Scientific replies to creationist statements

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Introduction

Here, I will attempt to address some of the recurring creationist statements that are perceived as fallacies in the scientific community. In particular I will treat those relating to biology, which is possibly the most frequently contended academic discipline in this context, along with cosmology. This document is not propaganda; I will merely try to describe and present the arguments from a neutral scientific perspective, as supported by available evidence available at the time of writing. The statements addressed are ones made frequently by creationist organisations and individuals in the media and in creationist literature. Examples of sources where the claims are made are [1-8]. Some of the statements are actually replies themselves that attempt to counter or debunk scientific claims. The most publicised contention, that biological evolution incorrect, is not tackled here and the reader is directed to the excellent sources [9] and introductory texts that give an overview of the evidence [10, 11]. Rather, more specific points, about evolution and other theories that touch on biology, are addressed. The material discussed reflects the general consensus in the majority of the biologist community. Much of the material discussed is readily available in open access journals and sources. References are included to support the claims made here. As always, the reader is encouraged to look at these if they require more detail.

1. Evolution cannot add new genetic information to existing species.

The assertion is false. It is made, for example, in [12-15]. Mutations create new alleles i.e. versions of genes, and occasionally, these mutations are beneficial for survival and will become selected for and fixed in the population of a particular species. While it is true that most point mutations turn out to be deleterious and do not add more quantity of genetic information, there are several other evolutionary processes by which a genome can acquire new genetic information. One of these is gene duplication, which can occur by the following mechanism. During prophase I of the meiotic cell cycle, homologous chromosomes cross-over at chiasmata resulting in homologous recombination. Usually, this process results in chromosomes of equal length, but sometimes unequal crossing occurs, which results in some of the progenitor cells having more or less of the original genetic material. The cell with the larger fraction will inherit more genetic material than usual. This can result in the duplication of one or many genes.

Another mechanism is by slippage in the DNA replication machinery. The DNA replication machinery is not always perfect and may cause mispairing of the template strand and the new strand. This can result in forward or backward slippage, which shortens or elongates the DNA segment. Evidence for this includes microsatellite sequences, which have been strongly linked to diseases such as Huntington's disease.

New DNA can also be introduced into a genome by transposable elements and can result in horizontal gene transfer i.e. transfer of genes between species [16]. In particular, retroviruses are able to do this by integrating themselves into host genomes [17-19] where they can remain latent as endogenous sequences. When they revert to the lytic cycle to produce new virus particles and infect other cells, they can carry the new genes from the host genome [19, 20]. They can then reinfect cells intracellularly or extracellularly [21]. Examples of endogenous viruses are plentiful in the human genome and they are called human endogenous retroviruses (HERVs). It has been suggested that retroviruses may have speeded up evolution by this type of mechanism. In fact, genome sequencing projects have revealed that 42% of the mammalian genome is composed of transposons. Since their integration, however, most of these sequences have lost their potential to re-assemble into virus particles due to mutations accumulated the genes that allow them to be active. Long terminal repeat (LTR) retrotransposons are a subclass of retrotransposon. They comprise about 8% of the human genome and approximately 10% of the mouse genome[22]. LTR retrotransposons are also abundant in plants [23, 24].

Duplication of a whole chromosome can also occur. One mechanism is by nondisjunction of homologous chromosomes during cell division. This means failure of chromosome pairs to separate properly. This could arise from a failure of homologous chromosomes to separate in meiosis I, or the failure of sister chromatids to separate during meiosis II or mitosis. The result is aneuploidy, which is an abnormal number of chromosomes in a cell. Down's syndrome is a type of chromosomal abnormality in which a particular type of aneuploidy occurs, called trisomy, which results in three copies of chromosome 21. This type of aneuploidy can be clearly observed in the karyotype of these individuals. There is even evidence of whole genome duplication. Our normal body cells are diploid, i.e. they have $2n$ amount of genetic material. In humans, $n = 23$, so we have 23 pairs of chromosomes, one set from each parent. Gametes are haploid, i.e. they have n amount of genetic material, which is why when a female gamete and a male gamete fuse, they reconstitute the normal amount, $2n$, in the zygote, the first cell. Polyploidy is a change in number of the complete set of chromosomes. Although this kind of genome abnormality often results in prenatal death, some lineages in the past have managed to accommodate it. One example is the Japanese puffer fish [25]. Another example is the red viscacha rat, which is related to other viscachas and chinchillas. This vizcacha's genome, for example, shows evidence of a whole genome duplication which resulted in tetraploidy ($4n$) [26]. Evidence for whole genome duplications such as these also come from sequence analysis studies of whole genomes.

