

Semiotic Scaffolding of living systems*

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ABSTRACT

The apparently purposeful nature of living systems is obtained through a sophisticated network of semiotic controls whereby biochemical, physiological and behavioral processes become tuned to the needs of the system. The operation of these semiotic controls takes place and is enabled across a diversity of levels. Such semiotic controls may be distinguished from ordinary deterministic control mechanisms through an inbuilt anticipatory capacity based on a distinct kind of causation that I call here "semiotic causation" to denote the bringing about of changes under the guidance of interpretation in a local context. Anticipation through the skilled interpretation of indicators of temporal relations in the context of a particular survival project (or life strategy) guides organismic behavior towards local ends. This network of semiotic controls establishes an enormously complex semiotic scaffolding for living systems. Semiotic scaffolding safeguards the optimal performance of organisms through semiotic interaction with cue elements which are characteristically present in dynamic situations. At the cellular level, semiotic scaffolding assures the proper integration of the digital coding system (the genome) into the myriad of analogical coding systems operative across the membranes of cells and cell organelles.

LIFE AND MEASURING: BASICS OF A SEMIOTIC ONTOLOGY

The vision of nature as an intelligible place has nourished confidence in the scientific project ever since the times of the Enlightenment. One prominent source for this belief was in Thomas Aquinas' teaching in the 13th century which strongly emphasized the inner connection between the two great books, the book of God, i.e., the Bible, and the book of nature. The will of God manifested itself in his creation as

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well as in the Bible and therefore reading the "Book of Nature" was a necessary supplement to reading of "The Book of God". That God in his benevolence would not have created nature as an unruly and lawless place seemed obvious to most Christian thinkers (note 1).

Orderliness does indeed seem to be a widespread property of our universe, but it should be noticed that: (1) such orderliness need not embrace all phenomena in nature, and (2) it need not have been instituted in our world from the beginning, but may as well have appeared in the world through an emergent processes. Strangely enough, however, many modern scientists do not seem embarrassed by the obvious Christian metaphysical heritage of science, whereas the idea of emergence, i.e. the idea that the orderliness we observe in nature has itself emerged through processes which are not yet effectively understood, is often seen as a smuggling in of supernatural intervention through the backdoor. It is hard to see, however, why the belief in an orderly universe as instituted from the beginning (by a benevolent God?) should be seen as a less supernatural explanation than the belief in orderliness as something arising by its own "force" in an unruly and largely random universe. Both ideas are dependent on ontological presuppositions which cannot themselves be ultimately proven.

The ontology of an emergent universe was explored in the evolutionary cosmology of the American chemist and philosopher Charles Sanders Peirce, who posited the idea that our universe has an inherent tendency to "take habits" (note 2). Taken in its broadest or most primitive sense, the Peircean idea of "habit taking" can be seen as an act of interpretation, i.e. the formation of a mediating link between one regularity and another, as when a bell is interpreted by a Pavlovian dog to mean food. Habituation, in other words is *semiosis* (sign activity) in its most general sense, and seeing habit taking as a general property of our universe immediately lets us reconcile our cosmology with the fact that semiotic creatures (such as ourselves) exist on planet Earth – or, in other words, that there are creatures in this world capable of "making sense" of their environment, i.e. measuring it and making choices based on such measurements.

That measuring processes constitute a central aspect of life processes in general has been emphasized throughout the work of Howard Pattee (Pattee 1977; Pattee 1997). Convergently, Stuart Kauffman has recently also discussed natural

measuring processes in the context of the "non-ergodicity" of our universe. That the universe is non-ergodic implies that the universe never has had the time it would have needed, should its present state of affairs be in any way representative of its in-built possibilities (Kauffman 2000). The persistent movement of the universe into the next possible state, or the "adjacent possible" as Kauffman calls it, precludes its ever reaching a state that depends on statistical likelihood. Instead the universe is historical, for "history enters when the space of the possible that might have been explored is larger, or vastly larger, than what has actually occurred" (p. 152).

Kauffman is fully aware that the "burgeoning order of the universe" cannot be reduced to matter alone, to entropy (or the negation of entropy for that matter), to information, or to anything that simple. The propagation of organization and the subsequent growing diversification of the world is enabled in Kauffman's terminology by *autonomous agents* and, as we shall see, these agents are in a deep sense semiotic creatures. For an autonomous agent may be defined quite rigorously as an "autocatalytic system able to reproduce and able to perform one or more thermodynamic work cycles" and in his earlier work, Kauffman has shown that such agents will be expected to self-organize given the kind of system our Earth belongs to (Kauffman 1993).

However, in *Investigations*, Kauffman explicitly observes that such a definition leads to the more intractable questions of "measuring" and "recognition". For if work is defined as "the constrained release of energy" where will such "constraints" come from? Minimally, it will take work to produce them, and this is not all, for: "autonomous agents also do often detect and measure and record displacements of external systems from equilibrium that can be used to extract work, then do extract work, propagating work and constraint construction, from their environment" (Kauffman 2000, 110). Now, since a measurement always implies an act of interpretation, this immediately brings us to the heart of biosemiotics.

Because the ability to measure is the exclusive property of living systems; measurements do not take place in ordinary chemical systems. By way of illustration, let us consider the chemotactic behavior of the *E. coli* cell. In naturally occurring systems, nutrients will not normally be homogeneously distributed in space but will typically be present in certain localities and absent in others. This is the logic behind the appearance of the chemotactic capacity in early evolution. *E. coli* cells are

certainly primitive creatures, but they are, in fact, capable of measuring the concentration of nutrients they encounter while swimming, and to register any change in the concentration they might come upon. An eventual change in the concentration of an edible amino acid will - at least when more profitable nutrient sources are absent - cause the bacterium to swim upstream toward the source of the amino acid.

