

# Dimensions of the Human Being and of Divine Action

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*Humans are three-dimensional, body-soul-spirit entities, but nevertheless unitary, indivisible persons. Animal behavior includes deterministic and random constituents. It may be modeled in terms of information systems, containing regulatory loops. Goal settings for these may be fixed, as in "lower" animals, or governed by internal adaptive supervisory systems freely selecting from alternative routines, as in conscious "higher" or "soulful" animals. A meta-supervisor in humans provides self-consciousness, free will, conscience and spiritual behavior. As with space, each further dimension includes the previous one, but cannot emerge from it or be reduced to it.*

*In the natural origin of each human individual, God providentially works through deterministic events, random ones such as mutations and neural modifications, as well as the option of selecting the outcome of some of these. This hidden feeding-in of formative information would represent the fundamental novelty implied by God "creating" the individual.*

## 1. Epistemology for scientific and theological realities

*Our world, including human nature, can be studied by both science and theology. Although the kinds of data are different, plausible interpretations, concordant with reality, will harmonize. As human nature is God's creation, its essence is closely connected with its origin in God's action. Interestingly, parallels between facets of God's activity and dimensions of human nature can be detected in hints from scripture and science.*

What is the essence of human nature? Can we know it? And can we know *how* God made humans collectively and is making humans individually? What does it mean to be human? Human nature has different aspects or dimensions, like body, soul, and spirit. Science provides biological and some psychological descriptions, and the Bible's definition of humanness is spiritual - "created in the image of God".<sup>2</sup>

Is it possible to combine these aspects into an integrated, harmonious picture? Or would this be an unreasonable, futile quest? After all, by definition, science is incapable of dealing with spiritual realities revealed in the Bible, and the purpose of the biblical revelation is not scientific information. Perhaps inserting "God did it" into gaps of scientific knowledge might risk positing a "god-of-the-gaps", whose relevance diminishes with increasing scientific knowledge. But more seriously, one would risk suggesting that God is *not* working through natural, scientifically knowable processes, as well.

But as God is the Creator or Author of both the natural (or visible) and the spiritual (or invisible) realms, it is indeed reasonable to look at reality from both a scientific and a theological perspective, expecting to find an integrated, harmonious, or complementary picture. Implicit in this endeavor is the assumption that God works through *all* processes, whether knowable or not, whether natural or supernatural. Of course, this does not make God responsible for moral evil. Where he allows personal creatures like humans to freely decide on their own about some action, they are given a corresponding responsibility.

In trying to find such a harmonization of scientific and theological aspects of human nature, we must be careful to distinguish the data from their interpretation. For the theological aspect, the biblical texts in their original form present the only relevant, primary data. For the scientific aspect, it is observations and measurements reported in the primary literature. Spiritual realities are eternal given facts, but their theological interpretation, as a human endeavor, is error-prone. Natural realities are given facts of creation, but science which investigates and interprets them develops, changes and is influenced by many human deficiencies. This implies that any integral model can never be final, but has to be reviewed, discussed and corrected as new data or insights become available.

Would such a model be nothing but a complementary set of two separate, fully independent descriptions?<sup>3</sup> Ideally, science has to produce identical results, independently of the different world-views or religious commitments of investigators, so that peer review, confirmations and refutations are possible on the basis of generally accessible data. This implies that science must use methodological natu-

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ralism, respecting as off-limits any metaphysical contents, whether they be Christian, atheist, or whatever.

On the basis of its epistemological and ethical commitments, the Christian faith certainly provided an excellent starting position and environment for doing creative and productive science - which is why modern science originated and grew in Europe after the Reformation, when biblical thinking was emphasized instead of the former appeals to authorities.<sup>4</sup> Nevertheless, when doing *science*, Christian researchers will not try to introduce biblical revelation - even where there are no reasons for questioning its reliability -, but will build on data accessible and acceptable to everyone.

At first sight, such methodological naturalism is just as applicable to entities mentioned in the Bible. The Bible does not restrict itself to theology, but reports and mentions anything relevant to God's salvation history. This includes aspects of the creation, human nature, medicine, history, sociology, politics, ethics, etc. Of course, such biblical statements may be data for science, even if merely taken as records of human opinions, on a par with extra-biblical data.

But there is a catch when fields like Bible exegesis, philosophy, metaphysics, and in particular - in the present context - human specifics are concerned. In these realms, pure methodological naturalism might miss important data, because these areas are inseparably linked with theological aspects.

Theology must take seriously even those biblical statements or passing remarks which seem to lack theological relevance. Although the primary focus in the Bible is always a theological one, apparently non-theological details may not simply be disregarded as nothing but ancient opinions, because the theological core is qualified by its environment. It just may be that, in a given context, God wanted to commit to writing some theological aspects indissolubly bound up with "natural" data.<sup>5</sup> The outstanding example for this is the historicity and bodily nature of the resurrection of Jesus. Belief in an ultimately divine authorship of the *entire* text of the biblical originals must be the guiding hermeneutic, if the theological core is not to be compromised or even lost.

As a consequence - if there is divine inspiration at all -, one is often forced to think about harmonizing biblical statements with other data. Any neat compartmentalization would be inadequate or even misleading. In this sense, I shall use data from nature and from the Bible, taking into consideration their respective characters, intents or weights in dealing with the question of the nature of humans and their creation. It would be inappropriate to consider human nature in a scientific context alone, because it is defined by God's having created humans "in his image".

In referring to biblical texts, the term "to create" shall here be restricted to translating the Hebrew *bara'* (or the Greek *ktizo*), which implies God creating something fundamentally new out of nothing. On the other hand, God (or humans) may "make" (Hebrew *^asah*) something using a precursor object.<sup>6</sup> God may use both modes of operation on a creature. He may "create" something, e.g. the universe, and then "develop" it further by "making" galaxies, stars and other things in it, using "natural" processes made possible by what he created in the beginning. Or he may "make" (or develop) a preexisting entity and, at a certain point in time, "create" in it a novel dimension not derivable from anything previously available. I believe that this is what has happened in God's creating humanity in his own image.<sup>7</sup>

Scripture teaches that God not only created humanity, but also that he creates each human individual.<sup>8</sup> What does this mean? I believe that this similarly indicates some combination of natural and supernatural processes.

