



EVOLUTION

How Has Life and Its Diversity Been Produced?

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With complementarity, a fully harmonic interpretation of Bible and nature is, in principle, possible. Both atheistic evolutionism and young-earth anti-evolutionism are unrealistic. Macroevolution is still fully speculative: evolutionary mechanisms are inadequate, evolutionary evidences ambiguous. There are fundamental limits to empirical investigation in the transastronomical size of the combinatorial space of genomes and in the contingency of elementary events. But biblical evidence allows for evolution. The all-embracing providential activity of the Creator and the personal dignity of the human creature are tentatively presented as theological arguments in favor of evolution as God's method of creation.

World Views and Axioms

The question of the origin of life may be approached from various different viewpoints. Much confusion in this area results because presuppositions are not stated, concepts are used without a clear definition, or different categories are confused.

I believe that there is an objective reality or truth, and that we can, partially and in various ways, get to know truth. According to the Old and New Testaments, God is the Creator, and everything else that exists ultimately owes its existence to Him. This is the *theistic* view of creation. In contrast to the *deistic* view, it includes the belief in God's continuing creative activity in sustaining and governing the created realm. In contrast to the *pantheistic* view, it implies that the Creator and the creation are absolutely distinct...without, of course, denying any contact he might choose to have with his creation. *Atheism* (and, in practice, agnosticism) seems to have a close affinity to some forms of pantheism. Its god may be matter-energy itself. Religion appears to be an innate tendency of all humans.

Most Christians believe the Bible to represent a special revelation from God, but do not claim it to be the product of any kind of mechanical dictation by his Spirit. The Bible's

subject is clearly theological: God's dealings with mankind. Anyone trying to deduce non-theological matters from its statements has to keep in mind this primary focus. Nevertheless, the fact of its inspiration implies that treating it merely like any other book would be inadequate. It is God's Word in human words. As such it absolutely transcends human minds, and we are not in a position to judge this "input from above."

This far, all Christians would probably agree, but many do not seem to appreciate that, as a consequence, we do not dispose of the criteria necessary to sort out what is human from what is divine in the biblical texts. Might God be willing to tolerate human errors to be introduced into these writings, as long as this would not thwart his intentions? Being absolutely truthful and kind, he would not want to let any sincere readers of his Word be confused by untruths. His revelation in the Word may be compared with his natural revelation in creation. Natural scientists would not expect to find any genuine inconsistencies in nature. If they do find apparent contradictions, they will be convinced of the inadequacy of their understanding instead. Therefore, I believe the Bible (in its originals) to be free from errors, just as nature is consistent.

Although the Bible's main thrust is clearly theological, not scientific, it does occasionally touch on aspects of nature. I am not advocating the use of such statements as the basis for investigations in the realm of natural science, but I expect that once we have understood them properly, we will not find any errors. Certainly the authors were not infallible, but I believe God kept them from committing any errors to the biblical texts.

Life and Complementarity

Occasional biblical statements seem to contradict what we know from nature. There are two inadequate responses: a philosophical warfare mentality, which considers scientists blind or the Bible out of date; or isolationism, which believes biblical texts are wholly uncorrelated with any non-theological reality. Exponents of these views tend to lack patience with the "biblicism" of those who try to harmonize biblical remarks about nature with the models of natural science.

If the Bible's focus of interest is theological, then why should we want to consider it at all when asking questions about nature? One motivation is apologetic. It is important to show that the alleged conflicts between empirical reality and the Bible are based on faulty interpretations on either side, and that, therefore, there is no excuse for not taking the Bible seriously. It *has* to become clear that one can accept every biblical statement as true, without falling into the trap of subverting science. On the other hand, I expect that a thorough understanding of the real biblical teaching about creation and nature will give us important epistemological guidelines governing our scientific inquiries. As God charged us with cultivating the earth and caring for it, we may trust his Word to support us in this task. Today's debate about the ethics of gene technology is a case in point. And it will clearly be influenced by our beliefs about creation and evolution.

As our comprehension of both nature and the Bible is partial, the models of both natural science and theology remain approximations to the truth, and occasional inconsistencies

between different parts of our view of reality are probably unavoidable. But such difficulties often contain the seed of a deeper understanding if dealt with properly. If they persist after careful scrutiny of the facts on both sides, they may represent complementary aspects of the truth.¹

Physicists have invoked complementarity to describe the apparent contradiction between the wave and particle aspects of light. This unexpected realization has been of help in understanding quantum mechanics, which has proved to provide a deeper insight into physical reality. The tension between the apparently contradictory concepts of God's holiness and mercy lead theologians to a deeper appreciation of the implications of Christ's substitutionary sacrifice on the cross.

The concept of complementarity may also be applicable to questions like the origin of life or the nature of man, where complementary aspects of reality from different disciplines, like natural science and theology, overlap. Here, care has to be taken to respect the different domains of discourse. For instance, *Homo sapiens* fossils may not always represent humans in the theological sense. But such different aspects of the same reality must be fully compatible with each other.² Complementarity *between* nature and the Bible implies the following principles:

(1) As God is the author of creation and of revelation, there must be an ultimate *harmony* between the data from both domains, even though we may not always be able to *conceptualize* it. Truth cannot contradict truth.

(2) The *data* of natural science and of theology have to be distinguished carefully from their *interpretations*, which always remain provisional, subject to revision.