This behavior depends upon a sophisticated interaction of some fifty different proteins that co-operate in executing a *comparison of measurements* taken at two successive points in time – as well as in mediating the result of this comparison to the many aggregates of proteins spread along the surface of the cell that are responsible for flagellar movements. The collective effect of this co-operative effort is the establishment of a scaffolding mechanism assuring that the bacterium moves towards the best available nutrient source – or eventually, if no such nutrients are available, that it changes its movements into a random search behavior, i.e., tumbling around itself without a definite direction.

What goes on in this measuring sequence is the formation of an interpretant (here: the change in flagellar movement) that is related to something exterior to the cell (the distribution of nutrients in the outside environment) in a way that reflects the historically- and evolutionarily- acquired integration between the sensory system of the cell to its motoric faculties. In other words, the reason why an interpretant is formed here and now is that the cell through its evolutionary ancestry has evolved this particular mechanism for a mediation between its sensoric capacity (e.g., the receptors at its surface) and its needs (the regularly assured movement towards nutrients). History thus not only matters to the cell, but literally operates inside the cell through the structural couplings – or semiotic scaffolds – that it has served to build into the system. And this is exactly what distinguishes living systems from non-living systems: the presence in the former of historically created semiotic interaction mechanisms which have no counterpart in the latter.

This mechanism is so different from anything taking place in the non-living sector of nature, that it deserves to be distinguished as constituting a special kind of causation, different from but dependent upon traditional efficient causation. I have coined the term *semiotic causation* for this kind causation of *bringing about effects through interpretation* (note 3), as when, for example, bacterial movements are caused through a process of interpretation based on the historically defined needs of a

sensitive system (Hoffmeyer 2005).

Of course, such “semiotic causation” cannot *in itself* execute its effects, but must always operate through the mechanisms of material efficient causation. The relation between the two kinds of causation is like the relationship between a court of law and a sheriff, says Peirce: "*Law, without force to carry it out, would be a court without a sheriff; and all its dicta would be vaporings*" (CP 1. 213 (note 4)). Or to paraphrase Kant: *Semiotic causation without efficient causation is helpless, but efficient causation without semiotic causation is blind*. Semiotic causation is the term for that system of relations that gives direction to the flows of metabolic energy through a living system and thus to the behavior of an organism (Santaella-Braga 1999).

Biosemiotics deals with habit taking in this precise sense, as exhibited by living cells and the interactive patterns in which they take part, i.e., as organisms or as supra-individual entities. But whether or not such habituation is a meaningful concept in the inorganic world, as Peircean cosmology requires, is a metaphysical question that is not of direct concern to biosemiotics. For it is an empirical scientific fact that the equivalent of measuring processes do undoubtedly take place in every living system, and this basic semiotic activity alone amply justifies the study of living systems as semiotic entities.

THE SCAFFOLDING OF LIFE PROCESSES

Life depends on the fine tuned co-ordination of an astronomical number of biochemical reactions taking place inside and across different kinds of membranous structures (Hoffmeyer 1998; Hoffmeyer 1999). The total area occupied by cell membranes in the human body, for example, has been calculated as one third of a squared kilometer (Hoffmeyer 2000). Moreover, the area of membranes filling up the internal space of cells, i.e. the membranes around the mitochondria, endoplasmatic reticulum, Golgi apparatus, and the many smaller cell organelles, are probably several orders of magnitude larger than the area of the outer cell membrane itself, resulting in a total area of membranes in the human body of perhaps 30 km².

These membranes generally are fluid structures that need to be upheld actively at the expense of metabolic energy. Thus, nothing in this complex arrangement has any *inherent* stability, so the maintenance of a living system requires a very intricate system of dynamic interactions. And while this system is of course *powered* by metabolic energy – *it must be controlled by semiotic means*. This is to say that local processes must subserve the needs of global functions, and this result can only be obtained through communicative activity connecting distant parts and different functional domains of the body (or organism) to each other.

For even inside the single cell - and a human body consists of some 50,000 billion single cells - the task of communicative coordination is not a simple one. A multitude of pathways for signal transduction are involved in each and every task, and one major problem to avoid is the possibility of so-called signal transduction “cross-talk” interfering with the transfer of messages, i.e., the prevention of signal molecules destined for one distinct pathway becoming interpreted as relevant by other pathways (see Bruni 2003; and this volume for a discussion of the intricate semiotics of signal transduction).

The semiotic coordination of the processes described here makes up the branch of biosemiotics called *endosemiotics*, i.e. the semiotics of processes taking place inside the organism. *Exosemiotics*, on the other, hand is the term used for biosemiotic processes going on between organisms, both between and within species, as well as for the semiotic processes connected with the interpretation of abiotic markers in the environment, as when migratory birds make use of stellar configurations in order to find their way. That these endo- and exo- prefixes have thus come to refer to the two sides of the borderline around bodies, is a terminological distinction only and should not be taken to signify any privileged role in biosemiotics for either side of the interface, or boundary. In fact, semiotics is in principle *always* connected with some kind of inside-outside interaction.

Thus, through the totality of life processes in the world, a *semiosphere* is created that envelops the earth in much the same way the atmosphere, hydrosphere or biosphere envelops the planet (Hoffmeyer 1996; Hoffmeyer 1997) (note 5). This semiosphere truly is a sphere like the atmosphere, the hydrosphere or the biosphere, in that it penetrates these spheres for living organisms and consists in communication:

sounds, odors, movements, colors, electric fields, waves of any kind, chemical signals, touch, etc.