## 2. Dimensionality of living organisms

*The human species is apparently the result of a long process of evolution. This process is punctuated by some discontinuities which science finds hard to deal with, such as the origins of life, of sentience, and of self-consciousness. If the stages delimited by these punctuations are taken to be different dimensions, the Bible has some surprising help to offer. This is not to say that "the Bible teaches modern science", but that biblical texts may allow for an interpretation which harmonizes with aspects of reality of which its human authors may have been unaware - as was the case with various prophecies.*

Even on the simple level of space-time, different dimensions are clearly distinct, yet intimately interconnected in the total reality. Each of these dimensions transcends and pervades the ones previously considered. I propose to view the mystery of human nature and of its relationship to God's creative ac-

tivity in terms of different dimensions: body, soul, and spirit - somehow analogous to the dimensions of space-time. These human "dimensions" are embedded in space-time but transcend it. Similarly, the soul is embedded in the body but transcends it, and the spirit is embedded in the soul but transcends it.

Four-dimensional space-time is first augmented by the dimension of biological semantic information,<sup>9</sup> generating biological life - the body. Starting with such "lower" life, the sentient, psychological, or "soulful" dimension produces higher animals (or "living souls"<sup>10</sup>). These include hominids up to Homo sapiens. But when in this hominid God's image was created,<sup>11</sup> the new spiritual dimension made Homo sapiens truly human in the biblical sense. To be precise, we are not sure at what stage of hominid evolution this happened.

Being created in God's image applies to all humans. But a further dimension - a fourth human dimension beyond body, soul, and spirit - is eternal life, given to believers at conversion. Those humans who receive this eternal or spiritual life by faith become children of God.<sup>12</sup>

On a scientific level, these dimensional augmentations are not explained. They are usually believed to represent, at most, higher levels of complexity gradually emerging, rather than new dimensions.<sup>13</sup> The origin of life remains a complete mystery, and so are the origins of the psychological and spiritual realities. The psychological realm is usually treated as a property of neural activities in the brain. Anything called "spiritual" is equated with psychological aspects, without distinguishing between what I labeled as the second, third and fourth human dimensions. I base their distinction on biblical indications, and they conform to experience. New dimensionalities for the origins of higher animals and of humans are compatible with the use of the term "create" in Genesis 1:21 and 27.<sup>14</sup>

All living organisms descended from one or a few original simple living systems by the darwinian process of random mutations and natural selection - a view fully compatible with biblical theology if God is seen as "making" (or evolving) all species fully or partially through natural processes.<sup>15</sup>

The strongest evidence for common descent of different species consists of shared errors, like certain mobile genetic elements inserted at exactly corresponding positions in their DNAs. If such an element was inactivated before the speciation event leading to the species compared, the homology cannot be attributed to identical needs of the two species, but can only testify to their common descent. The same argument applies to other errors like deletions, mutations to stop codons, and frameshifts.<sup>16</sup> Many such homologies have recently been found between humans and apes.<sup>17</sup>

Thus, as a consequence of the extensive genome sequencing efforts of the last few years, the "fact of evolution", which has been touted for almost 150 years without stringent support, has now at last become virtually incontrovertible. Yet, in two respects, it is still unknown whether the known mechanisms of evolution are adequate.

First, the origin of life is very far from being formulated in a plausible model. It is premature to call life an "emergent property" of chemical systems. I do expect living systems to have a corresponding chemical description. But whether and how chemistry can "cause" life is still pure speculation.<sup>18</sup>

And second, the evolutionary emergence of novel functions is still a mystery. Once self-replicating systems with heritable genomes exist, it is conceivable that new functional sequences emerge by darwinian mechanisms. But natural selection presupposes a minimal functionality as a selectable substrate. How can novel molecular sequences of minimal functionality originate spontaneously out of ones completely lacking the function under consideration? Are they accessible through mutational random walks in the huge sequence space?<sup>19</sup> Theoretically, a sufficient density and contiguity, in sequence space, of every functional specificity required might solve the problem. But whether this situation really applies is unknown and, according to presently available data, questionable.<sup>20</sup>

In this paper, I am not going to deal with these two problems. Instead, I shall now try to characterize the two mysterious transitions of biological organisms which I attribute to new dimensions: the one from lower life to "higher" animals<sup>21</sup> called "living souls", and the other from these to biblically genuine humans created in the "image of God". Scientific data to be considered are an organism's behavior and the structures on which it may be based.

### 3. Control of behavior

*Dimensionality in the nature of organisms may be modeled in a framework of information or control systems. But reductionism is neither implied nor logically required. A higher dimension is*

*not uniquely determined by a lower-dimensional configuration, but it allows an additional freedom, in which novel behavior becomes possible.*

What is the "soul" or psychological dimension? Is it just an "emergent property" of the nervous system evolving and growing sufficiently complex? The simplest central nervous systems apparently are restricted to providing an information flow from sense organs to organs for movement. Let's look at the logic of such behavioral mechanisms - whatever their way of implementation - beginning with lower, not yet "soulful" organisms.

Even bacteria display nontrivial behavioral responses to their environment, like swimming toward higher nutrient concentrations. The simplest case of behavioral response may be modeled in terms of an information or control system containing a negative feedback loop. This model has been argued in detail by Donald M. MacKay.<sup>22</sup> It consists of four logical elements:

- (1) *receptor(s)* - sensing external conditions;
- (2) *comparator* - detecting a mismatch between the receptor's indication and a preset goal;
- (3) *organizer* - activating the effector according to the comparator's decision;
- (4) *effector(s)* - producing the behavior needed.

