardin Zoologique d'Acclimatation.* He opined that the zoo and the Society had been constructed[5] to *"exit the domain of theory and to enter that of practice"*.

In addition to patronage, at least three other factors linked the Society to the politics of the Empire. A first concerned theory, specifically the utility of a limited variability of type hypothesis to schemes of colonial settlement. A second relates to the core of expertize in colonial matters available through the offices of the Society. A third feature, really a fortuitous circumstance skillfully exploited by the Society, was the institutional structure of French science itself.

Several factors complicated the European settlement of French Algeria. France's Government changed hands four times between 1830 and the resolution of the Franco-Prussian War. In the colony itself, three major wars, fearsome fevers, and a series of insurrections discouraged European settlers. Moreover, conflicts of interest between settlers, the Army, Parisian capitalists speculating on land, and resident civil authorities made it difficult to develop a coherent Algerian policy. Allied with the Army but claiming to represent settler interests, the Society acted within this confusing milieu to support Napoleon III's plan to settle Algeria with transplanted French peasants who would own small plots of land and work them with their own hands.

Until the 1850s, most of the military and civilian medical studies of Algeria counseled the Government to abandon the colony to its fevers, or at least to refrain from settling it with a French agrarian population. However, the core theoretical belief of the Society, the limited variation of species theory, held that the French would eventually adapt to life in Algeria and attain there a state of health equivalent to or better than that which they enjoyed in France. Geoffroy Saint-Hilaire stated this belief several times, and he argued the case with a fund of information gleaned from studies on exotic animals performed at the Museum and elsewhere. His colleague at the Museum, the anthropologist and zoologist Armand Quatrefages de Bréau, made the same point although he diluted the force of the argument by calculating that it might take as many as forty generations for the French to adapt to life in North Africa.

In addition to promoting a theory predicting the success of French settlement schemes for Algeria, the Society assembled a critical mass of experts on Algerian development. Here links with the French Army were crucial, for the Army administered the colony for all but a few months of the period 1830 to 1871.

Several members of the Society had served with the French forces in Algeria during the 1830s, 1840s and 1850s. Many of these veterans returned to France convinced that the country should be retained and ultimately settled by French colonists. In recognition of the importance of Algeria as a source of exotic animals, and as a place to conduct experiments with the material assistance of the French Government, Society founders created an organizational structure particularly responsive to scientific questions bearing on the development of Algeria. The Society quickly established itself as a consultant to the French Government on Algerian agricultural development.

Special commissions carried out the Society's day-to-day tasks, which included answering questions from individuals or Government agencies, monitoring experiments, and arranging the exchange or shipment of plants, seeds and animals. The founders created a permanent commission to organize the flow of materials and information dealing with the agricultural and hygienic problems of Algeria. This permanent commission on Algeria numbered nineteen members in 1860, and about half of them had a first-hand knowledge of conditions in the colony. The interests of this group, composed largely of metropolitan scientists and administrators, ranged over the whole of economic zoology, botany and tropical hygiene[6].

Members of the Society who had seen the colony eagerly wrote articles for the group's Bulletin and participated in several of the Society's other commissions, committees and projects. Albert Geoffroy Saint-Hilaire, Isidore's son, sat on the Society's permanent commission for Algeria for several years. He was joined there by General Daumas, Director of Algerian Affairs at the Ministry of War and the author of reports on Arab falconry and the use of North African horses to improve the French Army's mounts. Daumas became president of the permanent commission on Algeria at its inception in 1855 and served in this function until it disappeared in the wake of the Franco-Prussian War.

By 1860, some 135 Society members listed Algeria as their home address --more than any other French province, Paris and its region excepted. By this time the group was funding and consulting on Algeria-based projects to improve silk manufacture, as well as ovine and bovine agricultural animals.

The War Department frequently turned to the Society for advice on colonial development, not only because so many of its officers were active in the Society, but also because the grander institutions of French science, especially the *Académie des Sciences,* wanted little to do with questions of the most practical import --questions of colonial agriculture and health. In one instance, the Ministry of War asked the *Académie* to devise a cheap plan for an Algerian meteorological service. The *Académie* lingered on the problem for three years, and infuriated the Minister by delivering a report he termed[7] a *"dead letter filled with theoretical meteorology and devoid of the requested instructions"*.

Similar instances of inappropriate advice by the elite institutions of French science could be enumerated, and collectively they drove the administrators for Algerian affairs into the offices of the Society. The *Académie des Sciences* was little concerned with applied science, and its habit of constituting special committees to consider questions slowed the response time. The Society, of course, had various standing committees constituted to deal especially with the problems of Algerian development, and because it staffed those committees and commissions with a goodly number of veterans and military men, they issued prompt responses geared to what the Army hoped to accomplish in Algeria.

To conclude, let me suggest how a study of this scientific society might refine our historiographic images of 19th century French imperialism and the institutions of French science. Most studies of modern French imperialism begin with the Third Republic, the period of the so-called scramble for colonies. Henri Brunschwig, an influential historian of French imperialism, typifies this trend. He locates the French imperial impulse in the psychology of defeatism which followed French losses in the Franco-Prussian War. He claims that prior to 1870, there was no significant interest in the fate of the colonies[8]. I think this image needs to be revised, and I would argue that by 1860 some scientific circles, particularly the elite members of the Society, were committed to the concept of a new French Empire.

More generally, the history of scientific societies provides perspective by elucidating "informal" dimensions of scientific life that clash with highly functional interpretations of the Paris Museum of Natural History and other French scientific institutions.

For example, studies by Camille Limoges and Daniel Headrick portray the Museum and the Museum professoriate as unconcerned with the problems of colonial development[9]. In a sense they are right, for in terms of formal policy, the Museum remained committed to pure research and museology until late in the 19th century. There was not, as Headrick notes, a Museum school that trained administrators for colonial work and issued certificates that would open the door to colonial careers.

But the metropolis, no less than the empire, has it shades of formal and informal power relationships. We need to look beyond certificates and formalities to assess the Museum's real role in the French Empire. More than a dozen Museum staffers, nine of them professors, joined the Society. Most of these men became officers in the group and several of them contributed to colonial projects on zoology and meteorology, especially as these two sciences related to human settlement. During the 1850s, there were at least two dozen botanical gardens in Algeria. The one at Algiers, and many more, were staffed by Museum-trained naturalists. Although these "graduates" of the Museum's school for gardeners did not have certificates, they did not need them. Many of their number won colonial posts upon recommendation of their supervisor or the Museum director.

Thus, if even a portion of the "informal" activities of the Museum and its staff are considered, it seems that the institution was a key actor in the construction of Algerian agronomic policy, both directly through supplying personnel for colonial projects, and indirectly through the advisory role of its professoriate at the Society and that professoriate's promotion and maintenance of a transformist theory of acclimatization.

Finally, let me consider Lewis Pyenson's recent suggestion that French colonial science progressed along a functionary axis[10]. By this he means that research in the colonies was driven by metropolitan intentions and needs. Implicit in this formulation is the notion that scientists at the core of Empire in Paris retained intellectual control of practices conducted in the colonies. But this version of the core-periphery model may not hold up if the "informal" activities of the scientific societies are factored into the picture, for unless we adopt a simple geographical definition, it becomes difficult to demarcate between the core and periphery of scientific practice. In the case of the Society, experiments on animals and crops of colonial significance were conducted in Paris, the provinces and the colonies. Moreover, after the death of Isidore Geoffroy Saint-Hilaire in 1861, the core of the Society's theoretical activity may have migrated to Algiers. There, Auguste Hardy, a Society officer and Museum-trained botanist who administered the Algerian botanical garden network and provided the Society with experimental space and staff, re-formulated Geoffroy Saint-Hilaire's theories along more practical lines[11].

Thus by integrating the "informal" perspective provided by the history of scientific societies with the more formal history of French scientific institutions, it may be possible to rise above analytical models proposing a firm core-periphery dichotomy and re-evaluate the contribution of the Empire to French science.

University of California, Santa Barbara

Notes

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[1] For a more detailed and documented discussion of these themes see my *The Société Zoologique d'Acclimatation and the New French Empire: Science and Political Economy During the Second Empire and Third Republic,* Indiana University Press (forthcoming).
[2] I. G. Saint-Hilaire, *Histoire naturelle générale des règnes organiques,* 3 vols, (Paris, 1854-1862), **vol.2,** p.430-441.
[3] *Ibid.,* p.437.
[4] Claude Blanckaert, "On the Origins of French Ethnology: William Edwards and the Doctrine of Race", *History of Anthropology,* 5, (1988), p.18-55, esp. p.34-35 which discuss an 1835 memoir by Désiré Roulin.
[5] Guerin-Méneville, "Faits divers", *Bulletin de la Société zoologique d'acclimatation,* 6, (1859), p.228-232, p.231.
[6] M. A. Osborne, *The Société Zoologique d'Acclimatation and the New French Empire: The Science and Political Economy of Economic Zoology During the Second Empire,* Ph. D. dissertation, University of Wisconsin, 1987. See chapter 4, "The Société Zoologique d'Acclimatation and Algeria during the Second Empire," p.192-257.
[7] Académie des Sciences, *Comptes rendus,* 41, (1855), p.1127-1149.
[8] Henri Brunschwig, "The Origins of the New French Empire," in G. H. Nadel, P. Curtis, eds, *Imperialism and Colonialism,* New York, 1968, p.111-122.
[9] Camille Limoges, "The Development of the Muséum d'Histoire Naturelle of Paris, 1800-1914," in R. Fox, G. Weisz, eds, *The Organization of Science and Technology in France, 1808-1914,* Cambridge, 1980, p.211-240; Daniel R. Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850-1940,* New York, 1988, p.222-231.
[10] Lewis Pyenson, "Pure Learning and Political Economy: Science and European Expansion", in R. P. W. Visser, H. J. M. Bos, L. C. Palm, H. A. M. Snelders (eds.), Proceedings of the Utrecht Conference, *New Trends in the History of science,* Amsterdam, 1989, Rodopi, p.209-278, esp. p.274-278.
[11] Hardy's numerous experiments, mostly on plants, shook his belief in the heritability of a progressive, acquired acclimatization to climatic conditions. See "De la transplantation des arbres en Algérie", *Revue horticole de l'Algérie,* 1, (1860), p.178-183, p.194-200, p.182. Hardy also circumvented the wishes of Society committees in Paris by keeping animals in Algiers that the Society wanted to station in the interior of the colony.

PATRIARCHAL SCIENCE: THE NETWORK OF THE OVERSEAS PASTEUR INSTITUTES

Anne Marie MOULIN

The growth of the Pasteur Institute into its overseas branches[1] offers an intriguing case: a scientific imperialism which, although supported by colonialist lobbies and strongly flavoured with French chauvinism[2], was not a mere by-product of 19th century expansion in Africa and Asia[3]. Two characters demonstrate the relative autonomy of this phenomenon. Firstly, the network of the Pasteur Institutes was initially established in both French dominions and foreign countries. Secondly, the network successfully outlived the toll of colonialism.

The scientific community which developed this network pursued some common goals and interests with the politicals, but they also followed a line of their own. Its members saw themselves as spreading a new Gospel, the so-called "Pasteurian methods" as they embraced the ideal of a scientific revolution of which they became zealous propagators. This new science was produced by a mostly, but not entirely, French body of scientists which described themselves as a "school". They obeyed the rules of their founder whose teachings and doings were engraved in their memory. The criteria for belonging to the "Pastorians" were less institutional than spiritual[4] : sharing of tradition[5], fostered by teaching and strengthened by personal ties between master and disciples. The connections between the Pasteurian scientific ideology and the network of the Pasteur Institutes will be put here into sharp focus. This scientific ideology at the same time bore a distinctive nationalist character and heralded the advent of the "world-science"[6], the almost unchallenged worldwide expansion of western science. In a word, and using a metaphor congenial to the topic, the scientific imperialism of the Pastorians cross-reacted with colonial imperialism without being absorbed into it.

During the last few years, Pasteur's work has been scrutinized by historians of science. They have begun to unravel the many scientific myths which were woven into the fabric of Pasteur's official saga and to analyze Pasteur's strategy in his march to power, the so-called "Pasteurization of Society"[7]. Less attention has been paid to the export of pasteurianism to the Tropics[8] and even around the world[9]. However, the pastorian sanitary movement and the colonial expansion closely

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interacted; they supported each other and converged to support the idea of a radical change in medicine, the perception of a revolutionary era.

The pastorian school effected a conceptual shift. Beyond their adhesion to "pasteurian methods" its members vindicated "pasteurian science", a paradoxical brand of science, universal in scope and goals but nevertheless implicitly held as French: this radically new approach included for them the commitment to the germ theory of disease, the implementation of new bacteriological techniques, and a fresh view of field epidemiology[10]. As we will see, the specificity of this science was linked to the dedication of a social group to a historical model of science, perpetuating the image while adapting the model. This group exemplified many characteristics not only of a doctrinal school, but of a monastic order. They had a "saint" as founder and obeyed a rule. Pasteur, of course, was their founding saint; pasteurian methodology was their rule. These particular methods of the great man Pasteur, developed in a historical context, were assimilated into universal scientific laws. The transforming principle which mutated historical contingency into rational necessity was set in motion at an early stage.

This mode of fusion between the contingent and the necessary has been described as the earmark of scientific ideology; but even so shrewd an epistemologist as Georges Canguilhem has been tempted to assign an extra-temporal value to pasteurian studies and make an exception for them. Canguilhem blurred the distinction between science and ideology in relation to Pasteur and presented the pasteurian microbiology as "the end of medical theories"[11]. Pasteurian ideology, it is true, was difficult to grasp. The Pastorians displayed a remarkable intellectual mobility; they shifted their targets according to the context. They identified their practice with "methods" versus theories, "doctrines" versus systems, "applications" versus pure science, non-profit research versus industry-linked research, according to circumstances. This elastic ideology animated the network of overseas Pasteur Institutes (itself, like Pasteur's work, an empirical assay), which (again like Pasteur's work) acquired stable characteristics only secondarily. Once stabilized, these characteristics would guide the establishment of new Institutes and would ensure the propagation of the pasteurian scientific style[12].

Genesis of the Institution

Pasteur had thoroughly meditated on the choice of his research topic when late in his life he finally turned to human microbiology. He did not elect smallpox which had brought universal fame to Jenner nor tuberculosis which had made illustrious the name of his German enemy Koch. He tackled rabies, an uncommon but always fatal disease whose horror struck the imagination and about which little was known. After unsuccessful attempts to discern its agent, Pasteur bypassed the question of etiology and focused instead on the therapeutics of the disease. The human therapeutic experiment successfully performed on the child Joseph Meister on July 5, 1885, opened up a series of equally successful treatments in Pasteur's lab and led to the foundation of the Pasteur Institute of Paris, initially an institution for antirabies "vaccinotherapy".

The modest goal of rabies treatment spread rapidly throughout France and to many foreign countries. Pasteur soon concluded that

"one Institute is enough for France. But I am nevertheless convinced that the Pasteur Institute could receive in due time all people who have been bitten anywhere in Europe."

As crowds of patients rushed to Paris from England, Germany, Russia and even Egypt, the new method started to be implemented in many places. The Administrative Board of the new Institute in Paris registered the movement:[13]

"Monsieur Pasteur, convinced of the efficacy of his treatment whose harmless character is more marked every day, has done its best to facilitate the creation of new foci of antirabies inoculation.... Physicians from London, Vienna, New York and Odessa, have carried with them rabbits inoculated in the lab under their eyes.... Nothing would be easier than to imitate in all details the work being done at the Rue d'Ulm where Pasteur's lab was temporarily located and to vaccinate in each country the people bitten there. Monsieur Pasteur has been but too eager to provide foreign visitors with all the information they require. In return, this multicentric experimentation brings back the expected confirmation of the method and enforces the conviction of the adepts in front of the opposition".

But the Pasteur Institute did not restrict its scope to rabies treatment. In 1881, Pasteur himself had put forth a series of statements on the inductive mode. Relying on his experience with virus attenuation in cattle anthrax and fowl cholera, he announced:[14]

"We are now in possession of anthrax virus vaccines. These vaccines can protect against death, without being themselves mortal. They are living vaccines, suitable for cultivation, transferable anywhere without being altered: in short, prepared according to a particular method which nevertheless can be safely generalized, since it has been fully successful at least one time".

This grand program underwent a series of successive extensions. First the range of disorders under investigation covered all infectious diseases, and at the peak of the germ theory of disease nearly the whole field of pathology, *"except for certain neoplasms and certain hereditary diseases"*. The second extension was geographical: the whole world was the legitimate field of microbiologists'curiosity. Biologists used their new tools, microbacteria, for mapping the three kingdoms and the five continents of Nature[15]. The Pastorians saw the Institute[16] as *"the main scientific focus: here microbiological research all over the world is coordinated"*.

Pasteur's concern for overseas diseases has been eagerly highlighted by his early historiographers. They carefully collected anecdotes pointing to this effect: that Pasteur had repeatedly brooded over the yellow fever issue, going to Marseilles to investigate the causes of a mysterious epidemic; he had cared deeply for the mission sent by him to Alexandria (where Thuillier died of cholera)[17].

The Pastorians loaded their early discourse with historical references whose symbolic impact they perceived: rabies treatment had inaugurated a scientific revolution, and since they had been right once, they should have just to follow the track. History was on their side, they could capture its potential by manipulating its semantic[18]. Pasteur himself had shown the way. By coining the term vaccination (from the Jennerian vaccine) for his grand program of universal prophylaxis, he appropriated one century of immunization. In 1902, the French laws for hygiene (an example often quoted of "pasteurian" legislation), inspired by the Pastorian deputy Chamberland, pivoted on the smallpox vaccination, made compulsory[19]. For a popular audience, this paradigm of preventive medicine acquired a pseudo-pasteurian character. In the same spirit, there was a confusion between the specific pasteurian techniques, such as rabies treatment and diphtheria serotherapy (which had largely benefitted from concomitant German research), and the development of bacteriology at large. Even Koch's postulates, generally referred to as Henle-Koch's postulates, which defined criteria for microbial diseases, were sometimes attributed to Pasteur.

In the same spirit, the Pastorians not only reported carefully their contemporary activities but also canvassed the historical context of their work. Every Pastorian displayed the proofs of his lineage: he was trained by one of the early companions of the prophet. The claim of transmission has been pursued by the successive generations. Each Institute drew its legitimacy from its link to a Pilgrim Father and made an official version of its foundation circulate[20].

This capture of the powers conferred by History could not have occurred if a community had not received the prophet's legacy and heard Pasteur's message[21], probably apocryphal:[22] *"Go and Teach All Nations"*, uttered under an oak in the Garches park[23].

The first markers of pasteurianism were invented very early. The epithet pastorian was already in use in the 1890s and is said to have been invented by the novelist Fleury for the emerging community. Teaching played a considerable role in the making of the Pastorians and was a constant concern of Pasteur's spiritual heir, Emile Roux[24]. The teaching started with the foundation of the Institute in 1888. In contrast with the teaching from the faculty, based mainly on the clinic (the basic sciences were said to be "accessory"), it focused on microbiology in all its aspects and included predominantly lab work, which turned students into competent microbiologists[25]. Microbiology was not part of the official curriculum before World War I, and the teaching previously offered by the professor Victor Cornil at the Medical School remained almost entirely theoretical. The transfer abroad of microbiological techniques was easy[26]. They were based on the use of a microscope, an incubator, an autoclave, and animal facilities. But the Pastorians insisted on the special skills which they displayed in adapting this equipment to changing conditions, thanks to their particular training[27].

The first course attracted fifty students, one third of whom were foreigners. In the following years, the "Grand Course" displayed an uninterrupted two-way flow of men and ideas. Foreign students returned to their home countries and retained a link to their tutors. The network of the Pasteur Institutes was made possible by this circulation. The Saigon Institute was, in 1891, the first example of this tentative extension to the universe of the pasteurian model.

The 1891 Model: Saigon

The story of this foundation needs to be told in detail since it constitutes a motif which will be replayed with many variants. The Saigon episode is symptomal of the collusion of the colonial lobby and the Pastorian scientists. In 1890, the *Corps de Santé Colonial* was created[28]; it had long been advocated by Eugène Etienne[29], the influential leader of the ascending "colonial party"[30]. Training took place at the newly-created *Ecole de Santé Navale* in Bordeaux. Additionally, the students of the *Corps de Santé* came for a stage to the Pasteur Institute and were rapidly enrolled in the Pastorian cohorte[31]. The Institute initially only staffed five full-time researchers, the department heads and a few technicians. The other researchers received little or no money. The *Corps de Santé Colonial* which trained tropical doctors provided the Pasteur Institute with a multiplier of power and lessened its financial burdens: they supplied an elite of military servants, well-trained and ready to obey to the Pasteur command while being appointed by the state. The "War on disease", a new issue in medicine[32] that was reinforced by Metchnikoff's theories of phagocytosis[33], fitted perfectly the new medical corps.

The collusion between the military and the scientists is obvious in the Saigon episode. Etienne, then sous-secrétaire for the Colonies (there was no Ministry at this point), asked Emile Roux to appoint a trainee to start a department of bacteriology and vaccinotherapy in Cochinchine. Clearly, the Pastorians appropriated the Jennerian legacy. In the subsequent years all vaccinations would be included under the pasteurian revolution, which was celebrated in all French books on hygiene and public health.

Albert Calmette, himself a military doctor[34], settled within the precincts of the military hospital of Saigon. He overcame the difficulty of importing cows for smallpox vaccine production by successfully adapting the strain to the local buffalos. This adoption was the first signal of local "acclimatization". The laboratory provided bacteriological analyses when available for diagnoses of the main contagious diseases (typhoid, cholera, liver abscesses, dysenteria) and took in charge the surveillance of drinking water and food. Calmette also ventured into tropical pathology: beri-beri, malaria, elephantiasis.... Above all, he started preventive treatment against rabies. He identified the "disease of mad dogs", which had long been familiar to the natives, to the pasteurian scourge. He had again to adapt the original procedure for attenuating the virus through animal passages. Rabies treatment would be the distinctive Pastorian signal[35]. In 1921, for example, the main justification for the establishment of the Teheran branch was the presence of rabid wolves in the wild Zagros montains in Kurdistan. In other countries, if rabies had been unnoticed, cases would be actively sought.

But Calmette did not restrict himself to medicine. At once imitating and adopting Pasteur's own fields of interest, he studied fermentations such as the local production of rice alcohol and identified in the indigenous methods a special yeast called *Amylomyces rouxii,* in honor of the director in Paris. Special attention was given to the fabrication of nuoc-mam, the main condiment of vietnamese food, and morphine, opium being not prohibited in the colony. Studies on silk were not even missing, a clear reference to the studies conducted by Pasteur in the south of France on the diseases of the silkworm. In two years, Calmette had made of the Pasteur Institute in Saigon an *"Institut Pasteur en petit"* which would in turn serve as the model for other Institutes. His first reports unmistakably suggested a pattern in striking conformity to Pasteur's pathway: from industrial fermentations to plant and animal diseases and finally to human infections. This pattern would be replicated more than once. The statutes of the Athens branch in 1921 first mention *"the study of the virulent diseases of man and cattle which are ravaging the Greek territory";* then follows[36] *"the application of the pasteurian methods to agriculture and fermentation industries (wine-making, dairies), the development of which is crucial for the future economy of Greece"*.

An overseas Institute was first a modest laboratory dominated by a Pastorian personality and informally linked to Paris. Only after a trial and error period was an official agreement signed up between the colonial authority (or the local one) and Paris, which organized the budget, dispatched responsabilities, and conferred to the new organism financial and moral personality. The new branch was thus legitimated by being firmly anchored to the mother institution and receiving its orders.

Many colonial Institutes were founded according the above pattern, on the joint initiative of politicians and Pastorian leaders. Tunis is a case in point. The Agriculture Director, Paul Bourde, sollicited scientific help from Pasteur for solving yeast selection for wine-making. The problem was crucial for the settlers who hoped to benefit from the phylloxera crisis in metropolitan France. Pasteur sent his own nephew, Adrien Loir, and charged him with the additional task of investigating[37] *"the main diseases of the Regency"*. In 1893, Loir started rabies vaccination and smallpox vaccination. He exchanged information with the local medical body and explored a pathology new to him. Millet, the *Résident Général,* was partisan of an autonomous cultural development supported by a local elite. He urged Loir to transform his modest department[38] into *"a center for scientific research according to the pasteurian methods"*. The appellation *"Institut Pasteur"* was in current use long before it became official and before the Institute was built up in its present location, with Charles Nicolle, the future Nobel Prize winner, at its head.

Same plot, again, with the foundation of the Pasteur Institute in Morocco. The first one was in Tangiers at the outposts of French penetration[39]. In 1906, in retribution for the murder of a young Frenchman, the ambassador, Regnault, obtained a land in the best neighbourhood of the city and Emile Roux[40] urged the Administrative Council *"to support both scientific interests and French influence"*. Remlinger came from Constantinople to Tangiers and the new Institute opened in 1913.

But the initiative belonged sometimes to outsiders whose contribution would be frequently overlooked by official history. In Algiers, two professors of the Medical School, Trolard and Soulié, established in 1894 rabies and smallpox vaccine departments. They also developed anthrax vaccine and a variant against the sheeppox which threatened the cattle *(clavelée)*. The lab, under control of the civil administration, was also concerned by the wine-making problems:[41] *"Dr Trolard plans, briefly, to put into practice all the discoveries which Pasteur's school has brought to us"*. Trolard even planned to experiment on the diphteria serotherapy which Roux had just introduced into the pediatric wards of the Necker Hospital in Paris. Nevertheless, in 1909, he was dismissed and replaced by Edmond Sergent, the head of a mission sent to Algeria by Roux for testing the vectorial transmission of malaria (the role of the mosquito) (who had been there since 1900[42]).

This same pattern of a collaboration between local authority and the Paris direction was operating in different contexts. In 1893, the Ottoman Sultan Abdülhamid, a former sponsor of the Pasteur Institute, was frightened at the onset of a cholera epidemic, and asked Pasteur to send him an expert in bacteriology[43]. André Chantemesse came to Constantinople for a short mission and was succeeded, by Maurice Nicolle, who founded the Imperial Institute of Bacteriology. There he investigated local diseases, from the oriental sore to piroplasmosis and plague. The rabies department had been organized by a[44] *zimmi,* Zoeros Pasha, who had followed the Course in Paris. After his dismissal, this department was staffed by a French Pastorian, a military physician from Tunis, Paul Remlinger. Remlinger assumed the directorship of both Institutes when Maurice Nicolle, vexed by the administration, left Constantinople.

The Institute, which was never called a Pasteur Institute, continued to be supervised by the Ottoman administration; the Pastorian experts were confronted with foreign colleagues for cross expertize on the cause of incoming epidemics. This subtle division of labor was one of the Ottoman strategies to control foreigners while still benefitting from technological advances[45]. An Ottoman pastorian, also a *zimmi,* Haïm Bey, nevertheless remained in charge of the Institute until 1932, long after Mustapha Kemal came to power. Emile Roux was in close touch with the French embassy in Constantinople. From his rocking-chair in Paris, he appears to have been well-informed on the political events in the Ottoman Empire and of the struggles between Old Turbans and Young Turks, moslems and minorities.

