Biosemiotics (2009) 2:205–220
DOI 10.1007/s12304-009-9041-9

ORIGINAL PAPER

On the Nature of the Subjectivity of Living Things

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Received: 30 January 2009 / Revised: 19 March 2009 / Accepted: 2 April 2009 /
Published online: 29 April 2009

Abstract A biosemiotic view of living things is presented that supersedes the mechanistic view of life prevalent in biology today. Living things are active agents with autonomous subjectivity, whose structure is triadic, consisting of the individual organism, its Umwelt and the society. Sociality inheres in every living thing since the very origin of life on the earth. The temporality of living things is guided by the purpose to live, which works as the semantic boundary condition for the processes of embodiment of the subjectivity. Freedom at the molecular and cellular levels allows autonomy and spontaneity to emerge even in single cell organisms, and the presence of the dimension of mind in every living thing is deduced. Living things transcend their individualness, as they live in historically formed higher order structure consisting of the lineage-species and the society. They also transcend materiality, having the dimension of mind.

Keywords Subjectivity · Sociality · Triadic structure of subjectivity · Purposiveness · Microdynamic structural polymorphism · Freedom at the molecular and cellular levels

Introduction

The perennial question, “what is life?”, now has an answer, accepted widely by most molecular biologists as well as many others, which asserts that living things are machines, each superbly constructed as an assembly of molecular machines. This view is considered to be supported by contemporary biology, which has been highly successful both in basic research and practical applications, especially due to the power of molecular biology. Biology is, as objective natural science, now considered to be as trustworthy as physical science to obtain reliable knowledge, and the mechanistic view of life is an inevitable consequence of the advanced knowledge of biology.

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However, that view is not without problem. Monod (1970), an outstanding player in the early molecular biology research and one of the most penetrating and radical thinkers in biology to this day, admitted the existence of purpose in living things, and wrote, since science requires the postulate of objectivity to get true knowledge, the very existence of purpose represents a flagrant epistemological contradiction (because "purpose" is a subjective matter), and that is the central problem of biology.

As an ex-molecular biologist, I feel I am obliged to transcend the mechanistic view of life, and present a view which more faithfully depicts the core of what it means to be alive. Biosemioticians already well recognize the basic characteristics of living things as their being active agents with autonomous subjectivity, and consider that the world they live in is not the objective physical environment but the Umwelt, which is the world living things subjectively constitute as the world of meaning (Sebeok and Umiker-Sebeok 1992; Hoffmeyer 1996; Barbieri 2007). Such an attitude toward life seems to be on the right path toward grasping the nature of life, but much is still needed to arrive at the picture of living things covering all forms of life from bacteria to the human and clarifying their distinction from nonliving things.

It seems that the basic form of life is generally taken to be an individual organism which is self-sufficient to maintain its existence. Such an atomistic view of living things, which seems to be deeply ingrained in our mind, especially perhaps in the Western mind, misses an essential aspect of life. As I discussed briefly in my previous paper (Kawade 2001), every living organism inheres sociality, and its subjectivity is structured as a triad of the individual, Umwelt and society. This point mainly concerns the horizontal aspect of living things. They are temporal beings, and my view on the vertical axis of their existence has, as its core, in contrast to nonliving things, the "purpose" of maintaining their identity, i.e., their form as an individual as well as a lineage and species, through some time period. The purpose can exist in every organism because of its certain freedom from physical causality and freedom of action at the molecular and cellular levels. And from this, existence of the dimension of mind in every living organism is deduced. Thus, in my view of living things depicted below, each one of them transcends the individualness, as it lives in a historically formed higher order structure consisting of the lineage-species and the society; it also transcends the materiality, having the dimension of mind.

Triadic Structure of the Subjectivity of Living Things

The image usually evoked by the words "a living thing" will be an individual organism with its physical body, perhaps an animal, but of course also a plant or even a microbe, which can lead its life in isolation on its own account. Actually, however, an individual organism is not a self-sufficient entity. Its material organization and life style is totally dependent physically and semiotically on the history of the lineage and the species (and hence of the whole living world) and also on its environment, including the society it belongs to. So, an individual organism with its physical body is not the whole of what "a living thing" signifies. It is, as the actual "doer" of life processes, the embodiment of the subjectivity of a particular living being, and needs for its existence, its Umwelt, which is the subjectively constituted environment, as well as its society. Namely, the subjectivity of a living thing ontologically has the triadic structure consisting of individual, Umwelt and society, as detailed below.

Individual

No one of us humans will deny that each one of several billions of human beings living on earth now and in the past is idiosyncratic in its physical constitution, biological behavior, living experience, and mental dimension. I think this idiosyncracy of each individual holds true for any species, although in lower forms of life the differences among individuals of a given species may be quite small. The organism is, needless to say, a dynamic structure that constantly changes and develops by metabolic activities to maintain its integrity and identity, until finally it ceases existence by death. However, it does not totally disappear then, because some aspects survive the death physically and semiotically. For instance, its general body design principles as well as its genes are inherited by its progeny; also, some aspects of its way of living may be memorized socially as cultural inheritance. So, an individual is an entity that has the private aspect that is idiosyncratic and disappears upon its death, as well as the public aspect that survives its death.

