

The Reception of Darwin's Theory in the English-Speaking World

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Immediately following publication of his *Origin of Species*, Darwin was deeply anxious about the response of the scientists whose opinion he valued most. Would they be converted from belief in the *independent* introduction of new species to his own theory of their derivation from pre-existing species? In his book he admitted that he had faced many difficulties in the development of his ideas, such as the scarcity of intermediate forms in the fossil record and the caste system among neuter insects. Darwin counted every convert, specially prizing the approval of Thomas Henry Huxley, his geological mentor Charles Lyell, and the botanical expert Joseph Hooker. In North America, the Harvard botanist Asa Gray immediately wrote a supportive review. Even Darwin's scientific opponents, such as Gray's Harvard colleague, Louis Agassiz, conceded that Darwin's advocacy of evolution had been quickly adopted by many of the best minds of the day. It is, however, necessary to distinguish between accepting the reality of evolution and accepting that natural selection provided an adequate understanding of the process. This distinction is important because even Huxley, Darwin's most vigorous defender, expressed doubts whether natural selection working on small variations was sufficient to explain the pace of evolution. Huxley, unlike Darwin himself, resorted to sudden mutations to accelerate the process.

In this talk, I shall examine the diversity of reactions to Darwin by a scientific community that was not unanimous in its approval of Darwin's mechanism. Some, like Richard Owen, judged it to be premature; others such as Charles Lyell and Alfred Russel Wallace considered it incomplete, preferring to postulate a non-material agency to account for the spiritual capacities of the human mind. Just as the scientific responses were diverse, so were the religious. Although many Christians were shocked by Darwin's proposal of continuity between humans and their animal ancestors, others, including clergymen, were among Darwin's earliest converts. Their contention was that a God who could make things *make themselves* was more to be admired than one who had created fixed species in their present form.

Reactions to Darwinism as a biological theory in the Ottoman era

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The reaction of the Ottomans to Darwinism and evolution, as Sükrü [Hanioglu](#) shows clearly, had its origins in the capital of the empire in the last quarter of the 19th Century and quickly caused much debate between rival parties, i.e. between intellectuals with Western backgrounds and the strong figures of religion (Ulema) who opposed the idea as vigorously as its defenders. Typically, Darwinism came to the scene in the Ottoman world as the continuation and confirmation of the German materialistic thinking (“scientific materialism”) embodied by the works of the famous Ludwig Büchner in his interpretation of evolution. Overall, what was remarkable in this reaction, as [Hanioglu](#) points out, is its irrelevance to the actual ideas of Darwin and the structure of biological evolution.

Here I summarize and illustrate this irrelevancy by focusing on two prominent thinkers of the era spanning from the 1870s to the 1920s, whose intellectual works also touched upon Darwinism, and exemplify the widespread opinion about biological evolution as then understood. The first is Ahmet Mithat Efendi, who was the very first person to describe Darwinian evolution in his periodical *Dagarcik* in the early 1870s, thus introducing the idea of evolution into the Ottoman intellectual atmosphere. The second figure is the very famous short story writer and patriot Ömer Seyfettin, a member for a while of the Union and Progress Party, who wrote stories of high literary quality and humour, reflecting the many facets of Ottoman daily life and its intellectual currents, in the course of which Darwin and evolution were also introduced.

In the works of these two strong intellectuals, who were widely read and influential at the time, I suggest that the evolution and Darwinism propounded (Ahmet Mithat) and incorporated into popular texts (Ömer Seyfettin) were not really relevant to the ideas and hypothesis put forward by Darwin in the *Origins of Species*, nor in his further works such as *Descent of Man*, *Sexual Selection* etc. What they took as evolution and Darwinian ideas were indeed vulgarizations of natural selection and, curiously, an “argument from design” kind of explanation for adaptation.

