Chapter 6
Introducing Universal Symbiogenesis

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Abstract One of Neurath's ambitions was to increase the uniformity of scientific languages. A modern day attempt to obtain this goal of a uniform scientific language can be found in the field of evolutionary epistemology. Evolutionary epistemologists are characterized by their quest for universal formulas of evolution that can explain evolutionary change in a variety of phenomena. The most known are universal selectionist accounts. The latter are introduced and implemented within philosophy of science and extra-philosophical fields alike. But what about other evolutionary theories such as symbiogenesis? The process of symbiogenesis need not be confined to either the microcosm or the origin of eukaryotic beings. On the contrary, just as natural selection today is being universalized by evolutionary biologists and evolutionary epistemologists, so symbiogenesis can be universalized as well. It will be argued that in its universalized form, symbiogenesis can provide: (1) a general tool to examine various forms of interaction between different biological organisms, and (2) new metaphors for extra-biological fields such as cosmology, the cultural sciences, and language. Furthermore universal symbiogenesis can complement, if not provide an alternative, for universal selectionist accounts of evolution. As such, universal symbiogenesis can provide a scientific language that enables more uniformity between different disciplines.

Keywords Evolutionary epistemology • Universal selectionism • Universal symbiogenesis

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6.1 Introduction

In his “An international encyclopaedia of the unified sciences”, Otto Neurath (1936) contemplated on how different sciences use different scientific languages. The cacophony of scientific languages makes it difficult for scholars working within these different sciences to communicate adequately with one another and to surpass their disciplinary boundaries. Neurath argued that we should strive to increase the uniformity of scientific languages.

Classically, languages that enable such increase in uniformity are associated with formal languages, more specifically the language of mathematics or logic. More recently, the language of evolution also takes on such unifying proportions. Since the rise of evolutionary epistemology (Campbell 1974) and evolutionary psychology (see Barrett et al. 2002 for an overview), a variety of phenomena are understood from within a selectionist framework. The theory of natural selection is applied to the evolution of scientific theories (Campbell 1997; Hull 1988; Plotkin 1995; Toulmin 1972), culture (Blackmore 1999), language (Pinker and Bloom 1990) and the brain (Changeaux 1985; Edelman 1987).

“Universal” selectionist/Dawinian accounts (Cziko 1995; Dawkins 1983) have turned out to be very fruitful in uniting, at the very least, the humanities or life sciences with the biological sciences. The great success of this selectionist approach is partly due to the fact that a “universal” jargon is provided to researchers working within different disciplines and faculties. The fact that numerous disciplines flourish by the adoption of the universal selectionist approach makes one wonder whether other evolutionary theories can undergo the same faith. Can other evolutionary theories also be universalized and serve to study not only biological processes but also extra-biological processes? In other words, can other evolutionary theories also provide the lexicon for a universal, unifying scientific language?

Here it will be argued that the latter is indeed the case and one nonselectionist evolutionary theory, symbiogenesis, will be universalized.

6.2 What Is Evolutionary Epistemology (EE)?

Evolutionary Epistemology is a discipline that investigates how evolutionary theory can be applied to study the evolution of phenomena such as cognition, knowledge, science, culture or language. Beneath, a short summary of the basic tenets of EE are given, followed by a distinction between older and younger branches of the field.

6.2.1 The Traditional Goal of EE

Originally, EE focussed on how evolutionary theory, especially natural selection theory, can inform scholars on how we and other organisms gain knowledge. According to the Stanford encyclopedia of philosophy,

> Evolutionary Epistemology is a naturalistic approach to epistemology, which emphasizes the importance of natural selection in two primary roles. In the first role, selection is the generator and maintainer of the reliability of our senses and cognitive mechanisms, as well as the "fit" between those mechanisms and the world. In the second role, trial and error learning and the evolution of scientific theories are construed as selection processes. (Bradie and Harms 2004: 1)

Firstly, natural selection can be understood not only as the maintainer but also as the generator of the reliability of our senses and cognitive mechanisms. This is because adaptation results in a fit between the senses and cognitive mechanisms and the outer world. Secondly, natural selection can also serve as a metaphor to explain trial and error learning and the evolution of scientific theories.

The first idea is called the EEM program (evolution of epistemological mechanisms), while the second idea corresponds to the EET (evolutionary epistemology of theories) program of evolutionary epistemology (Bradie 1986). Traditionally the EEM program is understood to be normative. Because natural selection is the generator of our cognitive mechanisms, cognition can only be explained by making use of natural selection. The EET program on the other hand is understood to be merely descriptive. It endorses the view that the evolution of life by means of natural selection and the evolution of science undergo analogous processes. Although no causal forces of natural selection are a priori assumed to underlie both the evolution of science and life, this is not a priori excluded to be the case either.

Early evolutionary epistemologists particularly focused on traditional philosophical questions concerning knowledge. Problems investigated include the reliability of our senses, the reference problem, and synthetic a priori claims (see the works of Lorenz 1941; Popper 1963; Toulmin 1972; Munz 2001). What distinguishes an EE-approach to knowledge acquisition from classic epistemology is elucidated by Munz (2001: 9). Scholars who worked within a "first philosophy", assumed that knowledge concerns the relation between a human knower and something known (according to rationalists) or knowable (according to empiricists). With the emergence of a sociology of knowledge, it is the relation between different human knowers that is under investigation. The possibility of there existing a knowledge relation between a knowing agent and the outer world becomes questionable. Rather, it is argued that regimes define what counts as knowledge and what does not. Within EE, however, knowledge becomes defined as the relation between all biological organisms and their environment. Natural selection justifies such a relation, because organisms that survive are adapted to the environment. Fish for example, can be argued to provide knowledge of, or even a theory of water, because fish are adapted to an aquatic environment. Fitness can therefore become a measure for correspondence between an organism and the environment. In this regard, both physical traits as well as the products of physical traits, such as cognition, culture, or language, need to be examined from within evolutionary theory.