Umwelt

Every living thing from bacteria to the human is equipped with appropriate sensor and effector apparatuses that are necessary and sufficient for maintaining its life and serve to form its Umwelt. As the Umwelt is the world subjectively perceived and constructed by the organism, it dynamically grows and develops as the organism grows and goes through its life experiences. Since this process must be unique to the particular organism, its Umwelt is idiosyncratic in nature. But the Umwelt should naturally have much in common with those of other organisms, especially of the same species. Therefore, the Umwelt consists of two aspects, public and private; the former is that shared by other organisms and the latter is peculiar to the particular organism, different from those of others even of the same species, and disappears upon its death.

Society

The Umwelt is generally considered to include everything in the world other than the organism itself, and so there will be other living things of the same and different species in it, themselves autonomous subjects on their own. A living thing will, during its life, necessarily encounter with other living things. When two subjects belonging to the same species meet, there will occur active interactions involving bidirectional exchange of signs, because they largely share their Umwelten and have common interests for maintaining their living form. Then the relationship between the two is essentially that of “I and you”, and is distinct from that of “I and it”, which holds between a subject and an object, and will not involve bidirectional semiotic interactions. The former relationship is a dynamic one, causing in general some changes in the partners, which in turn will cause a change in their relationship, and the change can go on indefinitely in a self-organizing manner. The totality of such dynamic relationships over a population is what is recognized as a "society" or at least its primordial form.

I am using the word society in a broad sense to mean an assembly of any number of autonomous subjects connected by bidirectional semiosis, rather than an assembly of individuals of the same species. The I-and-you relationship is possible not only between two individuals of the same species but between individuals of different species, when they live together in symbiosis, as is extremely common in the living world, being engaged in bidirectional semiosis both as autonomous subjects. Other living things in the Umwelt not in symbiotic relationships are, for the subject in question, present as objects, although they are in themselves autonomous subjects.

So, the society I am talking about is a subjective one, viewed from the inside of the particular subject, like the Umwelt which is the subjective world. It has the private aspect that is peculiar to the individual, and the public aspect that is shared by other subjects. The latter will correspond to the usual, objective notion of society.

The society, or the totality of a group of the I-and-you relationships will, influencing and developing the activities of the subjects involved, have its own dynamism, rules and structure, and so, must be separated out from the Umwelt conceptually. The Umwelt then consists of objects, either animate or inanimate.

The Triad

Thus, the subjectivity of a living thing is considered to consist of three elements, the individual organism, the Umwelt and the society, linked inseparably to each other by bundles of semiotic and physical relationships, creating the world of meaning, although the outlines and the boundaries of the three elements are not necessarily always clear-cut. The subjectivity is obviously not a static but dynamic structure, born upon the birth of the organism together with its Umwelt and society, and develops with the growth of the organism. It has the private and public aspects, as the three elements do, and upon the biological death of the organism, its private aspect disappears but its public aspect will survive.

The private aspects of these elements are essentially what are observed and described from within the living subject, and in principle cannot be completely clarified objectively from the outside, only inferences being allowed. However, it is an empirical fact that communication between different subjects is possible, and it is evident that mutual understanding and empathy are possible to certain extents through the public aspects of the triad.

This triadic structure appears to represent the ontology of living things better than the subject-Umwelt dyadic picture that appears common among biosemioticians. It fits well with the concept of the three categories of Peirce's metaphysics. An individual organism separated from the rest of the world can do nothing actual and is mere potentialities with diverse possibilities, representing the Firstness. The individual in relation with its Umwelt, working in it, appears to be a subject-object dyad in the real world, representing the Secondness. The triad of subjectivity appears to be clearly of the nature of the Thirdness. The individual-Umwelt relation must be mediated by the society, the individual-society relation must be mediated by the Umwelt, and the life of the individual is realized by unifying the Umwelt and the society with the individual.

In passing, it may be noted that, although the term “subject” here usually refers to the individual-Umwelt-society triad, it may sometimes mean the individual as the autonomous agent of actual working; it may not be realistic to rigidly distinguish the two usages (actually the boundaries of the three elements are not clear-cut). The situation seems similar to the case of the term “sign”, as it is used to mean the representamen-object-interpretant triad, but it may also mean only the representamen, the sign vehicle.

I owe the idea that sociality is inherent in every living thing to Imanishi (1941, 2002), who asserted that society is not grouping together of individuals, but a communal field of living, without which survival of the individual is not guaranteed (see Kawade 1998). Recent ethological studies on many kinds of animals and plants are revealing various modes of social interactions, strong or weak. Even bacteria, each cell of which is able to live in isolation, are now known to form various types of community to successfully live in natural environments (Shapiro and Dworkin 1997). However, the notion of sociality inherent in every living thing seems far from being accepted generally. It is true that there are various cases of organisms which can live without social interactions. Single cells of various bacteria can grow in isolation, plants and animals that self-fertilize can live by themselves, etc. Certainly, a direction of evolution has been to increase the ability to live in isolation, but this is simply to increase the possibility of survival of the lineage in changing physical environments. If there were an organism that could live alone but produced no offspring, it would sooner or later die and disappear from the living world leaving no traces. So a living thing must replicate and produce its offspring. If offspring is produced, possibilities of interaction between the individuals will inevitably arise, and those which can form a mutually helping community will have a better chance of survival than those which cannot do so. Individuals of bacteria and self-fertilizing plants and animals can replicate by themselves and keep producing offspring, but they will be less advantageous in the long run than cross-fertilizing species, because their genetic constitution tends to be fixed and they become vulnerable to environmental changes.

