The marring of creation and some implications for ecosystem functioning

Warren Shipton

God's judgment regarding human moral failure resulted in partial loss of genome stability, replication fidelity, and soil fertility. In addition, there were climate and topography changes, altered interactions between organisms, and ultimately death was experienced. Brief statements as to the nature of the changes following the Fall are given in the first nine chapters of Genesis. These alterations may be explained, at least partially, by reference to aberrations in the translation of genetic information, changes to regulatory elements, and the rare transfer of genetic information between organisms. This is not to discount the possibility of intelligent beings contributing to unsatisfactory outcomes. The curses pronounced on the earth led to changes in ecosystem functioning too. Population control now variously depends on predation, obligatory carnivorism, sanguivory, destructive competition, and devastation caused by disease and pest species. Suggestions are made concerning the phenomena operating before the Fall to ensure population control and ecological balance.

The well-balanced, very good ecosystems established at the beginning were changed following the Fall, with some alterations occurring abruptly and others developing over time, as indicated in the first nine chapters of Genesis. The possible changes experienced are suggested based on the limited information available in the inspired Word and from knowledge of ecosystem functioning today under various scenarios. Possible explanations are provided for some of the more spectacular changes recognized, such as predation, obligate carnivorous behaviour, and devices/products/organisms that function to induce pain and suffering. Possible biological and abiotic agents involved as change makers are identified.

The dynamics underpinning balanced ecosystem functioning are reasonably well understood today. In such systems, predatory/carnivorous activity, destructive competition, disease, crowding, and the impact of extreme environmental events are recognized as playing a significant role in population control. How population control was organized in the beginning, in the absence of these phenomena, needs to be addressed in order to give credibility to the Creation Model, given the assurance that all creation is dependent on sustenance provided at the hand of God (Psalm 145:15). Possible answers are provided.

Change comes

The scene that greeted Adam and Eve as creation Day 6 drew to a close was majestic and tranquil. Since they were in a special garden, we might reference the great gardens of today's world as the lowest point in our imagination. We should not think that there was a single terrestrial ecosystem in the beginning. The earth was filled with vegetation from the third day, and a special garden was established by God (Genesis 1:11–12; 2:8). The existence of varied ecosystems might be argued to have existed from the beginning. Specialized plants capable of flourishing at different altitudes and latitudes (many species are similar) were undoubtedly created in the beginning, as they can have unique features. Furthermore, if the river Euphrates, mentioned in Genesis 2:14, corresponds even remotely with the present-day river, a number of ecosystems would have been encountered over its length. Even if this idea is disallowed, river systems require a source higher than the mouth suggesting varied ecosystem along their course.

Scripture clearly indicates that three curses fell on the earth as a result of human disobedience. Firstly, the lack of thankfulness and subsequent disobedience shown by Adam and Eve brought both direct and indirect consequences to them and to the animal intermediary used by Satan to undertake his deception. The coming birthing process was now destined to be more painful and eventually death would reduce them to dust (Genesis 3:19). The serpent also was cursed and destined to move on its belly all the days of its life (Genesis 3:14). It was abhorred in a similar manner as experienced by Cain after he was cursed. Cain was shunned (Genesis 4:11–14). The later biblical record indicates that the serpent was regarded as venomous and hence dangerous (Numbers 21:6; Job 20:16). These departures from God's ideal represented but the beginning of changes (Genesis 3:17). The Apostle Paul indicates that all creation was subject to futility and corruption (Romans 8:20–21). He speaks of creation groaning under the "bondage of corruption" (v. 21, NKJV). The Greek word *phthora* used for the second descriptive term means "destruction, corruption, decay, perishing"[1] and

is applied to physical and moral decay (1 Corinthians 15:42; 1 Peter 1:4; 2:12).

The pronouncement that death would follow disobedience (Genesis 2:17) presupposes an ageing process as the event was long delayed (Genesis 5:5). Longevity has been linked to the genes possessed. A prominent theory of ageing asserts that the accumulation of mutations leads to frailty and, eventually, mortality.[2] God's creation was corrupted as a result of the Fall (Genesis 6:11), leading to death.

The key Hebrew word *shachath* used in the Old Testament, associated with the idea of corruption, carries the basic meaning 'go to ruin'. In its different stem forms it can mean 'spoil, ruin, pervert, corrupt' and 'be marred, spoiled'.[3] The most relevant Bible examples of this are where writers used the word to refer to the perishing of a body part following damage by the (likely malicious) action of another (Exodus 21:26), and the creation of an imperfect piece of pottery by a potter (Jeremiah 18:4). Here the emphasis is on organ malfunction and on frustration of purpose that represented a departure from an ideal or goal. How this might relate in today's world can be understood by reviewing relevant information concerning selected human diseases. Rare gene variants have been identified that give rise to proteins that do not work properly. Hence, diseases such as cystic fibrosis and sickle-cell anaemia can be accounted for.[4] The Maker's original intentions have been frustrated by the emergence of these variants. In these examples, gene replication fidelity has failed, giving rise to diseases that cause pain and other unwelcome outcomes.

Also, in Genesis 3 verse 17, there are some possible implications involving soil fertility, photosynthetic efficiency, less cooperation involving microbes, and perverse relationships between plants and insects.

