CONCEPTUAL CHALLENGES TO EVOLUTIONARY BIOLOGY: A NECESSARY STEP

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ABSTRACT. *Modern evolutionary biology has been founded by Alfred Russel Wallace and Charles Darwin who independently proposed that natural selection was a principle driving force of life on earth. While over a century of research into evolutionary biology has revealed a substantial amount of knowledge on life on earth, the discipline has been mainly informed by Platonic essentialism and biological reductionism. These concepts provide both a limited and insubstantial scope for examining and understanding the interplay between evolution and biology. This paper's aim is to critically examine the conceptual problems arising from Platonic essentialism and biological reductionism within evolutionary biology. The paper also poses how Platonic essentialism and biological reductionism can be supplanted for more insightful approaches.*
KEYWORDS*: Platonic essentialism, biological reductionism, natural selection, similum, self-organisation, Lamarckian inheritance*

1. Introduction

Modern evolutionary biology was prompted by Alfred Russel Wallace and Charles Darwin who independently proposed that natural selection was a principle driving force of life on earth. Of course, evolutionary theory did not begin with these two thinkers, but can be found in various cultures stemming back for thousands of years. Vedic civilisation provides the first literate accounts of evolution. These ideas may have been passed to the pre-Socratic Greeks who were the first to convey the idea that nature is governed by physical principles and not by divine ordinance. The pre-Socratics attempted to construct their own theory of everything (ToE); Anaximander proposed that the cosmos was infinite and was constituted by the *apeiron* – itself being eternal, boundless, the creatrix. Alternately, Heraclitus argued that fire was the basis of the cosmos, while Anaximenses believed that air was the prerequisite element of existence. Furthermore, Thales considered that matter had originated from water. Muslim scientists such as Al-Jãhiz and Al-Ṭūsī proposed their own versions of a theistically guided evolution. The ideas of these two thinkers come closest to modern evolutionary biology. While evolutionary biology has a long history, its present theoretical assumptions are being challenged by various thinkers.

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The aim of this paper is to critically examine two conceptual problems within current evolutionary biology; Platonic essentialism and biological reductionism. These two over-arching concepts presently inform evolutionary biology.

2. Platonic Essentialism and Evolutionary Biology

Systematic intellectual analysis of the world can be only carried out and communicated using language (Wittgenstein 1922). The language can be that of everyday discourse, or formalised into arbitrarily defined entities denoted by symbols. Any language consists of discrete entities. How these entities capture the nature of real objects informs intellectual analysis. Platonic school of thought assumes existence of ideal entities that underlie appearance of real objects. Use of this approach has been effective in many natural sciences, especially in physics and chemistry where mass, atoms, electrical charges, chemical bounds and forces allowed analysis of natural phenomena that is both intellectually satisfying and practically applicable with effective results. In legal discourse entities are precisely defined and often categorically distinguished, though they may be arbitrary.

This language-based essentialist approach assumes permanence of objects and rules governing their relations. Rules of physics and chemistry determine the existence of objects in the real world, rules of law and of society determine human behaviour. The world is understandable in this way, but it is static. Change in such a world can occur only through different combination of objects and of forces. No new primary entities can emerge while complex entities are but a combination of primary ones. In such an approach any complex object or situation can be decomposed to its primary parts and forces. Any situation can be created or controlled given enough resources. This reductionist approach has been repeatedly shown to fail with regard to the understanding of human life where radically different holistic approaches have been advocated to be more effective. This, however, is the domain of humanities.

Biology has been traditionally classed as a natural science. Reductionist approaches to living things are abundantly applied in molecular biology. Many results of biochemical and genetic studies are practically applicable with useful outcomes. They help us to understand how single organisms work, but do not provide any information about the causes and origins of biodiversity. The situation is radically different, however, in environmental biology. Here the basic entity used is species (Ereshefsky 1992, Ghiselin 1997). Unlike basic entities of physics or chemistry, there is not one, single generally accepted definition of species. Some 23 different definitions are used (Mayden 1997). The definition of species varies from sub-discipline to sub-discipline and from one practical application to the other. The notion of species was formalised by Carl Linne (1735) in his *Systema Nature*. It assumes that individual organisms are but imperfect representations of ideal separate entities. The nature of each species is defined as a single static organism exemplified by the holotype (an individual best representing the ideal of a given species). Each species so defined is given a binomial name constructed in a strictly defined way and comprising two Latin words. The first word is a capitalised noun denoting the genus to which a species belongs, the second is a non-capitalised adjective denoting the species: *Homo* (human) *sapiens* (the wise) or *Felis* (cat) *domesticus* (domestic) (International Commission on Zoological Nomenclature 2013). Irrespective of which definition is used, a species has only one form that cannot be changed and its name is used as an entity in intellectual analyses. Thus, biological systematics listing species and grouping them into higher order categories of genera, families, orders, classes and phyla provides a static picture of biodiversity. When applied to the past, largely based on studies of fossils that are considered to represent some species, it also provides a static picture, though species defined from the fossil material may be different from the extant ones. The only way to describe the process of organic evolution when using currently recognised basic entity of a species is to state that some past species became extinct while some new species "emerged" or were created. In this description, evolution proceeds by a number of discrete steps, each appearance of a new entity (species) requiring a special creation. Mechanisms underlying such creation may remain unknown or unexplainable.