So I conclude that sociality inheres in every living thing as its integral element. The image of a single organism living in isolation as the basic model of living things is an artificial, distorted image, representing only their mechanical aspect.

Our resistance against accepting sociality of nonhuman living things may also be caused by a notion that forming a society needs the work of mind that is lacking in those creatures. But forming a society in the meaning used here is simply a necessary aspect of life and does not require human mind and the like (but I will discuss later the presence of the dimension of mind in every life form).

One might argue that at the very beginning of life on the earth, sociality of living organisms would not be conceivable, because life presumably emerged as a single cell in a rare event and no interaction between organisms would have been possible. This point is the topic of the next section.

Origin of Life

The origin of life is still far from clear, but it seems generally accepted that chemical evolution proceeded on the early earth yielding chemical soup of various complex compositions, from which life emerged by some physicochemical processes. We cannot define life in exact terms, but broadly speaking, what appears necessary is the metabolic and self-replicative activities enclosed in a relatively small space with a membranous structure. The prebiotic chemical world could have been quite complex, comprising various reactions that yielded numerous kinds of compounds, including those found in the present day living things. If the chemical world becomes extremely diverse in composition, there can theoretically be possibilities of spontaneous formation of autocatalytic loops of chemical reaction chains that self-replicate (Kauffman 2000). However, it is difficult to envisage how a cellular structure emerged that enclosed in a small compartment a self-sufficient metabolic network and maintained its integrity for a while.

One way to evade this difficulty will be to assume that life emerged not as a complete cell, but as a population of incomplete cells, or “cellules”, which are heterogeneous in composition and activity and can interact with each other to maintain themselves as a population. Those groups of cellules with better mutual help will have better chances of survival, and gradually evolve toward independent existence, a full-fledged cell. Sociality of the cellules was essential from the beginning in this scenario.

A radically different, plausible idea is the hypothesis of a noncellular origin of life (Martin and Russell 2002, 2007; Asano 2008). Numerous sites of hydrothermal vents on the ocean floor of the early earth are good candidate places for emergence of life, where marked gradients of temperature, pH and redox potential, together with various catalytic activities of metal sulfide precipitates, must have made diverse chemical reactions possible. Metal sulfide precipitates form a three-dimensional porous structure with numerous small compartments in the size of cells of living organisms, within which the various reaction products can be kept at high concentrations. The metal sulfide precipitates will work in two dimensions as catalysts and in three dimensions as a precursor of cell walls and membranes of free-living organisms. The collection of the microcompartments would have been physically stable enough during the geological time periods to allow the transition to take place within them slowly from geochemistry to biochemistry, possibly proceeding through the stages where molecules of RNA, protein and DNA were gradually born and found their appropriate roles. The inorganic walls of the compartments were not completely tight, allowing mutual help among different compartments for better biochemistry, and as the biosynthetic system of membrane lipids was acquired, the way to free-living cells was opened.

In another theory on the origin of cells, Woese (2003) hypothesizes that the world of molecules, possibly the RNA-world, was populated by a variety of higher-order architectures that he calls “supramolecular aggregates” as the counterparts of cells today. Starting from these aggregates, simple and loosely organized aboriginal cell designs appeared, and cellular evolution took place in a communal mode in the diverse collection of primitive entities, with horizontal gene transfer playing the principal role in the early cell evolution. It is the community as a whole, the ecosystem, which evolves.

Thus in both hypotheses, sociality or communality among primitive cells or cell-like structures, and even among molecules and molecular aggregates is essential for the emergence and evolution of life and cell. It is also worthwhile to point out that the transition from the nonliving to the living world is smooth with no clear-cut discontinuous step, and it is impossible to precisely pinpoint the step of the birth of life, unless one arbitrarily gives the definition of life.

Continuity of living and nonliving things can be pointed out also in a number of other ways (Kawade 2006), but nevertheless, it does not mean that we cannot point out distinguishing features of living things. From the viewpoint of how a living thing is organized out of nonliving matter, the cardinal point is the presence of purpose as the guiding principle that works in the manner of downward causation. It is the topic of the next section.

Purposiveness of Living Things

In the hierarchical structure of the world of matter, physical entities exist at various levels of complexity from the superstrings and quarks up to the whole universe, entities at a higher level being formed by interaction of lower level entities, thereby increasing in complexity and diversity; bodies of living things represent certain levels in this hierarchy of matter. An important general point as regards the hierarchical structure is well-known: the range of possible structures that can be realized by assembling lower level elements becomes greatly expanded as the level goes up, and in order to form a particular system at a higher level, certain boundary conditions must be imposed, in addition to applying physical laws, to the events involved (Polanyi 1968). For instance, atoms and molecules assemble to form the earth, and on the earth, to form mountains, rivers, clouds, thunderstorms, oceans, etc. The processes of formation of these structures is totally governed by physical laws but realized only under the specific physical conditions that prevailed when they were formed; these conditions were those occasioned by the history of the universe and the earth.