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(3) No observation of science and no biblical statement (the data) may be taken out of its *context* when interpreting it, lest we risk producing an apparent conflict. There are no context-free data. There is no absolute objectivity of interpretation.

(4) *Open questions* are not necessarily inconsistencies. Where we are not able to harmonize all observations, our interpretation must be either faulty or incomplete.

Although life is a phenomenon open to scientific investigation, it remains a largely unfathomed mystery. The simplest autonomously viable entities, bacteria, are so complex that they have not even been analyzed completely - let alone synthesized. Conceiving of how they could have been produced by the interplay of random events on an initially

lifeless earth is an even more demanding task. Multicellular organisms represent enormously more complicated structures, occurring in many fundamentally different forms. How were they produced?

The model of a recent creation is incompatible with the empirical evidence available today.³ It is no longer an acceptable option. Various old-earth creation models do not share this problem, but they do not propose any specific, detailed creation mechanisms. At present, evolution is the only creation model available for scrutiny by the methods of natural science. As the possibility of an extraneous causation and governance cannot be ruled out, life must not be tacitly presumed to have emerged and evolved autonomously. With the model of biological evolution, two main problem areas have to be considered:

(1) Are there, apart from specific divine guidance, *adequate mechanisms* for evolution? Does it work? Is the probability for life of any conceivable kind to emerge and evolve high enough to make it not too implausible at least once in our universe?

(2) Is there *unambiguous evidence* for evolution? Atheists, of course, are dependent on evolution at least somewhere in the universe. For them, there is just no way around it, no matter where the facts point. Theists, on the other hand, are free to rationally weigh the evidence.

In biology, the question of the origin of meaningful information is of crucial importance. In general, this is a very hard problem, which in most contexts and with today's limited knowledge is too difficult to deal with. Therefore, I want to concentrate on a few aspects which I feel might be amenable to some investigation. The issues touched upon will be selected accordingly, while some others will be mentioned in passing.

Microevolutionary Mechanisms

For a realistic evaluation of the adequacy of proposed mechanisms, a clear distinction has to be made between *microevolution* and *macroevolution*. I define a macroevolutionary step or development as any transition producing a fundamentally novel structure and function, based upon a sequence of deoxyribonucleic acid (DNA) which is not derivable from a previous one by means of a series of individually selected mutational steps, but only through a random-walk process involving a series of *nonselcted* intermediates. This definition may not be conventional, but it points out a crucial distinction. The assumption that any macroevolutionary event consists of a series of microevolutionary ones is usually treated as axiomatic. If it holds, any distinction between the two modes of evolution is basically irrelevant. An argument that it does *not* hold⁴ will be summarized below.

The mechanism of *microevolution* consists of three distinct steps:

- (1) Genomes can *mutate*, producing genotypic variants.
- (2) If expressed, these may produce phenotypic *variants*.

(3) Natural (or artificial) *selection* favors the reproduction of individuals better adapted to their environment. In this way, relative fitness values of phenotypic variants with respect to their current environment are defined.

Selection works on those variants which are in fact produced.
Can we always count on some variant able to cope with a given environment
to be available within a reasonable amount of time?

Thus, population gene pools, including their individual constituent gene components, may possibly change with time. The three observations are necessary conditions for evolution to happen. But are they *sufficient*? Selection works on those variants which are in fact produced. Can we always count on some variant able to cope with a given environment to be available within a reasonable amount of time? Could all existing functions arise by these processes?

The feasibility of *macroevolution* implies three more requirements:

- (4) Occasionally, *new functions* must emerge.
- (5) Functions must be *improved*.
- (6) There must be *progressive chains* of improvements.

These additional requirements will be discussed. But first, microevolution needs some further comments.

Apart from point mutations, there are other mechanisms producing variants, but they usually do not create any new *functional information*. A definition of functional (constructive, or semantic) biological information will be given below. Deletions and most insertions destroy such information: sequence shufflings by genetic recombination, transposition, duplication and other mechanisms move preexisting information. These other genome modifications may, of course, have profound functional consequences, often on a regulatory level, but possible constructive effects they might have on their target genes or larger contexts are likely to occur very much less frequently than constructive effects of point mutations.

One has to distinguish between new features produced by shuffling or recombining *preexisting* functionalities, on the one hand, and new functional features which *never existed* before, but arose in sequences having no function, or a different one, on the other hand. Although it might in some cases be difficult to distinguish between these two kinds of novelty, it is clear that many fundamentally new features must have been produced in the biosphere as a whole. Unfortunately, the term "evolutionary novelty" is sometimes

indiscriminately applied to both of these possibilities. The first kind is certainly relevant for the origin of biological information. A recent investigation led to the (still disputed) estimate of 1000 to 7000 basically different protein exon or domain subunit families.⁵

Considerations of *population genetics* are very important in an evaluation of evolutionary mechanisms. A mutation conferring a selective advantage benefits its carrier immediately, but it will take some time to penetrate an entire species. Its fixation, by elimination of the previous wild-type allele, will take even longer. Penetration and fixation times increase not only with decreasing selective advantage, but also with the size of the population. Because individual selective advantages are typically quite small, this implies that large populations are genetically very stable: in these, natural selection inhibits change and promotes stability.⁶ A mutation conferring a disadvantage will usually be eliminated quickly. The frequency of a selectively neutral one will drift, increasing and decreasing randomly. In a large population, it will often be lost. On the average, the general effect of these and other complications (interdependencies between different genes, variability of the environment, etc.) will probably be to make harnessing advantageous, or adaptive, mutations *more difficult*. Thus, considering individual neutral and adaptive point mutations only will tend to overestimate the chances for success of progressive evolution.

