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From green bodies to green people: A long way to understanding symbiosis

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Abstract Twenty years after the publication of Darwin's Origin of Species, A. de Bary introduced the term "symbiosis" and offered to biologists another interesting topic: tight mutual ties between organisms. Soon thereafter, in 1883, A. Schimper coined the term "chloroplasts" for chlorophyll-containing bodies in plant cytoplasm while raised the question of their origin. Finally, in 1909, K. Merezhkovsky suggested the term "symbiogenesis" for emergence of new organisms by merging. These are original scientific foundations upon which the words like evolution, man's place in nature, equilibrium, symbiosis, cooperation and competition were built, before being transferred from original concepts of evolutionary biology and ecology to various growing environmental trends. Here, I focus on some of these "term-inflation" events and outline their implications for the science vs. humanities debate.

Key words Symbiosis, symbiogenesis, selfish gene, extensions of scientific terms, evolutionary biology, environmetalism.

1. THE KNOWLEDGE OF NATURE…

Viewing the historical development of science dispassionately we can see that there really were interesting "switches" where the trends suddenly turned (KUHN 1962). And, undoubtedly, one of the most important causes of such unpredictable events are the foregoing changes in the historically and context dependent meanings of scientific terms. In other words, what counts is the semantic realm covered by the particular concept at a given time. People forms ideas which need to understand. However, such understandings goes through its own evolution, and of course it has consequences.

Characteristically, the concept of evolution itself can be a good example here: the name is derived from the Latin word evolutio, which means the development, such as coil or bud (this is, by the way, the main reason of close connection between evolution and embryology in the late nineteenth century – remember Haeckel's biogenetic law). Thus, if we find in contemporary texts the term "evolutionists" or "evolution", we must be aware of what those actually mean. In fact, evolutionists in this context are the preformists, i.e. proponents of the view known as preformism which claims that evolution is nothing but revealing already existing structures and arrangement (the original etymology of the word). But Darwinian "evolution" was not the preformism, it was epigenesis – recurrent origination in every generation (DARWIN 1985; RADL 1930). So we understand evolution today. The term persisted, meaning, however, turned a hundred eighty degrees.

Natural sciences, unlike philosophy, are not suited or adapted for continuous reviewing of definitions of their well-established terms, even though there is quite a good precedent for why such care is important. In biology, the phenomenon of so-called horizontal (or lateral) gene transfer points inconspicuously to fact, that all structures (genes as well as terms) are context-dependent and in the new environment, surrounded by new relationships, they will behave differently – or at least they can (HOFFMEISTER & MARTIN 2003).

In the following, I deal with similar transfers of some well-known "scientific" terms from realm of symbiotic studies, and the subsequent changes in their meanings because of their "intellectual inflation" which in turn affect all of us.

1.1 Evolution: competition or cooperation?

One of the last sentence in Darwin's most famous work, in the *Origin of Species*, begins with these words: "Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows..." (DARWIN 1985). In the book, for the first time explicitly, Darwin presented the idea of "struggle for life". As a result, life began to be seen as a brutal struggle between individuals and species themselves. Thus, life became competition with all the consequences. Unfortunately, among the most important was the very rapid transfer of the concept of competition from natural sciences to the social sphere.

Struggle and competition were torn out from their original scope inside biology and have become applied to something for what they have not been adapted. As we know, the consequences in the form of social Darwinism which, in fact, was (and sometimes still is) one of the biggest barriers to common adoption of Darwinism as a scientific explanation of the origin of life, were directly terrible. This particular case is especially noteworthy for two things. First, understanding of Darwin's term "struggle" as "fight" was a mistake, since Darwin's original intention was rather the "effort to something" than "the fight for something". And second, it is a typical example of how understanding and use of certain terms is influenced by the overall state of the society itself.

In Russia, located in a completely different socio-economic situation in the late nineteenth century, Darwinism was understood and interpreted a little differently. Competition was suppressed and the mutual cooperation of organisms and their ability to help each other came to the forefront, whether within the same or different species (KHAKHINA 1992; SAPP 1994). Also for this reason, another biological term became widely used beyond its original framework: the concept of recently discovered "symbiosis".

1.2 Symbiosis: ecological concept or the driving force of evolution?

After its description by A. de Bary in 1879, symbiosis soon became considered to be a form of interaction between different organisms in which joint existence is beneficial for the individuals and secures for the partners an essential selective advantage. Thus, the value of symbiosis was defined by the fact that, upon entering into an association, an organism became better adapted to the environment because of the use it makes by the peculiarities already possessed by its partner (KHAKHINA 1992).