The concept of the semiosphere adds a semiotic dimension to the more well-known concept of the biosphere, emphasizing the need to see life as belonging to a shared universe of sign activity through which cells, organisms and species all over the planet interact in ways that we still hardly understand. And yet every single species (including humans) has only limited access to this semiosphere, because each species' capacity for sensing and interpreting potential cues in its surroundings, i.e. its *interpretance* (note 6), has evolved to fit a particular ecological niche. Put in the terminology of Jacob von Uexküll, each species is confined to its own limited Umwelt, or "internal model" with which individuals of a species constructs an understanding of its surroundings.

Moreover, the semiosphere poses constraints and boundary conditions upon the Umwelts of various species populations, since each are forced to occupy specific *semiotic niches*, which is to say that each will have to master different sets of visual, acoustic, olfactory, tactile and chemical signs in order to survive in the semiosphere. It is thus entirely possible that the semiotic demands made upon species' populations are often a decisive challenge to their success. If this is so, then ecosystem dynamics, for example, shall have to include a proper understanding of the semiotic networks operative in ecosystems.

The network of semiotic interactions by which individual cells, organisms, populations, or ecological units are controlling their activities can thus be seen as scaffolding devices assuring that an organism's activities become tuned to that organism's needs. And just as the scaffold raised to erect a building will largely delimit what kind of building is raised, so too do the semiotic controls on biological activities delimit when and how such fine-tuned activity should take place. To conceptualize and analyze the myriad of semiotic scaffolding mechanisms operative at and across different levels in natural systems is the core subject matter of biosemiotics.

THE CONCEPT OF SCAFFOLDING

Semiotic scaffolding operates by assuring performance through semiotic interaction with cue elements that are characteristically present in dynamic situations such as the catching of prey, invading host organisms, or mating. The significance of dynamic scaffolding in the human sphere has been pointed out already by the Russian psychologist Lev Vygotsky, who was probably the first to emphasize the importance during child development of scaffolding, i.e. experiences with external supporting structures (including linguistic ones). At crucial developmental moments, adults help give the child the experience of successful actions that child alone would not be able to produce (Vygotsky 1986). Some obvious examples include physically supporting the first few faltering steps of a near-walker, or supporting a baby in water to allow for swimming movements.

A striking case of a linguistic scaffolding is when a child is "talked through" a tricky challenge by a more experienced agent and thereby succeeds in solving a problem which was otherwise beyond its abilities (such as learning to tie his or her shoelaces). Later, when the adult is absent, the child may often conduct a similar dialogue with herself – in which case the speech sounds serve as an external memory-scaffold to guide the difficult activity and to avoid errors. In such cases "the role of language is to guide and shape our own behavior - it is a tool for structuring and controlling action, not merely a medium of information transfer between agents" (Clark 1997, 195).

In turn, the concept of scaffolding was later taken up and further developed within the fast-growing segment of robotics research concerned with so-called autonomous agents (e.g., Brooks 1993; Hendriks-Jansen 1996; Clark 1997). Autonomous agents are mobile robots ("mobots") capable of functioning in messy and unpredictable real-world settings such following as close as possible alongside a wall in a crowded office. "The New Robotics revolution" writes Andy Clark "rejects a fundamental part of the classical image of mind. It rejects the image of a central planner that is privy to all the information available anywhere in the system ... The problem with the central planner [model] is that it is profoundly impractical ... The reason is that the incoming sensory information must be converted into a single symbolic code so that such a planner can deal with it" (Clark 1997, 21).

Instead, autonomous agents operate on the principle that Hendriks-Jahnsen calls "interactive emergence": "Patterns of activity whose high-level structure cannot be

reduced to specific sequences of movements may emerge from the interactions between simple reflexes and the particular environment to which they are adapted ... The emergent behavior of the system as a whole is the result of various autonomous activities interacting with each other and with the environment, and not a centralized system making decisions based on internally represented courses of action or goals" (Hendriks-Jansen 1996, 8-9).

Significantly, as seen from a biosemiotic point of view, Hendriks-Jansen emphasizes that "Interactive situated behavior cannot be explained in terms of a deductive or generative law. It requires a *historical* explanation because there can be no rules to predict the sorts of behavior that might emerge" (p.9). Addressing the question of similar scaffolding mechanisms in biological creatures, Clark has suggested a "007-principle": "In general, evolved creatures will neither store nor process information in costly ways when they can use the structure of the environment and their operations upon it as a convenient stand-in for the information-processing operations concerned. That is, know only as much as you need to know to get the job done" (Clark 1997, 46)

Both Clark and Hendriks-Jansen are writing interchangeably about autonomous agents and biological creatures in ways which are likely to meet objections from many biologists. Thus, in the case of a wall-following robot, a human constructor pre-selects the "situatedness" of the given activity. But how does an organism select its own "situatedness"? Situated activity presupposes a kind of fitting between environment and organism, so Hendriks-Jansen contents himself by pointing to "natural selection" as *the* explanation for interactive emergence in the organic realm.

But the anticipatory or teleological capacity of natural selection is not as self-evident as most scientists seem to suppose. For natural selection not only presupposes superfecundity – i.e., that more individuals are born than can possibly survive, but more generally it presupposes the operation in organisms of a "strive" for survival. But a strive already implies a *telos*, something of the kind philosophers call 'aboutness' or intentionality, (although *intentionality* in this case does not imply thoughts and consciousness).