Once a gene has duplicated, both copies are free to evolve independently. They may accumulate different mutations throughout time and encounter different selection pressures. Often, one copy will maintain the ancestral function of the gene, whereas the other gene may find a new function. It may subfunctionalise, which means it may perform a similar but slightly novel function as the ancestral gene, or it may neofunctionalise, meaning it may acquire a completely novel function [27]. Otherwise it may become a pseudogene, of which there are several examples in our genome. Examples of neofunctionalisation, along with pseudogenes, constitute strong evidence for the formation of novel genes. Gene duplication, along with mutation, genetic drift and natural selection, are the consensus mechanisms that account for evolution.

2. Evolution violates the 2nd law of thermodynamics / evolution cannot create complex structures.

Here is the second law of thermodynamics:

The entropy of a closed system decreases over time

Entropy, S, is sometimes consistent with what we intuitively perceive as disorder. The fallacy probably arises from the observation that organisms are highly ordered systems. They have low entropy with respect to the rest of the universe. Indeed, chemical complexity is one of the hallmarks of living entities that sets them apart from nonliving entities. Living things are never at equilibrium with their surroundings. For example, they maintain high concentrations of ions inside them. Furthermore, they constantly have energy requiring reactions happening inside them that are needed for life processes, such as replicating DNA, building long proteins from amino acids, or transporting molecules. So how can the highly ordered steady state be maintained without violating the 2nd law? The answer is simply that organisms are open systems. This means they exchange both matter and energy with their surroundings.

Under physiological conditions most chemical reactions in living things occur at constant temperature and pressure. This allows a more useful formulation of the second law of thermodynamics, given the first law, using a quantity called the Gibbs free energy, G. G is a state variable defined by the following equation:

$$G = H - TS$$

where T is the temperature, S is the entropy and H is the enthalpy. G tells us how much energy is available in the system to do work. Reactions will happen spontaneously if the free energy change, ΔG, is negative.

$$\Delta G = \Delta H - T\Delta S$$

This is called an exergonic reaction, whereas if the free energy change is positive it is called an endergonic reaction. Some reactions, such as the dissolving of salt in water, are entropy driven, while other reactions are enthalpy driven, such as the combustion of alcohol. Living things can couple endergonic reactions to exergonic reactions by assimilating high energy molecules. In other words, they allow their endergonic reactions to take place while still maintaining an overall negative ΔG by doing it at the expense of exergonic reactions. In this way, you could say that living things “feed” on free energy that is available in their surroundings. Indeed, you are actually increasing the free energy of your system when you eat food. Consider for example, the complete oxidation of the sugar glucose to carbon dioxide and water:

$$C_6H_{12}O_6 + 6O_2(g) \dashrightarrow 6CO_2 + 6H_2O \quad \Delta G = -2870\ \mathrm{kJmol}^{-1}$$

It is exergonic. This energy can be used for endergonic biosynthetic reactions. What the metabolism of your cells is ultimately doing is converting the energy from foodstuffs such as fats and sugars to make ATP, the energy currency molecule of the cell. If you stop eating for a long period of time, you will die, and the equilibrium with the rest of the universe will be restored. Living things are adapted to use food in their environment.

Crystal formation is also relevant here, since crystals are highly ordered structures that can occur spontaneously. In crystal formation, the $-T\Delta S$ term is unfavourable because the system is increasing in order, but above a critical saturation point, this is compensated for by the ΔH term so enthalpy overcomes entropy, and crystal formation can occur. The result is an overall negative value of ΔG for the crystalisation process; hence the reaction occurs spontaneously. This phenomenon was reflected upon by Erwin Schrödinger, a Nobel laureate and pioneer of the new quantum theory in physics. He correctly surmised that biological systems and crystals must have some properties in common, namely that they are able to replicate orderly structures like themselves, but that biological hereditary material must be an “aperiodic crystal” i.e. a crystal that carries a code instead of the uniform giant lattice macromolecular structure of inanimate crystals.