6.2.2 Is This the Only Role EE Can Play?

EE has mainly been occupied with the "evolutionizing of epistemology"; natural selection theory is used to analyze knowledge. But EE can also fulfil another role which involves the "epistemologizing of biology" (Callebaut and Pinxten 1987: 17). What does this mean?

One of the founding fathers of EE, Donald T. Campbell (1974) indicated that natural selection not only works within the evolution of life, it is also active within the evolution of cognition. He abstracted a template of natural selection which he called blind-variation-and-selective-retention. According to Campbell, this template or scheme can serve as a heuristic that informs scholars on how natural selection can be active in the evolution of life, cognition, or language.

By introducing his blind variation and selective retention scheme Campbell was implicitly raising the following questions: how do you study an evolving entity properly, what is the right methodology?

The question of how to study evolution methodologically was also asked by scholars working within the units and levels of selection debate. The concept "unit of selection" was first introduced by Lewontin (1970). At that time, this concept did not relate to the then prevailing EE debate that Campbell had introduced. On the contrary, Lewontin wrote his article to tackle Hamilton's idea of the existence of group selection (for a more elaborate overview, see Gontier 2006c). But interesting is that, although unfamiliar with Campbell's blind variation and selective retention scheme, Lewontin (1970, 1) too abstracted what he calls *"a logical skeleton"* of natural selection. This skeleton, "*phenotypic variation, differential fitness and heritability of that fitness"* can be applied to *"different units of Mendelian, cytoplasmic, or cultural inheritance"*. This skeleton can thus be universalized and it can explain the evolution of certain biological and cultural processes. Moreover, Lewontin argued that this skeleton also sets clear boundaries on what can be understood as a unit of natural selection. Something can only evolve by means of natural selection if the conditions set out in the skeleton are met. Lewontin therefore also methodized biology: he introduced an epistemic framework that allows one to investigate what the units of selection are, and how evolution by means of natural selection occurs.

Lewontin's paper was highly influential, and lead to a series of methodological questions about the application range of natural selection and how the mechanism proceeds.

In 1976, Dawkins wrote his book *The Selfish gene*, and in it he argues, contrary to the Modern Synthesis, that the unit of selection is not the phenotype, which he regarded as a mere vehicle,[1] but the gene. Genes, as units of selection, can be universalized into replicators. In his 1983 paper, entitled *universal Darwinism*, Dawkins claimed that anywhere in the universe where evolution occurs, this evolution would entail the selection of the replicator. A replicator is defined as "any entity in the universe of which copies are made" (Dawkins 1982: 162). He further raised the possibility that there also exist cultural replicators, memes, that evolve by means of natural selection.

Dawkins as well as Lewontin were formulating their ideas exclusively within evolutionary biology and were at that time unaware of the discussion going on within EE. Although Campbell already formulated his template of natural selection in the late 1950s, these ideas were not known within evolutionary biology. These endeavours would become combined by Brandon (1982) who wrote an article entitled *The levels of selection*, and Brandon and Burian (1984), who together published an anthology that combined all the different endeavours that set forth to find universal methodologies to study life at all its ranks, as well as the products of life such as cognition, language and culture.

From then onwards, both evolutionary epistemologists and scholars working within the units and levels of selection debate would engage in finding systematic ways to identify the various units and levels of selection, as well as how the mechanism of natural selection occurs. This search for a universal methodology to study evolution by means of natural selection at all levels of reality is best characterized as the "epistemologizing of biology".

6.2.3 Current Trends

If we investigate current trends, three observations can be made.

Firstly, the evolutionizing of the field of epistemology, as set out by both the EET and EEM program, has primarily been conducted from within a selectionist, adaptationist framework. It is investigated how natural selection shapes our cognitive devices, and how adaptive the latter are.

Within current evolutionary biology however, the adaptationist approach has been either complemented or criticised by numerous different evolutionary theories. The most important ones are neutral theory, (developmental) systems theory, symbiogenesis and (see Schwartz 1999 for a good overview).

Only some of these theories are finding their way into evolutionary epistemology. Wuketits (1990, 2006) has introduced a non-adaptationist approach to cognition, Riedl (1984) has developed a contructivist approach to knowledge, and system

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[1] David Hull (1980, 1981, 1988) would later on again counter this idea by introducing the universal notion of an *"interactor"* that was to be understood as the proper unit of selection. The interactor largely corresponds with the phenotype that is traditionally understood to be the unit of selection and it is selected at the level of the environment.

theoretical approaches have been introduced by Hahlweg and Hooker (1989). These latter theories can be characterized as a form of "new EE" that can be distinguished from traditional, selection-focussed EE (Gontier 2006a).

Central to these new forms of EE is that they focus on the active role that an organism can play during its evolution. Although an oxygen-breathing human, for example, might provide a theory on the atmosphere that surrounds it, this human being does not provide an adequate theory about the outside temperature. This is because humans are, to a certain extent, able to actively construe a niche for themselves. Certain internal systems, such as hormones, regulate body temperature, and humans can also wear clothing to protect them from the external temperature. These traits do not allow one to assume that there is a complete 1:1 correspondence between humans and certain aspects of their environment. Organisms, more often than not, are not fully adapted to their environment (Gould and Lewontin 1979; Lewontin 2000) and therefore only provide partial knowledge and theories about their environment. New EE tries to incorporate these findings in theories on knowledge. But although constructivist and system theoretical views have been implemented, various evolutionary mechanisms currently remain understudied.

