Life Without Evolution

A Comprehensive Deconstruction of Biological Evolution According to Darwin Presented in 3 Essays

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Essay 3

Deceptive Definitions

"A single word can tell a thousand lies"
(unattributed)

Contents

Defining What?

The study of organic evolution covers a huge range of topics and ideas, and definitions of the subject vary markedly according to the perspective of the author. As the following three examples illustrate, evolution may refer to the history of life, to the mathematics of population genetics, or to a philosophical premise.

> To the biologist, organic evolution means the gradual unfolding of the living world on this planet.
>
> *Animal Biology*, Grove and Newell 1961.

> Evolution: The change in genetic composition of a population over successive generations, which may be caused by natural selection, inbreeding, hybridization, or mutation.
>
> *Biology Online Dictionary*, accessed 2018.

> Only in the most general sense can we talk about *the* idea of evolution, as though it were a unified concept. At this level, "evolution" means no more than the belief that the existing structure of the world in which we live in has been formed by a long series of natural changes.
>
> *Evolution: The History of an Idea*, Peter J. Bowler 1989.

Some compositions define evolution as a concept, while others focus on the mechanism; some are expressions of microevolution, some of speciation, and others of macroevolution; and though some encapsulate evolution in just three words, others elaborate using fifty or more.

Within the bubble of evolutionary biology, definitions represent statements of assumed fact. But from the point of view of philosophy and religion, social history and history of science, and in dictionaries and encyclopedias, definitions are more likely to contain the words 'theory' and 'belief'.

Modern scientific definitions that describe evolution in terms of genetic mechanism are intended to apply to all levels of organic transformation. Yet the mechanisms of evolution on a grand scale, including the origins of levels of complexity and modes of transmutation between different body plans, are largely unexplained. If the processes of large-scale evolution are unknown, then what, exactly, is being defined? Such attempts to define the unknown are laden with unstated – and unproven – assumptions; they also conceal the boundaries between fact, theory and belief.

This essay makes the case that the term *evolution* has no consistent or useful scientific meaning in biology, and simply denotes an adherence to a naturalistic world view. It concludes that the word 'evolution' should be dropped from teaching syllabuses, in favour of a variety of other existing terms that define more precisely the observations, phenomena, or theories to which they apply.

The Original Meaning of 'Evolution'

The Latin roots *evolutio* and *evolvere* give the sense of a gradual development as 'unfolding' or 'unrolling'. The early implication (17th and 18th centuries) was of a process of expansion from a preformed or preordained plan. A vestige of this belief is retained by contemporary *theistic evolutionists*, who affirm that evolution is the way in which God's plan for the world has been gradually unrolled. The actual word 'evolution' was first used in the study of life to describe the unfolding development of an embryo from its egg, and later applied to the development of all life on Earth from its primordial state (Bowler 1989). The connection between the unfolding embryo and the unrolling of all life was more than a simple analogy: many 19th century naturalists followed the doctrine of 'ontogeny recapitulates phylogeny', the idea that the stages of an organism's embryological development mirror its evolutionary history.

> Naturalists who accept the theory of evolution, consider that the development of each individual represents to a certain extent that which the species has itself gone through in the lapse of ages; that every individual contains within itself, so to say, a history of the race.
>
> John Lubbock, *The Beauties of Nature*, 1893.

The concept of evolutionary development as reflected in an animal's embryological development was a tenacious one, and lingered well into the 20th century:

> There is in fact a tendency for the development of various individuals to reproduce to a lesser or greater extent features manifested by the various adults belonging to the ancestral stock. The expression "the development of the individual recapitulates the history of the race" expresses the truth as it appears in a lineage…
>
> H. H. Swinnerton, *Outlines of Palaeontology*, 1947.

The recapitulation theory is now scientifically discredited in an absolute sense, but developmental biologists still believe that certain embryological stages retain evidence of former evolutionary states, and that many developmental genes are 'conserved' from primitive ancestors. Darwin's contention that the evidence from embryology was 'second to none in importance' has never been fully quenched, and the quest to reveal the secrets of evolution through the secrets of embryology has been a recurring allure ever since.

During the latter part of the 19th century, evolution gradually became the adopted term to cover all developmental theories in opposition to the theory of special creation. This point is made clear in a historical definition from the full Oxford English Dictionary:

> Evolution (Definition 6c): The origination of species of animals and plants, as conceived by those who attribute it to a process of development from earlier forms, and not by a process of 'special creation'.
>
> *Oxford English Dictionary*, 2nd edition 1989.

Although evolution, by this time, was fundamentally conceived as a naturalistic process open to scientific investigation, religious belief in the notion of a preordained plan or purpose has never been extinguished. To repeat the point, many religious creeds to this day teach that evolution is the manner in which God enacted his plan for creation.

It was not Charles Darwin who popularised the use of 'evolution' in its modern context, but the philosopher and sociologist Herbert Spencer – the same influential thinker who introduced the phrase 'survival of the fittest'. Spencer constructed a 'progressive' view of evolution in his *Synthetic Philosophy*, which he extended to include all biological and social phenomena, justifying his views on morality, education, and free-market economics. He was 'one of the principal proponents of evolutionary theory in the mid nineteenth century, and his reputation at the time rivalled that of Charles Darwin' (Int. Ency. Philos., accessed 2018). Though Darwin adopted the phrase 'survival of the fittest' in later editions of his *Origin of species*, he never accepted the word 'evolution' with the same enthusiasm. He was wary of the progressive view of evolution associated with Herbert Spencer's philosophy, which implied religious notions of an inevitability towards an anthropocentric goal, and which also countered his own point that organic change is not always towards higher designs. It was Spencer's popularisation of the term 'evolution' that prevailed, while Darwinian mistrust of the idea of progress also endured. Nevertheless, it cannot be denied that the fossil history of life shows an overall advance from the simplest organisms to the most complex – a form of progression. Indeed, at least one authority has defined evolution in these terms:

> Evolution (Definition No.2): The gradual development of more complex organisms from simpler ones.
>
> *Chambers Biological Dictionary* 1990.

The human brain, regarded as the most complex entity in the known universe, arises towards the end of the history of life on Earth, not at the beginning or in the middle. Indeed, Julian Huxley, who could not be regarded as anything but a Darwinist, opined that 'it is not unscientific anthropomorphism to regard man as standing high on any scale of evolutionary progress' (1963, p120). There is much justification, therefore, in the progressive view of life, and despite the protestations of Darwinian purists, it remains the case that 'most people still imagine that evolution is an essentially progressive process' (Bowler 1989).

Just as Charles Darwin did not introduce or popularise the word 'evolution', neither did he 'discover evolution'. A common but mistaken belief, still earnestly perpetuated today, is that no one wrote about evolution before *On the Origin of Species* published in 1859. This is true only in the sense that the word 'evolution' had not come into common usage among scientific thinkers. But for a hundred years or more before that date, naturalists and philosophers had published contributions to debates around 'progressive development' and 'the transmutation of species'.

> Transmutation.. is the notion that new species emerge from existing species and that all existing species are the product of change in older ones… This view was common by the 1830s, and Darwin did not invent the idea.
>
> National Center for Science Education, ncse.com, accessed 2019.

Darwin himself wrote of 'the mutability of species' and 'a theory of descent with modification'. Alfred Russel Wallace, in his 1858 paper *On the Tendency of Varieties to Depart Indefinitely from the Original Type*, discussed 'modifications in form' resulting in 'progression and continued divergence'. Fifty years earlier in 1809, Jean-Baptiste Lamarck (who introduced the term 'biology') published the first comprehensive theory of 'transformism' in his *Philosophie Zoologique*.* Those in

* In France it is Lamarck, and not Darwin, who is 'regarded as the father of evolution' (Patterson 1978) and commemorated as 'Fondateur de la Doctrine de l'Evolution' (Turner 2013). Recent work in epigenetics has rekindled debate on *Lamarckian evolution*, or the inheritance of acquired characteristics.

support of theories of natural development – later to be identified as 'evolutionists' – were known as 'progressionists' or 'transmutationists'. The term 'transmutation' is still occasionally met with today, and imparts a more accurate understanding of 'transformation by mutation' than the modern catch-all term 'evolution'.

Early evolutionists in Europe were divided between those who tried to harmonise new discoveries about the natural world with their Christian beliefs, and those who used them as a means to escape religious control. This philosophical dichotomy has not disappeared, and 'evolution' is still the focus of emotive arguments between theistic and atheistic Darwinists. The ghosts of evolution past – God's unfolding plan, some lingering truth in recapitulation, the Victorian ideal of progression, excessive Darwin mythology – burden us with a great deal of fanciful thinking and emotional baggage; a burden that could be left behind if the word 'evolution' were removed from the language of objective science.

Clarity and Confusion

When correctly and appropriately applied, the splitting of the study of evolution into the fields of microevolution and macroevolution can draw out an appreciation of many of the difficulties that persist in Darwinian theory. Observable genetic changes in living populations (microevolution) and observable changes in the fossil record (macroevolution) may be considered as separate topics. Teachers and students are then given the opportunity to compare and contrast evolution at micro and macro levels, and develop informed opinions regarding unity or duality of process. Unfortunately, definitions of these terms are inconsistent, and attitudes to their application and significance can be subjective or even prejudiced. This very unscientific regard for scientific terms is condoned, and even encouraged, by those involved with the public teaching of evolution who do not wish macroevolution to be considered as a separate, unexplained process. For example Douglas Futuyma, in his undergraduate textbook *Evolution* (2009), offers glossary definitions that are deliberately obscure:

> Microevolution: A vague term, usually referring to slight, short-term evolutionary changes within species.
>
> Macroevolution: A vague term, usually meaning the evolution of substantial phenotypic changes, usually great enough to place the changed lineage and its descendants in a distinct genus or higher taxon.

The terms micro- and macroevolution thus add as much confusion to the evolution debate as they do clarity. Accordingly, in the interests of exact science, these terms are best avoided along with the mother term 'evolution'.

