Thoughts on creation: 1— pre-Fall designed outcomes of biological interactions

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A definition of life is proposed that enables plants and single-celled photosynthetic organisms to be considered life-possessing in both biological and biblical terms. The considerable emphasis given to seed-bearing plants in the first chapter of Genesis is taken as pointing readers to understand the ecological interactions enjoyed by seed-bearing plants, single-celled photosynthetic, and other such organisms in the beginning. Exploration of the likely pre-Fall interactions involving these organisms is made. This provides substantial answers to population control issues when considered together with regulatory rules likely to have operated then. In the absence of destructive competition, carnivorism, parasitism, and environmental disturbances, reproduction would have fulfilled its purpose in some organisms once the earth was filled.

The parameters accepted as defining life impact attitudes and theories dealing with the discovery of extra-terrestrial life, contraception, abortion, whether death occurred before Adam's sin in Eden, and other phenomena. Among Christians, opinions differ regarding what biological entities can be regarded as living based on biblical word studies. The words soul (*nephesh*), flesh (*basar*), blood (*dam*), spirit/wind (*ruach*), and life (*ḥāyâ*; plural–*ḥayyîm*), as used in the Bible, have been taken to indicate the key characteristics shown by organisms possessing life. Hence, vertebrates and invertebrates are held to show the basic characteristics of life (consciousness, capable of pain sensation, air breathing, and possess flesh and blood in some form), but the terms are never used to refer to plants. Hence, plants do not possess life in the biblical sense. This allows the conclusion to be reached that no death occurred in Eden before Adam's sin, even though plants were designated to be eaten.[1]

Another approach is to interpret the terms used above (particularly consciousness, ability to communicate and feel pain) to mean that only those creatures with these characteristics were subject to death as a consequence of the Fall. Hence, insects could have died biologically from the start, for they do not have the capacity to feel pain or to be self-aware. For some, this still leaves plants classified as non-living.[2] It is evident, then, that conclusions differ among creationists, leaving individuals in a somewhat unhelpful position when speaking to those who do not believe in the Bible. It fails to provide what some would consider a coherent account to answer evolutionary speculations. In order to answer some of these issues, the concept of life is considered, and suggestions are made as to the most likely ecological principles operating in the beginning.

Characteristics of life and living things

Among scientists, living organisms are considered to show various characteristics. They possess cellular organization (the genome may be minimal), have metabolic potential (anabolic and catabolic abilities), respond to stimuli, possess homeostatic mechanisms and adaptive capability, and are capable of autonomous reproduction. In reproducing new cells, the metabolic machinery needs to elaborate more of the fundamental material making up the organism. This means that an increase in size or numbers occurs.[3]

When applying the criteria many scientists use to identify life, it is evident that a single cell (e.g. a spermatazoan) or a single animal that is capable of reproducing through sexual means (e.g. a lone mouse) does not exemplify life, even though it is alive. All attempts to define life have encountered similar problems.[4] This was brought into focus in attempts to identify the existence of life elsewhere in the cosmos. In order to remove some of the difficulties, the following definition was suggested by NASA: Life is a "Self-sustaining chemical system capable of Darwinian evolution". This definition does not allow for design and purpose in life. The use of the word 'system' is meant to accommodate a cell or one member of a breeding pair. By using the words 'self-sustaining', the formulators of the definition deny involvement from outside agencies or intelligences for the continuance of the system's operation. Proponents of Darwinian evolution assert that an organism that is considered alive contains a genetic system that replicates imperfectly. The introduced differences are heritable, so the replicates vary in their fitness.[5]

The definition proposed by NASA scientists discounts the possibility of immortality as it does not allow for a sustaining role by God or for the existence of a soul. More seriously for some evolutionary biologists, the identification of defect sequences in DNA and their elimination through technological manipulation is viewed as a move to goal-driven change rather than allowing random forces free expression, which is the supposed hallmark of evolutionary change.[6] This means that despite much effort no entirely satisfactory definition of life has been generated to satisfy modern scientists.