From the very beginning, even the simplest prokaryotic (bacteria-like) life forms take an interest in their surroundings with regard to finding solutions to survival problems such as how to feed, how to escape predation, and how to reproduce. None

of these strivings are explainable through schemes of simple efficient causation, for they all presupposes some kind of "orientation" from the system towards the environment and towards the *future*. Thus, the inherent teleological nature of living systems cannot be "explained" by natural selection because natural selection wouldn't work without it. And this "teleological property" of living beings was, of course, exactly the reason why Kant reached the conclusion that life evades scientific analysis. The Kantian conception of science was purely physicalist and he did not doubt that functionalist explanations in biology – e.g, the perennially beloved "machine metaphor" - violate the physicalist ideal to which biology still often subscribes – thus unwittingly (one must suppose) admitting logical contradictions into its core body.

And this is why the semiotic dimension of natural processes must be drawn into any dynamic analysis of such systems. Rather than talking about interactive emergence, as Hendriks-Jansen suggested, I would recommend using instead the concept of *semiotic emergence*. The primary mechanism behind semiotic emergence is semiogenic scaffolding, the key to nature's tendency to take habits in the biological realm.

SCAFFOLDING AND EMERGENCE

The emergence of new scaffolding devices (unknowingly) function like stepping stones in a river, leading evolutionary processes forward one step at a time and - in average - farther away from the bank at each step. In themselves, such semiotic scaffolding patterns may take many forms and rely on many different principles, but the core property of a semiotic scaffold remains that of focusing the energy flow (behavior) of the concerned system or subsystem upon a rigidly limited repertoire of possibilities, or in guiding the system's behavior to realize a definite sequence of events. A receptor molecule at the surface of a cell may be tuned to open a neighboring channel when, and only when, being hit by a small set of possible domains on protein surfaces, just as the offspring of a bird may be tuned to learn only one or a very narrow band of sequences of sounds. When the proper cue arrives, the receptor opens the channel or the young bird learns the species' song. The receptor

may be misled, however - as when an HIV virus iconically mimics the surface domains of one of the organism's own proteins - and the bird may be fooled e.g. if it's been deposited in the nest of a foster bird without further contact with adult birds of its own species (cf. Soler and Soler 1999). Semiotic scaffolding mechanisms depends on acts of *interpretation* (understood in the most encompassing, and not merely human anthropomorphic sense) and interpretation always runs the risk of being wrong.

For illustration, let us consider the case of infertility in the so-called eyeless mutant of the axolotl, as discussed by Leo Buss (Buss 1987). Under normal conditions, the amphibian eye will be produced by chemical interactions between the newly formed optic vesicle and the embryonic ectoderm layer. A chemical inducer produced by the optic vesicle is used for the scaffolding of this interaction. What happens in the *eyeless* mutant of the axolotl is that this step is disturbed because the ectoderm of the mutant does not respond properly to the inducer, so that no eye will be formed and the mutant develops blind. This however, is not the only problem this poor creature has to cope with – for it also lacks the capacity for leaving offspring. This is because the eyeless mutant develops a *secondary* deficiency in the region of the brain called hypothalamus, which will only be properly developed through induction via signals that are sent to it from the eye. In the *eyeless* individual, no eye exists to direct the development of the hypothalamus, and thus the hypothalamus therefore cannot produce gonadotropin hormones – and in the absence of these hormones, the individual becomes sterile.

The deficiencies of the eyeless mutant clearly illustrates the tinkering ways in which ontogeny has become scaffolded by evolution. There is presumably no other reason why the development of hypothalamus should depend on the presence of a functional eye than the eventual formation of the eye in a location that happens to be anatomically close to that region of the brain where hypothalamus is normally developed in this lineage. Making the development of hypothalamus dependent upon the prior formation of an eye effectively assures that hypothalamus will become constructed at the exact right moment in embryogeny. And this is precisely the situation that is not so, of course, in the eyeless mutant – but rare mutants are statistically of little concern in evolution. *Rather*, the axolotl eye just happened to be in the neighborhood of the nascent hypothalamus-region in normal individuals and it

is most likely for no other reason than this that evolution managed to exapt the eye for a secondary role as an ontogenetic switch for the initiation of proper development of a hypothalamus. As Buss says: 'Ontogeny must re-enact the interactions which gave rise to it' (Buss 1987, 97). In the terminology of this paper, ontogeny is safeguarded by myriads of semiotic scaffolds that depend on one another in long chains of successive steps.

In other words, all that was needed to assure that proper induction would take place was that some factor could be counted on as a reliable cue for the onset of hypothalamus development. We must suppose that the sensitivity of cells in the hypothalamus region to induction from the eye has been molded by natural selection, but very probably a number of other constituents might equally as well have become its target. Natural selection thus is responsible for producing the safe channeling (under normal conditions) of an inductive relation between eye and brain development, but the choice of this *particular* relation (between the development of those parts of the hypothalamus that will later enable gonadotropin production and the presence during embryological development of a rudimentary eye) as a theme for the semiotic scaffolding of hypothalamus development was probably more or less random.

In the same way, natural selection has safeguarded the inductive relation between optic vesicle and ectoderm layer at the location where the eye is supposed to form, but the fact that *this* relation became the focus for the selection process didn't necessarily itself offer any "selective advantage." Yet once this relation had become safeguarded through the strengthening influence of natural selection, it did thenceforth, however, offer a reliable cue for the successive construction of yet further semiotic scaffolding. In this way, ontogeny may be seen as being based upon a highly integrated web of historically coordinated semiotic scaffolding devices that guide the construction of the embryo safely through a procedure involving millions of possible choices taken by cell lines all along the developmental patchwork of the ontogenic process.