It was the Ukrainian-American geneticist Theodosius Dobzhansky who introduced the subdivisions of micro- and macroevolution into the English lexicon of evolutionary biology. His 1937 book *Genetics and the Origin of Species* is considered to have been a seminal work in the *modern synthesis* of evolutionary theory, and his changing appraisals of the micro/macro debate through subsequent editions reflect the general direction of thought taken by the majority of biologists. In the preface to the original 1937 edition he wrote:

> Some writers have contended that evolution involves more than species formation, that macro- and micro-evolutionary changes may be distinguished. This may or may not be true; such a duality of the evolutionary process is by no means established.

By the 1951 third edition Dobzhansky had concluded that publications in the 1940s had,

> …ended the belief which used to have a surprisingly wide currency, that paleontology had discovered some mysterious "macroevolution" which is inexplicable in the light of the known principles of genetics.

Then finally in his 1970 *Genetics of the Evolutionary Process* (essentially his fourth edition) Dobzhansky explains:

> A loose distinction is often drawn between microevolution and macroevolution, according to the magnitude of the morphological, physiological, or genetic changes. One may say that microevolutionary changes are possibly reversible, whereas macroevolutionary ones are not. This does not mean there are two kinds of evolution… The distinction is quantitative, and any boundary can only be arbitrary.

So initially there was some weight of opinion that macroevolution represented a different kind of evolutionary change operating beyond the formation of species. By the 1950s the modern synthesis had gained supremacy, and macroevolution had been demoted to a mysterious belief. By 1970 the terms macro- and microevolution had become accepted as loose descriptors of different magnitudes of evolutionary change, but the distinction was viewed as arbitrary and certainly did not refer to any difference in process.

However, just two years later in 1972, the hugely contentious theory of *punctuated equilibria* was launched, and its authors Niles Eldridge and Stephen Jay Gould, with the support of several other leading paleontologists, reopened the debate about whether macroevolution required a different explanatory theory. It is a debate that continues to this day: see, for example, paleobiologist Douglas Erwin's *Macro-evolution is more than repeated rounds of microevolution* and some of his more recent publications.

Historical mention should also be made of George Gaylord Simpson's 1944 influential contribution *Tempo and Mode in Evolution*, in which he relegated 'macro-evolution' to mean the origin of species and genera, and added the term 'mega-evolution' to cover the origin of taxonomic groups above this level. The latter term was never widely adopted, and 'macro-evolution' remained susceptible to different interpretations. Using Simpson's definition subscribers to the single process view of evolution were now able to dismiss macroevolution as little more than the process of speciation – i.e. little more than microevolution. Supporters of the dual process view, on the other hand, applied the term to cover origins of higher level groups, equivalent in meaning to Simpson's mega-evolution. This ambiguity of usage is convenient to those authors who wish to divert attention from any micro/macroevolutionary divide, and who therefore refrain from seeking to clarify these terms.

But flat denial of any distinction of process between micro- and macroevolution is still the easiest option for educators upholding Darwinian gradualism and hoping to avoid difficult questions. Students and the public are simply taught that micro-evolution and macroevolution are essentially the same process, and no mention is made of any dissenting opinions. The website *Study.com* (accessed 2018) exemplifies this uncompromising stand in its life science course for middle school, in which it defines the two terms and the relationship between them as follows:

> Microevolution is defined as changes in gene frequency in a population from one generation to the next.
>
> Macroevolution is evolution on a big scale, the descent of many species from one common ancestor over billions of years.
>
> The same mechanisms that we see in microevolution work at the macro-evolution level.

Educational sources that are open about the macroevolution controversy are much harder to find, but full marks to the *Oxford Dictionary of Geology and Earth Sciences* (2013) for including a statement about the controversy in its definition:

> Macroevolution: Evolution above the species level, i.e. the development of new species, genera, families, orders, etc. There is no agreement as to whether macroevolution results from the accumulation of small changes due to microevolution, or whether macroevolution is uncoupled from micro-evolution.

Another tactic employed by single-process supporters is to claim that the terms micro- and macroevolution are rarely used by proper scientists, but frequently 'misused' by creationists. This mistruth is applied by Austin Cline (2018) in a contribution to *ThoughtCo*, which claims to be 'the world's largest education resource':

> For biologists, there is no relevant difference between microevolution and macroevolution. Both happen in the same way and for the same reasons, so there is no real reason to differentiate them. When biologists do use different terms, it is simply for descriptive reasons.
>
> When creationists use the terms, however, it is for ontological reasons – this means that they are trying to describe two fundamentally different processes. The essence of what constitutes microevolution is, for creationists, different from the essence of what constitutes macroevolution. Creationist are under the impression there is a magic line between microevolution and macroevolution, but no such line exists in science. Macroevolution is merely the result of a lot of microevolution over a long time.
>
> In other words, creationists are appropriating scientific terminology which has a specific and limited meaning, but they are using it in a broader and incorrect manner. This is a serious but unsurprising error – creationists misuse scientific terminology on a regular basis.

The blame-it-on-the-creationists cover-up combines prejudice with poor research. The following introductory statements from a peer-reviewed paper prove that evolutionary biologists do indeed differentiate the terms, and do indeed argue about whether they represent one or two processes:

> A persistent debate in evolutionary biology is one over the continuity of microevolution and macroevolution – whether macroevolutionary trends are governed by the principles of microevolution.
>
> The continuity of selective processes over microevolutionary and macro-evolutionary time continues to be a source of disagreement in evolutionary biology [4 references cited]… In dispute is whether the effects of selection operating over microevolutionary time, or at the population level, account for observed trends over macroevolutionary time.
>
> The existence of the terms 'microevolution' and 'macroevolution' reflects the controversy [10 references cited] over the unity of process of natural selection operating at different time scales.
>
> Andrew M. Simons, *Journal of Evolutionary Biology* 2002.

The conflicting applications and interpretations of the terms microevolution and macroevolution – inconsistent definitions, controversy over whether they refer to one process or two, denial of said controversy, and the association with creationism – destroy any clarity they could potentially bring towards a better understanding of the limitations of Darwinian theory. Much of this confusion is intentional, serving to disarray attacks on the reigning paradigm. In the interests of clarity, therefore, these terms are best avoided in cogent debate about origins.

If all three terms 'evolution', 'microevolution', and 'macroevolution' are to be abandoned, they must surely be replaced by a more honest scientific terminology that is less susceptible to subjective manipulation. There is no requirement, here, to invent new words: a generous choice of suitable terminology is already in existence and in common use. 'Evolution' is currently defined by an extensive variety of different biological principles, and the solution is simply to refer to these principles by name without any further regurgitation of the 'e' word.

The History of Life: Replacing 'Macroevolution'

Definitions of macroevolution typically begin 'macroevolution is evolution…', ensuring that 'macroevolution' inherits all the ambiguity and subjectivity of meaning associated with its parent term. In particular, its usage fails to distinguish between factual and theoretical elements.

In its factual sense, macroevolution refers to observational accounts of the history of life as glimpsed through the fossil record, documenting trends and patterns of change in the forms of life appearing through time:

> Macroevolution is evolution on a grand scale – what we see when we look at the over-arching history of life: stability, change, lineages arising, and extinction.
>
> *Understanding Evolution*, evolution.berkeley.edu (accessed 2018).

In its theoretical sense, macroevolution deals with ideas about lines of descent and mechanisms of transmutation regarding the origins of higher groupings:

> Macroevolution: Evolution on a relatively large scale, involving, for example, the emergence of entire groups of organisms, such as the flowering plants or mammals.
>
> *Oxford Dictionary of Biology,* 2019.

In either sense we can dispense with the language of both 'macroevolution' and 'evolution' by simply talking about the subject matter itself, such as the history of life, the study of the fossil record (paleontology), or the emergence of higher groups.

And there are indeed plenty of subjects to talk about. The nature of the paleontological record is as much about extinction and distribution as it is about first appearances, and as much about geology as biology. Topics include the dating and deposition of sedimentary rocks and fossils, global distribution of fossils and continental drift, and causes of mass extinctions such as supervolcanic activity. Other studies come under the scope of climatology and astronomy, such as extreme climatic cycles, fluctuations in the earth's orbit and tilt, and meteoric impacts. To group together such an assortment of subjects under the lazy terms 'evolution' or 'macroevolution' is an abandonment of critical thinking.

During the last two decades there has been a growing aspiration to construct the history of life using molecular evidence. This theoretical approach, based on DNA sequencing, mutation rates and molecular clocks, is in contrast to the empirical methods of paleontology. Predictions based on molecular techniques rely on assumptions about common ancestry, transmutation, and rates of mutation that lead to circular conclusions based on the original assumptions. Interestingly, lines of descent drawn from these genetic analyses do not always concur with those constructed from the fossil evidence. It remains to be seen whether attempts will be made to define macroevolution in terms of demonstrable genetic mechanisms.

A Gradual Process

Another set of definitions, though less commonly used, express macroevolution in terms of process:

> Macroevolution, or evolution of superspecies taxa, is the process of transformation of "organismal" life flows on the Earth during its geological history.
>
> I. A. Vislobokova, *Paleontological Journal,* 2017.

The notion of process introduces much ambiguity. Is 'process' referring to fact or theory? Is it referring to one process, or to many processes? Is it referring to process that is well understood, such as natural selection, or to process that is poorly understood, such as the material basis for large-scale transmutation? Defining macroevolution as 'the process of transformation' is therefore uninformative and misleading, since we do not know exactly what the process is, or how it works.

Still other definitions combine evolution as the history of life with the Darwinian notion of gradualism, or a gradual process:

> Evolution: The gradual process by which the present diversity of plant and animal life arose from the earliest and most primitive organisms, which is believed to have been continuing for at least the past 3000 million years.
>
> *Oxford Dictionary of Biology*, 2019.