The second curse followed the despicable murder of Abel by his brother Cain (Genesis 4:8, 12) and the third and final curse was associated with the universal Flood (Genesis 7). The restricted gene pool represented in the limited number of life-forms admitted to the Ark would exert longterm consequences. One such possibility might be the early elimination of some forms on account of their inability to function efficiently in a now radically changed world. If an early mutation occurred in a life-form coming from the Ark, then some very damaging consequences might follow (founder effects). Reference to current experience following major flooding events indicates several possible outcomes. The enormous upheaval experienced and the prolonged flooding would have resulted potentially in soil fertility decline that led to post-Flood nutritional deficiencies in plants and animals and occasional toxicity issues involving heavy metals. There would undoubtedly have been a change in the composition of the microbiota and even the elimination of selected microbes as experienced during prolonged flooding.[5] Subsequent impacts on the biogeochemical cycles would have followed, with the possible alteration in the balance of atmospheric gases. Other changes undoubtedly occurred.

Image: Microbewiki, Kenyon College Department of Biology

Figure 1. Galls on roots induced by *Agrobacterium* sp. after DNA transfer to the plant

It could be argued that one significant consequence of the Flood involved the watering arrangements on Earth. The appearance of the rainbow as a covenant sign (Genesis 9:12–15) might be conjectured to indicate that the previous watering arrangements were different in form or intensity (cf. Genesis 2:6) and changed at the time of the Flood. This would mean that the ravages of local flooding, erosion, and further disruption of soil fertility now could be anticipated.

All these changes would have impacted food chains and web functioning. Further, the movement towards the emergence of pathogens, thorns, thistles, venoms, predation, carnivorism, and sanguivory would have been witnessed among organisms capable of feeling pain. The latter three phenomena were accentuated post-Flood. We can reasonably argue that all organisms in the Ark survived on a plant-based diet during their trip. Undoubtedly, some animal groups became extinct after the Flood on account of resource limitations.

Change makers

A number of agents can be considered to have facilitated some of the changes that occurred post-Fall. These could have involved both abiotic and biotic components. The Curse spoken by God can be seen as an act allowing changes to happen in a radically different world. From our knowledge of the many heritable changes recognized today,[6] there is an expectation that some genotypes would have flourished whereas others might have been stressed, as they were

now functioning outside their optimum operational design parameters.

A role for human participation in change is also inferred. The first change noted at the hand of humans was desensitization to other humans (Genesis 4:8; 6:5). Domestication of selected animals and interbreeding experiments can be imagined. In such endeavours they selected for desirable phenotypic characteristics, which are considered to be a reflection of changes in regulatory gene activity and mutations.[7] For instance, the production of the mule (e.g. Genesis 36:24; 2 Samuel 13:29), involving a male donkey and female horse cross, gave desirable characteristics coming from both parents.[8]

The biblical record indicates that Adam needed to cultivate the soil (Genesis 3:17, 23). Some of the plants he chose may have included the progenitors of wheat and barley, as they are known to have originated in the Fertile Crescent. It is well understood that some plant derivatives have arisen through the selection of phenotypic variants with desirable characteristics.[9] Spectacular gene rearrangements have been undertaken in recent years involving both plants and animals.[10]

Adverse intelligent agencies could have been involved in changes occurring in nature. This possibility is often not considered, but Alvin Plantinga, the American philosopher, is one who has suggested this, as the following quote indicates.[11]

> "The world may very well contain sin and suffering, not just on the part of human beings but perhaps also on the part of other creatures as well. Indeed, some of these other creatures might be vastly more powerful than human beings, and some of them—Satan and his minions, for example—may have been permitted to play a role in the evolution of life on earth, steering it in the direction of predation, waste and pain. (Some may snort with disdain at this suggestion; it is none the worse for that)."

The story of Job's distressful experience with boils (Job 2:4–7) indicates something of the skill of Satan in the manipulation of nature post-Fall. Job did not know the back story, which paints Satan as having control of the physical and biological realm within limits permitted by God (Job 2:6–7). It is not beyond reason that genetic manipulation could have been permitted within limits specified and inferred in Genesis 3 and possibly 9 (the fear factor mentioned may have indicated the development of carnivorism).

Interactions among organisms can lead to changes in the genetic complement held in a cell. Transfer of genetic information can occur occasionally through processes other than sexual reproduction, and this can lead to changes in the characteristics displayed by an organism.

Genuine evidence for gene transfer among organisms is suggested by some well-researched examples. The classic example involves the bacterium *Agrobacterium* and related bacteria. These are well-known for their ability to transfer plasmid DNA (small, circular, double-stranded DNA molecules not part of chromosomal DNA) to selected living plants in the natural environment. The plasmid DNA from *Agrobacterium* can be integrated into the chromosome of selected plants. There, the foreign DNA will cause tumour-like growths (figure 1), even in the absence of living bacteria.[12]

Bacteria are able to transfer genetic information between bacterial species and genera (horizontal gene transfer) on a regular basis through the operation of well-known mechanisms (conjugation, transformation, and transduction) of which phage (bacterial virus)–mediated transduction is significant. Such transfer frequently involves genomic islands and also plasmids that confer antibiotic resistance.[13]

Other organisms can be involved in gene transfer. For example, the transfer of DNA between a bacterium (*Escherichia coli*) and a yeast (*Saccharomyces cerevisiae*—single-celled eukaryote) has been recorded in culture.[14] It is conceivable that related events could occur in natural situations, such as in biofilms. It is important to note that the organism receiving the new information is still abundantly recognizable and it is not transformed into something different; evolution as viewed by modern science is not illustrated in these examples.