Secondly, selectionist EE goes beyond the study of philosophical issues of knowledge. Traditionally, the application of evolutionary theory outside the biological realm into areas such as philosophy, anthropology, psychology, linguistics or economics was understood to merely be of a descriptive nature. Now however, EE is regarded as a normative discipline that enables the study of philosophical and extra-philosophical phenomena alike by making use of evolutionary theory. A shift has taken place where epistemology went from being the subject of study to being the provider of a new, on evolution-based methodology.

Because of their engagement in the units and levels of selection debate, evolutionary epistemologists study how on the one hand, genes, organisms, groups or species, and on the other, culture, language, or social norms evolved by natural selection. The application of selectionist accounts to domains such as language and culture raises the question of how many units and levels of selection there really are and how exactly natural selection works on these units and at what levels. In light of this, numerous selectionist formulas have been developed. There is the blind-variation-and selective-retention scheme, first introduced by Donald Campbell (1974, 1997); the generate-test-regenerate scheme developed by Plotkin (1995), and the replication-variation-environmental interaction scheme, advanced by Hull (1980, 1981, 1988). For a discussion of all these different formulas see Cziko (1995) or Gontier (2006c).

This "epistemologizing" of natural selection has introduced a new framework, called "Universal selectionism" (Cziko 1995), that claims that all and only selectionist accounts are valid when studying the evolution of both life and non-life. As such, EE functions as a unifying language. Although, to my knowledge, nobody is drawing the relation with the unity of science debate and Neurath's plea to make different scientific theories more uniform, universal selectionist formulas today are taking on the role of such a universal, unifying scientific language. Universal selectionist formulas are offering a uniform methodology that can be equally applied by biologists as well as sociologists, anthropologists or linguists.

Thirdly, because of the success of selectionist approaches, the "epistemologizing" of theories other than natural selection has by and large been neglected, and some adherents of universal selectionism go so far as to claim that such epistemologizing is unnecessary. Yet, if we take evolution seriously, we also need to investigate how these theories possibly provide insight in both biological as well as sociocultural evolution.

Here, it is defended that scholars should engage in epistemologizing all known evolutionary mechanisms. We need to abstract a logical skeleton of all known evolutionary mechanisms and identify the units and levels whereupon these mechanisms work. This allows for a systematic way to study how evolutionary mechanisms underlie both the evolution of life and products of life such as language, cognition or culture. Abstracted skeletons can serve as a template or heuristic, that informs scholars working in both the life and human sciences on how a mechanism proceeds, and where, at what ranks of reality it occurs.

These future templates will also serve as a universal language that enables better communication between various disciplines such as evolutionary biology, evolutionary linguistics, evolutionary psychology and evolutionary anthropology. Skeletons can serve as universal templates that test the possibility that certain phenomena evolve by means of a certain mechanism, and they can serve as templates that allow scholars to model the evolution of those phenomena. In other words, these templates or skeletons can serve as a universal language that enhances interdisciplinarity between the various sciences in exactly the way Neurath intended it.

6.3 Epistemologizing Symbiogenesis

Given the merit of the selectionist approach, it is legitimate to ask whether other evolutionary theories, such as symbiogenesis, can also provide universal templates that can serve as methodologies to study aspects of both biological and sociocultural evolution. In the remainder of this article, we first examine the basic principles of symbiogenesis. Secondly, we abstract a universal template of symbiogenesis, and thirdly, we implement this template in both biological as well as sociocultural evolution.

6.3.1 Symbiogenesis

Symbiogenesis is an evolutionary mechanism that explains the origin of eukaryotic beings. Its modern version is formulated by Lynn Margulis (1999), Margulis and Sagan (2000), Margulis and Dolan (2002), but the ideas on symbiosis and symbiogenesis date back to the early 1900s and were first formulated by Constantin Mehrezskhovsky (for an overview see Sapp 2003; Sapp et al. 2002).

All living organisms are classifiable according to two cell types, prokaryotes and eukaryotes. All unicellular organisms are prokaryotes. Characteristic of the cells of these organisms is that they do not contain a nucleus. Eukaryotic organisms, on the other hand, are all organisms whose cells contain a nucleus that in turn contains the chromosomes that package the genes. Only the first kingdom of life, the bacteria and Archaea, are made up of prokaryotic beings. All other kingdoms, i.e. the protists, fungi, animals and plants, are eukaryotic beings.

Besides a nucleus, an eukaryotic cell often contains organelles. Organelles are little cell bodies that contain their own genetic material. These organelles (e.g. mitochondria and plastids) are only inherited from the mother.

The serial endosymbiotic theory explains both the origin of eukaryotic beings as well as the organelles that reside inside them. The theory demonstrates how once free-living prokaryotes entered each others bodies. Through these mergings they evolved into nucleated, eukaryotic beings. And also the organelles of these eukaryotic organisms are descendents of once free-living prokaryotes that merged with early life forms.

More specifically, two billion years ago, spirochetes and thermoplasma merged. Somehow, spirochetes must have penetrated thermoplasma and they must have become trapped in these new hosts who in turn were unable to digest or delete this newly acquired material. This merger resulted in the emergence of nucleated organisms called protists. Thus symbiosis (the living in close contact or merging of different species into one another) lead to symbiogenesis (the emergence of new biological entities through permanent symbiosis). Some of these protists further merged with bacteria known as paracocci. The paracocci that entered these early protists evolved into organelles called mitochondria. The cells of most multicellular life contain mitochondria. They allow a cell to breath. Plant cells also contain chloroplasts, i.e. organelles that are involved in photosynthesis and that are responsible for the green colour that plants have. These chloroplasts, SET-theory shows, are the descendents of once free-living cyanobacteria.