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Semantic Information

The set of all possible DNA sequences of a given length N defines a *combinatorial space* of 4^N configurations. For $N=133$, hardly enough for a small functional domain of a protein, this number exceeds the estimated number of nucleons in the universe! But *semantic*, meaningful, functional, or constructive biological information is not defined by this combinatorial space of all possible sequences, since there may be sequence stretches which are meaningless, variable, redundant, or synonymous with others.

The "meaning" of a genome or a gene is defined by its biological function. Human symbolic *languages* provide an instructive metaphor for the DNA "language." Only a limited fraction of the set of all possible symbol sequences has any meaning at all, and the meaning is determined by various factors, such as the context of a given human language, as expressed by its speakers and literature. How large is the semantic information content of a given sentence? It depends on the conventions governing the particular language, on the intention of the speaker, and possibly on the situation of the message recipient. It is probably not too difficult to estimate an average amount of synonymy between words. But how about "synonymous" sentences, abstracts, personal messages, discussions, etc.? It is probably impossible to measure these intensely personal

specifications. Similarly, we can hardly hope to do more than arrive at approximate estimates of lower or upper bounds for the amount of semantic information contained in specific biological messages, such as protein domains or genes.

Can biological semantic information be spontaneously generated? Can it originate without an information source of at least equal semantic content? It is claimed that it is gradually produced by *self-organization* in a long series of microevolutionary events. Environments are certainly capable of modifying gene pools. In a sense, a gene pool "asks questions" concerning its variant genomes, and the environment "answers" them. In this way, some *information* is generated by matching environment and gene pool. Such events constitute a mutational random-walk exploration of the genomic configurational space available by a species.

But the amount of information that can be collected in this way is basically limited by the scope of the set of variants which can be produced. Certainly there is no limit to the mutations possible, but the detrimental ones are eliminated and do not contribute to the functional information eventually stored. In a conceivable extreme case of a genome optimally adapted to its environment, all mutations may be detrimental, and no further information can be gleaned from the actual environment.

But even when far from the optimum, the evolutionary progress will often be frustrated. The macroevolutionary path leading to a selectable better adaptation may contain configurations of lower adaptive value or too many equivalent ones. Most non-detrimental mutations are believed to be selectively neutral. Alternative nonlethal branches leading to dead ends may exist, increasing the number of nonselected steps required - parallel and sequential - for the "wave-front" of exploratory mutants to finally reach a selectable point. With too many dead end branches too many trials are lost on them. With a mutation rate of 10^8 per nucleotide replicated, two-step mutations are already too rare to be observable with bacteria in large chemostats. Non-selected paths have to be very short in order to retain a reasonable chance of realization, before the next uninteresting equilibrium stage with a large stabilized population lacking a genuine novelty is reached. This unfavorable situation does not represent an extreme case, but is characteristic for macroevolutionary paths.

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Natural selection of a new function presupposes a *minimal functionality*: where nothing is selectable, nothing can be selected. This minimal functionality, therefore, must be produced by random processes. The probability of its spontaneous emergence depends on its semantic information content, or the size of the minimal specification required to

define it,⁷ but not on the possible pathways leading to it. It is, however, difficult to estimate the size of such minimal specifications.

One approach might be to consider the invariant configuration of a set of known sequences performing a given function in different organisms. Certain sequence positions are observed to be occupied by the same amino acids in all known versions of a protein of a given specificity. It is then assumed that functionality requires these specific occupations. An analogous argument applies to positions permitting a certain restricted variability. For good measure, all amino acids chemically similar to the ones actually observed at a given position might be added to the set of permissible ones (Yockey⁸). The totality of these restricted occupations found for a given protein type constitutes its invariant configuration. This is a lower-bound estimate for minimal functionality, since positional interdependencies and species-specific requirements are ignored. It may be compared with an upper-bound estimate of the longest feasible non-selected path.

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The result is that reaching a given invariant by a mutational random walk within 300 million years is already too improbable for three specific amino acids.⁹ This estimate, presupposing 3.05 codons per amino acid, 2.16 mutations per specific amino acid change (geometric average), and a mutation rate of 10^8 per nucleotide replicated, is based on very optimistic assumptions: 10^{16} moles C per year metabolized in the earth's biosphere (today's total biomass production) consisting entirely of bacteria (5×10^6 nucleotide pairs and 10^{14} moles C per bacterium), and all of this DNA continuously participating in this particular random walk. Yet *known invariants* comprise not 3, but about *30 amino acids* for basic enzyme functions, such as cytochrome c or ribonuclease¹⁰, or at least 5 amino acids for additional adaptations differing between groups of organisms.¹¹ These requirements are even below the real lower bounds for functionality, as they reflect unique occupations only. At present, it is unknown whether any smaller invariants might provide some minimal functions. The restrictions on functional structures, such as enzymes, are such that all mutations we observe today are detrimental or at best neutral. To suppose otherwise for earlier organisms is speculative.