The emergence of this pattern of subtle scaffolding devices through evolution is, of course, in a certain sense the outcome of natural selection. But it should also be noticed that an important aspect of this process is the capacity - or talent one might say - of individual cells and cell assemblies to change their internal settings in

integrated waves (e. g. signal transduction cascades) under the influence of external (or new) molecular cues. The semiotic logic of localized dynamic biochemistry in a given embryonic tissue thus would tend to tell us as much or more about the actual “causality” behind semiotic emergence than do explanations in terms of “natural selection” alone.

SPAM

According to neo-Darwinian understanding, the gradual fixation of favorable mutations in DNA molecules due to natural selection is *the* mechanistic backbone for change in organic evolution. One reason for the overwhelming success of this understanding may be that genomes are in fact the most fundamental scaffolding devices for the ontogenetic production of organisms, and if you monitor the construction of a scaffold you are sure to catch also an important temporal aspect of the dynamic processes scaffolded. If, for instance, you monitor the ongoing addition of new notes to a musical score you will certainly get some insight into the tempo and speed of the composing process, and even a deaf person might become an expert in this. Too, there can be no doubt that the genomic structure is the most rigid and conservative scaffold for the evolutionary process, and monitoring the changes in gene frequencies down through generations will, of course, present you with a timetable which is tightly coupled to true evolutionary change.

For ease of illustration, let us consider a well-known case of linguistic scaffolding taken from the history of the development of the Internet, namely the term *spam*. This word has become customary all over the world for referring to the violation of privacy through invasion of other people's electronic mailboxes by non-invited advertising mail. Yet only a few people outside of the English speaking world would know that this new meaning of the word “spam” derives from a very specific situation – in particular, a single *Monty Python's Flying Circus* skit in which a group of Vikings sing a chorus of "SPAM, SPAM, SPAM, SPAM ... lovely SPAM, wonderful SPAM..." in an increasing crescendo, drowning out nearby conversation, much in the way that unsolicited e-mail “drowns out” other email on the Internet.

Additionally, the song's lyrics themselves constitute an endless repetition of worthless or annoying text similar to the e-mail variety of "spam."

Now, technically, the term "spam" is a so-called telescope word formed by the contraction of the phonemic extremities of "sp(iced) (h)am", i.e. *spam*. But although this term has been intentionally introduced and functions now, of course, in its present significative role – we can be quite sure that neither the original inventors of the spiced ham brand name SPAM, nor the cast members of *Monty Python*, had any idea of the particular world wide usage awaiting it. Rather, the metaphoric transformation of "spam" from the *Monty Python* setting to the Internet vocabulary was a non-necessary and *creative* act.

Moreover, this new relation ("spam" = electronic junk mail) only stuck because it happened to hit an unfilled locus in linguistic space, nominalizing a non-verbalized general experience in modern society. Yet through this metaphorical transformation onto the experiential plane of the Internet, the term now has become an linguistic actant in its own right, generating a range of new habits – e.g., we can engage in making rules for Internet services to "eliminate spam" or discuss and execute punishments towards "spam-sinners." And we may eventually expect even further conceptualizations to develop on the top the original concept. In this way, new terms can themselves be "scaffolding devices" for cultural development.

The point is that the coining of the term spam was a *creative* response to the *novel needs* of a new cultural situation. As such, it was not a result of conscious deliberations; instead, it just happened to grow spontaneously out of already existing linguistic resources by a sort of tacit interactive consensus.

It is tempting to see the appearance of the term "spam" as a prototype case for the origin of new digitally coded signs in nature, i.e. in evolution. Thus the digitalization of the *Monty Python* sketch in one simple phonetic sequence served to *scaffold* a complex social experience by making it an easy general resource for communication. And this kind of semiotic scaffolding, I suggest, is exactly what digitally coded messages such as genes are in general good for.

For new genes may often be formed very much through the same kind of scaffolding conversions that we have seen to be instrumental in furthering the inclusion of new words in a language. Thus, in the case of the new term "spam" the decisive point was the conjunction of a pointed meaning (submitted by *Monty Python*)

and a social need (created by spam sinners). Likewise, in the biological realm, we can suppose that gene duplication accompanied by the hitch-hiking down through generations of one of the copies of non-essential or masked genetic material (prone to all kinds of non-lethal mutations) would assure the availability of a rich resource base for potential future genes. The decisive cause for the birth of a new functional gene would be a lucky conjunction of two events: (1) an already existing non-functional gene might acquire a new "meaning" through integration into a functional (transcribed) part of the genome, and (2) this gene-product would hit an unfilled gap in the "semiotic needs" of the cell or the embryo.

In this way, a new gene may become a scaffolding mechanism supporting a new kind of interaction by imbuing some kind of semiotic advantage upon its bearer – and this is what I mean by the term *semiogenic scaffolding*. By entering the realm of digitality, the new semiotic functionality becomes available not only to the cells of the organism carrying it, but also to future generations as well (and, if we allow for horizontal gene transfer, possibly even to unrelated organisms).

Digitality in the life sphere thus provides for the sharing (or objectivity) of ideas (functions) and thereby also assures their conservation over time. But this very function is itself dependent on the relative inertness of the genetic material and its very indirect and highly sophisticated way of interfering with the worldliness of cellular life. Genes, like human words, do not *directly* cause change in the world around them (i.e., we do not believe in spells), but do so only when some body interprets them. And just as words serve to support human activity and communication, genes support cellular activity and communication. Genes and words are both marvelous semiotic scaffolding tools.