Thus, bacteria, or bacteria and eukaryotic organisms can merge and these horizontal mergings can result in the evolution of new structures if not new species. The latter process is called symbiogenesis. Contrary to the Modern Synthesis that emphasizes that evolution occurs vertically, through speciation, SET theory demonstrates that evolution can occur through the horizontal mergings of different lineages.

6.3.2 Universal Symbiogenesis

The physicist Freeman Dyson (1988, 1998, 1999) was the first to universalize symbiogenesis. He used symbiogenesis to explain how life originated on this planet. His theory, known as the *"double origin theory"*, synthesizes two competing views on how life evolved on earth. Spontaneous generationists such as Oparin (1955) or Fox and Dose (1972) argue that life evolved from spontaneously evolved protein-like structures and/or cells. RNA only evolved later, within these protein-like structures. Adherents of an RNA world (e.g. Eigen and Schuster 1977; Eigen 1996; Gilbert 1986; Orgel 1994), on the contrary, assert that genes evolved first. These two competing views are united by Dyson (1998) through symbiogenesis. He argues that Eigen's autocatalytic molecule could only develop inside protein-like cells as the first parasite of this protein-like life. Life thus did not originate once but twice: once as metabolism and once as information. And metabolism and information, respectively protein cells and genes, got combined symbiotically. Dyson (1988: 81):

> I am suggesting that the Oparin and Eigen theories make more sense if they are put together and interpreted as the two halves of a double-origin theory. In this case, Oparin and Eigen may both be right. Oparin is describing the first origin of life and Eigen the second.

By applying the mechanism of symbiogenesis to the molecular level, he brings symbiogenesis into the physical and chemical realm and as such he broadens the explanatory scope of symbiogenesis. But Dyson (1998) goes further than that. Besides its role in the evolution of life, he uses an abstract principle of symbiosis to explain both processes in the universe (such as galactic cannibalism, symbiotic stars, black wholes) as well as processes in science (e.g. the synthesizing of theories).

According to Dyson, two evolutionary phenomena occur universally: speciation events and symbiosis events. Both lie at the basis of order-disorder transitions, differentiation, and the emergence of new structures. And all occur during rapid phases in history which are punctuated by long periods of stasis. Dyson thus does for symbiogenesis what evolutionary epistemologists have done for natural selection. That is, he universalizes the principle so that it can be used to explain a variety of different phenomena. As such, he provides different scholars with a universal language. Dyson (1998: 121) defines universal symbiogenesis as:

> . . . The reattachment of two structures, after they have been detached from each other and have evolved along separate paths for a long time, so as to form a combined structure with behaviour not seen in the separate components. (Dyson 1998: 121)

This definition is very useful to explain certain physical and biological phenomena. However, this definition is also somewhat biased towards physical and biological phenomena. There is no need whatsoever to a-forehand assume that symbiogenesis can only occur when structures have first become detached before merging, or that only two structures can engage in symbiogenesis. Especially cultural ideas, scientific movements or languages are often made up of a variety of entities that somehow got combined. In other words, if we adjust Dyson's definition of universal symbiogenesis, we might be able to also explain extra-biological phenomena such as language and cultural evolution. We might thus be able to universalize the language even more and provide a universal methodology in Neurath's sense.

What is basic to symbiogenesis? And what should a logical skeleton of symbiogenesis consist of (the following is paraphrased from Gontier 2007: 174–175)?

(1) Basic to symbiogenesis is *interaction*. We are looking for a universal formula of symbiogenesis that is applicable to as many different phenomena as possible. Therefore it is wise not to specify a-forehand the type of interaction (mutualism, parasitism, symbiosis, commensalism), the type of entities that interact (individuals, lineages, traits) or the number of entities that interact. Specification would lead to exclusion and the goal here is to find as many possible types of symbiogenesis as possible.

(2) Symbiogenesis also implies *horizontal mergings* that lead to *permanent* and *irreversible* changes, which form the basis of evolutionary *novelty*. Carrapiço and Rodrigues (2005: 59060R-2) reason that symbiogenesis is an evolutionary mechanism that unfolds through symbiosis: *"... symbiogenesis should be understood as an evolutive mechanism and symbiosis as the vehicle, through which that mechanism unfolds."* It is important to emphasize that once something emerged by symbiogenesis, it can (further) evolve vertically. However, the latter is always preceded by a horizontal merging of different entities. The merging is permanent and irreversible because the merged entities become one new entity that demonstrates behaviour not seen in the separate components.

(3) Such horizontal mergings can occur *rapidly*, and are always *discontinuous*. They are discontinuous because the merging results in the evolution of something new.

(4) Finally, as Margulis (1999) emphasizes, symbiogenesis entails *"individuality through incorporation"*. A new distinctive entity emerges *only* through the interaction of other entities.

This logical skeleton can be universalized into the following formula of universal symbiogenesis (Gontier 2007: 174–175):

> Universal symbiogenesis occurs when new entities irreversibly and discontinuously evolve out of the horizontal merging of previously independently evolving entities.

Because the goal is to delineate different phenomena as symbiogenetic, including phenomena that were previously not identified as such, the above definition is kept unspecified. Nonetheless, we can call the interacting agencies or entities *symbionts*. In biology, examples of symbionts are viruses, bacteria or parasites that interact with their host. When such horizontal interaction leads to the emergence of a new entity, this entity is called the *symbiome* (Sapp 2004: 1047). The symbiome can again become a possible unit of horizontal or vertical evolution (including evolution by means of natural selection).

We can also provide an evolutionary epistemological, universal dimension to the concept of the "symbiont" and the "symbiome". Symbionts are the units of symbiogenesis, and the symbiome is the outcome of symbiogenesis. In cultural evolution, scientific theories or cultural ideas, for example, might be either symbionts or symbiomes, if they evolved out of the synthesis of different streams of thought. These notions can therefore complement Hull's "interactors" and Dawkins' "replicators".