Atoms and molecules can also assemble to form bodies of living things, but the boundary conditions working there must be different in nature from those for nonliving things, because living things have the purpose of maintaining their identity through active metabolism to keep their body alive and to produce their progeny. Purpose is a subjective matter and gives rise to meaning and value in the world of physical objects. So the boundary conditions to form living things are twofold: physical conditions that are common in nature with those for nonliving things, and semantic conditions, peculiar to living things, that select the processes meaningful for their purpose.

Purposiveness, however, is not limited to living things. Machines that human beings make do have purposes, although they are not alive. To construct a machine, a certain design is necessary to designate the way how to combine the constituent elements, so that the purpose set by the designer is fulfilled. The design is therefore the boundary condition semantic in nature, and works together with the physical boundary conditions imposed on the constituent materials. Machines are physical structures whose actions are totally describable in physical terms. Is it then possible to describe their purposes in physical terms? The answer is No. Just consider a classical example of machines, a clock. It has the purpose of measuring time, but if it is placed among people who don't have the conception of measuring time, the clock will be just a physical object without any purpose. So, the purpose of a machine is not inherent in the machine itself but is given by the person who makes or uses it; it is something that resides in the machine-man relationship, something that emerges in the higher system composed of machine and man.

Then, what about the purpose of living things? Unlike machines, living things are able to organize their bodies by themselves, and so their purpose appears to inhere in individual organisms, not given from the outside. Is it true?

Before answering that question, let us consider the hierarchical structure of the organism's body. It is composed of a number of levels from atoms and molecules to cells and organs, and the elements at each level work to achieve their respective purposes: a hemoglobin molecule for transporting oxygen, a ribosome for peptide synthesis, the heart for pumping blood, etc. These structures are physical systems that work according to physicochemical laws, and they can be isolated from the body under appropriate conditions without losing their physical activity. In the isolated state, they no longer achieve their purpose, however good their work is physically. Obviously, their purpose does not reside in themselves but emerges when they are incorporated into a cell or a body, i.e., into a higher level of hierarchy.

Returning to the question of the purpose of living things, let us first consider the purpose of self-replication. Self-replication is an indispensable function of living things, but actually it is not necessarily demanded on each individual organism. An individual of bisexual species requires another individual of the opposite sex for replication, and individuals of social insects except a few never replicate themselves. Thus, self-replication is realized very often not by individual organisms but by a group of them. Namely, the purpose to replicate is realizable, in general, not in individuals but in the higher order system, i.e., the society, the lineage or the species (note that I use the word society in a broad sense as before, including the relationships between mother and child, between sex partners, etc.).

It is true that individuals of bacteria are complete in replicating ability, needing no other individuals for replication. In their case too, however, their survival for a long period as a species requires that they form a big enough population to allow cellular aggregate formation and to contain mutants that will withstand environmental changes. Therefore, the self-replicating ability of an individual is not the sufficient condition for a living thing; the sufficient condition is realized only in a higher order system, the population and the lineage, with the possibility of aggregate formation as well as mutation and evolution.

Then, how about the other aspect of being alive, i.e., the activity of maintaining the organism's body by metabolism? As every individual organism can autonomously maintain its life, it may seem natural to consider that the purpose to live is inherent in it. Certainly every individual is born from its parent(s) and develops by its own ability through a series of processes that take place according to physicochemical laws. But it must be acknowledged that those physicochemical processes are organized and controlled by the boundary conditions, semantic in nature, that are not invented by the individual but are formed on a higher level by the lineage -species through the evolutionary history and are imposed on the individual. The view that a living thing organizes itself by its own ability is valid only as regards the mechanical aspect of the organism; an individual organism exists as a living thing by virtue of active participation and internalization of the higher levels of hierarchy, the lineage-species and the society.

An individual organism is born, not into a blank space, but into the Umwelt-society complex historically formed by the lineage-species, and from there starts developing its own subjectivity. It thus lives always in a web of living things on a higher level of hierarchy. The purpose to live does not arise in the individual, but emerges in its relationship with the higher levels of hierarchy to be realized in the individual-Umwelt-society triad. Thus life is something that transcends the individual.

Hoffmeyer (1996, p.95) presented a metaphor, 'inside us there is "someone" ', and explained it saying 'Life is based on the principle of "someone" inside "someone" inside "someone" inside .....', thereby describing a hierarchical network of sign processes in multicellular organisms. It is applicable even to single cell organisms, as they have "someone" inside in the form of the historically formed and inherited interpreter(s) of sign processes that go on in them.

A significant point to note here is that, although an individual is incorporated inextricably into the social and historical web on a higher level, it has a high degree of freedom in the way it lives, materializing the endowed purpose in its own way. Freedom at the molecular and cellular levels is the topic of the next section, together with the dimension of mind.