Evolution in Anatolia

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As a result of the continental collision between the Arabian and Anatolian plates, Anatolia has formed a land bridge between Africa and Eurasia since the late Mesozoic. Accordingly, Turkey has been the home of a varied fauna and flora and the crossroads between different populations and cultures since Paleolithic times.

Biostratigraphical differences indicate that a tremendous number of mammalian species emigrated from Asia and Africa through Anatolia into Europe, and that some of them returned via the same route. In the last two decades, intensive field work at Hayranlı-Halimhanı, İnönü I, Sinap, Paşalar, Çandır and Çorakyerler has provided many new findings and contributed valuable knowledge to the fields of biostratigraphy and biochronology. Among these, Sinap, Paşalar, Çandır and Çorakyerler feature hominoid fossils and so have increased our understanding of hominid ancestors and relatives.

Being situated on the route of the early hominids from Africa to Eurasia, fossils of hominids themselves are also found in Anatolia, providing some of the earliest evidence of this group in the northern hemisphere. Evidence of early human occupation of Turkey comes mainly from studies of artifacts and other findings from a small number of caves located mainly in Antalya and also in Southern and Eastern Anatolia, Antakya, Gaziantep, and near Istanbul. However, there has been a recent discovery of earlier artifacts together with faunal remains from the Dursunlu Site, an abandoned open coalmine to the north west of Ilgin, Central Anatolia.

The only early *Homo* fossil known from Turkey is a calva (skullcap) that was found in 2002 in Denizli. The paleolithic sites of Kaletepe, Karain, Yarımburgaz, Kanal, Tıkalı, Merdivenli and Ucagızlı also show evidence of the presence of genus *Homo*. Finally, Initial Upper Paleolithic findings at Ucagızlı shed light into research on the first Modern humans.

The Contemporary Evolution of Evolutionary Theory

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Evolution can be seen as a two-step process. First, hereditary variation arises by mutation; second, selection occurs by which useful variations increase in frequency and those that are less useful or injurious are eliminated over the generations.

Natural selection is much more than a “purifying” process, for it is able to generate novelty by increasing the probability of otherwise extremely improbable genetic combinations. Natural selection in combination with mutation becomes, in this respect, a creative process. Moreover, it is a process that has been occurring for many millions of years, in many different evolutionary lineages and in a multitude of species, each consisting of a large number of individuals. Evolution by mutation and natural selection has produced the enormous diversity of the living world with its wondrous adaptations.

Darwin and other 19th-Century biologists found compelling evidence for biological evolution in the comparative study of living organisms, in their geographic distribution, and in the fossil remains of extinct organisms. Since Darwin’s time, the evidence from these sources has become stronger and more comprehensive, while biological disciplines that have emerged recently—genetics, biochemistry, ecology, animal behavior (ethology), neurobiology, and especially molecular biology—have supplied powerful additional evidence and detailed confirmation.

Molecular biology, a discipline that emerged in the second half of the 20th Century, nearly 100 years after the publication of *The Origin of Species*, provides the strongest evidence yet of the evolution of organisms. Moreover, it makes it possible to reconstruct evolutionary relationships that were previously unknown, and to confirm, refine, and time all evolutionary relationships from the universal common ancestor up to all living organisms. The precision with which these events can be reconstructed is one reason why the evidence from molecular biology is both so useful to evolutionists and so compelling.

Among the important issues currently investigated by evolutionists, I will formulate four “transformations”: matter-to-life, egg-to-adult, brain-to-mind, and ape-to-human.