6.4 Applying Universal Symbiogenesis

Where can we apply this universal scheme of symbiogenesis? It will be evinced that universal symbiogenesis can be distinguished, at the very least, in the evolution of viruses, plants, languages and cultures.

6.4.1 Universal Symbiogenesis and Hybridization

Under certain conditions, a symbiotic relation between organisms can become hereditary. The botanist Joshua Lederberg was the first to notice that when such “hereditary symbiosis” occurs, it highly resembles plant hybridization. It resembles hybridization in that sense that phylogenetically distinct genomes are blended into one organism and this process is often irreversible (Sapp 2003: 244; Carrapiço 2006). Symbiosis can thus be regarded as a type of hybridization, or hybridization can be understood as a special kind of symbiosis because both mechanisms can introduce evolutionary novelty through the combination of different phylogenetic lineages.

Traditionally, especially zoologists tended to classify hybrids as exceptional sports of nature that are irrelevant in the explanation of the origin of new species. Examples such as the donkey or mule allowed them to argue that the crossings of lineages leads to infertility and when infertility occurs, evolutionary lineages end. Hence, no further evolution can occur. But today, due to important progress that is being made within both botany as well as zoology, hybridization is now considered a major creative force (Ryan 2006). Nowadays, we know that the crossings of lineages often allows for the introduction of novel features. And, most importantly, hybridization does not necessarily lead to infertility and the subsequent ending of a stock. In fact, most hybrids are able to reproduce just fine.

These new insights pose an interesting challenge to Neodarwinian, selectionist thought. The latter traditionally understands the evolution of a new species to occur vertically, through a branching off from a common stock. Mayr’s (1997) biological species concept argues that the impossibility to produce fertile offspring is the key criteria to recognize the evolutionary emergence of a new species. In fact, the term speciation, i.e. the formation of new species, is nowadays considered to be synonymous to branching or splitting off. But Mayr’s characterization of speciation also immediately implies that members of the same species that belong to opposite sexes are able to produce fertile offspring. Thus the possibility for different organisms to cross horizontally or to “hybridize”, cannot allow for new species to emerge. On the contrary, the possibility for organisms to exchange genetic material successfully is considered the criterion for including these individuals into the same species.

Hybridization, understood as an evolutionary mechanism that can allow for the introduction of new species, on the contrary, takes crossings as the criterion for speciation. Here, the different mergings are what allows for the distinction into species.

Speciation understood as the introduction of novel species by means of vertical splitting processes; or speciation understood as the introduction of novel species by means of horizontal hybridization processes, are mutually exclusive concepts. They pose a challenge to evolutionary scholars who in the future need to figure out how both can explain the evolution of life.

Nonetheless, the point being made here is that hybridization can be considered a type of universal symbiogenesis: the horizontal mergings of different entities can rapidly result into the emergence of new variants if not species altogether. And this process is often irreversible. The jargon of universal symbiogenesis can thus be applied to both the origin of eukaryotes as well as the origin of hybrid plants and animal species, thereby proving its qualities as a universal methodology.

6.4.2 Universal Symbiogenesis and Viruses

Several authors (Gontier 2006b: 204–6; Roosinck 2005; Ryan 2002, 2004, 2006; Sapp 2003; Villarreal 2004) have recently proposed that the scientific jargon of symbiogenesis can also be extended to the domain of virology.

Viruses are often considered to parasite their hosts, but the virus-host interaction can quite often be viewed as a symbiotic union. Viruses can introduce their genetic material into genomes of somatic cells and also into germ cells. These genetic exchanges occur horizontally, during the ontogeny of their host, and when the germ cells are infected, the newly introduced viral genes can possibly be transmitted during phylogeny. Especially such germ line transmission of viral genes, also called “viral colonization” by Villarreal (2004: 315) can possibly lead to the introduction of novel features in the host (Villarreal 2004: 296), if not lead to the evolution of new species altogether.

In line with the universal symbiogenetic template, viruses can therefore be considered as agents that, through their mergings with other agents, allow for the rapid emergence of novel features.

Evidence that viral infection of host germ cells can lead to the introduction of new features comes from ERVs, endogenous retroviruses. Retroviruses are viruses such as the HIV virus. Endogenous retroviruses are retroviruses that have become part of the genome. The non-coding regions of the genomes of all vertebrates (the so-called Junk DNA) all contain parts and pieces of ERVs (Ryan 2004: 560, Villarreal 2004: 297–298). In humans, they even make up half of the genome, where “*they replicate in Mendelian Fashion, as an integrated part of the sexual reproduction of the host, to inhabit the genome of all future generations*” (Ryan 2004: 560).

Because of their high occurrence in the vertebrate genome, evolutionary geneticists are increasingly willing to attribute to these ERVs a major role within evolution. Ryan (2002) pictures our past to be characterized by “plague culling”: he envisions vertebrate species to have been frequently plagued by exogenous retroviruses. Such epidemics most probably resulted in the weeping out of entire species. But when the genotypes of host individuals were able to cope with the constant presence of the viruses, the retroviruses became endogenous, and a new symbiotic union arose (Ryan 2004: 561).

Eventually, some of these originally quiet genes might have become translated and their expression might influence developmental pathways and eventually give rise to speciation. Ledeberg (Sapp 2003: 243, and 2004: 1048) already assumed that such "infective heredity" might be possible and molecular genetics can nowadays easily test these hypotheses.

Because symbiogenesis can be expanded to include processes in virology, Ryan (2002: 117) redefines symbiogenesis as follows:

> Symbiogenesis is evolutionary change arising from the interaction of different species. It takes two major forms: endosymbiosis, in which the interaction is at the level of the genomes, and exosymbiosis, in which the interaction may be behavioural or involve the sharing of metabolites, including gene-coded products.