Freedom at Molecular and Cellular Levels and the Dimension of Mind

If the notion of living things being active agents with autonomous subjectivity is valid, they must have certain degrees of freedom from the determinacy of physical laws, and of freedom to act and choose their response to inputs from the outside. But the bodies of living things are made of molecules that must obey the physical causality laws. Then how is such freedom possible in the physical world of molecules?

In my previous paper (Kawade 1996), I contended that molecules in living systems are not simply physical objects, but semiotic entities carrying out biological functions in the world of meaning they form. In support of this, various kinds of indeterminacy and arbitrariness at the molecular level were described; molecules obey physical laws, but the laws work not as determiners but constraints of the behavior of molecules. I now add below even more important cases of indeterminacy and freedom at the molecular and cellular levels.

The chemical structure of various molecules with biological functions, especially proteins and nucleic acids, has been elucidated, and there seems to be a general belief or expectation among biologists that the molecular structure determines the biological function of the molecule. In this view, molecules will work simply obeying physical causality relationship, like a machine made of solid gears whose action is precisely determined by physical laws; namely, the structure and function are "tightly coupled", and a given input to the system will yield a certain fixed output. Actually, however, various cases of protein molecules are being recognized whose structure-function relationship is "loosely coupled", rather than tightly coupled. A well-studied example is the behavior of muscle proteins, actin and myosin.

Muscle contraction occurs when molecules of the two proteins slide with each other, utilizing the energy of ATP hydrolysis. The general conception used to be that the length of the sliding motion is determined by the energy of the ATP molecules hydrolyzed. But since the techniques of microscopically observing single protein molecules have been developed (Aihara and Okada 2004), the sliding length accompanying hydrolysis of one ATP molecule is observed not to be constant, but varies greatly depending on experimental conditions (Oosawa 2000, 2001). This finding can be understood by considering that protein molecules are soft unlike rigid machines made of metal, and a given molecule can have a number of different "states". Protein molecules are small and their state is always fluctuating due to exchange of thermal energy with water molecules around them which are comparable in size. The energy input from the hydrolysis of a single molecule of ATP is not much greater in magnitude than this incessantly fluctuating thermal energy. Therefore, the magnitude of the output, the sliding length, in response to a constant input of energy is not constant, but depends on the state of the protein molecule at that instant.

It has been recognized that a protein molecule with a given amino acid sequence generally has a number of different 3-D structures — the "states"—which are not far from each other in energy level, and may thermally fluctuate from one state to another in the time scale of seconds (microdynamic structural polymorphism). In the different states, the protein may act in different ways, e.g., bind with different ligands or with different strengths. Some protein molecules have memory of its history of the states, and their function depends to some extent on their history. So the cell can choose the states of the protein molecules—their meaning for the system— appropriate for the current situation.

A further example of striking findings by the one-molecule measurements is the reaction of a growth factor protein (EGF) with its receptor protein embedded in the cell surface membrane (Sakou 2004). There are millions of the receptor molecules in a cell, constantly moving around on the membrane by thermal diffusion. Upon binding of the growth factor molecule, the receptor is activated, resulting in dimer formation and phosphorylation. This receptor activation occurs even on molecules not bound to the growth factor, because the ligand-bound, activated receptor molecules on the same membrane diffuse and act on ligand-free receptors. That is, the growth factor molecule must be looked upon, not as reacting with an isolated receptor molecule, but as reacting with a member of a system consisting of numerous fleeting receptor molecules, thereby having its action amplified.

Observations of the actions of various proteins such as these indicate a general rule that the function of a protein molecule is not uniquely determined by its chemical structure but depends on its state, and intricate biological functions can be accomplished by organizing protein molecules and other simple elements into a network, a higher order structure.

If we look at a living cell, a system at a higher level of hierarchy, we can observe how freedom from physical causality at the level of protein molecules, involving fluctuation of their physical states, can lead to realization of autonomy and spontaneity of the cell as a subject. This we learn from the experiments on paramecium (Oosawa 2001, 2005). Paramecium is a single cell organism with an ellipsoid body a few tenths of a millimeter in length, and swims in water by swinging several thousand cilia on its surface. It moves straight forward and, after several seconds, abruptly changes its directions by reversing the direction of swinging of the cilia for a short period; the reversal occurring on the whole surface results in backward movement, and that on a limited area of the surface results in a change of direction. The switching of swimming direction occurs spontaneously or is caused by stimuli from the outside. There are numerous ion channel molecules on the cell surface, and due to their thermal fluctuation of opening and closing, the membrane potential always fluctuates and, from time to time, forms a sharp spike, strong enough to cause a spontaneous change of the swing direction of cilia.

When the environment of a paramecium cell is altered, it may move toward a place with favorable conditions. For instance, when it is placed, after cultivation at 25 C, in a temperature gradient, it gradually gathers toward the place at 25 C, by frequently changing the swimming direction at unfavorable temperatures and less frequently at favorable ones. This action is caused by the temperature sensor proteins on the cell membrane that form ion channels, which change the probability of generating a sharp pulse of membrane potential depending on the temperature.