During the end of nineteenth century, the possibility of evolution by the sudden, radical steps, in contrast to gradualistic processes, has been abundantly discussed. And here comes the symbiosis on the scene: because one of the ways how to break statistic improbability of such non-gradualistic evolution is increasing of complexity through the union of previously prepared blocks, i.e. through fusion of previously symbiotically living systems. So, the possibly role of symbiosis in evolution gave birth to a new term, *symbiogenesis* (i.e. "born from symbiosis"), introduced by Russian botanist Konstantin Sergeevich Merezhkovsky (1855-1921) in 1909 and explained as "the origins of organisms through combination and unification of two or many beings, entering into symbiosis" (KHAKHINA 1992, SAPP 2003). Between years 1905-1918, Merezhkovsky wrote a serie of articles where he argued that chloroplasts, previously called chromatophores, are actually symbiotic micro-organisms inside cells, and that nucleus and cytoplasm also emerged through a blend of two distinct phylogenetic lines. In fact, the symbiotic nature of chloroplasts proposed also the author of the term "chloroplasts", German botanist Andreas Schimper (SAPP 1994).

Originally, the symbiosis concept of de Bary was first of all ecological, including all possible complex associations on a parasitic-mutualistic scale, but it became soon a new paradigm of biological sciences how to look at the nature of interactions between living organisms (DOUGLAS 1994, 2010; KOZO-POLYANSKY 2010; MARGULIS 2000; MARGULIS & SAGAN 2002; MARGULIS & FESTER 1991; PARACER & AHMADJIAN 2000; SMITH & DOUGLAS 1987; WALLIN 1927). In other words, it became the complement or sometimes even the counterbalance to Darwinian idea of evolution through the "struggle" (DARWIN 1985).

2. …THE NATURE OF KNOWLEDGE…

The way in which a man defines life and thus his own existence is an essential guide for its understanding the nature as a whole. Biology, as one of the few scientific disciplines, if not the only one, can offer apparently obvious answers on many existential questions. Or another way: Biology deals with such questions which means that *they are discussed* at all. Biology has a vocabulary that people understand, or at least so they think, partialy because it uses in many cases words borrowed from natural language. But it is not so easy.

These words were transformed into rigid terms, they became carriers of a specific meaning within which they are used in science. Metaphorically speaking, they found their own context which they successfully colonized. Once again, it is similar to gene interactions or to horizontal gene transfer. If you change the environment, you change the meaning. However, changes can be far-reaching, although of course not necessarily. Thus, the transfer of some chosen attractive concepts back into natural language must be very cautious (SAPP 2009). The puzzle of the origin of life and especially the origin of man is one of the eternal and fundamental questions but the possible answers can very significantly affect the other attitudes.

2.1 The phantom of anthropocentrism

For the sake of argument, anthropocentrism can be defined as such analyses of the world, where human beings take the key, central place. Man is the measure of things and value-determinant. The criterion for value is essentially a benefit to humans. This idea is understandable: On the one hand, biology due to evolution take the man from pedestal of divine uniqueness and place him "back" in the nature among the other animal species. But on the other hand, through this rationalizing its own existence grounded "only" in chance and necessity, in evolutionary history, biology requested a center of knowledge which can no longer be independent of human. Thus, problem with anthropocentrism is that certain degree of relating facts to man is just necessary; the question is to what extent.

Biology created many metaphors, models for scientists, that confuse people precisely because they are *models* (MARKOŠ 2002; MARKOŠ *et al.* 2009). However, human models are of course anthropomorphic, i.e. anthropocentric. They can not be different because if they were, they would be in conflict with what they have to express, i.e. the "reality" seen with our eyes. One thing is a metaphorical expression of "teeth and claws" of nature in Darwin's time − as a placeholder for a complex system of scientific evidence, and the second thing is to remove such a metaphor or model from its natural context, and, in this way, to remove its original meaning, and yet then continue to inquiry: for example for concluding that nature is evil. Indeed, the greatest difficulty is in fact with the transmission of terms concerning the alleged nature of the world and so directly or indirectly questions of good and evil. In other words, with concepts such as selfishness and altruism.

2.2 Selfishness versus altruism

By describing genes as being "selfish" in his most famous work, The selfish gene, Richard Dawkins manufactured a huge ball of misunderstandings (DAWKINS 2006). Although he repeatedly emphasized that genes are in no case driven by any motives or will, the idea of selfishness affiliated to the entity of the gene has penetrated deep into brains of many people. While darwinism focus on individuals, neodarwinism claims that the basic unit of evolution is a genetic material, genes, molecules of DNA. Thus, genes are the only thing that counts, they are the subject of evolution and substrate of natural selection (therefore, this kind of thinking is sometimes also referred to as genocentrism. Explaining phenomena in nature from the perspective of genes turned out to be very fruitful, the reductionist nature of the metaphor (beause it is mere model, i.e. the description of reality, not reality itself), however, irritates due to reduction of living organisms to mere "survivol machines, vehicles".

As well as teeth and claws in the case of Darwin, the world of neodarwinism seems to be nothing more than a pile of selfishness. Only for this reason, many people tend to think that such an image

of selfish, bad world can't be in no sense genuine, and, again, it raises a big barrier to common adoption of one of the best scientific explanation of the evolution and origin of life. One widespread myth is that concepts of the selfish genes supposedly excludes pure, disinterested altruism. But this is not true: Natural selection chooses replicators for their ability to survive in an environment that includes other replicators and their products. And, in many instances, the cooperation among replicators is the best way how to copy them to another generation. But maybe the most important message her, however, is that there is no intention to ascribe mental attributes to something that is mindless. It is only the model surrounded by context that we simply can not ignore. It is only the mataphor.