The first and fourth elements, interfacing with the environment, may be multi-channel devices.

A man-made example of such a control system is the one used for temperature control in refrigerators. The nervous system of multicellular animals may contain many such loops. An organism's behavioral complexity is correlated with that of its central nervous system. In each regulatory loop, the comparator reacts in accordance with its goal setting. In lower animals and in some systems in higher animals, the behavioral goals of such loops are genetically fixed. The goal is set from outside the loop, as with a refrigerator whose "goal" temperature is set by turning a knob.

In such loops, the organizers operate automatically. At this level, consciousness is not required, even if such lower regulatory systems reside in conscious beings. The pupil of our eye adjusts automatically to the amount of incident light.

Other regulatory information systems are under conscious control. Some behavior in higher animals is not genetically fixed, and therefore more complex, requiring two additional logical elements, again according to MacKay:<sup>23</sup>

- (5) *feedforward* system - forwarding the receptor's sensory input directly to the organizer;
- (6) *supervisor* - guiding the system adaptively, adjusting the goal and the organizer's behavior.

For flexibly adapting to a variable environment, a simple on-off decision of a comparator is insufficient. An additional (possibly multi-channel) feedforward system provides the organizer with direct "knowledge" of the details of the sensory input. And a supervisor may, from the inside, adjust both the goal for the comparator's initiating a reaction and the organizer's subsequent behavior. In this case, the organizer contains selectable subroutines for different actions. Which one is chosen, under given circumstances, depends on the supervisor's decision.

Of course, such an information system containing these six elements could also be modeled in a computer. But in this case the supervisor's selection options, together with their conditions for activation, would have to be pre-specified - again corresponding to a genetically fixed system. A robot or a computer will never be conscious, although it is perfectly capable of modeling even complex information systems. Apparently, a robotic system would not be flexible enough for the behavior needed by higher animals, and so reducibility of psychology to the body is not proven.

We get the impression that higher animals, like we, have a certain freedom of choice. Apparently, emotions sensibly dealing with hunger, fear, sexual drive, etc. imply some consciousness. The resolution of conflicts between impulses like hunger and fear would, in some situations, require adaptability and a choice. Through their internal supervisor, animals might choose different behavioral subroutines under different environmental conditions, with sufficient leeway to allow for learning or even sometimes arbitrary decisions.

These psychological functions could be called "soul". The animals created in Gen.1:20 are described in a way that suggests "higher" life forms.<sup>24</sup> They are called "living souls". They *are* souls, not bodies *having* a soul. This corresponds to contemporary trends in both neuropsychology and theology which usually reject a dualism separating body and soul. There is a difference between a dualism (or "trialism"), sometimes postulated in theological discourse to make room for soul and/or spirit, and the differ-

ent dimensions I suggest. Body and soul considered dualistically are different interacting entities, but different dimensions are aspects of the same unitary entities.

Some psychological functions have been localized to certain brain regions. Apparently, brain states correspond to psychological states. The soul is embodied in the brain. That does not mean it is *caused* by it. Calling the soul an "emergent property" of the brain, reducible to brain activity, begs the question.

Humans have self-consciousness, in addition, as distinct from purely emotional or sentient consciousness. Self-consciousness is impossible to ascertain in animals, even apes.<sup>25</sup> Our psychological regulatory system, containing instances of circuits consisting of the six logical elements mentioned, seems to be embedded in a still higher, spiritual one, defined by the "image of God". If it could be modeled like the lower informational systems discussed, it would need at least one additional logical element, (7) a *meta-supervisor*. The image of God provides us with personality, explicitness,<sup>26</sup> conscience, freedom of choice and responsibility, spiritual goals and behavior, and the possibility of dialog with God. Symbolic language and abstract reasoning probably also belong to this human-specific set of faculties.

To summarize, the behavioral repertory of lower animals consists of genetically programmed execution of pre-specified reactions - biological functions. That of higher animals includes instinctive, emotional selection between different actions - psychological functions. That of humans allows, in addition, self-conscious, free, responsible decisions based on conscience - spiritual functions.

According to this model, the human being is three-dimensional, body-soul-spirit,<sup>27</sup> but still a unitary, indivisible person. Spiritual functions have psychological correlates, and these have correlates in biochemical structures, configurations, and activities in the brain. But no reductionism of spirit to soul and soul to body is implied. Such reductionism fails to provide sufficient causes for the effects observed. And it contradicts our personal experience of being self-conscious, responsible, free agents.<sup>28</sup> A simple analogy for this non-reducibility may be the fact that we communicate non-material ideas, yet their transmission uses physical substrates, such as paper and ink, sound or light waves. Clearly, ideas are not products of storage or transmission media.

#### 4. Creation of dimensions and of individuals

*God uses diverse modes of creation. I am not setting these modes in parallel to the different dimensions found in created entities. All of God's modes may be applied to all of the created dimensions. The two sets are "orthogonal", the Creator transcending all aspects of creation. All that is required by my model is that the dimensionality of any of God's modes of action transcends the dimensionality of the entity created or operated on.*

In Genesis 1, the verb "to create" is used three times: for the universe, higher animals, and humanity.<sup>29</sup> This may be correlated to the physical, the sentient (or psychological), and the spiritual dimensions. In each case, something fundamentally new originated, that didn't exist before.

