

## The age of synthesis: From cognitive science to converging technologies and hereafter

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This paper describes the development of two of the most important scientific disciplines in the last quarter of the 20th century, cognitive science, which emerged in 1975, and nano-bio-info-cogno (NBIC) converging technologies, which emerged in 2000. In this century, we will achieve cross-disciplinary integration, innovation in comprehensive knowledge and comprehensive development in human resources. NBIC converging technologies will greatly expand human cognition and communication, improve human health, enhance social outcomes, strengthen national security and unify science and education. Cognitive science and converging technologies will have major effects on the future human development. I argue that the 21st century represents an age of synthesis, reflected in the continual reintegration between scientific disciplines in recent times. This new age of synthesis will require innovations in thought and methodology that differ from those underlying the age of analysis in the 20th century. I predict that these developments will allow every individual to realize comprehensive development. Accordingly, the education system will be transformed, and a comprehensive human resources system will be created.

**synthesis, age of synthesis, cognitive science, converging technologies**

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The 1950s were a fruitful and important decade for philosophy and sciences including psychology, linguistics, and computer science, among others. In 1956, a large meeting of cognitivists was held at the Massachusetts Institute of Technology (MIT). At this meeting, Miller, one of the founders of cognitive psychology, presented findings regarding the human ability to subitize and estimate (below seven and above seven pieces of information, respectively), the span of attention, the span of immediate memory, and other limits on the human capacity for information processing [1]. A year later, Chomsky established the concept of transformational grammar [2], and subsequently published a scathing review of Skinner's verbal behavior [3]. Chomsky argued that a theory of transformational or generative grammar was necessary for providing a satisfactory explanation of language.

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These theories involved internal representations, and characterized their underlying order. Chomsky rejected behaviorist assumptions about language as a learned skill, and argued that language comprehension should be considered in terms of an innate mentally represented grammar, consisting of universal rules. At this time, pioneers such as McCarthy, Minsky, Newell, and Simon were founding the field of artificial intelligence [4–17]. The overarching focus of this research in the 1950s and 1960s was investigating the capacity of human information processing, and the period spurred cross-disciplinary research seeking to explore the human mind, involving psychology, linguistics, philosophy, computer science and other fields of science. Cognitive science was established in the United States in 1975, signaling a new age in science referred to as “the age of synthesis”.

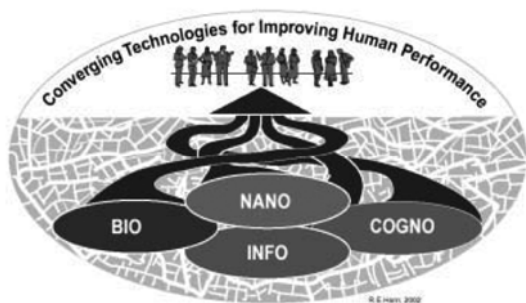
The term “converging technologies” refers to a recent

developed disciplines based on a larger-scale synthesis of nanotechnology, biotechnology, information technology and cognitive science (NBIC), established by a collaborative project among more than 70 scientists in 2000. This new discipline seeks to combine findings from these four fields, to become a directional “arrow” (referred to as the “NBIC arrow”) to guide improvements in human performance, speed technological progress and lead to changes in human technology as profound as those caused by the emergence of spoken language learning approximately one hundred thousand generations ago [18] (Figures 1 and 2).

A trend towards continuous reintegration has occurred in the transition from cognitive science to converging technologies. In the current paper, I describe this transformational process, draw conclusions about its key features, and make predictions about its potential implications for the future.

## 1 The age of synthesis

Analytical science was a hallmark of the 20th century, constituting an “age of analysis” [19]. During this period, each discipline and branch of science was subjected to a thorough analysis of its scope, with scientific fields and disciplines becoming increasingly narrow. The fields of science became deeper, while the breadth of knowledge became more limited. Technological achievements gained from space exploration to earth development, and science and technology dominated the 20th century. However, this pe-



**Figure 1** Changing the social “fabric” towards a new structure [18].



**Figure 2** NBIC “arrow” [18].

riod was also associated with a lack of human-focused research. This began to change in the last quarter of the 20th century, with increasing researches focused on human abilities, exemplified by the establishment of cognitive science.

### 1.1 Analysis and synthesis: Two basic methods for understanding the world

Analysis and synthesis are two basic scientific methods for understanding the world. Analysis refers to a top-down method of gaining information, in which an object of interest is divided into various parts for investigation. This method is based on ancient taxonomy. Conversely, synthesis is a bottom-up method in which all parts of an object of interest are combined into an overall whole for investigation. This method is based on an ancient holistic view of objects.

Analysis and synthesis are related to two logical methods, deduction and induction. As such, the review of analysis and synthesis must be related to the investigation of deduction and induction.