Genome changes give unwanted outcomes

With the passage of time, remarkable changes were seen among the plants and animals. Disease, predation, the development of omnivorous and carnivorous lifestyles, and destructive competition were observed together with the appearance of noxious plants and animals. Relatively straightforward explanations can be given for some of these developments, while others require a more complex approach. A number of examples will be given to explain the emergence of altered biological capacities in members active in the food web. This does not exhaust the spectrum of possibilities operating in the biological world.

Carnivores and omnivores: specialized features

The order Carnivora includes a number of species. Some are obligate carnivores (felines or cats), while most of the remaining members are omnivores, consuming variable amounts of meat and vegetable matter.[15] A number of anatomical features have been associated classically with carnivorous animals. They have specialized teeth. The canine teeth (long, sharp, and well formed) vary the most, and such variability can be seen in populations in confined geographical locations. The differences noted are considered to be accounted for by developmental factors (e.g. diet)

as well as selective pressures.[16] Some of the features give advantages in catching and dissecting prey (teeth, mouth structure, claws), but others such as the organization of the digestive tract, may have little to do with its potential to handle vegetable matter if the missing digestive functions were present (refer to the giant panda example discussed later).

Obligate carnivores (felines) have lost the ability to synthesize selected amino acids and cannot synthesize adequate quantities of vitamin A and arachidonic acid. They show low activity in some intestinal synthetic enzymes and an inability to taste sugars.[17] In poorly functioning biochemical pathways delivering low levels of activity, output levels can be increased by changes to regulatory genes. Where an activity has been lost, some suggestions have been made as to how this might have happened.[18] Loss of activity drives animals to seek alternative, satisfying food sources as illustrated in vampire bats (figure 2). They have lost various functions (10 suggested) through inactivating mutations leading to obligate blood feeding. One mutation led to extensive morphological and physiological changes to the stomach.[19]

With omnivores, loss of metabolic capabilities does not generally occur. Bears (family Ursidae) generally are able to exist satisfactorily on a well-balanced vegetarian diet. Some extinct members were entirely vegetarian with appropriate adaptations to suit the particular specialized diet. The variation seen today is a reflection of selection among the options present in the genome of the animals held in the Ark.[20] A fascinating member of the family Ursidae is the giant panda. It has a digestive tract, digestive enzymes, and gut microbiota that show a strong resemblance to those found in the carnivores. The explanation for this seems to reside in the similarity shown between the protein to non-protein energy ratio in the diets of both. On the other hand, pandas have skull, jaw, and dentition that resemble those of herbivores. In addition, they have lost a functioning taste receptor often associated with meat eating.[21]

Image: Mokele/Wikimedia, CC BY 3.0

Figure 2. Skeleton of vampire bat, showing piercing teeth thought to have originally functioned to pierce fruit

Taste loss is widespread in carnivores. The carnivores that are exclusive meat eaters are unable to sense sweet-tasting compounds, due to a defective receptor. The giant panda lacks the functional gene for savory taste (umami receptor). The presence or absence of particular functional receptors (loss of gene function mutations) appears to be related to food preferences. This means that bears that feed on berries have an intact sweet-taste receptor.[22]

Venoms

Venoms are natural substances secreted by some organisms that are injurious to health in small amounts when introduced, usually via a bite or sting. Venoms are widespread in nature and have a toxic effect on selected body systems (e.g. neurotoxins, cytotoxins). Several examples will be taken to illustrate how some damaging poisons may have originated. By giving these examples, it is not inferred that no toxic materials were present pre-Fall. A planned role for toxins might be demonstrated by taking one example. The role of toxin genes in the simpler life-forms, such as soil- or water-dwelling bacteria, is presumably to facilitate their survival and growth there and need not be connected with disease in those environments. This appears to be the case with *Bacillus cereus*, a soil-dwelling bacterium that lives happily with invertebrate hosts. The ability of this organism to grow in food items permits it to cause diarrhoeal disease in humans through its toxin-producing capacity.[23] Changes in human activity patterns since the Fall are responsible for the occurrence of this type of food poisoning.

If death-dealing toxins were part of the original design experience for feeling life-forms, we would need to assume that most animals and birds possessed toxin immunity in the beginning. While immunity exists to a limited extent today,[24] the proposition of an almost complete reversal in the living arrangements of animals does not appear to be a viable one.

With snake venoms, it has been postulated that some venoms may have arisen from non-toxic genes that performed a number of cellular tasks around the body. Highly venomous snakes appear to have many more copies of the venom genes than do non-venomous snakes (pythons). The theory underlying this proposal suggests that the proto-venom genes were first expressed at low levels in many tissues, including the oral secretary glands, and this was followed by higher expression levels for some genes in these glands and a small number of other tissues. To enable these changes to occur in saliva, gene duplication and further mutation in one of the duplicated DNA strands could have occurred, and exon shuffling may also have been involved.[25] Increase in the expression of venom genes can also be theoretically linked

to suggested changes in the regulatory sequences of genes.[26] Certainly, creationists can resonate with the idea that proto-genes may have been present from the beginning where they served useful design purposes, and that gene duplication and other targeted changes occurred following the Curse to allow the functioning of the now altered ecosystem.[27]

Thorns and prickles

Thorns are modified branches, while prickles are modified outgrowths from epidermal cells (figure 3). Thorns and prickles protect plants from excessive herbivory.[28] It seems possible that some population control measures were lost following the Curse, leading to high levels of herbivory from insects and mammals. The appearance of these structures would have functioned to offer some protection.