This expansion of symbiogenesis into the viral realm again demonstrates the potential of symbiogenesis to provide a transdisciplinary, universal jargon if not a methodology to study certain horizontal evolutionary events.

Villarreal (2004: 304) even goes on to argue that also the eukaryotic nucleus has a viral origin. Margulis' (1999) SET-theory hypothesizes that the nucleus is the result of the symbiotic merger of different prokaryotes. Villarreal (2004: 304–5) disagrees that it were prokaryotes that engaged in the symbiotic merger. He compared the genes of all prokaryotic organisms and found that there are 324 genes held in common. However, none of these genes are involved in DNA replication. The genes responsible for the latter thus must come from a different source. Villarreal (2004) and Villarreal and Defilipps (2000) take viruses to be the most likely candidates to have donated the genes responsible for the formation of the eukaryotic nucleus. In his account, viruses are "gene-creating machines". Around 80% of the genes that are found in viruses are not found in any other pro- or eukaryote. They are thus unique to viruses. According to Villarreal it were viruses that engaged in symbiogenetic relations, and this resulted in the origin of the nucleus.

Finally, a very new and highly promising application of symbiogenetic jargon can be found in medicine. Today, physicians are genetically modifying viruses or bacteria which they subsequently induce into patients as a type of treatment for certain illnesses (Ryan, personal communication). In this regard, the process of symbiogenesis is artificially applied.

6.4.3 *Universal Symbiogenesis and Culture*

So far we have seen how universal symbiogenesis can fruitfully be applied within the most important fields of biology, including (evolutionary) zoology, botany, virology, and exobiology. But can the jargon of symbiogenesis also be expanded to extra-biological fields such as culture? Here it will be proven that this can indeed be done. The reason for this is that also in culture, the blending and crossing of different cultural artefacts or ideas occurs very frequently.

6.4.3.1 Cultural Anthropology and the Nature Culture Divide

The divide between nature and culture is an old discussion that has already been debated upon by the ancient Greeks if not by more ancient civilizations. The contemporary version of the divide dates back to the nineteenth and twentieth century, when the rising fields of anthropology and sociology would set themselves off against evolutionary biology (Eriksen and Nielsen 2001: 16–36; Ingold 1986: 30–73).

The dichotomization between the fields was mainly the result of the evolutionists' turn to social Darwinism, eugenetics and historicism (e.g. Darwin 1871, 1872; Spencer 1976, 1978; Haeckel 1883, 1912; and Galton 1909). The latter falsely assumed that the human species could be divided into different "races". They postulated the existence of developmental laws of nature and culture and argued that not all "ethniés" were equally evolved. In other words, they argued that cultural diversity was the result of biological, racial diversity.

Anthropologists such as Boas (1924, 1930, 1932, 1962), Kroeber (1963), Malinowski (1944) and Radcliffe-Brown (1957) broke with this tradition and endorsed the idea of psychic unity: they argued that all humans were equally evolved both at a biological as well as a cultural level. Rather than argue that biology determined the level of culture or civilization one finds oneself in, they argued that there is not one biologically determined culture. Rather, there exist a multitude of unrelated cultures. All are particular and contingent upon the society one lives in. Culture, in this regard, is what is learned or nurtured, while nature is what is innate.

Because of the equation of culture with nurture, and nature with innateness and heredity of this innateness, the idea grew that nature and culture evolve according to radically different processes. Nature is classically argued to evolve through descent with modification (as the Neodarwinian doctrine describes), and thus biological evolution is considered to be vertical. The transmission of different cultures however is mostly considered to be a horizontal event, since people are not only encultured by their parents, but also by their siblings, peers, caregivers, teachers, etc. To explain these kinds of horizontal transmission processes, anthropologists use concepts such as acculturation, diffusion or integration.

Furthermore, when evolutionary biologists identified the genes as the carriers of hereditary information, they also found out that the genes that encode for features are more often than not passed on unchanged. In this regard, genes are very rigid and integer. Cultural traits, on the other hand, are not unchanging, rigid entities. Cultures constantly change because new ideas (e.g. the risks of global warming) or artefacts (e.g. cell phones, iPods, radars) are introduced that change our way of living. Cultural traits are also not integer. The multitude of ideas or artefacts that make up a culture or a cultural individual are not always invented in that specific culture by that specific individual. In fact, the majority of cultures is made up of ideas and artefacts that originated in other cultures. These traits are acquired through trade, diffusion, politics, warfare, cultural hegemony, etc. In this regard, Kroeber, one of the founding fathers of cultural anthropology, noted the following:

> "[T]he great part of the content of every culture is probably of foreign origin, although assimilated into a whole that works more or less coherently and is felt as a unit. However diversified or specialized a culture grows in its development, it can therefore always largely retrace its course; and it does normally do so, by absorbing more generalized content from other cultures, and thereby not only assimilating to them but to the totality or the average of human cultures." (Kroeber 1963: 67–8)

Communism, for example, arose in the West but is now the political system of Cuba and China; Russia became capitalistic; Christmas is celebrated on the ancient Roman fest of light because ancient scholars conflated the birth of Jesus with pagan celebration of the re-birth of light; nachos with salsa and guacamole are becoming the favourite appetizers in the North of Europe; western music is played on mp3 players that are made in China; the dress style of the 1960s and 1970s is nowadays fashionable again and has been dubbed "vintage", etc.

Culture does not follow a linear means of transmission that is typical of evolution by means of natural selection. Rather, grandchildren can teach their grandparents how to use the computer, Americans can teach the Japanese how to dance the foxtrot, or a contemporary philosopher can learn about logic by reading the works of Aristotle.