### 1.2 Synthesis: A new age for mankind

Since the second half of the 20th century, the shortcomings of analysis and deduction have become increasingly apparent. Even earlier, Gödel’s theorem demonstrated that simple methods of analysis and deduction do not function satisfactorily, even in mathematics and logic [20].

In 2000, a research program sponsored by a NSF grant awarded to the World Technology Evaluation Center (WTEC) sought to identify the leading fields of science in the new century. Over 70 outstanding scientists took part in the program. The consensus that emerged identified the importance of nanotechnology, biotechnology, information technology and cognitive science, leading to the combination of these fields into a new discipline referred to as NBIC converging technologies.

This development heralded a new era of scientific development in the 21st century, focused on the integration of numerous disciplines in science and technology. The 21st century thus constitutes an “age of synthesis”.

## 2 Cognitive science: Three integrated targets

Cognitive science has two important qualities. First, it is experiential, as reflected in the three major experiential findings of cognitive science identified by Lakoff: “The mind is inherently embodied; Thought is mostly unconscious; Abstract concepts are largely metaphorical.” [21]. Second, it is integrated and comprehensive, with three integrated targets: cross-disciplinary integration, innovation in comprehensive knowledge, and widespread development in human resources. These qualities will be examined in detail in the following sections.

## 2.1 Cross-disciplinary integration

In education, analysis is commonly used in the study of natural, social and mental phenomena. This includes almost every discipline in these fields. Over time, disciplinary categories have generally become increasingly detailed in knowledge but narrow in scope.

The United Nations Educational Scientific and Cultural Organization (UNESCO) identifies five gates and 60 first-level disciplines, while the BSO (Broad System of Ordering) recognizes nine gates and 60 first-level disciplines. Seventeen gates, 38 groups and 362 disciplines are recognized by US standards, while 20 groups, 159 first-level disciplines and 654 second-level disciplines are recognized by UK standards, 10 gates, 64 first levels, 558 second levels are recognized by German standards, and nine gates, 49 groups and 1250 disciplines are recognized by Japanese standards. Eleven gates, 58 first-level, 573 second-level and almost 6000 third-level disciplines are recognized by Chinese standards established in 1992 [22,23].

In such a complex and tiresome analytic system of disciplinary divisions, it is not possible to learn and master all areas of knowledge. Rather, students are increasingly required to focus on a narrow field and develop expertise in a particular discipline. Such an analytical education system may lead to the loss of valuable comprehensive abilities as a cost of learning and mastering such narrowly constrained expertise.

Cognitive science has broken the barriers of these strict disciplinary categories and established links across many disciplines. As a new discipline that crosses natural science, human science and engineering, cognitive science has the potential to aid the development of many disciplines that have traditionally been separated.

## 2.2 Innovation in comprehensive knowledge

Science is problem-oriented, with scientific disciplines emerging in response to the existence of specific problems. Otherwise, disciplines would be artificial, discrete, and constrained. Science is thus able to break disciplinary barriers to enable continual development. In this way, new fields of science or technology can continue to emerge between disciplines.

Integration may take place between some disciplines or fields that initially appear, such as the number of unrelated new fields coming into being in the framework of cognitive science. For example, cybernetics emerged from the integration of computer science and neuroscience, neurolinguistics from the integration of neuroscience and linguistics, neuropsychology from the integration of neuroscience and psychology, the simulation of cognitive processes from the integration of psychology and computer science, computational linguistics from the integration of computer science and linguistics, psycholinguistics from the integration of

psychology and linguistics, the philosophy of psychology from the integration of philosophy and psychology, anthropological linguistics from the integration of anthropology and linguistics, cognitive anthropology from the integration of psychology and anthropology, and evolution of the brain from the integration of neuroscience and anthropology [24]. Importantly, none of these new integrative fields or disciplines would have emerged without the development of cognitive science.

## 2.3 Comprehensive development in human resources

Modern education is comprised of various disciplines, and thus involves an analytical methodology. Contemporary education systems require methods and divisions to function, thus strengthening interdisciplinary divisions themselves.

In a system of discipline and education, every student, even if they are a generalist, a versatile person or a genius, will be trained as some type of specialist, expert, or professor. Such a system is unlikely to foster the development of people like Liang Zhuge (181–234), who was proficient in chronometer and geography as well as military affairs 1800 years ago in ancient China, or Leonardo da Vinci (1452–1519), widely considered the greatest artist, sculptor, architect, engineer and scientist in history. Likewise, it is unlikely that Aristotle (–384– –322), an ancient Greek encyclopedic scholar, or Lao-tzu (–571– –471), an ancient Chinese thinker, could have emerged from the contemporary educational system. In addition, contemporary education would be unlikely to produce figures like Confucius (–551– –479), Jesus (–2–36) or Buddha (–565– –486), who are considered to have devoted their lives to improving the human condition.

The emergence of such figures is not possible under the modern education system, which encourages a person to behave as an insect living on a single leaf, lacking knowledge about other leaves, not to mention the whole forest. Rather, people are required who can behave as eagles that hover freely over the forest of human knowledge and have an overview of it as a whole.