Paramecium memorizes the temperature at which it is kept for a while. When, for instance, after incubation at 25 C, it is transferred to 30 C, the organism changes the swimming direction frequently, and after some time returns to regular movements; i.e., it adapts to the new temperature. This adaptation is probably caused by chemical modification of the temperature sensor molecules. Memory is formed also about the salt concentration of the medium, and adaptation to a new salt concentration occurs similarly.

These activities of a paramecium cell are spontaneous and reflect its autonomy, as they are not determined by the environmental changes to which it responded. These observations indicate that the behavior of a paramecium cell under a given condition will vary according to its “internal state” which changes according to the environment and therefore depends on its own history.

What is called here the internal state of a cell is constituted by the assembly mainly of protein molecules including various sensors, ion channels, motors, signals, etc., which can take on different states under normal conditions due to microdynamic structural polymorphisms, chemical modifications by methylation and phosphorylation, redistribution of the elements within the cellular organization, and so on. It will fluctuate all the time spontaneously and in response to the situation inside and outside the cell. Two cells may therefore behave differently in the same environment according to their history; also possible variations in the number of the constituent protein molecules in different cells may contribute to their individuality, i.e., differences in behavior. Such spontaneity and autonomy have been observed also with bacteria (Salmonella), which swim using flagella with molecular mechanisms entirely different from paramecium’s cilia.

Some of the cellular internal states may be considered to be of the nature of pleasure and displeasure (Oosawa 2001, 2005). A paramecium organism swimming smoothly in an environment to which it is well adapted looks to be in a pleasant state, in comparison with the one in an unaccustomed environment, whose movements look erratic and in an unpleasant state. Of course I am aware that talking about pleasure-displeasure of a single cell organism is transcending the limit of natural science, but certain kinds of anthropomorphic terms and concepts are necessary to describe the behavior of living organisms.

Pleasure-displeasure is a matter of emotion. Emotion is something that occurs in an animal as a bodily response to things and events around it, instantaneously measured as regards their value for its survival. Emotions have high adaptive values and must have played an important role in the evolution of animals. They may appear to require the presence of a nervous system, but it is worth noting that not only paramecium and bacteria described above, but almost all living cells are equipped with various sensors, ion channels and pumps, which are basically the same in function as those protein elements in nerve cells that play the fundamental roles in neural functions.

Emotion may occur in all possible modes and strengths. I presume every living thing has some form of emotion, however primitive and undeveloped it may be. It seems plausible to assume that the primordial feeble forms of emotion in single cells gradually developed through natural selection because of their adaptive value, resulting in invention of the nervous systems utilizing the available elements such as ion channels and various sensors.

Emotion, at least in well-developed forms, is obviously an aspect of mind. I am now led to the view that every living thing has mind, or at least the dimension of mind. I dare not try to give a definition of mind, but it is, among us humans, something obvious and clearly recognizable, yet the presence of mind in people other than oneself is only assumed and hardly demonstrable in objective ways. Even more difficult to answer is the question of whether or not living things other than humans have mind. For investigators of primate behavior, as well as lay people who keep dogs or cats as pets, there won't be any doubt as to these animals' having some sort of mind, with functions including emotions such as pleasure, fear, anger, etc, however different in quality and strength from those of humans (Fujita 2007). Then a question that naturally arises is what animals have mind and what others do not. This question, however, is not a legitimate one, because it presupposes that mind is either present or absent in a given living thing, while in fact mind is not of all-or-none character, but can be present in all sorts of quality, mode and strength, just like the subjectivity of living things. If evolution is admitted to be continuous, it will be impossible to draw a sharp line, in the evolutionary tree of living things, between those which have mind and those which do not.

Imanishi also argued (2002, p. 31): " in the primitive behaviors of living things, recognizing and action are directly linked, and for their integrativeness, the action or recognizing must somehow be felt by them. Then we may imagine a kind of latent consciousness or protoconsciousness. Autonomy, or subjectivity, was inherent in living things from the genesis of living things in this world, and consciousness or mind was latent in this autonomy. It is not too strange to admit that cells and plants have their own mind, although they are of different kinds from ours."

In the realm of res extensa, we are ready to accept the presence of materials of minute dimensions, such as 10^{-27}g (mass of an electron), that far exceed the limit of our sensibility. Then, it will be one-sided if one does not admit the possibility of feeble forms of mind in all living things that do not directly appeal to our senses, although of course mind is not anything expressible quantitatively. Besides, the distinction between res extensa and res cogitans has become blurred, thanks, among others, to the progress of sciences.

Conclusion: What is Life?

In place of a definitive answer to the question of what is life, I will point out the presence of mind, or at least the dimension of mind, as the most basic characteristic of all living things that distinguishes them from nonliving things. Of course the word mind used here means something very different from the human mind, and may better be called "Ur-mind", if I may use the German prefix that means primordial, or be designated as {mind} (the notation by Salthe 1998). Living things should be understood to have had, from the very origin of life, an internal dimension that transcends materiality, that is, {mind}, which developed through the organic evolution ultimately to become the human mind.