In summary, living things maintain entropy inside themselves at the expense of their surroundings, i.e. the rest of the universe. Therefore there is no contradiction with the second law. The universe can have areas of local low entropy, such as cells. Cells are constantly rebuilding themselves and dividing using negative entropy (negentropy). Given enough time, all closed systems will eventually move towards their lowest energy state. Naked DNA outside a cell without the enzymes and energy required to re-synthesise it and repair it, will undergo spontaneous chemical breakdown and oxidation. This is why the events depicted in the film “Jurassic Park” is very unlikely, since the half life of DNA outside cells is too short to obtain dinosaur DNA that is still usefully intact.

3. Evolution leads to immorality.

This statement is made in, for example, [28-31]. This is partly a philosophical/theological claim, since the general idea seems to be that evolution leads to a loss of morals and separation from God, but it is still included since it touches on biology. Related philosophical and sociological points are discussed elsewhere.

The origin of our morality is an interesting question but bordering on what is out of reach by the testability or deducibility of exact science at the time of writing. However, a few evolutionary explanations have been provided by evolutionary psychology and game theory that suggest how the brain might have biologically evolved to have moral or altruistic behaviour. They suggest that some social psychological phenotypes like certain instinctive social behaviours could have been formed by genetic inheritance and evolutionary selection in much the same way as physical traits. Humans are essentially social animals. Like other social animals, we encounter situations in which we have to interact with other individuals. Many such situations resolve to instances of a “game” that is described by game theory. A game consists of a set of players, a set of moves (or strategies) available to the players and a specification of payoffs for each possible strategy combination. For example, a simple game with only two players and two strategies is the prisoner’s dilemma (PD). Games such as these are typically represented with a payoff matrix like so (in the case of PD):

	Player B	
	Cooperate	Defect
Player A Cooperate	3, 3	0, 5
Defect	5, 0	1, 1

Numbers in the matrix denote payoffs for players A and B respectively. Each player has only two possible strategies: cooperate or defect. Numbers denote the payoffs of the players. Simple games such as these can often be investigated by inspection without necessarily resorting to analytical formal solution concepts. Consider the game being played a large amount of times; the strategies are numerous since they are now a sequence of cooperate or defect. Such a game is called the iterated prosonner’s dilemma (IPD). Consider the following three strategies for the IPD:

1. Always Defect
2. Always Cooperate
3. Tit for Tat:
    - Unless provoked, the player will always cooperate
    - If provoked, the player will retaliate
    - The player is quick to forgive

Simulation programs that run many iterations of the game have shown that adopting a strategy that resembles reciprocal altruism, such as Tit for Tat will eventually bring a greater cumulative payoff on the long term compared to Always Defect. More importantly, in a population of predominantly Tit for Tat individuals, Tit for Tat individuals will outperform Always Defect individuals, thus eliminating Always Defect individuals if they occur sporadically. This is an example of the emergence of an evolutionarily stable strategy (ESS), i.e. a strategy that when played by a population cannot be invaded by a specified external strategy. More detailed analyses of IPD show that TFT-like strategies and other cooperative strategies are ESSs [14, 15]. This simple example shows that it might be possible that the emergence of social strategies could come about by evolutionarity mechanisms. Examples of IPD in nature occurs in bats with sharing of food and in pigeons and impala with reciprocal allogrooming to remove parasites [32, 33]. ESSs are sometimes, but not always, Nash equilibria, in which neither players have anything to gain by changing their own strategy.

The example shows a simple case of how evolutionary natural selection might be able to bringing about an altruistic morality even if evolutionary mechanisms are aimed at preserving individuals’ own “interests” or “selfish genes”. However, these evolutionary mechanisms based on game theory do not necessarily account for “true altruism”, where people cooperate with or help individuals who are not necessarily in a position to reciprocate. The origin of this type of altruism, to the knowledge of the author, has no definite scientific explanation, although some theories have been made. It could be that primordial human communities were smaller and were comprised of members of close kin, who were in a position to reciprocate a good deed towards them, thus benefiting the perpetrator of the good deed and encouraging a moral structure of social cooperation. Similarly to the PD described above, cooperation could have emerged as an ESS. Intuitively, certain aspects of communal living gave a clear survival advantage, such as division of labour and increased strength when hunting or gathering resources as a group. Nowadays, we are increasingly interacting in a global community where isolated human populations no longer exist (or very few), but we have still maintained this behaviour. There are many cases of what seems to be true altruistic behaviour. It has been suggested that we have merely kept this as an instinct since our brain cannot differentiate between close and distant kin. Alternatively, it could simply be a social attitude that came about along with the increased intelligence capacity and complexity of our brains.