But is the history of life a gradual process? Tom Kemp, curator of the Oxford University Museum of Natural History, did not think so in 1985:

> Before the early 1970s, most palaeontologists interpreted their fossil records in the light of the prevailing view of how evolution works, the neo-Darwinian, or synthetic theory. Thus they attributed differences in the fossils found at different points in geological time to natural selection acting on individual organisms, causing gradual evolutionary change in a more or less continuous fashion.
>
> …palaeontology is now looking at what it actually finds, not what it is told that it is supposed to find. As is now well known, most fossil species appear instantaneously in the record, persist for some millions of years virtually unchanged, only to disappear abruptly – the "punctuated equilibrium" of Eldredge and Gould.

Not everyone agreed with Tom Kemp's assessment of the fossil record in 1985, and not everyone agrees with it now. Today there is a broad consensus that some species appear and disappear gradually in the fossil record and some abruptly. Certainly huge numbers of species disappear suddenly during mass extinction events, and not by some gradual process. Concerning the origin of groups above the level of species and genera, Kemp himself (2007) appears to portray a more gradualistic interpretation:

> However, the fossil record indicates that the length of time it takes to complete the assembly of all the new characters associated with the origin of a new higher taxon such as a tetrapod, a bird, or a mammal from the common ancestor shared with its living sister group is counted in tens of millions of years…

Statements such as these require clarification. It may be that new characters appear collectively over tens of millions of years, concealing the fact that each individual character may appear at short intervals during that longer time scale. And there is certainly evidence of some higher taxa appearing in a non-gradual way: all modern orders of mammal – rodents, bats, primates, etc. – appear suddenly in the record following the end-Cretaceous extinction event. Many taxonomic groups appear as well as disappear abruptly in fossil chronology, and so introducing the idea of gradualism as a definitive feature of macroevolution or evolution is a preconception of Darwinian thinking rather than an observation of fossil evidence. Here we have an example of evolution being defined in a way that is not representative of all the facts.

In order to preserve the important distinctions between fact and theory, fact and interpretation, and fact and assumption in the history of life, it is best to avoid the term 'process' as well as the terms 'macroevolution' and 'evolution'. Unknown mechanisms of large magnitude transmutation should not be referred to as a 'process' or 'gradual process', since no such process has yet been revealed. In preference to speaking of 'the process of evolution' or 'the process of macroevolution', far greater transparency is communicated by speaking of *theories* pertaining to the origin of levels of organisation, the origin of body plans, and the origin of higher taxonomic groups.

The Fundamental Mechanism – Natural Selection

In the public consciousness, and to some extent in the scientific community, there is a tendency to equate evolution with its essential principle, natural selection. Not surprisingly, this principle features in some definitions:

> Evolution: The process by which different kinds of living organism are believed to have developed from earlier forms, especially by natural selection.
>
> *Concise Oxford English Dictionary*, 2011.

> In biology, evolution is the change in the characteristics of a species over several generations and relies on the process of natural selection.
>
> Yourgenome.org, accessed 2020.

> The theory of evolution by natural selection… is the process by which organisms change over time as a result of heritable physical or behavioural traits.
>
> Livescience.com, accessed 2020.

> Microevolution: Evolutionary change within species, which results from the differential survival of the constituent individuals in response to natural selection.
>
> *Oxford Dictionary of Geology & Earth Sciences*, 2013.

Yet the emphasis on selection ignores the other major component of evolutionary theory: sources of variation. Other mechanism based definitions, to their credit, include natural selection as only one of several causes:

> Evolution (Definition No.1): The change is genetic composition of a population over successive generations, which may be caused by natural selection, inbreeding, hybridisation or mutation.
>
> *Biology Online Dictionary*, accessed 2018.

> Evolution (Biology): Change in the gene pool of a population from generation to generation by such processes as mutation, natural selection, and genetic drift.
>
> Dictionary.com, accessed 2020.

And we could add gene flow and gene transfer to the list of causes of variation.

Definitions of evolution focusing on natural selection have a simple and memorable appeal, but offer small semblance to reality. Selection by itself explains very little, and practical observations of selection in the wild rarely result in evolution in the sense of producing new species. Conversely, it is perfectly possible to scientifically study natural selection without interpreting it as, or even giving mention to, evolution.

Descent with Modification and Common Ancestry

Definitions of evolution as common descent with modification can be remarkably economical:

> Biological evolution, simply put, is descent with modification.
>
> *Understanding Evolution,* evolution.berkeley.edu (accessed 2018).

> In a biological context, the word evolution is best defined by three words: descent with modification.
>
> *Digital Atlas of Ancient Life* (accessed 2020).

Other authors expand a little more on the meaning:

> Evolution may be defined as any net directional change or any cumulative change in the characteristics of organisms or populations over many generations – in other words, descent with modification.
>
> J. A. Endler, *Natural Selection in the Wild*, 1986.

And others still, elaborate on the importance of common descent as the central concept of evolution:

> The “Big Idea” is that living things (species) are related to one another through common ancestry from earlier forms that differed from them. Darwin called this “descent with modification,” and it is still the best definition of evolution we can use, especially with members of the general public and with young learners.
>
> Eugenie Scott, *Dealing with Antievolutionism*, 1996.

The problem with defining evolution in terms of descent with modification is that ‘descent with modification’ is a poorly defined idea in itself. It draws no distinctions between common ancestry envisioned on vastly different scales, between observational fact and conjectural theory, or between natural and artificial means of alteration over generations. Before defining evolution, the requirement here is to clarify what is meant by descent with modification.

When Eugenie Scott described the ‘Big Idea’ in evolution she was not simply referring to the fact that varieties of potato or breeds of domestic pigeon have been bred from common parentage: the implication is that all plants and animals on Earth are distantly related according to Darwin’s tree of life. The scientific term for this principle is *universal common descent* or *universal common ancestry,* and may be defined as follows:

> Universal common ancestry (UCA) is a pillar of modern evolutionary theory. As first suggested by Darwin, the theory of UCA posits that all extant terrestrial organisms share a common genetic heritage, each being the genealogical descendant of a single species from the distant past.
>
> Douglas Theobold, *Nature,* 2010.

Though widely assumed to be a fact, note that universal common ancestry is defined here as part of evolutionary 'theory'. Some researchers consider the statistical molecular evidence is still 'not sufficient enough to reject the alternative hypothesis of the separate origins of life' (Yonezawa and Hasegawa 2010). In actual fact, the debate over single or multiple origins only concerns the primordial, simplest unicellular organisms. Whether the entirety of life, living and extinct, descended from one, or two such originally developed forms, the principle is much the same. When evolution is defined in terms of 'descent with modification', the tacit assumption is that of universal common descent or something very close to it.

The real challenge to common descent is not the principle but the process. In attempting to account for the history of life on a grand scale, whether we call it evolution, macroevolution, or universal common ancestry, the same old problems present themselves: what are the natural law processes that can elucidate the origins of levels of complexity and large-scale transmutation? Theories, hypotheses and speculations abound, but none have so far garnered universal acceptance.

Defining evolution as descent with modification encourages the subconscious blurring of fact and fiction. We all know that breeds of cattle or varieties of cabbage can each be bred from common ancestors? But to conceptually equate this artificially directed process with some natural law process that explains the common ancestry of sea lions with seaweed, is an unsupported leap of imagination. In a notional sense it may still be 'the best definition of evolution we can use'; but 'descent with modification' is undoubtedly the most beguiling segue from science to science fantasy.

Focus on Species

Many definitions of evolution focus on the concept of species and how new species are formed:

> This slow descent with change of one species from another is called *evolution*.
> Alex Novikoff, *Climbing Our Family Tree*, 1945.

> Evolution (Definition No.2): The sequence of events depicting the development of a species or of a group of related organisms; phylogeny.
> *Biology Online Dictionary*, accessed 2018.

> Evolution (Biology, Definition 2a): Changes in the genetic composition of a population during successive generations, often resulting in the development of a new species.
> *The Free dictionary*, accessed 2018.

Note that the focus is invariably on species alone, except in the second definition which adds the uninformative phrase 'group of related organisms' – uninformative because, according to the theory of universal common ancestry, all organisms are related. Definitions never expand into 'descent with change of one genus', or 'the development of a family', or 'the development of a new order'. Yet the silent assumption in all these definitions is that what applies to the formation of species must also apply to the formation of higher taxa. It is an assumption that may well be wrong. The third definition, incidentally, contains another false assumption: changes in genetic composition do not ‘often’ result in the development of new species; they do so very rarely.

The phrase ‘origin of species’ is indelibly associated in Western culture with Darwin, evolution and changing world views; and yet the origins of classes, orders and families, let alone phyla, are far greater unresolved mysteries. Once again, the assumption is that ‘origin of species’ must incorporate the origin of all taxonomic levels by simple extrapolation. Defining evolution in terms of species and the origin of species is therefore especially misleading, because it simply *cannot* be assumed that divergence between species and divergence between higher taxa were achieved by the same process.

The process or processes that lead to the origin of new species are commonly and variously described as evolution, microevolution, and macroevolution. But the precise and unequivocal term for this process is *speciation*. In the pursuit of clear and accurate science, it is speciation that needs to be defined and not evolution:

> Speciation: The development of one or more species from an existing species.
> *Oxford Dictionary of Biology*, 2019.

> The other evolutionary process is true speciation, or what Romanes in 1897 called “the multiplication of species in space”. It is the splitting of an originally uniform species into several daughter species.
> Ernst Mayr, *Animal Species and Evolution*, 1966.

Mayr refers to speciation as ‘the other evolutionary process’ to distinguish it from linear genetic change without splitting. The example he gives of the latter is,

> It is quite possible to have evolutionary change without any multiplication of species. An isolated population on an island, for instance, might change in the course of time from species *a* through *b* and *c* into species *d* without ever splitting. In the end there will be only one species on the island just as in the beginning.

But the distinction between the origin of species through linear change or through branching is far from clear cut. In Mayr’s example the island population has admittedly not given rise to new species by splitting within itself, but it has nonetheless split and diverged from the mainland population from which it originated. Populations may develop into new species with or without splitting, but the process of genetic change may be much the same in both cases. The insistence that speciation through branching is somehow a separate process from the origin of a new specie through linear change is therefore somewhat illusory, and the simpler definition of speciation as ‘the development of one or more species from an existing specie’ covers all scenarios.