Although individual researchers since the 18th century, when Linnean system was established, perceived its inadequacy when it came to the description of faunal or floral change (e.g. J-B Lamarck, Erasmus Darwin), it was only when Alfred Russel Wallace and Charles Darwin questioned the very nature of species, recognising in their analyses the primary value of individual variation, that the process of organic evolution became explainable by the mechanism of natural selection sorting random individual changes in what is today understood as molecular regulation of individual development coded by the genetic material. Thus, as Charles Darwin observed, there is no real difference between a species and a variety or breed while they all ignore individual variation.

> *... I look at the term species as one arbitrarily given, for the sake of convenience, to a set of individuals closely resembling each other, and that it does not essentially differ from the term variety , ... The term variety, again, in comparison with mere individual differences, is also applied arbitrarily, ...(Darwin 1859 [1952]:29).*

Ernst Mayr (1963) attempted to reconcile the concept of species with the mechanism of evolution by creating what is now known as the "biological species concept". He defined 'species' as a collection of interbreeding individuals. There are problems regarding the degree of interbreeding, testing of interbreeding is sometimes practically difficult, while it is absolutely impossible if individuals separated by a number of generations are considered. Therefore, in practice researchers must decide about the potential for interbreeding of organisms using morphological and physiological criteria like in the Linnean species. Despite rejection by Charles Darwin of species as a useful category of biological studies, the concept has survived into the 21st century. Its persistence and continued recognition by official biological sciences makes the understanding of evolution and its study difficult.

Although, as Darwin and Wallace discovered, unique individuals are actual units of biological evolution, the abundance of individuals and their short existence make it impractical to recognise them as entities and assign each a separate name. Thus, it is practical to define collective units comprising many individuals for purposes of particular studies or utilitarian applications. Each such unit, however, can be only approximately defined because to include individually variable organisms it must abstract from some aspects of their variation. It becomes idealised to a certain extent. When organisms can be usefully grouped based on body size and shape, their differences in body colour will be ignored. Ideally, grouping criteria should be multivariate and include all characteristics of organisms. Since, however, living organisms, even the smallest ones, are highly complex and comprise many individually variable parts, a multivariate ideal may easily become too complicated for practical purposes. In principle any grouping of organisms will have to ignore some characteristics. If it so happens that these characteristics, being individually variable, confer differential reproductive success on lineages of individuals, they will be subjected to natural selection and produce evolutionary change, unexplainable by the rules upon which approximative grouping was based.

Therefore, an essentialist approach to the description of biological variation and biodiversity is inept and inappropriate for the study of evolution. Evolution is a change in individual variation. As such it must be studied quantitatively at the level of populations of interbreeding and interacting individual organisms and in lineages of individuals. If any groupings need to be applied for practical purposes in biological studies they should acknowledge individual variation and admit their own imperfect, approximative nature. Lack of such admission combined with the use of a specific name of a grouping may easily lead to the creation of an essentialist entity in scientific discourse.

We have argued that the concept of species is at variance with the logic of the theory of evolution and should be abandoned in evolutionary discussions (Henneberg and Keen 1990). We have proposed to replace the term “species” with the notion of “similum” (Henneberg & Brush 1995). A similum is simply a number of individual organisms similar to each other more than they are similar to other organisms. The degree and nature of similarity can be defined with regard to specific purposes of application of the term. Unlike species, the term admits that it is based on similarity, not identity, and it has no historical baggage of its use in science. It does not imply categorical ideal definition and it recognises variability of individuals. Simila may easily change through time as they are based on mutual similarities of actual variable organisms, not on similarity of organisms to some invariable ideal.