Between these special events, and persisting through the second and third of these, there was a continuous history of development. Of course, this natural development or evolution is just as much God's doing as the special creative acts explicitly declared as such. These other events or processes in Genesis 1 are described by terms such as "God made" or "the earth brought forth", indicating God's mediate action, using materials, objects, and processes already in existence. For such mediate divine action, theology uses the term "providence", while science considers these processes to be "natural" or "law-like". God's commands "let there be ..." do not, by themselves, imply instant creation out of nothing. They do not indicate by what mode or mechanism the entities were to be produced. They are just declarations of what he wanted to happen.<sup>30</sup>

But creation by God is not restricted to these dimensional origins. Each human individual, as well, is created, as Isaiah 43:7 indicates: "... every one who is called by my name, whom I created for my glory, whom I formed and made." Each person grows out of a natural conception. In this developmental process, God is creating (*bara'*, as in Gen.1:27), forming (*jatzar*, as in Jer.1:5; Gen.2:7) and making (*^asah*, as in Gen.1:26). But in what sense does he *create*, if the process is natural? A natural process is determined by natural law, with some stochastic variation. Do some aspects of an individual's origin leave open the possibility that supernatural, but scientifically undetectable events might be involved?

The parameter space involved, in which the formational processes of individual conception and development occur, is transastronomically huge: only about 270 binary selections among alternatives suffice to produce a transastronomical number of different combinations.<sup>31</sup> That such high multiplicity of possibilities applies to development is indicated by the many biochemical events which result in random outcomes, in scientific parlance. Mutations, selection of genes inherited from mother or father, genetic recombinations, details of the spatial configuration of the neural network and synapse formation are largely random. The particular outcome of each of these events is presumably the consequence of some elementary or quantum event or events bifurcating (or multifurcating) between almost equally probable possibilities. As quantum events are not deterministic, the final biological results of these developmental processes cannot be predicted. Science can only treat them as genuinely random.

Therefore the Creator's activity may reasonably be modeled as guiding natural development in the physical, sentient, and spiritual realms, using many hidden supernatural selections among equally possible elementary events.<sup>32</sup> I am not claiming that this must necessarily be the case, just that it is a logical possibility of God guiding the process in detail, without science being able to detect such "interference". The term "create" implies the origin of a novel person - defined by such selections. Such an understanding of God creating a novel entity or reality by performing quantum selections may be generally applicable to any aspect of formative natural processes, e.g. in evolution.

If God would refrain from affecting the formation of an individual, the various biblical indications<sup>33</sup> pointing to a divine action leading to specific human individuals' constitutions would be incomprehensible. I take my notion of God using such hidden options as being supported scientifically by the transastronomical probability spaces of elementary events, most of which would produce system failure, and theologically by the explicit biblical indications of God's being active in the whole process.<sup>34</sup>

The term "spiritual" may refer to either the human spirit or God's Spirit. This may cause some ambiguities, which I try to clarify by the following suggestion. God's image has been given to *all* humans. That makes them spiritual in the sense of the human spirit, namely real humans, or persons responsible to God for their decisions. But only *some* accept God's offer of salvation, receiving the new, eternal life - a fourth dimension, beyond body, soul, and (human) spirit. Those trusting in God's promises are saved by Christ, becoming spiritual in the sense of God's Spirit, by being born again - a new creation.<sup>35</sup> By the way, this applies to Old Testament believers like Abraham, as well.<sup>36</sup> Maybe Isaiah 43:7 also distinguishes the gifts of the human spirit ("whom I created for my glory") and of God's Spirit to a human becoming a child of God ("who is called by my name").

Thus, God operates directly ("creating") and indirectly ("making") throughout all of creation, not only initially, but continuously. He operates through natural processes. We recognize these as non-unique, repeatable events. We speak of God's providence. But he also operates in unique events. There he applies creative choices. We speak of his creative activity. Both modes pervade all of reality, from the cosmos through macro events to elementary quantum events.

The unique, non-repeatable mode of creative choices applies to the origin of the cosmos, the selection of natural laws, fundamental parameters and cosmological fine-tuning, to miracles (or signs) in the macro realm, and - as I am suggesting here - to the selection of some, probably many, quantum events. The repeatable, providential mode of natural processes applies to the continued existence of the cosmos, natural laws and fundamental parameters, their regularity, deterministic macro events and stochasticity, as well as truly random (unselected) quantum events.

Of course, science cannot distinguish between unique and normal quantum events - for science, all are random. And it must be mute about all other unique events as non-repeatable. Persisting consequences of unique events, of course, remain subject to scientific investigation - such as those of the big bang and other "historical" events.

## 5. Randomness and its implications

*If God occasionally uses selection of specific outcomes in quantum and other random events, in order to guide natural processes in a desired direction, such interventions remain hidden from scientific investigation. Therefore all occurrences of randomness mark areas where God's hidden options are possible, e.g. in the evolution of novel biological functionalities and in the constitution of human individuals.*

It is essential to understand what randomness - in a scientific sense - implies. In everyday parlance, "random" and "chance" are often taken to exclude meaning, purpose, design, or even human and divine freedom of choice. In science, "randomness" has a restricted but specific meaning. In some contexts, science is, in principle or practice, incapable of predicting the specific outcomes of individual events. There, it considers an entire set of them as a whole, dealing with this set by means of stochastic mathematical methods. In this paper, I am using "randomness" in the scientific sense exclusively.

Even deterministic processes may produce a huge number of different possible outcomes, as seen in deterministic chaos.<sup>37</sup> Chaos is possible when there are nonlinear processes, e.g. growth processes, which of course are ubiquitous in biology. To this, we have to add the effects of quantum uncertainties and other stochastic processes. Thus, the number of possible outcomes is often infinite, for all practical purposes. This means that we find random processes and randomness everywhere in creation.

And wherever there is randomness, science cannot distinguish between truly random events, providentially decreed as such by God, and specific events, selected by his creative choices.<sup>38</sup> Of course, God's creative options include both the decision about whether to direct a given quantum event (or leave it genuinely random) and the decision about its result.<sup>39</sup> God's hidden options are limitless.

In particular, randomness, with possible divine guidance, also applies to biological systems. Randomness is found in the evolution of a species, as well as in the development (and the personal history) of each individual.