ANTICIPATION AND BRAINS

Scaffolding mechanisms in general depend upon the ability to anticipate and prepare for important situations and events in the life cycles of the concerned entities. To scaffold life processes through genomic control mechanisms obviously becomes difficult when organismic life cycles become more complicated or when animals engage in complex social processes. Genomic scaffolding necessarily operates

through the controlled assembling of protein resources which are then released in sophisticated temporal patterns reflecting the upcoming needs of the organism. Such mechanisms do work sufficiently well so long as the behavioral repertoires of animals are limited to instinctually triggered responses to foreseeable events.

But large-brained animals such as birds and mammals are generally dependent upon not just instinctual reflexes, but the processes of *learning* – and while such processes are assisted by genetically assured behavioral preferences, the whole advantage of learning ability must be the inherent element of flexibility inferred on behavior by the learning process – and thus the transfer of behavioral control from the genomic level to the cerebral level. This introduces the need for even newer sets of scaffolding mechanisms – and foremost among these are the diversity of control mechanisms exhibited by the neuro-endocrinological apparatus.

An amusing example of the semiotics of neuro-endocrinological scaffolding has been observed in the cooing behavior of ring doves (*Streptopelia risoria*). Before a female ring dove lays her eggs, she and her mate go through a series of courtship displays. As courtship proceeds, hormonal changes in the female trigger the growth of follicles in her ovaries, each of which eventually bursts to release an egg. Now it has been shown that if a female dove is operationally hindered in making the so-called “nest-coo” she will not be able to ovulate, even despite the enthusiastic courting by males. Yet in control experiments, tape recordings of nest-coos were played to females with no males present. Now follicles thus immediately began to grow.

The conclusion seems simple: Female doves are not cooing, ultimately, at the males - they are, in fact, cooing at their own ovaries to trigger the release of eggs. And since ovaries are not supposed to possess means for meaningful absorption of sound, this mechanism must be operating through the brain of the animal. And what the experiment shows is that the brain does not tell the ovaries to make eggs until after it has interpreted the sounds emanating from its own throat.

Why such a strange mechanism has actually evolved can only be guessed at, but perhaps courtship ritual and thus cooing behavior is in fact more safely correlated with the actual time of mating than a purely endogenously-based release system would have been. The obvious, although speculative, explanation would be that the cooing behavior measures the state of a relation between two birds and two sexes, which is likely to be superior metric for reproductive success than would be a simple

measure of the hormonal state of the female organism itself.

The advantage of preparing for future events or situations – i.e. *anticipation* – is, of course, the main reason for the evolution of *semiotic causation*. The animal that flees at the moment that it senses the presence of smoke obviously runs a better chance of leaving offspring than does an animal that doesn't respond until the heat is actually felt. The most important tool for surviving is thus anticipation and organisms are involved in anticipatory action and relations all the time. They must decide when to grow and when to withhold growth, when to move, when to hide, when to sing and so on, and this way of adjusting one's own behavior depends on a capacity to predict the future at least to some limited extent.

For instance: "Is it likely the sun will shine or not?" "Is it likely that little flies will pass by if I make my web here?" "Will the predator be fooled away from the nest if I pretend to have a broken wing?" etc. In most cases, it will be the instinctual reflex system of the animal, rather than the brain, that makes this kind of prediction – but the underlying logic is the same: an animal profits from its ability (whether acquired through phylogeny or through ontogeny) to identify trustworthy regularities in the surroundings and to orient its own actions accordingly.

Now most - if not all – such trustworthy regularities are *relations*. For instance: the relation between the amount of daylight and the approaching summertime that tells the beech when to burst into leaves; or the play of sun and shadows which tells the spider where to construct its web; or the relation between the clumsy movements and an easy catch that tells the predator which individual prey animal to select – and that thus also tells the bird how to fool the predator away from its nest.

In the first two of these examples (the beech and the spider), a certain organismic activity is released as a response to pure (non-semiotic) natural relations, so-called *categorical relations* – whereas in the third example the bird produces a fake categorical relation (clumsy behavior as expectedly related to easiness of catch) and then takes advantage of the semiotic relation established by the predator when it lets itself be fooled by a false sign. In this case, in other words, the bird fools the predator because it somehow (genetically or ontogenetically) 'knows' how the predator is going to (mis)interpret the seeming categorical relation. Observe, too, however, that in this case the predator may not always be fooled – and this shows us that we are not here dealing with just material forces (*efficient causality*) – but also

and more importantly with *semiotic* causality whose consequences are not strictly deterministic: e.g., the predator may misinterpret the sign (the faked clumsy behavior), but it also may not.

Anticipation is thus essentially a semiotic activity in which a sign is interpreted as a relation between something occurring now and something expected to occur later, such as a dark cloud alarming us to an upcoming thunderstorm. And from its very first beginnings in Augustine's writings in the fourth century, a *sign* is conceived as something awakening us to infer something else. For Augustine, a *signum* (sign) "is anything perceived which makes something besides itself come into awareness" (quoted from Deely 2001, 221). And while Augustine's definition is too narrow in its focus on perception, since elements of awareness may well be signs also without being perceived, yet he did point to the core of the matter when he defined a "thing" as: "what has so far not been made use of to signify something" (p. 221). This implies that "things" may well be "signs" but that *they need not be so*. It also implies that the essence of the sign is its *formal relational character* of evoking an awareness of something which it is not itself – and thereby implying the full Peircean triad of sign, object and interpretant (here: the altered awareness). The evoking of such a referential triad is, of course, by no means exclusive to the workings of human awareness but is rather, as was later realized, a purely *logical* relation to be established in *any* system capable of autonomous anticipatory activity.