Prickle formation also has been recorded with eggplant crosses. Those formed between the diploids *Solanum aethiopicum* and *S. macrocarpon*, which lack prickles, led to prickle formation in the F1 hybrid. Also, crosses between the diploids *S. macrocarpon* and *S. melongena* led to prickle formation in some F2 hybrid progeny.[29] These plants had gained the ability to produce prickles in contrast to their assumed original state in Eden. A possible explanation is offered by a study of a spontaneous mutant involving *S. vivarum*. The change was from the prickly state to a prickle-free one. The biosynthetic pathways differed in the prickle bearing and prickleless variants and, significantly, the genes involved in the prickly variant were related to stress and defence responses.[30] In yet another plant (prickly poppy), experimental elevation of prickle density has been shown to be related to hormone levels,[31] again pointing to the significance of biosynthetic pathway regulation. Hence, it seems evident that regulatory alterations could be primarily responsible for prickle development. This idea is strengthened by recent work with roses. Changes in regulatory pathways were indicated as operating in leaf trichome (outgrowth of epidermal tissues that function in defence; they represent fine and smaller outgrowths in contrast to prickles) formation and other features.[32]

In citrus, thorns develop on account of thorn stem cells experiencing arrested growth on account of the activity of two regulator genes. When the activity of these genes is disrupted (induced mutations to the recessive state), the thorns develop into new branches instead.[33] Here again, regulatory changes were key to thorn appearance.

An incompetent God?

The mere existence of carnivores has brought forth the accusation that a loving and omnipotent God would not have allowed such suffering and carnage to exist.[34] Those attempting to resolve the issue might reject the idea of God or embrace the concept of progressive creation through the evolutionary process. An alternative is to contend that the outcomes observed today came as a consequence of the moral failure of the progenitors of the race. Such failure and subsequent ones had consequences for the entire biological realm through alterations in the expression of the genetic code in a vastly physically changed world. In the beginning, there was no need for carnivory in order to control population growth. The Creator had a well-defined strategy that did not involve suffering and pain (Genesis 1:31; Isaiah 65:25: Revelation 21:4).

Several options have been outlined by John Morris; namely, features were present originally (maybe benign) that would later be needed—the genome contained the potential to be changed by the forces of nature and by selection to give rise to carnivory (organism designed to suit environmental conditions as a function of survival variability) or the sinister forces of evil led by Lucifer were somehow involved.[35] In the study of ecosystems of isolated islands devoid of mammalian predators, a situation is observed somewhat resembling the stability envisaged in the beginning.[36] In such situations, mammalian predatory activity is unnecessary for the maintenance of population balance. It is true that in some of these situations losses and gains of species may be experienced due to pressures of food supply or to predation by invertebrates (e.g. centipedes),[37] but a dynamic equilibrium occurs over time.

Well-balanced components of vegetation were established initially to cover the earth (Genesis 1:11–12), with the planned starting fauna added later (vs 24–25). The fauna seeded into the existing ecosystems were meant to multiply, meaning that there would have been a succession as they spread throughout the terrain. Finally, a homeostatic state would have been reached in the absence of mammalian predators. Once this state had been attained, its continuance would have been dependent on population control.

Population control mechanisms

The actual number of offspring produced (fertility) and natural ability to reproduce (fecundity) has profound effects on the survival of plants and animals. In the beginning, these features were designed to enable population increase to occur in a planned manner throughout the various ecosystems existing. In the beginning, it can be anticipated that there were multiple dispersal centres, represented by different ecosystems, that were seeded with animals, birds, and other life-forms at creation (multiplication was mandated, Genesis 1:22). This would have ensured the functioning of the ecosystem moving towards the planned final state. Nevertheless, in order to reach this state, a succession

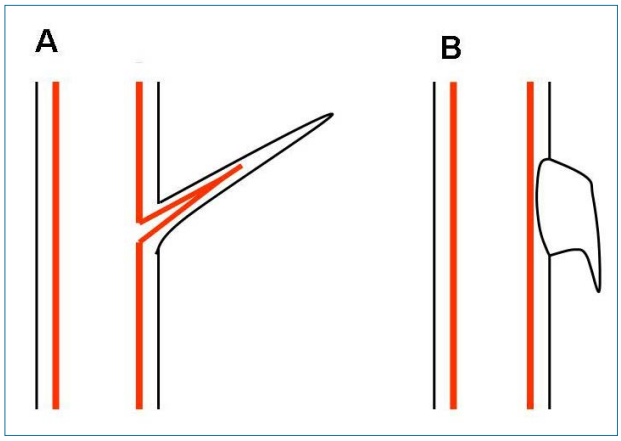

Figure 3. Illustration of a thorn or modified branch (A) contrasted with a prickle with no vascular connection (B)

conceivably occurred as the creatures spread out and occupied virgin vegetated terrain. At some point, reproductive activity in the fauna would necessarily have been slowed to achieve the balance planned and then terminated as, with no death as an option in feeling organisms (how life and death are viewed biblically may differ among creationists), overpopulation would have become an issue. Substantial changes in the physical environment, either seasonally or with the passage of time, are not thought to have occurred.