When a foreign country entering the era of industrialization such as the Ottoman Empire appealed to the Pasteur Institute, it was not only the signal of the quest for modernity addressed to the elites, but the mark of a diplomatic choice. After the war, the Shah of Persia sent a mission to Emile Roux, composed of Zoka el Molk, delegate of the Persian Government to the Peace Conference, the dean of the medical school in Teheran, and the shah's own brother. A cousin of the shah, the prince Farman-Farma, offered a piece of land to the Institute whose first director was Jean Mesnard[46].

The diplomatic choice was in some cases still more explicit. During the First World War, Sir Armand Ruffer, himself a former Pastorian trainee in Paris and director of the *Conseil quaranténaire d'Egypte* for 20 years, had been asked to reorganize the bacteriological staff in Athens. He never reached the Greek capital because his ship was hit by a German torpedo. After the war, the British played an equivocal game by sending arms to the kemalist army momentarily defeated by the Greeks. The French doctor Arnaud, director of the Army Health Services in the Greek Army, seized this opportunity. He persuaded the wealthy Basil Zaharoff to sponsor the foundation of a Pasteur Institute in Athens[47] in order to

"intensifying the links of scientific cooperation between Greece and France, by uniting the efforts of scientists of the two countries at the level of research and practical applications of pasteurian methods".

The Greeks gambled on the French scientific influence[48].

Medicine was diplomacy through different means. In Latin America, where the Pastorians' influence had been considerable, the biologists were often in favour of a link to a remote power whose scientific influence was not detrimental to their political autonomy, in contrast to the British and later American allegiance[49]. The Pasteur Institute in Brazil was founded nearly simultaneously with the Institute in Paris, but disappeared after the Emperor Pedro II fell. Subsequently, the Republicans established the Instituto Serologico do Manguinhos, later Instituto Oswaldo Cruz (after his founder's name, himself a former trainee from the Pasteur Institute) which, although strongly influenced by the pasteurian model, maintained its autonomy and fixed its own scientific goals and standards.

The Pasteur Institute was much more reluctant to legitimize a scientific establishment if suggested by a minority group in the Middle East. When the Egyptian doctors Khouri and Zeitoun requested the Pasteur label for their modest Department of Microbiology in Alexandria *(Institut Pasteur d'Egypte),* they did not obtain permission from the rather condescending Dr. Roux[50]. In the 1920s, the criteria for recognition hardened: the scientific director had to be nominated by the Paris Institute, and scientific control was entirely in the hands of the Paris management. Moreover, the new Institute did not receive any financial help and had to subsist through the sale of vaccines and sera (a condition hardly fulfilled by the mother institution!).

Nor was the Pasteur Institute of Palestine, founded in Jerusalem by Leo Boehm (still during the Ottoman period) ever officially recognized as part of the network, in spite of the support given by the pastorian Marmorek, member of the Zionist League. The Institute, called the "International Institute of Public Health"[51], was *"a bond between small Palestine, lost and ignored in the Middle East and the big scientific centers of France and Germany";* it had to face political unrest. It produced bacteriological analyses and smallpox and rabies vaccines. Its bulletin was written in Hebrew and in French (for the Arab doctors).

Another case in point is the Shangai Institute, created in 1928. The initiative came from Chinese students who had studied in France. Money was available from the indemnities paid by China after the Boxer's rebellion. Scientific production was meager. The Shangai labs, without any program of collaboration with Chinese scientists and curriculum for the Chinese, remained second rank centers[52]. For this failure the historian of China Marianne Bastid-Bruguière incriminates the vagueness of the Pastorian project and suggests that addressing the failures rather than successes of the Pastorians would better illuminate the complex nature of Pastorian science. Pastorian science came to fruition only when a local drive for efficiency and adaptation complemented Paris' desire to extend its sphere of influence.

The Paris Institute wanted to keep control of what was going on at its periphery. The colonial Institutes had been primarily established for practical purposes. It remained implicitly granted that the Pasteur

Institutes were devoted to applied research and that Paris was more dedicated to pure research[53]. An independent pavilion in Paris was established to shelter experiments related to tropical pathology but too complex to be done abroad, the so-called Pavillon d'Outremer, directed by Marchoux, who had pioneered in creating the laboratory of microbiology of Saint Louis du Sénégal in 1896[54]. However, the vocabulary commonly in use did not make this distinction. Brami, the general secretary for Indochina, spoke of the *"development of the pasteurian theories and methods."* The pasteurian epistemology ignored the gap between pure and applied science[55] : doctors in the Tropics hoped to make discoveries in proportion to their distance from the metropole in the wilderness of unexplored countries. Remlinger complained from Morocco about the "Europeanlike" pathology of the country:[56] *There is no room here for original research, for pure science"*.

The Institute invested a considerable amount of energy to the periphery; Roux and Calmette, respectively director and vice-director, followed carefully what transpired there. While the Institute underwent a crisis in terms of recruitment and of finances between the two wars[57], the overseas houses appeared more successful. The network was managed by a handful of men who exchanged one place for another: Remlinger left Turkey for Morocco, Blanc left Athens for Teheran, then Teheran for Casablanca, Baltazard Casablanca for Teheran.... From Tunis, Charles Nicolle did not spare his sharp criticisms toward the obsolete management of Emile Roux. Perhaps he dreamt of gathering around him the forces of the empire and becoming the "Emperor of the Mediterranean Sea"[58]. He corresponded with Pasteur Vallery Radot, Pasteur's grandson, and discussed a reorganization of the institution. The Paris Institute, at Emile Roux's death, was lagging behind some of its more brilliant progeny[59].

These difficulties illustrate the paradox of imperialist science. Pasteurianism had based its success on fidelity to a historical model, which was linked to a period of relative grandeur and prosperity for France. The post-independence period saw the Pastorians confronted with the task of maintaining themselves in a new geoscientific space. Then the existence of a Pastorian community (and no longer the attachment to outdated scientific methods) would be their remaining asset. This cultural community transcending new national borders may be strong enough to maintain exchange and mutual recognition and even allow revival, when political circumstances allow it[60].

Once more, the Pastorian institution played with its mixed definition (a **private** institution dedicated to **public** health) and obscured at will the undesirable components of its image. In the period of transition after the independence, it participated in the making of professional local elites, unduly postponed[61]. Not only did most of the colonial Institutes remain, but some new ones appeared, the most well-known being at Bangui (1960) and the Cameroun Institute in Douala, but also in Addis-Abeba in Ethiopia (1953); and a Japanese project in Kyoto is being discussed today.

The Pastorian strategy has reorientated itself. Its historical reference has shifted from outdated scientific methods, once presented like archetypes, to something much more like an *ethos*. The ideological nature of the former scientific discourse is thus recognized and reinforced. Still, a potentially devastating charge has been leveled against this remaining claim: some countries are questioning the universal value of the Western scientific approach. In Moslem countries, the fundamentalists, well aware of the growing divorce between scientific progress and national development, have pointed out the evil character of a science based on materialism and atheism, and medicine has not been immune from their attacks[62]. But even there, the Pastorians could claim that some of their heroes were perfectly aware that they came to restore the harms which civilization had introduced: Jamot, in East Africa, acknowledged, notwithstanding the administration, that colonizers had created the pathways of infection and disrupted the mechanisms of balance of primitive societies[63]. In Cochinchina, the indigens suggested that France had brought smallpox and Calmette took the pains of quoting from ancient local scholars to disprove the charge[64].

The magical tour which, thanks to funding from Aids agencies, transformed a modest Microbiology Institute in Bangui in Central Africa, founded in 1950, to a sophisticated molecular biology lab, is suggestive of a "redéploiement" of the Pastorian ideology and an indirect proof of its remaining vitality[65]. The French anthropologist Bordier used to say: *"Transformism in Medicine is pastorism"* [66]. The metaphor captures the essence of pastorism: adaptation of pasteurian methods to new cultures was its political password as adaptation of virulent cultures was its scientific one. Thus we may understand that this scientific imperialism survived without the Empire. While the content of the pastorian doctrine radically changed, the Pastorians survived on their historical capital. The Pasteur Institute of Paris is no longer a geographical center[67] *"where all microbiological research is coordinated";* but the Pastorians still claim to be at the origin of historical times in Public Health and Medicine.

Centre National de la Recherche Scientifique et Institut National pour la Santé et la Recherche Médicale (U138), Paris

Notes

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[1] In 1990, the network of the overseas Institutes comprised about thirty establishments throughout the world. Every year a meeting of the directors was held, alternatively in Paris and in another Institute. The network was represented by a permanent delegate at the Pasteur Institute in Paris. J.L. Durosoir, L'Institut Pasteur, *Recherche Scientifique,* Les Dossiers de l'Outremer, 1985, 90, p.47-52.

[2] Albert Calmette, promoter of the overseas Institutes and vice-director of the Institute in Paris wrote: "Without Pasteur's discoveries, the development and emancipation of indigenous populations, and the exploitation of their discoveries, colonial expansion of France and other great civilized nations would have been impossible". quoted by N. Bernard, *Microbiologie, L'oeuvre de Pasteur et ses conséquences,* Masson, Paris, 1937, p.6.

[3] For a distinction between Imperialism in Medicine and Medicine in Empire, see *Disease, Medicine and Empire,* R. MacLeod and M. Lewis eds., Routledge, London, 1988, p.1-17.

[4] For a comparison with the British schools on tropical medicine, see M. Worboys, "Manson, Ross and Colonial Medical Policy: Tropical Medicine in London and Liverpool, 1899-1914", in *Disease, Medicine and Empire, op. cit.,* p.21-37; P.E.C. Manson-Bahr, *The History of the School of Tropical Medicine in London 1899-1949,* Lewis, London, 1956; with the Dutch, see *Dutch Medicine in the Malay Archipelago 1816-1942,* G.M. Van Heteren and coll., Rodopi, Amsterdam, 1989.

[5] See R. Dedonder, "Depending on location, the various Institutes differ with regard to their administrative situation. Some are directly linked to the Pasteur Institute in Paris; some in foreign countries have special agreements with Paris; others no longer have formal links. But each time you enter such an Institute you feel immediately the parenthood, even through the smell(!).", *World's Debt to Pasteur,* S. Plotkin ed., Alan Liss, New York, 1985, p.135.

[6] Xavier Polanco, *La science-monde,* La Découverte, Paris, 1989.

[7] C. Salomon-Bayet, *Pasteur et la révolution pastorienne,* Fayard, Paris, 1986; B. Latour, *The Pasteurization of French Society,* Harvard University Press, Cambridge, 1990.

[8] Interesting remarks appear in *Imperial Medicine and Indigenous Societies,* D. Arnold ed., Manchester University Press, Manchester, 1989.

[9] On the history of the Pasteur Institute, see A. Delaunay, *L'Institut Pasteur, des origines à aujourdhui,* Editions France-Empire, Paris, 1962. On the overseas Pasteur Institutes, see H. Mollaret et J. Brossolet, *Alexandre Yersin ou le vainqueur de la peste,* Fayard, Paris, 1985; H. Mathis, *L'oeuvre des Pastoriens en Afrique noire,* Presses Universitaires de France, Paris, 1946.

[10] For a discussion of the national styles in bacteriology (French versus German) see 0. Amsterdamska, "Medical and Biological constraints: early research on variation in Bacteriology", *Social Studies of Science,* 1987, 17, p.657-687.
[11] G. Canguilhem, "L'effet de la bactériologie dans la fin des théories médicales", *Idéologie et rationalité dans l'histoire des sciences de la vie,* Vrin, Paris, 1977, p.55-77.
[12] The history of this still very active and influential institution retains the character of a "hot topic". Research has been made sometimes difficult by the understandable reluctance of some institutions to open their archives; and it has been further complicated by the dispersion of the documents among many countries.
[13] Minutes of the Administrative Council, 22 May 1886, Archives of the Pasteur Institute, Paris, p.2.
[14] L. Pasteur, *Comptes rendus de l'Académie des Sciences,* 1881, 92, p.1383.
[15] The French divide the world into five continents, while the Americans divide it into seven! In 1893, the Administrative Board of the Pasteur Institute registered the departure of three simultaneous missions, Loir in Australia, Le Dantec to Brazil, Calmette in Saigon, while antirabies departments were founded in Algiers and Lisboa. Minutes of the Administrative Council, Pasteur Institute, Paris, 22-2-1893, Archives of the P. I., Paris.
[16] N. Bernard, Lettre au Gouverneur Général d'Indochine, 1924, Archives of the P. I., Paris.
[17] A. M. Moulin, "Révolutions politiques et Révolutions médicales", *Revue du Monde Musulman et de la Méditerranée,* 1989, 52, p.111-123.
[18] See for example the Pastorian appropriation of Laveran's discovery of the malaria agent, Plasmodium, prior to Pasteur's medical work, Ed. et E. Sergent, et L. Parrot, *La découverte de Laveran,* Collection du centenaire de l'Algérie 1830-1930, Masson, Paris, 1931.
[19] C. Marenko et S. Godevarica, *La vaccination des sujets en France 1880-1890,* University of Paris IX, Paris, 1982, unpublished dissertation.
[20] C. Nicolle, "L'Institut Pasteur de Tunis", *Archives de l'Institut Pasteur de Tunis,* 1906, 1, p.5-16; G. Blanc, "L'Institut Pasteur du Maroc", *Archives de l'Institut Pasteur du Maroc,* 1932, 1; P. Remlinger, "L'Institut Pasteur de Tanger", *Maroc Médical,* 1913, 49, p.1-5; N. Bernard, "Les Instituts Pasteur d'Indochine", *Comptes Rendus de l'Académie des Sciences Coloniales,* 1927, p.415-424; R. Wilbert et M. Delorme, "Pastoria, centre de recherches biologiques et d'élevage de singe, Institut Pasteur de Kindia", *Bulletin de la Société de Pathologie Exotique,* 1931, 24, p.131-149; M. Robert, "L'Institut Pasteur de Bangkok", *Bulletin de la Société de Pathologie Exotique,* 1920, 13, p.720-725....
[21] "The Pasteur Institute organizes scientific missions some of which have developed on a permanent basis and constitute the present network." J. L. Durosoir, 1985, *op. cit.*
[22] Rapport Commission Lacroix pour la réorganisation de l'Institut à la mort d'Emile Roux, 1934, also quoted by Dujarric de la Rivière, *Emile Roux,* s.l., s. d., p.301, Archives of the P. I., Paris.
[23] Close to the department for serums and vaccine production.
[24] E. Lagrange, *Monsieur Roux,* Goemaere, Bruxelles, 1954. The epithet Pastorian comes from M. de Fleury, *Pasteur et les Pastoriens,* Paris, 1895.
[25] M. Faure, "Cent ans d'enseignement à l'Institut Pasteur", Colloquium "Les cent ans de l'Institut Pasteur", Paris, 1988.
[26] For a general discussion of technology transfer to the periphery, see D. R. Headrick, *The Tentacles of Progress: Technology Transfer in the eve of Imperialism,* Oxford University Press, Oxford, 1988.

[27] See for example in M. Nicolle, "how one can use an oven, two boxes and a candle to start an operational, if primitive, microbiology laboratory", M. Nicolle and P. Remlinger, *Traité de microbiologie générale,* Doin, Paris, 1902.
[28] *Histoire des médecins et pharmaciens de marine et des colonies,* H. Pluchon, ed. Privat, Paris, 1985, p.222 and sqq.
[29] H. Sieberg, *Eugène Etienne und die franzosische Kolonialpolitik (1887-1904),* Westdeutscher Verlag, Koln, 1968.
[30] H. Brunschwig, *Mythes et réalités de l'impérialisme colonial français,* A. Colin, Paris, 1960.
[31] See Lapeyssonie, *Histoire de la médecine coloniale,* Seghers, Paris, 1984 and also his *Toubib des Tropiques,* Laffont, Paris, 1982.
[32] See interesting comments in A. Tauber, *From Metaphor to Theory,* Oxford University Press, Oxford 1991.
[33] In 1934, Charles Nicolle still recalled his teaching: "those marvellous living beings and patroling cells, their instincts, their weapons, their battles and their tactical fantasmagory." C Nicolle, *Introduction à la carrière de la médecine expérimentale,* Alcan, Paris, 1934, p.19.
[34] N. Bernard, *La vie et l'oeuvre d'Albert Calmette,* La Colombe, Paris, 1961.
[35] "La vaccination antirabique, inséparable de toute activité pastorienne", M. A. Chabaud et R. Néel, Les Instituts Pasteur de Tanger et de Casablanca, *Maroc Médical,* 1963, 456, p.350.
[36] Statuts de l'Institut Pasteur hellénique, Journal officiel, 1er Mars 1920, Article 2.
[37] Archives of the Foreign Office, Paris, File Tunisia, Instruction Publique, **vol.310.**
[38] A. Loir, Archives of the Foreign Office, File Tunisia, Instruction publique, id.
[39] See M. A. Chabaud et R. Néel, *op. cit.,* 1963, 456, p.349-351; R Néel, "L'Institut Pasteur du Maroc", *Presse Médicale,* 1963, 71, p.1783-1785.
[40] Minutes of the Administrative Council, Archives of the P. I., Paris, 24-7-1909.
[41] Rapport sur le fonctionnement de l'Institut Pasteur depuis le ler Novembre 1894, jour de l'inauguration, jusqu'au 31-12-1896, *Bulletin de l'Académie de Médecine,* 1897, 37, p.358.
[42] Notice sur l'Institut Pasteur d'Alger, Carbonel, Alger, 1949.
[43] See A. M. Moulin, "La médecine ottomane à l'heure pastorienne", *La ville dans l'empire ottoman,* P. Dumont et F. Georgeon ed. (forthcoming).
[44] A *zimmi* belongs to a non-Moslem minority group (Jews, Greek Orthodoxes, Armenians ...) that is "protected" by the Sultan.
[45] E. Ihsanoglu's paper, in this book.
[46] M. Ghodssi, "L'Institut Pasteur de l'Iran", *Bulletin de Liaison AAED de l'Institut Pasteur,* Paris, 1964, 22, p.34-41.
[47] P. Mercier, "L'Institut Pasteur hellénique", *Bulletin de Liaison AAED de l'Institut Pasteur, Paris,* 1962, 13, p.54.
[48] Dr Athanasaki to Albert Calmette: (he thanks him) "along with Dr. Roux, to bring your enlightment to create in Greece an accomplishment which will radiate, I hope, extending French influencethrough the entire Orient". Letter, 9 May 1920, Archives of the P. I., Paris.
[49] I. Lowy, "La fièvre jaune à Rio et la mission de l'Institut Pasteur", communication at the Colloquium "Les cent années de l'Institut Pasteur", Paris, 1988.
[50] Lettres de M. Zeitoun et J. Khouri à A Calmette, 8 Octobre 1928, Archives of the P. I., Paris
[51] S. Kottek, Les tribulations de l'Institut Pasteur de Palestine, forthcoming paper.
[52] M. Bastid-Bruguière, "Les Instituts Pasteur de Chine", *Les cent ans de l'Institut Pasteur,* M. Morange ed., La Découverte, Paris (forthcoming).

[53] For a discussion of the question, applied to the case of the Maghreb Institutes, see M.P. Laberge, "Les Instituts Pasteur du Maghreb : la recherche scientifique médicale dans le cadre de la politique coloniale", *Revue Française d'Histoire d'Outre-Mer,* 1987, 274, p.27-42 and her thesis *Politiques scientifiques au Maghreb : l'implantation du système scientifique dans les sociétés maghrébines de 1830 à 1980,* Thèse de lettres, Montréal, 1987.
[54] This laboratory was transferred to Dakar in 1913 and officially recognized as Pasteur Institute in 1923.
[55] See R. Dedonder, director of the Pasteur Institute, in 1985: "There is a continuous thread between the most fundamental discoveries and the practical subjects that Pasteur was confronted with.", *World's debt to Pasteur,* S. Plotkin ed., Alan Liss, New York.
[56] P. Remlinger, *Maroc Médical,* 1913, 49, p.8.
[57] H. Plotz, "Report on the Pasteur Institute", Rockefeller Archive Center, R. F., 1. 1. Box 2, file 16, p.17-19. See A. M. Moulin, "Death and Resurrection of Immunology at the Pasteur Institute (1917-1940)", *Immunology: Pasteur's Inheritance,* P. A. Casenave and P. Talwar eds, East Wiley, forthcoming.
[58] Letter from Etienne Burnet to Charles Nicolle, 1920, Musée de l'Institut Pasteur.
[59] See Pasteur Vallery Radot's report to the Board of the Pasteur Institute, 1933, Archives of the P. I., Paris.
[60] Such examples might be China and Vietnam.
[61] Few natives had reached positions of responsibility, prior to the independence.
[62] Z. Sardar, *The Touch of Midas,* Manchester University Press, Manchester, 1983.
[63] J. P. Dozon, "Quand les pastoriens traquaient la maladie du sommeil", *Sciences Sociales et Santé,* 1985, 3, p.27-56. See early comments on the "germ exchange" promoted by colonization in C Nicolle, *Responsabilités de la médecine,* Alcan, Paris, p.46: "To these imported ills, was added the expansion of particulardiseases for these countries, as a consequence of the civilizing enterprise".
[64] A. Calmette : "I cannot discuss this question in an absolute way". "La Rage en Cochinchine et les vaccinations antirabiques", *Annales de l'Institut Pasteur,* 1893, 6, p.6.
[65] A popular topic: see B. Dyan, "Sur le front de la science et de la santé", *Géo-Science,* 1989, p.134-146.
[66] A. Bordier, "Les microbes et le transformisme", *Bulletin de la Société d'Anthropologie de Paris,* 1988, 11, p.743.
[67] N. Bernard., cf. note 16.

GÉOGRAPHIE ET COLONISATION EN FRANCE DURANT LA TROISIÈME RÉPUBLIQUE (1870-1940)

Daniel DORY

A un moment où - en France tout au moins - les recherches concernant l'histoire des sciences de l'homme connaissent un début[1] d'institutionnalisation et où la parution d'un manuel de base sur l'historiographie des sciences[2] facilitera sans doute l'accès de cette problématique à de nouveaux chercheurs, il nous a paru utile de proposer ici quelques réflexions théoriques et programmatiques portant sur les rapports entre géographie et colonialisme, en France, durant la Troisième République

C'est ainsi qu'après avoir montré en quoi ce thème et cette période présentent un intérêt tout particulier pour l'histoire de la géographie, on fera rapidement le point sur quelques problèmes d'interprétation qui surgissent en l'état actuel des recherches historiques. Enfin un programme visant à combler les lacunes les plus gênantes de la connaissance du sujet sera ébauché.

De la géographie coloniale comme laboratoire

La colonisation moderne a, en quelques décennies, transformé des paysages à une échelle inégalée et à une vitesse inouïe. Elle a conduit au déplacement et à de nouveaux modes de répartition des populations souvent considérables, a introduit certaines cultures vivrières et - surtout - de rente, et a abouti à la marginalisation voire à la disparition de productions agricoles traditionnelles. Des territoires nouveaux émergèrent, dont les frontières se cristallisèrent plus ou moins vite, mais inéluctablement; des villes entières surgirent et de nouveaux villages furent bâtis souvent au bord des routes, elles aussi nouvellement aménagées. Avec elle enfin, les paysages caractéristiques des missions chrétiennes, des entrepôts portuaires, des plantations parfois, virent également le jour. En outre des milliers de mètres cubes de rapports, études, monographies, projets furent produits avant, pendant et après ces bouleversements, qui font de cette période l'un des moments les plus passionnants de l'histoire des relations entre les sociétés et les milieux naturels. On comprend donc aisément la portée de la remarque suivante de Marcel Dubois[3] : *"Quel plus beau champ d'expérience pour la géographie, considérée comme la science des rapports de la terre avec l'homme, que l'étude de la colonisation?"*

P. Petitjean et al. (eds.), Science and Empires, 323–329.

Or force est de constater, d'une part, que l'étude géographique de la colonisation a revêtu en France une importance - tant institutionnelle que épistémologique - sans rapport avec l'ampleur du phénomène qu'elle avait pour objet. Ce fait, sur lequel on reviendra, n'a pas encore reçu d'explication vraiment satisfaisante. Faute, en grande partie, de recherches systématiques en la matière[4].

Mais, d'autre part, on remarquera également le peu d'intérêt dont font preuve les agents de la colonisation - administrateurs, militaires, ... - envers la géographie universitaire de l'époque. Fait très éloquent à cet égard : ce n'est qu'à partir de 1926, date à laquelle Georges Hardy devient directeur de l'Ecole Coloniale (il le restera jusqu'en 1933) que la géographie entre au programme de cette institution[5]. Ce qui ne veut, bien sûr, pas dire qu'auparavant les administrateurs coloniaux n'avaient aucun contact avec la géographie, mais simplement qu'ils n'en avaient pas sous une forme institutionnelle.

D'ailleurs l'utilisation de connaissances **pratiques** en géographie a été mise en évidence tant lors du partage de l'Afrique que lors de la constitution et de la délimitation des territoires coloniaux, sans parler des explorations qui précèdent et suivent cette période, et des projets qui, tels celui du Transsaharien, reposent sur une argumentation de caractère principalement géographique[6].

On sait, par ailleurs, grâce aux études portant sur la géographie en France à la fin du XIXe siècle et au début du XXe, siècle que plusieurs types de géographies coexistent et sont alors en concurrence[7] que l'on peut désigner hypothétiquement de la façon suivante :
- la **géographie historique** dominante à l'Université jusqu'à la fin du XIXe siècle (Himly est professeur de géographie à la Sorbonne jusqu'en 1898);
- la **géographie scolaire** pensée en référence à la version contemporaine de l'économie libérale. C'est le "legs Levasseur" (Rhein);
- la **géographie vidalienne** en voie de constitution ;
- la **géographie coloniale** plus appliquée, mais non dépourvue de références théoriques.

Bien entendu cette distinction n'est en aucun cas à considérer comme comprenant des catégories étanches. En effet, les rapports entre le "legs Levasseur" et la géographie vidalienne seront étroits, notamment par la production de manuels, atlas, cartes murales ... De même la géographie coloniale académique surgira simultanément et dans une mesure non négligeable au sein même du courant vidalien (Dubois aura Vidal comme enseignant à l'Ecole Normale Supérieure et il contribuera régulièrement aux *Annales de Géographie* jusqu'en 1905, date de sa querelle avec Gallois...).

En outre, les activités des diverses sociétés de géographie, sur lesquelles ou reviendra, apparaissent comme transversales aux quatre modalités de la géographie évoquées plus haut.

On le voit, élaborer la démarche consistant à interroger le statut de la géographie coloniale au cours de cette période a non seulement un prodigieux intérêt **historique et théorique**, mais encore permet de mieux saisir les enjeux actuels des démarches qui, sous l'enseigne de la géographie tropicale et/ou du développement, poursuivent l'étude, voire l'aménagement des mêmes territoires.

Quelques problèmes tenant à l'état actuel de l'historiographie

Il ne peut être question ici que de proposer quelques exemples de problèmes cruciaux et pourtant impossibles à élucider en l'état actuel des connaissances.

Tout d'abord, il convient de citer le rôle exact des sociétés de géographie dans l'émergence et l'affirmation de la géographie académique en général et coloniale en particulier.