## 3 Converging technologies: Integrating at larger scale

NBIC converging technologies are synthesizing at higher levels and larger scales. Spohrer [25] predicted that: “In the next century (or in about five more generations), breakthroughs in nanotechnology (blurring the boundaries between natural and human-made molecular systems), information sciences (leading to more autonomous, intelligent machines), biosciences or life sciences (extending human life with genomics and proteomics), cognitive and neural sciences (creating artificial neural nets and decoding the human cognome), and social sciences (understanding

“memes” and harnessing collective IQ) are poised to further pick up the pace of technological progress and perhaps change our species again in as profound a way as the first spoken language learning did some one hundred thousand generations ago. NBICS (nano-bio-info-cogno-socio) technology convergence has the potential to be the driver of great change for humankind.”).

The following section evaluates the influence of converging technologies on the future of human societies.

### 3.1 Expanding human cognition and communication

The first domain focused on in the fulfillment of the overall motivating vision of NBIC convergence was “Expanding Human Cognition and Communication”. The major goal in this domain is the promotion of technological breakthroughs that have the potential to enhance individuals’ mental and social interaction abilities. Throughout the 20th century, a number of purely psychological techniques were proposed for strengthening human personality characteristics, but systematic research has generally failed to confirm the alleged benefits of these methods [26,27]. Current evidence suggests that a combination of methods, drawing upon varied branches of converging science and technology, may be more effective than attempts that rely upon mental training alone [18].

Golledge argued that converging NBIC technology could broaden the human ability to think “outside the box” in several sensory domains, listing the following examples of convergence of NBI and spatial cognition methods: “Natural language-driven mobile and wearable computers; Internet search engines based on human wayfinding practices; Smart fabrics that sense the environment and warn us of pollution levels, etc.; Smart environments (e.g. remote auditory signage systems) that talk to us as we travel through them; GPS-based personal guidance systems that facilitate travel (e.g. tourism) in unfamiliar places; Smart maps that explain themselves at the touch of a stylus or as a result of gaze or gesture (e.g. “You are here” maps or on-screen computer representations of data) (Figure 3); Robotic guide dogs that carry large environmental databases and can develop routes to unfamiliar places; Smart buildings that inform visitors about their contents and inhabitants, e.g. transit terminals (Figure 4); Remote auditory signage (Talking Signs/Remote Infrared Auditory Signage) (at places or on vehicles, including mass transit); Talking fluorescent lights inside buildings such as shopping centers and transit terminals (Figure 5); GPS-based guidance systems with Pointlink capabilities to locations and websites for place-based information [28]”.

### 3.2 Improving human health and physical capabilities

Because of the need for biomedically-informed project design, understanding the cell-molecule interface (i.e. micronanoscale interactions) will be an important development



Figure 3 Talking maps [18].

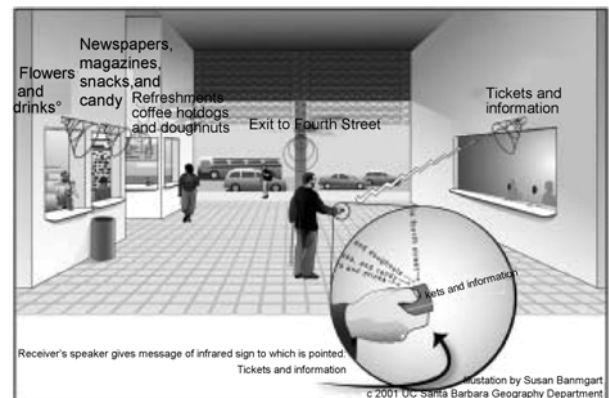
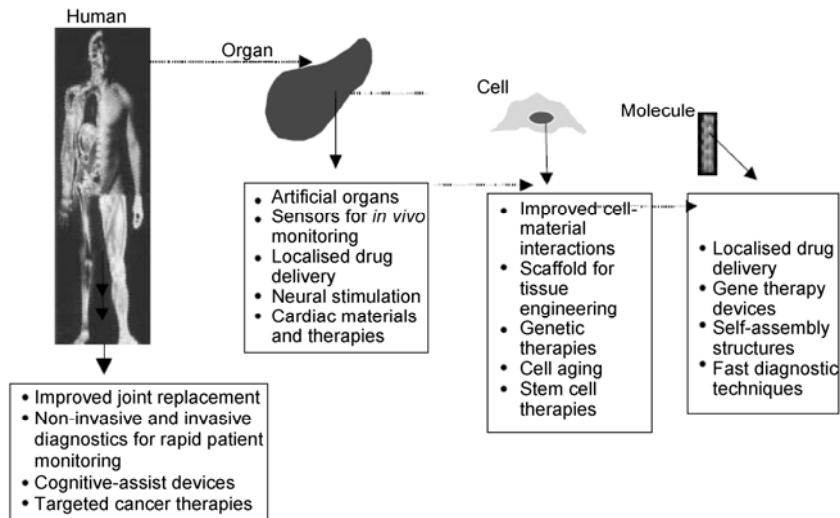


Figure 4 Transit terminal with remote auditory signage [18].