The colonization of the post-Flood earth would have been entirely different from that experienced in the beginning. There was one centre for dispersal after the Flood. Post-Eden dampening of population growth would have occurred via the (now) natural death process and through changes in the other biological events, involving disease and predation and due to anticipated upheavals in the physical environment. Fertility and fecundity issues would have been one of the first noticeable changes taking place post-Flood. Population numbers are determined by numerous factors, including food quality and quantity, physical environment, biological interactions, the nature of the genetic code, population structure, disease, and innate drivers. Most of the factors known today that influence population increase would not have been operational in the beginning. For example, diseases, ageing, mineral deficiencies, and environmental chemical contamination were unknown. Today, these factors influence fertility and, ultimately, population growth.[38] Both density-dependent and -independent factors influence population levels, and their significance varies with the biological entity under consideration.

Population density in resource-limited situations influences the fecundity of animals.[39] Density-dependent processes are found with predation, parasitism, resource competition, and other interactions. Apex predators are significant in the regulation of populations of various animals in some ecosystems. For example, in Ghana the rise of the baboon population to plague levels can be accounted for by the decrease, and sometimes disappearance, of lions and leopards in selected parks.[40] On the other hand, invasive predators (e.g. cats, rodents, dogs, and pigs) have been responsible for the extinction or precipitous reduction in populations of birds, mammals, and reptiles in other geographical locations.[41]

The social environment of some animals induced by crowding can impact their reproductive behaviour through alterations in brain function so that self-regulatory strategies are operational.[42] It is contended that in a stable, complex ecosystem intraspecific competition and self-regulation is always present.[43] In reality, the interplay of mechanisms involved in density-dependent population fluctuation has been difficult for scientists to identify fully.[44]

Density-independent regulation occurs commonly through the operation of abiotic factors, such as extremes in environmental parameters.[45] This can lead to abrupt shifts in population levels rather than the dampening effects classically seen with density-dependent regulatory events. This was observed during the deadly bushfires in Australia in 2019/2020.[46] The effects exerted by stressors may be more subtle, as illustrated in the life cycle of Chinook salmon. Juvenile survival may be affected not only by water temperature but stream flow.[47] With epiphytic plants, density-independent factors can be significant in determining population dynamics in a canopy as, for instance, light, moisture, and nutrient availability, levels of turbulence and radiation, and gas concentrations.[48] There is no good reason to suggest that similar factors influenced population dynamics in the beginning.

In the pre-Fall environment, some food resource competition conceivably developed for selected life-forms, particularly in tree canopies and the transition area between ecosystems. With fish breeding, as found in spawning habitats today,[47] the quality of the habitat could have influenced egg incubation success. A breeding hierarchy possibly existed with selected animal groups that may have influenced population increase. Self-regulatory behaviour could have been a dominant feature. Ultimately, there would have been a need for fundamental changes in population increase expectations over time in ecosystems where death and pain were not experienced. Conceivably, this could have occurred through changes to the gene regulatory network organized by the Designer in line with the concept of His continual sustaining activity (Hebrews 1:3; cf. Genesis 18:10–11, 14; 21:1–2). It is noted that, from plants to mammals, changes to the gene regulatory network can have dramatic effects on reproductive output so that increases, decreases, and even no output have been observed.[49] Changing the regulatory

setting represents a rather straightforward option to the human mind.

Conclusions

The changes that occurred in the biological world following God's judgments on account of human moral failures and rebellion have resulted in substantial alterations in ecosystem functioning. All forms of life have been impacted negatively on account of operational aspects of their biological machinery being upset. Both abiotic and biotic agents have been involved in inducing changes in the expression of genetic information, leading to some unusual outcomes. Some of these were predicted in Scripture and can begin to be explained in scientific terms. Some of the most untoward results involved the appearance of disease, predatory activity among larger life-forms, pain-inducing thorns, prickles, and venoms. These outcomes now contribute towards population control in a world where death is a familiar phenomenon. Density-dependent and -independent mechanisms of population control are now familiar. In the pre-Fall world, some of the milder forms of population control recognized today conceivably existed with self-regulatory phenomena perhaps predominating. At some point, in the absence of life-forms returning to dust, additional population control mechanisms involving reproductive ability would have been necessary. This might have involved changes to the gene regulatory network, or other options might have been planned.