To illustrate these kinds of cultural transmission processes, Kroeber argued that cultural evolution needs to be depicted by a different tree than the one that depicts evolution by means of natural selection (Fig. 6.1).

Cultural evolution is not merely characterized by a branching off of lineages from one common stock as is the case with evolution by means of natural selection. Rather, lineages can cross and blend and a variety of common ancestors can be identified for these different lineages. Kroeber:

> Once the genetic diversification or 'evolution' has gone beyond a certain quite narrow degree, there is no more possibility of reversal and assimilation. By contrast, cultures can blend to almost any degree and not only thrive but perpetuate themselves. (Kroeber 1963: 67–8)

Cultures absorb new elements all the time and these mergings can even be traced, to a certain extent, because the cultural influences leave traces (in written texts or traditions). Furthermore, contrary to evolution by means of natural selection, the transmission of culture can happen very quickly. Almost anywhere in the world, old photo cameras have been replaced by digital ones, flat screens are part of many households in the West, youth everywhere is on Facebook, My Space, Twitter or You Tube and none of this existed 10 or sometimes even 5 years ago.

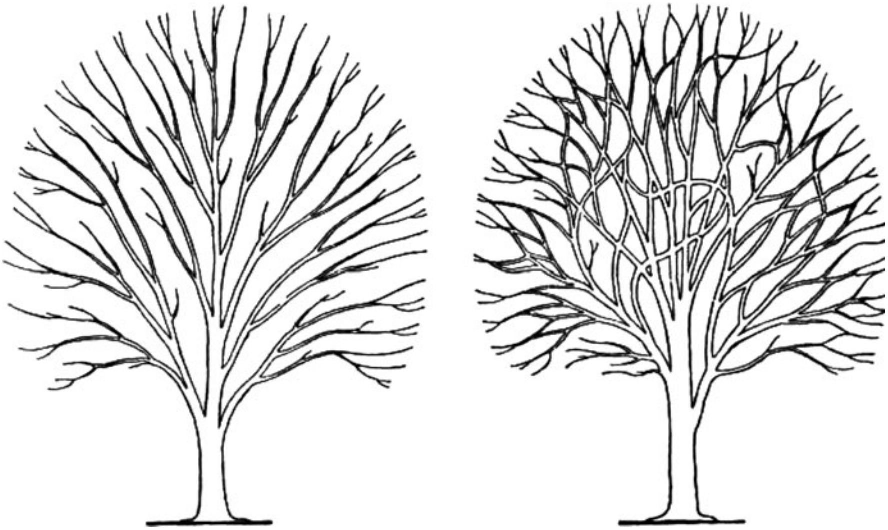

Fig. 6.1 Kroeber (1963: 68) depicted the tree of life to be a process of branching, as is dictated by the theory of evolution by means of natural selection (on the *left*); while he portrayed cultural evolution as a tree that contains branches that do not merely split, but also merge (on the *right*)

Regarding his cultural tree, Kroeber (1965: 68) wrote the following:

> . . . the course of organic evolution can be portrayed properly as a tree of life, as Darwin has called it, with trunk, limbs, branches, and twigs. The course of the development of human culture in history cannot be so described, even metaphorically. There is a constant branching-out, but the branches also grow together again, wholly or partially, all the time. Culture diverges, but it syncretizes and anastomoses too.

Given the above outline on horizontal evolution within different fields of evolutionary biology, the parallel with evolution through symbiogenesis and the cultural transmission model depicted by Kroeber is obvious. Symbiogenesis too explains how different lineages can cross, merge and rapidly lead to new entities. At the time that Kroeber and Boas were formulating their ideas on culture, de Bary, Frank and Merezhkowsky were also writing on symbiogenesis (for an excellent overview see Sapp et al. 2002). Unfortunately, the latter's ideas did not reach mainstream evolutionary biology let alone cultural anthropology.

What happened in anthropology is therefore somewhat unfortunate. Not being able to depict let alone explain cultural evolution by means of natural selection, anthropologists gave up an evolutionary biological approach to culture altogether. For many years, anthropologists would argue that cultural evolution is a process so different from the evolution of life (equated with evolution by means of natural selection), that methodologies other than evolutionary biological ones need to be applied to the subject. In fact, many anthropologists even refused to use terms such as "evolution" altogether and preferred terms such as "cultural transmission" or "diffusion" instead (Borgerhoff Mulder et al. 2006). In this respect, two different scientific languages emerged, one for the natural sciences, and one for the humanities. Nonetheless, acculturation or diffusion can also be seen as means or vehicles of universal symbiogenesis, just as symbiosis is one of the vehicles for endosymbiogenesis.

6.4.3.2 Hybridization Models of Culture and Language

With the success of the Modern Synthesis and the rise of Post-Neodarwinian, sociobiological theory (Dawkins 1976; Williams 1966), a minority of anthropologists turned to biology in order to explain certain cultural phenomena. Eventually, evolutionary psychology (Dunbar et al. 1995) would take on the investigation of culture from within a selectionist framework. But evolutionary psychologists, as the name implies, are mostly found in the psychology department.

When social and cultural anthropologists make use of biological thought to explain culture, they by and large still turn to fields other than evolutionary psychology. The fact that different cultures live in close contact with one another for instance has lead to the introduction of cultural ecology (Ingold 1986: 40), an approach that has loose parallels with the ecological approach within biology. But both in biology as well as in anthropology, an ecological approach does not immediately imply an evolutionary approach.