Figure 5 Talking neon lights in airport terminal [18].

in extending the application of nanobiotechnology. A broad approach to the widespread and successful introduction of nanobiotechnologies in extending the human lifespan will require interdisciplinary collaboration and extensive information exchange. Figure 6 illustrates the possible levels of intervention and some of the emerging solutions in which nanobiotechnology could play a role in the repair or



**Figure 6** Examples of levels for intervention of nanobiotechnology in extending human life [18].

replacement of damaged biological components [29].

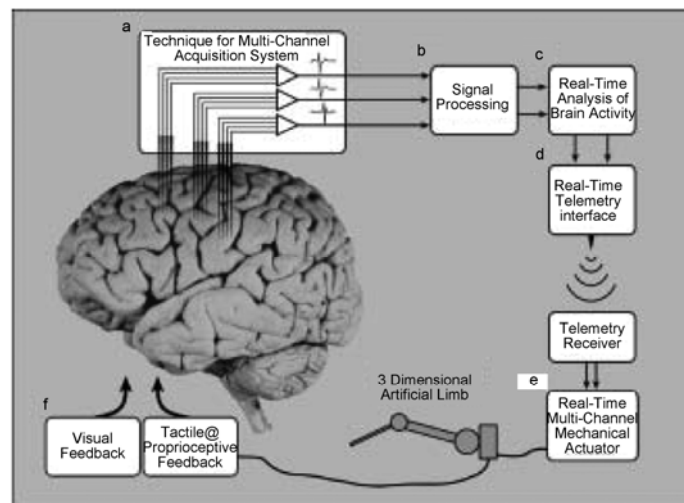
In the field of human-machine interaction, it is widely considered that recent advances in nanotechnology could significantly affect the development of brain-machine interfaces (BMIs) and neuroprosthetic devices. By establishing direct links between neuronal tissue and machines, these devices could enable the use of voluntary neuronal activity to directly control mechanical, electronic, and even virtual objects as if they were extensions of the body.

At the core of this new technology is the increasing ability of electrophysiological methods to reveal the underlying mechanisms of conscious and intentional neural processes (e.g. moving an arm) from the raw electrical activity of large populations of individual neurons. These neural signals can then be translated into a format that can be used to control external devices. Moreover, by providing ways to

deliver sensory (e.g. visual, tactile, auditory, etc.) feedback from these devices to the brain, it may be possible to establish reciprocal (and more biologically plausible) forms of interaction between large neural circuits and machines. These developments may fulfill the requirements for artificial actuators that can augment human motor performance, functioning as simple extensions of the body. On the basis of this research and recent developments in nanotechnology, the construction of a set of closed-loop control BMIs may be possible, allowing the restoration or augmentation of motor performance in macro, micron, and even nano environments (Figure 7) [30].

### 3.3 Enhancing group and societal outcomes

The major benefits of NBIC innovations are beyond the



**Figure 7** General architecture of a closed-loop control brain-machine interface: Neuroprosthesis for restoring motor function of damaged brain areas [18].

individual level, benefitting groups of individuals, the economy, culture, and society as a whole. In particular, these innovations seek to enhance group productivity, communication, and cooperation.

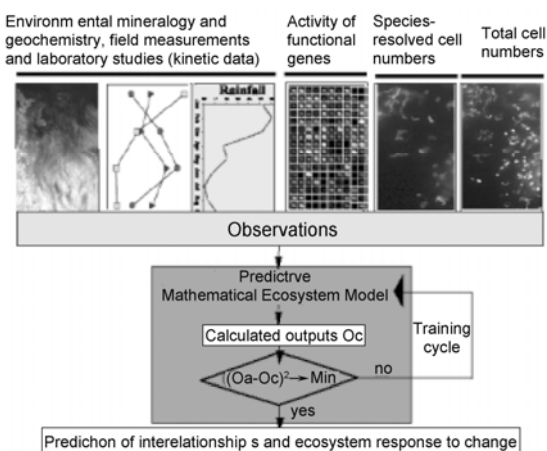
Banfield proposed a model (Figure 8) to explain how input from the cognitive sciences will be invaluable to guide the development of supermodels of complex processes. This model incorporates information about the physical and chemical environment with information about population size, structure and gene expression to analyze community interactions and predict the system's response to perturbations.

In studies with microbial models (Figure 9), Banfield [31] found that overuse and/or unbalanced use of resources can lead to the build-up of toxins, shortage of food, overpopulation, and death. Nano-bio-geo integration may allow us to tease apart the complex interdependencies between organisms and their surroundings, so that we may ultimately gain sufficient understanding of environmental systems to avoid the adverse consequences of resource depletion indicated by interactions at the microbial level.