3. Biological Reductionism: A Time for Change

The previous section has outlined how Platonic essentialism has informed modern evolutionary biology, leading to current misconceptions of biological processes. In this section, the rudiments of biological reductionism will be critically appraised. Biological reductionism is predicated on the idea that physical phenomena and living entities can be reduced and understood according to their constitutive parts. Secondly, an understanding of these parts/units is accessible to empirical observation, forming the basis for scientific knowledge/investigation. Thirdly, unlike Aristotle who believed that an entity was *more* than the sum total of its parts, biological reductionism contends that an entity "*has to be"* the sum of its parts (Wolf 1981:42). Biological reductionism is an empirical method grounded in the idea that biological properties and processes are intrinsically constituted by molecular principles (Mazzocchi 2010:340). These molecular principles are ultimately based on a uni-linear flow of information i.e. DNA → RNA→ Proteins (Mazzocchi 2010:340).

Biological reductionism has been the favoured theoretical model used to examine evolutionary and molecular biology. The entrenchment of biological reductionism has been mainly influenced by historical factors which are beyond the scope of this paper to outline in detail. The advent of the European Renaissance (1450-1550) pathed the way for challenging religious ideas of humanity and the cosmos. The heliocentric model proposed by Nicolaus Copernicus led to the eventual demise of the Ptolemaic geocentric model. The Copernican Revolution changed European's conceptions of the universe, in that the earth was no longer central in the Divine order, but rather a planet following physical principles, not Divine order. The endpoint of the Copernican Revolution came via Isaac Newton's seminal work *Philosophiae Naturalis Principia Mathematica* (1686). The *Principia* developed a theory of planetary motions in which gravity was central. Newtonian physics revealed the universe, as foremost, a physical entity accessible to empirical investigation. For example, planetary motions could be segmentally divided and examined according to each of these parts (Wolf 1981). In this way, entities could be examined and understood according to their constitutive parts. Newton's mechanistic model extended his belief that Truth favoured simplicity, not complexity (Mazzocchi 2008:10).

> *Newton's ideas foregrounded the notion of a mechanistic or "clockwork universe", providing a unified explanatory model for cosmic motion. Reductionist assumptions contained in Newtonian physics extended to other fields of science, eventually defining modern science (Mazzocchi 2010:8). In the same vein, Descartes also believed that the universe could be reduced to its parts and investigated (Mazzocchi 2008:10), which influenced Newton's Principia. By the dawn of the eighteenth century the pervasive power of reductionism had transformed the episteme, thwarting the possibility of a counter scientific worldview. The scientific stage had been set.*

> *Newton and his forebears set the stage, perhaps unwittingly, for a materialistic and objective view of reality. Newton's laws, science's grand 'rules of the game,' as the celebrated physicist Richard Feynman once referred to them, and their central premise,* ***that things exist independently of each other****, underpin our own philosophical view of the world (Bartlett 2003:12).*

I would argue that the ascendancy of biological reductionism has arisen from the existential imperative (Jackson 1998), that is posited on human concern with retrieving some semblance of control over the lifeworld. In this way, biological reductionism constitutes a method for reaffirming *auctoritas* – for re-authoring the lifeworld. The last thirty years has seen the ascendancy of molecular biology as a stratagem for controlling living matter by reducing it to its molecular parts. Thus, the sheer complexity posed by biological systems is simplified and reconciled within the ambit of human manipulation. On this theme, Levi-Strauss (1966:23), notes that by qualitatively diminishing an object (via miniaturisation), it becomes "quantitatively simplified"; hence, human tendency to simplify, to rearrange, and to miniaturise is driven by a concern to make a "real object less formidable", thereby bringing it under human control (Jackson 1998:31).

In relation to current biological reduction, emergent properties of entities cannot be entirely explained at molecular and cellular levels of organisation, nor are they predictable (Kim 1999; Mazzocchi 2011:9). Rather, biological entities and processes must be cognised in terms of relationality operating at all levels of organisation (Bateson 1972, 2000, Laszlo 2004). Life is cybernetic, comprising of complex and irreducible feedback systems and cycles between organisms and their environments (Freeman 1992; Mazzocchi 2006). Biological organisms (non-linear systems) are characterised by abrupt changes which prompt noticeable changes at molecular and cellular levels (Coffey 1998:882). In Systems biology the degree of dynamic variation between interactive units fosters systemic plasticity and integrity (Coffey 1998:882). Additionally, biological systems are adept in modifying strategies which enhance self-organisation – the ability for inter-cellular communication (Coffey 1998:882). Self-organisation determines the structure and processes of organelles (Mistelli 2001:181). Self-organization provides an efficient method to organise complex structures. "The properties that determine the organization are the intrinsic properties of the structure's components" (Mistelli 2001:184).