References

1. Abbott-Smith, G., *A manual Greek–English lexicon of the Greek New Testament*, Charles Scribner's Sons, New York, 1922; Thayer, J. (Ed.), *Thayer's Greek English lexicon of the New Testament*, Hendrickson Publishers, MA, 1995.
2. Frankel, S. and Rogina, B., Evolution, chance, and aging, *Frontiers in Genetics* **12**:733184 | doi.org/10.3389/fgene.2021.733184.
3. Brown, F., Driver, S., and Briggs, C., *The Brown-Driver-Briggs Hebrew and English lexicon*, 7843, Shachath, Hendrickson Publishers, MA, 1994; biblehub.com/bdb/7843.htm.
4. Chial, H., Rare genetic disorders: learning about genetic disease through genetic mapping, SNPs, and microarray data, *Nature Education* **1**(1):192, 2008.
5. Peluola, C., Fernando, W.G.D., Huvenaars, C. *et al*., Effect of flooding on the survival of *Leptosphaeria* spp. in canola stubble, *British Society for Plant Pathology*, 1–7, 2013 | doi.org/10.1111/ppa.12036; Randle-Boggis, R.J., Ashton, P.D., and Helgason, T., Increasing flooding frequency alters soil microbial communities and functions under laboratory conditions, *MicrobiologyOpen* **7**(1):e00548, 2018 | doi.org/10.1002/mbo3.548.
6. Rey, O., Danchin, E., Morouze, M. *et al*., Adaptation to global change: a transposable element-epigenetics perspective, *Trends in Ecology and Evolution* **31**(7):514–526, 2016.
7. Jensen, P., Behavior genetics and the domestication of animals, *Annual Review of Animal Biosciences* **2**:85–104, 2014; Trut, L., Oskina, I., and Kharlamova, A., Animal evolution during domestication: The domesticated fox as a model, *Bioessays* **31**(3):349–360, 2009 | doi.org/10.1002/bies.200800070.
8. Leighton, A.C., The mule as a cultural invention, *Technology and Culture* **8**(1):45–52, 1967.
9. Sang, T., Genes and mutations underlying domestication transitions in grasses, *Plant Physiology* **149**(1):63–70, 2009 | doi.org/10.1104/pp.108.128827.
10. Barnes, W.M., Variable patterns of expression of luciferase in transgenic tobacco leaves, PNAS **87**(23):9183–9187, 1990; Blakemore, E., Human-pig hybrid created in the lab—Here are the facts, *National Geographic News*, 26 Jan 2019; nationalgeographic.com/news/2017/01/human-pig-hybrid-embryo-chimera-organs-health-science; Firger, J., Ten weird ways scientists are changing the world with gene editing, *Newsweek*, 11 August, 2017; newsweek.com/crispr-gen-editing-science-650018; Rehbinder, E., Engelhard, M., Hagen, K. *et al*., *Pharming: Promises and risks of biopharmaceuticals derived from genetically modified plants and animals*, Springer-Verlag, Berlin, Germany, pp. 54–62, 2009.
11. Plantinga, A., *Where the Conflict Really Lies: Science, religion and naturalism,* Oxford University Press, UK, p. 159, 2011.
12. Lacroix, B. and Citovsky, V., Transfer of DNA from bacteria to eukaryotes, *mBio* **7**(4),e00863-16, 2016; mbio.asm.org/content/mbio/7/4/e00863-16.full.pdf.
13. Chen, J., Carpena, N., Quiles-Puchalt, N. *et al*., Intra- and inter-generic transfer of pathogenicity island-encoded virulence genes by cos phages, *The ISME J.* **9**:1260–1263, 2015.
14. Heinemann, J.A. and Sprague, G.F. Jr., Bacterial conjugative plasmids mobilize DNA transfer between bacteria and yeast, *Nature* **340**(6230):205–209, 1989; Soltysiak, M.P.M., Meaney, R.S., Hamadache, S. *et al*., Trans-kingdom conjugation within solid media from *Escherichia coli* to *Saccharomyces cerevisiae*, *International J. Molecular Sciences* **20**(20):5212, 2019 | doi.org/10.3390/ijms20205212.
15. Lariviere, S. and Stains, H.J., Carnivore, *Encyclopedia Britannica*, 16 Aug 2017; britannica.com/animal/carnivore-mammal.