Some definitions of speciation are best avoided altogether because they define the process in terms of ‘evolution’, the very word in need of deletion in the first place owing to its duplicity of meaning . For example,

> Speciation: Evolution of reproduction isolation within an ancestral species, resulting in two or more descendant species.
> Douglas Futuyma, *Evolution*, 2009.

But we need only substitute the philosophically loaded word ‘evolution’ with the neutral word ‘development’ in order to render this particular slant on speciation acceptable to all.

The term ‘speciation’ helps to dispel much fuzzy thinking. Scientists may call insecticide resistance or camouflage change in moths ‘evolution’ or ‘microevolution’, but they could not call such things ‘speciation’. At the other end of the scale, the term ‘macroevolution’ may cover everything from the origin of species to the origin of phyla; but ‘speciation’ is a much more clearly defined term and refers only to the origin of species. If we wish to explore the origin of a class or order, then we talk about the origin of that class or order: we do not talk about evolution or macroevolution.

Genetic Definitions and Microevolution

In academic science and college education the family of definitions most commonly encountered are those that view evolution in terms of genetics. Here are a few examples:

> Since evolution is a change in the genetic composition of populations, the mechanisms of evolution constitute problems of population genetics.
>
> Theodosius Dobzhansky, *Genetics and the Origin of species*, 1937.

> Evolution (Definition No.1): Changes in the genetic composition of a population during successive generations.
>
> *Larousse Dictionary of Science and Technology*, 1995.

> Changes in allele* frequency in a population are the basis of evolution.
>
> Jones & Gregory, *Cambridge Advanced Sciences: Biology 2*, 2001.

> Biological evolution may be defined as a change in the frequency of an allele through time.
>
> Michael Majerus, *The Peppered Moth*, 2004.

> The fundamental process of evolution is a change in the inherited characteristics of a population or species. It is an alteration of the genetic composition of a population.
>
> Douglas Futuyma, *Evolution*, 2009.

Note that these genetic definitions of evolution are indistinguishable in meaning from this genetic definition of microevolution previously cited:

> Microevolution is defined as changes in gene frequency in a population from one generation to the next.
>
> *Study.com*, accessed 2018.

The single process view of evolution, at all levels, is therefore implicit in genetic definitions. And yet, much of what is studied under the title of microevolution – building genetic resistance to rat bait for instance – has little to do with evolution in its

* Alleles are alternative forms of the same gene, giving rise to variation in expressed characters.

primary meaning of origin of species. Microevolution and evolution may therefore describe radically different outcomes, despite the fact that the two terms share a common genetic definition.

On reflection one can see that genetic definitions suffer the same failing as other attempts to define evolution: they are too conceptually broad to have any purposeful meaning. There is no distinction between natural and artificially induced genetic changes, between fluctuating and directional genetic changes, or between genetic changes on vastly different scales.

In practical application a 'change in genetic composition' could refer to a single gene substitution, or to a 10% modification of the entire genome. It would be unusual for any sexually reproducing population not to show some small change in allele proportions over a few generations, if only through the mixing of genes and the loss of certain individuals. Taking the idea of 'changes in allele frequency' literally, almost every offspring born to every parent could be called 'evolution', rendering the genetic definition of evolution an utterly meaningless concept.

Improvements to the wording include the qualifications that changes must be cumulative, and must result in the formation of a new specie:

> Evolution: The cumulative change in the genetic composition of the population of an organism over succeeding generations, resulting in a species totally different from remote ancestors.
>
> *The Chambers Dictionary*, 2006.

But very few versions of the genetic definition of evolution, or microevolution, conform to these tighter parameters.

An inability to separate phenomena that could lead to speciation from those that could not, is the basic genetic definition's most critical flaw. Consider the migration of Europeans to the Americas beginning in the 16th century, followed by the importation of African slaves. Human populations that had developed into distinct races through thousands of years of geographic isolation on separate continents, were now brought back into contact. This example of *gene flow* has had a marked effect on the genetic composition of the indigenous peoples, and certainly conforms to the genetic definition of evolution. Yet this represents a merging of populations, the complete opposite of the divergence that is required for the process of speciation. It seems nonsensical that a change in genetic composition that arrests or reverses the possibility of speciation should be defined as 'evolution'.

Gene flow, genetic drift and natural selection all affect the frequencies of alleles in populations, but in the great majority of observed cases that is all they do: speciation is not the result. Clarification is simple enough: when we study sources of genetic change in populations, such as gene flow, drift or selection, we define this area of study as population genetics, not as evolution.

It is now customary to refer to pathogenic viruses and bacteria as 'evolving' in response to drugs or the body's natural immune system. Before evolution became the pervasive theme it is today, micro-organisms were said to mutate, adapt, develop resistance or develop new strains. Any process that causes genetic change in populations is most accurately identified and understood by its own specific terminology, and least well understood by being notionally defined as 'microevolution' or 'evolution'. No origin of species, no evolution.

Defining evolution only in terms of population gene frequencies also assumes that sudden, large mutations in individuals have never influenced the course of biodiversity – an assumption that has been repeatedly questioned ever since Thomas Huxley first challenged Darwin's insistence on gradualism. Examples of 'single event' evolution might include some of the most important organisational steps in the early history of life, such as the origins of cell organelles or sexual reproduction.

Although genetically-based definitions are generally considered the 'standard' or 'scientific' choice, they are not favoured by all:

> When we discuss organic evolution, we must be especially precise. Here I part company with many of my colleagues: I do not find the traditional "evolution is changes in gene frequencies through time" to be a useful definition, even if it were modified to "cumulative changes in gene frequencies through time."
>
> Eugenie Scott, *Dealing with Antievolutionism*, 1996.

Scott felt that 'descent with modification' was a simpler and less technical definition for fresh students and the public. But veteran biologist Ernst Mayr objected much more strongly to the genetic definition, arguing it was wrong:

> Geneticists said that evolution is a change in gene frequencies among populations. But this is nonsense. Changes in gene frequency are the *result* of evolution, not the mechanism.
>
> Ernst Mayr, *Skeptic* Magazine, 2000.

In 1988 Mayr suggested his own, non-genetic definition: 'Evolution is change in the adaptation and in the diversity of populations of organisms.'

Of all the definitions of evolution so far discussed, those based on genetics are the most vacuous. They are too diffuse in meaning, and describe phenomena that do not, or do not usually, lead to the origin of species. Genetic definitions perpetuate the illusion that any kind of genetic change, however small or insignificant, should be labelled 'evolution'. This is perverse, because many academics consider genetic definitions to be the most 'scientific'. As an area of study, 'microevolution' is more clearly understood as 'population genetics', and the mechanisms that are observed in that area of study, such as mutation, adaptation, selection and drift, are best identified by their own terminology, and not by the nebulous term 'evolution'.

Post-Genetic Definitions: Epigenetic Inheritance

> Traditional studies are based on the thinking that genetic information in the genome is the mediator for inheritance between generations. However, it is becoming increasingly evident that epigenetic factors independent of DNA sequence can also play important roles in the transmission of specific characteristics.
>
> Wei *et al., Human Reproduction Update*, 2015.

Since the 1990s 'epigenetics' has increasingly become a topic of considerable controversy in the scientific literature, with some authors claiming it represents a revolution in genetics and evolution, and others dismissing such claims as hype. The whole concept of epigenetics is problematic, not least because the term has been applied to many differing concepts. But the common thread that runs through historical changes to the meaning of epigenetics is gene regulation: the processes that activate or repress genes during development, and maintain those altered states through cell division.

The 'epi' in epigenetics suggests a level of control 'over' or 'above' genes, managing or even dominating their expression. However, epigenetic effects on specific genes are facilitated by enzymes, other proteins and various forms of RNA, all of which are encoded by other genes. The relationship between genes and their epigenetic regulators is therefore characterised by a dynamic interdependence, and the conceptual boundary between what is perceived to be epigenetic and what is simply genetic is somewhat fluid. To illustrate this entanglement, the term 'epigenetics' is generally used today to describe heritable changes that are not the result of changes in DNA sequence, yet various authors have pointed out that 'epigenetic' modifications in plants are often associated with nearby insertions of repeat or mobile genetic elements (Weigel & Colot 2012, Turck & Coupland 2013).

It should be made clear that epigenetic modifications to genes are not responsible for all the regulation of gene activity; much of the switching on and off of genes during normal development is accomplished by the productions of other genes operating at different hierarchical levels. But a dawning of the potential significance of epigenetic systems is realised in, for instance, metamorphic insects. The morphological difference between larval and adult stages is extreme, yet both develop from the same genome. The implication here is that the morphological difference between two species may be due not simply to a divergence in their DNA, but also to the expression of their DNA.

Terminology used in epigenetic studies tends to shadow the language of genetics, giving rise to expressions of epivariation, epimutation, epialleles, epigenomes, epigenotypes, epigenetic drift, and population epigenetics.

Research in molecular biology is revealing the epigenetic/genetic interface to be extraordinarily complex, as captured by this editorial comment in *Nature* journal:

> The complexity of genetic regulation is one of the great wonders of nature, but it represents a daunting challenge to unravel.
>
> Nature Editorial, *Nature* 2010.

Epigenetics is undermining the old adage, 'it all comes down to the genes', and evolution is now being defined in new ways. The workings of epigenetic processes, and how they can influence variation, adaptation, inheritance and even speciation without any alteration to DNA sequence, may be grasped through a summary of some of the more familiar examples.

Common Toadflax

The *peloria* variant of the common toadflax flower *Linaria vulgaris* was known to Linnaeus in the 18th century, but it was not until the 1990s that this atypical 'sport' was found to arise not through a genetic mutation but by an epigenetic mutation. The 'epimutation' has a dramatic effect on the appearance of the snapdragon-like flower, altering its normal bilateral symmetry into a radially symmetrical form. *Peloria* can appear spontaneously in a population, in an individual, or even in a single stem; but it can also be inherited from one generation to the next.