Pour ce qui est de la première, N. Broc (1974) après avoir signalé que *"la période 1870-1890 demeure l'âge d'or de ces associations"* (p.550), écrit :

"C'est en grande partie sous la pression des sociétés de géographie (...), que les pouvoirs publics vont être amenés à organiser en France un véritable enseignement supérieur de la géographie" (Broc, 1974 p.552).

D'autre part, dans un article extrêmement stimulant, C. Rhein, après avoir évoqué la géographie des historiens universitaires et celle, scolaire, du "legs Levasseur" affirme :

"Une troisième conception de la géographie est celle d'une géographie purement pratique et strictement utilitaire, mise au service des intérêts commerciaux et de la cause coloniale : cette conception est **évidemment** bannie des institutions académiques et universitaires, **puisqu'elle** est essentiellement celle que les sociétés de géographie pratiquent" (Rhein, 1982, p.235) (souligné par nous).

Ces deux citations ne sont pas nécessairement antinomiques. Leur juxtaposition même peut permettre de progresser en avançant une hypothèse basée sur trois propositions :

a - Il existe au cours de la seconde moitié du XIXe siècle un essor considérable de l'intérêt pour la géographie - notamment axé sur les explorations et les terres exotiques - qui a créé un climat favorable à l'éclosion et au développement de nombreuses sociétés de géographie;

b - Ce courant s'est fait l'avocat d'un enseignement rénové de la géographie dans un contexte idéologique libéral et politique marqué par la défaite de 1870 où la volonté de revanche en Europe et les entreprises coloniales outre-mer apparaissaient parfois contradictoires, et surtout étaient véhiculées par des couches différentes de la classe dominante[8] de l'époque;

c - Pour se traduire au plan de l'enseignement supérieur, il fallait à cette nouvelle géographie à la fois marquer une continuité avec les préoccupations "désintéressées" des historiens[9], par ailleurs très européo-centrées[10], mais également parler du monde actuel dont la colonisation était justement un aspect des plus importants.

Le résultat sera un hybride instable, tant au plan académique que théorique.

- Au **plan académique,** Marcel Dubois est le premier géographe à devenir professeur en Sorbonne, mais dans une chaire subventionnée par le Ministère des Colonies (1893).

- Au **plan scientifique,** dans sa leçon inaugurale, Marcel Dubois, après avoir mentionné le rôle des sociétés de géographie (1893, p.125)[11], fondera ensuite la légitimité scientifique de la géographie surtout sur les progrès des sciences naturelles, et revendiquera une approche franchement naturaliste pour la discipline (p.126-127) : *"C'est la science d'analyse des caractères physiques d'une colonie, ce n'est pas l'art d'en donner des tableaux pittoresques, qui nous indiquera sa destinée"* (Ibid p.134). Or cette insistance sur les données naturelles - justifiant la légitimité de la géographie comme science, distincte de l'histoire - fera manquer à cette géographie coloniale académique l'appréhension des faits sociaux, au cours d'une dérive où le déterminisme vulgaire le plus souvent climatique prendra une importance considérable.

De cette dérive déterministe l'ouvrage de G. Hardy intitulé *Géographie et colonisation* (1933) constitue un témoignage particulièrement frappant. A titre d'exemple du raisonnement mis en oeuvre, citons le passage suivant[12], choisi parmi bien d'autres très similaires :

"La Colombie, l'Equateur, le Pérou, la Bolivie, qu'on groupe généralement sous le nom de pays andins, rentrent nettement dans la zone intertropicale. C'est dire que leur peuplement européen apparaît, dès l'abord, comme un paradoxe. Mais, comme le relief est ici fort accusé, leur climat n'est pas sans nuances, et ce sont ces nuances qui expliquent tout".

Des recherches approfondies seraient à mener sur le point de savoir dans quelle mesure cette pauvreté de la démarche géographique est à mettre en rapport avec l'affirmation contemporaine et à ses "frontières" d'une éthnologie ambitionnant à rendre compte de la totalité du champ social.

A la fin du XIXe siècle et au début du XXe siècle coexistent donc dans l'université française deux géographies porteuses de projets scientifiques qui pour n'être point contradictoires n'en sont pas moins distinctes. La géographie générale vidalienne (surtout centrée sur la France, et dans une moindre mesure l'Europe) tout d'abord. Sa légitimité scientifique repose sur des bases naturalistes dont l'interprétation s'opère de façon restrictive au moyen d'une conceptualisation assez faible des faits sociaux (en regard de la sociologie qui se développe sur ses marges...). Le tout débouchant sur une très fragile synthèse régionale à usage essentiellement scolaire.

D'autre part, on a affaire à une géographie coloniale académique, elle aussi recourant à une légitimation naturaliste, mais beaucoup moins nuancée, à un moment où le public auquel elle s'adresse a de moins en moins besoin de données naturalistes pures, les problèmes coloniaux devenant très rapidement essentiellement sociaux[13]. En outre, le lieu privilégié de la "production - consommation" de la géographie coloniale se fera à partir de 1889 à l'Ecole Coloniale, donc en dehors de l'Université proprement dite (et ce, bien avant que la géographie y soit inscrite en tant que telle au programme).

Ce moment de coexistence débouchera sur une hégémonie du courant vidalien qui marginalisera **au plan académique** la géographie coloniale telle que l'enseignait notamment Marcel Dubois; et cette hégémonie durera jusqu'à la fin de la période qui nous intéresse ici. Mais d'autre part, on peut soutenir que l'oeuvre de colonisation, dans ses projets et ses problèmes scientifiques et pratiques, aboutira à la marginalisation de la géographie dans son ensemble - alors que le paradigme vidalien est dominant - réduite à un simple compte-rendu d'influences climatiques plus ou moins mécaniquement déterminantes (ex. : Hardy). Cette issue s'expliquant en grande partie par l'échec tant de Vidal que de Dubois dans l'élaboration d'une théorie géographique consistante des relations complexes intervenant à l'interface nature/sociétés.

C'est ainsi que, tout compte fait, le formidable laboratoire, ou champ d'expériences, que la colonisation aurait pu être pour forger une théorie géographique fondamentale a été gâché. L'ethnologie s'est alors emparée sans concurrence du social exotique, et la sociologie du champ social européen, processus faisant écho à la "tropicalisation" des diverses sciences naturelles. C'est qu'une géographie sans théorie propre ne pouvait être qu'une discipline auxiliaire ou un savoir d'appoint. En fait, elle sera les deux sans guère de profit pour son développement ni pour son prestige intellectuel.

Les conditions dans lesquelles, quelques décennies plus tard, une version académique de la géographie coloniale/tropicale se manifestera, notamment dans l'oeuvre de P. Gourou, s'expliquent, au moins partiellement, par ces antécédents. Mais ceci relève déjà d'une autre histoire que celle de la géographie sous la Troisième République.

Vers un programme de recherches

Les considérations qui précèdent, bien que très vraisemblables en l'état actuel des connaissances, nécessitent pour être définitivement vérifiées (ou infirmées), la réalisation d'une quantité importante de travaux, à mener de façon organisée et dans une perspective synthétique

Parmi les domaines où l'urgence apparaît la plus grande, mentionnons les trois suivants :

- une **recherche prosopographique** comparée sur les interférences entre sociétés de géographie et groupes de pression coloniaux, tant politiques (le parti colonial) qu'économiques (Chambres de commerce, ...);
- des **études scientométriques** permettant d'avoir une vision quantitative des publications géographiques consacrées à des sujets coloniaux, ventilées par thèmes et par régions du monde;
- l'élaboration de solides **biographies** d'un certain nombre de personnages-clés de la géographie coloniale, tels Marcel Dubois, Georges Hardy, Pierre Foncin, Henri Labouret...

L'heure nous semble en venue où la recherche en histoire de la géographie peut, grâce à ses acquis déjà considérables, se proposer d'approfondir des questions stratégiques. Les avatars de la géographie coloniale française durant la Troisième République constituent à cet égard une source particulièrement féconde d'hypothèses portant sur les relations d'un savoir scientifique en voie de constitution avec un phénomène qui bouleverse littéralement la face du monde.

Intergéo-CNRS, Paris

Notes

[1] La Société Française pour l'Histoire des Sciences de l'Homme fut fondée à Paris en 1986. Une première manifestation de ses activités a débouché sur la publication d'un numéro spécial de la *Revue de Synthèse,* n° 3-4, 1988 comprenant outre des articles théoriques, des contributions concernant la linguistique, la géographie, l'ethnologie, la psychologie et la psychologie sociale.

[2] Kragh, H., *An introduction to the historiography of science,* Cambridge University Press, Cambridge, 1987.

[3] Dubois, M., "Leçon d'ouverture du cours de géographie coloniale", *Annales de Géographie,* T. III, 1893-1894, p.133.

[4] C'est afin d'amorcer cette étude systématique de la géographie coloniale, puis tropicale, qu'une première table ronde fut réunie à Paris (en 1987) afin de confronter les approches de chercheurs d'origines disciplinaires diverses et de produire des matériaux de base permettant de poursuivre la réflexion. Cf Bruneau, M., et Dory, D., (eds.) *Les enjeux de la tropicalité,* Masson, Paris, 1989.

[5] Voir sur ce point : Cohen, W. B., *Empereurs sans sceptre,* Berger Levrault, Paris, 1973, p.132-138 et 144.

[6] Cf. Pourtier, R., "Les géographes et le partage de l'Afrique", *Hérodote,* 41, 1986, p.91-108. Carrière, B., "Le Transsaharien, histoire et géographie d'une entreprise inachevée", *Acta Geographica,* 74, 1988, p.23-38.

[7] Voir, notamment, Berdoulay, V., *La formation de l'Ecole Française de Géographie (1870-1914),* Bibliothèque Nationale, Paris, 1981. Broc, N., "L'Etablissement de la géographie en France : diffusion, institutions, projets (1870-1890)", *Annales de Géographie,* **vol.83,** 459, 1974, p.545-568, Rhein, C., "La géographie, discipline scolaire et/ou science sociale? (1860-1920)", *Revue Française de Sociologie,* **vol.XXIII,** 1982, p.223-251

[8] Cette question a été, entre autres, abordée dans : Dory, D., *A propos de quelques problèmes théoriques de l'histoire de la géographie,* Union Géographique Internationale, Conférence Régionale de Barcelone, 1986. Voir également : Mayeur, J. M., *Les débuts de la Troisième République, 1871-1898,* Ed. du Seuil, Paris, 1973 (surtout p.124-133); Rebérioux, M., *La République radicale? 1898-1914,* Ed. du Seuil, Paris, 1975, p.117-156; et surtout Girardet, R., *L'idée coloniale en France de 1871 à 1962,* La Table Ronde, Paris, 1972 (réimprimé dans la collection Pluriel en 1986).

[9] On aurait cependant tort de poser une simple équivalence entre science académique et science désintéressée, comme en témoigne, par exemple, le rôle et la place de l'enseignement universitaire de l'économie politique.

[10] Voir à cet égard le témoignage de Hubert Deschamps dans la préface au livre de W. B. Cohen, *op. cit.,* p.8; Cf également : Deschamps, H. *Roi de la brousse, mémoires d'autres mondes,* Berger Levrault, Paris, 1975.

[11] Le rôle des sociétés de géographie est analysé par McKay, D. V., "Colonialism in the French Geographical Movement, 1871-1881", *The Geographical Review,* **vol.33,** n° 2, 1943, p.214-232. Pinchemel, P., "Les sociétés savantes et la géographie", *Actes du 100ème congrès national des sociétés savantes,* C.T.H.S. - Bibliothèque Nationale, Paris, 1976, p.69-78. A noter également que la prochaine publication de la thèse de D. Lejeune constituera un jalon important dans la recherche sur ces questions, Cf. Lejeune, D., "Les sociétés de géographie en France, dans le mouvement social et intellectuel du XIXe siècle" (Compte-rendu de thèse), *L'Information Géographique,* **vol.5.3,** 1989, p.84-85.

[12] Hardy, G., *Géographie et colonisation,* Gallimard, Paris, 1933, p.46. Rappelons au passage que G. Hardy sera directeur de l'Ecole Coloniale de 1926 à 1933.

[13] Nous empruntons des éléments de cette hypothèse à l'article de Pourtier, (1986), *op. cit.,* surtout p.100-101.

LA FRANCE ET L'ÉMERGENCE DES SCIENCES MODERNES AU CANADA FRANÇAIS (1900-1940)

Raymond DUCHESNE

L'émergence des sciences modernes au Canada français, au cours de la période qui va de 1900 à 1940, fournit l'exemple, assez rare me semble-t-il, d'une situation où des facteurs culturels suffisent seuls à favoriser l'impérialisme scientifique, en l'absence de liens économiques ou politiques étroits.

Il n'y a pas à chercher bien loin les causes du rapprochement culturel et scientifique entre la France et le Canada français. Ici, deux ambitions se rencontrent. Dans la période qui entoure la Première Guerre, l'impérialisme culturel semble un élément dominant de la politique étrangère française, objectif auquel les milieux universitaires et intellectuels vont apporter leur soutien. Par exemple, dans la correspondance du rectorat de l'Université de Paris, des doyens de la Faculté des Sciences et de la Faculté de Médecine, on retrouve la trace d'une préoccupation très vive pour tout ce qui a trait au rayonnement culturel et scientifique de la France dans le monde. Le quai d'Orsay a-t-il à cette époque une intention particulière à l'égard du Canada? On ne saurait l'affirmer, même si des travaux récents nous portent à le croire[1]. Chose certaine, même en l'absence d'une telle politique, l'initiative des recteurs, des doyens et des professeurs eux-mêmes y aurait suppléé. En fait, la France universitaire ne semble attendre qu'une ouverture pour pratiquer au Canada sa politique commune de diffusion de la langue et de sa culture.

Dans le domaine scientifique, cette ouverture lui sera offerte en 1920 lors de la réforme des universités françaises du Canada. Grâce à des liens déjà anciens - qu'il serait trop long de rappeler ici -, l'Université française jouit au Canada d'un prestige inégalé. Les médecins canadiens, particulièrement, sont francophiles et ce sont eux qui vont pousser les universités canadiennes à rechercher activement la coopération de la France. Deux citations suffiront à illustrer l'état d'esprit qui prévalait au début de la coopération franco-canadienne. Celle d'André Honnerat d'abord, Ministre français de l'Education, qui déclare, peu après la Première Guerre[2] :

"La France, aux heures sombres de son histoire, a appris à connaître ses amis véritables à l'étranger : ils étaient tous de ses anciens élèves".

P. Petitjean et al. (eds.), Science and Empires, 331–338.

Ce à quoi le doyen de la Faculté de Médecine de Montréal répond :

"Les Canadiens français réalisent plus que jamais qu'ils ne peuvent, par leurs seuls efforts, continuer à faire bloc solide et réussir sans le secours de la France, à montrer aux Américains qu'ils sont capables de rester en Amérique les défenseurs de l'idéal français dans les domaines littéraires et scientifiques".

Les moyens du rapprochement scientifique entre les deux pays

L'influence française sur les sciences modernes au Canada français s'exercera de bien des manières. Nous n'examinerons ici que les trois principaux véhicules de cette influence : l'engagement de professeurs français, les bourses d'Europe et l'Institut Scientifique Franco-Canadien. A compter de 1920, on réorganise l'enseignement supérieur des sciences du Canada français[3]. A Québec, l'Université Laval crée l'Ecole Supérieure de Chimie, qui est, en fait, l'embryon d'une faculté des sciences. De son côté, l'Université de Montréal crée une véritable faculté des sciences.

A Québec comme à Montréal, les programmes et les diplômes sont français : les certificats couronnent une année d'études spécialisées dans une discipline (i.e. physique, zoologie, botanique, chimie, etc.) et l'étudiant obtient la licence ès sciences en cumulant trois certificats. Le doctorat ès sciences complète le cycle des études. On offre également à Montréal le certificat P. C. N., obligatoire pour les étudiants en médecine. Les programmes sont à ce point semblables que, par un décret de 1923, le Gouvernement français accorde l'équivalence aux licences ès lettres, sciences et droit de l'Université Laval et de l'Université de Montréal. On ne sait trop pourquoi, les universités canadiennes réclament également - et obtiennent - pour leurs diplômés le droit de concourir aux épreuves de l'agrégation.

Pour réformer les universités canadiennes, les professeurs canadiens ne suffisent pas. On doit faire appel à l'étranger. L'effort le plus systématique en ce sens est fait par l'Université Laval qui engage une demi-douzaine de jeunes professeurs, des chimistes pour la plupart, fraîchement diplômés de l'Université Catholique de Fribourg[4]. Certains n'enseigneront que quelques années au Canada, d'autres y feront toute leur carrière. On recrute également quelques professeurs en Belgique.

Mais c'est surtout en France que l'on recherche des candidats. Dès la création de la Faculté des Sciences de l'Université de Montréal, la chaire de biologie est confiée à Louis-Janvier Dalbis. Jusqu'alors professeur au Collège Stanislas de Paris, Dalbis est davantage un pédagogue qu'un chercheur. Au Canada, il se distinguera par son action en faveur d'un rapprochement avec la France dans le domaine de l'éducation et des sciences. En 1931, un autre professeur français lui succède : Henri Prat, de l'Ecole Normale Supérieure, qui se spécialisera en microcalorimétrie appliquée aux phénomènes biologiques. En 1927, le professeur Pierre Masson, de l'Université de Strasbourg, accepte la chaire d'anatomie pathologique à la Faculté de Médecine de l'Université de Montréal. Déja réputé pour ses travaux en neurologie, le docteur Masson aura une influence durable sur le développement de l'anatomie pathologique au Canada français. Son ancien collègue de Strasbourg, le docteur Louis Berger, enseigne à Laval.

L'influence française passe également par les jeunes Canadiens qui, de plus en plus nombreux, font des études en France. A compter de 1920, leur nombre s'accroit grâce à l'intervention du Gouvernement de la province de Québec qui adopte la loi "pour aider les élèves gradués à suivre des cours additionnels". Cette loi, que l'on n'appellera plus autrement que la loi des "bourses d'Europe", doit permettre à de jeunes diplômés des universités du Canada français de poursuivre des études[5] à l'étranger. On souhaite ainsi constituer une relève où les universités pourront recruter leurs professeurs. Les recteurs sont d'ailleurs invités chaque année à proposer leurs candidats.

A l'origine, le prestige de la Sorbonne est tel que la loi oblige les boursiers à étudier à Paris. Même si un amendement de 1922 lève cette obligation, la capitale française continue d'avoir la préférence des étudiants canadiens. En 1925, par exemple, sur 45 boursiers du Québec en Europe, 33 étudient à Paris[6]. Cette proportion se maintiendra jusqu'à la Deuxième guerre. Pour encourager les boursiers à étudier à Paris, quelques personnalités canadiennes fondent en 1926 la Maison des étudiants canadiens à la Cité universitaire, la première maison nationale, inaugurée d'ailleurs en grande pompe par le Président de la République et le Prince de Galles. Les bourses sont offertes aux étudiants de toutes disciplines, y compris les beaux-arts et la musique. Toutefois les médecins et les scientifiques sont favorisés : entre 1920 et 1960, date où la loi est abrogée, ces deux groupes se voient accorder 56% des bourses. En 1930, par exemple, on compte à Paris une vingtaine d'étudiants en médecine venus "faire une spécialité" auprès de patrons français. On remarque le docteur Arthème Breton, de la Faculté de Médecine de l'Université de Montréal, qui se spécialise en bactériologie à l'Institut Pasteur. Quelques scientifiques aussi, dont le chimiste Léon Lortie, qui soutient à la Faculté des Sciences de Paris une thèse sur les terres rares avec le chimiste Georges Urbain. Pour sa part, le géologue J. Willie Laverdière, de l'Université Laval, préfère étudier à l'Université Catholique de Lille avec le chanoine G. Delépine.

Pour compléter l'action des professeurs français et des Canadiens diplômés des universités françaises, on crée en 1926 un instrument particulièrement efficace de l'influence française : l'Institut Scientifique Franco-Canadien[7]. Le but de l'Institut est de resserrer les liens intellectuels entre la France et le Canada en invitant des universitaires à donner des cours ou des conférences dans le pays hôte. Dans les faits, cependant, l'ISFC va surtout servir à assurer la présence de la science française au Canada. Créé à l'initiative de Louis-Janvier Dalbis et d'Edouard Montpetit, secrétaire de l'Université de Montréal, l'ISFC est subventionné par les gouvernements québecois et français.

Sous la présidence de Dalbis, l'ISFC est officiellement inauguré le 27 janvier 1927. Pour la circonstance, on a invité le philosophe Etienne Gilson, qui enseigne alors à Harvard, à prononcer une conférence sur Saint Bernard. Même si la philosophie est à l'honneur à cette occasion, un bon nombre de conférenciers et de maîtres invités par la suite seront des scientifiques et des médecins. Entre 1927 et 1940, ces deux groupes représentent plus de 40% des maîtres français invités au Canada, dépassant les philosophes (25%) et les professeurs de lettres (20%)[8]. Le programme typique des Français invités au Canada comprend un cours de dix ou douze leçons, habituellement réservé aux étudiants avancés, quelques conférences publiques, consacrées soit à des sujets scientifiques, soit à des questions d'actualité, et enfin, une tournée des universités canadiennes ou américaines de l'Est.

En février 1927, le premier professeur invité par l'ISFC est le chanoine Delépine, qui donne une douzaine de leçons de géologie générale à l'Ecole Polytechnique de Montréal. Il est suivi par un professeur de l'Université de Strasbourg, le docteur L. Boez, qui donne un cours général de bactériologie à la Faculté de Médecine de l'Université de Montréal. Assez souvent, le professeur invité se partage entre les trois grandes universités du Québec : Montréal, Laval et McGill. C'est le cas du docteur Cyrille Jeannin qui, à l'automne de 1928, donne une série de leçons d'obstétrique à Laval et à Montréal. Les physiciens et les ingénieurs profitent également des activités de l'ISFC. Dès 1927, Léon Brillouin donne à l'Université de Montréal et à McGill quelques conférences sur les plus récents développements de la physique. Au début de 1929, l'ingénieur Pierre Franck donne un cours d'aéronautique à l'Ecole Polytechnique. A l'automne de la même année, c'est au tour du physicien Jean Cabannes de donner à l'Université de Montréal un cours général sur les ondes électromagnétiques.

Instrument du rayonnement culturel de la France, l'Institut heurte quelques susceptibilités. Chez les catholiques intégristes, l'Université française inquiète encore : *"nous envoyons des jeunes gens en France"*, peut-on lire dans une revue ultra-catholique[9], *"ils nous reviennent désaxés. En matière religieuse et sociale, la lumière vient de Rome, non de Paris, ni de Lyon"*. Chez les nationalistes aussi, on grogne un peu. A l'Université Laval, qui hésite à appuyer l'Institut, au moins un doyen affecte[10] d'y voir le *"colonialisme intellectuel dans toute son intégrité"*. La plus forte attaque viendra cependant d'un professeur de l'Université de Montréal, le Frère Marie-Victorin. En 1936, celui-ci s'en prend publiquement à Dalbis et à l'Institut pour avoir détourné des sympathies et des ressources qui auraient dû aller à l'Acfas. *"Dans un pays"* écrit-il[11],

> "où tant de choses sont à créer dans l'ordre intellectuel, rien ne vaut que ce qui peut durer suffisamment pour faire école, et il ne faut pas demander à un conférencier de faire école. Consacrée au développement non pas uniquement de la science française, mais de la science tout court, l'Acfas se propose de mettre nos jeunes Canadiens français à l'école des maîtres, mais dans des conditions où le contact soit assez long et assez intense pour allumer définitivement la flamme".

Cette sortie, inspirée d'ailleurs en bonne partie par des rivalités personnelles, sera exceptionnelle. Dans l'ensemble, l'action de l'ISFC est très bien accueillie au Canada français.

En invitant ainsi cinq ou six professeurs français chaque année, de 1927 au milieu des années 60, l'ISFC constitue le principal instrument de la présence scientifique française au Canada. Bien sûr, son influence diminue avec les années, à mesure que la communauté scientifique québécoise prend de l'importance et de la maturité, mais au moins jusqu'à la guerre, l'ISFC demeure une institution culturelle et scientifique de première importance au Canada français.

Les résultats du rapprochement

Quels ont été les effets durables de l'influence française sur les sciences modernes au Canada français? Il est certain que les liens tissés depuis le XIXe siècle par les intellectuels canadiens et français, l'habitude prise par les médecins canadiens de compléter leur formation à Paris, l'influence des maîtres français enseignant dans les universités canadiennes, les bourses d'Europe et les activités de l'ISFC, tout cela a assuré à la science française au Canada une présence disproportionnée avec son importance réelle dans le monde entre les deux guerres. En d'autres mots, la France a joué au Canada français un rôle qui autrement serait allé à la Grande-Bretagne ou aux Etats-Unis. Le développement des sciences au Canada anglais le démontre amplement[12]. Mais, plus concrètement, quels ont été les effets durables de ce rôle joué par la France en tant que métropole scientifique?

Des contemporains ont insisté sur le fait que les professeurs français et les Canadiens qui avaient complété leur formation en France ont contribué activement à l'institutionnalisation de la recherche dans les universités du Québec. Ce sont, en effet, les anciens d'Europe qui ont les premiers créé des laboratoires, des équipes de recherche, des revues scientifiques, etc, au Canada français, ayant rapporté de France l'idéal et les habitus de la recherche, partie intégrante des moeurs universitaires. Toutefois, il faut reconnaître que le résultat eut été le même si le modèle avait été américain, britannique ou allemand. D'ailleurs, le comportement des chercheurs canadiens-français formés ailleurs qu'en France ne se distingue pas sous ce rapport[13].

C'est au plan institutionnel que les rapprochements entre la France et le Canada sont les plus frappants. On a déjà noté l'équivalence des programmes et des titres universitaires. On sent également influence de la France dans l'organisation générale des institutions d'enseignement et de recherche. Dès le tournant du siècle, Montréal a son Ecole Polytechnique et son Ecole des Hautes Etudes Commerciales. On y ajoutera par la suite un Institut du Radium, affilié à celui de Paris, et un Institut de Microbiologie, dont le modèle déclaré est l'Institut Pasteur. Dans les facultés de l'Université Laval et de l'Université de Montréal, on crée des "instituts" plutôt que des départements, selon l'habitude nord-américaine.

Mais, outre cette parenté de forme, l'influence française se fait-elle sentir plus profondément dans l'enseignement et la recherche au Canada entre 1920 et 1940? Il semble bien que, malgré tous les efforts en ce sens, la présence de maîtres français n'ait pas eu d'effets durables. Remarquons que la médecine y aurait été plus sensible que les disciplines scientifiques. En 1934, le doyen de la Faculté de Médecine de Laval déclare[14] :

"avouons-le sans fausse honte, nous aurons pendant longtemps encore besoin des leçons qui nous viennent du dehors, et la sympathie active de l'Ecole française doit nous être un réconfort et un appoint considérable".