Thus, the acquisition of the huge amounts of functional information in the biosphere by random processes incurs preposterous improbabilities.¹² It is out of the question that a known invariant could have been found by random processes - unless there are many other, unknown configurations providing the same functionality. In this case, the exclusive occurrence of a single one of all possible configurations would amount to a "frozen accident." It would provide a strong argument for evolution happening, in fact, because in this case common functional selection pressure would not explain the

invariance. But it would also show that it is rather difficult to accidentally hit a new functionality, which in turn would make it hard to understand why so many different functions have been found at all. The number of functional sequences would have to be transastronomically large, or else no lucky hits could be expected. Yet the frequency of a given function among all possible sequences would have to be very small, or else many differe

nt solutions to each problem should have been found in different lines of descent.

Are the functional invariants found in the biosphere *frozen accidents* or evidence of *design*? Does each of them represent just one of a myriad of possible configurational sets or the only functional one? Is functionality in configurational space rather frequent or extremely rare? I know of no indications that it might be frequent; the few relevant observations available point the other way.¹³ Unfortunately, there does not seem to be any way of finding answers to these questions. The configurational space of all possible genomes is by far transastronomical in extent.

To invoke an extraterrestrial origin of biological information may expand the probabilities by at most a few orders of magnitude. Even providing every star in the universe with a life-supporting planet - an assumption which is certainly too optimistic¹⁴- would be insufficient.

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Even for a single protein domain of 100 amino acids, there are 10^{130} different sequences, coded by 10^{180} possible sequences of 300 nucleotides. In analogy to Yockey's¹⁵ estimate, at most one among 10^{64} polypeptides of this length might be expected to display a given enzymatic activity of the rather small complexity of cytochrome c. If there are 10^5 different enzymes, only one among 10^{59} polypeptides of length 100 may have any enzymatic activity at all. To provide just one molecule of DNA coding for each of 10^{59} polypeptides would require 10^{19} earth-sized planets, each containing an ocean 1 km deep, covering the planet's surface, of a concentrated solution (10 mmolar in nucleotides) of single-stranded polynucleotides of length 300. As no "primitive" enzyme activities are known, there is at present no conceivable way to reasonably reduce this estimate. Yet, on the other hand, the smallest viral genome is 10 times larger, the smallest genome of an autonomous organism 10,000 times. This means that it is in principle impossible to cover an appreciable sample of the configurational genome space by any conceivable method of investigation - experimental, computational, or otherwise. Science cannot answer the information problem.

Is Macroevolution Feasible?

I have postulated three requirements for macroevolution, in addition to those necessary for the microevolutionary mechanism: emergence of new functionalities, improvement by positive mutations, and a reasonable prevalence of such constructive mutations to form progressive chains of improvements.

When a *new function* is to emerge, its minimal functionality must arise accidentally, before it can be selected. The possible emergence of a new functionality in a hidden state (in a temporary pseudogene or under cover of a different function) does not change this requirement, since the development of a function which is not expressed must proceed by means of a random walk. Once a minimal function is present, its further improvement by single-step mutations, under the influence of natural selection, is conceivable. But at least the original emergence of this new function must correspond to a macroevolutionary step, which is much more difficult, as has been shown. Every one of the many different biological functions in the biosphere had to arise at least once.

In order to explain how new functional information could arise, the concept of a hierarchy of complexity has been proposed. According to this view, a fundamentally new level of functionality might emerge, once the complexity of the lower level structures has reached a certain degree. These ideas pertain mainly to higher levels of biological complexity than the ones I am discussing here. They certainly describe a biological reality,¹⁶ but do not provide an explanation for the emergence of information in the individual hierarchical steps. The lowest and simplest of these steps, describing the mutational random walk in a DNA sequence, might be the most promising for investigating the origin of information, as much too little is known regarding the higher hierarchical levels. Therefore, I refrain from discussing hierarchy theory any further.

Each of the newly emerged minimal functions must be capable of *improvement* by random mutation - up to the near-perfection usually found in present organisms. This *seems* to be more easily accomplished than the emergence of a new functionality, but it is not self-evident that it is possible. Not even a single "positive" or adaptive mutation, in the sense of an improved function previously unavailable, has been documented in any organism. Takeover of functions from other organisms, by means of episomes, transduction, genetic recombination, allele assortment and the like, cannot be counted as an emergence of a new or improved function in the biosphere, nor can regaining a function lost previously, or the display, under stress, of a temporarily unused function. A function which is available in principle, but not used under normal conditions, may be induced under stress; but it is lost again upon return to a natural-like environment, presumably because it represents an additional burden on the organism. Observed alleles with slightly different functionalities may indeed be related across a few mutations. But as they exist side by side, we have no indication that either of them represents an evolutionary advance. Both of them may be needed for full flexibility in different environmental, anatomical, or developmental contexts. In any case, their relatedness by descent is an inference, not a documented evolutionary improvement.

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There must be *progressive chains* of improvements. This implies that improvements are common, rather than exceptional occurrences. Each of the macroevolutionary mutational paths *between* positively selectable configurations must be very short and proceed by random processes composed of neutral mutations only. A huge number of mutations must have caused successful functional improvements, in order to produce today's biosphere. Furthermore, all parts of the configurational space used by any species must be interconnected, as the biosphere is believed to be monophyletic.