Irrespective of this, behaviours that advocate human solidarity and the many human virtues aspired to by theist doctrines stand on their own merit from a purely humanist perspective. Simply, there is no reason why these virtues and moral behaviours, such as “true altruism”, cannot be adopted and practised by people who accept or “believe in” evolution. Furthermore, and more importantly, there is no evidence to say that they are not. On a higher level, our morality could partly be grounded on the simple realisation that other sentient minds exist outside our own, and we are intelligent enough to realise that they therefore also entitled to respect and well being.

Evolution suggests nothing negative for morality. It is simply a theory that explains the diversity of life and changes that occur in populations over time. In fact, not just evolution but the whole of science, by its very nature, is apolitical and imposes nothing on human relationships directly. It is not necessarily true either that evolution leads to atheism. The belief in a higher being or a deity or a creator of the universe can sometimes be compatible with evolution. A Poll of the Gallup Organization in 2006 showed that 27 % of the public in the USA believed in theistic evolution [34]. This indicates belief in both evolution and in a deity, presumably with the deity allowing evolution to take place as described in biology. This is somewhat akin to the belief of deism. It is true, however, that evolution and much of geology is contradictory with young Earth creationism. This is because evolution maintains that the first forms of life arose 3.7×10^9 yr ago and have been evolving since then. This is compatible with the consensus in geology that the earth is 4.5×10^9 yr old. On the other hand, young earth creationism maintains the earth is 6000 yr old, a calculation made by counting the generations from creation to Christ in the Judeo-Christian Bible. Numbers for general acceptance of “evolution” by adults in the rest of the Western world for 2006 are generally higher, with Iceland, Denmark, Sweden and France, having 80 % and Japan 78 % [35]. In England, numbers are slightly lower, namely 48 % [36]. It is interesting, however, that having a university education makes you more likely to accept evolution [34]. This suggests that much of the “mistrust” in evolution may be due to a mere lack of understanding of the theory or the framework it is built on. However, this may represent an instance of a more general failure from the scientific community to present their work in a clear, accessible and correct form as much as a failure from the recipients’ side to comprehend it.

Maintaining that evolution is responsible for 20th century mass murderers such as Stalin, Mao and Hitler is unfounded. The reason that these historical figures acted the way they did was not because of their acceptance or rejection of evolution but because of their political inclinations and socio-economic ideologies. There was also a variety of political and socio-economic circumstances and historical factors that influenced their decisions. Excerpts from Hitler’s Mein Kampf suggest he might have severely misinterpreted some evolutionary ideas and perversely distorted them in a social context to believe in “racial superiority” [37]. Throughout history, racist ideologies such as these, and totalitarian ideologies, seen in the rule of Stalin, Hitler, Mao, Pol Pot etc., have often resulted in mass murders and extensive human suffering. It would be much more evident and logical put the “blame” on such ideologies and not something as arbitrary as acceptance of evolution or lack of theism. Violent totalitarian ideologies are a much more convincing signature as a cause for these episodes of history. Some contemporary communities in Europe have very high atheist or agnostic population percentage and they are not encountering mass murders or particularly abnormal amounts of suffering. Nor is there any evidence that these communities suffer from “social evil” more than predominantly theistic counterparts. However, this issue is less scientific and more philosophical/theological and social/political so will not be discussed extensively here.