The molecular mechanism associated with this type of epigenetic effect is known as *DNA methylation*, whereby a methyl group is attached to part of the DNA molecule. In the case of *peloria*, methylation marks a floral symmetry gene causing it to remain inactive. When the gene is copied during cell division, or during the formation of gametes (egg or pollen), the methylation mark may be copied along with it.

The significance of this epigenetic phenomenon is that a new morphological trait can arise and spread in a population without any change in the frequency of genes. Here, then, is an example of an apparent evolutionary change that does not conform to the standard genetic definition of evolution. But the *peloria* mutation is unstable with spontaneous reversions to the typical form sometimes observed, and there is no suggestion that a radial symmetry is advantageous or adaptive. There is no evidence, therefore, that this variant could become selected for or 'fixed' in a population. Given that the number of known naturally occurring epimutations in plants is 'only about a dozen' (Weigel and Colot 2012), current evidence suggests it is unlikely that epi-mutations have contributed greatly to global floral variation or diversity.

Thale Cress

Vernalisation, the process by which spring flowering is induced following prolonged exposure to low winter temperatures, has been studied in some detail in thale cress *Arabidopsis thaliana*. The molecular pathways that enable this flowering response to temperature change are very complex and involve many genes and their productions; but central to the mechanism is the epigenetic regulation of a flowering inhibitor gene.

The epigenetic 'memory' of winter does not employ DNA methylation, but uses a different mechanism know as *histone modification*. Histone proteins form the scaffolding around which DNA is coiled, and chemical changes to these proteins (which may involve another form of methylation) change the physical structure of the DNA packaging such that genes are blocked from activity.

In the same way as individuals and populations show natural variation in their genes, there can also be natural variation in epigenetic gene regulation. An example of this variation is observed between the winter memories of thale cress and the closely similar specie alpine cress *Arabidopsis alpine*. Both species make use of a similar, though not identical gene to encode a protein that inhibits flowering. In young plants the flowering inhibitor is active until the onset of winter, when a prolonged period of low temperatures induces a response that suppresses the inhibitor gene by epigenetic histone modification. The development of flowers then begins during late winter and early spring. Upon the return of warmer temperatures the behaviour of the two species then differs. In the annual thale cress the epigenetic effect is stable and flowering continues through the spring and summer; but in the perennial alpine cress the epigenetic effect reverses and flowering is limited to a short period.

The contrast in flowering behaviours is related to the respective life histories. The annual specie diverts all energy and growth into the production of flower and seed before the plant dies; the perennial specie limits flowering and then puts on leaf growth to store energy for the following year. Epigenetic regulation of flowering duration can therefore be adapted to benefit different species. Assuming thale and alpine cresses have a common recent ancestor, it would appear that natural variations in epigenetic regulation have been selected during the process of specie divergence.

Is this an example of epigenetic variation contributing to speciation without any change in DNA code? Probably not in this case, because such changes in epigenetic mechanisms would usually require changes in the genes that operate them. Might epigenetic variation have contributed significantly to speciation in plants overall? Again, probably not so far as we know, because 'documented cases of variation in development under epigenetic control are still very rare' (Turck and Coupland 2013).

Water Flea and Desert Locust

In animals, the development of offspring is determined primarily by the genes they inherit from their parents. But growth and development are also influenced by the state of the mother's internal and external environments during pregnancy. Two classic examples of *maternal effect* are seen in the water flea *Daphnia cucullata* and the desert locust *Schistocerca gregaria*.

Young *cucullata* daphnid water fleas are developmentally sensitive to the presence of invertebrate predators living in the same habitat. Chemical traces left by predatory midge fly larvae induce late embryonic and juvenile daphnids to grow a helmet-shaped spine above the head, making them difficult for predators to handle. *Cucullata* can therefore develop into two distinct morphs, the helmeted form appearing in proximity to predators and the non-helmeted form persisting where there is no danger of attack. Morphs are likely to be determined by the switching on and off of genes controlling growth of epidermal cells, but the exact mechanism has not yet been elucidated.

This induced morphological defence, however, can also be inherited through maternal effect. Females that have been exposed to chemical cues from predators give birth to helmeted offspring, even when the offspring themselves are not raised in the presence of predators. This cross-generational epigenetic response can therefore pre-adapt each generation to short-term changes in the presence or absence of predators. Helmeted individuals do not survive and reproduce as successfully as non-helmeted, and in the complete absence of predators helmet size reduces over a few generations.

Note that when this adaptive maternal effect was first reported in 1999, it was described as 'genetypic plasticity' (Haukioja 1999) and 'adaptive phenotypic plasticity' (Agrawal et al. 1999). By 2012 the same phenomenon was being interpreted as 'epigenetic regulation' (Harris et al. 2012).

A similar environmentally induced maternal effect is observed in the desert locust. This insect can exist in two morphs or 'phases', recognised as the solitary form and the gregarious form. Locusts that are raised in isolation develop a cryptic green colouration and may be wingless, while their behaviour is typically shy, nocturnal and sedentary. But crowded conditions induce a whole suite of trait shifts in the gregarious form: colouration changes to a conspicuous yellow and black, long wings develop, the body becomes smaller with a larger brain, and individuals swarm together to adopt a day-flying migratory behaviour. Females that have experienced crowding produce offspring of the gregarious morph, and, if crowding continues, the display of gregarious traits reaches a peak over several generations.

The molecular mechanisms that bring about phase transitions are staggeringly complex, and appear to involve the interaction and regulation of thousands of genes. According to Ulrich et al. (2015):

> In summary, increasing evidence points to a pivotal role of epigenetics in controlling phase transitions in locusts, yet definite evidence, i.e. more than correlational, is still lacking.

Epigenetic mechanisms are likely to include DNA methylation and histone modification, as well as other mechanisms involving non-coding forms of RNA. The complexity of these mechanisms, together with the relative infancy of epigenetic research, present a huge challenge to the working out of precise pathways of epigenetic control in phase switching.

Again, the change in language over two decades is perhaps revealing of scientific fashions. Haukioja (1999) mentions ‘inter-generational responses’ in locusts, Bateson *et al*. (2004) refer to ‘developmental plasticity’ in the desert locust, and Simpson and Miller (2007) to ‘phase characteristics’ and ‘polyphenism’ in the same specie. But just a few years later Ulrich *et al*. (2015) titled their review paper *Epigenetics of Locust Life Phase Transitions*.

The maternal effects observed in water fleas, locusts and some other organisms are a form of ‘soft inheritance’ that allows adaptation to fluctuating environmental factors which is much more rapid than natural selection. But whereas selection changes the genetic (or epigenetic) composition of populations, soft inheritance makes use of genetic and epigenetic systems that are already in place – no novelty is being generated.

The Dutch Famine

A ‘human experiment’ on the effects of maternal malnutrition on next generation health was provided by the wartime Dutch Hunger Winter of 1944/45. Research carried out from the 1990s onwards has shown that babies conceived around the time of the famine suffered poorer health in adult life. Diseases found to be more frequent or of earlier onset in this group include type 2 diabetes, coronary artery disease, obesity, cholesterol imbalance, breast cancer and schizophrenia (Veenendaal *et al.* 2012, Tobi *et al.* 2018).

One might assume such health conditions were simply brought about by poor development of the foetus due to lack of essential nutrients. But there is now a body of evidence implicating an adaptive switch to a ‘thrifty epigenotype’ that aids survival in harsh environmental conditions at the cost of greater health problems in later life. For example, increased deposition of fat or a lower metabolism might be adaptations to surviving periods of food scarcity.

Heijmans *et al.* (2008) reported ‘the first evidence that transient environmental conditions early in human gestation can be recorded as persistent changes to epigenetic information.’ The team showed that offspring conceived during the Dutch famine, now in their sixties, had reduced DNA methylation of a gene playing an essential role in prenatal growth and development. Further work on the famine cohort by Tobi *et al.* (2018) found methylation changes to other genes, or regions of genes, involving energy and fat metabolism. Although these epigenetic alterations are correlated with maternal malnutrition, the molecular mechanisms and their specific effects have yet to be resolved.

Research by Veenendaal et al. (2012) concluded that some epigenetic effects could be passed on to a second generation. The grandchildren of women who conceived during the famine were recorded to have increased neonatal adiposy (fat deposit) and a greater tendency to be obese in adulthood. Interestingly, this effect was inherited only from famine cohort fathers and not through mothers. A historical study of three generations in Overkalix, Sweden, documented correlations between food shortages experienced by grandparents and the longevity and health of their grandchildren, including associations with cardiovascular and diabetic deaths. These cross-generational effects also appear to be confined to the paternal line (Pembrey 2010). Gene expression that is inherited by sex-specific epigenetic transmission is referred to as *Genomic imprinting*.

The results of the Dutch and Swedish health studies demonstrate that variation among human individuals and human populations is not only genetic in the traditional sense, but also epigenetic. It is now known that identical twins can have different epigenetic tags on their genes, depending on how well each was nourished in the uterus.

Human and Chimpanzee Divergence

The memetic utterance 'humans and chimps share 99% of their DNA', intended to emphasise the similarity between the two primate species, requires greater scrutiny. A 1% difference in the genome (1.2% to be precise), still represents a significant amount of coded information – about 35 million DNA base pairs (amnh.org, accessed 2019). Further, some genes have a major effect of the structure and functioning of an animal – the expressed *phenotype* – while others appear to do little or nothing. The catchily simplistic meme '99% similar' is now complicated by our increasing knowledge of epigenetic factors.

In a research paper entitled, *Dynamics of DNA Methylation in Recent Human and Great Ape Evolution* (Hernando-Herraez et al. 2013), the author summary begins:

> Differences in protein coding sequences between humans and their closest relatives are too small to account for their phenotypic differences. It has been hypothesized that these differences may be explained by alterations of gene regulation rather than primary gene sequence.