Moreover, just as predictability must precede prediction, a system of useful dyadic relations must first have been realized on planet Earth before the emergence of biological life. Only then could more sophisticated systems survive based on the capacity for anticipation –i.e., for bringing themselves in relation to the pre-established set of dyadic relations under the formation of true triadic or semiotic relations. And while the underlying system of dyadic relations may well be understood in terms of the things related, the emergence of true triadic semiosis in the shape of living beings and their activities established a new kind of causality peculiar to this new form of *relative being* – causalities which are far too sophisticated to be accurately grasped through the simple dynamics of dyadic relations between inanimate things.

SEMIOTICS AND RELATIVE BEING

Although most biologists do in some sense recognize that communicative processes are part of natural systems, many instinctively conceptualize these processes *only* in terms of the biochemical and genetic processes involved, and that are proposed to result in such communicative behaviors. To talk of messages or semiosis, they feel, just blurs our minds – and this is the reductionist credo ruling almost every department of biology throughout the world. And so the simple question asked from these quarters when confronted with “biosemiotics” normally is: What's all this fuss about?

What it is all about, I think, is quite a simple thing: namely, the reality of *relative being*. Relative being is a strangely obvious thing which is nevertheless generally dismissed by science as not really "real". For example, Jupiter has a number of moons circling around it, but the *relation* between the moons and the planet is not seen as anything “real in itself” in that doing so doesn't add anything to a strict analysis of the properties of the individual celestial bodies themselves. The simple genitive case seems neatly to exhaust the whole relation: the moons are indeed Jupiter's. And it is of course true that, in principle, a “relation” could be drawn between *any* two physical objects in the world, and in all but a very few cases, such relations would turn out to be absolutely uninteresting whether seen from the point of view of science, or from the point of view of ordinary people's everyday life.

However: not all relations are of this inconsequential kind, and to give an example of 'relative being' which cannot easily be dismissed as “fictitious” let me suggest the relation of *parenthood*. For all we know, King Frederik the Ninth of Denmark was the father of Queen Margrethe the Second. But His Majesty passed away a long time ago, and we have no doubt that Margrethe will likewise pass away, too, at some point in the future. Yet, due to royal destiny, their *relation* will in all likelihood persist for a *very* long time as the relation between two real entities that it is: i.e., the relation of parenthood, of this particular father to this particular daughter. *Thus*, this kind of 'relative being' seems to have a reality of its own which *cannot* be reduced to the individual persons that substantiate the relation. Such relations have been called *ontological relations* in that they are “real” (i.e., actually existing)

functional factors of the actually existing world (Deely 1990; Deely 1994; Deely 2001).

But are there ontological relations in nature? One of the first to answer this question in the affirmative was the anthropologist and biologist Gregory Bateson (Bateson 1972; Bateson and Bateson 1987). According to Bateson, the reality of ontological relations is exactly what distinguishes life from non-life. For relations in the prebiotic sphere have also sometimes been thought of as being ontological, as for instance in the case with astrology. But since no likely mechanism whereby relations between planets (say a conjunction between Mars and Venus as seen from Earth), could possibly influence the destiny of individuals or nations on Earth has ever been established, such a belief is generally (and correctly) rejected by scientists as superstition. For we have absolutely no warrant for believing that those relations have any distant causal effects on the world *qua* relations. In this case - as in the prebiotic world in general - it makes more sense to talk about "related things" rather than about *relations* - and maybe the general unwillingness of science to accept relations as ontologically real owes much of its strength to the ancient (and now strangely revived) struggles science had to fight against dogmatic beliefs connected to mystical or religious persuasions.

When we turn to the investigation of animate nature, however, *relations* tend to become considerably more important than autonomous "things". The human shoulder, for instance, is a ball-and-socket joint that enables a person to raise, twist, bend, and move the arms forward, to the sides and behind. The head of the upper arm bone (*humerus*) is the ball and a circular depression (*glenoid*) in the shoulder bone (*scapula*) is the socket. A soft-tissue rim (*labrum*) surrounds and deepens the socket. The head of the upper arm bone is coated with a smooth, durable covering (*articular cartilage*) and the joint has a thin, inner lining (*synovium*) for smooth movement, while the surrounding muscles and tendons provide stability and support.

Here, then, are a whole assembly of *relations* which are all remarkably adjusted to each other. The primary functional relation, of course, is that between the shape of the ball of the arm bone and the contour of the shoulder socket, and we can assume that this relation has indeed been functionally modulated by natural selection, all along the way from its likely evolutionary origin as the appendages, or fins, in fish. Clearly these relations are of quite another kind than the relations pertaining to the

planetary system.

The relation, in fact, is so central to the function of the animal that one can hardly imagine the one bone changing without entailing a corresponding change occurring in the other bone (or in some other relation within the system). Or, if such a unilateral change should happen due to an unfortunate mutation, the resulting individual would surely be functionally deficient and leave little or no offspring. Conversely, if a mutation should occur that affected both bones in a coordinated way, *conserving* their internal relation – the resulting individual might perhaps manage quite well in the evolutionary competition. In this case, the relation *as such* does indeed seem as real and perhaps even more important to the system than the individual bones making up the relation. And this state of affairs may well be the rule rather than the exception in the realm of the biological world.