As for social Darwinism, it is a social theory that makes quite different claims from biological evolution. Belief in biological evolution does not in any way predispose a person, community or nation to adopt the doctrines and practices of social Darwinism. It is also important to mention here that the term "Darwinism" out of its scientific context was a term coined by sociologists, not by Charles Darwin, when they applied evolutionary ideas to social theories and refers more to the sociological works by Herbert Spencer, Thomas Malthus, and Francis Galton. It is true that eugenics and racialism took place in Nazi Germany, but once again, these practices are not based on scientific theory and have no grounding in biological evolution. The theological inclination of Hitler is historically unclear and debatable. Some sources indicate Hitler had some theist inclinations and that he rejected some evolutionary ideas [37]. There is no clear evidence that any particular genetic group of people in the world are more intellectually or physically able than any other. Racial superiority is a social phenomenon that has no scientific grounding and based on arbitrary and subjective premises. In fact, the scientific framework suggests that all modern humans are descended from a single population of early humans that lived in East Africa about 150×10^3 yr ago [38, 39] and that our genetic differences are biologically insignificant. Indeed, the average genetic variation between two people is only 0.1 % i.e. they have 99.9 % sequence similarity [40]. The concept of a "race" is often defined as pertaining to a common lineage/ancestry. Historically this "classification" of human peoples was used in some anthropological studies for convenience but it was done without specific genetic evidence. It was based mostly on a set of arbitrary morphological attributes, geographical localisation of peoples and partial family trees. Therefore this is a very clumsy and very limited classification and taking it even further out of context by saying a particular "race" is "superior" in any way is unfounded and unscientific. Furthermore it is a hallmark signature of extremist socio-political ideologies.

The repercussions of evolution on moral philosophy are therefore not negative. The theory simply offers explanations for some types of altruistic behaviour and is merely a well established scientific consensus. It has no bearing on the dignity or "moral status" of individuals that accept it, nor should it carry any socio-political labels.

4. Science cannot explain the origin of life.

While it is true that we do not currently have a comprehensive scientific understanding of the origin of life, there are a few strong theories supported by evidence, and there is no scientific reason why these theories should be given lower preference or lower status than any other non-scientific explanations such as creation myths.

The theories concerning of the origin of life are called abiogenesis and prebiotic chemical evolution. Essentially, there are two main hypotheses: the "information first" and "metabolism first" hypotheses. Initially, the former was preferred, since RNA was observed to have catalytic as well as information storage roles, this making it a good candidate for the first genomes. At first, it was thought that ribonucleotides formed from the molecules that were on the primordial earth and that these polymerised to form RNA molecules that could replicate (called replicases). Many people have tried to synthesise ribonucleotides in prebiotic conditions, thus starting the field of prebiotic synthesis. The "metabolism first" hypothesis is that the very first forms of proto-life were simply perpetuating cycles of chemical reactions. In this scenario, the first genomes were hence "compositional genomes", meaning that the information was simply the list of the chemical reactants that participated in the cycle. This hypothesis has gained attention recently and is supported by the simple observation that the enzymes and reactants of basic metabolic pathways and cycles is conserved right down to lower species. The two hypotheses could be complementary, however, and some theories combine aspects of the two to give a bigger picture.

One theory, put forward predominantly by Russell and Koonin, that places the origin of life at hydrothermal vents, is as follows. The Earth's early ocean and atmosphere contained a mixture of N_2, H_2O, CO/CO_2 and H_2. In addition, ammonia, sulfides, phosphates and trace amounts transition metals such as iron, nickel, manganese, cobalt and zinc were present in the early ocean near deep-sea hydrothermal vents [41]. Many examples of these are found scattered throughout the ocean floor of the earth. These vents also provided an environment that is sheltered from UV radiation and extremes of pH and temperature. Porous iron sulfide precipitates that form at these vents produce hyrothermal mounds. The cavities in these materials acted as primordial cells with inorganic semi-permeable membranes that allow enclosed isolated chemical reactions. The mineral surfaces found in these vents are generally good at adsorbing organic molecules. The basic reactions that produce the simple organic ions and organic molecules, such as methane (CH_4) and acetic acid (CH_3COOH), took place in this milieu, catalysed by greigite (Fe_5NiS_8) and mackinawite on the surface of the inorganic iron sulfide membrane of these chambers. Hence these metal-sulphide catalysts acted as the first biological catalysts. Some theories additionally point out that materials from bombardments of the early Earth might have also provided catalytic substances for pre-biotic reactions. The iron sulphur cuboidal complexes found in these minerals resemble closely the [4Fe-4S] centers found in many modern enzymes such as ferredoxins and acetyle-CoA synthase. The overall reaction for the formation of proto-life from raw materials already existing on the hydrothermal vent's environment is shown below [42]:

$$\{210CO_2 + H_2PO_4^- + Fe, Mn, Ni, Co, Zn^{2+}\}^{\text{ocean}} + \{427H_2 + 10NH_3 + HS^-\}^{\text{hot spring}} \text{ -->}$$
$$\{C_{70}H_{129}O_{65}N_{10}P\ (Fe, Mn, Ni, Co, Zn)\ S\}^{\text{proto-life}} + \{70H_3C{\bullet}COOH + 219H_2O\}^{\text{waste}}$$