Postulating the presence of {mind} in every living thing comes naturally from the conception of its being an autonomous subject that has its own purpose of living to maintain its physical identity by metabolism for some time and leave its offspring. "Purpose" is a matter in the world of meaning, semiotic in nature. Every living organism has sensors that measure its environment and acts to fulfill the purpose by taking actions that are consistent in themselves and compatible with the situation, such as swimming of bacteria toward an area of higher nutrient content, and a frog's stretching its tongue to catch a fly. These actions do not need participation of mind in its usual sense, but as far as their overall features of consistency toward an end and compatibility with the situation are concerned, they are basically the same as intentional actions of humans. Such purpose-oriented actions can be understood to be carried out with Ur-intentions, or {intentions}, which will develop through evolution toward genuine "intention" as nervous systems emerge and grow and the mind develops. Intentionality was taken to be "the unique aspect of all living creatures" also by Hoffmeyer (1996, p. 47).

As described before about paramecium and bacteria, a living cell assumes various different "states" depending on the situation and its history. For instance, when it is successful in its {intention} toward fulfilling its purpose to live, its state will be that of {pleasure} or {satisfaction}, and when it is not, its state will change to {displeasure} or {sadness}. A living organism will thus experience change of state from moment to moment, and such "internal states of the living subject being experienced" will represent its {emotion} and {feeling}.

According to Weber (2002), Susanne Langer and Hans Jonas also posited feeling at the very base of the existence of living things. He quotes Jonas: "Feeling is the primary condition for something to be 'worth the effort'. ... Thus the ability to feel as it came about in organism, is the mother value of all values." Discussing Langer, he writes: "feeling translates the biological meaning of a value which has been encountered into a subjective perspective: the value of a situation becomes manifest as feeling", and quotes Langer: "... behavior — the acts of an organism as a whole in relation to extraorganic conditions — comes to be guided and developed by feeling".

One may also recall Peirce's metaphysics, which explained the Firstness as the "qualities of feeling" (see, e.g., Yonemori 1981, p. 71). This "feeling" here seems not very far from the "internal state" of the cell described above.

It may not be easy to admit the presence of {mind} in plants, which do not have nervous systems, but they do have senses for light, gravity, sound, contact, etc., and can respond to environmental stresses, such as high and low temperatures and drought (Tsukaya 2001). As they live actively maintaining their existence as autonomous subjects in essentially the same way as animals, there is no reason to deny the presence of {mind} in plants.

To summarize then, the core of an organism's being alive, in distinction from machines, is to have the internal dimension that makes the organism act with {intentions} and {feelings} toward fulfilling the autonomous purpose of maintaining its identity through metabolism and self-replication. The purpose does not originate in the individual organism itself, but is formed historically and socially in the higher order structure of the lineage-species and the society, and is mapped onto each individual. An individual is thus an existence that internalizes the higher-order structure; in this sense, it transcends the individualness, although every living individual has its own individuality.

And the individual has a high degree of freedom, and lives to pursue freedom of creating new horizons of existence, exploring and exploiting what Kauffman (2008) calls the adjacent possible.

Thus, every living thing lives, unlike machines, as an autonomous agent, weaving its idiosyncratic history. It will experience various internal states — {feelings} — in response to events encountered through its life and acts accordingly. Its whole life may best be likened to a "narrative", as it consists of developments along a more or less consistent story, like a drama involving emotions and desires; it is told, not in language except by humans, but in various modes of semiosis, and can be interpreted and understood to some extent by other living things, which are also weaving their own narratives. Totality of such interactions forms the semiosphere, and its development constitutes the evolution of life.

So far so good, but I have to somewhat qualify my argument about the distinction of living from nonliving things. In discussing the origin of life, I pointed out that life and non-life are continuous, with no clear-cut objective line of demarcation being possible between them. I also noted that subjectivity, as well as mind, is not an all-or-none character but can be in various different forms, degrees and qualities. Then, it will be logically inevitable to consider that nonliving things do not completely lack the dimension of subjectivity and mind, although of course our sensibility cannot detect it directly. Matter at every level of its hierarchy tends to associate to form higher-level structures, and that process is to be seen to contain aspects of "agentive individuality" (Salthe 1998), however weak it may be, which becomes discernible when living things appear on the stage. As life is continuous to non-life, so is subject to object, mind to matter, semiosis to dynamics, meaning to physicality, culture to nature. It will then be futile to try to decide whether or not a tornado, a city, a proton, etc. are semiotic entities or not; they are physical objects, but do not lack the semiotic dimension. Every physical objects, from quarks and superstrings up to the whole universe, must be regarded to have the dimension of mind, in agreement with Peirce (see Ito 2006, chap.3); only it becomes clearly perceptible when matter is organized into human beings. We know much about the physical laws governing the so-called objective world of matter, but we simply don't know how to deal with the mental dimension of matter.

So my view belongs to the "qualitative organicism" (Emmeche 2001, 2004), and is subsumed in Peirce's pansemiotics ("all this universe is perfused with signs") and panpsychism ("the matter is effete mind"). Imanishi (2002, p. 20) also considered life of nonliving things: "There is then no reason to confine 'life' only to living things, but we can say that there is nothing without life and wherever things exist, there is always life. ...... The things that constitute this world are similar in essence, but at the same time they are different. Although they differ, simultaneously we can perceive a prevailing commonality; in this we can glimpse the character of this world, which originally grew and developed from one thing."