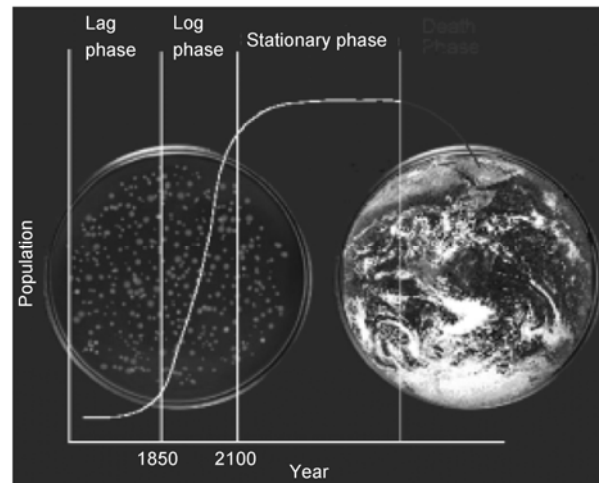
### 3.4 National security

The US Department of Defense states seven national security goals for NBIC: (1) Data linkage, threat anticipation, and readiness. (2) Uninhabited combat vehicles. (3) Warfighter education and training. (4) Chemical/biological/radiological/explosive (CBRE) detection and protection. (5) Warfighter systems. (6) Non-drug treatments for the enhancement of human performance. (7) Applications of brain-machine interfaces [32].

Figure 10 shows a wrist monitor that predicts performance by monitoring sleep. Sleep is determined by the lack of motion of the wrist monitor. The graph in the figure predicts performance based on the amount of rest that the soldier has had [33].



**Figure 8** Example of an ecosystem model [18].



**Figure 9** Microbial communities growing within a confined space (here shown in a petri dish, left) [18].

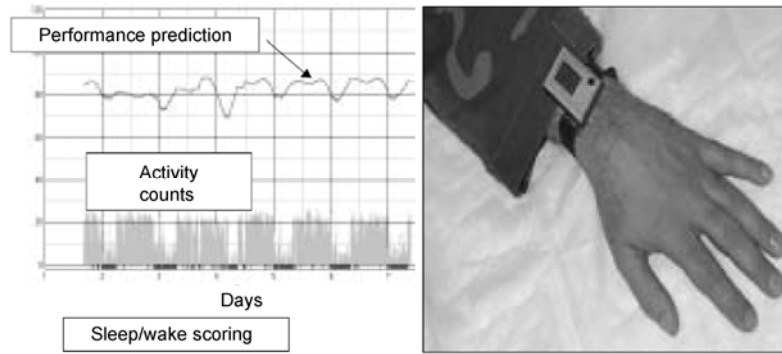
Murday [34] developed a soldier system involving nano-bio-technologies for future applications, as shown in Figure 11.

### 3.5 Unifying science and education

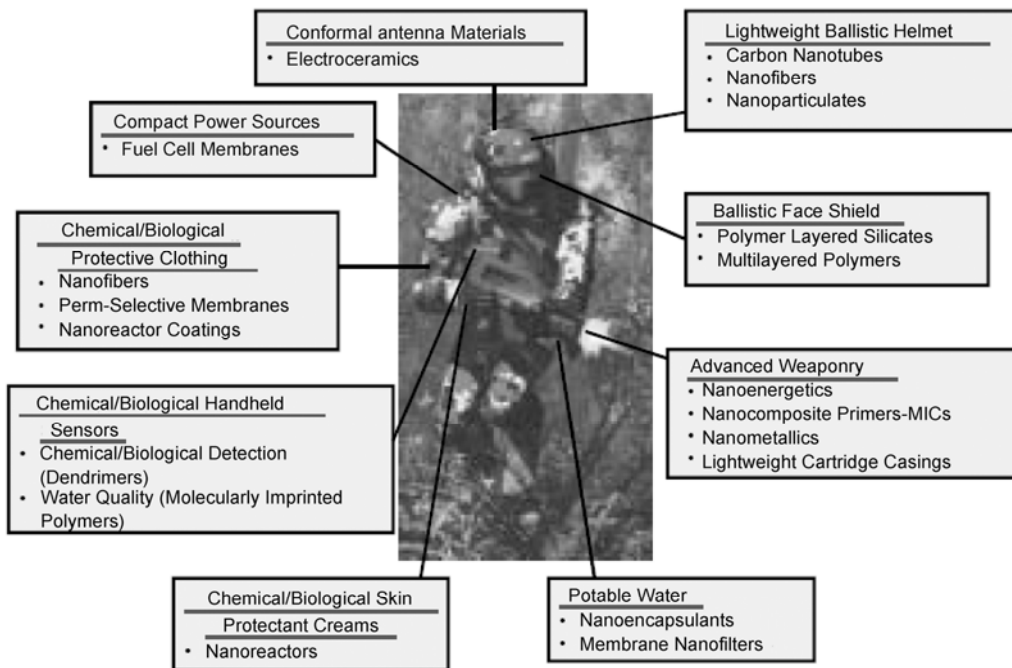
Currently, education in science and engineering is highly fragmentary, each part constrained by the boundaries of a particular discipline. Akins et al. predicted that, in the future, knowledge will be based on unifying concepts offered by nanotechnology, biotechnology, information technology, and cognitive sciences through educational institutions. Natural, engineering, social, and human sciences will converge. The corresponding basic concepts that unify science will be introduced at the beginning of the teaching process in K-12, undergraduate, and graduate education. New tools will be developed by convergent technologies to provide high-quality, anywhere-anytime educational opportunities. NBIC science and engineering education will be made available to most students and as continuing education to interested adults [35].