For instance, there are aspects of randomness in brain structure.<sup>40</sup> Neurons and their dendrites grow during development into configurations which apparently are partly random. Then, in adults, the configuration may remain largely fixed. It belongs to the constitution of the individual. But the dendrites sprout spines, which form synapses, connecting to other neurons. The spines grow and disappear throughout life on various time scales.<sup>41</sup> There may be randomness in synapse formation, but selection in their maintenance, by reinforcement of the circuits actually used. The stable synapses may reflect learning, memory, decisions, etc. There are about  $10^{10}$  dendrites with a total of about  $10^{14}$  spines in a human brain, resulting in a transastronomical number of possible configurations.

Although this fine-structural architecture looks largely random to scientific investigation, much of it may be the result of hidden divine creative choices - as well as free-will decisions of the individual.

Randomness is also found in evolutionary processes, driven by natural selection of random mutations. Some proteins, which are essential for the survival of the organism, change very little during the course of evolution. Others change more rapidly, even virtually at random, in some portions which contribute little to their functions (neutral evolution). In spite of the relative constancy of conservative protein sequences, they usually differ in different species. Substitutions in conservative proteins start out as random mutations, but are expected to have consequences for the species fixing them. Thus, even in the most slowly evolving molecules, whose sequences are severely constrained by functional requirements, randomness plays an important role.

With slowly evolving proteins, phylogenies spanning hundreds of millions of years of evolution can be computed. In order to improve the signal-to-noise ratio for phylogenetic analysis, sequences are sometimes concatenated. In one example, a phylogeny of 45 species of all three domains of life was derived from the alignment of 23 concatenated conservative proteins with a total of 6600 amino acids.<sup>42</sup> The path from the universal root to humans involved 1900 consecutive amino acid substitutions, or 1 in every 3-4 amino acids (this is a minimum estimate, as there may have been reversals). For the short-lived prokaryotes, such as bacteria, there were even many more amino acid changes, e.g. 4414 in the case of *Haemophilus influenzae*.

Yet, each consecutive substitution was the result of one of a transastronomical number of randomly possible mutations, since there are 20 possible amino acids at each of the 6600 positions. And each of the adaptive mutants had to be selected and fixed in the population, which does not occur immediately.

With ribonucleic acids (RNA), the situation is similar. For an RNA phylogenetic tree, one investigation aligned 1574 nucleotides of the extremely conservative small subunit ribosomal RNAs of each of more than 2500 eukaryotic species.<sup>43</sup> The human line has accumulated 389 substitutions since the eukaryotic ancestor, or 1 in every 4 nucleotides, at least. For nucleotides, there are fewer mutational choices than for amino acids, as there are only 4 different nucleotides, but still the total number of possible combinations is transastronomical, and each mutation is random before selection sets in.

How frequent are adaptive mutations which get fixed in a species? Are 3.8 billion years<sup>44</sup> enough to allow for 100 or more sequential adaptive mutations in a highly conservative protein? Is it reasonable to assume that a sufficiently large part of all random mutations produce something useful for the organism? How does the evolutionary process work at the level of individual mutations?

## 6. The mechanism of evolution

*The highly random character of the basic evolutionary mechanism makes spontaneous, unguided evolution very slow and inefficient. On the other hand, the biosphere is extremely complex and efficient. This suggests some divine guidance of quantum and other random events. Conversely, the possibility of God applying an extensive but hidden creative influence underlines the providential importance of the highly random structure of natural systems and processes.*

To investigate molecular evolution in a particular bacterial enzyme, DNA polymerase I of *Thermus aquaticus*, its highly conserved active site, containing 8 amino acids, and 5 adjacent positions were extensively mutagenized and then assayed *in vitro*.<sup>45</sup> All adjacent and half of the active site positions produced various mutants retaining some activity, even wildtype level. But among the *naturally* occurring DNA polymerases I, 80% have the standard active site. In 7 of 34 prokaryotes, 6 natural variants were found (of 17 billion possible substitutions), yet all but one of them were different from any of the artificial ones.

This implies that in nature, selection weeds out even most of those mutants that would be active *in vitro*. We don't know if *any* of them are truly synonymous with some wildtype actually found, i.e. equally useful in the organismal and environmental context. In any case, only a very small fraction of the functional mutants are in fact found in real organisms. Why is this so? Apparently, real ecosystems in nature are much more restrictive than feasible laboratory experiments, making natural evolution correspondingly more difficult.

A single mutational step seems to be a rather simple event. In fact, this is not the case. J. Felsenstein did some calculations of microevolutionary dynamics on the basis of what he considered the most probable estimates for the relevant parameters.<sup>46</sup> The huge majority of new mutations are deleterious. Even most of the slightly beneficial ones are lost to genetic drift, especially in large populations. Very few of the adaptive ones may go to fixation in the population. As a result, the substitution rate is an extremely small fraction of the mutation rate, probably less than 1 in 10 million. It is virtually independent of the mutant's fitness, as fitter mutants occur much less frequently. In fact, the vast majority of successfully fixed mutants have a very small selection coefficient, yielding at best a minute improvement.

Thus, the darwinian mechanism of random mutation and natural selection is extremely inefficient and slow, even for just improving already existing functionalities. In accordance with this estimate, most of the new genes are apparently derived from pre-existing ones by means of minor modifications or domain shuffling by genetic recombination. It is still very much an open question how really novel domains and functionalities arise.<sup>47</sup> Does this require some guidance - by divine hidden options?

## 7. Biological information - emerging or designed?

*The Creator has an infinity of options for ways of influencing and guiding the natural processes of species evolution and individual development, without science being able to detect any of it. This might solve the problem of the origin of novel biological functionality and of meaningful personal individuality. As such divine influence need not be absolute, but the right dose may be given according to God's design in each case, human free will and theodicy (the question of God's justice) need not be problematic, either. Any creaturely freedom translates into a corresponding responsibility.*

Random mutations and natural selection may suffice for bringing about some improvements of already existing functions. Yet, each of these mutation-selection steps provides for at most one bit of information - in the form of a yes/no answer - being transferred from the environment to the species in which the mutation is eventually fixed. This mechanism may be too slow for producing novel functions by random walks within the times indicated by the fossil record, not to speak of generating entire viable organisms in the first place.