Acetate and water are the waste products of the reaction. The other products, the simple organic molecules, were precursors for more complex organic molecules. In this setting, amino acids, especially glycine, fatty acids and nucleotides were formed [41, 42]. These are the monomers of proteins, lipids and nucleic acids respectively, the main macromolecules of life. The semi-permeable FeS membrane would have allowed passage of small unreactive molecules but not the larger products of these reactions. It would also have been permeable to H^+, thus providing an already present protonmotive force throughout the proto-cell, a force that modern cells have to make on their own. The protonmotive force is an element in the modern mechanism of energy production that is conserved all the way down to prokaryotes, a fact that reinforces the plausibility of its existence as an early prebiotic mechanism involved in energy requirements. Along with this energy of H^+ flow in the mound, the energy from reactions involving acetate polymerised the amino acids to form small peptides. Ribonucleotides are the type of nucleotides that make up RNA. While a complete route of chemical synthesis of ribonucleotides from simple pre-biotic precursors has not yet been observed experimentally under putative pre-biotic conditions, many of the partial reaction routes have been already observed experimentally [43]. These include the formation of cytidine from a ribose, the polymerisation of ribonucleotides to RNA, and many other reaction routes, all observed under putative pre-biotic conditions. The only problematic step is the formation of the ribose from the simpler precursors, but in light of the rest of the evidence, this may be due to the presence of an as yet unexplored synthetic route or an unknown catalyst. Prospects of discovering these minor missing routes, however, seem hopeful and is currently being investigated. Polymerisation of amino acids resulted in small polypeptides, which could have engulfed iron-sulphide clusters to produce primitive enzymes.

Monomer precursors, such as ribonucleotides, and other molecules could have accumulated to high concentrations by thermal gradients in the pore systems of the hydrothermal mounds. As well as providing thermal and electrochemical gradients and inorganic catalysts, these compartments also acted as a concentrating device [44]. Nucleotides have been shown to accumulate over 108-fold in such milieus [44]. Nucleotides could form longer chains of polynucleotides. One of the defining characteristics of life is the ability to replicate their genetic material for reproduction. As mentioned earlier, the discovery that RNA, the intermediate information messenger between DNA and protein, has catalytic as well as information storage capabilities, has made it a good candidate for primitive genomes as well as the primitive enzymes, i.e. they can achieve both functions. It has been shown that small RNA molecules can selectively bind and assemble amino acids. Hence, immobilised RNA molecules formed in the proto-cells could have acted as templates to select and assemble amino acids into peptides. These accumulated inside, sequestered sulfide clusters and catalysed the formation of other RNAs. This marked the first step towards proto-cells with evolutionary capability, since they represent entities with a rudimentary encapsulated genome that directs the formation of enzymes that carry out metabolism and replication. Hence, this model, put forward by Russell et al., suggests co-evolution of proteins and RNA inside these early proto-cells.

The accumulation of peptides inside the proto-cells led to the formation of a proteinaceous film that lined the inorganic compartment. This film could have acted as a primitive cell membrane and allowed the proto-cell to escape the iron sulfide surface of the mound, hence giving them autonomy and the possibility of dispersal. As the proto-cells evolved, at some point, fatty acids must have taken over the function of cell membrane. As mentioned before, they can form from pre-biotic precursors at mineral surfaces. This might have been their early mechanism of formation, but perhaps they could have additionally been formed by enzymes inside the proto-cells by continued addition of C_2 groups to form the stable dodecanoate, a C_{12} fatty acid. The work of Szostak and colleagues have shown that proto-cells with fatty acid membranes enclosing self-replicating machinery in the form of RNA replicases can undergo evolution by the competitive dynamics of the membranes [45]. The specifics of the replication machinery inside the proto-cells, however, i.e. whether it was just RNA replicases acting as primitive genomes or a co-evolving mix of RNA and proteins, and which components came first, are details that could differ slightly in the two models and has not yet been clearly resolved at the time of writing of this document.