Convergence in Evolutionary History

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Evolution differs from many sciences in that it appears not to be predictable. Nor is this surprising because neo-Darwinian formulations repeatedly emphasize the random and accidental, be it at the level of mutation or such catastrophes as a mass extinction. In all such events, so it is argued, evolutionary history skitters in some new, and entirely unexpected direction. From this perspective any end-product—say a human—is as big an evolutionary fluke as any other, say a mushroom. But is this actually correct? I would argue to the contrary, that evolution is far more constrained than is generally supposed and in fact shows considerable predictability. There are three reasons for this:

- a) The fact that evolutionary convergence is not common, it is ubiquitous. By this I mean that repeatedly organisms, be they viruses or mammals, navigate to very similar functional solutions. Not only does convergence cover the gamut of all life, but so too it occurs at all levels of the biological hierarchy, that is from molecules to behaviour and cognitive systems.
- b) A significant part of complex biological systems, and here the eye and the nervous system immediately come to mind, are based on molecular systems that evolved billions of years before the complex structures themselves emerged. There is thus a considerable degree of inherency in biological systems.
- c) The common conceit that major transformations, say the origin of the eukaryotic cell, are effectively fortuitous can be shown to very unlikely, and here too we can see inherency operating at all levels.

None of the above is inconsistent with Darwinian evolution, but it does suggest that simply identifying the mechanism, as Darwin so brilliantly did, does not mean that the theory of evolution is any more complete than any other science. Rather, this line of enquiry indicates that by being forced to follow deeper organizational principles not only is evolution predictable, but these principles may be inherent in the structure of the universe and so reflect inevitabilities that were seeded at the Big Bang.

Dmanisi and Human Evolution in Europe

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The site of Dmanisi, Georgia, has produced surprising evidence for the early dispersal of hominins out of Africa. Dmanisi dates to approximately 1.77 million years ago and has revealed a wealth of cranial and post-cranial hominin fossil material along with many well-preserved animal bones and quantities of stone artifacts. These fossils bring into question whether *Homo erectus* was the first hominin out of Africa and whether *Homo erectus* features, such as relatively large body and brain sizes, were necessary adaptations for this dispersal. The Dmanisi hominins have a surprising mosaic of primitive morphology, such as small body and brain sizes and an absence of humeral torsion coupled with derived human-like body proportions and lower limb morphology. Postcranially they are largely comparable to earliest *Homo* (cf. *H. habilis*) and have changed our ideas in relation to the morphological correlates of hominin migration and dispersal. There are also similarities with the later *H. floresiensis* that may bear on the interpretation of this controversial later hominin taxon. The Dmanisi hominin remains are the first discovered outside of Africa to show clear affinities to early *Homo*; they represent the missing link between Africa, Asia and Europe.

The stone tool assemblage from Dmanisi has been described as a Mode 1 industry similar to the Oldwan chopping-tool industry of East Africa. No bifaces or developed Oldowan artifacts have been found. Dmanisi shows that hominids did not require sophisticated stone-tools to disperse out of Africa.

The evolution of Biological Complexity

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This talk presents mathematical and computer modelling approaches to the evolution of biological complexity. In the 1930s, Haldane, Wright and Fisher introduced the first mathematical models and theoretical calculations for evolutionary processes. These models allow scientists to describe the change of the frequencies of different alleles in a population under the influence of mutation, reproduction, and selection. The fitness of an individual is based on its genotype.

While these methods of population genetics are still much in use today, other approaches have included complexity in various ways. On the level of the genome, complexity is investigated by representing genetic information not as a bitstring, as previously, but as a network of interacting units. Genes regulate each other's activity, and the gene regulation network interacts with the signalling and metabolic networks of the cell. Mutations affect the interactions between the elements of these networks, and selection is based on their performance.

On the population level, complexity is taken into account by replacing the fitness landscape with density- and frequency dependent selection. Density dependence and frequency dependence imply that the fitness of an individual does not only depend on its own phenotype, but also on the population size and on the frequencies of the other phenotypes. Competition as well as cooperation is reflected in such models. Often, game theory is invoked to explain cooperation between individuals. A further degree of complexity is added when the spatial extension of populations is taken into account, which limits the possible interactions between individuals to those that are sufficiently close to each other.