A definition of life on Earth appropriate to this article might be: *Life is the property of any entity that possesses a chemical/biochemical system holding a genetic code that enables it to fulfil its original design functions and to enable it to operate under changed conditions.* This definition acknowledges that life came by design and has purpose. It recognizes the centrality of a genetic code, the existence of a vast array of organisms, and the possibility of immortality on the one hand and of a more restricted existence on the other (e.g. plants consumed for energy generation). It also allows for adaptive changes as postulated in mediated design that permits a complex feature to appear as conditions change. Mutations and other copying mistakes were not a part of the God-instituted strategy pre-Fall; they appeared as a consequence of the Curse.[7] A good example of mediated design is the ancient derivation of today's cereal crops from wild plants through artificial selection involving mutations in regulatory genes or coding genes.[8]

Status of plants and single-celled organisms

The biblical assurance is that God created all things whether visible or invisible (John 1:2–3; Colossians 1:16; Hebrews 2:10). Brief details are given in Genesis 1 covering the life forms (possessing cellular features) made to inhabit the waters, air, and land. If a broad collection of texts is consulted, both animals and plants can be considered as representatives of life. Several texts relate animal life and death to plant functioning, senescence, and cessation of existence. This allows the deduction to be made that if equivalence exists in senescence and death, then both groups are representatives of life. Notice: "My days are like a shadow that lengthens, and I wither away like grass" (Psalm 102:11, NKJV); "For they shall soon be cut down [evildoers] like the grass, and wither as the green herb" (Psalm 37:2). In these verses the Psalmist likens the fate of all flesh and evildoers to the fate of withering/cut grass—they die. Hence, they both surely were alive previously. Job offers an excellent account of trees possessing life and yet subject to frustration of purpose (Job 4:7–10).

> "For there is hope for a tree, if it is cut down, that it will sprout again, and that its tender shoots will not cease. Though its root may grow old in the earth, and its stump may die in the ground, y*et* at the scent of water it will bud and bring forth branches like a plant. But man dies and is laid away; indeed he breathes his last and where *is* he?"

Other texts also reinforce the idea that plants are living things. Notice the following: "For no sooner has the sun risen with burning heat than it withers the grass; its flower falls, and its beautiful appearance perishes. So the rich man also will fade away in his pursuits" (James 1:11); "Now in the morning [after Jesus cursed a tree], as they passed by, they saw the fig tree dried up from the roots" (Mark 11:20). Thus, the Bible establishes plants as possessing life and being subject to frustration of purpose—they, being part of the "the creation" (Romans 8:19–22), are subject to disease, environmental stresses, and outrageous exploitation. If single-celled cultures of either eukaryotic plants (e.g. callus cultures) or animals (e.g. stem cells) are considered, they are capable of regeneration activity under artificial conditions. Plant cells can regenerate a functioning plant, an appropriate animal stem cell can regenerate an organ, but not an individual. These cells are living.

Seeds are "living" because they have the potential to give rise to future life (they are life-giving), as long as they retain viability and provided they are placed under favourable conditions for germination. The Bible goes further and says in the words of Jesus: "unless a grain of wheat falls to the ground and dies, it remains alone; but if it dies, it produces much grain" (John 12:24). Each seed will, under favourable conditions, give rise to a new plant after the pattern held in it (1 Corinthians 15:36–38). Since the living plant does not arise through spontaneous generation, viable seeds represent life and the future. They have life in them.

Unicellular organisms often could come under the heading of the invisible things spoken of by the apostle Paul (Colossians 1:16). Certainly he was not speaking specifically about microscopic biological entities, but these could be included. Today we know that not all single-celled cells are invisible. *Syringammina*, a single-celled foraminifer genus (in the subphylum Foraminifera—single-celled organisms with a hard external shell), can reach 20cm; and *Gromia*, an amoeba, can grow to 38cm.[9] These sea creatures can reproduce and

Figure 1. Single-celled *Gromia sphaerica* amoeba. Their size can be assessed against the black shrimp. The inset shows individual cells with their mud trails.

the latter is mobile, leaving visible mud trails as evidence (figure 1). *Gromia* in particular, could be included in the Genesis 1 account that speaks of God creating or giving life to "every living thing that moves" (v. 21). We are left in no doubt, then, that single-celled organisms can be classified as life-possessing both biblically and scientifically.