16. Meiri, S., Dayan, T., and Simberloff, D., Variability and correlations in carnivore crania and dentition, *Functional Ecology* **19**(2):337–343, 2005.
17. Kim, S., Cho, Y. S., Kim, H-M. *et al*., Comparison of carnivore, omnivore, and herbivore mammalian genomes with a new leopard assembly, *Genome Biology* 17, article 211, 2016; genomebiology.biomedcentral.com/articles/10.1186/s13059-016-1071-4; Zafalon, R.V.A., Risolia, L.W., Vendramini, T.H.A. *et al*., Nutritional inadequacies in commercial vegan foods for dogs and cats, *PLoS One* **15**(1):e0227046, 2020 | doi.org/10.1371/journal.pone.0227046
18. Shipton, W., Thoughts on the nutritional challenges faced by felines, *J. Creation* **31**(3):119–127, 2017; creation.com/how-did-cats-become-carnivores.
19. Blumer, M., Brown, T., Freitas, M.B. *et al*., Gene losses in the common vampire bat illuminate molecular adaptations to blood feeding, *bioRxiv* preprint, 19 Oct 2021 | doi.org/10.1101/2021.10.18.462363.
20. van Heteren, A.H., Arlegi, M., Santos, E. *et al*., Cranial and mandibular morphology of Middle Pleistocene cave bears (*Ursus deningeri*): implications for diet and evolution, *Historical Biology*, 2018; doi.org/10.1080/08912963.2018.1487965; Weston, P. and Wieland, C., Bears across the world, *Creation* **20**(4):28–31, 1998; creation.com/bears-across-the-world.
21. Nie, Y., Wei, F., Zhou, W. *et al*., Giant pandas are macronutritional carnivores, *Current Biology* **29**(10):1677–1682.e2, 2019; sciencedirect.com/science/article/pii/S0960982219303951.
22. Jiang, P., Xia Li, J.J.. *et al*., Major taste loss in carnivorous mammals, PNAS **109**(13):4956–4961, 2012; | doi.org/10.1073/pnas.1118360109.
23. Arnesen, L.P.S., Fagerlund, A., and Granum, P.E., From soil to gut: *Bacillus cereus* and its food poisoning toxins, *FEMS Microbiology Reviews* **32**(4):579–606, 2008 | doi.org/10.1111/j.1574-6976.2008.00112.x.
24. Bittel, J., The animals that venom can't touch, *Smithsonian Magazine*, 30 Sep 2016; https://www.smithsonianmag.com/science-nature/animals-venom-cant-touch-180960658/; Hopp, B.H., Arvidson, R.S., Adams, M.E., *et al*., Arizona bark scorpion venom resistance in the pallid bat, *Antrozous pallidus, PLoS One* **12**(8):e0183215, 2017; | doi.org/10.1371/journal.pone.0183215.
25. Fry, B.G., Roelants,K., Champagne, D.E. *et al*., The toxicogenomic multiverse: convergent recruitment of proteins into animal venoms, *Annual Review of Genomics and Human Genetics* **10**, 483–511, 2009 | doi.org/10.1146/annurev.genom.9.081307.164356; Ham, K., How did snakes get their venomous bite? *Answers in Genesis*, 22 Dec 2014; answersingenesis.org/reptiles/how-did-snakes-get-their-venomous-bite; Reyes-Velasco, J., Card, D.C., Andrew, A.L., *et al*., Expression of venom gene homologs in diverse python tissues suggests a new model for the evolution of snake venom, *Molecular Biology and Evolution* **32**(1):173–183, 2015 | doi.org/10.1093/molbev/msu294; Zimmer, C., On the origin of venom. *National Geographic Magazine*, 9 Jan 2013; nationalgeographic.com/science/phenomena/2013/01/09/on-the-origin-of-venom.
26. Hargreaves, A.D., Swain, M.T., Hegarty, M.J. *et al*., Restriction and recruitment—gene duplication and the origin and evolution of snake venom toxins, *Genome Biology and Evolution* **6**(8):2088–2095, 2014 | doi.org/10.1093/gbe/evu166.
27. Bell, P., Snakes: designed to kill? *Creation Ministries International*, 28 Aug 2012; creation.com/snake-carnivory-origin; Lightner, J.K., Gene duplication, protein evolution, and the origin of shrew venom, *J. Creation* **24**(2):3–5, 2010.