Useful configurations have to be found rapidly, at least by *some* species on earth. There has not been much opportunity for search processes. Four billion years is a very short time and the amount of earthly biomass very small if compared to the immense number of possible DNA sequences! If the *inhabitable* area within the configurational space is an infinitesimally small part of the total, by far the largest part of the possible mutations in any given organism will be detrimental. In all but very small populations, by far the largest part of the remaining ones will be effectively neutral, and only the minute rest may have any potential interest for evolution. The vast bulk of the exploratory trials will be lost - in accordance with relevant observations.¹⁷ The huge amount of sophisticated functional information known to exist in the biosphere would then appear to be sort of a mystery. In order for evolution to be plausible, on the other hand, an appreciable fraction of the combinatorial space would have to contain viable genomes. This certainly applies for the region of the combinatorial space explored by life. But is there a reason to believe this minute corner to be in principle different from any other region? Many *random* DNA sequences would have to contain functionally meaningful stretches! Is this a reasonable expectation? Huxley's typing monkey thought experiment suggests otherwise if actually computed.

Although, as a rule, texts about evolution do not even bother to mention such problems, *none* of these processes required for macroevolution have been documented to occur. Furthermore, requirement (4), the origin of new functions - which is an absolute prerequisite for (5) and (6) has been shown to be likely to involve enormous improbabilities. As long as no hard facts to the contrary are available, this fundamental difficulty must not be ignored!

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Thus, the known evolutionary mechanisms account for microevolution only, while macroevolution at present looks implausible. (Denton¹⁸ forcefully raises the same issue, but does not offer a solution.) Are these mechanisms, therefore, true evolutionary mechanisms at all? If macroevolution does not occur, "microevolution" should not be called evolution at all. It would then merely represent a mechanism for maintaining stability with some variability, possibly some limited change and diversification, including speciation, within a restricted character space, making such a species, genus, or family capable of better coping with changing environments.

Evolutionary Evidences

The second approach to the question of the reality of evolution is to consider the evidences adduced to support it. There is a host of solid observations which can be interpreted in the evolutionary framework. Some of these observations can be subjected to statistical tests and are sometimes shown to be *highly significant*. But the crucial point is that each one of these observations is *ambiguous* as far as its evidence for evolution is concerned. Occasionally, it has been claimed that evolutionary theory has indeed passed critical tests, according to Popper's¹⁹ strong criterion of falsifiability for scientific theories. But in most cases, microevolution alone has been tested.²⁰ In others, tests were done against the implausible null-hypothesis of randomness.²¹ As is shown below, all of these observations are ambiguous because plausible alternative explanations exist, which would make the evidence irrelevant for evolution. It may be difficult to conclusively show which one of these alternative interpretations applies - or possibly both. But as the proposition that there is no Creator is not demonstrable, the possibility that evolution is an illusion has to be taken seriously.

(1) The evidence for highly significant *similarities* between the features of different organisms is impressive. Some of these similarities encompass the entire biosphere, and it is not surprising that for Dobzhansky "nothing in biology makes sense apart from evolution."²² Yet, in each single case, these similarities may be due to similar *functional requirements*. Strictly speaking, the features concerned would then have to be called analogous, rather than homologous. It is in practice impossible to prove that a given feature is absolutely functionless in its total organismal and ecological environment. But if it has any useful function, it is under selective pressure, and the feature just might *have* to be similar in different organisms in order to be functional. Why are there so many occasions where "convergent" or "parallel" evolution has to be invoked?²³ Evidently, there are many similarities which, even in an evolutionary framework, are not indicative of a common descent. Such functionalist considerations may apply even to weak similarities, whose functional significance might be hard to detect. Very little is known, as yet, about context- or species-specific functionalities, or about functional interdependencies among different features. Again and again, DNA sequences once believed to be functionless are discovered to have some function; usually the first indications are nonrandom features. After codon synonymity, 5'- and 3'-noncoding gene

sequences and introns, propositions for third codon positions and at least some pseudogenes²⁴ have joined the list.

Plausible population dynamics models explain why usually no fossils representing the transitions should be found.

But in order to find out whether evolution is real, we need positive evidence, not explanations for its lack.

(2) The similarities with respect to a given feature between different organisms can be used to compute a similarity tree (or cladistic tree) if the feature has measurable aspects. Significantly *similar cladistic trees* of different features, but referring to the same group of organisms, are often found. Does this prove evolution, as has been claimed? The null-hypothesis of a merely accidental similarity between the trees.²⁵ is unreasonable, even within an evolutionary framework, because it ignores possible *functional interdependencies* between the features considered. If there is a dependency between different functions, their cladistic trees are bound to be similar. Such dependencies are not the exception, but the rule! It is astonishing that the possibility of complete independence between different features of a functional organism is even considered.²⁶ Of course, the correlations between functional interdependencies and tree similarities need not be absolute, since the same problem is sometimes solved in different ways - possibly due to other functional correlations.

(3) In the history of life, there appears to be a tendency of an *increasing complexity* of the organisms. Even if it is hard or impossible to objectively define progress in life forms, may not this tendential complexity increase indicate evolution? Not necessarily. It may just as well reflect the requirements of a functioning ecology in the presence of an increasing *diversity* of life forms. Such an increasing diversity, however, may fit a non-evolutionary paradigm just as well.