4. New Developments in Evolutionary Biology

A characteristic of Systems biological models is the central role of self-organisation in ensuring cellular stability and plasticity (Mistelli 2001: 184). It has become clear that a study of the characteristics of single molecules is insufficient in understanding the complex behaviour of cellular dynamics (Mistelli 2001:184). This movement from analysing separate units of information to the interaction of collectives, readjusts the scientific gaze towards observing higher level patterns of biological organisation of lower level mechanisms (Mazzocchi 2010:341). Recent developments in evolutionary biology foreground epigenetic factors in modifying human developmental stages (Jablonka *et al* 1992; Jablonka & Lamb 1995; Portela & Esteller 2010). The amount of research pointing to the gene/environment interplay in human developmental patterns is both considerable (more than 2,500 epigenetic published papers in 2009) (Portela & Esteller 2010). It is now known that life style habits and environmental responses of recent ancestors (i.e. grandparents) can have deleterious health effects on first and second generation progeny (Simmons 2008). Research confirms the significance of Lamarckian inheritance in the inter-generational transmission of acquired traits. Lamarckian inheritance includes "both non-DNA variations and developmentally induced variations in DNA sequence (Jablonka & Lamb 2008). A version of 'soft inheritance' is soma to soma transmission that by passes the germline, and in which offspring phenotypes are akin to their parents (Jablonka & Lamb 2008:392). Soma to soma inheritance may include the transmission of chemical substances within mammalian placenta (pharmacological substances, alcohol) and via lactation; acquiring of symbionts and parasites via ingestion of faeces; parental behaviours (i.e. nutritional and lifestyle habits) that form "similar developmental reconstruction" in offspring phenotypes (Jablonka & Lamb 2008:392). Thus, the epigenetic re-formulation of evolutionary biology is based on the following premises:

1. Not all heritable traits are produced by DNA.
2. Some heritable changes may be non-random.
3. Not all evolutionary change is slow, as evinced by inter-generational micro-evolution.
4. Evolutionary divergence may not have to follow a tree like formation (Jablonka & Lamb 2008:243).

One reason for the persistence of epigenetic markers during human developmental stages is that they provide a greater range of phenotypes from the same genotype (Portela & Esteller 2010:1057). Levites (2000) contends that epigenetic variation drives biodiversity. For example, nutritional changes in the environment may induce systemic alterations in plant development. Similarly, ongoing stress in animal species may disrupt hormonal regulation, triggering systemic changes (Jablonka & Lamb 2008:247). From a point of view of human evolution, epigenetic variation may have led to novel adaptive strategies as a consequence of human culture. Culture provided the capacity for ancestral *Homo* to create ecological niches via the use of technology, whereby enhancing fitness during the Pleistocene period. Culturally programmed behaviour in *Homo* required long term acquisition of higher order cognition mediated by social others. However, as it has been shown, the evolutionary mismatch between ancestral and modern environments has meant that modern *Homo* is becoming increasingly susceptible to deleterious epigenetic inheritance. New risk factors such as alcohol and tobacco consumption, prolonged drug use, sedentism and high-fat and high-processed carbohydrate diets, (all of which were absent in ancestral environments) inform epigenetic dysregulation, resulting in a suite of somatic and psychiatric disorders (Samaco *et al* 2005; Schanen 2006; Tsankova *et al* 2007; Huber *et al* 2007; Simmons 2008; Javierre *et al* 2008; De Sario 2009; Turunen et al 2009; Stearns *et al* 2010; Zerwas & Buik 2011).

5. Conclusion

This paper has contended that Platonic essentialism and biological reductionism are theoretically untenable in fully understanding evolutionary biological processes. Indeed, these two concepts have led to a scientific myopia. A systematic investigation of these concepts reveals critical shortcomings in evolutionary biology. We have provided an historical overview why these two concepts became entrenched in science. Foucault contends (1963, 1970), that socio-historic forces have constructed science as a discourse of truth and power, thereby legitimating the scientific process. For Foucault, knowledge is linked to power, and that power both verifies and excludes what is deemed as 'truth'. The rise of systems and epigenetic approaches is presently challenging long held assertions of Platonic essentialism and biological reductionism within evolutionary biology.

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