In this 'first comparative analysis of DNA methylation patterns between humans and all great apes', the researchers discovered that numerous genes common to human, chimpanzee, bonobo, gorilla and orang-utan exhibited different methylation patterns between species. These included about 170 genes with methylation states unique to humans, some of which are known to be associated with developmental and neurological features. The results also showed that 10% of all genes tested had significant methylation differences between humans and chimps, much greater than the 1% difference in DNA sequencing seen between the same species. The study reinforced the view that,

> …epigenetic changes contribute significantly to species divergence, and therefore they should be considered in studies of human evolution.

The research team also found that some epigenetic changes in primates were coupled with proximal changes in gene coding, but others were not. In agreement with other researchers, this team noted that the evolutionary implications of epigenetics were still poorly understood, and that the mechanisms involved were also under-explained.

New Definitions

The realisation that alterations in gene expression may in inherited across generations, and that variation can occur without any change in DNA sequence, has led to the redefining of 'evolution' to include transgenerational epigenetic inheritance:

> Evolution: The set of processes that lead to changes in the nature and frequency of heritable types in a population.
>
> Jablonka & Raz, 2009.

> Evolution: Heritable changes in organisms that take place over a period of time involving several generations.
>
> *Dictionary of Science & Technology*, 2007.

> The theory of evolution… is the process by which organisms change over time as a result of heritable physical and behavioural traits.
>
> livescience .com, accessed 2020.

> Evolution is change in the heritable characteristics of biological populations over successive generations.
>
> *Wikipedia*, accessed 2020.

In these updated definitions, the principle of change to the composition of genes in populations has been replaced by the broader notion of changes to all heritable types or characteristics. In becoming wider in scope than traditional genetic definitions, these new all-inclusive definitions dilute the meaning of 'evolution' to an even greater extent, further perpetuating the illusion that any kind of change in genes or their expression should count as evolution.

Apparent Lamarckism

Cases where environmental factors induce alterations in gene expression in subsequent generations, have resurrected interest in the idea of Lamarckian evolution, or the inheritance of acquired characteristics. Among Lamarck's evolutionary ideas published in the early 19th century, he proposed a process whereby the use and disuse of organs, in response to the needs of the environment, could alter heritable characteristics through some internal mechanism. In the Darwinian concept of evolution, the environment interacts with heritable characteristics by selecting or deselecting them; Lamarck believed the organism's response to the environment could actively change its own heritable characteristics. (It is often forgotten that Darwin accepted the 'use and disuse' hypothesis alongside his favoured theory of natural selection: indeed, it formed the basis of his ill-fated 'gemmules' theory.)

Epigenetics has also challenged the long-established *Weismann's principle*, or the theory of continuity of germ plasm. Publishing in 1886, August Weismann proposed that in animals the germ (reproductive) cells were separated from the somatic (body) cells, and that there was no mechanism for germ cells to be modified by the body or the environment. Weismannism became an integral part of neo-Darwinian theory and a hurdle for any form of Lamarckian inheritance; but the principle has now been brought into question by observed transmission of altered methylation and chromatin states.[*]

Examples of *intergenerational defence priming* or *transgenerational stress memory* have now been discovered in a wide range of plants, including wild radish (Agrawal et al. 1999), dandelions (Verhoeven et al. 2010), and potatoes (Kuznicki et al. 2019). Plants that are attacked by herbivores or pathogens produce immune or defence responses, and these responses are often transmitted ready primed to the next generation, even when the attacks are no longer present. As biologist Erkki Haukioja (1999) phrases it, 'if the parents environment affects how the genetic code in the offspring is translated, then certain acquired traits can be delivered to the offspring.'

[*] Much of the debate over epigenetic inheritance is remarkably similar to arguments held between Weismannians and Lamarckians at the end of the 19th century.

Jablonka and Lamb (1995) suggested that, 'different mechanisms of epigenetic inheritance should be understood and studied within a shared evolutionary framework… that acknowledges the Lamarckian aspects of heredity and evolution.' (Cited in Jablonka & Raz 2009.)

Epigenetic memories in plants and in animals are 'pre-evolved transgenerational response mechanisms' (Pembrey 2010) and 'must be the product of Darwinian evolution, which would have produced the (epi)genetic mechanisms that underlie such transgenerational effects' (Weigel & Colot 2012). None of the observations of transgenerational epigenetic inheritance described above are truly Lamarckian, in the sense of the environment directly inducing a novel adaptive trait. However, in their work with cloned dandelions, Verhoeven et al. (2010) found that some methylation changes in offspring were independent of genetic variation, and that stress-induced methylation changes could generate random differences between cloned individuals, thereby increasing variation in the population without any change to the DNA sequence. Such an increase in random variation may present new opportunities for adaptation and selection in times of stress; but once again, this is no truly Lamarckian mechanism whereby the organism might direct the modification of its own heritable traits in response to specific survival challenges.

A New Evolutionary Synthesis?

The rapidly expanding field of epigenetics has prompted a number of theorists and researchers to call for a revision of evolutionary theory. Some argue that the standard genetic model only needs to be extended, while others consider it requires something more radical. Epigenetics is also being invoked to account for the insufficiencies, or perceived insufficiencies, of the standard model, and old ideas of macromutation and saltation (transmutation by leaps) as well as Lamarckism are being revisited. Here is a selection of some of the more provocative comments:

> Experimental results in epigenetics and related fields of biological research show that the modern synthesis (neo-Darwinist) theory of evolution requires either extension or replacement (Noble 2015a).

> By 2004, large-scale genome projects were already indicating that genome sequences, within and across species, were too similar to explain the diversity of life. It was instead clear that epigenetics – those changes in gene expression caused by chemical modification of DNA and its associated proteins – could explain much about how these similar genetic codes are expressed uniquely in different cells, in different environmental conditions and at different times (Nature Editorial 2010).

Jablonka and Raz (2009) concluded that a broader redefinition of evolution allows:

> …possibilities denied by the "Modern Synthesis" version of evolutionary theory, which states that variations are blind, are genetic (nucleic acid-based), and that saltational events do not significantly contribute to evolutionary change. The epigenetic perspective challenges all these assumptions, and it seems that a new extended theory, informed by developmental studies and epigenetic inheritance, and incorporating Darwinian, Lamarckian, and saltational frameworks, is going to replace the Modern Synthesis version of

> evolution. We believe, therefore, that the impact of epigenetics and epigenetic inheritance on evolutionary theory and the philosophy of biology will be profound.

Earlier authors foresaw the controversy, for instance Ho and Saunders (1979):

> We argue that the basic neo-Darwinian framework – the natural selection of random mutations – is insufficient to account for evolution… We propose, therefore, that the intrinsic dynamical structure of the epigenetic system itself, in its interaction with the environment, is the source of non-random variations which *direct* evolution…

The clamour and ebullience for a new vision of evolution is dampened by the conservative view that epigenetics has generated nothing that cannot be amended into the standard model:

> There is no evidence yet that epigenetic variation contributes to evolutionary change, and considerable difference of opinion on whether or not it is likely to do so (Futuyma 2009).

> In college, biologists learn how Darwin and Mendel, whose ideas eventually resulted in the modern evolutionary synthesis, prevailed over Lamarck an Lysenko. Now, from a cursory reading of the literature, it is possible to get the impression that this is changing. But, although epigenetics is clearly enriching modern genetic research, reports of an end to genetics have – in our opinion – been an exaggeration (Weigel & Colot 2012).

> Since the human genome was sequenced, the term "epigenetics" is increasingly being associated with the hope that we are more than just the sum of our genes. Might what we eat, the air we breath, or even the emotions we feel influence not only our genes but those of our descendants? The environment can certainly influence gene expression and can lead to disease, but transgenerational consequences are another matter. Although the inheritance of epigenetic characters can certainly occur – particularly in plants – how much is due to the environment and the extent to which it happens in humans remain unclear (Heard & Martienssen 2014).

> Epigenetics is not a scientific revolution but a set of new mechanisms related to the old concept of gene regulation. While many scientists and science commentators enjoy… the far-reaching revolutionary claims of epigeneticists to have found new principles of hereditary transmission, development, and evolution, others are concerned about the disregard of principles of gene regulation and of evolutionary and developmental biology that have been established during the past 50 years (Deichmann 2016).

There are powerful elements of dogmatism and protectionism attached to neo-Darwinism, and threats to its intellectual hegemony are resisted through hostility and distain, as described by Jablonka and lamb (2015):

> In disciplines as diverse as animal behaviour, plant ecology and epidemiology, it is recognized that through epigenetic inheritance acquired variations can have an impact on later generations. Sadly for us, in our own field of evolutionary biology, with few exceptions, either the significance of epigenetic inheritance is down-played or the subject is treated with hostility; many evolutionary biologists have not bothered to get acquainted with epigenetic research.

Appearing on the Jeremy Vine Radio 2 show in 2019 to promote his new book *Outgrowing God*, Richard Dawkins fielded questions and comments from callers including one caller who was interested in epigenetics. Richard's response was as follows:

> Epigenetics is a much misused term. It actually means little more than development, embryonic development. But it has come to mean in recent years a kind of quasi-Lamarckism, a kind of inheritance of acquired characteristics, which it shouldn't ever have been used to mean… There's a certain amount of evidence, rather dubious evidence, that certain things that happen to you during your life can get transmitted to the next generation, and the word 'epigenetics' has come to be used for that. But really epigenetics is all about the way embryos develop normally: the reason why liver cells differ from kidney cell, differ from muscle cells, is epigenetic. But the word has come to be taken over by people who believe that gets transmitted into the next generation.

The 'misuse' of the term Dawkins dislikes can only mean its misuse by other scientists, including those referenced above. Richard Dawkins's limited understanding of epigenetics appears to be 30 or 40 years out of date, and perhaps he would have done better to have kept abreast of developments in the field rather than focusing on writing another book about God. But Dawkins has good reason to disregard transgenerational epigenetic inheritance: it potentially challenges the gene-centric world view of the selfish gene, something upon which he has built his reputation and personal wealth.