Et un observateur de cette époque affirme[15] que *"c'est par leurs médecins que les deux pays se ressemblent le plus"*. Ce sentiment semble assez généralement partagé, mais il est difficile de voir sur quoi il se fonde réellement. Dans les sciences où la recherche progresse le plus, soit la chimie, la botanique et la microbiologie, on ne trouve que des signes fugaces d'une influence française. Les chimistes canadiens formés en France entretiennent quelques liens avec leurs anciens maîtres et publient quelques travaux, seuls ou avec des chercheurs français, dans les *Comptes rendus de l'Académie des sciences* et les *Annales de Chimie*. Les botanistes[16], au contraire, dominés par le Frère Marie-Victorin, personnalité scientifique de premier plan, sont exclusivement tournés vers l'école américaine de systématique et d'écologie. En microbiologie, l'influence française, défendue par les professeurs et les anciens élèves canadiens de l'Institut Pasteur, dispute longtemps la première place à l'influence américaine. Peu avant la guerre, la France paraît l'emporter lorsque le docteur Léopold Nègre, de l'Institut Pasteur, collabore activement à la création de l'Institut de Microbiologie de Montréal, et lorsque les Services de Santé du Québec adoptent le bacille Calmette-Guérin dans la lutte contre la tuberculose, de préférence aux vaccins américains[17]. Mais la guerre met un terme à la coopération entre les chercheurs français et canadiens. Ceux-ci se tournent alors définitivement vers les Etats-Unis.

Conclusion

L'histoire de la microbiologie illustre, en raccourci, celle de l'influence scientifique française au Canada. Très présente au moment où l'enseignement supérieur des sciences s'organise, la France fournit les modèles et les cadres. Mais la recherche elle, est encore trop peu développée pour subir les effets durables de cette influence.

Au moment où elle commence réellement à émerger et où les chercheurs canadiens pourraient avec profit se tourner vers la France survient la brutale rupture entraînée par la Deuxième guerre mondiale. Les professeurs français sont rappelés en Europe et les étudiants canadiens prennent le chemin des universités américaines. La relation privilégiée que le Canada français entretenait avec la science française se réduit à presque rien. Tout au plus quelques savants français réfugiés au Canada après la débâcle de 1940 réussissent-ils à maintenir une présence française. Parmi eux, on remarque quelques anciens collaborateurs de Frédéric Joliot-Curie, comme Pierre Auger, Hans von Halban et Lew Kowarski, qui participent aux recherches angloaméricaines sur l'énergie atomique à Montréal. A la fin de la guerre, la nomination du physicien français Marcel Rouault, spécialiste de la diffraction des électrons dans les gaz, à la tête du Département de physique de l'Université de Montréal, où il est chargé de réorganiser les études et de développer la recherche, constitue un fait exceptionnel. Développant les liens noués à l'occasion de la guerre, les savants du Canada français se tournent désormais vers les Etats-Unis en tant que métropole scientifique.

Université du Québec en Abitibi-Témiscamingue

Notes

[1] Jacques Portes, *La France, quelques Français, et le Canada, 1850-1870,* thèse de 3ème cycle, Université de Paris I, 1974.

[2] Archives nationales, AJ16-6703, Faculté de Médecine de Paris.

[3] Sur l'histoire des sciences au Canada français : Luc Chartrand, Raymond Duchesne et Yves Gingras, *Histoire des sciences au Québec,* Montréal, 1987; Raymond Duchesne, *La science et le pouvoir au Québec, 1920-1965,* Québec, 1978.

[4] Danielle Ouellet, *Adrien Pouliot,* Québec, 1986, p.92-93.

[5] Luc Roussel, *Les relations culturelles du Québec avec la France, 1920-1965,* thèse de Ph. D., Université Laval, 1985, p.31-44; Raymond Duchesne, "D'intérêt public et d'intérêt privé : l'institutionnalisation de l'enseignement et de la recherche scientifiques au Québec (1920-1940)", dans *L'avènement de la modernité culturelle au Québec,* sous la direction de Yvan Lamonde et Esther Trépanier, Québec, 1986, p.209 et sq.

[6] Roussel, *op. cit.,* p.34

[7] L'Institut Scientifique Franco-Canadien a fait l'objet de recherches récentes : Chartrand et al., p.253-257; Jean-Claude Guédon, "L'Institut Scientifique Franco-Canadien : élites, culture et vulgarisation scientifique", *Protée* 16, 1988, p.67-75; Lewis Pyenson, "Pure Learning and Political Economy: Science and European Expansion", in R. P. W. Visser, H. J. M. Bos, L. C. Palm, H. A. M. Snelders (eds.), Proceedings of the Utrecht conference on *New Trends in the History of Science,* Amsterdam, 1989, Rodopi, p.260-266.

[8] Roussel, *op. cit.,* p.54

[9] *Notre temps,* 7 février 1953.

[10] Roussel, *op. cit.,* p.85.

[11] *Le Devoir,* 26 septembre 1936.

[12] Lewis Pyenson, "The Incomplete Transmission of a European Image : Physics at Greater Buenos Aires and Montreal, 1890-1920", *Proc. of the American Philosophical Society* 122, 1978, p.92-114; Yves Gingras, "The Institutionalization of Scientific Research in Canadian Universities: The Case of Physics", *Canadian Historical Review* 67, 1986, p.181-194.

[13] Duchesne, "D'intérêt public...", *op. cit.,* p.209-211.

[14] Roussel, *op. cit.,* p. 56

[15] Armand Yon, *Le Canada français vu de France (1830-1914),* Québec, Presses de l'Université Laval, 1975., p. 118.

[16] Robert Rumilly, *Le Frère Marie-Victorin et son temps,* Montréal, 1949.

[17] Alain Stanké et Jean-Louis Morgan, *Ce combat qui n'en finit plus. Un essai sur la vie et l'oeuvre du microbiologiste canadien Armand Frappier,* Montréal, 1970.

AUTOUR DE LA MISSION FRANÇAISE POUR LA CRÉATION DE L'UNIVERSITÉ DE SÃO PAULO (1934)

Patrick PETITJEAN

Lors de la fondation de l'Université de São Paulo (USP) en 1934, une grande partie des enseignants du noyau central, la Faculté de Philosophie, Sciences et Lettres (FFCL), a été engagée en Europe[1]. La participation de ces missions étrangères a souvent été décrite de manière apologétique, particulièrement pour la période de 1934 à 1938.

Les missions étrangères de l'USP ne sont pas brusquement sorties du néant. Il n'y a pas eu les indiens, les bandeirantes, et puis la FFCL-USP, avec ses étrangers. Il s'agit de repérer comment la mission française, en particulier, s'est formée, de quelles stratégies et de quel contexte elle est le fruit; comment aussi elle s'est insérée dans les projets et les contradictions qui ont marqué les premières années de l'USP, quel espace elle y a occupé.

Les premières coopérations (1908-1925)

Le ***Groupement des Universités et Grandes Ecoles de France pour les Relations avec l'Amérique Latine*** est un organisme fondé en 1907 au Collège de France à Paris, à l'initiative de scientifiques, en vue de développer le "rayonnement intellectuel français" dans les universités latino-américaines. Autour du Doyen de la Faculté de Sciences de Paris, il regroupe des représentants de la plupart des institutions scientifiques. Sa finalité est double : d'un côté le développement de la coopération universitaire, de l'autre la concurrence avec l'Allemagne, c'est-à-dire une stratégie "d'expansion intellectuelle" dans le cadre de la rivalité entre les puissances européennes[2].

Pendant plus de 30 ans, le Groupement essaiera, sous diverses formes, de développer l'influence universitaire française en Amérique latine[3]. Il prendra appui sur la place de la langue et de la culture françaises en Amérique latine, plus que sur le rôle diplomatique ou économique de la France dans la région. Au Brésil particulièrement, la mission artistique française de 1816 reste l'acte fondateur de la présence française dans ce pays, et est l'étalon avec lequel on mesure la réussite d'une coopération. Sur le plan proprement scientifique, après l'époque des voyageurs naturalistes, l'Empereur Pedro II avait engagé de

P. Petitjean et al. (eds.), Science and Empires, 339–362.

nombreux enseignants français dans les années 1870/80 et participé à l'Académie des Sciences, jetant les bases d'une tradition de relations scientifiques.

L'idée de créer des universités au Brésil est une des idées-force du Groupement, depuis le premier voyage de Georges Dumas, l'animateur des relations avec le Brésil, en 1908 à Rio de Janeiro. De retour d'un autre voyage à Rio en septembre 1931, il rappelle, après avoir participé à une réunion de la commission universitaire chargée de mettre sur pied une Faculté des Lettres[4] que

"c'était la quatrième fois au moins en 25 ans que j'étais invité à m'occuper de cette fondation. Cette fois, cela va peut-être déboucher. La commission a adopté à l'unanimité un projet de Faculté des Lettres que j'avais rédigé en suivant au plus près l'organisation de l'Ecole Normale supérieure".

En 1908, Georges Dumas est le premier délégué du Groupement envoyé au Brésil. Ce séjour se déroule principalement à Rio, avec dix conférences en psychologie. Il fait le voyage de São Paulo, invité par Bettencourt-Rodrigues[5]. Dans le comité qui l'accueille, figurent déjà Victor de Silva Freire, Ramos de Azevedo, Ruy de Paula Souza, Vergueiro Steidel. Ce premier séjour est l'occasion pour Georges Dumas de commencer une collaboration journalistique avec le *Correio Paulistano* auquel sont liées plusieurs de ses relations paulistes.

En juillet 1909, le Groupement envoie une délégation de cinq étudiants participer à un congrès académique à São Paulo; ce sera la seule délégation étrangère. Pendant leur visite, une section pauliste du Groupement est fondée lors d'une réunion chez Vergueiro Steidel, qui prendra le nom de **Union Scolaire Franco-Pauliste** le mois suivant. Le comité directeur comporte des représentants des établissements d'enseignement supérieur de la ville (Faculté de Droit, Ecole Polytechnique) et des médecins.

En 1910, l'USFP envoie en retour une délégation étudiante, et décide la création d'une **Chaire d'Etudes brésiliennes** à la Sorbonne, et d'une **Chaire d'Etudes françaises** à São Paulo. Les frais sont partagés par l'USFP et le Groupement.

A Paris, Oliveira Lima occupe la chaire en 1911 (12 cours sur **la formation historique de la nationalité brésilienne)** - Arojado Lisboa en 1912 (9 cours sur **le milieu physique brésilien)** - Rodrigo Octavio de Menezes en 1913 (7 cours sur **le droit des étrangers au Brésil).**

A São Paulo, Georges Dumas lui-même vient inaugurer en 1912 la **Chaire d'Etudes françaises**, avec 11 cours à partir du 30 septembre sur **la psychologie générale.** Pour la plupart, ils sont publiés à la une du *Correio Paulistano,* journal du Parti Républicain, qui se plaît à souligner le caractère progressiste de son éminent collaborateur Georges Dumas, et indique[6] que *"l'auditoire est composé des éléments les plus fins de notre milieu scientifique et intellectuel".* Léon Hourticq lui succède en 1913 pour un cours sur **l'histoire de l'Art,** puis Chabot en 1914 pour des conférences sur **la pédagogie.** L'USFP disparaît pendant la guerre.

La principale perspective de l'USFP est la création d'un lycée français à São Paulo. Le projet prend forme en 1916, une souscription est lancée. Mais il tarde à se réaliser. Après la guerre, Georges Dumas relance ses projets paulistes. En juin 1919, dans un rapport à l'Office National des Universités, il expose les projets d'un lycée et d'une Faculté des Lettres à São Paulo. En mars 1920[7], à l'occasion de l'Assemblée Générale de l'Office, il précise sa pensée : *"collaborer à une oeuvre nationale, et non pas à une exportation universitaire".* en créant un lycée franco-brésilien, et non pas français.

Georges Dumas, présent à Rio, vient poser la première pierre du lycée le 4 novembre 1921[8]. Les premiers cours, pour les élèves externes, ont lieu en 1924, dans des locaux prêtés par le lycée des Arts et Métiers. Les nouveaux locaux sont inaugurés en septembre 1925[9]. Georges Dumas est encore là, avec Paul Janet. Tous deux sont conférenciers pour l'Institut Franco-Brésilien de Haute Culture à Rio cette année[10]. Mais changement : Georges Dumas est récusé par le *Correio Paulistano ("Georges Dumas, qui fut notre collaborateur, ..."),* alors tenu par des dissidents du Parti Républicain. Quelques mois avant cette inauguration, Fernando de Azevedo[11] a présenté le lycée comme une étape pour la formation d'une université à São Paulo.

L'Institut Technique Franco-Pauliste

En l'absence de réalisation d'une Faculté de Lettres, Georges Dumas se contente d'organiser un détour par São Paulo pour une partie des conférenciers français de l'Institut de Université de Paris à Buenos Aires ou de l'Institut de Haute Culture de Rio[12]. Ainsi, Pierre Janet, Georges Dumas et Chiray en 1922, Henri Abraham et Henri Piéron en 1923, Emile Marchoux et Paul Janet en 1925, etc. Comme du temps de l'USFP, ce sont des conférences de culture scientifique générale (en nombre encore plus restreint), s'adressant à la société "éclairée", comme à Rio. Il n'y a pas de structure locale forte, tout juste des notables francophiles qui organisent l'accueil et le programme social des conférenciers.

Au moment du passage de Georges Dumas pour l'inauguration du lycée en 1925, a lieu une tentative un peu différente : la création d'un **Institut Technique Franco-Pauliste (ITFP),** pour[13] *"diffuser la culture technique française".* L'Institut doit faire des cours spécialisés, sur des sujets précis, choisis à São Paulo, Georges Dumas ayant la responsabilité de trouver l'enseignant adapté à la demande. L'ITFP est créé par José Lobo, secrétaire d'Etat à l'intérieur, Geraldo de Paula Souza (directeur de l'Institut d'Hygiène), Ramos de Azevedo (directeur de l'Ecole Polytechnique) et Pedro Dias de Silva (directeur de la Faculté de Médecine) : un schéma d'organisation très institutionnalisée, déjà existant pour l'USFP, et qui se retrouvera à l'USP.

Lors de la première séance de l'ITFP en 1926[14], à l'Institut d'Hygiène, Geraldo de Paula Souza explique que que l'ITFP a été créé **à l'initiative** du Gouvernement pauliste, **avec l'aide** du Gouvernement français, et **par l'intermédiaire** de Georges Dumas. On se rapproche de la situation qui existera pour la mission française lors de la fondation de l'USP. La première année, Georges Kuss (médecine sanitaire) fait des cours à l'Institut d'Hygiène, Alexandre Mauduit (électrotechnique) à l'Ecole Polytechnique, Henri Laugier (physiologie) à la Faculté de Médecine et Henri Piéron (psychologie appliquée) à l'Ecole Normale.

En fait, l'hiver 1926 voit passer à São Paulo un nombre record de scientifiques français : en plus des quatre de l'ITFP, on peut rencontrer Marie Curie et Paul Hazard, venus pour l'Institut de Haute Culture de Rio, Ascoli et Delbet, sur le retour de Buenos Aires. Ces passages suscitent, le 1er août 1926, l'irritation du chroniqueur culturel du journal *O Estado de São Paulo (OESP* par la suite) : l'article n'est pas signé, mais Fernando de Azevedo lui-même est chargé de cette rubrique, et en est donc sans doute l'auteur. Selon lui, toutes ces conférences, à São Paulo comme à Rio, par des professeurs français, c'est bien, mais c'est un luxe sans conséquences : la culture doit être développée à la base, par des réformes de l'enseignement secondaire, puis du technique supérieur. Mais ce n'est que la moitié du chemin : il faut un enseignement supérieur sans finalités professionnelles, et l'ébauche n'en existe pas encore au Brésil. Il critique ensuite un projet de loi déposé au Sénat pauliste par le Dr Abelardo Cesar, pour la création d'un Institut des Hautes Etudes, tache qui serait confiée à Georges Dumas : l'auteur de l'article, tout en reconnaissant les mérites de Georges Dumas, estime que c'est aux Brésiliens d'abord de faire des efforts, condition indispensable pour qu'un tel Institut soit enraciné.

Les Paulistes veulent chaque année 4 professeurs pour les disciplines suivantes : hygiène, médecine, pédagogie et sciences naturelles. En 1927, viennent Guy Laroche (médecine), Paul Fauconnet (sociologie) et Emile Marchoux (extension des villes et problèmes hygiéniques). L'année suivante, Auguste Chevalier vient à l'Ecole Polytechnique (l'identification des matières du bois).

C'est le seul cours réel de 1928. L'ITFP n'a guère duré longtemps, et on revient à la situation du début des années 1920 : une halte de quelques jours pour des conférenciers de Rio ou de Buenos Aires. L'ITFP n'est qu'un sigle creux pour couvrir (et financer) les escales de Hartmann et Rivet en 1928, ou Henri Claude en août 1929. Robert Garric constate en 1933 que l'ITFP n'existe même plus sur le papier; il craint un danger d'américanisation de la vie intellectuelle[15] à São Paulo, avec *"l'arrivée de deux professeurs américains à l'Ecole Libre des Sciences Politiques, les Français auxquels on avait d'abord fait appel ayant fait défaut"*.

Pas de locaux fixes, pas de financement régulier, pas de structure vraiment constituée à São Paulo, et surtout, difficultés à répondre aux demandes précises des Paulistes (qui prenaient à contre-pied la stratégie d'influence culturelle du Groupement) : l'ITFP ne survit pas. Ce type d'Institut est décalé par rapport aux besoins nouveaux. Malgré tout, Robert Garric et Victor de Silva Freire proposeront encore en 1933 à Armando de Salles Oliveira, représentant de l'Etat brésilien à São Paulo, de re-créer un Institut semblable à celui de Rio.

A la veille de la création de l'USP

En janvier 1934, quand est pris le décret fondateur de l'USP, des liens existent donc depuis plus de 25 ans entre universitaires français et paulistes. L'origine de ces liens et leur mode d'existence relèvent avant tout de liens personnels, voire informels, plus que directement étatiques, notamment avec d'anciens étudiants, formés en France, dans les écoles d'ingénieurs ou en médecine. Les relations ont été épisodiques, jamais stabilisées. Pour expliquer cette instabilité, il faut prendre en compte la faiblesse des établissements supérieurs à São Paulo et les crises politiques des années 1920/30, mais le manque de profondeur de ces relations et leur caractère encore largement "mondain", viennent aussi des spécificités du premier groupe universitaire francophile, de la stratégie des autorités françaises, et de l'intégration de Georges Dumas dans l'élite pauliste.

La relation personnelle privilégiée de Mesquita avec Georges Dumas a joué un rôle permanent. L'intensité des liens, comme les difficultés épisodiques, se lisent dans le volume et la régularité des chroniques de Georges Dumas et des autres universitaires français dans *OESP,* le journal de Julio de Mesquita. Georges Dumas avait déjà écrit quelques articles avant 1913, mais collaborait principalement avec le *Correio Paulistano.* Sa liaison avec *OESP* commence véritablement en 1923, et il publie plusieurs dizaines d'articles jusqu'en 1930. Il s'agit soit de chroniques sur la vie intellectuelle française, soit de présentation de ses travaux, soit encore d'une participation aux débats sur l'éducation au Brésil. Un des conférenciers de l'ITFP aura aussi une collaboration intense avec *OESP* sur ce dernier sujet : Paul Fauconnet, qui, après son passage en 1927, publiera une vingtaine d'articles chaque année, de 1928 à 1930, sur l'éducation, l'enseignement, la sociologie et la littérature. De 1931 à 1934, les difficultés politiques de Mesquita distendent les liens. Mais, à partir de la fondation de l'USP, une partie de la mission française est mise à contribution, en particulier Paul Arbousse-Bastide (des centaines d'articles jusqu'en 1951), puis Roger Bastide. Mais tous ne collaboreront pas (Claude Levi-Strauss, par exemple).

L'identification de Georges Dumas à l'élite pauliste va transformer la coopération universitaire avec la France en un enjeu politique entre les différents partis : on sera contre la mission française parce qu'on est contre Julio de Mesquita. Contrairement à sa prétention à la neutralité politique, la mission française ne pourra jamais l'être entre les différents partis politiques paulistes. Si le "progressisme" supposé des universitaires français est plutôt bien vu au début des années 1930, après le Front Populaire, l'image deviendra négative, même auprès de Julio de Mesquita, libéral mais conservateur.

C'est en raison de ses liens personnels avec Julio de Mesquita que Georges Dumas a été associé à la préparation de l'Université de São Paulo. Un groupe informel existe autour de *OESP,* avec Julio de Mesquita et Fernando de Azevedo, à l'origine d'une enquête en 1926 sur la nécessaire refonte de tout le système éducatif brésilien, à laquelle répondent jour après jour les principaux intellectuels. André Dreyfus, dans la séance de la société de psychologie en hommage à Georges Dumas après sa mort, évoque même[16] *"les réunions nocturnes de* ***OESP*** *avec Georges Dumas".* La réalité est cependant plus complexe. Le groupe des onze, chargé au début de janvier 1934 d'examiner le projet de décret préparé par Fernando de Azevedo[17], ne peut être réduit à des universitaires francophiles, bien au contraire, même si Julio de Mesquita en est l'animateur. Dans le double projet (politique et éducatif), où s'inscrit la création de l'USP, la branche politique est la seule francophile. Fernando de Azevedo fait le lien entre les deux volets. Mais le groupe des onze est surtout représentatif de l'évolution des scientifiques paulistes. C'est une génération plus jeune que le groupe de l'USFP, de formation moins tournée vers l'extérieur, et qui a diversifié (et choisi) ses relations internationales. Ce phénomène était déjà présent lors de l'ITFP, en particulier avec Geraldo de Paula Souza. Si la plupart des établissements supérieurs sont représentés dans ce groupe des onze, c'est moins par leurs responsables institutionnels que par les scientifiques les plus gagnés à l'idée d'une Faculté des Sciences et des Lettres. Typique est la position de Victor de Silva Freire : plus agé d'une génération, francophile actif depuis 30 ans, directeur de l'Ecole Polytechnique, il commence par proposer un autre modèle d'université, plus directement lié aux applications (et aux intérêts industriels).

La situation des relations universitaires franco-paulistes en janvier 1934 n'est donc pas aussi favorable qu'il y paraît à la lecture de la correspondance diplomatique officielle. Bien sûr, dès le projet de décret, Georges Dumas et les diplomates français vont se mobiliser. Mais les amis paulistes de Georges Dumas ont des positions divergentes sur la conception de l'USP, et, en réalité, la France est mise en concurrence avec les autres pays susceptibles d'envoyer des missions universitaires.

Côté français, la situation n'est pas meilleure : c'est une offre vieillissante de coopération. Le Groupement n'existe plus que sur le papier, et Georges Dumas fonctionne plus comme un attaché aux relations avec le Brésil pour le compte du Ministère des Affaires Etrangères que comme un universitaire[18]. Il est au service d'une stratégie de coopération de plus en plus réduite à la défense et à l'illustration du prestige culturel, même s'il continue à garder une certaine ambivalence (contribuer à une oeuvre nationale brésilienne, mais sous hégémonie française). Il n'y a donc pas encore de politique construite de coopération universitaire, pas de tentative de poser le problème de "quelle coopération, pour quelle type d'université". Georges Dumas et ses réseaux informels sont appuyés par le Service des Oeuvres pour contribuer au "rayonnement français".

Pour constituer les missions universitaires, à São Paulo comme à Rio, Georges Dumas s'appuie donc plus sur des liens personnels, voire religieux ou même familiaux, que sur les structures universitaires officielles (le Rectorat de l'Académie de Paris et la Faculté des Sciences, le Ministère de l'Instruction Publique, ...). Le décalage entre les demandes paulistes et la capacité des réseaux de Dumas à y répondre a déjà été perceptible au moment de l'ITFP en 1927/28. Cependant les réseaux de Dumas vont se révéler suffisamment souples pour trouver des candidats au départ en quelques jours, mais dans des secteurs limités. De plus, contrairement à la situation de l'Italie qui cherche à s'appuyer sur la communauté italienne, la diplomatie française ne s'intéresse guère à l'Amérique latine, et ses priorités financières, dans les années 1930, sont ailleurs. Cela se sent au moment de constituer les missions, et, quand le décret paraît, c'est un handicap supplémentaire.

La fondation de l'USP (1934) et le recours aux enseignants étrangers

La décision de créer l'USP est prise en quelques semaines : entre le retour d'exil de Julio de Mesquita à la mi-décembre 1933 et la sortie du décret le 25 janvier 1934, Fernando de Azevedo (alors directeur de l'Instruction publique de l'Etat de São Paulo) a pu écrire un projet d'université à la demande de Julio de Mesquita et d'Armando de Salles Oliveira, et le faire corriger par le groupe des onze. L'idée de base de Fernando de Azevedo est de regrouper l'ensemble des établissements de formation professionnelle supérieure, d'ajouter les centres de recherche, et de créer une Faculté de Philosophie, Sciences et Lettres (FFCL) non pas comme un autre établissement à côté du reste mais comme le **noyau central** de l'Université, à l'image des universités européennes du XIXe siècle. La séparation entre plusieurs facultés plus spécialisées viendrait plus tard. Faire de la FFCL le noyau de l'Université était à la fois le moyen d'illustrer l'unité profonde du savoir, et le besoin et la nécessité d'une culture désintéressée[19]. L'Université de Princeton et l'Université de Paris sont les références explicites de Fernando de Azevedo.

Quand se pose la question du recrutement d'enseignants pour la FFCL, André Dreyfus, Rocha Lima et Teodoro Ramos sont les seuls parmi les scientifiques brésiliens à trouver grâce auprès de Julio de Mesquita et de Paulo Duarte. Rocha Lima, occupé à l'Institut de Biologie, n'est pas disponible, et les deux autres se récusent, estimant que, malgré une compétence dans une étroite spécialité (la génétique et le calcul vectoriel), ils se disent incapables de donner des cours de biologie générale ou de de mathématiques fondamentales[20]. Aucun institut existant, en dehors de la Faculté de Médecine, ne peut fournir des professeurs de qualité suffisante.

"On ne pouvait pas se laisser assiéger par les prétentions des demi-cultures qui menaient l'assaut avec les armes de la politique partidaire. Il y en a même qui voulaient faire donner l'armée contre les atteintes à la brasilianité" :

Julio de Mesquita ajoute[21] qu'à l'Ecole Polytechnique, on refuse d'enseigner Fermi et Louis de Broglie, et que les instruments scientifiques datent de plusieurs décennies.

Cette volonté de rechercher des idées et des enseignants en Europe, plutôt que de s'appuyer sur ce qui existait sur place, est sans doute un trait de ce *grão fino* brésilien, plus tourné vers une Europe mythifiée que vers les réalités de la société brésilienne. Maugüé[22] critique Mesquita :

"la fondation de l'Université répondait à des besoins réels. Mais, prenant les effets pour des causes, Mesquita pensait que la supériorité de l'Europe venait de sa culture, et non pas que sa culture venait de son avance économique et politique".

C'est une permanence dans les relations scientifiques entre le Brésil et les pays européens que cet appel à des Européens, même pour de courtes périodes, plutôt que d'envoyer des Brésiliens se former en Europe, puis revenir et susciter leurs propres élèves. Il y a peu de livres scientifiques en portugais, et le français reste la langue scientifique dominante jusque dans les années 1930; et encore, à cette époque, elle recule plus face à l'anglais et à l'allemand que par le développement des traductions en portugais. Contrairement à d'autres tentatives d'appropriation de la science moderne (par exemple en Egypte ou en Inde), la classe dirigeante brésilienne ne se préoccupera que très tard de mettre à la disposition des établissements supérieurs des livres scientifiques traduits. C'est un reflet de son isolement social, mais aussi une des causes du maintien de la marginalité de la science dans la société brésilienne.