Furthermore, processes such as culture contact, language mixing or language borrowing are often compared to hybridization processes in plants. Anthropologists interested in multiculturalism, for instance, launch concepts such as cultural hybrids to explain transnationality, creolization, acculturation, deculturation or ethnic shopping (Chavez 2006; Hannerz 1980, 1992, 2002; Pinxten and De Munter 2006). With these notions they want to capture the rapid flow of culture from one person to the next, within different generations. Individuals or cultural groups constantly interact with one another and are interconnected, controlled, absorbed, or rejected through economy, life style, religion and ideology. The notions of symbiont and symbiome can be applied as a universal delineator that captures all these cultural concepts; and creolization, deculturation or ethnic shopping can be regarded as vehicles of universal symbiogenesis.

Hybridization models and ecological approaches are also found within sociolinguistics to explain phenomena such as language variation, language contact, language mixing and language borrowing. Mufwene (2002, 2005) has developed an ecological approach to language evolution/variation, based upon the neo-Darwinian population geneticist approach. Although the latter would imply that he emphasizes selection and thus speciation, he actually emphasizes the contact that exists between individual idiolects, and their possibility to exchange information and merge, similar to the reproduction process in biology where members of the same species and of the opposite sex can exchange genes. Rather than focus on the vertical selection phase, Mufwene thus uses the horizontal moment of genetic recombination during reproduction to draw analogies between language evolution and the evolution of life.

Croft (2000, 2002) actually uses an evolutionary epistemological model to explain the evolution/variation of languages. More specifically, he makes use of Hull's (1988) replication variation and environmental interaction scheme to explain language variation. However, he also recognizes that the latter approach is insufficient to explain all phenomena in language variation. Rather, language mixing and language borrowing is better explained by using metaphors of hybridization, which Croft dubs the "*plantish approach*".

Both Croft and Mufwene are working within the field of historical linguistics, also known as sociolinguistics or diachronic linguistics. The latter traditionally investigate language variation and the historical diversification of languages, but they do not a priori work within an overall evolutionary biological framework. And although both Croft and Mufwene make use of the term language evolution, they do not speak of language evolution in the same sense as evolutionary linguistics (Hurford et al. 1998) talk about it. The latter are much more inspired by evolutionary psychological, selectionist approaches. Nonetheless, both Croft as well as Mufwene argue that their models can also be applied within the field of evolutionary linguistics where they can help in the study of the actual evolution of languages.

However useful, hybridization models, both in culture as well as in linguistics, can be misleading. For one, hybridization is often not regarded as an evolutionary process, but as we have already demonstrated above, the latter is false. Hybridization can indeed be considered a creative force in evolution, and a specific example of symbiogenesis.

But cultures are not like animal or plants species when they hybridize. Hybridization can be a rather rigid process, that always implies the emergence of a new generation. Languages and cultures, or individual speakers can always absorb new elements without having to produce a new generation. Furthermore, individuals can easily undo themselves of acquired cultural traits or dialects, while animal and plant hybrids cannot, the hybridization is often permanent.

Therefore, it is better to use the jargon of universal symbiogenesis to describe the horizontal evolution of language and culture and therefore to bridge the gap between the natural and life sciences, as Neurath already pleaded for. Biological individuals, their languages and their cultures, all are chimeras, entities that are stitched and patched together and that form new wholes with behaviours not seen in the individual parts.

Socialism for example is a symbiont or symbiome of communism, Marxism, capitalism, and enlightenment theory. A computer is a combination of electricity, light, plastic, steel, typewriters and television screens (Margulis and Sagan 2002: 172). None of them evolved to become part of a modern day computer, but at one point in history, they all got symbiogenetically combined, leading to a new entity with specific behaviour.

The universal symbiogenetic jargon can thus be expanded to the humanities and provide a universal methodology to examine the above described horizontal forms of cultural evolution. And also in language evolution, the jargon can be applied successfully. Creoles for example can be understood as chimeras that combine the host lexifier and symbiont substrate language, or vice versa.

In sum, the universal symbiogenetic account can also be put to use in the humanities and here it can provide a complementary view to selectionist speciation models that all too often overemphasize selfishness and competition. The merit of universal symbiogenesis is that it allows for the introduction and even for the recognition of interaction, cooperation and exchange (especially in this regard, see Speidel 2000).

6.5 Conclusion

Traditionally, EE was understood to be a discipline that studied cognition and classical philosophical problems from within evolutionary theory. As such, it did not differ much from Quine's naturalized epistemology. However, through the years, EE has become a discipline that not only tackles philosophical problems from within natural selection theory. It also studies phenomena other than cognition and deals with problems other than knowledge. Contrary to traditional EE that focussed exclusively on natural selection as the evolutionary mechanism that allows for the biologizing of epistemology, scholars working within new EE are also looking at other evolutionary theories to study traditional epistemological questions.

The merit of all these approaches however also make it necessary to investigate whether it is possible to epistemologize evolutionary theories other than natural selection. Applying the tenets of new evolutionary epistemology to all known evolutionary mechanisms will provide us with more methodologies to examine evolution at all ranks of life.

In this article, it was specifically investigated how symbiogenesis can be universalized and how it can provide a methodology in both the life and human sciences.

It was demonstrated that symbiogenesis can be universalized and in its universal form, it can include at minimum the epidemiology of viruses, hybridization, cultural and linguistic evolution. Universal symbiogenesis even has potential in medical applications. Moreover, the well-used notions of *symbiont* and *symbiome* can be applied as universal concepts that can complement Dawkins' replicators and Hull's interactors.

The enormous potential of an evolutionary view based on symbiogenesis is yet to be felt in many extra-biological fields and even within zoological-centred evolutionary biology. The universal symbiogenetic formula presented in this article hopes to contribute in a positive way in making the importance of symbiogenesis known in these fields. In the wake of Neurath, it will introduce another language if not methodology, that will bring the natural and the life sciences together.

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