Not all single-celled biological entities can reproduce even though they can metabolize and move. Sperm (Hebrew *zera*) are a case in point. They contain the potential to initiate life when they meet a suitable ovum (*zara*) under ideal conditions. The sanctity of *zera* is noted in Scripture (Genesis 38:9–10), which can be argued as being partly on account of them symbolizing life.

In the plant kingdom, ovules may give rise to offspring through parthenogenesis, a process not requiring fertilization by sperm. Surprisingly, this phenomenon is seen in the animal kingdom as well, being found among invertebrates and a few vertebrates. The Komodo dragon is one reptile that participates in virgin births of males, presumably through the fertilization of an egg by another egg thus allowing doubling of the genes and enabling live young to hatch.[10] This illustrates the difficulty of distinguishing between living and non-living against a check list. According to the proposed definition, these single-sex entities are living.

Ecosystem functioning in the beginning

Both photosynthetic and non-photosynthetic organisms satisfy the definition of life as argued in the previous section. Plants originally were given as an animal food source, meaning that some planned resource utilization and population control (e.g. grazing restricts seed production in grasses and limits photosynthetic resources available for growth) was experienced in paradise. On the other hand, grazing activities (pruning) are known to be beneficial to branch strength and fruit formation in other plants. A return to the original diet will occur in the New Earth. There the emphasis with forms of life other than humans is on the promise that nothing will "hurt nor destroy" (Genesis 1:30; cf. Isaiah 11:8; 65:25; Revelation 21:4).

The ecosystem in the beginning was characterized by the absence of hurtful, destructive activity too. This raises several questions. One is: How are we to view the collection and consumption of plant tissues, fruits, and seeds and the consumption of whole living entities (photosynthetic), such as non-motile diatoms and motile dinoflagellates by sophisticated capture mechanisms? The answer seems to reside in whether an organism can experience hurt (Hebrew *ra'a'*). This word has the meaning of spoiling, breaking in pieces, and to afflict in a physical, social, and moral sense.[11] Affliction in a physical sense involves pain and the development of a negative mental state. The ability to respond to unwelcome stimuli (nociception) is possessed by seemingly all forms of life, even bacteria. Nociception is not pain, for the latter involves the development of negative, internal mental states. It is conceded by experts that most mammals feel pain and this can be extended perhaps to most vertebrates. Higher animals show an altered mental attitude in their efforts to avoid such distressful situations in the future. This change in attitude can be recognized by an alteration in behaviour towards particular stimuli. In simpler animals, various criteria nominated for the perception of pain, based on the human model, are not satisfied. This means they do not sense pain. The situation with most invertebrates is much less clear on the basis of the criteria available to assess whether pain is experienced.[12]

On resource utilization, photosynthetic organisms were designed to fulfil a number of functions which included primary production, forming replicating propagules, and acting as a food source for various life forms. In fulfilling some of these functions, the ingested tissue may perish as such. Hence, partial destruction of material assets was designed to occur among vegetables, grass, and shrubs, and related photosynthesizers, and entire destruction was a possible occurrence with fruits, nuts, and grain (although dispersal by animals was also presumably a design function for some plant propagules). The engulfment of single-celled (photosynthetic) and simple planktonic organisms was surely a planned outcome, for such organisms are at the base of the food chain in aquatic environments. This represented a fulfilment of their design function and is not to be classified in the same category as the destruction coming on account of human disobedience.[13] The latter can encompass such phenomena as debilitation by disease organisms, destructive harvesting of resources for gain, and elimination through human-generated environmental stresses. The organisms mentioned as being harvested according to God's design initiatives do not experience pain. This leads us to consider the likely interactions present in the beginning.