Batterson and Pope (2002) made detailed predictions regarding their vision of the development of K-12 education by 2015:

“Over the next 15 years, converging technologies (CT), the synergistic interplay of nano-, bio-, information, and cognitive technologies (NBIC) will enable significant improvements in how, where, and what is taught in grades K-12 and will also support the lifelong learning required by a rapidly developing technological economy. Through national and state standards, half the schools in the United States will be teaching science based on the unifying principles of science and technology (NRC 1995) [36] rather than the isolated subjects taught since before the industrial revolution. New tools for learning such as neuroscience sensors, increased quality of Internet service via guaranteed



**Figure 10** Sustaining performance: managing sleep [18].



**Figure 11** Soldier system of the future [18].

bandwidth, and a new understanding of biological feedback for self-improvement will provide new, highly efficient learning methods for all, in particular guaranteeing that all children can read by age five. Students will no longer be dependent on rigid regimentation of the classroom or schoolhouse and class schedules, as they will have courses and supplemental information available to them from numerous venues around the clock [37].”

Advances in NBIC research could help to meet the requirements of an increasing number of special-needs students each year, with fewer staff resources. With technological development, students can increasingly interact with other students worldwide to share information, language, and culture. The worldwide student population of more than 50 million students may be increasingly joined by millions of older adults as the importance of lifelong learning is realized. In Batterson and Pope’s (2002) educational model,

the requirement for new buildings is reduced, as students can take advantage of 24/7 availability of coursework at their homes, work areas, and at school. Capital investment savings could then be redirected to increased pay for educational staff, to attract and retain the highest quality teachers and curriculum developers. It is envisioned that the division between education and recreation would be increasingly blurred, as all citizens could visit the school building throughout the day to improve their lives.

#### 4 Conclusions: Future forecasts

I have argued that the two most important developments in science and technology in the last quarter of the 20th century are the emergence cognitive science (in 1975) and NBIC converging technologies (in 2000). In the following

sections, I will outline several predictions for the future based on the development of cross-disciplinary synthesis.

#### 4.1 Entering the age of synthesis

Cognitive science, comprised of six major disciplines, constitutes a type of knowledge synthesis. Converging technologies, encompassing cognitive science, are an even more comprehensive and scalar type of synthesis. The trend towards scientific synthesis has provided an extremely broad foundation of scientific knowledge, as well as unparalleled prospects for scientific and technological progress and human cognitive development.

Reviewing the development of scientific and intellectual history of mankind reveals a transition from analysis to synthesis, then from simple synthesis to a more complex synthesis. Continual reintegration is a persistent trend in the development of human technology into the future.

This trend of integrated development is reflected in many modalities, including scientific research, discipline formation, personnel training and so forth. Integration and development are likely to become even more comprehensive on the basis of integrated knowledge, the development of synthetic disciplines and broad capabilities. Further, this trend is likely to have a strong impact on politics, economy, society, culture, education and other aspects of society in China. In the new age of synthesis, NBIC converging technologies have the potential to substantially change the human species. It is important that the nature of these changes is predicted and that suitable preparations are made.

New developments in cognitive science and converging technologies are, however, not currently a major factor in the vision of our government and top decision makers. This is exemplified by the absence of reference to these two disciplines in the Chinese administration's "scientific concept of development". Moreover, cognitive science has not yet been included in the national disciplinary catalog in China, even though other developed countries and world-class universities are doing their best to support the research of cognitive science and converging technologies. This state of affairs is worrying. Many years ago, I argued that a university could not be considered world-class if it did not conduct

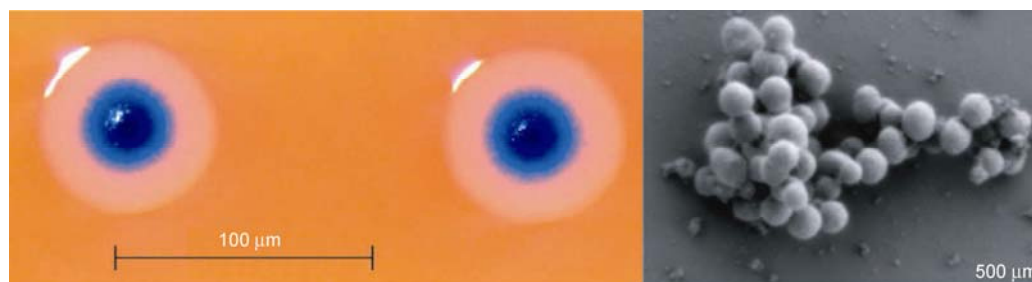
research into cognitive science. Unfortunately, my argument was not heeded by university leaders or decision-makers at the national level.