I conclude that not only is it absurd to deny the reality of *relative being*, because it is *relative being* rather than things (i.e., individual creatures or populations) that evolution persistently optimizes – and by denying this, one is prevented from developing a proper scientific understanding of both biosemiosis and of purposefulness. For semiosis is all about bringing oneself *in relation to* a relation. And from the beginning of life, organisms have based their survival on this capacity for anticipation – i.e. for interpreting events or structural configurations as *signs* for one thing and another. For as Peirce saw, the proper and most fundamental definition of a sign is something “which is in a relation to its object on the one hand and to an interpretant on the other, in such a way as to bring the interpretant into a relation to the object, corresponding to its own relation to the object” (CP 8. 322).

The fact that signs are often false or that relations (at least for humans) are more often than not imaginary does not preclude signs or relations from having causal significance. When the predator hunts the bird with a clumsy behavior its actions are equally real whether the bird actually does have a broken wing or not. If the bird is only pretending that its wing is broken, then the predator will most likely not catch it – but the movements of the predator were not for that reason any less caused by the (misleading) interpretant formed in its brain. By accepting the reality of relative being – and thus of semiotic causation – we not only open up an explanatory space for a reconciliation of human semiotic existence (such as is manifested in the writing a scientific paper) with that of organic existence in general, but we are also immediately

brought to see the semiosphere as an emergent process nourished by the interpretative interaction of countless organisms and cells – or in other words, by *biosemiosis*.

NOTES

- 1) An exception, perhaps, would be the early nominalism followers of Sir William of Ockham, who would not accept any limits to the freedom of God and who, by implication, would not exclude the possibility that God might have created a totally unintelligible nature. Such a view would hardly have allowed for science to develop, but eventually it was replaced by the ideas expressed by philosophers such as Voltaire, Rousseau and the other Enlightenment thinkers.
- 2) " ... if the laws of nature are results of evolution, this evolution must proceed according to some principle; and this principle will itself be of the nature of a law. But it must be such a law that it can evolve or develop itself. Not that if absolutely absent it would create itself perhaps, but such that it would strengthen itself, and looking back into the past we should be looking back through times in which its strength was less than any given strength, and so that at the limit of the infinitely distant past it should vanish altogether. Then the problem was to imagine any kind of a law or tendency which would thus have a tendency to strengthen itself. Evidently it must be a tendency toward generalization, -- a generalizing tendency. But any fundamental universal tendency ought to manifest itself in nature. Where shall we look for it? We could not expect to find it in such phenomena as gravitation where the evolution has so nearly approached its ultimate limit, that nothing even simulating irregularity can be found in it. But we must search for this generalizing tendency rather in such departments of nature where we find plasticity and evolution still at work. The most plastic of all things is the human mind, and next after that comes the organic world, the world of protoplasm. Now the generalizing tendency is the great law of mind, the law of association, the law of habit taking. We also find in all active protoplasm a tendency to take habits. Hence I was led to the hypothesis that the laws of the universe have been formed under a universal tendency of all things toward generalization and habit-taking" (CP 7. 515, see note 4).
- 3) An interpretation is a sign process as seen from the point of view of the person or living system engaging in it. Sign processes - or semiosis - are processes whereby something refers to something else, as when an animal is seized by alarm upon the smell of smoke. The smoke in this case acts as a sign vehicle that provokes the formation of an interpretant in the animal, i.e., a sense of danger causing it to flee. A sign then consists in a triadic relation of a sign vehicle, an object (here danger) and an interpretant. According to Peirce: "A sign... is an object which is in a relation to its object on the one hand and to an interpretant on the other, in such a way as to bring the interpretant into a

relation to the object, corresponding to its own relation to the object" (CP 8. 322)

- 4) The designation CP abbreviates (Peirce 1931-1935) and (Peirce 1958). The abbreviation followed by volume and paragraph numbers with a period between follows the standard CP reference form.
- 5) The concept of *the semiosphere* was originally introduced by the Russian-Estonian semiotician Yuri Lotman (Lotman 1990) who explicitly used it in analogy with Vernadsky's concept of the *biosphere*. In Lotman's writings however, the semiosphere remained a concept primarily connected to cultural processes: "The unit of semiosis, the smallest functioning mechanism, is not the separate language but the whole semiotic space in question. This is the term we term *semiosphere*. The semiosphere is the result of and the condition for the development of culture; we justify our term by analogy with the biosphere, as Vernadsky defined it, namely the totality and the organic whole of living nature and also the continuation of life" (*ibid.* 125) (Vernadsky 1926; Vernadsky 1945). Additionally, one might claim that Vernadsky's concept of the *biosphere* does indeed cover the meaning the I have given here to the term *semiosphere*, but the concept of biosphere has not survived in the sense given to it by Vernadsky, but the latter is now used simply as "the ecosystems comprising the entire earth and the living organisms that inhabit it" (Webster's Encyclopedic Unabridged Dictionary 1996). For further details on the origin of these terms, see (Sebeok 2001). Semiotician and historian John Deely approves of my use of the term *semiosphere*, however, and suggests the term "signosphere as a term more appropriate for the narrower designation of semiosphere in Lotman's sense, leaving the broader coinage to Hoffmeyer's credit" (Deely 2001, 629).
- 6) *Interpretance* may be defined as the capacity of a system to respond to signs through the formation of 'meaningful' interpretants. High interpretance allows a system to "read" many sorts of "cues" in the surroundings. High-level interpretance means that the system will form interpretants in response to complex cues, which might not be noticed or even be noticeable by low-level agents.

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