(4) *Fossils* are *very old*, up to almost one billion years for multicellular organisms, and possibly three billion for single cells. This cannot be reasonably disputed.²⁷ The occurrence of life and death long before the advent of man has to be accepted. Yet this does not rule out *old-earth* non-evolutionary models, such as the one of "progressive creationism." Evidence for a long history of life is not evidence for evolution.

(5) The fossil record displays many obvious *lines of descent*, usually on the taxonomic level of the family or genus. Some of them span millions of generations. It is an outstanding feature of the fossil record that the origin of virtually none of these lines is known.²⁸ We do not see a "tree of life," but something like a "bamboo thicket." For a long time, this fact has been neglected by evolutionary biologists, and only relatively recently the model of "punctuated equilibria" has been proposed.²⁹ The lines of descent

observed in the fossil record represent the periods of *equilibrium* or stasis, while the transitions corresponding to the *punctuations* of this model remain *invisible* (apart from some reasonable but uninteresting transitions on lower taxonomic levels). Plausible population dynamics models explain why usually no fossils representing the transitions should be found. But in order to find out whether evolution is real, we need positive evidence, not explanations for its lack. Is there evolution, or are there equilibria without transitions?

Thus, we have to conclude that the scientific evidence for evolution is ambiguous,³⁰ in spite of the many contrary claims.

Creation and Chance

Chance describes an observation made regularly in connection with natural occurrences. The scientific concept of randomness implies that it is not feasible or not possible to trace the cause of a given individual event in the ensemble of an effect under consideration. The cumulative outcome of many such events can often be described by stochastic theory, but the outcome of individual events is unknown; it cannot be measured. The ultimate individual event, an elementary event, involves a single elementary particle, such as an electron.

The cause of such an event is, as far as science is concerned, in the invisible world. It may or may not be individually willed by the Creator. Conceptually, there are different possibilities. Either he determines the outcome of each elementary event individually, or he manages them collectively, e.g. by specifying Gaussian normality, mean and standard deviation, or higher level principles, not caring about individual events as such. Or he might imperceptibly guide chaotic dynamic systems by means of a few disturbances. Chance is not an alternative to God's action: it may be the usual way his creative activity "manifests" itself to us.

It is important to note that theism does not present a "God of the gaps." God's activity is not restricted to events not explainable by science, such as the cause of the Big Bang or of elementary events. How can natural occurrences, which are usually believed to be deterministic, be said to be a consequence of God's activity? The assumption of absolute determinism is erroneous. There is no way of finding out what causes individual elementary events. But each macroscopic event is ultimately composed of and influenced by elementary events not susceptible to scientific investigation.

**To call the specific mutations leading to the selectable variant
a chance occurrence is equivalent to pleading ignorance of causation:
the evolutionary step has not been explained.**

It has traditionally been believed that creation necessarily implies a miracle. But what is a miracle? God is continually active in his created universe. His being the Creator cannot easily be separated from his being the Sustainer. Anything happening according to "*natural law*" is just as much God's doing as those of his "*miracles*" lacking ordinary causation. Natural scientists recognize his normal activity as "natural law," because it is normal, reproducible, and understandable. Apart from his ordinary acts, his "extraordinary" ones would not be recognizable as such. Furthermore, God may do "miracles" entirely within "natural law." A biblical miracle is a theological concept: its essence is not lack of conformity to any laws, but the spiritual message to be conveyed to the observers. Thus, the concept of a miracle does not necessarily help understanding creation. It may cause confusion.

As far as God's methods in creation are concerned, it may be worth while to briefly mention the widespread tendency to mix up three issues which are quite distinct:

- (1) divine authorship versus material autonomy;
- (2) an old versus a young earth;
- (3) evolution versus no macroevolution.

I consider the first issue to be resolved for a theist, and similarly the second one for a natural scientist, while the third one remains open. Belief in the autonomy of matter-energy makes belief in evolution inevitable, belief in a young earth makes it impossible, but belief in creation does not prejudge the issue.

Mutations in individual genetic molecules are the crucial point in evolution, as any conceivable evolutionary development is ultimately based on them. A natural mutation in a DNA molecule is a consequence of an elementary event, such as a C^{14} decay or a cosmic ray impact. Yet it may have consequences for an entire organism growing out of a germ cell containing this DNA, and possibly for a species. Therefore, the physical cause for a given evolutionary step can never be investigated, and there is in principle no way to get around this ignorance.

It is customary to consider some selective pressure the cause of a given evolutionary development. In doing so, one tacitly assumes that any structure needed will automatically be produced by mutations sooner or later. But the crucial link in the chain of causation is not natural selection, but the specific mutations leading to the selectable variant. To call it a chance occurrence is equivalent to pleading ignorance of causation: the evolutionary step has not been explained.

The demonstration of stochastic distributions characterizing chance events cannot eliminate the possibility of a precise providential predetermination by the Creator, should he choose to do so. In any case, science has no way of finding out what causes individual

elementary events. The claim that there is "nothing but chance" behind mutations is non-scientific. It is a matter of personal belief. Such a use of the concept of chance masquerading as science is an abuse of the popular respect for science.

Warfare Paradigm

The "warfare" model, the belief that creation and evolution are mutually exclusive, is shared by the two extreme positions of dogmatic atheism and "recent-creationism." But is it true? Both views have serious flaws. While the crucial difficulties the *atheists* face are with *natural science*, the ones of the *recent-creationists* are with *biblical theology*. The denial of a Creator makes the origin of information, and therefore evolution, definitely implausible. On the other hand, a short-term, immediate creation, excluding all developments, dissociates creation from natural science.