#### 4.2 Importance of innovation in thoughts and methods in the current era

Research in cognitive science, particularly cognitive anthropology (involving culture, evolution and cognition) and evolutionary psychology has suggested that the fundamental difference between humans and non-human animals is the development of human-specific symbolic language. Non-human animal evolution occurs at the genetic level, over a time-span of hundreds or even thousands of years. However, human evolution can occur at the level of thoughts, culture and technology, based on social transmission through language. Cultural evolution can lead to substantial changes in a matter of a few decades, a generation or at most a few generations. The history of life on Earth spans billions of years. *Homo sapiens* emerged 160 million years ago, as a result of genetic evolution. This process involved billions of years of slow biological evolution. Throughout the Paleolithic, Mesolithic and Neolithic periods, approximately 5000 years ago, humans developed language and writing. Since then, human progress has largely proceeded not at the level of genes, but at the level of tools and cultural advancement (Figure 12).

Human social progress has become exponentially faster since the invention of writing. Written language facilitated the retention of knowledge, while language facilitated the transmission of culture. The use of synthetic chromosomes to create artificial life by Venter exemplifies the last line of Table 1 and the synthetic method [38,39], occurring much earlier than was forecast by Roco, Bainbridge and others in 2002.

Analytical methods substantially altered human society in the early 20th century. An integrated approach to cognitive science had a similar effect during the second half of the 20th century. NBIC converging technologies, following an even more integrated approach, are set to fundamentally change human society in the 21st century. Because humans use language to think and act, changes in the ways people



**Figure 12** Life recreated. Blue colonies (left) indicate a successfully transplanted genome, with self-replicating bacteria revealed in an electron micrograph [39].



**Table 1** Important developments in human civilization since the invention of writing

Generations	Several key advancements
-400	Neolithic, agricultural products, writing, libraries
-40	Universities
-24	Printing
-16	Renaissance in S&T, accurate clocks
-10	Industrial revolution
-5	Telephone
-4	Radio
-3	TV
-2	Computers
-1	Microbiology, Internet
0	Examining the building blocks of matter (nanoscience) Biotechnology products Global connection via the Internet; GPS/sensors for navigation
1/2	Unification of science and converging technologies from the nanoscale Nanotechnology products Improving human performance advancements Global education and information infrastructure
1	Converging technology products for improving human physical and mental performance (new products and services, brain connectivity, sensory abilities, etc.) Societal and business reorganization
<i>n</i>	Evolution transcending the human cell, body, and brain?

think and do things are caused by changes in the way language is used. Consequently, the tools and techniques emerging from language also alter, causing societal change at multiple levels. The transition from analysis to synthesis, then from synthesis to more comprehensive synthesis, has involved innovations in thoughts and methods at the linguistic level. This highlights the importance of the innovation of ideas and methods for societal progress. It is clear that substantial innovation of ideas and methods is required in the age of synthesis, differing from the innovations underlying the age of analysis.

### 4.3 Importance of comprehensive internal development at the individual level

The age of synthesis has the potential to benefit the development of individual people.

In the analytical era, the left hemisphere was predominant in controlling thought and behavior. I predict that the left and right hemispheres will play more balanced roles in the future, because individuals with highly lateralized brains will be able to perform parallel functions of the left and right hemisphere more efficiently than those with just or mainly left brain [40].

Therefore, the analytic functions of the left hemisphere should be increasingly recognized, as well as the synthetic function of the right brain, so that individuals can become more comprehensively developed. Cognitive neuroscience has shown that mental capabilities cannot be improved

without an adequate understanding of the brain and mind (Figure 13).

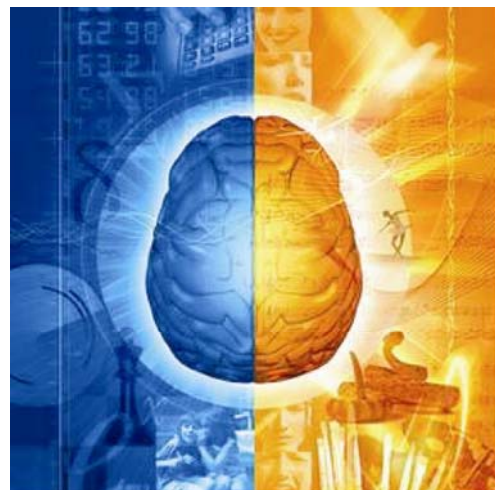
Robinett argued that new cognitive capabilities might be enabled by a full understanding of the brain. These abilities include virtual presence, improved senses, memory, imagination, etc. Robinett also envisaged developments such as the ability to “download yourself into new hardware”, by which a person can achieve instant learning, the development of a hive mind by multiple individuals, speed-of-light traveling, and even self-directed evolution [41].