There is no consensus of opinion regarding the potential significance of epigenetic inheritance in the proliferation of biodiversity. While some authors plead for a remodelling of evolutionary theory, others contend that epigenetics is not even a clearly defined subject. It is interesting to note that those who speculate most about the possible impact of epigenetic inheritance, often share a dissatisfaction with the explanatory power of neo-Darwinism. Perhaps the underlying debate is not about epigenetics at all, but about the adequacy/inadequacy of orthodox evolutionary theory in accounting for organismal transmutation. As molecular biology uncovers further levels of complexity and integration in the functioning of living things, attempts at all-encompassing mechanistic definitions of evolution are becoming increasingly more abstract.

Evolution as Theory and Belief

In the teaching of biological sciences few definitions phrase evolution in terms of a theory, and never in terms of a belief. But in general knowledge references evolution may be so defined:

> The term evolution refers to the theory that existing animals and plants have evolved, or developed, through a process of continual change from previous life forms.
>
> *Dorling Kindersley Illustrated Family Encyclopedia,* 2004.

> Evolution: The process by which different kinds of living organism are believed to have developed from earlier forms, especially by natural selection.
>
> *Concise Oxford English Dictionary,* 2011.

And in the sense of an idea in history, Peter Bowler's definition of evolution as a naturalistic belief is repeated here:

> Only in the most general sense can we talk about *the* idea of evolution, as though it were a unified concept. At this level, "evolution" means no more than the belief that the existing structure of the world in which we live in has been formed by a long series of natural changes.
>
> *Evolution: The History of an Idea,* Peter J. Bowler 1989.

The derivatives 'evolutionist' and 'evolutionism' are seldom used in science today, the consensus being that evolution is established fact and no longer considered as postulated theory or belief. But in the broader expanse of thought, to include the humanities, this is not the case:

> Evolutionist: someone who believes in or supports the theory of evolution.
>
> *Cambridge Dictionary,* accessed 2020.

> Evolutionist: a person who believes in the theories of evolution and natural selection.

> Evolutionism: belief in the theories of evolution and natural selection.
>
> *Oxford Learner's Dictionaries*, accessed 2020

Thinking they are the masters of all truth and reality, scientists forget that science is premised upon a philosophy: the philosophy of naturalism. And it is a philosophy with which at least half the world, accepting the existence of God and/or the supernatural, is inclined to disagree. In the light of religion or philosophy, evolution is indeed defined as a theory or belief.

What is 'Evolutionary Time'

The phrase is frequently encountered, but how does 'over evolutionary time' differ in meaning from the less circumlocutory 'over time'? Does the adjective endow the noun with some special or distinct quality? Perhaps miraculous events may be conceived to occur in 'evolutionary time scales' or in the 'evolutionary past', that might not be imagined possible in the normal dimension of time.

If *Homo erectus* is my ancestor, then what further insight is gained by declaring him my 'evolutionary ancestor'? 'Evolutionary lineage' and 'evolutionary relation' are similar examples in which the descriptor is superfluous to the understanding of the relationship.

An 'evolutionary adaptation' is synonymous with an adaptation and an 'evolutionary trait' with a trait, since all adaptations and all traits are believed to have evolved. The 'evolutionary purpose' of a structure or behaviour is unlikely to deviate very far from its purpose, nor its 'evolutionary advantage' from its advantage.

In peer-reviewed journals, evolutionary biologists often talk of groups of genes, metabolic pathways and developmental pathways that are 'evolutionarily conserved'. If certain features are thought to be conserved, that means that they have not changed or evolved; so in what sense are they evolutionary? By the same token, species that are described as 'evolutionarily stable' would appear to be species that exhibit nothing evolutionary.

An 'evolutionary biologist' is distinguished from a biologist only in prestige. Since the principle of evolution is taught to underpin and govern the whole science of biology, there can be no biology without evolution.

No other prefix used in so great a variety of contexts conveys so little in meaning. Professor of geology H. H. Swinnerton (1947, p273) wrote of 'one evolutionary species of fish' succeeding another in the fossil record. Zoologist Julian Huxley (1953, p136) thought that no other specie could threaten man's 'evolutionary dominance'. Botanist David Bellamy (1972, p33) described 'evolutionary plumbing' in vascular plants. Philosopher and author Kim Sterelny (2007, p58) noted that the 'evolutionary temptation' to defect is too great to allow real altruism to evolve. And science writer Bob Holmes (2010, p31) reported that speciation may be a question of 'evolutionary accident-proneness'.

The inclusion of 'evolutionary' in speech and text has become habitual. In his chapter *How Natural Selection Works*, Julian Huxley (1953) introduces 'evolutionary escape', 'evolutionary time', 'evolutionary straight line', 'evolutionary change', evolutionary opportunity', 'evolutionary career', and 'evolutionary trends' within the space of just six paragraphs – with an addition sprinkling of 'evolution' five times and 'evolved' twice. Biologist Kenneth Miller (1999) invokes 'evolutionary terms', 'evolutionary instinct', 'evolutionary adaptation', 'evolutionary logic' and 'evolutionary basis' – not to mention 'evolution' four times – within a single page to explain primate infanticide. It seems that in order to gain an 'evolutionary understanding', common sense and basic logic must be abandoned in favour of 'evolutionary sense' and 'evolutionary logic'.

We cannot distinguish an evolutionary novelty from a novelty, or an evolutionary curiosity from curiosity; neither an evolutionary use from a use, or an evolutionary reason from a reason. The evolutionary origin of a specie is the same as its origin, and the evolutionary fate of a specie is the same as its fate. An evolutionary trend in a fossil series is a trend, and the evolutionary record of life is the record of life. The rate of extinction in the fossil record is not qualified or expanded upon by calling it the evolutionary rate of extinction.

If 'evolutionary' adds no meaning in science, indeed if it has no meaning at all, the question arises as to why scientists so frequently and repetitively interpose the word. Reading from his new book *How to Argue with a Racist* in February 2020 on the BBC Radio 4 series *Book of the Week*, geneticist and broadcaster Adam Rutherford gives us a clue. Referring to his mixed Indian and European ancestry within the context of his British nationality and racial prejudice he has suffered, he confesses,

> I am the evolutionary descendent of colonialisation, empire, racism and some pretty odious ideologies.

Now, aside from the fact that 'evolutionary descendent' means nothing more than a descendent, note that colonialisation, empire, etc. are not causations that give birth to anything evolutionary in a biological or genetic sense. Adam is simply fixated on the word 'evolutionary', and will introduce it whenever and wherever he can, because he does not want his audience to forget that he is an evolutionist. He also understands that 'evolutionary' is a recognised code word for acceptance into the scientific community.

But 'evolutionary' would not have been a word used by the author of *The Animal Creation: A popular Introduction to Zoology* published in 1865. Thomas Rymer Jones, fellow of the Royal Society and professor of natural history and comparative anatomy at King's College London, opened his 450 page account of form and classification in the animal kingdom under a very different veil:

> Among the innumerable beings which crowd this world not one is idle; all are actively employed each in its separate sphere of usefulness, and though they blindly do the work imposed on them by their Great Creator, ignorant of other ways, the grand result is perfect harmony.

And on the final page of the same book he concluded:

> Thus placed above the brute creation, Man forms the culminating point of the great scheme of Nature here below, while his intellectual superiority, and, much more, his immortal destiny, ally him closely with higher and unseen existences.

This Victorian author made no secret of the fact that his science and his religion coalesced into a single world view. Yet, aside from occasional allusions to the 'Divine instructor' investing each animal with its 'duty' in the harmony of Nature, he was confident enough in his faith not to feel the need to drill it through all the zoological descriptions that made up the bulk of the book. Not so the evolutionist, whose faith in naturalism appears to depend on a constant, frankly obsessive repetition of doctrine.

In any other field of science – chemistry, physics, geology – it is quietly assumed that the discovery of knowledge is based on natural law. Only in biology, and of course in evolution, is there this perpetual insecurity to keep self-reminding of the naturalistic premise. 'Evolutionary' simply means 'pertaining to natural law origins', so to keep using the word in a scientific context is tautological, since science is already defined by natural law. Substituting 'evolutionary' with its true underlying meaning results in some rather foolish phrases: naturalistic time, natural past, or natural law origins biologist.

The verb 'evolved' is an equally pointless and meaningless insertion. We know that humans have larger brains and live in complex social groups. But to say that humans *evolved* larger brains and *evolved* to be social animals, adds no further information. Certainly there is no shortage of theories, hypotheses and speculations put forward to account for these human faculties; but many of these ideas are competing, and we have no way of knowing which, if any, are correct. The continual use of 'evolved' creates the impression of a deeper, more scientific understanding that is not actually there. In the same manner, the adverb 'evolutionarily' is intellectually pretentious: if human populations are recognised as diverse, to express them as evolutionarily diverse is mere affectation.

In his book *Finding Darwin's God*, Kenneth Miller uses the word 'evolution' or its derivatives (evolutionary, evolutionist, etc.) an average of about 2.6 times per page.

Contrast this usage with Peter Bowler's average of about 1.7 per (slightly longer) page (including 'evolutionism', a word not used by Miller) in his *Evolution: The History of an Idea*, and we glean a further insight. Miller's book is promoting the acceptance of evolution (to Christians), and he employs the simple tactic of slogan repetition to instil his message – i.e. evolution this, evolutionary that. Bowler's work, on the other hand, is an objective history of the subject; the author has no cause or mantra to promote, utilises a more imaginative vocabulary, and succeeds in conveying a far more incisive and balanced comprehension of evolution within the context of Christian society.

While serving the purpose of indoctrination, repetitive use of 'evolutionary' also reassures both author and student of a shared world view. It confirms acceptance into the established scientific paradigm, where the mere mention of 'creationist' triggers social rejection. There is also the matter of research grants. The classification of a group of molluscs might struggle for funding, where a study into the 'evolutionary relationships' within the group might succeed.