Interactions among organisms

Organisms in any community are linked in complex ways. They are dependent on each other for the transfer of nutrients and energy. All ultimately are dependent on the sun's energy to drive the processes seen in nature. The more complex the pattern of interactions, the more resistant the system is to change. Conserving interaction features are significant to the long-term survivability of ecosystems.[14] Photosynthetic organisms are central to ecosystem functioning and this is inferred in the first chapter of Genesis in that seeds and seed-bearing plants are mentioned six times.[15]

The suggestion is made here that this emphasis points to significant clues regarding ecological principles operating

Table 1. Interactions involving seed of animal and of plant origin considered to have operated in the pre-Fall world (illustrative references only are given)

Type of Interaction	Event	Some Organisms Involved
Primary producers	Organic matter production[19]	Diatoms, dinoflagellates, land plants, sea grasses, sea weeds
Decomposers, detritivores	Degradation of waste materials including dung and the chlorophyll molecule[20]	Bacteria, fungi, protozoa, invertebrates primarily
Commensal	Growth of orchids on trees[21]	Orchids, trees
Protocooperation	Bacteria gain benefits from plant exudates and confer benefits to plant[22]	Plants and bacteria
Mutualism	Germination and establishment of orchid seedlings; photosynthetic zooxanthellae operating inside invertebrate corals.[23]	Orchid seeds and fungi; zooxanthellae and corals
Amensalism	Germinating seeds release allelochemicals[24]	Plants
Competition	Pollination, fusion, and exclusion of gametes in sexual reproduction; response to light and space.[25]	Flowers, mammals, birds; sea weeds, crustose algae
Consumption of eggs	Egg gathering for food[26]	Fish to zooplankton
Consumption of plant material	Herbivory, granivory, and frugivory[27]	Humans, various animals, birds
Consumption of photosynthetic unicells	Food gathering[28]	Ciliates, diatoms, dinoflagellates, zooplanktonic grazers

in the beginning—look at the plants and their characteristic interactions! A related thought may be applied to aspects of animal and human behaviour. The instruction to be fruitful and multiply by means of seed is mentioned frequently or implied elsewhere in Scripture (e.g. Genesis 1:22, 28; 7:3; Numbers 5:28). Hence, it seems reasonable to accord significance to the word translated "seed" associated with the animal kingdom too. Readers might bear in mind that in this paper an attempt is being made to identify the ecological principles most likely to have operated in the world immediately following creation. Changes have occurred since then, an issue that will be addressed partially in a subsequent paper.

Photosynthetic organisms were designed to fulfil a number of functions as indicated above. Photosynthesizers do not possess highly developed sensory systems and certainly do not possess even an elementary nervous system such as seen in insects.[16] A nervous system is necessary for the detection of pain; hence, plants cannot be considered to suffer pain. Plants do have an elementary communication capability (they possess chemoreceptors mechanoreceptors). Plants may generate chemical signals that attract helpful insects, stimulate pheromone production in insects, signal other plants that insect attack is imminent, or release volatiles with biological activity that influence a range of other biotic interactions. Herbivore-damaged plants also are able to release volatiles that repel sap-feeding insects. Communication via chemicals released from roots allows them to signal stress to their neighbours, allowing them to respond appropriately.[17] Mechanoreceptors respond to touch. An electrical signal is generated in response to changes in ion frequencies caused by movement, as in the Venus flytrap.[18]

The spectrum of interactions that photosynthetic plants are involved in is extensive, especially their seeds, and single-celled organisms and their gametes. If we add to this list the interactions and the fate of generative elements of animal origin, the data in table 1 can be assembled. Such information enables us to understand some of the mechanisms operating to achieve population control and stability of the ecosystem (addressed later). The inclusion in the table of the phenomena of amensalism, competition, and phagocytosis (a form of predation in the language of science) requires a little explanation.

Amensalism may be observed during the germination of many seeds. Inhibitory chemicals (allelochemicals) may be released that can inhibit or delay the germination of other seeds, thereby giving the plant a competitive advantage.[29]

This highlights one problem that must be answered in creation ecology. How were populations of organisms restricted in their increase without recourse to hurt? Fortunately, the question does not arise with plants since they cannot sense pain, leading to the acceptance of inhibitory chemical release as a design function. Similarly, there should be no issue with the release of antibiotics and biocides effective against microorganisms that do not possess mechanisms capable of feeling pain.