Long paths of sequential random events characterize both phylogenetic evolution and ontogenetic development. These paths comprise many bifurcations between alternatives of virtually equal probabili-

ties. These may be points of divine selection, hidden from possible scientific investigation, but of momentous significance for the species or individual involved. This may occur even in normal, "simple" evolutionary improvements of function. Without overriding any natural process, God may guide in detail the evolutionary paths of species, as well as the development of the bodily, psychological, and spiritual constitution of every individual. Each selection represents some hidden feeding-in of formative information into the system.<sup>48</sup>

For each adaptive mutation successfully fixed, there are, in principle, two possibilities. In the first case - the only one accessible to science -, the mutation is truly random (God's providence at the quantum level), the probability of selection is extremely low, the time to fixation extremely long, successful fixation very improbable, and the increase of information is due entirely to selection by the environment. In the other case, the particular mutation is determined by God's selective choice (quantum event guided by God), selection and fixation occur according to God's predetermined schedule (maybe through other guided quantum events), success is certain, and God's guidance is the source of the information increase. In both cases, scientists rightly see such events as random. In principle, the first case is repeatable and could be shown to be randomly dispersed. The second case is unique, and so its repeatability cannot be investigated. On the other hand, both cases are the outcome of God's design, either providential or creative.

In particular, in the case of a new individual, a novel personality requires a potentially huge number of such selections contributing to the final constitution. This divine guidance, invisible to science, would represent the fundamental novelty implied by "creating".<sup>49</sup>

Would such an intimate and pervasive divine influence support determinism and negate the individual's personality and free will? This would be a misunderstanding. Not even a fully deterministic influence of natural genetic and environmental factors on the individual's constitution and development could have this effect. The origin of the spiritual dimension (God's image) introduced the possibility of free-will decisions inherent in a responsible personality and a corresponding amount of independence from psychosomatic factors. This freedom is a foundational characteristic of the love relationship God desires to establish with humans, so we may confidently assume that he observes this objective in his creative guidance work. We are ignorant as to how this is done, but there will be an intimate interaction between God's providential or creative action and the individual human's free-will decisions throughout life, superimposed on any "natural" factors.

Similar considerations will apply at a higher level for the spiritual lives of the ones called and born again on the basis of their faith. They are both under the influence of the indwelling Holy Spirit and their own free-will decisions.

God has plenty of options to providentially and creatively direct (or override if necessary) both natural events and actions of personal free-will creatures, even without in any way overpowering natural causal connections or free will.<sup>50</sup> This is both hinted at by the testimony of Scripture,<sup>51</sup> and allowed for by creation's quantum indeterminacy. It might provide a plausible solution - although not a scientific one - to some of the still perplexing mysteries of biological and, in particular, human complexity.

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<sup>1</sup> A previous, shorter version of this paper was presented at the Annual Meeting of the American Scientific Affiliation, Colorado Christian University, Lakewood, CO (July 25-28, 2003).

<sup>2</sup> Gen. 1:27.

<sup>3</sup> Gould, S.J. (1999), *Rocks of ages: science and religion in the fullness of life* (Ballantine, New York) coined the term "Non-Overlapping Magisteria" for this idea; Haq, S.N. (1999), "Thou shalt not mix religion and science", *Nature* **400**, 830-831; Menuge, A.J.L. (2003), "Interpreting the book of Nature", *Persp.Sci.Christ.Faith* **55**, 88-98.

<sup>4</sup> Hooykaas, R. (1973), *Religion and the Rise of Modern Science* (Scottish Academic Press, Edinburgh); Nebelsick, H.P. (1992), *Renaissance and Reformation and the rise of Science* (T&T Clark, Edinburgh, ISBN 0-567-09605-1); Hutchinson, I. (2003), "Science: Christian and Natural", *Persp.Sci.Christ.Faith* **55**, 72-79; Menuge, A.J.L. (2003), "Interpreting the book of Nature", *Persp.Sci.Christ.Faith* **55**, 88-98.

<sup>5</sup> In the biblical texts, such "natural" data are phrased in an "anthropomorphic" language (the way something looks to an ancient observer). Exegesis has to take this into consideration.

<sup>6</sup> Held, A. & Rüst, P. (1999), "Genesis reconsidered", *Persp.Sci.Christ.Faith* **51**, 231-243, <http://www.asa3.org/ASA/PSCF/1999/PSCF12-99Held.html>.

<sup>7</sup> Gen. 1:26-27.

<sup>8</sup> Ps. 102:18; Isa. 43:1.7.15; Ez. 21:30; 28:13.15; Mal. 2:10. He even creates individual animals: Ps. 104:30.