3. …AND WHAT ARE THE IMPLICATIONS

As I stated earlier (LHOTSKÝ 2011), darwinian and neodarwinian evolutionary models was primarily formed and focused on evolution of higher groups of eukaryotes, i.e. on evolution after so-called Cambrian explosion; in other words, on last 600 million years (and, additionally, it was rather zoocentric). But this is not even 80% of the history of life on Earth, if we realize that its origin is traditionally dated to around 3.5 billion years in the past. If we want to consider the evolution as a whole, it is necessary to expand beyond its zoocentric part (in fact just a component). It is clear now that the evolution of prokaryotes, including the origin of eukaryotic cell itself, is an important part of the whole theory of evolution. Symbiotic interactions leading to symbiogenesis have acquired in evolutionary biology its irreplaceable status, for it is apparent that they have played a central, major role in the emergence of novelties in phylogeny within the "tree of life" (SAPP 2009).

Current biology simply cannot disregard no longer the matter of fact that any individual eukaryotic organism is, and has evolved, as a result of an extremely complex consortium of many species, which (metaphorically) must "strive" (as opposite of "struggle") for coexistence through joint cooperation on the functional integrity of the whole. It is a sophisticated ecosystem of cross-linked connections of linkages, where the resulting character always depends on the context of other relationships in which it is located.

3.1 Another metaphor to ripping out of context

In the sixties, American microbiologist Lynn Margulis (1938-2011) who unfortunately died prematurely last year, has "rediscovered" the forgotten concept of symbiosis as a possible major factor in evolution and its participation on important evolutionary events - in this case on a process of origin of some cellular organelles. Increasing evidence led Margulis in the sixties to formulating and publishing the so-called theory of serial endosymbiosis (MARGULIS & SAGAN 2002; MARGULIS 2000), under which the eukaryotic cell is a conglomeration of various bacterial partners. Twenty years later, molecular biology proved without any doubt similarity of DNA sequences in chloroplasts with those from DNA of cyanobacteria, and sequences in mitochondrial DNA with those from DNA of alpha proteo-bacteria group.

Symbiosis and especially its possible effect, symbiogenesis, as a process by which a new organisms as well as species may arise, has been rehabilitated from the phenomenon of marginal importance to the essential element of many biological fields of research and became the next vanishing point of evolutionary biology, parallel to the developing post-neodarwinism in form of selfish-gene theory (DAWKINS 2006). Accordingly, besides the classical neodarwinism, where the driving force for natural selection are only mutation, an alternative evolutionary model for arising of new entities in evolution has developed since the seventies: symbiogenesis, evolution by merging into symbiotic complex and their follow-up fusion (on evolutionary time scale). As a result, we have two apparently various teories of how evolution can work.

What I want to point out is the fact that those two views are not inconsistent. On the contrary: they are mutually complementary: but just as biological theories developed in some intention and used strictly (or at least carefuly) in contexts for which they were defined. Thus, from this general lack of understanding of what do scientific concepts mean and how they should be used, terms as selfishness or cooperation jumped from their original clearly defined "worlds" and stretched its meaning. Views have become world-views. Small difference in words, but in reality, a large one.

3.2 How to properly care for the world?

It goes without saying that people will always ask questions such as what is the nature of the world in which I live? And then: it is in agreement with what science says? The desire for knowledge is an integral and fundamental part of our character. Also it is quite understandable that no one wants to relegate himself to mere vehicle for something as "selfish genes" that struggle for life in a cruel world. Hence, for the same reasons, the similar transfer and inflation of another scientific concepts take place immediately: symbiosis as well as the Gaia theory (LOVELOCK 2000) were adopted as opposed to "eternal selfishness" – primarily for their emphasis on cooperation and mutually beneficial relationships between various organisms. As a matter of fact, many of key propositions of "environmentalism", growing continuously in last three decades, were inspired by words as "Gaia" or "symbiosis" (CRIST & RINKER 2009).

Without any doubt, nature and our world as a whole deserves our attention and care. Equally true is that the question of good and evil is one of those that can not be ignored. Nevertheless, it is extremely important to recognize that different issues exist in (and belong to) various dialogues, and, that pulling some emotionally charged words from the context of a debate and transfer them to another really can not work. As a conclusion, my intention is neither the negation of such borrowing of words between natural science, humanities and eventually other opinion currents, nor scientific purism. It is the fact, that symbiosis, like other similarly broad terms, is **both** the biological phenomenon of great importance **and** the metaphor for philosophy of life.

On the one hand, there is a huge vulnerability in possible misunderstandings on many levels, as in the following degradation or depletion of such term. But on the other hand, there is the considerable chance that the common denominator of so many different things reflects in some way the deeper reality, so far largely divided between various scientific disciplines (BATESON 2002). Our understanding of what symbiosis is has gone a long way – from green bodies, later called "chloroplasts", to environmental concepts like the "green Earth" or Gaia. It is remarkable moving of some very interesting topic from the natural sciences towards humanities. Along the way, I suspect we can expect many surprises, but still we must be on guard − and at least guess where we are going and why.

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