**The evidence for creation,
although logically *ambiguous*, is *persuasive* to an upright seeker;
it pervades all of creation.**

There are serious *scientific* arguments against evolution. They basically boil down to the insufficiency of natural information sources. However, they only apply in an atheistic, not in a theistic, framework of axioms. In nature, there is a tremendous amount of evidence for God's marvelous activity, but none of it is of the kind of a mathematical proof. Probability estimates yield remarkable results, but the inevitable uncertainty of the parameters required leaves a loophole to those who do not choose to believe. God wants to be loved out of a free decision, rather than a forced one. The *evidence for creation*, although logically *ambiguous*, is *persuasive* to an upright seeker; it pervades all of creation:

(1) The Anthropic Principle of *cosmology* has been formulated by scientists who were surprised by the number of cosmological constants which are "just exactly right" for life on earth to be possible at all.³¹ Just a small increase or decrease in the value of any one of over a dozen constants would have prevented galaxies, stars, the Earth, or the elements required for life to be produced. This principle has been called "Anthropic" to indicate that humans would not exist to observe the fact if any of these conditions were not what they are to within small tolerances.

(2) Similarly, the environmental conditions on *Earth* throughout its history display a remarkable collection of "coincidences" conducive to life.³² Very small changes in any of them could have made the Earth uninhabitable, like Venus or Mars.

(3) The origin and further development of *life* imply such an unbelievable series of specific molecular events that the probability of their occurrence is vanishingly small.

This is true for the simplest protein domain functions, let alone for whole enzymes, cells, organs, and organisms, or even realities like soul and spirit.

These facts have been recognized by many scientists, and even agnostics and atheists marvel. In order to appease their statistical consciences, some resort to metaphysical speculations like a "many-worlds" hypothesis: there might exist an infinity of universes besides our own, such that even the production of life and of man is deemed "certain to occur somewhere," although in any single universe the probabilities are infinitesimally small. Of course, these ideas are irrelevant if there is a Creator.

On the other hand, the usual *theological* arguments against evolution are based on questionable interpretations of both nature and the Bible, and often a deistic philosophy. They falsely assume that creation and evolution are *alternative* explanations within the *same*, scientific category. A model consistent with both biblical theology and natural science may view them as *complementary* explanations from *different* categories, instead.

God has given Adam the "cultural mandate" of obtaining dominion over the earth, in order to keep it and care for it. It is reasonable to claim that this implies the application of science. The natural order is comprehensible because God made man's mind congruent to his design of the universe. It is no accident that the rise of modern observational and experimental science and technology followed in the wake of the Reformation and the invention of printing, when a careful study of the Scriptures became widespread.³³ It is therefore proper to expect consistent, reliable, truthful results of scientific investigations. But it is not proper to expect misleading appearances in nature, such as an apparent age, which would have to be corrected by scriptural revelation. God does not expect scientists to deal with miracles violating natural law.

What is the theological implication of the concordant evidences for high ages of the universe, the earth, and the fossils? God would certainly be capable of producing an appearance of such ages in a miraculous fashion. But since he is truthful - not only in revelation, but also in creation - we should not expect him to do so. As many independent pieces of evidence point to concordant high ages,³⁴ their cumulative nature has a force we dare not ignore. It would represent an offense to God's character of veracity to postulate that he produced an appearance of something false.

Harmony Paradigm

Is theistic, or creative, evolution a contradiction in terms, as recent-creationists claim? If the *biblical* evidence is critically examined, the case *against* evolution is rather weak.³⁵ This may come as a surprise to many Christians desiring to be faithful to the Bible - and to atheists desiring to get rid of its claim. But particular translations and some traditional interpretations of the biblical texts have definitely misled many.³⁶ Of course, this has not been a problem as far as any central tenets of the Christian faith are concerned. These are clarified abundantly throughout the Bible. It is obvious that God is proclaimed as the Creator. But his creational procedures are not so obvious - they are spiritual non-essentials.

If the **biblical** evidence is critically examined,
the case **against** evolution is rather weak.

A question of great importance which is often raised in this context is the inerrancy of the Scriptures. Some argue that if the Bible could be shown to be in error when it speaks about creation - even about creational procedures - it could not be trusted when it speaks about salvation, either. This is true, since the Christian faith depends on the reality of God's revelation - and therefore the reliability of its expression in the Bible. However, this still does not answer the question of whether creation is compatible with evolution. An evaluation of contradictory claims in this area has to consider the biblical contexts, the original languages, and all sciences involved in the topics touched upon. To respect science does not mean to put fallible human activities on the same footing with God's infallible revelation. Disputing the validity of certain interpretations like young-earth creationism need not imply questioning God's Word. The creation is just as much a product of God's doing as is the Bible. An evaluation of models of natural science and biblical interpretations leads me to postulate the following compatibilities between concepts of the two different categories:

(1) *Creation* may very well be compatible with *evolution*. The claim that creation necessarily implies sudden creation, using neither source material nor mediate processes, is contradicted by various scriptural examples. God is persistently active in all so-called "natural" occurrences, which are even occasionally described by the Hebrew term "bara" (or Greek "ktizo") specifically denoting God's creating. The miracle-only concept of creation restricts God's realm of activity to production out of nothing. It is therefore deistic, rather than theistic.