- <sup>9</sup> The emergence of biological life from nonliving matter requires so much semantic or functional information that it is extremely unlikely to have been produced spontaneously: Rüst, P. (1992), "How has life and its diversity been produced", *Persp.Sci.Christ.Faith* **44**, 80-94, <http://www.asa3.org/ASA/PSCF/1992/PSCF6-92Rust.html>.
- <sup>10</sup> Gen. 1:20.21.24.30.
- <sup>11</sup> Gen. 1:27.
- <sup>12</sup> John 1:12; 3:3-7; 2 Cor. 5:17.
- <sup>13</sup> Bekoff M. & Sherman P.W. (2004), "Reflections on animal selves", *Trends Ecol.Evol.* **19**, 176-180.
- <sup>14</sup> Held, A. & Rüst, P. (1999), "Genesis reconsidered", *Persp.Sci.Christ.Faith* **51**, 231-243, <http://www.asa3.org/ASA/PSCF/1999/PSCF12-99Held.html>.
- <sup>15</sup> *ibid.*
- <sup>16</sup> Bonner, T.I., O'Connell, C. & Cohen, M. (1982), "Cloned endogenous retroviral sequences from human DNA", *Proc.Natl.Acad.Sci. USA* **79**, 4709-4713; Johnson, W.E. & Coffin, J.M. (1999), "Constructing primate phylogenies from ancient retrovirus sequences", *Proc.Natl.Acad.Sci. USA* **96**, 10254-10260; Hughes, J.F. & Coffin, J.M. (2001), "Evidence for genomic rearrangements mediated by human endogenous retroviruses during primate evolution", *Nature Genetics* **29**, 487-489; Max, E.E. (2002), "Plagiarized Errors and Molecular Genetics: Another argument in the evolution-creation controversy", <http://www.talkorigins.org/faqs/molgen/>, updating of an article in (1986) in *Creation/Evolution* **XIX**, 34.
- <sup>17</sup> Svensson, A.C., Setterblad, N., Sigurdardóttir, S., Rask, L. & Andersson, G. (1995), "Primate DRB genes from the DR3 and DR8 haplotypes contain ERV9 LTR elements at identical positions", *Immunogenet.* **41**, 74-82; Dangel, A.W., Baker, B.J., Mendoza, A.R. & Yu, C.Y. (1995), "Complement component C4 gene intron 9 as a phylogenetic marker for primates: long terminal repeats of the endogenous retrovirus ERV-K(C4) are a molecular clock of evolution", *Immunogenet.* **42**, 41-52; Smit, A.F.A., Tóth, G., Riggs, A.D. & Jurka, J. (1995), "Ancestral, mammalian-wide subfamilies of LINE-1 repetitive sequences", *J.Molec.Biol.* **246**, 401-417; Rouquier, S., Taviaux, S., Trask, B.J., Brand-Arpon, V., van den Engh, G., Demaille, J. & Giorgi, D. (1998), "Distribution of olfactory receptor genes in the human genome", *Nature Genet.* **18**, 243-250; Sharon, D., Glusman, G., Pilpel, Y., Khen, M., Gruetzner, F., Haaf, T. & Lancet, D. (1999), "Primate evolution of an olfactory receptor cluster: diversification by gene conversion and recent emergence of pseudogenes", *Genomics* **61**, 24-36; Poux, C., van Rheede, T., Madsen, O. & de Jong, W.W. (2002), "Sequence gaps join mice and men: phylogenetic evidence from deletions in two proteins", *Molec.Biol.Evol.* **19**, 2035-2037; Gilad, Y., Man, O., Pääbo, S. & Lancet, D. (2003), "Human specific loss of olfactory receptor genes", *Proc.Natl.Acad.Sci. USA* **100**, 3324-3327.
- <sup>18</sup> Rüst, P. (1988), "The unbelievable belief that almost any DNA sequence will specify life", unpublished presentation at the conference *Sources of Information Content in DNA* in Tacoma, WA; Rüst, P. (1992), "How has life and its diversity been produced?" *Persp.Sci.Christ.Faith* **44**, 80-94, <http://www.asa3.org/ASA/PSCF/1992/PSCF6-92Rust.html>; Rüst, P. (1994), "Die Herkunft des Lebens - Wissen und Glauben", Dokumentation 1/94 (VBG-Verlag, Zürich), 46 p.; Orgel, L.E. (1998), "The origin of life - a review of facts and speculations", *Trends Bioch.Sci.* **23**, 491-495; Forster, R. & Marston, P. (1999), *Reason, Science & Faith* (Concorde House, London, U.K.); Orgel, L.E. (2000), "Self-organizing biochemical cycles", *Proc.Natl.Acad.Sci. USA* **97**, 12503-12507; Lederberg, J. (2003), "Out of the warm little pond: prerequisites for an evolvable system", *Endeavour* **27** (2), 44; Collins, F.S. (2003), "Faith and the Human Genome", *Persp.Sci.Christ.Faith* **55**, 142-153.
- <sup>19</sup> Rüst, P. (1984), "Spezielle und allgemeine Evolutionstheorie: Fakten und Spekulation", in: *Zur Diskussion um Schöpfung und Evolution*, eds. Gutsche, E., Hägele, P.C. & Hafner, H. (Symon & Wagner, Marburg, Germany), 59-115; Yockey, H.P. (1992), *Information theory and molecular biology* (Cambridge University Press, Cambridge, UK), 131-177; Behe, M.J. (1996), *Darwin's Black Box* (The Free Press, New York); Dembski, W.A. (1997), "Intelligent design as a theory of information", *Persp.Sci.Christ.Faith* **49**, 180-190; Rüst, P. (1998), updated from the version of 1984, in 4. Aufl. (Studentenmission in Deutschland, Marburg), 51-112; Zhang, J. (2003), "Evolution by gene duplication: an update (review)", *Trends Ecol.Evol.* **18**, 292-298.
- <sup>20</sup> Rüst, P. (2001), "Creative providence in biology", *Persp.Sci.Christ.Faith* **53**, 179-183, <http://www.asa3.org/ASA/PSCF/2001/PSCF9-01Ruest.html>. The claim that artificial in vitro selection of ribozymes, starting with random sequence mixtures, proves this point ignores the wildly different numerical parameters characterizing natural protein evolution in the biosphere.
- <sup>21</sup> A working definition of what constitutes a "higher" animal, from both a biological and a biblical perspective, is given in Held, A. & Rüst, P. (1999), "Genesis reconsidered", *Persp.Sci.Christ.Faith* **51**, 231-243, <http://www.asa3.org/ASA/PSCF/1999/PSCF12-99Held.html>.
- <sup>22</sup> MacKay, D.M. (1991), *Behind the Eye* (Basil Blackwell, Cambridge, MA), 43.
- <sup>23</sup> *ibid.*, 51.
- <sup>24</sup> Animals moving quickly and purposefully require a certain size, a blood (or hemolymph) circulation, a nervous system of a certain complexity, and probably a certain level of consciousness. Lower animals lacking this combination are never called "living" in the Bible. God speaking to the "living souls" and blessing them appears to imply some consciousness, and "life" is closely connected with "blood" (Gen. 9:4; Lev. 17:11-14).
- <sup>25</sup> Tallis, R. (2nd ed. 1999), *The Explicit Animal: A Defense of Human Consciousness* (St. Martin's Press, New York, NY).
- <sup>26</sup> *ibid.*
- <sup>27</sup> 1 Thes. 5:23 may hint at such a three-dimensionality.