A posteriori, pour Paulo Duarte[23], il faut réserver à la France les chaires qui *"apprennent à penser",* et à aucun prix ne confier une telle mission à des représentants des pays totalitaires. Quelques années plus tard, Julio de Mesquita[24] abonde dans le même sens :

"Nous étions fondamentalement libéraux à un moment où le libéralisme avait disparu en Europe (...) Le choix des professeurs était fait pour promouvoir à tout prix ce libéralisme (...) Il fallait éviter que les chaires puissent tomber dans les mains d'adeptes du credo italien, surtout celles qui touchaient à la formation morale (...) Le Gouvernement et la colonies italiennes faisaient des pressions très fortes sur nous, et voulaient imposer un quasi-monopole (...)" (comme compromis) "on leur donne une partie des chaires en science et on donne aux Français, leaders de la démocratie libérale, celles dont dépend directement la formation spirituelle des futurs élèves".

Si cette fermeté pour le libéralisme contre le "modèle italien" est certainement plus facile à exprimer en 1958 que dans le contexte idéologique de 1934, il ressort du témoignage de Julio de Mesquita que l'enjeu principal du recrutement de la mission étrangère était une rivalité franco-italienne. La correspondance diplomatique confirme cette rivalité[25] : Julio de Mesquita veut des professeurs

"assez jeunes pour se consacrer avec une particulière ardeur à leur tache intéressante, et si utile pour nous, qu'ils auraient entreprise, assez jeunes même pour, à l'occasion, se fixer au Brésil".

Il veut des Français pour la philosophie, les lettres et les sciences sociales :

"l'idée est que l'âme de l'université pauliste soit d'essence française, les anglo-saxons, voire les Allemands apportant seulement l'appoint de leur esprit pratique et de leur technicité dans les enseignements qui ne touchent pas à la formation morale".

La répartition "nationale" des chaires est donc presque fixée avant le départ de Teodoro Ramos[26]. Une chaire est en litige, entre les Français et les Italiens : la physique mathématique. Les Italiens multiplient les surenchères pour reprendre quelques chaires de lettres sur le quota français, tandis que ces derniers, profitant de leurs liens avec Julio de Mesquita, vont essayer de grignoter une ou deux chaires de sciences naturelles sur les Allemands. Entre les deux, les fondateurs de l'USP essaient de profiter de la rivalité franco-italienne pour réduire leur coût financier et avoir des professeurs de qualité.

Teodoro Ramos, en tant que Directeur de la FFCL, est chargé du recrutement en Europe[27].

Le voyage de Teodoro Augusto Ramos en Europe

Teodoro Ramos arrive le 13 mars à Rome. Il visite des laboratoires, rencontre des universitaires, est reçu par Mussolini et le Ministre des Affaires Etrangères[28]. Selon le témoignage de Wataghin[29], Teodoro Ramos s'était adressé à l'Académie Italienne des Sciences pour trouver un mathématicien et un physicien. Francisco Severi lui avait indiqué le mathématicien, Fantappie, et Fermi, Wataghin, dont la première réponse avait été négative : il ne voulait pas s'isoler de la communauté scientifique. Mais

"c'était le fascisme, et je ne pouvais rester. Ils me firent aussi comprendre qu'il aurait été difficile pour moi d'obtenir un poste de titulaire en Italie. Que je ferais mieux d'accepter la proposition, qui était une proposition généreuse" (le salaire élevé).

Si Wataghin accepte l'exil en raison du fascisme, Fantappie part parce que fasciste : il était inscrit au parti fasciste depuis juillet 1921[30]. Le troisième est Piccolo, pour la littérature italienne, membre également du parti fasciste depuis 1922. Un quatrième Italien est engagé par Teodoro Ramos lors d'un second séjour le 15 mai à Rome : Ettore Honorato pour la géologie et la minéralogie, chaire pour laquelle il n'avait trouvé de candidat satisfaisant ni en France ni en Allemagne[31].

Sans attendre la venue de Teodoro Ramos à Paris, Georges Dumas fait le voyage de Rome pour commencer les négociations et ne pas laisser le champ libre aux Italiens. Le 19 mars donc, il débarque à Rome et le 22 il écrit à Jean Marx[32] que les négociations sont terminées. Il a obtenu 8 chaires pour les Français : géographie, sociologie, histoire, philosophie, littérature française, philologie gréco-latine, physique mathématique, plus littérature gréco-latine pour 1935. L'Italie en aura 3, l'Allemagne 2 (zoologie et littérature allemande).

"J'ai obtenu la chaire de physique mathématique pour nous et si nous présentons des candidats très sérieux pour la chaire de zoologie/botanique, il m'a paru possible que nous la soufflions à l'Allemagne (...) Quand Teodoro Ramos quittera l'Italie, il n'aura signé que pour 3 chaires. J'aurais pu insister pour zoologie/botanique, mais je venais d'obtenir physique mathématique. Et, s'agissant de l'Allemagne, on pourra rediscuter à Paris (...) j'ai déjà donné des noms : Borne, Dufresne, Carré, qui sont d'accord".

Suivent les aspects financiers : Teodoro Ramos lui a dit que l'Italie payait le voyage, que le traitement italien serait maintenu avec des augmentations pour le doubler en trois ans, et que l'USP verserait aussi un salaire. Dumas dit que la France fera pareil, et que pour les compléments, on s'arrangera entre Français (ce qui sera par la suite source de problèmes entre la mission française et le Ministère). *"On ne peut faire des professeurs au rabais"*. Georges Dumas donne ensuite toutes les indications pour bien accueillir Teodoro Ramos à Paris : le présenter à Edouard Herriot, l'entourer de mathématiciens (Picard, Vessiot, Borel), de philosophes (Brunschwig, Lalande), de sociologues (Bouglé), le faire assister à des réceptions à l'Académie des sciences, à l'Académie des sciences morales et politiques.

"C'est un grand mathématicien, et par ailleurs un philosophe qui s'intéresse à tout ce qui s'est publié chez nous dans l'ordre de la philosophie mathématique".

Dans une seconde lettre, Georges Dumas suggère de demander à Langevin des noms de candidats et écrit

"Je dis Langevin, parce que Teodoro Ramos a tiqué dessus dès que j'ai prononcé son nom, et cela a été beaucoup pour obtenir la chaire de physique mathématique, que l'espoir que je lui ai donné d'avoir un élève de Langevin (...) Il connaît peu ou pas de personnes, et si on veut le gagner tout à fait, le river à notre influence, il est indispensable de l'entourer à Paris de gens qu'il admire et de le mettre en relations suivies avec eux (...) Il y a un livre de mathématiques de Teodoro Ramos publié à Paris au cours des dernières années. Il serait facile de le trouver en faisant télégraphier à quelques éditeurs scientifiques, et d'en faire distribuer quelques exemplaires aux susdits savants pour qu'ils puissent en dire un mot à l'auteur".

Le programme de Teodoro Ramos, à Paris à partir du 14 avril, se déroule comme prévu : diplomatie et réceptions diverses; rencontre avec des universitaires : Bouglé, Denjoy, Montel, Hadamard, Langevin, Charlety, etc[33]. De son séjour à Paris, Teodoro Ramos rapportera également un article de mathématique sur les "intégrales hyperelliptiques", consécutif à des discussions avec Denjoy.

Mais le recrutement de professeurs disposés à s'exiler trois ans au Brésil s'avère plus délicat que prévu par Georges Dumas. Ses anciens réseaux fonctionnent pour des tournée de conférences pendant les vacances universitaires françaises, et ne répondent plus vraiment quand il s'agit de séjours prolongés. Or Teodoro Ramos voulait des contrats de 3 ans pour avoir des garanties sur le sérieux des enseignants. Georges Dumas obtiendra une dérogation, avec un avenant au contrat, prévoyant que si l'enseignant veut repartir en France au bout d'un an, le Gouvernement français est tenu de lui trouver un remplaçant au moins équivalent. Sur une demande écrite de Teodoro Ramos, Marx s'engage à trouver[34] *"un remplaçant de même qualité"*.

Même avec la dérogation, cela reste difficile : il faut se décider en quelques jours, et partir en quelques semaines. Finalement, seuls 6 contrats sont signés le 29 avril par Teodoro Ramos, et co-signés par Georges Dumas et Jean Marx, avec Emile Coornaert pour l'histoire de la civilisation; Robert Garric (qui a déjà été au Brésil en 1933) pour la littérature française; Pierre Deffontaines pour la géographie; Paul Arbousse-Bastide pour la sociologie; Etienne Borne (le seul rescapé des certitudes de Georges Dumas à Rome) pour la philosophie et la psychologie; Michel Berveiller pour la littérature gréco-latine. Mais de physique mathématique, point; pas plus que de zoologie ou de botanique. Sur les 6, 3 sont professeurs d'université : Coornaert, le plus agé, à l'Ecole des Hautes Etudes, Garric à l'Université de Lille, et Deffontaines à l'Institut Catholique de Paris. L'un est maître-assistant (Arbousse-Bastide), et les deux derniers sont des agrégés professeurs de lycée. Nous sommes déjà loin des enseignants notables de l'Institut de Haute Culture. Selon Emile Coornaert, la moyenne d'âge de cette délégation est la plus faible de toutes les missions étrangères, et la position hiérarchique en moyenne inférieure à celle des Italiens et des Allemands[35]. Il s'agit, de toute évidence, d'une délégation transitoire, la plupart des engagés n'ayant en réalité pas l'intention de rester les trois ans, et n'ayant accepté qu'en raison du début tardif de l'inauguration de l'USP (ce qui réduisait la présence nécessaire sur place à 6 mois).

En Allemagne, Teodoro Ramos[36] engage : Reinboldt, pour la chimie, Ravitscher pour la botanique, et Breslau pour la zoologie. Tous trois sont certainement les plus titrés des enseignants étrangers recrutés. Mais sur cette campagne de recrutement en Europe, les souvenirs de Paulo Duarte divergent encore[37].

Avec 6 Français, 4 Italiens, 3 Allemands, il s'agit, à peu de choses près, de l'équilibre prévu avant le voyage, et les fortes pressions franco-italiennes pour en avoir plus se sont neutralisées. La mission française n'est pas sortie du domaine des lettres et des sciences sociales. A ces 13 professeurs européens de 1934, s'ajoutent 3 Brésiliens : André Dreyfus (biologie), Plinio de Ayrosa (Ethnologie et langue Tupi-Guarani) et Antonio Soares Romero (Physique).

La deuxième mission en 1935

A la fin de l'année scolaire, le bilan officiel est très optimiste, même si on ne voit pas assez les professeurs en ville ou à l'Automobile Club[38]. Ce bilan positif est confirmé par Julio de Mesquita à Georges Dumas[39], ce dernier précisant cependant *"à certaines phrases de mes correspondants à São Paulo, je comprends qu'on voudrait un peu moins de "talas". C'était mon opinion."* Coornaert, Garric, Borne et Deffontaines étaient en effet des catholiques ("talas") marqués, et, est-ce un hasard, ce sont les 4 qui ne reviendront pas. Cette première mission était *"catholique et bien pensante"* confirme Pierre Monbeig[40], seul Arbousse-Bastide s'en distinguait, comme protestant, fils de pasteur et cousin de Georges Dumas[41], mais aussi, sur le plan philosophique, comme positiviste engagé, disciple de Georges Dumas, et qui, ultérieurement, se présentera en partie comme son héritier : tous deux étaient protestants, positivistes critiques, et porte-drapeaux de l'amitié franco-brésilienne.

Berveiller et Arbousse-Bastide continuent en 1935. Il y a donc 4 enseignants à remplacer, et un autre à trouver, la chaire de sociologie étant dédoublée. Paul Arbousse-Bastide s'en inquiéte dès le 15 septembre 1934[42] : il attire l'attention sur le danger constitué par les Italiens et les Allemands, qui veulent aussi des chaires de "culture". Les Italiens sont même prêts à tout payer. Il demande donc à Marx de se dépêcher pour trouver les remplaçants. Indiquant que *"les Brésiliens ont horreur des touristes"*, il insiste pour que, cette fois, les professeurs viennent avec l'intention de faire *"une oeuvre durable"*.

Autant la mission de 1934 a été improvisée et apparaît donc un peu comme une mission transitoire, reposant surtout sur la disponibilité immédiate des postulants, autant le recrutement des 5 nouveaux pour 1935 a été préparé dès l'automne 1934. Malgré tout, les difficultés ont été nombreuses pour trouver des volontaires.

Coornaert (histoire) est remplacé par Fernand Braudel, le seul déjà inséré dans l'institution universitaire : il avait une thèse en cours, et était l'élève de Lucien Febvre[43]. Garric (littérature française) est remplacé par Pierre Hourcade. Deffontaines (géographie) est remplacé par Pierre Monbeig (gendre de Paul Janet, un physicien qui avait fait partie des conférenciers du Groupement à Rio en 1925) qui a eu, par l'intermédiaire de sa femme, une bonne propagande pour le Brésil; les liens personnels de Dumas ont joué le rôle déterminant dans la composition de la mission de 1935[44]. Monbeig s'est aussi expliqué[45] sur les motivations de son départ pour le Brésil :

"on voulait connaître quelque chose de plus que l'hexagone, échapper à la vie du lycée à l'intérieur du pays. On a essayé de me motiver par l'argent : 2 ou 3 ans au Brésil pour devenir riche, puis un an sans travailler pour finir ma thèse, et cela m'avait convaincu".

Claude Levi-Strauss est recruté pour la seconde chaire de sociologie. Il a été l'élève de Georges Dumas à Sainte Anne. Selon son récit[46], il a eu trois heures pour se décider après un coup de téléphone de Bouglé, le directeur de l'Ecole Normale Supérieure. Bouglé lui a fait valoir que, après ses cours en semaine, il pourra le week-end aller étudier les indiens dans la banlieue de São Paulo ...[47]

Borne (philosophie) est remplacé par Jean Maugüé, qui avait suivi une partie des cours de Georges Dumas à Sainte Anne. Jean Maugüé indique[48] que Georges Dumas lui avait promis des indemnités substantielles en plus de son traitement. Il était normalien et agrégé de lettres comme Hourcade et Berveiller. Il raconte que Georges Dumas[49] voulait des professeurs en début de carrière car

"aucun maître "arrivé", sauf Braudel, n'était tenté par un pareil exil. Il partait donc avec la hantise d'échapper à l'enseignement des lycées de province, et le propos de revenir en France, la carrière assurée".

Au catholique Borne, succède donc le protestant Maugüé. Comme Braudel, avec lequel il était très lié, Maugüé était de gauche, et engagé dans le Front Populaire.

En plus de Claude Levi-Strauss, 3 professeurs sont recrutés pour de nouvelles chaires : un Allemand, Otto Gotsch, pour l'économie politique et l'histoire des doctrines économiques; un Portugais, Rebelo Gonçalves, pour la philologie portugaise, et un Brésilien, Taunay, pour la civilisation brésilienne. 7 Français, 4 Italiens, 4 Allemands, 1 Portugais et 4 Brésiliens forment le corps professoral de la FFCL en 1935.

De fait, les stratégies pour constituer les missions ont été différentes en 1934, 1935 et 1938. Le poids des rivalités avec les autres pays (Allemagne et Italie) se faisant nettement moins sentir lors des renouvellements que pour la première mission. Cette rivalité reste cependant un argument des Brésiliens pour essayer d'obtenir des conditions plus favorables : d'un côté des enseignants plus stables et de meilleure qualité, et de l'autre, une participation financière plus importante des pays d'origine. L'argument sert aussi pour forcer Dumas et Marx à ne pas faire traîner les choses. Par la même occasion, cela leur permet aussi de peser sur la configuration politique et religieuse de la mission, surtout dans la période conflictuelle qui précède 1940.

Pour la mission de 1934, la composition est largement le produit de la nécessité de trouver en quelques jours des candidats à l'aventure, prêts à partir un mois plus tard. Cela a favorisé le recrutement de jeunes pour cette première mission, et a obligé Dumas à activer de nouveaux réseaux universitaires et à changer ses méthodes de recrutement. Le premier bilan ayant été positif, la mission de 1935 est encore plus jeune, même s'il n'est jamais simple de remplacer ceux qui reviennent, et de nombreuses personnes sont, à chaque fois, sollicitées. Georges Dumas[50] se plaint fréquemment des gros problèmes pour trouver *"des jeunes, actifs et pleins d'avenir, si ce n'est déjà connus"* qui acceptent pour 3 ans de partir au Brésil.

La mission de 1935 est celle qui apparaît en rupture radicale avec les traditions du Groupement : par l'âge (et donc par sa position hiérarchique dans l'Université), par sa politisation (marquée à gauche), y compris par sa religion. Et aussi par sa durée : 4 feront leurs 3 ans, et les autres encore plus : Maugüé restera jusqu'en 1944, Monbeig jusqu'en 1947, et Arbousse-Bastide jusqu'en 1948[51].

La moyenne d'âge de la mission de 1935 est très faible : 29 ans. Le doyen est Paul Arbousse-Bastide, né en 1899, et le plus jeune, Berveiller, né en 1910. 3 sont normaliens (Hourcade, Maugüé et Berveiller), et tous sont agrégés : Braudel dès 1923 (d'où sa position hiérarchique supérieure), Arbousse-Bastide en 1928, Monbeig en 1929, Berveiller, Levi-Strauss et Maugüé en 1931, Hourcade en 1932[52]. La figure typique est donc celle du jeune agrégé, enseignant dans un lycée de province, très différente de celle des enseignants qui venaient dans le cadre de l'Institut de Haute Culture. Ces coopérants sont confrontés à des problèmes nouveaux : des étudiants à former et à suivre, dans un contexte socio-politique conflictuel.

Les universitaires français à l'étranger, entre l'exil et le provisoire

Près de 60 ans après la fondation de l'Université de São Paulo, le rôle des missions étrangères apparaît, *a posteriori* comme très largement positif. Il y a des raisons à cela : les premières années de l'USP ont été un double succès, à la fois politique et éducatif; nombre de professeurs recrutés étaient, ou devinrent, célèbres : rares sont les universités, même en Europe, qui ont concentré pendant quelques années autant de talents à la fois; ils ont formé une génération de scientifiques brésiliens tout aussi remarquable. Il paraît indéniable que, en comparaison avec les premières universités à Rio, l'USP a rapidement atteint un niveau et une stabilité importants. Si le contexte politique général a joué un rôle (la distance vis-à-vis du pouvoir central et de ses réseaux d'influence), la rupture fondamentale entre l'encadrement professoral de l'USP et les milieux universitaires traditionnalistes brésiliens est sans doute plus décisive. Que cet encadrement soit pour l'essentiel étranger, les premières années, a permis d'effectuer une telle rupture de manière irréversible, malgré les crises des années 1934/40.

Il faut reconnaître qu'un élément important de cette image positive vient du **devenir** de plusieurs de ces professeurs étrangers : physiciens et mathématiciens italiens, enseignants français en sciences sociales sont souvent devenus des sommités dans leur discipline. Et, *a posteriori* encore, ils ont ainsi contribué à donner une image positive de l'USP, comme "creuset" de talents, européens et brésiliens.

Il reste que l'influence des missions étrangères, en particulier françaises, sur l'histoire des idées au Brésil, comme, inversement, l'influence de leur séjour brésilien pour ceux d'entre eux qui ont poursuivi leur carrière en Europe, restent encore largement à étudier de manière systématique. Et ce, en allant au-delà des souvenirs des uns et des autres. Elles ont été certainement considérables, mais cette étude ne cherchait pas à analyser cette question.

Il semble cependant indéniable que le séjour brésilien a fortement encouragé la créativité de jeunes intellectuels mis dans le contexte de la création d'une université. Ainsi, dans son entretien avec Tassara, Braudel[53] souligne que

"il nous a fallu changer profondément notre vision des choses, nous avons été forcés de nous changer dans toutes nos réactions. Il fallait s'adapter à notre milieu. J'ai été un homme tout-à-fait différent. Je n'aurais pas écrit le même livre sur la Méditerranée sans avoir été au Brésil. Une histoire de ce type intéressait les étudiants, alors que l'histoire évènementielle était pour eux sans surprise, et extérieure. L'invasion de l'histoire par les sciences humaines passionnait mes étudiants".

Comme pour Braudel, le séjour de Levi-Strauss[54] au Brésil a été fondamental pour la formation de sa pensée. Mais, dans son entretien avec Tassara, il précise en quoi : il était professeur de philosophie, sans formation et sans expérience de terrain, mais

"je me suis créé ethnologue sur le terrain peu à peu, pendant les vacances". "J'étais un jeune philosophe qui apprend l'ethnologie pratique, avant d'en rien savoir sur le plan théorique". "Cela m'a permis de comprendre le travail sur le terrain, même si le travail en lui-même n'a pas eu grande valeur, parce que beaucoup trop court".

Inversement, si ces missions étrangères ont pu avoir un tel rôle, fondamentalement différent de l'influence restreinte qu'avaient eu les conférenciers français des Instituts de Haute Culture, ou des Instituts équivalents anglais ou italiens, elles le doivent à la conjonction de nombre d'éléments, qui ont provoqué un **changement de perspective** parmi ces enseignants. La finalité de leur travail est dirigée vers l'USP, et non pas vers le prestige culturel du pays d'où ils viennent : non plus "représenter" la haute culture française et être ainsi des ambassadeurs intellectuels, mais au contraire, aider les étudiants à connaître le pays, à réduire leur dépendance intellectuelle, *"apprendre aux étudiants à penser"*, comme le souligne Monbeig[55]. Ainsi, pour les enseignants français, leur jeunesse a effectivement joué un rôle important, en ce sens qu'ils n'avaient rien à perdre à s'impliquer dans l'USP, même s'ils n'oubliaient pas leur carrière future en France. Georges Dumas et Jean

Marx leur ont reproché cette trop grande implication. Un tel projet n'est pas contradictoire avec les perspectives de carrière des enseignants à leur retour en France, bien au contraire. Ils ont donc pu contribuer à former des scientifiques brésiliens de haut niveau, en sciences sociales, comme l'ont fait en sciences exactes les autres missions étrangères, qui se révèleront après 1945. La jeunesse de la délégation française, comme les problèmes politiques des Italiens et des Allemands, puis la guerre, ont permis cette moindre dépendance vis-à-vis des Etats d'origine et de la diplomatie, cette autonomie intellectuelle qui était une condition de la réussite d'une telle entreprise, autonomie qui, *a contrario,* n'existait pas avec les missions antérieures du Groupement. Cela permet l'inscription de ces missions dans la durée et la stabilité, favorisant ainsi ce changement de perspective. A partir de 1939, les problèmes sociaux de la mission sont relégués au second plan, et les remplacements presque impossibles. De plus, le régime Vargas se stabilise, et modifie ses relations internationales : un contexte qui limite aussi les tourmentes politiques auxquelles la mission ne pouvait échapper. Enfin, l'USP elle-même a acquis un poids suffisant, pour avoir une existence en elle-même, moins tributaire des aléas politiques.

Dans ce contexte, on comprend mieux la vision beaucoup plus idyllique du recrutement des enseignants que, avec le recul, 50 ans après, la veuve de Georges Dumas, Aimée Dumas[56], conserve :

"Teodoro Ramos et Georges Dumas ont choisi des jeunes, parce que leur investissement est beaucoup plus intense et plus grand. Il y a eu beaucoup d'offres de jeunes qui voulaient partir. Plus de candidats que de places au départ. Les professeurs étaient enchantés. Presque tous sont restés plus longtemps que prévu. Georges Dumas leur donnait le conseil de ne surtout pas faire de politique. Et ils ont tous suivi ce conseil. Les professeurs ne partaient pas pour que cela serve à leur carrière, ils voulaient voir une nouvelle civilisation".

Tout au contraire, trouver des candidats était difficile, échapper aux tourmentes politiques était impossible, et la vie interne de la mission française était particulièrement agitée. Ce sont les autres missions étrangères qui apparaissent comme plus stables, presque comme des havres de tranquillité; sans doute, dans le cas italien, pour être plus liée à son Gouvernement, et plus incorporée à une influence politique; et dans le cas allemand, inversement, pour être totalement dégagée des liens gouvernementaux.

Les relations au sein de la mission française sont placées sous une double détermination : celle qui provient de la situation sociale et professionnelle de ces enseignants en France, dans la mesure où le retour reste l'horizon de tous, même si la contrainte de rester sur place pendant les 5 ans de la guerre va éloigner cet horizon pour plusieurs d'entre eux; et celle qui provient de leur insertion à l'USP. Cette double détermination provoque de nombreux problèmes (et conflits) économiques, relationnels, pédagogiques, et politiques.

Les spécificités de la mission française expliquent cette vie agitée. La difficulté de trouver des candidats à l'exil a obligé Georges Dumas à recruter des jeunes, plus disponibles. Les contradictions sociales et intellectuelles de l'Université française de cette époque ont joué un rôle fondamental pour susciter des volontaires pour São Paulo : faible mobilité, cloisonnement disciplinaire, hiérarchie pesante, isolement des jeunes agrégés en province, rigidité des nominations, etc. Il y a donc une véritable **rupture obligée** avec l'orientation suivie jusqu'en 1934 en matière de coopération universitaire. Ces missions sont loin d'être une conséquence inéluctable de la politique de rayonnement culturel, qui fut la doctrine officielle de ces années.

En premier lieu, la politique antérieure n'est plus qu'une "offre déclinante". Etouffé par une logique diplomatique et souffrant d'une conception étriquée (tout pour le prestige culturel français) de la coopération universitaire, le Groupement ne sait guère répondre aux besoins scientifiques qui se développent en Amérique latine dans les années 30, particulièrement en Argentine et au Brésil, qui sont ses principaux objectifs[57]. Dans les années 1930, il ne sert que de trésorier pour payer la mission universitaire : Monbeig[58] n'en a retenu que cet aspect, et les autres missionnaires l'ont totalement oublié. Il a perdu sa vie propre, et son noyau animateur de scientifiques autonomes (qui avait fait son dynamisme dans les années 1910 et 1920) pour devenir une succursale du Service des Oeuvres : la diplomatie l'a emporté sur la science[59]. Et l'Université de Paris reste à l'écart de ce type de coopération.

En second lieu, Georges Dumas tire un bilan très négatif des "jeunes agrégés" de la mission de 1935, après avoir tissé des lauriers à celle de 1934. Il leur reproche trop de politisation, trop d'égalitarisme, trop de conflits, trop d'implication personnelle. Il renvoie sur Mesquita la responsabilité de cette nouvelle politique : choisir des jeunes plutôt que des notables. Dumas et Marx pensent qu'il s'agit d'une erreur, et la mission de 1938 marque un retour en arrière vers des professeurs de faculté. La composition des missions françaises est plus le produit des contradictions de l'Université que le fruit d'une orientation judicieuse en matière de coopération universitaire.

En troisième lieu, les enseignants français doivent assumer l'héritage de cette politique de prestige culturel, notamment la subordination sociale et politique à Mesquita et au *grão fino,* même si cet héritage lui-même n'est pas exempt de contradictions. On ne peut expliquer la restriction des missions françaises aux sciences sociales, à l'exclusion jusqu'en 1945 de toute chaire en sciences "exactes", sans prendre en compte cet héritage. Il en est de même de l'implication des Français dans les affrontements politiques ou de leurs rapports avec leurs étudiants et collaborateurs.