Finally, the complexity of ecosystems is included by considering the interaction of species with their environment, which contains other species and is in turn changed by this interaction. When the interactions between species in an ecosystem are reduced to feeding relationships, a foodweb is obtained. Models for foodwebs describe how the population densities change with time depending on the availability of food, on predation and other death causes. The response of the foodweb structure due to changes in the connections and species properties can be investigated in simple computer models. Here, the most interesting question is how complex foodwebs can be stable.

The Evolution of Self-Assembling Systems

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The remarkable ability of biological matter to robustly self-assemble into well defined composite objects excites the imagination. Virus capsids, for example, can be reversibly dissolved and re-assembled from their component parts simply by changing the solution pH. How does nature achieve this feat? Can we uncover the "positive design rules" for inter-particle interactions that allow the self-assembly of a particular desired three dimensional structure [1]? Can we use evolutionary algorithms to design these particles?

We employ computer simulations to design particles that reversibly self-assemble into well defined three dimensional composite objects. Examples include DNA nano-structures, virus capsids, and protein quaternary structure. Our calculations allow us to rationalize a number of trends found for homomeric protein complexes, including why evolution naturally takes the system into an interaction space where the evolutionarily newer interactions are weaker and the self-assembly dynamics are hierarchical [2]. Although a much larger number of options may be thermodynamically accessible to protein complexes, evolution selects only a subset of the possibilities. Finally, we use simple toy models of self-assembling systems and gene networks to explore more subtle evolutionary questions related to evolvability and robustness.

The Evolution of Cooperation

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Cooperation between individual units, or more generally social behaviour, is commonly found in groups consisting of bacteria, eukaryotic cells and multicellular organisms. There are many cases of social behaviour in which one member of the group (the co-operator) appears to risk a loss of fitness relative to another (the beneficiary). On the face of it this poses a problem for any attempt to explain the evolution of cooperation as a consequence of individual-level selection. Darwin was keenly aware of the difficulty. Indeed while referring to the non-reproducing female workers in social insect colonies, he went so far as to say that it "...at first appeared to me insuperable, and actually fatal to my whole theory" (*The Origin of Species*, first edition, chapter 7).

The topic has attracted much interest since then, especially in recent years. Different solutions have been proposed for how a trait that apparently reduces the fitness of its bearer can nevertheless evolve, i.e., spread through a population. We will consider clonal groups of single cells that live in the same environment. Various factors (e.g. stochastic variations in gene activity) can lead to the spontaneous appearance of phenotypic heterogeneity among the members of the group. Thus the genotype of the individual is consistent with more than one phenotype. If the phenotypes happen to complement each other, group-level selection for cooperative social behaviour becomes possible. Such selection can stabilise a probabilistic genotype-phenotype relationship within single cells. Once that happens, clonality becomes no longer essential for the maintenance of cooperation. This hypothesis will be discussed with special reference to the cellular slime moulds or social amoebae.

Science, Evolution and the Quran

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I focus on the confusion between words and terms, dogmatic phrases and controversies. Scientists have the right to describe evolution and to say whether it is a scientific fact, a theory or hypothesis. Rather than comment on the compatibility of evolution with the Quran, I would like to emphasize that the Quran itself recommends doing scientific study.

In the statements I quote here, evolution is clearly put forward to have neither target nor purpose. Is it not a contradiction then, that in evolutionary events a certain target and purpose are clearly observed? If survival among animals is pointless, and evolutionists have no purpose in their works and in their struggle to overcome their opponents, what is the benefit of all this trouble?

In his work “The God Delusion”, Richard Dawkins begins the first chapter with Albert Einstein’s words “A Deeply Religious Non-Believer”. From my point of view, the reason for the conflict between creationists and evolutionists is their misunderstanding of God. Curiously, the perception of God on both sides is the same. Evolutionists see God in the same way that Creationists do. Creationists use their perception of God as a means of suppression. It is a critical matter of debate that evolutionists are either unable or not eager to oppose the use of this perception of God as a means of suppression by putting forth how God should be accurately perceived.