- <sup>28</sup> MacKay, D.M. (1991), *Behind the Eye* (Basil Blackwell, Cambridge, MA), 238ff.
- <sup>29</sup> Gen. 1:1.21.27.
- <sup>30</sup> Ps. 33:9 is sometimes erroneously claimed to prove that every divine declaration of intent is followed by its immediate and miraculous fulfillment. As many prophecies pertaining to the distant future show, this is not always the case.
- <sup>31</sup>  $2^{270} = 1.9 \times 10^{81}$ .
- <sup>32</sup> Rüst, P. (2001) "Creative providence in biology", *Persp.Sci.Christ.Faith* **53**, 179-183, <http://www.asa3.org/ASA/PSCF/2001/PSCF9-01Ruest.html>; Rüst, P. (2002), "God's Sovereignty in Creation - a reply to Howard Van Till", *Persp.Sci.Christ.Faith* **54**, 216-217.
- <sup>33</sup> Not only the statements using "bara" (like Is.43:7) are relevant here, but many others, too, e.g. Ps.139:13 ff.
- <sup>34</sup> I have argued before that Van Till's notion of a "robust formational economy principle" is unlikely to apply to the biosphere, not for theological, but for scientific reasons: Rüst, P. (2001), "Creative providence in biology", *Persp.Sci.Christ.Faith* **53**, 179-183, <http://www.asa3.org/ASA/PSCF/2001/PSCF9-01Ruest.html>; Rüst, P. (2002), "God's Sovereignty in Creation - a reply to Howard Van Till", *Persp.Sci.Christ.Faith* **54**, 216-217.
- <sup>35</sup> John 1:12; 3:3-7; 2 Cor. 5:17.
- <sup>36</sup> John 8:56.
- <sup>37</sup> Williams, G.P. (1997), *Chaos Theory Tamed* (Joseph Henry, Washington, DC), 230, shows a computer graphics presentation of the attractor of the chaotic domain of the logistic equation, generated by S. Kuzminsky.
- <sup>38</sup> That God may guide apparently random events is indicated, e.g., in Prov. 16:33.
- <sup>39</sup> God's "interference" may even represent a specific probability density function modifying the natural stochastic one.
- <sup>40</sup> MacKay, D.M. (1991), *Behind the Eye* (Basil Blackwell, Cambridge, MA), 20, shows a typical sample of intercell connections in the cerebral cortex.
- <sup>41</sup> Ottersen, O.P. & Helm, P.J. (2002), "How hardwired is the brain?" *Nature* **420**, 751-752.
- <sup>42</sup> Brown, J.R., Douady, C.J., Italia, M.J., Marshall, W.E. & Stanhope, M.J. (2001), "Universal trees based on large combined protein sequence data sets", *Nature Genet.* **28**, 281-285.
- <sup>43</sup> Van de Peer, Y., Baldauf, S.L., Doolittle, W.F. & Meyer, A. (2000), "An updated and comprehensive rRNA phylogeny of (crown) eukaryotes based on rate-calibrated evolutionary distances", *J.Molec.Evol.* **51**, 565-576.
- <sup>44</sup> Holland, H.D. (1997), "Evidence for Life on Earth More Than 3850 Million Years Ago", *Science* **275**, 38-39.
- <sup>45</sup> Patel, P.H. & Loeb, L.A. (2000), "DNA polymerase active site is highly mutable: evolutionary consequences", *Proc.Natl.Acad.Sci. USA* **97**, 5095-5100.
- <sup>46</sup> Felsenstein, J. (2001), "Taking variation of evolutionary rates between sites into account in inferring phylogenies", *J.Molec.Evol.* **53**, 447-455.
- <sup>47</sup> Zhang, J. (2003), "Evolution by gene duplication: an update", *Trends Ecol.Evol.* **18**, 292-298.
- <sup>48</sup> But if a selection is hidden, science has no way of knowing whether it was required for functionality, or whether an alternative route could have led to a functionally synonymous protein. This implies that it may be impossible to meaningfully define the true amount of functional information contained in a biological system.
- <sup>49</sup> Perhaps this concept of divine micro-guidance could be applied to the cosmological fine-tuning required to prepare a planet inhabitable by intelligent beings, cf. Ross, H. (1998) *Big Bang Refined by Fire* (Reasons to Believe, Pasadena, CA), 13. Although observational searches for other habitable planets have failed so far (of over a hundred found, none is habitable, cf. Lissauer, J.J. (2002), "Extrasolar planets", *Nature* **419**, 355-358), the estimates of the probability of formation of such planets are still rather poorly constrained, cf. Franck, S., Block, A., von Bloh, W., Bounama, C., Garrido, I. & Schellnhuber, H.J. (2001), "Planetary habitability: is Earth commonplace in the Milky Way?", *Naturwissenschaften* **88**, 416-426.
- <sup>50</sup> The existence of angels - personal, responsible, superhuman spiritual powers -, some of which are in rebellion against God, may provide a solution to the theodicy question with respect to natural evils.
- <sup>51</sup> Gen. 50:20; John 19:30; Luke 24:26.