In either case, however, the result is a system capable of Darwinian evolution. The only requirements for evolution are threefold:

1. genetic inheritance from parent to offspring
2. genetic mutation/variation
3. competition between individuals (for stable and continued genome replication)

If these three conditions are met, evolution follows as a necessary condition. This has been simulated computationally. Therefore modern genomes are the “survivors” of billions of years of evolution of these self-replicating systems. Because proteins are better suited catalysts and DNA better at information storage, proto-cells that developed mechanisms for using DNA and proteins would have had a survival advantage. Since early organisms may have had to obtain ready-made organic nutrients instead of having to synthesise them from even simpler precursors, a population increase of primordial organisms in a nutrient-limited environment would have given early genomes capable of synthesising their own nutrients a great survival advantage. This represents the makings of a more advanced metabolism. At some point, DNA must have taken over the role of RNA as the main genetic information storage molecule. Theories about the evolution of the translation system and early peptide conformations also exist [46, 47].

In another theory, the organic precursors for the formation of the first biological polymers could have also come from meteorites. The study by [48], shows that oceanic impacts of meteorites could have produced some important organic chemical precursors. Since impacts are thought to be quite frequent in the early earth, this may have been an important source. In another study, a complex population of organic materials in comet 81P/Wild 22 was discovered by the Stardust Spacecraft [49]. This further shows that organic precursors for biologically important molecules can form in outer space.

Another very versatile chemical molecule that could have acted as the first genomes is PNA (peptide nucleic acid), which seems to be much easier to synthesise in pre-biotic conditions than RNA.

The evolution of photosynthetic blue-green algae is thought to have been a major event in biotic history, since they are responsible for oxygenating the atmosphere. Before these, there were only prokaryotes, i.e. bacteria and archea, not capable of photosynthesis. The subsequent endosymbiotic engulfment of aerobic heterotrophic prokaryotes and photosynthetic prokaryotes by nucleated cells was another major event, marking the formation of ancestral eukaryotic cells. Some of the evidence for the earliest life comes from stromatolite fossils that date to about 3.5×10^9 yr ago; this is a considerable amount of time for evolutionary events to happen.

5. Irreducible complexity disproves evolution.

This claim is made, for example, in [14, 50-52]. The argument of irreducible complexity is essentially that complex biological systems that are composed of many parts cannot be explained by models of evolution. This is because all the parts have to be present together simultaneously for the system to function and so natural selection, which is “blind”, could not have caused all the parts to evolve simultaneously to give the function of the whole complex. Multiprotein biological complexes are one of the main entities put forward in favour of irreducible complexity. The argument is false is because such systems’ individual parts and subsets of their individual parts can have functions of their own, which allows for the possibility of gradual evolution of the system. Ken Miller, a biology professor at Brown, elegantly explains why in one of his lectures.

Some proteins have the ability to form homomers i.e. the same protein chains assemble to form the multimer. This requires comparatively few mutations to stabilise and so is a plausible early evolutionary step towards complex formation [53]. When genes duplicate, their molecular interactions tend to be conserved, hence forming potentially new components of the multiprotein complex. There is evidence for this type of mechanism as one of the main drivers of complex evolution [54, 55]. Many of the large protein complexes used as examples of irreducible complexity have been shown to have possibly evolved from pre-existing sources. The individual parts of the bacterial flagellum, for instance, have functional homologs in the bacterial genome, showing that the parts on their own could have been functional. The subset of the 10 membrane spanning proteins that make up the membrane-spanning part of the bacterial flagellum are direct homologs with the 10 proteins of the type 3 secretory system. This is an example of how a large subset of a larger complex could have still had a function. It also suggests that subsets of the proteins could have sequentially amalgamated while still possibly being functional along the course of the evolutionary development of the larger complex. Many publications describe theories of how the complex has evolved over time.