NBIC technologies can help us to integrate existing knowledge about the multiple drivers of human behavior into an overarching understanding of human activity. The realization of this target would enable a significant leap in the understanding of human behavior (Figure 14) [42], potentially leading humankind to constitute a new species.

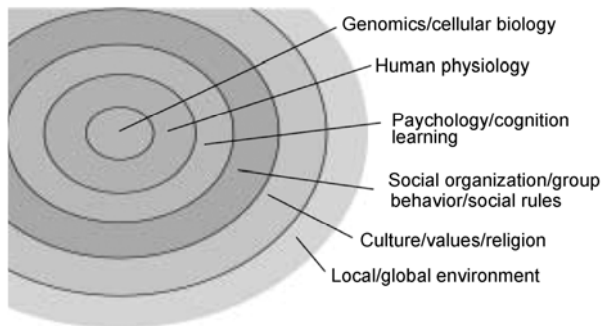
Finally, it should be recognized that the returns of science and technology must be human-oriented, at the level of the individual. That is, the livelihood of humans should be an overarching goal, including the prevention of potential harm and the cessation of the harm currently caused by science and technology. It must be considered that developments in converging technologies could potentially have negative, as well as positive consequences. At present, the Earth is warming, ocean ice is melting, the environment is being harmed, and energy is being depleted. Moreover, some human activities are having serious deleterious effects on humanity. Addressing these negative aspects of technology is a central concern for the future.

### 4.4 Changing education, creating comprehensive human resources in a broad developmental system

Genuine improvements for the future will rely on societal



**Figure 13** In the human brain, the left hemisphere is thought to control language, the dexterity of the right hand, the ability to classify, and routine behavior in general. The right hemisphere is thought to specialize in reacting to emergencies, organizing items spatially, recognizing faces and processing emotions. Adapted from MacNeillage [40].



**Figure 14** Integrated studies of human behavior: Socio-tech [18].

changes that allow humans to permanently inhabit the earth without causing its destruction. This will require not only scientists and philosophers who can perform mathematical and logical analysis, but also thinkers and creators who are able to use comprehensive cognition to perform arts and integrated thinking.

The ancient Chinese thinker Mencius stated: “All things are prepared within me. If I reflect on myself and find that I am sincere, shouldn’t I be overjoyed? If I conduct myself on the principle of reciprocity, will my search for Humaneness not be close at hand?” [43].

This statement illustrates Mencius’ thoughts regarding the oneness of heaven and humanity, considering man as an integral part of nature. Taking a different but equally valuable approach, Marx stated: “I share what everyone has in common”. This comment illustrates the ideological level of a Millennium’s “greatest thinker”. Writing about the extraordinary talents and achievements of da Vinci, the famous Renaissance scientist and art master, Vasari [44] wrote: “In the normal course of events many men and women are born with remarkable talents; but occasionally, in a way that transcends nature, a single person is marvelously endowed by Heaven with beauty, grace and talent in such abundance that he leaves other men far behind, all his actions seem inspired and indeed everything he does clearly comes from God rather than from human skill. Everyone acknowledged that this was true of Leonardo da Vinci, an artist of outstanding physical beauty, who displayed infinite grace in everything that he did and who cultivated his genius so brilliantly that all problems he studied he solved with ease.”

Galileo, an Italian physicist, astronomer, mathematician and philosopher, and pioneer of modern experimental science stated “nature is perfect”. This thesis continues to inspire the modern sciences, with Chomsky writing, in reference to Galileo’s statement, that “the task of the scientist is to demonstrate this, whether studying the laws of motion, or the structure of snowflakes, or the form and growth of a flower, or the most complex system known to us, the human brain.” [45].

A number of scientists have predicted that the global educational and information system will be fundamentally

changed in the first 15 years of this century [35]. NBIC converging technologies are likely to unify science and education, providing a broader foundation that includes cognitive science. In the current era, we may be able to remove constraints on students and learning, including the physical classroom and the social discipline that has existed since the modern education system emerged. It is hoped that brilliant scientists and academic masters will emerge, resembling Leonardo da Vinci and Galileo in the Renaissance period. Moreover, I hope for the emergence of more thinkers like Confucius, Mencius, Lao Tzu, Chuang Tzu, who, despite living approximately 2000 years ago, were concerned with the fate of humanity more seriously than anyone in the current era.

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