After all, I conclude by emphasizing infinite creativity of living things, in contrast to nonliving things, in their search of new forms of existence in this world.

Acknowledgments My sincerest thanks are due to Jesper Hoffmeyer, whose encouragement enabled me to publish this essay here.

References

Aihara, K., & Okada, Y. (eds). (2004). *<1 bunshi> seibutsugaku (<One molecule> biology)*. Tokyo: Iwanami.

Asano, K. (2008). Seimei no kigen no atarashii kasetsu (New hypotheses of the origin of life). *Kagaku (Science), 78*(3), 277–286.

Barbieri, M. (Ed.) (2007). *Introduction to biosemiotics. The new biological synthesis*. Dordrecht: Springer.

Emmeche, C. (2001). Does a robot have an Umwelt? Reflections on the qualitative biosemiotics of Jakob von Uexküll. *Semiotica, 134*, 653–693.

Emmeche, C. (2004). A-life, organism and body: The semiotics of emergent levels. In M. Bedeau et al. (Eds.), *Workshop and Tutorial Proceedings, Ninth International Conference on the Simulation and Synthesis of Living Systems (ALife IX)* (pp. 117–124).

Fujita, K. (2007). *Doubutsu-tachi no yutakana kokoro (The rich minds of animals)*. Kyoto: Kyoto University Press.

Hoffmeyer, J. (1996). *Signs of meaning in the universe*. Bloomington: Indiana University Press.

Imanishi, K. (1941). *Seibutsu no sekai (The world of living things)*. Tokyo: Koubundo.

Imanishi, K. (2002). *(Translated by P. J. Asquith et al.) A Japanese view of nature. The world of living things*. London: Routledge Curzon.

Ito, K. (2006). *Peirce no uchuron (The cosmology of Peirce)*. Tokyo: Iwanami.

Kauffman, S. A. (2000). *Investigations*. New York: Oxford University Press.

Kauffman, S. A. (2008). *Reinventing the sacred. A new view of science, reason and religion*. New York: Basic Books.

Kawade, Y. (1996). Molecular biosemiotics: molecules carry out semiosis in living systems. *Semiotica, 111*, 195–215.

Kawade, Y. (1998). Imanishi Kinji's biosociology as a forerunner of the semiosphere concept. *Semiotica, 120*, 273–297.

Kawade, Y. (2001). Subject-Umwelt-society: The triad of living beings. *Semiotica, 134*, 815–828.

Kawade, Y. (2006). *Seibutsu-kigouron: Shutaisei no seibutsugaku (Biosemiotics: The biology of subjectivity)*. Kyoto: Kyoto University Press.

Martin, W., & Russell, M. J. (2002). On the origin of cells: a hypothesis for the evolutionary transitions from abiotic geochemistry to chemoautotrophic prokaryotes, and from prokaryotes to nucleated cells. *Phil. Trans. Roy. Soc. Lond., B358*, 59–85.

Martin, W., & Russell, M. J. (2007). On the origin of biochemistry at an alkaline hydrothermal vent. *Phil. Trans. Roy. Soc. Lond., B362*, 1887–1925.

Monod, J. (1970). *Le hasard et la nécessité*. Paris: Editions du Seuil.

Oosawa, F. (2000). The loose coupling mechanism in molecular machines of living cells. *Genes to Cells, 5*, 9–16.

Oosawa, F. (2001). Jishu, jihatsu to kotaisa (Autonomy, spontaneity and individual differences). In K. Kaneko (Ed.), *Fukuzatsu-kei no biophysics (Biophysics of complex systems)*, pp. 155–192. Tokyo: Kyouritsu Shuppan.

Oosawa, F. (2005). *Hyo-hyo raku-gaku. Atarashii gakumonn wa koushite umare-tsuzukeru (Light-hearted science research. New fields thus keep being born)*. Tokyo: Hakujitsusha.

Polanyi, M. (1968). Life's irreducible structure. *Science, 160*, 1308–1312.

Sakou, Y. (2004). Saibounai jouhou shori system o 1 bunshi keisokusuru (One-molecule measurements of the intracellular information processing system). In Aihara and Okada (Eds.), pp. 43–81.

Salthe, S. N. (1998). Naturalizing semiotics. *Semiotica, 120*, 381–394.

Sebeok, T. A., & Umiker-Sebeok, J. (Eds.) (1992). *The semiotic web 1991: Biosemiotics*. Berlin: Mouton de Gruyter.

Shapiro, J. A., & Dworkin, M. (eds). (1997). *Bacteria as multicellular organisms*. New York: Oxford University Press.
Tsukaya, H. (2001). *Shokubutsu no kokoro (The mind of plants)*. Tokyo: Iwanami.
Weber, A. (2002). Feeling the signs: The origins of meaning in the biological philosophy of Susanne K. Langer and Hans Jonas. *Sign Systems Studies, 30*, 183–200.
Woese, C. R. (2003). On the evolution of cells. *Proceedings of the National Academy of Sciences of the United States of America, 99*, 8742–8747.
Yonemori, Y. (1981). *Peirce no kigougaku (The semiotics of Peirce)*. Tokyo: Keisou-shobo.