Another example is the ATPase complex, a very important complex in cellular metabolism. It has also been shown to have possibly come about from pre-existing sources. The human version of the complex contains many polypeptide chains (subunits) organised into a catalytic part (F1) and a membrane-spanning part (F0). It is surmised that the two parts evolved independently. The F1 has a clear evolutionary origin. Hexameric helicases, for instance, which are probably older proteins, have a similar structure to the F1 ATPase, and they share chemical similarities such as ATP hydrolysis and similar motifs. This indicates they are possible evolutionary precursors.

Yet another example is complex I of the respiratory chain, which has 46 subunits in mammals. Again, functional sources composed of subsets of the whole complex have been identified as possible evolutionary precursors [56]. This supports the theory that functional parts and functional sets of parts came together to eventually form the larger complete protein complex. Core components of the complex that are present in bacteria show similar phylogenetic profiles and tree histories, supporting the idea that the more complex versions found in mammals are refined versions that originated from the more rudimentary bacterial ancestor by gradual addition of single components. While we do not have a complete theory of the evolutionary history of all known multiprotein complexes in terms of these evolutionary “stepping stones”, it offers a plausible naturalistic alternative to “intelligent design”.

Similar arguments apply to macroscopic organs. The eye is often cited by creationists as an example of irreducible complexity. Earlier animals that had rudimentary photoreceptors that although were also designed for sensing light, had not exactly the same function as the modern eyes found in mammals. It is therefore likely that modern mammalian eyes could have evolved from simpler precursors. Consider the pentadacyl limb. Limbs on water-dwelling animals might have started out as flippers or fins, which help swimming. Some theories say that water dwelling ancestors of terrestrian animals might have used limbs to push plants aside while escaping predators, which would have been a significant survival advantage. Using them to crawl on land might also have helped evasion of predators or given other survival advantages. The modern pentadactyl limb has other functions in mammals, such as grabbing food or grabbing branches in the case of monkeys, steering while moving in water in the case of whales, and flying in the case of bats. A monkey’s arm, a whale’s flipper and a bat’s wing are all homologous in skeletal anatomical morphology, yet they have different functions from each other and their possible precursor. It is also worth mentioning here that neutral novel alleles can still become fixed in populations, priming the genes to find a new function when a selection pressure appears. To summarise, many biological systems may seem “irreducibly complex” at first sight, but further examination of the system reveals that there are evolutionary “stepping stones” that could blindly lead up to the formation of the system. Evolution provides an elegant solution to this.

Conclusion

Scientific theories attempt to find naturalistic explanations for phenomena in the world. While the theories are sometimes incomplete, they offer a valuable alternative to supernatural explanations. Biological organisms are truly beautiful constructs of amazing complexity so their origin is likely to stir up much contention.

Many consider the modern scientific method to have begun with Galileo Galilei (1564-1642), since he was among the first to advocate empiricism and emphasis on experimentation. Coincidentally, this corresponds to the European emergence from the Dark Ages. The bulk of our scientific knowledge therefore comes from 4 centuries of continued application of the scientific method. It would be unfair to judge our ancestors, who had no access to this knowledge, by today's standards and say that it was foolish of them to seek supernatural explanations for the amazing phenomena that we can see around us. The human mind seems to be naturally inquisitive and imaginative, so in a sense it is more natural to believe in the supernatural rather than to say "I don't know".

While naturalistic explanations are ever more filling gaps where supernatural or theistic explanations held, some contentions endure in the modern era, such as those described. It is noteworthy that there are some questions that science cannot currently answer and might never answer. Two in particular: the ultimate origin of natural laws and the nature of human emotion, consciousness and our recurring connection or longing for the transcendental. It may even be that it is not even the jurisdiction of science to answer these questions. While scientific theories do exist for the origin of the universe, the question abides nonetheless since the form of such theories still begs for an origin. In this sense, philosophical wonder abides in spite of all the scientific advances that we made. Individual experiences of spirituality are powerful and should not be dismissed in the bigger picture of our philosophical quest.

What has changed, in the opinion of the writer, is the possibility to use Occam's razor to weigh the framework of the scientific consensus and emerging theories against a supernatural framework for specific phenomena. A theistic explanation for, say, the origin of our genetic information, discussed above, unavoidably raises a plethora of questions and implications, both technical and human, particularly about the nature of the deity in question. These questions can grow exponentially depending on the nature of the deity and the issue is discussed elsewhere. However, the application of Occam's razor in this instance could be a mere matter of personal individual interpretation.

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