Cet héritage détermine en grande partie la manière dont la mission française a pu s'insérer dans la "demande" de coopération qui s'est exprimée à travers l'USP. **Une demande en réalité encore émergente :** derrière le double projet de l'élite pauliste (projet politique et projet éducationnel), et parfois malgré cette élite, la croissance des classes moyennes provoque une demande de science, que ne peuvent satisfaire les structures traditionnelles de l'enseignement supérieur brésilien d'avant l'USP. Là encore, cette émergence ne va pas sans contradictions permanentes : la surdétermination politique de certains conflits universitaires et choix d'orientation, le caractère fluctuant des choix, l'apparition des étudiants comme force sociale autonome, etc.

Dans un tel contexte, pour nombreux qu'ils aient été, les divers conflits ne s'en situent pas moins dans le cadre de la participation à une "création collective", l'USP : la phase de naissance d'une institution nouvelle est souvent le théatre de multiples conflits, mais en même temps constitue un creuset qui contribue à leur donner une issue positive, et les resitue dans une dynamique constructive.

Sans y voir un miracle ou une aberration historique, il faut reconnaître que le succès des premières années de l'USP et notamment des missions étrangères, n'était guère prévisible ni à plus forte raison prévu. Ce n'était pas une nécessité historique, ni la conséquence obligée d'une activité de coopération universitaire construite depuis plusieurs décennies. Au contraire, le rôle de la mission française est le fruit, très largement contingent, de la rencontre entre une "offre" déclinante de coopération par le Groupement et le Ministère des Affaires Etrangères d'un côté, et une "demande" émergente de science par les élites brésiliennes de l'autre.

Des équilibres se sont établis entre deux logiques (l'offre et la demande), chacune sujette à de fortes contradictions internes. C'est une conjonction de causalités qui débouche sur des équilibres parfaitement instables, perpétuellement remis en cause. Mais, pouvait-il y avoir une telle image de réussite, sans ruptures, imprévisibilité et déséquilibres?

Centre National de la Recherche Scientifique, Paris (REHSEIS) et Strasbourg (Centre de Recherches Nucléaires)

Notes

[1] Pour ce travail, les principales sources consultées sont les archives diplomatiques (en France) du Ministère des Affaires Etrangères (Service des Oeuvres), dont les cartons sont présentés sous l'abréviation SO443, SO444, SO440, etc. Ont été aussi consultées les archives du Rectorat de l'Académie de Paris (archives nationales, série AJ16) et celles de l'Office National des Universités (série 70AJ). Côté brésilien, ont été utilisés les annuaires publiés par la FFCL-USP pour les années 1934/35, 1936, 1937/38 et 1939/49 - les journaux de l'époque (essentiellement *Correio Paulistano, O Estado de São Paulo* et *A Folha da Manha)* - des témoignages (anciens et récents) de Français ou Brésiliens, enseignants ou élèves, impliqués dans la coopération scientifique, ou présents les premières années de l'USP. Je voudrais ici particulièrement remercier le Professeur Marcelo Tassara d'avoir bien vouloir me laisser accéder aux témoignages qu'il avait recueillis pour son film sur l'histoire de la USP, notamment ceux de Fernand Braudel, Aimée Dumas, Claude Levi-Strauss, Jean Maugüé, Paul Arbousse-Bastide, François Perroux, Pierre Monbeig. Voir les aussi les témoignages recueillis pour la préparation du livre de Simon Schwartzmann, *A formação da communidade cientifica no Brasil,* FINEP/Cia. Eda. nacional, 1979, conservés à la FGV/CPDOC (história da ciência, convenio FINEP/CPDOC).

[2] Brigitte Schroeder-Gudehus, dans *Les scientifiques et la Paix* (Université de Montréal, 1978), a analysé les relations scientifiques internationales avant la guerre de 1914/18, et la naissance de tous ces organismes pour développer l'expansion intellectuelle, en France, en Allemagne et en Grande Bretagne, à cette même époque.

[3] Patrick Petitjean, *Entre science et diplomatie, l'organisation de l'influence scientifique française en Amérique latine, 1900/1940,* communication au congrès de Hambourg 1989, Société internationale d'histoire des sciences (non publiée); Patrick Petitjean, "le Groupement des Universités et Grandes Ecoles de France pour les Relations avec l'Amérique Latine, et la création d'Instituts à Rio, São Paulo et Buenos Aires 1907/1940", p.428, *Anais do 2o congresso latino-americano de História da ciência e da tecnologia,* Nova Stella Editora, 1989.

Georges Dumas a une double formation de philosophe et de médecin. Sa thèse porte sur Auguste Comte et Saint-Simon, "les deux messies positivistes". Elève de Pierre Janet, il est professeur de psychologie à la Sorbonne et à Sainte-Anne. Il travaille sur l'expression des émotions, les hallucinations, les crises mystiques, etc. Tout en étant un spécialiste de Comte, et globalement positiviste, il était rejeté par les positivistes brésiliens. Entre 1908 et 1940, il est la cheville ouvrière de la coopération universitaire et scientifique avec le Brésil. Jean Marx est le directeur du Service des Oeuvres entre les deux guerres. Sous sa direction, le service jouera un rôle particulièrement dynamique dans les relations franco-brésiliennes.

[4] Lettre de Dumas à Marx, 30/04/1932, SO442.

[5] Portugais, **Bettencourt-Rodrigues** a été condisciple de Georges Dumas à la Faculté de Médecine de Paris. Ami de la famille Mesquita. Médecin du Consulat de France à São Paulo. Il fait partie du groupe de médecins qui constituent en 1903 l'Institut Pasteur de São Paulo. Professeur à la Faculté de Droit, **Vergueiro Steidel** était un des responsables du Parti Républicain Pauliste, auquel le *Correio Paulistano* était lié. **Victor de Silva**

Freire, ingénieur formé à l'école des Ponts et Chaussées à Paris en 1891, a été directeur des travaux publics de l'Etat de São Paulo entre 1897 et 1938. Elu comme directeur de l'Ecole en 1933 par ses pairs, il fut de ceux qui s'opposèrent à son incorporation à l'USP, puis au transfert des chaires de sciences fondamentales vers la FFCL.

[6] *Correio Paulistano,* 03/10/1912. Voir aussi *OESP,* 05/11/1921.

[7] Archives nationales, 70AJ-2A. Discours de Georges Dumas lors de l'Assemblée générale de l'Office National des Universités, le 27/3/1920. Partant de la constatation que les étudiants brésiliens vont en masse aux Etats-Unis, et non pas en France, Dumas propose, pour inverser le courant, de fonder des lycées, non pas français, mais franco-brésiliens : "ce seraient des lycées franco-brésiliens où nos agrégés collaboreraient avec des professeurs brésiliens pour former des élèves à la culture nationale et à la culture française, suivant la méthode de l'enseignement français. C'est donc une oeuvre nationale à laquelle nous collaborerons, et non une exportation universitaire. Nos lycées auront une situation privilégiée parmi les établissements étrangers, ce qui leur garantira les sympathies nationales et les mettra à l'abri de tout mouvement de xénophobie". Dumas insiste sur l'idée d'aller vite, en raison des concurrents jésuites et américains. En décembre 1919, a été fondée la "Société anonyme des lycées franco-brésiliens", pour la création du lycée de São Paulo, en faveur de laquelle Dumas demande le soutien de l'Office, accordé unanimement.

[8] *OESP,* 05/11/1921.

[9] *Correio Paulistano,* 06/09/1925.

[10] Patrick Petitjean, "le Groupement des Universités, ...", *op. cit.,* note 3.

[11] *OESP,* 17/03/1925.

[12] Patrick Petitjean, le Groupement des Universités, ..., *op. cit.,* note 3.

[13] *Correio Paulistano,* 30/07/1926, et plus généralement les 3 journaux (voir note 1) entre juillet et septembre 1926.

[14] *Idem.*

[15] Rapport du voyage de Garric en 1933, 21/10/1933, SO442. Voir la note 25, lettres du 16/02 et du 21/02/1934.

[16] A l'occasion de la mort de Georges Dumas, une séance d'hommage est organisée par la Société de Psychologie de São Paulo, avec notamment des discours d'André Dreyfus et Julio de Mesquita, *OESP,* 27/07/1946.

[17] Fernando de Azevedo donne, dans son livre *A educação entre dois mundos* (voir note 1), la liste des 11 participants de ce groupe : Valdeimar Ferreira et Vicente Rão, de la Faculté de Droit - Raul Briquet et Agesilau Bittancourt, de la Faculté de Médecine - André Dreyfus et Henrique Rocha Lima, de l'Institut de Biologie - Antonio Ferreira de Almeida Jr et Fernando de Azevedo, de l'Institut d'Education - Teodoro Ramos et Franciso Emelio de Fonseca Telles, de l'Ecole Polytechnique - et Julio de Mesquita.

[18] Patrick Petitjean, *Entre science et diplomatie, ..., op. cit.,* note 3.

[19] Fernando de Azevedo, *OESP,* 25/01/1954, repris dans *A educação entre dois mundos.* Paulo Duarte (voir note suivante, p.45-46) rapporte que, en raison de leur *"formation française complète",* Julio de Mesquita et lui-même avaient choisi la Sorbonne comme "modèle d'une université scientifiquement organisée", avec un regroupement des lettres et des sciences comme noyau central. En second lieu, l'Université de Cambridge aurait servi de référence, mais pas les universités américaines, trop éclatées en instituts. "A 80% nous avons suivi le modèle français", insiste Paulo Duarte.

[20] Paulo Duarte, témoignage recueilli pour le livre de Simon Schwartzmann, avril 1977, EHC54, p.50.

[21] Paulo Duarte : "A universidade e os profesores extrangeiros", *OESP,* 25/01/1947.

[22] Jean Maugüé : *Les dents agacées,* éditions Buchet Chastel (en particulier p.92 pour l'appréciation sur Mesquita).

[23] Paulo Duarte, *op. cit.,* note 21.

[24] Julio de Mesquita, "Pensamento director dos fundadores da USP", 21/03/1958, dans *Politica e Cultura.*
[25] Lettre au Ministère de l'Ambassadeur à Rio (16/02/1934) et lettres à l'Ambassadeur du Consul de France à São Paulo (21/02/1934, 22/02/1934 et 23/02/1934), SO443.
[26] *Idem.*
[27] Pauliste né en 1895, diplômé de l'Ecole Polytechnique de Rio de Janeiro, mathématicien de l'école d'Oto de Alencar et Amoroso Costa, Teodoro Ramos était, depuis sa thèse de 1918, enseignant à l'Ecole Polytechnique de São Paulo. Il faisait partie de cette génération de scientifiques formés au Brésil même pour l'essentiel. Il avait fait deux voyages à l'étranger : en 1924 aux Etats-Unis, et en 1930 en Europe, à l'occasion de congrès divers. Il avait en particulier séjourné quelques semaines en France en 1930, au moment de la publication de son ouvrage de mathématiques en français : *Leçons de Calcul vectoriel.* Avec Amoroso Costa, il était le meilleur mathématicien brésilien de l'époque. Il avait aussi occupé de nombreuses charges politico-administratives : maire de São Paulo (1933), secrétaire d'Etat à l'éducation et à la santé publique (1931), sans parler des commissions officielles sur de nombreux sujets. Voir : *Anuario da Escola Polytecnica de São Paulo,* 1936.
[28] *OESP,* avril et mai 1934 : reportages et interviews sur le voyage de Teodoro Ramos en Europe.
[29] Gleb Wataghin, témoignage recueilli pour le livre de Simon Schwartzmann (voir note 1), EHC16, p.14-15.
[30] Le premier cours de Piccolo suscite des remous divers : il y fait l'apologie du fascisme et de Mussolini. Paulus Aulus Pompeia raconte aussi que Fantappie "arrivait à l'estrade, levait la main et faisait le salut fasciste". Même Wataghin fait le salut fasciste lors du premier cours, mais ne recommence plus. Fantappie est le responsable du groupe fasciste, et seuls Wataghin et Occhialini n'assistent pas aux réunions. Les étudiants de Fantappie répondent à son salut par des bruits et du chahut, notamment des battements de mains sur les tables, faisant croire à Fantappie qu'il s'agit du salut brésilien ... La plupart des professeurs italiens sont rappelés brutalement au début de 1942; seul Wataghin reste, et Occhialini se réfugie en Grande Bretagne. Une autre image des Italiens est celle donnée par Paulo Duarte (voir référence 20, p.33) : il n'y aurait eu absolument aucun fasciste parmi eux, au contraire, des gens de gauche, ou neutres. Pour le cours de Piccolo : lettre du Consul au Ministère, 06/06/1934 et lettre du Consul à l'Ambassadeur, 17/07/1934 , toutes deux en S0443. A cette deuxième lettre, est jointe la reproduction d'un article du journal *A Plateia,* (12/06/1934) où il est indiqué : "Une conférence franchement fasciste ... Il déclare parler au nom de Mussolini ... Est-ce un cours de littérature italienne ou de fascisme? ... Le Gouvernement doit prendre ses responsabilités devant un tel comice politique". -- Sur la participation de Piccolo, de Fantappie et d'autres professeurs italiens à la section fasciste des enseignants de l'USP : Paulus Aulus Pompeia, témoignage recueilli pour le livre de Simon Schwartzmann (voir note 1), EHC51, p.14-21 et 41.
[31] Cf. note 28.
[32] Lettre de Dumas à Marx, 22/03/34, SO443. et lettre de Dumas à Marx, sans date (fin mars 1934 d'après le contexte), SO443.
[33] Cf. note 28.
[34] Lettre de Teodoro Ramos à Marx, 28/04/1934, SO443. et réponse de Marx à Teodoro Ramos, 01/05/1934, SO439. Le texte du contrat se trouve en S0442. Il précise les conditions d'enseignement (5 heures de cours par semaine, des assistants de préférence brésiliens), le règlement de conflits éventuels, l'obligation de rester jusqu'à la fin de l'année universitaire, l'obligation de dire dès septembre 1934 s'il y a poursuite la deuxième année, ainsi que les conditions financières : voyages aller-retour payés par les Français (mais rien sur le financement d'éventuelles vacances intermédiaires en France

pour ceux qui restent trois ans, ce qui sera source de conflit), compléments de salaire par les Français, salaires versés par les Brésiliens pour moitié en francs et pour moitié en monnaie brésilienne. Et, "le professeur X s'engage à réserver toute son activité à l'étude et à l'enseignement de matières de son cours. Il ne peut exercer aucune profession ni aucune occupation en dehors de son enseignement à la FFCL. Il doit aussi s'abstenir dans l'exercice de ses fonctions à l'université de toute propagande ayant un caractère politique ou religieux". C'est en raison de cette clause (se consacrer uniquement à son cours) que l'USP refusera que Claude Levi-Strauss puisse en 1938 faire son expédition en Amazonie tout en conservant son poste à l'USP.

[35] Lettre d'Emile Coornaert à Dumas, 27/07/1934, SO442. En réalité, si on remonte aux dates de naissance indiquées dans les annuaires (voir note 1), si la moyenne d'âge des Allemands est, approximativement de 45 ans, celles des Français et des Italiens sont très voisines, autour de 37 ans. Cela changera avec la mission de 1935.

[36] Cf. note 28.

[37] Paulo Duarte, E79, témoignage recueilli par le groupe d'histoire orale du CPDOC. Là encore, ses souvenirs mettent en scène une toute autre histoire : "J'ai été en France contracter quelques professeurs. Teodoro Ramos est venu avec moi, qui en a choisi d'autres en Allemagne et en Italie, et Georges Dumas a indiqué l'autre partie. Lors du coup d'Etat de 1937, les professeurs français, qui étaient 15 à l'USP, et italiens, ont commencé à partir, ...". Nulle part ailleurs on ne retrouve trace de la présence de Paulo Duarte aux côtés de Teodoro Ramos en 1934 en Europe, pas plus que d'un si grand nombre de Français à l'USP en 1937, ou de leur départ.

[38] Lettre de Dumas à Marx, 17/10/1934, SO442.

[39] Lettre de Dumas à Marx, 14/10/1934, SO443.

[40] Entrevue de Pierre Monbeig avec Michel Paty et Patrick Petitjean (REHSEIS-CNRS), mars 1987.

[41] Jean Maugüé, *op. cit.*, note 22.

[42] Lettre de Paul Arbousse-Bastide à Marx, 15/09/1934, SO443.

[43] Jean Maugüé, *op. cit.*, note 22.

[44] Pierre Monbeig, cf. note 40.

[45] Témoignages recueillis par le Pr. Tassara (note 1).

[46] Claude Levi-Strauss : *Tristes tropiques.*

[47] Bizarrement, Paulo Duarte (voir référence 20, p.88) prétend que Dumas, un conservateur selon lui, s'était opposé au recrutement de Claude Levi-Strauss, à l'époque, au parti socialiste. Mais que Paul Rivet l'avait choisi et imposé.

[48] Jean Maugüé, *op. cit.*, note 22.

[49] Jean Maugüé, *op. cit.*, note 22.

[50] Lettre de Dumas à Marx, 02/10/1937, SO444.

[51] Anuarios da FFCL-USP : 1934/35, 1936, 1937/38 et 1939/49.

[52] *Idem.*

[53] Cf. note 45.

[54] Cf. note 45.

[55] Pierre Monbeig, cf. note 40.

[56] Cf. note 45.

[57] Patrick Petitjean, *Entre science et diplomatie, ..., op. cit.*, note 3.

[58] Pierre Monbeig, cf. note 40.

[59] Patrick Petitjean, *Entre science et diplomatie, ..., op. cit.*, note 3.

PART IV

Final Round Table

"SCIENCE ET DÉVELOPPEMENT : UNE POLITIQUE SCIENTIFIQUE PEUT-ELLE TIRER UN ENSEIGNEMENT DE L'HISTOIRE DES SCIENCES?"

Sous la présidence de :
José Israël VARGAS

Avec la participation de :
Yvon CHATELIN, José LEITE LOPES,
Abdur RAHMAN, NAKAYAMA Shigeru,
Juan-José SALDAÑA et Jean-Jacques SALOMON

Yvon CHATELIN

Pour situer mon intervention dans le Colloque, je dois dire d'abord que je ne suis ni un historien ni un sociologue des sciences, mais un naturaliste et un africaniste. J'ai passé de très nombreuses années dans les pays de l'Afrique noire francophone, et je cherche ce qui peut être utile à des pays en développement comme ceux-là. Force est de constater qu'il existe des milliers de publications sur les grandes périodes de la science européenne, et encore peu sur les débuts de la science en Inde, au Brésil, ou en Afrique. Le Colloque qui s'achève m'a montré que la situation est en train de changer, il faut s'en réjouir, et rendre hommage à tout le travail qui a été accompli.

Comment répondre maintenant à la question précise posée à cette Table Ronde : l'histoire des sciences peut-elle servir l'élaboration des politiques scientifiques?

Ma première réaction a été celle-ci : mais oui, bien sûr, l'histoire des sciences peut aider l'élaboration des politiques scientifiques. La raison de cette réaction, c'est que les scientifiques eux-mêmes se servent de l'histoire. En général, cela se passe dans des situations de crise scientifique, quand il faut faire disparaître un paradigme ancien, et en proposer un nouveau. A ce moment là, les chercheurs de laboratoire se font pour quelque temps historiens, ils retracent l'origine de leurs idées, de leurs méthodes, pour mieux les comprendre et les critiquer, et pour les transformer plus facilement. Il y a des cas célèbres : je pense par exemple à la naissance de la mécanique quantique, à la naissance de la tectonique des plaques. Et il y a une multitude d'autres cas, moins connus.

Je prendrai celui de l'agriculture. On voit actuellement paraître un très grand nombre de travaux sur l'histoire de l'agriculture et l'histoire de la recherche agricole, principalement aux Etats-Unis. Cela vient de ce que l'agriculture est dans un état de crise grave (disparition des classes rurales, désorganisation des marchés, etc.) et que les sciences agronomiques sont très largement responsables de la situation. Ce que veulent ceux qui font l'analyse de la recherche agronomique passée, c'est essentiellement soutenir un changement de politique. Pour établir les bases d'une nouvelle politique, on a besoin de la compréhension de l'histoire récente. Un exemple avec la sélection des plantes. On peut montrer aujourd'hui comment elle a été systématiquement orientée sur des critères (productivité, aptitude à la grosse mécanisation, tolérance aux insecticides, etc) qui ont conduit à la crise actuelle. On comprend qu'on aurait pu, ou qu'on pourrait encore, l'orienter autrement : vers la qualité nutritive des produits, vers la résistance aux maladies, vers une mécanisation réduite, etc. Au cours de ce Colloque, nous avons eu deux

P. Petitjean et al. (eds.), Science and Empires, 365–392.

communications (Robert Anderson, Darwin Stapleton) sur la Révolution Verte et le rôle de la *Rockefeller* et de la *Ford Foundations:* elles vont dans le sens que je viens de décrire, car elles présentent l'analyse historique d'une certaine politique scientifique, pour en préparer une nouvelle. Voilà un type de travail historique dont les *"policy-makers"* sont obligés de tenir compte.

Pour une participation efficace des historiens à l'élaboration de politiques scientifiques, il me semble presque évident qu'il faut étudier en priorité le passé récent. Je vois l'intérêt des autres approches historiques et j'admets que, pour comprendre les conditions culturelles du développement scientifique, il faut considérer une longue histoire : la culture c'est ce qui dure. Mais pour participer aux politiques scientifiques actuelles de façon plus directe, il faut se rapprocher de notre époque : la science, ce n'est pas ce qui dure, c'est au contraire ce qui change sans cesse et très rapidement.

Il faut remarquer que près de quarante pour cent des communications de ce Colloque ont parlé de périodes relativement récentes. Le plus souvent, c'était de la fin du XIXe et du début du XXe siècle qu'il s'agissait. Je pense que les historiens peuvent étudier un passé plus proche encore : les dernières années des périodes coloniales, qui ont beaucoup d'importance pour expliquer la situation actuelle, les années cinquante, les années soixante ... D'ailleurs ce n'est déjà plus un passé tellement récent. Nous allons bientôt entrer dans le XXIe siècle, et la totalité du XXe appartiendra aux historiens ...

Se rapprocher de la science actuelle implique une adaptation des méthodes de travail, nul n'en doute.

Le premier effort consiste à approfondir la compréhension de la science elle-même, de ses pratiques, à faire l'épistémologie de ses paradigmes. Que faisaient les naturalistes au XVIIIe siècle? Essentiellement de la taxonomie. Que font les naturalistes aujourd'hui? Ils étudient des systèmes complexes qu'on appelle des écosystèmes, avec des moyens très perfectionnés. Ce n'est plus du tout la même chose. Je me permets de remarquer aussi, d'une façon très générale, que les historiens ont eu tendance jusqu'à présent à mettre en relief les déterminismes d'ordre social ou d'ordre culturel (rôle de l'Etat, des intérêts privés, etc), et à sous-estimer ou à passer sous silence les contraintes d'ordre scientifique ou épistémologique. Cela gêne certainement le dialogue entre historiens et scientifiques. Quand un historien rectifie cette situation et remet les raisons d'ordre technique et scientifique à leur juste place, il fait évidemment un grand pas vers une meilleure entente avec les scientifiques et également avec les *"policy-makers"*. Je pense qu'un bon exemple en a été donné au cours de ce Colloque, avec une communication (François Delaporte) sur la médecine tropicale dans laquelle le rôle de la structure théorique sur le développement de la discipline a été analysé et évalué.

Le deuxième effort à accomplir pour décrire l'histoire scientifique récente, c'est de se mettre à l'étude de groupes ou de communautés scientifiques, à l'étude de stratégies d'ensemble. Pour les périodes anciennes, l'histoire des sciences peut reposer sur des cas individuels; il n'y avait pas beaucoup de scientifiques au XVIIIe siècle, et leur nombre est encore réduit quand on fait le tri de ceux qui n'ont pas eu d'importance véritable et qu'il n'est guère nécessaire d'étudier. Pour le passé récent, la situation est très différente. Il faut appliquer des techniques qui permettent de saisir le fonctionnement de collectivités, constituer des bases de données, faire des statistiques, de la bibliométrie. Cette dernière technique, la bibliométrie, prend une telle place aujourd'hui dans la "recherche sur la recherche" que je pense qu'elle devient indispensable pour beaucoup d'approches historiques.

Il me semble nécessaire aussi de définir des ordres de grandeur pour une analyse aussi globale que possible. Un ordre de grandeur dans le temps : on peut considérer par exemple une période d'une trentaine d'années comme favorable, parce qu'elle permet de suivre parallèlement le déroulement d'un (ou de plusieurs) problème scientifique, et la carrière complète d'un (ou de plusieurs) chercheur. Un ordre de grandeur dans l'espace : par exemple, un institut de recherches, ou une discipline dans un pays donné, dont on pourra analyser toutes les étapes de développement et toute la production scientifique. C'est ainsi que l'on peut arriver à mon sens à des résultats très concrets qui intéresseront plus les *"policy-makers"* que des approches plus théoriques couvrant de longues périodes et de trop vastes domaines scientifiques.

La science actuelle soulève beaucoup d'interrogations que l'on ressent intuitivement ou superficiellement, mais que l'on ne peut pas analyser au jour le jour, sans recul. Je prendrai l'exemple du comportement individuel des chercheurs. Il est clair qu'il existe entre scientifiques (pour un même domaine) des styles de travail différents : travail individuel ou collectif, ouverture vers la multidisciplinarité ou spécialisation étroite, motivation désintéressée ou poursuite du prestige, etc. La structure d'une recherche se présente comme un réseau plus ou moins densément interconnecté suivant les comportements de ses acteurs. Ce n'est que sur une période et un espace de travail définis comme dit précédemment que l'on peut montrer comment les comportements individuels structurent le fonctionnement de la science. En d'autres termes, on a besoin de l'analyse du passé récent pour établir une typologie des comportements scientifiques et pour expliquer leurs causes (origine sociale et culturelle, éthique personnelle, influence des institutions, de la compétition, etc.). Cela prend une grande importance lorsque l'on pense à la politique de formation des chercheurs des pays en développement. Il est courant de dire que ces pays ont besoin d'un type de savant nouveau, en tout cas très différent du savant positiviste et réductionniste, enfermé dans sa spécialité.

Je conclus donc mon intervention en soutenant la conviction que les historiens ont à jouer un rôle dans l'élaboration des grandes politiques scientifiques. **Que pourrait-on leur proposer de mieux que d'aider à former une nouvelle génération d'hommes de science?**

Institut Français de Recherche Scientifique pour le Développement en Coopération, Paris

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José LEITE LOPES

Je ne suis pas historien des sciences, je ne suis pas un expert en politique scientifique, je suis un chercheur en physique théorique des particules élémentaires et en théorie des champs, la physique des premiers principes si vous voulez. J'ai une expérience aux Etats-Unis, où j'ai reçu une formation scientifique, et en France, comme enseignant. Avec ce bagage, j'ai lutté au Brésil pour développer la science, la recherche, l'enseignement universitaire : en tant qu'acteur de la recherche, nous rencontrons des difficultés et des obstacles; nous sommes forcés, pour faire notre travail scientifique, non seulement de lire les mémoires des grands chercheurs, mais aussi de comprendre les raisons des obstacles qui, dans notre pays, s'opposent au développement de la science. Et c'est là que nous rencontrons, non seulement les fruits apportés par les Empires, par ce qui est désigné aussi sous le nom de "centres", mais aussi un poids lourd, négatif, historique, qui est sur nos épaules. Et c'est ce poids qui nous empêche de développer plus la science. Nous rencontrons toutes les difficultés internes, qui nous sont propres, et qui ont pour racines certaines colonisations répressives, en particulier la destruction des belles civilisations pré-colombiennes : maya, aztèque, mexica, etc. Ceux qui vont en Amérique centrale et au Mexique voient les réalisations de ces civilisations : c'était beau l'astronomie, les mathématiques chez les Aztèques; et surtout, le rôle de la symétrie dans la construction de l'architecture pré-colombienne. Il faudrait que le groupe d'historiens, organisateur de ce colloque, envoie quelqu'un étudier tout cela.