Continuing with the idea of competition, the phenomenon comes in a number of reasonably innocuous forms in the plant kingdom. In many environments, plants compete for light. In forests, it is observed commonly that those requiring full exposure continue to grow upwards to achieve this while shade adapted species flourish at lower levels. Taking another example, in natural aquatic environments the supply of inorganic nutrients is low. If this was not so, then eutrophication would occur with disastrous consequences.[30] Algal growth is limited by nitrogen and phosphorus, but algae have the capacity to store phosphorus internally. Bacteria are able to take up these nutrients more quickly than algae, hence limiting the latter's growth.[31] We do not place this limitation of nutrients and competition for them in the same category as their availability in soils. In the latter instance, God indicated a diminution in fertility as a consequence of man's waywardness (Genesis 3:18–19; 4:12). In other interactions in the aquatic environment, such as between corals and macroalgae, there is competition for space and light. If the balance of coral-algal competition is maintained then a coral reef remains healthy, otherwise algae overgrow the corals.[32] In cases of limitation of resources, competitive exclusion could lead to total elimination if the population size of one of the competitors is limited. We do not envisage that this was happening in the newly created world.

Competitive phenomena also are observed in plants involving reproduction. Some plants are self-fertile, exhibiting competitive selfing. Here the anthers surround the stigma. On account of the close proximity of these structures, selfing is almost inevitable and this effectively prevents outcrossing. In other words, competition has a mostly one-sided outcome.[33] The final example of competition, which is understood as a design feature by perhaps all, is the sexual act. Some 40 million to 1.2 billion sperm cells are released during this act in humans, yet only one sperm succeeds when a suitable ovum is present. This one sperm is the winner in an intense competitive event.[34]

The case of phagocytosis appears to be a design feature in selected situations. If we take the genus *Alexandrium* in the dinoflagellates, which is both photosynthetic and capable of sexual reproduction, it provides a good example of an organism capable of feeding on diatoms, ciliates, and dinoflagellates via phagocytosis. Again, we can consider the diatoms. They are unicellular, mostly non-motile, sexually reproducing, photosynthetic organisms found in aquatic environments. They are responsible for about 40% of primary productivity. They are eaten by zooplanktonic grazers such as ciliates, dinoflagellates, and copepods.[35] This would appear to be a design outcome if we take terrestrial grazers of sexually reproducing, photosynthetic plants as our guide. Here, instead of eating portions of photosynthetic tissue (as with humans, cattle, and others), the whole organism may be consumed.[36] This means that at the commencement of the food chain in aquatic environments, the participants are involved in consuming other organisms. Since their responses to external stimuli are poorly developed, they appear to be in the same league as grass, fruit, and seed. All these have a primary production function by design and also can be destined for consumption thereby fulfilling a secondary function. In support of the design function concept for phagocytosis of unicells, it might be pointed out that the immune system of higher animals is dependent on the phagocytic activity of special cells to clear the circulatory system of foreign material. Such a system is hardwired in all so-called advanced organisms.

Incidences of phagocytosis (a form of predation) might be taken a little further by considering endo- and exo-cytosis events in humans. For example, reference can be made to communication between neurons via the synaptic vesicle cycle (figure 2). In the case of transmitting nerve signals,