Just as the word 'evolution' lends no further insight into a statement of scientific fact or theory, so its derivatives 'evolutionary' and 'evolved' imitate its semantic vacuity. The highly repetitive use of these words as a constant reminder of the naturalistic premise would be unnecessary in any other science, but biology must contend with the insecurity of ongoing challenges to the veracity of its founding principles. Evolutionary theory has failed as a naturalistic, scientific explanation of origins, and it has become more important to its leading advocates to uphold their materialistic beliefs than to uphold scientific scrutiny.

Humorous Definitions

The humorous approach, which forms the basis of all good satire, is often the most revealing. Humour and satire are employed by Jerry Bergman, professor in the science department at Northwest State Community College Ohio, Darwinian sceptic, creationist and prolific author, in this definition of evolution:

> Evolution is defined here as the progression from molecules to humans purely by natural forces, or progression from the goo to you by way of the zoo as a result of time, accidents, and the outworking of natural law.
>
> Jerry Bergman, *The Dark Side of Charles Darwin*, 2011

Sometimes a definition may be humorous, not because it is intended to be, but because it is so lengthy and convoluted as to defeat its purpose of providing simple clarity. For the most impenetrable definition of evolution ever written I nominate the following glossary entry:

> *Organic evolution*, or *biological evolution*, is a change over time in the proportions of individual organisms differing genetically in one or more traits. Such changes transpire by the origin and subsequent alteration of the frequencies of genotypes from generation to generation within populations, by alteration of the proportions of genetically differentiated populations within a species, or by changes in the numbers of species with different characteristics, thereby altering the frequency of one or more traits within a higher taxon.
>
> Douglas Futuyma, *Evolution*, 2009

Is evolution really so difficult to define; or is the problem more a matter of too many different concepts – i.e. everything – being defined as evolution? It seems that authors may vary the content and style of definition according to whim or wish, and yet no single version is wholly satisfactory. No other term in science is permitted such flexibility and subjectivity of definition, prompting the conclusion that 'evolution' is not a legitimate scientific term at all.

Life Without 'Evolution'

In his BBC Radio 4 series *The Life Scientific*, presenter Jim Al-Khalili interviewed in 2019 Senior Curator of Diptera and Syphonoptera Erica McAlister. Erica spoke of the number and diversity of fly species; of species new to science and of morphologically similar cryptic species; of fruit flies, the most genetically studied laboratory animal; of DNA, genes, genetics, genomes and populations changing over time; of fly maggots used to clean wounds in hospital, and many other topics. Not once, in the entire 30 minute program, did she use the words 'evolution', 'evolved' or 'evolutionary'. It was refreshing to hear a scientist talking about biology without resorting to the 'e' word, and her stories and explanations were all the better for it.

It would not be realistic to expect all those working or educating in the life sciences to eliminate 'evolution' from their vocabularies – the habitual addiction to the word is too engrained. But personal resolution is another thing. Those who so wish, may study and discuss the natural world and the history of life by adhering to terminology with clear and unambiguous meaning, and without using language that imposes any naturalistic or materialistic world philosophy. Free-thinking individuals, who care little for the false doctrines to which the blind and the passive succumb, may elect to live their own life without 'evolution'.

Summary and Conclusions

The term 'evolution' is applied to so broad a miscellany of principles and ideas, that it is impossible to produce a single definition that suits all purposes and perspectives. It is a term that draws no distinctions between science and philosophy; nor between observation and speculation, fact and theory, nor indeed between theory and belief. It combines the natural with the artificial, and treats organic divergence on vastly different scales as a single concept. Evolution knows no boundaries and excludes no assumptions. The repetitive, almost obsessive inclusion of the term throughout all scientific literature and scientific education has no bearing on precise and accurate science, and merely reflects an expected deference to the ruling materialistic world view.

The terms microevolution and macroevolution, in sympathy with the mother term 'evolution' from which they derive, have no consistent or precise definition in science and are similarly loaded with assumptions and preconceptions. There is no agreement among biologists and paleontologists as to whether these terms relate to one process or two, or as to where the dividing line between them should lie. In the interests of encouraging exact science and clarity of thinking, all three terms – evolution, microevolution and macroevolution – are best avoided where possible.

Topics long shackled together under the umbrella term 'evolution', such as the history of life, speciation, adaptation, population genetics, and many more, are far better comprehended within the scope of their own language and limitations, and not under the imposition of a grand, universal 'theory' or dogma. To eliminate the word 'evolution' is to eliminate the notion, and how strange that must seem to those deeply under the spell of its indoctrination. And yet to unshackle is to liberate. The natural world has so much more to communicate than just function and survival.

Increasing evidence of transgenerational epigenetic inheritance is challenging the gene-centric theory of evolution. Epigenetically transmitted traits arise in populations without any change in gene frequency, and do not conform to the standard genetic definition of evolution or to the laws of classical genetics. The concept of a stable genome directing the phenotype is being superseded, according to some authors, by that of a more plastic genome functioning in a bidirectional relationship with the phenotype and its environment. New definitions of evolution, broadened to include epigenetic inheritance, are now so general in meaning as to be almost meaningless.

Despite repeated public proclamations that 'there is no controversy about evolution in science', there is considerable controversy about the significance of epigenetics in the field of evolution. While there is no example of a truly Lamarckian novel trait, there is accumulating evidence that epigenetic DNA methylation patterns are as important to specie divergence as the DNA itself. Researchers on one side predict that epigenetics will rewrite our understanding of evolution, as those on the other dismiss the whole topic as a misinformed fad. Several authors (e.g. Lederberg 2001) have complained that the term 'epigenetics' is a polysemy (word of many meanings) and should be abandoned. If we are to abandon terms on these grounds alone, then surely 'evolution' presents a far stronger case.

It is extremely pertinent to the epigenetics evolution debate that the embryologist and geneticist Conrad Waddington, who coined the modern use of the term 'epigenetics' in 1942 and is regarded as a founding influence in developmental biology, was an open sceptic of Neo-Darwinian genetic theory:

> C.H. Waddington is today remembered chiefly as a *Drosophila* developmental geneticist who developed the concepts of "canalization" and "the epigenetic landscape." In his lifetime, however, he was widely perceived as a critic of Neo-Darwinian evolutionary theory. His criticisms of Neo-Darwinian evolutionary theory were focused on what he saw as unrealistic, "atomistic" models of both gene selection and trait evolution. In particular, he felt that the Neo-Darwinians badly neglected the phenomenon of extensive gene interactions and that the "randomness" of mutational effects, posited in the theory, was a false postulate. This last criticism dealt with the phenomenon known today as "developmental constraints." Although population genetics itself has evolved considerably from its form at mid-20th century, much of Waddington's critique, it is argued here, retains cogency.
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> Adam S. Wilkins, *Biological Theory,* 2008.

> Waddington regarded himself as a Darwinist since Darwin also, in *The Origin of Species,* included the inheritance of acquired characteristics. But significantly, Waddington was not a Neo-Darwinist since Neo-Darwinism, following Weismann, specifically excludes such inheritance. Waddington was a profound thinker about biology, and much else too. *The Strategy of the Genes* is a masterly account of the many reasons why he dissented from Neo-Darwinism, and it has stood the test of time.
>
> Denis Noble, *Journal of Experimental Biology,* 2015(b).

It thus becomes clear that those who embrace epigenetics as a path of discovery toward a new mechanism of evolution, are often those who, in the spirit of Waddington, express dissatisfaction with current theory; and that those who downplay the evolutionary significance of epigenetics are usually those who defend the orthodox position. The controversy surrounding epigenetics is therefore, in reality, a controversy about the adequacy of evolutionary theory. Yet those on both sides of the argument continue to stand behind the public mantra, 'There is no controversy about evolution in science.'

The solution for epigenetics, as in any other topic in the biological sciences, is to dissociate it from evolution. All speculation and counter-speculation would then cease, and the field of study could progress without the constraints of preconceived dogmatism. In the years to come, epigenetics will no doubt produce further insights into variation, adaptation, and perhaps speciation. Most assuredly, though, it will settle nothing about 'evolution'.

The notion of evolution – and ultimately it is no more than a notion – is so widely broadcast across all domains of contemporary global thinking, that the drumming in of the 'E' word reverberates unchecked in a mechanical and unconscious pervasion. 'Evolution' is the recognised password not just for academic influence, career opportunities, research funds and publishing in the sciences, but for anyone afraid of appearing irrational or foolish in the eyes of their peers. All children receiving a modern education are indoctrinated with the idea that evolution (whatever that may be taken to mean) explains the whole of life, and it is hard for any to escape this mindset when most of the signals they receive in later life reinforce the notion. Only the most independent thinker, unpersuaded by the sway of the majority, can attain a deeper perception: that there is no such thing as a grand, unified theory of life, and to pursue such a thing is an illusion. The teaching of Darwinism, like all entrenched doctrines, and as divisive as any, is as much about tribal acceptance and power as about intended rational enlightenment.

No one can exorcise the world of its many delusions, and the institution of evolution is not going to slip away any time soon. No matter. It is up to each person to decide for themselves what they judge to be delusion and what to be truth. But I can promise you this: language and thought are intimately connected, and changing your use of language will change the way you think.

Arguments about what is 'fact' and what is 'theory' in evolution, sometimes deeply philosophical and questioning of the very nature of science, are frequently encountered. Yet much of the content of evolutionary teaching would be more accurately identified as hypothesis, speculation, assumption, presumption, presupposition, and even fantasy. Introspective awareness of these different rational and irrational trains of thought is greatly enhanced by reconstructing sentences without the 'E' word and its derivatives. In conversations and debates about evolution, persistently challenge what other speakers mean by the terms 'evolved' and 'evolutionary', which they will liberally and lazily use, and introduce vocabulary that forces upon them a much more critical and sharply focused direction of thinking. Do not presume to say that this or that animal or plant 'evolved' to be this or that way, because you then presume to know how it came to be so.

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