(2) The creation "*days*" of Genesis 1 may very well represent *ages* of unspecified duration, possibly overlapping. This can be accepted without taking the text any less "literally."³⁷ Considering Gen. 2:4 (of the same immediate context!) and other passages, the "one-week short-day" interpretation is theologically arbitrary and requires the rejection of empirical evidences.³⁸

(3) Divine *providence* may very well be compatible with the occurrence of *chance* or random events. Chance, in the scientific rather than a philosophical sense, is a description of the natural functionings of creation, as the Creator has given them. God as Sustainer or Provider definitely does use chance.

(4) God's *goodness* may very well be compatible with *natural selection*. On the one hand, creaturely suffering is inseparably intertwined with the normal day-to-day functioning of the biosphere. In itself, it has nothing to do with evolution. We may consider it incompatible with God's goodness - thereby attributing it to the fall of a spiritual, free creature. But we must not deny his providential care in what is happening

in nature. On the other hand, the popular concept of natural selection is coined more by 19th century atheistic philosophy than by science.³⁹ We have to replace the metaphor of "struggle for existence" with the scientific concept of differential reproduction. Furthermore, computer program tournaments have shown that "blind" natural selection can even favor what we would label as nice and fair behavior.⁴⁰

If the Bible does not tell us directly how God creates, perhaps it gives some indirect indications regarding his "normal ways of acting."

(5) God's *creation* activity may even be compatible with the presence of biological *death*. We certainly must not give plant death and cell death connected with development and continuous bodily renewal in animals and man a negative theological connotation. Individual death in animals is logically unavoidable, as there has been animal life for hundreds of millions of years. Do we really know whether animal death is bad in God's sight? We certainly cannot claim that the biological preparation of man's earthly environment was not planned by God, although it took a few billion years. Whatever negative aspects of death are left, after these caveats, could be theologically attributable to either the fall of Satan or possibly a time-transcending aspect of the human fall - just as the redemptive effect of Christ's death transcends time, having "consequences backwards in time." And some of the providential dealings of God with believers seem to indicate that, even when human life is concerned, the negative aspects of biological suffering and death must not be stressed out of proportion. God is very much more concerned with *spiritual* death and life.

Creation Revealed

If the Bible does not tell us directly how God creates, perhaps it gives some indirect indications regarding his "normal ways of acting." Are there possible parallels between God's modes of creation and of revelation? Jesus appeared in completely human form, affected with human frailty (though not with sin). God's written revelation has been given through human authors, with their cultures and thought-forms, in human languages. The manuscripts have been copied, sometimes with a few copying errors, and all of the originals have been lost. The canon has been determined by fallible humans. I believe that God has kept his hand over the process, but he has done it in a hidden form. Giving mankind a miraculously written book in finished and incorruptible form would not be in conformity with God's way of doing things, as manifest in Scripture. His revealing himself through his Son and through Scripture leaves man the freedom to believe or not to believe. There is no evidence which logically proves his authorship. It remains a matter of a faith commitment.

Does the Bible provide any more specific indications of the divine methods of creation, which might be compared with the empirical evidence? Of what nature is the declaration of God's authorship in creation?

Whatever can be known regarding God is evident to them, for God has shown it to them. From the creation of the world onward his invisible qualities, such as his eternal power and divine nature, have been discerned mentally through his handiwork. (Romans 1:19-20, Berkeley translation)

But faith forms...a conviction of unseen realities...By faith we understand that the worlds were put in order at God's command, so that what we now see did not come from visible things. (Hebrews 11:3)

Thou openest Thy hand, and they [the sea mammals] are satisfied with good things...When Thou cuttest off their breath, in death they return to their dust. Thou sendest Thy Spirit, and more are created [bara!], and Thou dost replenish the surface of the earth. (Psalm 104:28-30)

These statements are strangely ambiguous about *how* God creates! Are these visible or invisible realities - natural or supernatural ones? It is a genuine case of complementary aspects of the same truth. Everyone can clearly see the reality of creation - yet it is by faith only that one perceives this evidence as compelling. The biological processes mentioned in the Psalm passage occur "naturally" - yet they are said to reflect God's creating.

These statements are strangely ambiguous about
how
God creates!

God reveals himself to his human creatures through Scripture and through the created order. But he does not use force of any kind in this revelation, not even the force of a logical proof. Why this restraint? A proof of the impossibility of evolution, e.g. by demonstrating that the earth is only a few thousand years old, would amount to a simple, uncontrovertible proof for the existence of a Creator. This in itself makes the feasibility of such a proof at least very doubtful. There is a venerable tradition of "proofs of God," but these may have been conceived as philosophical or moral arguments, such as Paul's in Rom. 1:19-20, rather than scientific proofs. God has created human beings as persons, and he respects this dignity he has chosen to give them. He uses loving moral persuasion and leaves them the freedom of choice. It appears that, in order to guard human freedom, evidence for creation has to be hidden in logical ambiguity. God has thrown the veil of stochastics over his footsteps. In this life, we "walk by faith, not by sight."

As no other scientific hypothesis has been formulated, there is, at present, no alternative to evolution as God's creation method. And evolution is even a very attractive option for

Christians who believe in the full inspiration of Scripture!⁴¹ There seems to be an inner congruence between developmental processes in nature and the way God deals with his creation according to Scripture.

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