Les conséquences de cette destruction pèsent très lourd et nous empêchent de développer la science aussi vite que nous le voudrions. Ensuite, il y a dans l'histoire de la science et de la politique scientifique un évènement très important : la découverte de la fission de l'uranium 235, en 1939, qui a donné naissance au projet Manhattan. Il n'était pas évident que l'on pourrait faire ce qu'on pensait, à savoir passer de la réaction en chaine nucléaire à une explosion ou à un contrôle pacifique de l'énergie nucléaire. La réussite du projet Manhattan constitue une discontinuité importante dans l'histoire de la politique scientifique mondiale : c'est de là que part l'institutionnalisation internationale de la science. La science est devenue, avec la technologie, une branche du pouvoir, une branche du gouvernement. Alors, tous les pays ont essayé de faire la même chose. Nous avons compris qu'il faut développer la science, et cela constitue un danger pour les pays les moins développés, en particulier, puisqu'on parle d'Empires, pour les anciennes colonies. Nous avons affaire à des économistes, qui sont un danger parce qu'ils ne résolvent pas chez nous les problèmes d'inflation. Nous avons affaire aussi aux scientifiques sociaux et politiques. Dans les pays avancés, il y a une telle concentration de chercheurs que, grâce aux institutions scientifiques, la politique de la science va dans une direction correcte. Mais chez nous, dans les pays les plus pauvres, il y a, au contraire, le danger d'une asphyxie de la science, c'est-à-dire de la recherche scientifique, par les économistes et par ceux que nous pouvons appeler des technocrates. C'est quelque chose qu'il faut prendre en considération.

Il y a une leçon importante à tirer de l'histoire des sciences, de la technologie et des sociétés, si l'on regarde les besoins spécifiques de chaque pays pour définir une politique scientifique, politique qui ne peut pas être identique partout : la base de tout, c'est l'éducation des gens, pour qu'ils soient non seulement compétents, mais surtout capables de créer de nouvelles connaissances. Pousser l'imagination créatrice, c'est cela la clé, c'est le secret du pouvoir des Empires. C'est la recherche, la création de nouvelles connaissances, la capacité de s'adapter, comme le Japon aujourdhui.

Au Japon, même s'il n'y a pas eu une forte contribution à la science fondamentale européenne, il y a eu une adaptation, une absorption rapide, une éducation forte, qui provoquent actuellement des progrès technologiques là-bas. Parce qu'il y a science et science : il y a aussi la science qu'on découvre, qui aboutit dans des livres, puis dans des bibliothèques; plus tard, quand il y a de la poussière sur ces livres, l'historien soulève la poussière, se penche sur les fondements de la recherche, et étudie chaque évènement. Un chercheur comme Abdus Salam a été mentionné comme un homme de l'intégration. Mais Salam est un grand physicien, qui existe comme un créateur en physique, indépendamment de savoir s'il a été intégré ou non.

Vous faites de chacun de nous, de chacune de ces découvertes, un objet d'études. C'est très important l'histoire des sciences, c'est très important la politique scientifique, mais le fondamental, le n°1, la base, c'est l'imagination. Ce n'est même pas la compétence. On dit qu'il faut former des gens compétents. Oui, mais avec seulement de la compétence, il est possible de faire un bon cours à l'Ecole polytechnique, à l'Ecole normale supérieure; il est possible de transmettre les connaissances acquises de Poincaré jusqu'à nos jours, mais il faut surtout transmettre ce qui n'est pas dans les livres, c'est-à-dire la recherche scientifique, la capacité de création, l'imagination; et cela, ce n'est écrit nulle part. Einstein n'a pas été programmé ou façonné, et pourtant, nous voulons refaire un Einstein identique, et ce n'est pas possible. La leçon principale à tirer de l'histoire des sciences, c'est donc celle-là : créer les conditions pour que puissent apparaitre des capacités d'imagination créatrice.

Je crois, si vous me permettez, que le XXe siècle politique a commencé en 1918, quand s'est achevée la politique de l'Empire austro-hongrois; et que le XXIe siècle a commencé l'année dernière, avec la révolution dans les pays de l'Est. En physique, le XXe siècle a commencé en 1880 avec la découverte des rayons cathodiques, des rayons X, de la radioactivité, de l'électron, et puis ensuite de la théorie quantique, de la relativité, etc. Et, en physique, à la différence de la politique, nous ne sommes pas encore au XXIe siècle. Et pour le Tiers-Monde, c'est encore plus vrai. Le Tiers-Monde, et nous n'avions pas encore utilisé ce mot, c'est les colonies des Empires, et les Empires sont toujours destructeurs comme ils l'ont été sur le plateau mexicain, aux Andes comme à l'embouchure de l'Amazone, avec les civilisations indiennes. Nous sommes dans un monde qui ne peut revenir en arrière, nous sommes obligés de nous intégrer aux pays avancés, auxc anciens Empires. Nous devons rendre les échanges les plus intenses possible, essayer d'être partie prenante de la mondialisation de la science. Il y a mondialisation de tout. Mais, pour nous comme pour vous, c'est l'imagination créatrice qui est la leçon fondamentale pour le progrès de la recherche, de la technologie, de la création. Telles sont les observations que je voulais faire. Et je me souviens aussi de l'histoire du *"policy-maker"*, qui ressemble à un animal à 100 pieds, et qui quelquefois ne sait pas par quel pied commencer : alors le singe lui a dit de se transformer en bipède, et le *"policy-maker"* lui a répondu qu'il ne sait pas comment, que c'est une autre affaire; c'est-à-dire qu'il y a les technologues, mais que sans les chercheurs, il n'y a rien.

Centro Nacional de Pesquisas (CBPF), Rio de Janeiro, et Université Louis Pasteur, Strasbourg

Abdur RAHMAN

Listening to the exchanges of last three days, and just speaking two words, I was reminded of an incident that happened to me at Cambridge when I called on Joseph Needham. He was sitting without light when I entered his room. I apologized for disturbing his thought, to which he replied, *"No, I wasn't thinking, I was only rearranging my prejudices"*. So having listened to the discussion of the last three days, I tried quickly to rearrange my prejudices which I present to you.

The first thing I would like to talk about is science policy. Since the Second World War, science policy has been formulated by the advanced countries because they undertook most of the research. They also formulated the policies for the developing countries. While they did this in terms of their economic and political objectives, they also did it in the context of their relations with developing countries. Recently, the advanced countries have incidentally moved away from the concept of "the white man's burden" to a sense of guilt, for what they have done to developing countries, and the developing countries have accepted the policies of intermediate technology, or appropriate technology, as it was advocated by the advanced countries for them. In this aspect, their way of thinking and formulating their own policies was derivative and defensive. Most of the time they occupied themselves with the problems of transfer of technology, trends of transfer, and conditions of transfer.

While the advanced countries moved away from "the white man's burden" to a sense of guilt, the developing countries have now moved away from aping the advanced countries, since they were not able to catch up with them. They started thinking nationalistically, asserting their own position, and tried to start looking into their past tradition, partly to create a distinctive culture of their own. In the process they created a divided society. The group on one side of this divide consists of those who have benefitted from the development of science and technology; they appreciate its development; their standards of living and their aspirations are linked with the advanced countries. On the other side is the vast majority of people who have not benefitted therefrom; they do not appreciate science and technology and they have started looking to the past. Now, in this context, I think that the historical perspective is very important. Nakayama and I think rather similarly and he mentioned the same thing.

Let us look what perspective the history of science gives to contemporary development. My own work, the preparation of a Science Atlas, and the project on "Culture and Development", have made me aware of three things which I feel are significant. First, there have been three main periods in which major changes in science and technology have taken place. The first was the Greek; the second was the Arabic; and the third was the European period. The development that took place in each period, was based on the absortion of earlier traditions and yet gave each a distinctive character. This gave a new paradigm for the development of science. Scientists in each period did not accept everything, but whatever came within their conceptual framework was accepted and transformed. Incidentally, this development was preceded by a larger scale translation activity, which was the basis of their selectivity and their development. Europe itself has developed what we would call a European scientific tradition, but actually there were three distinct trends which in the latter half of the nineteenth century came together to form a unified perspective of science as we know it today. The three trends were the travellers′ records who brought knowledge from different countries (fauna and flora, knowledge about people); the second trend was based on the activity of artisans, craftsmen and engineers who interacted with them, or the mining engineers who collected a large amount of details (in geology one can see the academic theory in contrast with what was built up by mining engineers); and the third tradition was the academic tradition (mathematics, physics, astronomy, and medicine), which was a continuous tradition altogether.

In these three trends, which came together in the latter half of the 19th century and in the early part of the 20th century, we can see that, in all the three, linkages with the earlier traditions exist. One of the very interesting things, which is often ignored, is that, in spite of the development that took place in Greece, in the Arab world, and in European tradition, traditional technology continues in the countries where they were developed even to this day, and one should understand the reason behind the continuation of the so-called traditional technologies.

The second significant point which I would like to mention, is that in each one of these traditions, the centres of science have been shifting : in the Islamic tradition from Bagdad to Spain, to Turkey, to Central Asia and India; in Europe, it started in Italy, went to the USA and has now reached Japan. In this shifting of centres, one may also notice that each centre, which takes over from the earlier centre, gives distinctive features and characteristics, to the development which takes place. By and large, we can see the transfer of technology from Italy, then in England, it was technology, science came later; in Germany, because of their limited natural sources, certain new elements of technology came; in the USA, it was the mass production system which gave the distinctive character; now, in Japan, it was again technology, they are now going over to science. I think that these are some of the factors that we should see. In each individual tradition, including the modern scientific tradition, each centre provides a distinctive position character.

The third significant point to be considered is that in any country when science reaches a high level, certain forces develop which tend to destroy the scientific tradition. It happened in the earlier traditions. Now let us take the contemporary example of Germany which, before the First World War, had reached a very high level of science (in each area, the language also becomes a central language when the country becomes a major contributing factor); Nazism destroyed this. In the Russian Revolution, Lenin created a base for science and there was an upsurge of science; Stalinism destroyed it. In Japan, it was linked up with the militarist tradition, and we know how the chauvinistic militarist tradition led to the horrors of the Second World War. In the USA itself, scientific development was taking place at a very rapid pace; McCarthy gave it a set back; and now there are military linkages where major spending is taking place, which is reducing the lead which the United States has. These factors are not peculiar to advanced countries; they are also operating in the developing countries as we can see from the emergence of various movements, in countries like India.

I would suggest that we do not consider science as a sort of totally monolithic unified tradition. We may notice its many strains, with their various trends, which, in different periods of a country, at a level of development, have a distinctive character. First, it is very necessary to de-segregate and carry out certain comparative studies within a cultural area. Second, it is also very necessary to understand sociological underpinnings of development, the political objectives of people, and, lastly, how this knowledge can be linked up in formulating a perspective for development. For instance, we have talked about the developing countries. In spite of all the models that have been applied in different countries, in spite of all the aid that has been made available by the United Nations agencies, scientific tradition as a self-generating tradition has not been able to take off in the developing countries. This is where some of the cultural, social, religious, and political factors come into the picture. Thus this is a very interesting area, which requires greater study. We have to shed our prejudices and the lines of thinking to which we have been attuned, because they are unlikely to give us the direction that we should take. It requires a different framework and conceptual perspective, in order first to understand the historical principles in the development of science and technology, and second to utilize them for the purposes of contemporary development.

New Delhi

NAKAYAMA Shigeru

The Centre Always Shifts

Scientists today, at least native English-speaking scientists, believe that most science is written and communicated in the English language. The present overwhelming usage of English practised in the world scientific community gives an impression that this state of affairs could be perpetuated in future generations as well. Such a situation could be viewed as "English (language) Imperialism" by non-English-speaking scientists with a grievance. The latter group of scientists might be relieved, however, to find the following lesson from the history of science.

Throughout the history of science, the centre of scientific activities has continually moved from one place to another: from ancient Babylonia to classical Greece, to Hellenistic worlds, to India, to the Islamic region, to Renaissance Europe, to 17th century England, to 18th century Paris, to 19th century German universities, and to 20th century USA. If we look closely, we find that the shift has taken place not always across national boundaries, but also, within one country, because the language employed to express science has changed.

Language Problems

A national boundary of science is a modern phenomenon, culminating today in incorporated defence science. In studies of the history of science, the language employed by the authors is more meaningful than their race or nationality, as the literature is revealing to us concerning the former but not the latter. Thus what we call, for instance, Greek science, is not that practiced by the Greek race in classical antiquity, but rather science which is written in the Greek language. In this way, we can define Latin science and also Chinese science, the latter of which includes science practised by Koreans and Japanese and written in the Chinese language in the pre-modern period.

While Arabic science had incorporated the peripheral languages of algebra and chemistry in addition to the Greek tradition, paradigms of Eastern science remained unchanged until the early 20th century because it centre stayed in China and it scientific language continued to be Chinese. The Japanese, however, began to switch their paradigm from the Chinese to that of the West in the 18th century and started to translate Western scientific works[1].

"Centre-periphery hypothesis" in science

The events which transpired when the shift of the scientific centre took place, or more precisely when the scientific language changed, constitute some of the major issues for a student of the history of science to contemplate seriously. In the following, I shall present a hypothesis - still not fully tested - to explain shifts of scientific centre in terms of the centre and periphery dichotomy.

Scientists at the scientific centre, of course, express their profession in the central language. On the other hand, those scientists in the periphery conceive of science in their native language but express the outcome in the central language; in other words, scientific bilinguality exists in the periphery. In the ordinary practice of normal science[2], the latter's state of affairs is considered to be disadvantageous, since peripheral scientists have to conform to the paradigm of the centre. For them, the model to follow always exists in the centre and what they must do to the best of their ability is to assimilate themselves to that model. They can never think of surpassing the standard of the centre or of changing a given paradigm. Even if they attempted to do so, there would be neither followers nor evaluators. On the other hand, central scientists can pursue their research without being concerned as to what is going on in the periphery. (This centre-periphery relationship can also be applied to academic disciplines between basic and applied sciences.)

If the above situation continues, stagnation may result with regard to the further extension of normal scientific practice. In the centre, while scientists look for sources of information only in the central language, they may cease to be receptive to new paradigms which often emerge in the non-orthodox context of a language other than the central language. On the other hand, upon accumulation of information from the centre as well as the periphery, peripheral scientists occupy a position advantageous to that of central scientists due to the variety and abundance of information available to them. Chances are that out of this state of affairs, a new paradigm will emerge. The "threshold" conditions that prevail when the periphery becomes the centre area are, first, when the language used in expressing their trade changes from the central language to their own native language, and second, when the latter begins to be cited by other language groups. With the lack of the second condition, a peripheral activity remains as a local paradigm and as local science, such as culture- and locality-bound sciences, including some forms of geological science. Japanese social scientists read Western language but write only in Japanese. They have more information than Western scholars and even their own local paradigm, but this activity is virtually unknown outside of Japan. Only lately, as Japanese economy attracts attention of Western scholars, have some of them started to introduce Japanese works in Western language[3].

Events in Germany in the 1920s

In order to explain the shift of the centre from Germany to the USA in the 1920's in terms of language, I conducted a survey on citation sources of scientific articles which appeared in major physics journals such as *Annalen der Physik, Zeitschrift fuer Physik* and Physical Review in 1900 and 1925[4].

German journals cited mostly German articles (80%-90%) in and around 1900 - although practically all German scientists could read English - whereas by about 1925, the incidence of German citations decreased to 60%-70%, while citations from English journals simultaneously increased. American journals, throughout this period, mostly cited articles by fellow Americans, but the quantity did not exceed 40%, the remainder being citations from German and British authors.

This survey does not directly prove the validity of the above-mentioned centre-periphery hypothesis, but indications are that the Americans collected a greater variety of worldwide information, while the proud Germans, who communicated exclusively within the German-speaking scientific community around the turn of century, apparently lost self-confidence in the course of time and cited more English journals.

Problems of Human Resources

Within the history of science discipline, there are a number of studies on the rise of scientific centres and their mechanisms, whereas there are far fewer studies detailing the reasons why the centres declined or disappeared. Not only is the latter study much less attractive, but it is difficult to approach, due to the lack of readily apparent evidence. Perhaps the normal course of development is such that, as aged science attracts fewer followers, it reaches a stage resembling natural death.

Although the centre-periphery hypothesis might have been at work slowly from the late 19th century onwards[5], what occurred in Germany in the 1920s may not be the process of natural death. It must have depended also on external factors, such as the defeat in World War I and the ensuing economical hardship, finalized by Nazi intervention in the 1930s.

The state of affairs is well documented by Isidore Rabi's experience of studying in Germany in the late 1920s[6]. In those days, German science had created its last and greatest paradigm of quantum mechanics. Rabi, who followed the American practice of studying in Germany before starting his scientific career after completing his Ph.D., was naturally attracted by the famous German scientists, such as Werner Heisenberg, Erwin Schroedinger and others. What he found in Heisenberg's seminar was that Heisenberg was the only German - more than half the seminar participants were Americans, and the rest were Chinese, Japanese and so on. The big names associated with the quantum mechanics paradigm were all there in Germany but no young followers were emerging. In his eyes, the decline of German science was all too apparent.

In those days, Rabi wrote scientific papers in German in the hope of obtaining recognition from his German peers. However, it was not language but scientific human resource, which contributed to the shift of the scientific centre. Language is only a superficial indication of centre shift, although written documents can be more easily dealt with (as evidence) in historical scholarship. The relocation of scientific manpower is more essential than language change in "migration of scientific leadership", a better expression than "shift of centre". A new scientific concept and new paradigm may be language-bound, but a scientific revolution can be completed only with those groups of scientists who support and develop a new concept or paradigm. In the above case, German is the original language of quantum mechanics concepts, but those concepts were completed by American followers who translated them into their own native language of English after returning home from study in Germany.

From the USA to where?

Since the mid-1980s, the "decline" theory of American civilization has been entertained among American authors[7]. Along with this argument, it may be worthwhile to examine the likelihood of a future centre shift from the USA to elsewhere, despite the fact that American science remains predominant in the contemporary world. The candidate countries to be examined here as recipients are Japan in the near future, and China in the distant future.

Problems with Language

One of the requirements for a 19th-century scientist was to be accomplished in three languages: English, German and French. This, of course, applied even to proud German *Wissenschaftler*. Hence there were few language barriers among European scientists.

One of the Ph.D. requirements for a 20th-century American scientist was, prior to World War II, to be accomplished in the above three languages, not only in reading but also in conversation, in order to communicate with European scientists. After the Second War, however, language requirements were reduced to mere reading ability. Today, American scientists do not require any language other than English or, even if a language requirement does exist, it is more a matter of ceremony. Americans believe that one can practice science with English only, as major contributions to science are all written or translated into English. Scientists in non-English-speaking countries entertain some doubt in this belief, but they also know that it is largely true in the current circumstances of the scientific world.

If we apply the centre-periphery hypothesis discussed above, the present situation in American science is clearly an indication of the beginning of a declining phase, since American scientists are only able to collect information available in the central language of English. Already, some perceptive observers[8] have noticed this blunder in the American camp concerning the collection of information, and have stressed the importance of scientists and engineers to learn the Japanese language.

Kanagawa University

Notes

[1] Shigeru Nakayama, *Academic and Scientific Traditions in China, Japan and the West*, University of Tokyo Press, 1984; and also his *The Transplantation of Modern Science in Japan*, Centre for studies in higher education, the University of California, occasional paper, n°23, 1982, 26p.

[2] In the sense of Thomas Kuhn, *Structure of Scientific Revolutions*, Chicago University Press, 1962.

[3] One recent interesting example is Tessa Morris-Suzuki, *A History of Japanese Economic Thought*, Routledge, 1989.

[4] Shigeru Nakayama "Kagaku no chushin no ido to paradaimu (Shifts of Scientific Centres and Paradigms)", *Kanagawa daigaku hyoron*, n°4, 1988, p.14-21.

[5] Critical arguments of Friedrich Paulsen on German university research at the end of the 19th century and the famous memorandam of Adolf von Harnack at the time of founding Kaiser-Willhelm Gesellschaft before World War I, are indications of German crisis-consciousness.

[6] Rabi's address to the History of Science Society, annual meeting at New York in December 1957. Also John S. Rigden, *Rabi, Scientist and Citizen,* New York Basic Book, 1987.
[7] Ira C. Magaziner and Robert B. Reich, *Minding America's Business: the Decline and Rise of the American Economy,* 1982, is one of the early examples.
[8] Such as Senator John D. Rockefeller.

Juan-José SALDAÑA

La fonction prédicative de l'histoire des sciences ainsi que son rapport à la prospective scientifique et technologique ne sont pas des questions évidentes. Tout au moins, elles ne sont pas tenues comme telles, jusqu'à présent, par les spécialistes de l'une et l'autre de ces matières, ni par les propres administrateurs de la science. Certains d'entre eux nient aussi toute possibilité de prévision sur l'évolution des sciences à partir de faits historiques; ainsi par exemple, Gérard Radnitsky[1], qui affirme :

"... il n'est pas possible de déduire de l'histoire des sciences que celle-ci doive procéder de telle ou telle manière : il n'est pas possible de déduire à partir de prémisses entièrement descriptives une conclusion normative quelconque".

L'argument ainsi avancé est connu et relève d'une "tromperie naturaliste" qui nie la capacité généralisatrice et normative du raisonnement inductif. Il suppose, en outre, que l'histoire des sciences procède encore de cette façon.

Dans les pays en développement, les demandes de science et de technologie sont habituellement produites par le développement économique. La planification économique est, en conséquence, utilisée pour l'ébauche de politiques scientifiques et technologiques avec prédominance de la formalisation, de la centralisation et du point de vue déductif. Dans certains cas, le rôle de cette planification s'est réduit à la légitimation de décisions prises, au lieu d'être un véritable instrument pour la prise de décisions. La planification ne sert alors qu'à des buts idéologiques.

Par ailleurs, ces méthodes ont été développées généralement dans les pays industrialisés et ensuite utlisées dans les pays du Tiers-Monde au cours des années 1960-70. Elles devaient servir à élaborer des scénarios pour l'évolution de la science et de la technologie, ainsi que pour leur transfert aux dits pays, avec un degré de fiabilité relativement élévé. Il s'agissait de donner, grâce au calcul mathématique, un critère scientifique pour d'éventuelles décisions politiques et d'assurer ainsi ses effets virtuels. Néanmoins, et J.-J. Salomon l'a clairement exprimé:[2]

"l'espace normatif de la prévision n'est pas l'espace objectif, logique, rationnel, du discours scientifique; malgré l'appareil mathématique utilisé, ce n'est rien de plus qu'un des éléments de l'espace équivoque où s'élaborent et s'appliquent les décisions".

La plupart des pays en développement ont élaboré des politiques explicites de science et technologie depuis 30 ans. Ils ont principalement suivi le chemin emprunté dans ce domaine par les pays industrialisés; ils disposent de l'appui et du conseil de plusieurs organismes internationaux. Cependant, il est facile de constater que ces politiques ont très peu contribué au développement; dans beaucoup de cas, elles se sont avérées totalement irréalisables. Plusieurs raisons sont souvent avancées, personnelles comme institutionnelles, culturelles comme économiques et politiques. Ceci a conduit plusieurs analystes à en tirer des conclusions pessimistes : ils avancent qu'il est structurellement impossible, pour des pays du Tiers-Monde, de formuler des politiques scientifiques et technologiques viables et cohérentes pour leur développement économique et social.

Mais, pour revenir à la question posée, tout en laissant de côté la validité des analyses faites sur ces "échecs" ou sur la problématique particulière pour la planification scientifique dans les pays sous-développés, il est possible, malgré tout, de se rendre compte que les facteurs issus du processus historique n'ont pas été pris en compte sérieusement.

L'histoire des sciences des pays de la périphérie, malgré des antécédents non négligeables, est encore pratiquement inconnue dans beaucoup de ces pays; dans d'autres, comme ceux de l'Amérique latine, ou dans les pays arabes, son étude systématique n'a débuté que très récemment[3]. Par ailleurs l'historiographie a, par ailleurs, privilégié l'étude de la contribution scientifique au *"mainstream"* de la science, les biographies à but hagiographique et une certaine histoire intellectuelle ou des idées scientifiques. Ce n'est que récemment qu'un intérêt se manifeste pour comprendre les mécanismes sociaux de la pratique scientifique dans ces pays. Une histoire sociale des sciences dans les pays périphériques peut beaucoup nous apprendre. Cela concerne notamment les conditions socio-culturelles spécifiques, qui, dans le passé et encore maintenant, constituent le contexte pour l'élaboration de politiques scientifiques et technologiques réalistes, capables d'avoir une influence positive sur les programmes de développement.

En effet, il n'est pas exagéré d'affirmer que l'irréalité a prévalu dans les tentatives de planification et d'orientation des activités scientifiques et technologiques, pour de nombreux pays du Tiers Monde. L'histoire traditionnelle des sciences a ignoré, pour des raisons européo-centrées, l'expérience scientifique de sociétés culturellement différentes de l'Europe et des Etats-Unis. Plus encore, elle a fait l'hypothèse que l'histoire devait se répéter, que le développement scientifique à la périphérie se réduisait à la diffusion et à la transplantation d'idées, de méthodes, de formes d'organisation et d'institutions, et même dans certains cas de personnes, en provenance des pays centraux. Mais l'histoire ne se répète jamais. En revanche ce qui s'est produit fut un *"interplay"* entre des cultures qui avaient différentes perceptions de la production et de l'utilisation des connaissances; dans beaucoup de cas aussi, le sens donné au mot "connaissance" était différent. C'est ainsi que la pratique scientifique périphérique a acquis un profil propre selon son contexte socio-historique. Cette spécificité est précisément ce qui a été ignoré, et continue de l'être, par les planificateurs en ce qui concerne les prises de décisions.

Ainsi donc, l'histoire des sciences des pays en développement est une composante nécessaire des diverses recherches concernant l'évolution future des sciences et de la technologie, et de leur contexte social. L'absence d'une telle composante fait courir un danger d'irréalité aux prévisions faites.

Enfin, les politiques scientifiques et technologiques ont également besoin d'une justification et d'une critique historiques dont la nature n'est évidemment pas d'ordre logique formel, mais d'ordre historique et social. Si on ignore l'expérience scientifique antérieure, on ne réussira pas à définir clairement les réalités à modifier dans les plans et les programmes; on ne pourra pas non plus prévoir, avec une certaine chance de succès, les actions à entreprendre. En plus de la connaissance de l'histoire sociale des sciences, cette critique suppose celle de l'histoire des politiques scientifiques et technologiques elles mêmes. Mais très peu a été fait jusqu'à présent sur ce sujet.