28. Barton, K.E., Tougher and thornier: general patterns in the induction of physical defence traits, *Functional Ecology* **30**:181–187, 2016.
29. Lester, R.N. and Daunay, M.C., Diversity of African vegetable *Solanum* species and its implications for a better understanding of plant domestication, Proceedings of a Symposium Dedicated to the 100th Birthday of Rudolf Mansfield, Gatersleben, Germany, 8–9 Oct 2001, *Schriften zu Genetischen Ressourcen* **22**:136–152, 2001.
30. Pandey, S., Goel, R., Bhardwaj, A. *et al*., Transcriptome analysis insight into prickle development and its link to defense and secondary metabolism in *Solanum vivarum* Dunal, *Scientific Reports* **8**, article 17092, 2018 | doi.org/10.1038/s41598-018-35304-8.
31. Hoan, R.P., Ormond, R.A., and Barton, K.E., Prickly poppies can get pricklier: Ontogenetic patterns in the induction of physical defense traits, *PloS One* **9**(5):e96796, 2014 | doi.org/10.1371/journal.pone.009679.
32. Feng, L-G., Luan, X-F., Wang, J. *et al*., Cloning and expression analysis of transcription factors related to prickle development in rose (*Rosa rugosa*), *Archives of Biological Sciences, Belgrade* **67**(4):1219–1225, 2015 | doi.org/10.2298/ABS150310098F.
33. Zhang, F., Rossignol, P., Huang, T. *et al*., Reprogramming of stem cell activity to convert thorns into branches, *Current Biology*, 18 Jun 2020 | doi.org/10.1016/j.cub.2020.05.068.
34. Templeton, C., *Farewell to God*, McLelland and Stewart, Toronto, pp. 197–199, 1996.
35. Morris, J.D., If all animals were created as plant eaters, why do some have sharp teeth? Institute of Creation Research, 1997; icr.org/article/if-all-animals-were-created-plant-eaters-why-do-so/.
36. Bellingham, P.J., Towns, D.R., Cameron, E.K. *et al*., New Zealand island restoration: seabirds, predators, and the importance of history, *New Zealand J. Ecology* **34**(4):115–136, 2010; newzealandecology.org/nzje/2905.
37. Borrelle, S.B., Boersch-Supan, P.H., Gaskin C.P., *et al*., Influences on recovery of seabirds on islands where invasive predators have been eliminated with a focus on Procellariiformes, *Oryx*, **52**(2):346–358, 2018 | doi.org/10.1017/S0030605316000880; Halpin, L.R., Terrington, D.I., Jones, H.P. *et al*., Arthropod predation of vertebrates structures trophic dynamics in island ecosystems, *American Naturalist* **198**(4):540–550; journals.uchicago.edu/doi/full/10.1086/715702.
38. Tanikawa, N., Ohtsu, A., Kawahara-Miki, R. *et al*., Age-associated mRNA expression changes in bovine endometrial cells in vitro, *Reproductive Biology and Endocrinology* **15**, article 63, 2017; rbej.biomedcentral.com/articles/10.1186/s12958-017-0284-z; Xing, M., Gu, S., Wang, X. *et al.*, Low iodine intake may decrease women's fecundity: A population-based cross-sectional study, *Nutrients* **13**(9):3056; mdpi.com/2072-6643/13/9/3056/htm; Fertility Society of Australia, The effects of environmental chemicals on fertility and fecundity, Apr 2021; fertilitysociety.com.au/wp-content/uploads/FSANZ-The-effects-of-environmental-chemicals-on-fertility-and-fecundity-April-2021.pdf; World Health Organization, Infertility, 2021; who.int/news-room/fact-sheets/detail/infertility.
39. Clutton-Brock, T.H., Albon, S.D., and Guinness, F.E., Interactions between population density and maternal characteristics affecting fecundity and juvenile survival in red deer, *J. Animal Ecology* **56**(3):857–871, 1987 | doi.org/10.2307/4953.
40. Carroll, S.B., *The Serengeti Rules*, Princeton University Press, Princeton, NJ, pp. 164–165, 2016.
41. Doherty, T.S., Glen, A.S., Nimmo, D.G. *et al*., Invasive predators and global biodiversity loss, PNAS **113**(40):11261–11265, 2016 | doi.org/10.1073/pnas.1602480113; Tambling, C.J., Avenant, N.L., Drouilly, M. *et al*., The role of mesopredators in ecosystems: potential effects of managing their populations on ecosystem processes and biodiversity; in Kerley, G., Wilson, S., and Balfour, D. (Eds.), *Livestock predation and its management in South Africa*), Centre for African Conservation Ecology, Port Elizabeth, South Africa, pp. 205–227, 2018.
42. Edwards, P.D., Frenette-Ling, C., Palme, R. *et al*., A mechanism for population self-regulation: Social density suppresses GnRH expression and reduces reproductivity in voles, *J. Animal Ecology* **90**(4):784–795, 2021; | doi.org/10.1111/1365-2656.13430.
43. György, B., Michalska-Smith, M.J., and Allesina, S., Self-regulation and the stability of large ecological networks, *Nature Ecology & Evolution* **1**:1870–1875, 2017; nature.com/articles/s41559-017-0357-6?proof=t; Sutherland, D.R. and Singleton, G.R., Self-regulation within outbreak populations of feral house mice: a test of alternative models, *J. Animal Ecology* **75**(2):584–594, 2006; Zhao, L., Fang, L-M., Wan, Q-H., and Fang, S-G., Male density, a signal for population self-regulation in *Alligator sinensis*, *Proceedings of the Royal Society B* **286**(1900, 2019 | doi.org/10.1098/rspb.2019.0191.
44. Fauteux, D., Stien, A., Yoccoz, N.G., Fuglei, E., and Ims, R.A., Climate variability and density-dependent population dynamics: lessons from a simple High Arctic ecosystem, PNAS **118**(37):e2106635118, 2021; | doi.org/10.1073/pnas.2106635118.
45. Juliano, S.A., Population dynamics, *J. American Mosquito Control Association* **23**(2 Suppl.):265–275, 2007 | doi.org/10.2987/8756-971x(2007)23[265:pd]2.0.co;2.
46. Lewis, D., Deathly silent: ecologist describes Australian wildfires' devastating aftermath, *Nature* **577**(7789):304, 2020.
47. Huntsman, B.M., Falke, J.A., Savereide, J.W. *et al*., The role of density-dependent and -independent processes in spawning habitat selection by salmon in an Arctic riverscape, *PLoS ONE* **12**(5):e0177467, 2017 | journals.plos.org/plosone/article?id=10.1371/journal.pone.0177467.
48. Nadkarni, N.M., Merwin, M.C., and Nieder, J., Forest canopies, plant diversity; in Levin, S.A. (Ed.), *Encyclopedia of Biodiversity*, Academic Press, Cambridge, MA, vol. 33, pp. 27–40, 2001; citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.571.208&rep=rep1&type=pdf.
49. Friedman, D.A., Johnson, B.R., and Linksvayer, T., Decentralized physiology and the molecular basis of social life in eusocial insects, arxiv.org/abs/1911.01321, 2019; Johnston, R.A., Vullioud, P., Thorley, J. *et al*., Morphological and genomic shifts in mole-rat 'queens' increase fecundity but reduce skeletal integrity, *eLife* **10**:e65760, 2021 | doi.org/10.7554/eLife.65760; lynch, V.J., Leclerc, R.D., May, G. *et al*., Transposon-mediated rewiring of gene regulatory networks contributed to the evolution of pregnancy in mammals, *Nature Genetics* **43**:1154–1159, 2011 | doi.org/10.1038/ng.917.

Warren A. Shipton *received his B.Sc.Agr. (hons) in 1961 and a Ph.D. from the University of Sydney and subsequently an M.Ed. from James Cook University. He has published extensively in the biological sciences, including biomedical science. He is a Fellow of the Australian Society for Microbiology. He has published widely in professional journals, has been a dean of science at James Cook University and president of Asia-Pacific International University. He has been accorded enduring professorial status by the Thai government.*