Four years ago, the professors of theology in Turkey asked me to make a conclusion at a symposium organized in Ankara. I began my speech as follows: We do not understand what we know. Knowing is different from understanding.

Whether creationist or evolutionist, both sides face the same problem: the matter of humanity. Both are humans. In a creationist’s opinion, since God created everything, he also created evolutionists. Thus, to assert that evolutionists have any drawback or deformity means to charge their creator directly or indirectly. According to an evolutionist, man has come into being by way of evolution. Since creationists are men, they have also come into being through evolution. Therefore, to accuse them means to accuse evolution. If both sides are correct in their accusations, neither source lives up to what is expected from it. If both sides are wrong, neither side knows its source properly. Creationists have misunderstood God. Evolutionists have been awed by power and attributed it to evolution; in so doing, they have ascribed a divine provenance to evolution, just as creationists do. Thus, what is the problem and what is the solution?

The Intelligent Design Movement—a Critique

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The argument from design has two parts. It asserts, first, that organisms evince to have been designed; second, that only God could account for the design. The argument from design was advanced, in a variety of forms, in Classical Greece and early Christianity. Its most extensive formulation is due to William Paley in his *Natural Theology* (1802). The eye – as well as all sorts of organs, organisms, and their interactions – manifest to be outcomes of design and not of chance, thus showing to have been created by God. In the 1990s, the design argument was revived in the United States by several authors.

Darwin's theory of evolution by natural selection disposed of Paley's arguments: the adaptations of organisms are not outcomes of chance, but of a process that, over time, causes the gradual accumulation of features beneficial to organisms. There is "design" in the living world: eyes are designed for seeing, wings for flying, and kidneys for regulating the composition of the blood. But the design of organisms is not intelligent, as it would be expected from an engineer, but imperfect and worse: defects, dysfunctions, oddities, waste, and cruelty pervade the living world. The design of organisms comes about by the interaction of mutation and natural selection, in a process that is creative through the interaction of chance and necessity.

Science and religious faith need not be in contradiction because they concern different matters. Science concerns the processes that account for the natural world. Religion concerns the meaning and purpose of the world and of human life, the proper relation of people to their Creator and to each other, the moral values that inspire and govern people's lives. The theory of evolution is consistent with a religious belief in God; Creationism and Intelligent Design are not: how to account for the incompetent design of the human jaw and the birth canal? People of faith should acknowledge Darwin's natural selection as the process that accounts for the inept design of organisms and for the dysfunctions, oddities, cruelties, and sadism that pervade the world of life.

Creationism – Historical and Contemporary Perspectives

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The theory of evolution has been the most controversial theory in science, not because of its drawbacks, but because many cannot accept the fact of sharing ancestors with animals. That explains why so many non-scientists have become involved in discussion about the theory when other great theories in science, such as relativity, have not attracted such attention. After Darwin published his theory of evolution, many people accepted it without problem whereas others were critical. In the 20th century the situation changed in the US with the rise of creationism. The pressure from religious fundamentalists in the USA hindered teaching evolution in high schools following the Scopes Trial in 1925. When fresh attempts were made to teach evolution effectively in the USA in the 1960s, creationists took up new legal strategies to prevent this. Their attempts to teach creationism along with evolution failed every time in the courts, mainly because it contradicted the US Constitution.

Creationists were successful, however, in changing the biology curriculum in collaboration with the Turkish Ministry of Education without much resistance from the scientists, making Turkey the only secular state where teaching evolution and creation together is allowed. This had dire consequences for science education in Turkey. In a recent survey, it was shown that the acceptance level of evolution among young teachers who graduated in recent years was significantly lower than that of teachers who had graduated in earlier years. In another survey, acceptance of evolution among the general public in Turkey ranked lowest among the 34 contemporary countries with a large gap from that of the second lowest country. M. Kemal Atatürk left Science and Reason as his legacy to the Turkish people. However, decrease in confidence in science resulting from inadequate science education in Turkey is a matter of concern for the future.