Universidad Nacional Autónoma de México

Notes

[1] Gérard Radnitsky, *Epistemologia e Politica della Ricerca*, Roma, Armando Editore, 1978, p.79.

[2] Jean-Jacques Salomon, *Ciencia y Politica*, México, Editorial S.XXI, 1974, p.131.

[3] La bibliographie sur ces pays s'est considérablement développée ces dernières années, mais elle se trouve dispersée dans de nombreuses publications. On peut faire une première approche de l'Amérique latine dans : *Quipu, Revista Latinoamericana de Historia de las Ciencias y la Tecnologia* (ISSN 0185-5093), qui parait tous les 4 mois depuis 1984.

Jean-Jacques SALOMON

"Science, politique de la science, développement" : y a-t-il des leçons à tirer de l'histoire des sciences? La réponse ne peut être à mes yeux que positive, mais j'admets volontiers que je ne suis pas neutre : historien des sciences de formation, j'ai passé une bonne partie de ma vie à m'occuper de la politique de la science dans les pays membres de l'OCDE. En fait, j'irai jusqu'à dire, en ce qui concerne précisément les problèmes du développement, que si les "décideurs" dans les pays industrialisés, à plus forte raison dans les pays en développement et plus encore dans les organisations internationales, avaient eu une culture historique plus prononcée, on aurait sans doute évité beaucoup des déboires que les politiques suivies depuis une trentaine d'années dans ce domaine ont connus. En particulier, on aurait évité ce que mon voisin Saldaña vient d'évoquer, à savoir "l'irréalité" dans laquelle ont été prises la plupart des décisions qui prétendaient, d'une part, promouvoir les ressources scientifiques et techniques, et d'autre part en tirer parti en fonction d'objectifs de développement...impossibles à atteindre.

Je crois qu'il y a effectivement des leçons à tirer de l'histoire, des leçons générales qui vont d'ailleurs de soi, et des leçons plus particulières. En les évoquant très rapidement dans cette table ronde, je dois d'abord introduire un mot de précaution en rappelant qu'il y a pays en développement et pays en développement; autrement dit, lorsque nous parlons du Tiers-Monde, nous devons toujours avoir à l'esprit qu'il s'agit d'un ensemble extrêmement hétérogène. En dehors des solidarités affichées, les différences demeurent, différences de tailles, de populations, de dotations en ressources naturelles, mais aussi de trajectoires historiques et de cultures. Il n'est pas question de comparer le Brésil, par exemple, au Congo, l'Inde ou la Chine au Tchad ou à la Tunisie, la Corée au Skri-Lanka ou à Madagascar. Les situations sont si diversifiées qu'il faut donc toujours conserver le sens des nuances et se méfier des analyses "globalisantes".

Première leçon : en accédant à ce que notre ami Roshdi Rashed a appelé la science moderne, les sociétés industrialisées sont passées par trois étapes successives, et je ne crois pas qu'il y ait un seul exemple d'une société qui soit passée à la deuxième de ces étapes sans passer par la première ou à la troisième sans passer par la seconde. La première étape a été celle de l'institutionnalisation de la science, le fait qu'il a fallu définir et préserver un lieu où la science expérimentale pouvait se pratiquer (les académies d'abord, puis les universités). Cela a pris du temps, et n'est pas allé, comme vous le savez, sans problèmes, car, face à d'autres institutions déjà bien établies, l'institution de la science a dû conquérir sa légitimité et défendre son autonomie contre toutes sortes de pouvoirs, politiques, religieux, économiques. La deuxième étape est celle de la professionnalisation, le fait que les scientifiques professionnels et salariés se sont substitués aux amateurs savants : la communauté scientifique s'est développée sur la base de spécialisations toujours plus nombreuses et avec un personnel dont les cursus et les titres ont été de plus en plus étroitement sanctionnés par des études longues, soumises par exemple à ces rites d'initiation que sont les formations *"graduate"* et *"post-graduate"*. En ce sens, la pratique de la recherche scientifique est devenue un métier parmi d'autres, inscrit et reconnu dans le système de production comme une profession parmi d'autres, non moins légitimement organisée, structurée et même syndicalisée que d'autres. Cela aussi a pris du temps. La troisième étape est celle de l'industrialisation de la recherche, et par industrialisation de la recherche j'entends non pas seulement le développement de la recherche industrielle, mais encore le fait que la science, l'institution scientifique, la recherche scientifique sont elles-mêmes devenues l'objet d'un processus d'organisation, de gestion, et de décision relevant des pratiques les plus banales (et néanmoins scientifiques) de la gestion industrielle.

Deuxième leçon : il y a de toute évidence des cultures et des sociétés qui sont mieux préparées que d'autres à accueillir et à plus forte raison s'approprier la science moderne. De ce point de vue, il faut tenir compte d'un certain nombre d'obstacles et de résistances, liés au milieu, à l'histoire, à la culture. Je sais bien que c'est là un propos désagréable à tenir ou à affronter, qui peut être fort mal interprété : un de mes interlocuteurs brésiliens, Amilcar Herrera, n'est pas loin d'y voir une forme de racisme culturel (voir le débat dans *Social Science Information* sur ce sujet au cours des années 1989-90, en particulier le n°29, 4ème trimestre 1990). Mais n'y a-t-il pas des sociétés "traditionnelles" dont l'histoire, la culture, l'organisation sociale, les croyances, les structures d'éducation, etc., ont constitué autant d'obstacles ou de freins à l'adoption de la science moderne? A quoi attribuer, sinon, les "blocages" de sociétés et de civilisations qui, avant la révolution scientifique du XVIIe siècle, n'étaient pas en retard technique et même étaient en avance à bien des égards, comme la Chine impériale, par rapport à l'Europe occidentale? Il suffit de lire Joseph Needham pour voir qu'on ne peut minimiser le poids de ces facteurs culturels.

Troisième leçon : l'histoire des sciences, comme l'a dit mon ami Rahman, comme l'ont dit plusieurs de ceux qui ont pris la parole avant moi et en particulier Nakayama, a connu des périodes différentes de succès scientifiques et techniques, avec constamment un déplacement des "centres" et par conséquent des "périphéries", par exemple, dès les débuts de la science moderne, d'Italie en France et en Angleterre, et par la suite de l'Europe aux Etats-Unis. Il y a des périodes où l'on voit certaines sociétés précéder les autres du point de vue de l'innovation, mais en gros aucune société n'a jamais conservé le monopole de ses innovations : l'Angleterre était en avance sur l'Europe continentale et à plus forte raison sur la France; cette dernière a vite rattrapé l'Angleterre, après le démarrage de son industrialisation, et les Etats-Unis ont non moins rapidement rattrapé l'Europe. Il est clair qu'aujourd'hui les Japonais rattrapent les Américains dans beaucoup de secteurs technologiques. Mais, si les pays qui sont en avance peuvent toujours être rattrapés, cela ne signifie pas que les pays qui sont en retard soient tous également en mesure de se retrouver dans le peloton de tête ni même, pour certains d'entre eux, de faire mieux que surnager dans la compétition scientifico-technique. Plusieurs, au contraire, ont toute chance de se retrouver hors de la course. De plus, il y a eu des cas de déclin, de régression et parfois d'effondrement : pensez aux pays d'Europe de l'Est dont le régime politique s'est effondré avec tout leur système économique. Qu'est ce que cela veut dire? Cela veut dire qu'il faut que certaines conditions soient remplies pour que l'institution scientifique et technique émerge, se développe, s'épanouisse, conserve ses atouts, rivalise avec les autres, etc. La partie n'est jamais gagnée, et s'il faut, pour la lancer, du temps - beaucoup de temps -, il faut aussi beaucoup de soins et de soutiens à la fois institutionnels, économiques et politiques pour lui permettre de continuer.

Bref, la pratique de la science moderne n'est pas une "donnée" qui se transférerait d'une société à l'autre comme un colis postal. Il y a d'ailleurs un autre aspect dont on n'a pas beaucoup parlé, c'est qu'il n'y a pas de diffusion de la culture scientifique sans infrastructure adéquate (école élémentaire, revues, journaux, musées, etc.) Quand on parle de science et de développement, on évoque les universités et les laboratoires les plus prestigieux, comme si on pouvait s'assurer un droit d'entrée au sommet de la pyramide sans commencer par travailler à consolider les premières marches. Jamais l'Europe n'aurait pu tirer parti des connaissances scientifiques et techniques au démarrage de la révolution industrielle si, d'un côté, il n'y avait pas eu la généralisation de l'éducation élémentaire, et de l'autre la diffusion de la culture technique, par une foule de moyens très différents, de l'école à la formation professionnelle, des ouvrages de vulgarisation à la reconnaissance de la démarche et des valeurs scientifiques au sein des institutions sociales.

Voilà les leçons les plus générales qu'on peut tirer de l'histoire des sciences et des techniques. Il en resulte, me semble-t-il, des leçons plus particulières que l'on peut appliquer aux problèmes et aux enjeux actuels du développement. Par exemple, il n'y a pas de raccourci, et l'on ne peut ni bousculer ni renverser les étapes : à quoi bon des scientifiques formés en Occident, s'il n'y a pas d'institutions scientifiques pour leur permettre à leur retour de mener des recherches? A quoi bon des laboratoires plagiant ce que les pays industrialisés possèdent de plus avancé, s'il n'y a pas d'infrastructure industrielle pour traduire les résultats de la recherche en innovations? Les objectifs du développement ne coïncident pas nécessairement avec ceux de la science en tant que telle et de la communauté scientifique internationale. Et, pour bon nombre de pays en développement, édifier une infrastructure scientifique à l'image des infrastructures les plus "sophistiquées" des pays industrialisés n'est peut-être pas l'objectif de développement le plus urgent à atteindre.

En outre, Roshdi Rashed a eu raison de rappeler que la transition de la science classique à la science moderne passe précisément par l'Etat national, et le plus souvent un Etat national d'abord caractérisé par des intérêts stratégiques, à la fois militaires et économiques. Le cas de l'Inde, du Brésil et de la Chine montre que le point de départ de l'émergence de l'institution scientifique au sens moderne est lié à ces intérêts stratégiques. L'Etat national d'ailleurs ne suffit pas, il faut encore qu'il y ait une forme de volontarisme montrée par les acteurs, pas seulement les militaires, mais aussi les élites politiques, les milieux économiques et bien sûr la communauté scientifique. Ce qui veut dire que la science n'est jamais un isolat dans les structures sociales. Or, dans beaucoup de pays en développement, la communauté scientifique qui émerge à peine demeure très isolée des structures locales politiques, économiques, sociales, alors qu'elle peut simultanément entretenir de nombreux échanges avec ses homologues dans les pays industrialisés. Il n'y a pas de contacts avec les hommes au pouvoir, qui verraient volontiers dans les scientifiques des troublions contestataires, et par conséquent parler dans ce cas de politique de la science, c'est tout simplement faire de la politique-magie.

Mes réflexions ne reviennent pas à dire que la science ne peut pas jouer un rôle important dans une politique de développement. Elles consistent à souligner deux points importants : d'abord, le développement dépend bien plus de la technologie que de la science en tant que telle ; ensuite, parmi les pays en développement, bien peu disposent de structures et d'équipes de chercheurs leur permettant de tirer parti de la recherche scientifique. La grande leçon de l'histoire des sciences, telle qu'elle ressort des constantes que j'ai évoquées, c'est qu'il n'y a pas de voie large, ni linéaire, ni accélérée pour se doter des moyens et des hommes qui font qu'un système de la recherche scientifique contribue efficacement aux objectifs du développement. Il faut du temps pour former des générations acculturées à la pratique de la science moderne, et il me semble, de ce point de vue, que la formation technique et l'éducation de base peuvent contribuer plus effectivement aux objectifs du développement que la science en tant que telle.

L'un des grands drames du développement, me semble-t-il, dans beaucoup de pays, en particulier en Afrique, est qu'on a bousculé les étapes et "mimé" le point d'arrivée des pays industrialisés, sans le temps, les déboires et les coûts que ceux-ci ont du assumer pour en arriver précisément où ils en sont arrivés. Dans les pays en développement à peine émancipés des tutelles coloniales, on s'est donné de belles universités, et parfois aussi de belles structures chargées de définir et d'élaborer une politique de la science, en l'absence d'une base, d'une infrastructure de connaissances élémentaires sur le plan technique et de laboratoires sur le plan scientifique conçus pour répondre aux besoins les plus urgents de l'économie et de la santé. Il n'y a pas de miracle là où ces conditions, en fait ces préalables, ne sont pas remplis : ou on se donne les moyens de diffuser la culture technique en fonction des besoins réels du pays, ou on se condamne à multiplier les disparités de développement sur le plan économique et social. Je citerai encore mon ami Roshdi Rashed, parce que j'ai trouvé que sa formule était très belle: *"on vise les effets de la science sans se donner les moyens de la produire",* et c'est effectivement ce qui s'est passé dans la plupart des pays en développement. Je dis bien la plupart, ce qui veut dire qu'il y en a heureusement un petit nombre qui ne sont pas tombés dans ce leurre : viser les effets de la science, sans se donner les moyens de produire et de consolider l'infrastructure intellectuelle de toute la société - infrastructure que seule la scolarisation et la formation élémentaire de toute la population peuvent apporter -, c'est créer une institution scientifique de façade ou planter une tour ultra-moderne au coeur d'une multitude de villages traditionnels.

Permettez-moi de terminer par une anecdote, que j'ai racontée dans un livre consacré précisément aux problèmes de la science et de la technologie au service du développement, *L'écrivain public et l'ordinateur* (Hachette, 1988). Cette anecdote illustre exactement mon propos : une politique de modernisation à marches forcées n'a pas seulement pour conséquence de créer des institutions de façade, elle a aussi pour résultat de multiplier les résistances de la population au changement technique, et finalement de susciter des manifestations d'obscurantisme et d'intégrisme qui vont jusqu'à récuser tout de qui est associé, d'une manière ou d'une autre, à la science moderne, "occidentale." Dans les années 73-74, période de la crise du pétrole, j'étais encore à l'OCDE, responsable de la politique de la science. L'Iran, considérant qu'il avait beaucoup de pétrole et que les pays de l'OCDE avait des difficultés à recycler les pétro-dollars, envoya auprès du Secrétaire général de l'OCDE son ministre chargé de la planification. Qui s'en souvient encore? L'Iran sous le règne du Shah prétendait devenir le troisième ou le quatrième pays industriel à la veille du XXIe siècle. Je me souviens, pour ma part, d'une campagne de presse dans les journaux français qui annonçait cet exploit à venir avec le plus grand sérieux.

Le ministre s'adressa au Secrétaire général et à tous les directeurs de l'OCDE à peu près dans ces termes :

"Grâce aux moyens techniques les plus modernes, médias, ordinateurs, cassettes-video, enseignements assistés et à distance, etc., vous pouvez nous aider à former rapidement et en grand nombre tous les scientifiques et ingénieurs dont nous avons besoin. Nous avons du pétrole, et vous avez non seulement les idées, mais surtout les moyens de nous les transmettre à un rythme accéléré. En dix ans, avec votre appui, nous serons dans le peloton de tête des pays les plus industrialisés".

Le tour de table qui s'en suivit fut aussi courtois qu'évasif. Quand on me demanda ce que j'en pensais, je n'ai pas pu me retenir d'exprimer mon scepticisme : *"Une décennie, c'est vraiment court, et tout ce que je sais de l'histoire des sciences me montre qu'un rattrapage prend plus de temps et suit des voies plus sinueuses."* Le ministre se montra très mécontent : *"Mais enfin, ce n'est pas sérieux, l'histoire des sciences, ça ne sert à rien, et d'ailleurs que vient-elle faire dans une organisation à vocation économique telle que l'OCDE?"* J'ai timidement répliqué - cela n'a pas été tellement apprécié par certains de mes collègues - qu'il existait un philosophe du nom d'Epictète auquel un disciple, lui montrant un figuier, déclara : *"Je veux des figues"*. Le philosophe répondit simplement : *"Il faut du temps"*. L'histoire des sciences vous apprend, en effet, qu'il faut beaucoup de temps, c'est-à-dire des générations pour former des institutions et une société capables de digérer les connaissances scientifiques et d'en tirer parti en fonction de ses propres besoins. Le ministre du Shah est revenu sans recettes-miracles dans son pays, où par la suite, vous le savez, il y eut une révolution et un procès fait aux hommes comme aux valeurs s'inspirant de la science occidentale. Le Shah a été renversé, le ministre a été passé par les armes, et c'est la fin de mon anecdote.

Conservatoire National des Arts et Métiers, Paris

José Israël VARGAS

Before we exchange views among ourselves, perhaps I should take advantage of the privilege of chairing this table, and also bring forth certain reflections that have been raised by some of you, particularly by Jean-Jacques Solomon. I had remarked before this round table to Jean-Jacques Solomon that I was struck by the fact that, having followed this meeting for some time, I have heard very few comments on techniques; not to mention technology, because we were more or less limited to examine problems up to the 19th century, and technology is something new. The question is the explosive result of this mix of science and techniques, on the one hand; on the other hand it is so obvious that their transfer or appropriation constitute a number of pre-conditions which have been rightly pointed out by Jean-Jacques Salomon to explain our present situation.

In Brazil where I come from I shock my colleagues - not all of them, as Leite Lopes is here to confirm - in the Academy of Science by telling them that we should not really occupy ourselves with science and technology for some time and that we should perhaps stress the need for general and basic education as the key factor for development. This leads me to the Japanese miracle. By the 1860-70s Japan had a crisis in the balance of payment, due to the amount of money it was spending on training people abroad, and on training and importing technologists and some teachers (not many teachers, mostly technologists). As a result, by 1900 it had a level of alphabetization higher than the English one. So this basic cultural environment seems to be indispensable for the progress of science and of the techniques.

The second point that struck me, during one of my many visits to Japan, was when I was taken to Kamakura where I saw the famous Buddha built by melting techniques in the 13th century. Now, it is about three or four times bigger than what Leonardo Da Vinci was trying to make about 200 years later in Florence. Similarly, Jean-Jacques Salomon has pointed out an essential ingredient: the domination of techniques which all societies, like the Japanese, the Chinese, and the Indian, and of course European, societies possessed. It is sufficient to look at their very sophisticated handicrafts to see this domination of techniques.

General education and techniques; then, of course, the political will which results - as has been pointed out here repeatedly - from the emergence of the national estate; and then, some kind of project: all this leads to the conclusion that these reflections are historical, meaning that the history of science and technology are important in formulating strategies for development. One might say that these developments which we are talking about have seldom been strategic, in the sense that they have not been planned, but that is the kind of pattern which reveals itself when one examines what happened in the past. Now again science is a modern phenomenon and this mix of science and technology is even more modern. That is why I would agree with M. Chatelin that one should be careful - although it is very bad to say so to historians - to look at our horizon over a shorter time frame. This explosive mixture has been revealed glaringly by the Manhattan project, to which Leite Lopes has called our attention. Of course there has been - and that is another topic we have been discussing - the transfer, the difficulties for transfer of science and technology, and the empires. However, to surpass the Empire after the war, international organizations were set up to promote science, culture, education. Hospitality for our Colloquium is provided by UNESCO which, 43 years ago, was organized for that. It was aimed basically at a wrong idea that it would be possible to transfer science, ignoring techniques and technology. As you all know, the realization of this fact led 11 or 12 years ago to the big Vienna conference on science and technology for development. UNESCO still can be saved, but I think that the Vienna conference is a complete failure - although I think that we all realize it had the virtue of calling the attention of the decision-makers, politicians, and scientists, to the very complex nature and interplay of science, technology and industrialization.

Dr Nakayama remarked that the language barrier was serving Japan well, the other way round; I mean that they could absorb what was written abroad, mostly in English, while the Japanese engineer and industrial estate now take advantage of the fact that not everybody knows Japanese to protect their own development; but this is not specific to Japan, it is very general. One should realize that significant discoveries of industrial and of certain economic importance were never published. That is why big companies are not using their patent service as much as they did in the past. If you look back at IBM or ITT records, you see that the number of patents are relatively dropping. The same thing is happening in Japan, while in other societies patent numbers are still growing, which means that they have still not yet discovered the facts of life, that good things should remain hidden ...

Jean-Jacques Salomon remarked to me that scientists write, but do not read much; engineers read a lot and do not publish anything. So I think that these elements, the historical elements, and the pattern of development, are different from region to region, and they have original cultural dimensions. I think that the Iranian case is the one that has convinced us here at UNESCO that development is indeed very important but has to be looked at within a cultural framework. That is another problem. One must realize that differences exist, and that there are cultural obstacles to development; Latin America is very typical of that. In the case of Brazil, one should not forget that we were colonized by Portugal and Spain. These two countries, in spite of their importance in the 16th century, and later, were bypassed by the industrial revolution and by *"la culture des Lumières"*, and we are the direct heirs of this failure to participate effectively in modernity, in the sense of science and technology contributions to the present day power structures.

The last remark I would like to make is that science and technology - even more technology - are obviously indispensable to promote development; which means multiplying the capacity to produce work, things, products, and services, through energy: the capacity to produce work. Again I was struck that in our discussions here nobody touched upon this extremely important element, energy, which is perhaps one of the key-indicators, in light of which we could examine different societies and their evolution. The collapse of the Empires resulted from the industrial revolution, from the utilization of coal, *"de la puissance motrice du feu"*. This was, by the way, the title of the famous work which led to the second principle of thermodynamics. The utilization of coal leads to the rationalization of these working machines and, later on, to oil, electricity, nuclear energy, "scientific" utilization, etc. I mean that there are a number of our colleagues who think that one can categorize the development of our society by the change in modes of production and utilization of energy. Of course, now the so-called "informational" revolution has introduced another element: information, whose structure, function and hierarchy, with matter and energy, constitute the raw elements of societal endeavours.

Academia Brasileira das Ciências, Rio de Janeiro

UNPUBLISHED COMMUNICATIONS

This is the list of the communications presented to the international colloquium "Science and Empires", which are not found in this book.

Raquel ALVAREZ PELAEZ, "European Eugenics and Latin American Eugenics: Relations and Influences".
Isidoro Maria da Silva ALVES, "Modèle, production et reproduction de la science : les Ecoles dans la constitution du champ scientifique au Brésil (XIXe et XXe siècles)".
José Jeronimo ALVES, "Le mouvement pour la science pure, et l'Académie Brésilienne des Sciences".
Robert S. ANDERSON, "American Interests, Foundation Planning and the Origin of the International Rice Research Institute".
Jean-Paul BADO, "La variole et l'installation de la médecine scientifique en Afrique Occidentale Française".
Eduardo A. BALBO, "Pinel and Esquirol in the Beginning of Argentine Psychiatry".
Salvador BERNABEU ALBERT, "The Scientists of the Desert".
Harm BEUKERS, "The Reception of European Medicine in Japan".
Paloma BLANCO FERNANDEZ de CALEYA, "Scientific Valuation of the Types in the José Celestino Mutis Herbarium".
Regis CABRAL, "Learning from Experience in Science Policy: A Comparison of Biotechnology and Nuclear Programs in Brazil".
Sylvia CHIFFOLEAU, "L'islamisation de la médecine en Egypte".
François DELAPORTE, "Le statut épistémologique de la médecine tropicale".
Eduardo ESTRELLA, "The Diffusion and the Reception of the Linnean System in Hispano-America".
FAN Dainian, "Liang Qichao and Science in Modern China".
Marcelo FRÍAS NÚÑEZ, "Ciencia europea y lucha contra las viruelas en el nuevo reino de Granada, 1782-1808".
Andres GALERA GOMEZ, "Félix de Azara and the American Nature".

Roberto GAMARRA, Ramón MORALES & Franciso PELAYO, "Agronomical Researches in Fernando Poo (Spanish Guinea)".

Dolóres GONZÁLEZ RIPOLL NAVARRO, "Cosme de Churucca and his Scientific Expedition to the Antillas".

Susantha GOONATILAKE, "Multilinear Evolution of Science as an Entropic Process".

Harald GROPP, "The Birth of a Mathematical Theory in British India".

Richard GROVE, "Early Colonial Science and the Origin of Global Environmental Concerns (1660/1800)".

Inés HARDING, "Organisation de la connaissance mathématique en Amérique latine".

Raphael HUERTAS, "La receptión del degeneracionismo psiquiátrico en la República Argentina".

Isaia IANNACCONE, "La vie et le travail mathématique de Giacomo Rho dans la Chine des Ming : introduction au *Shou Suan*".

IYANAGA Shokichi, "Développement des Mathématiques au Japon dans la période 1870-1920".

Serge JAGAILLOUX, "Problémes posés par l'introduction, l'enseignement et l'exercice de la médecine occidentale en Egypte".

Shaul KATZ, "From Göttingen to Jerusalem: the Transplantation and Perpetuation of the German Mathematical Research Tradition to the Hebrew University of Jerusalem".

KIM Oryun Kihyup, "Quest for a New Science in 18th Century Korea".

Samuel S. KOTTEK, "Les tribulations de l'Institut Pasteur de Palestine".

Leoncio LOPEZ-OCON, "La Comisión cientifica del Pacifico y la *Commission scientifique du Mexique* (1864-1867) : paralelismos y divergencias de dos proyecciones latinoamericanas de la ciencia europea".

Manuel LUCENA GIRARDO, "Science and Political Crisis: the Nautical School of Cartagena de Indias (1810)".

Paulo MARQUES, "Brazilian Nuclear Program and Human Resource Formation".

Harris MEMEL FOTE, "L'appropriation des sciences : l'exemple de l'Afrique Occidentale Française".

Soma Kumari MENDIS, "Communicating Modern Science in Local Languages in Developing Countries: Case Study from Sri Lanka".

Han MESTERS, "Education and Research in Tropical Medicine during the Period 1900-1947: Comparative Research Between India and Indonesia".

Georges METAILLÉ, "Chinese and Japonese Responses to "European" Botany".

Guillermo MIRA DELLI ZOTTI, "Notes on Elhuyar and Nordenflycht's Technical Expeditions in Mexico and Peru in Context".

MO De, "Study of Euclid's *Elements* in *Shu Li Jing Yun* (Quintessence of Mathematics, 1723)".

Paolo PALLADINO, "The Ecology of Empire: The Politics of Science in the British Empire".

Francisco PELAYO, "The Application of European Mining Techniques in New Granada".

Peter PIASECKI, "Process and Structures in the Diffusion of Colonial Officials from the German Reich in the African Colonies. The Foundation of the Hamburger Kolonial Institüt in 1908".

Juan PIMENTEL IGEA, "Ciencia e Imperio en la "expedición Malaspina", 1789-1794".

Miguel Angel PUIG-SAMPER & José Luis MALDONADO, "The Illustrated Model in the Spanish Botany and its Introduction to the American Colonies".

Yakov M. RABKIN, "Le concept de culture scientifique et la diffusion des sciences modernes".

Dhruv RAINA, "Mathematical Foundations of a Cultural Project: Ramachundra's Treatise *Through the Unsentimentalised Light of Mathematics*".

Kapil RAJ, "Refusing Diffusionism: the Institutionalization of Modern Science Education in Early 19th Century Bengal".

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