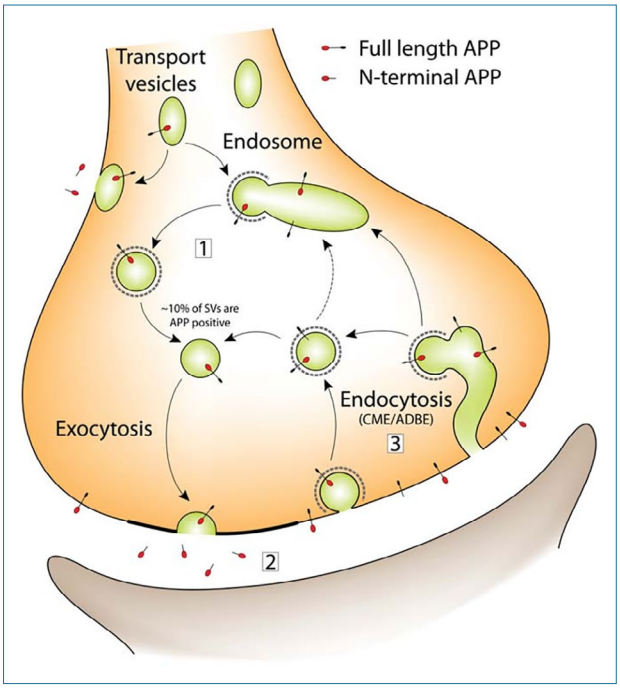

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Figure 2. Recycling pathways in the presynaptic terminal possessed by synaptic vesicles. The pathway illustrated is for the amyloid precursor protein involved in synaptic maintenance.[38]

this involves the release of neurotransmitter molecules at the nerve terminal. There vesicles prepare to release neurotransmitters previously taken up internally. This they do by exocytosis into the synaptic cleft. The synaptic vesicles now move on to become involved in endocytosis in order to recycle neurotransmitters. The processes involved are complex.[37]

While the destruction of photosynthetic tissues and organisms and the utilization of generative elements released into the environment as food items can be accepted as design outcomes, the question remains how extensive such utilization arrangements were (e.g. how do we realistically view insect dynamics?). In the present world, feedback loops involving predation, parasitism (in some instances this represents modified mutualism),[39] and competition for resources are significant in population dynamics and hence the stable operation of the ecosystem.[40] Suggestions are made in the next section about the principles that reasonably could be applied primarily to photosynthesizers and their utilizers in the pre-Fall world.

Regulatory rules

In post-Flood ecosystems four principal rules effectively explain population control. These are positive (induction) and negative (repression) regulatory events, indirect effects of one organism on another in a chain of interactions (cascade), and density-dependent or end-product inhibition phenomena. These same rules appear to apply to cellular regulatory events across the spectrum of free-living organisms.[41] Hence, there is no obvious reason why these rules cannot be accepted as being fundamental to life whether pre- or post-Fall. In the examples emphasized in this paper, positive regulation is illustrated (table 1) in mutualism, negative regulation is illustrated under the heading of competition and also amensalism, indirect regulatory effects (cascades) have been demonstrated involving fish, zooplankton, and phytoplankton and other plant/plankton-associated events,[42] and density-dependent phenomena can be shown by intraspecific competition of herbivores for food resources.[43] The examples taken fit comfortably into what is understood about the pre-Fall world. Accepting the assumptions made initially, this means that all four rules can be applied to the pre-Fall world. However, the absence of flesh-eating creatures, disease, and natural disasters means that population increase in the pre-Fall world would have continued uninterrupted, as there was no death. Assuming regional commencing concentrations of animals, birds, and other created moving organisms (without this postulate the advice to multiply would have had limited meaning; compare with human arrangements too), a time would come when the earth was filled. Then, the purpose of reproductive activities would have been fulfilled in some organisms (cf. Matthew 22:30).

Summary

Arguments are presented from Scripture and science enabling plants to be regarded as life-possessing organisms. The emphasis on seeds and seed-bearing plants in Genesis 1 suggests that more attention might be focused on the predominant interactions involving photosynthetic plants and their interactions in the ecosystem in order to understand operating conditions pre-Fall. Plants possess elementary sensory capabilities, but these do not represent perceptions of pain. It is argued that, in the pre-Fall world, they participated in the majority of interactions recognized in today's ecosystems except for parasitism, wholesale predatory destruction, and perhaps competitive exclusion phenomena. These interactions would have enabled ecosystem stability and some population control. However, reproduction in a raft of organisms would have become unnecessary once the earth was filled with their kind and adjustments would have been undoubtedly made by the Sustainer of all things.

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