The Challenges of Science Education Today

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Two recent sets of data have jolted science educators and policymakers in the Muslim world: (a) international surveys on the lack of acceptance of the theory of evolution in Muslim societies today; and (b) the results of the 2007 Trends in International Mathematics and Science Study (TIMSS). Indeed, surveys have shown that only about 15 % of respondents in various Muslim countries (ranging from Egypt and Turkey to Malaysia) stated that Darwin's theory is "True" or "Probably True". Other surveys showed that this widespread rejection of evolution reaches to the highest levels of education (university students and professors). The TIMSS results showed that Arab/Muslim pupils of Grades 4 and 8 performed at the very lowest levels compared to international standards. And there are other alarming trends highlighting serious deficiencies in how science is presented and (mis)understood in the Muslim world, including, in particular, the extraordinary popularity of the theory of "miraculous scientific content of the Qur'an". Muslim science educators are clearly faced with major challenges.

In this talk, I will first undertake a diagnosis of the ills affecting science education in the Muslim world, providing data and multiple first-hand experience. In particular, I will focus on the serious lack of understanding of the nature and philosophy of science (its methodology, its principles, and its mechanisms for discovering, checking, and ascertaining the uncovered truths). I will then attempt to determine the causes of those trends and the reasons underlying the current state of affairs, including: the absence of the philosophy of science from curricula; the heavy burdens of the teachers; the denseness of the content of almost all science curricula currently taught; the lack of resources; the sometimes inadequate teaching methodology; etc. Lastly, I will present a set of recommendations for ways of improving the situation and remedying to those problems, while keeping in mind and highlighting cultural aspects of the teaching of science.

Teaching Evolution in Turkey : Present and Future

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Research on the education of evolution in Turkey is scanty. A few studies have reported on the acceptance, belief and understanding of evolution amongst both trainee and practicing teachers, but these results are open to discussion.

Education researchers avoid studying in-class learning and teaching of evolution in middle and secondary schools because of the National Education Ministry's strict control over teachers and concerns about running counter to public opinion.

Nevertheless, it is possible to obtain indirect information by surveying matriculating post-secondary students for their understanding of biology and evolution. Such a survey of students specializing in biological education, along with examination of the secondary school biology curriculum and text books, and interviews with number of secondary school biology teachers, gives a good picture of the problems facing the teaching of evolution in secondary schools. These can be listed as:

- Teachers have insufficient time to teach biology (two hours per week).
- Evolution is covered in the biology curriculum as a single subject rather than as a theme.
- Most students come to secondary school with prejudices, objections, and misconceptions about evolution, which are reinforced in religious education courses.
- Teachers have inadequate knowledge of biology and lack the pedagogical strategies necessary to be able to help students to understand the evolutionary process and to provide relevant examples.
- Textbooks cover Darwin's evolutionary theory briefly and superficially together with Lamarckism and Creationism.
- Pre-service teachers are deficient in their understanding of the nature of scientific knowledge.

Most prospective secondary biology teachers accept evolution without understanding it. Having learnt a fragmented biology by rote, they think that evolution is not important to teach. Under these circumstances, we, university science education faculty, must consider our task.

In spite of this negative scenario, the future is promising for evolution education in Turkey. There is an increasing awareness of the educational needs in this area, together with research and educational activities in the science education community. Plans include:

- Collaboration of scientists and teacher educators for further research to improve the teaching and learning of evolution.
- Funding of projects, courses, workshops and teacher training in evolution education by the National Education Ministry and the Science and Technology Council of Turkey.
- Improvement of students' and teachers' understanding of the nature of science.
- Promotion of an evolution-based teaching philosophy and practice of thinking.
- Development of students' and teachers' conceptual thinking in biology.
- Development of science and biology standards and curriculum with the aim of demonstrating the impact of evolution on the whole field of biology.
- Prevention of criticism and negative teaching about biological evolution in religious education courses.