Daily News epaper

Feature

Do we need a new theory of evolution?

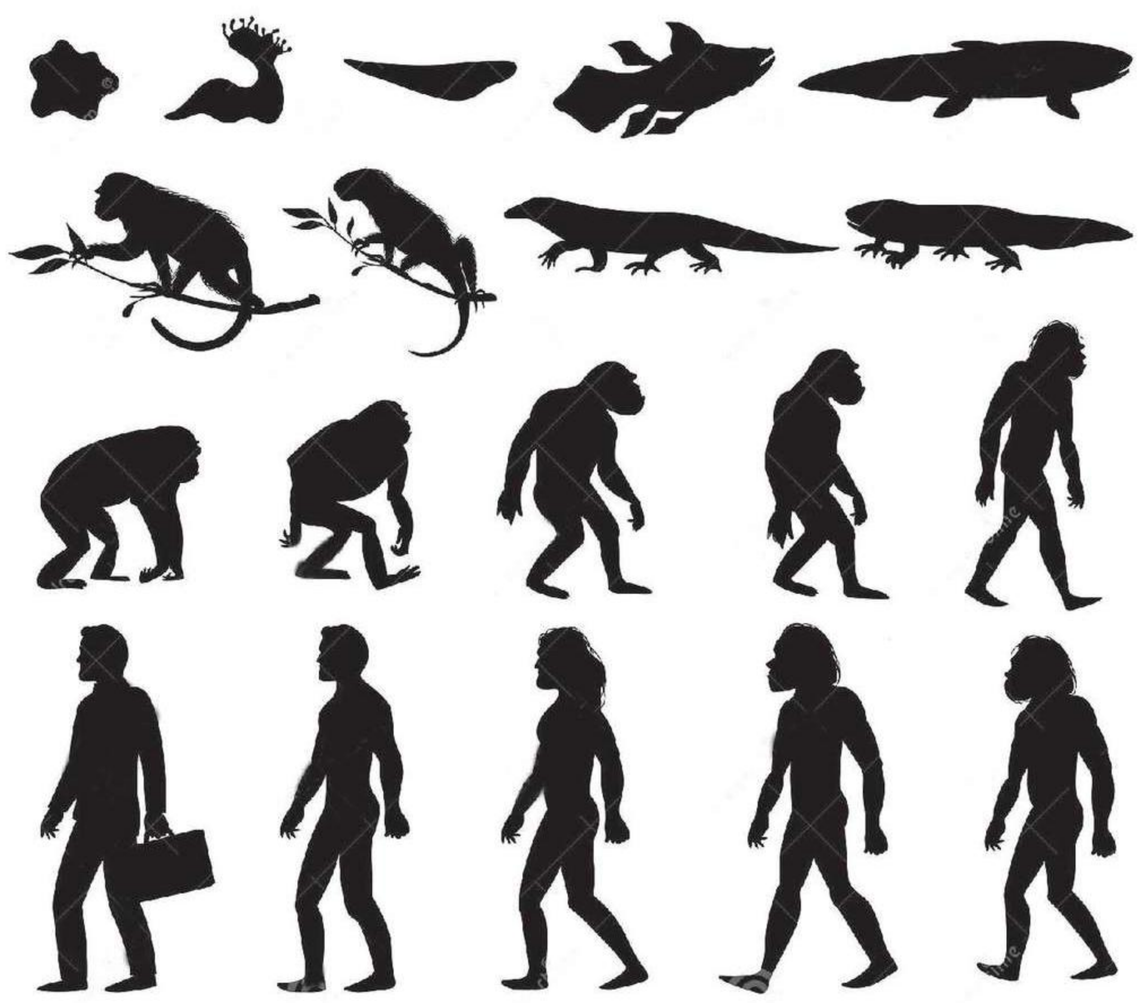
A new wave of scientists argues that mainstream evolutionary theory needs an urgent overhaul. Their opponents have dismissed them as misguided careerists – and the conflict may determine the future of biology

Strange as it sounds, scientists still do not know the answers to some of the most basic questions about how life on Earth evolved. Take eyes, for instance. Where do they come from, exactly? The usual explanation of how we got these stupendously complex organs rests upon the theory of natural selection.

You may recall the gist from school biology lessons. If a creature with poor sight happens to produce offspring with slightly better sight, thanks to random mutations, then that tiny bit more vision gives them more chance of survival. The longer they survive, the more chance they have to reproduce and pass on the genes that equipped them with slightly better eyesight. Some of their offspring might, in turn, have better eyesight than their parents, making it likelier that they, too, will reproduce. And so on. Generation by generation, over unfathomably long periods of time, tiny advantages add up. Eventually, after a few hundred million years, you have creatures that can see as well as humans, or cats, or owls.

This is the basic story of evolution, as recounted in countless textbooks and pop-science bestsellers. The problem, according to a growing number of scientists, is that it is absurdly crude and misleading.

THERE ARE CERTAIN CORE EVOLUTIONARY PRINCIPLES THAT NO SCIENTIST SERIOUSLY QUESTIONS. EVERYONE AGREES THAT NATURAL SELECTION PLAYS A ROLE, AS DOES MUTATION AND RANDOM CHANCE. BUT HOW EXACTLY THESE PROCESSES INTERACT – AND WHETHER OTHER FORCES MIGHT ALSO BE AT WORK – HAS BECOME THE SUBJECT OF BITTER DISPUTE



Foundational motivation

For one thing, it starts midway through the story, taking for granted the existence of light-sensitive cells, lenses and irises, without explaining where they came from in the first place. Nor does it adequately explain how such delicate and easily disrupted components meshed together to form a single organ. And it isn't just eyes that the traditional theory struggles with. "The first eye, the first wing, the first placenta. How they emerge. Explaining these is the foundational motivation of evolutionary biology," said Armin Moczek, a biologist at Indiana University. "And yet, we still do not have a good answer. This classic idea of gradual change, one happy accident at a time, has so far fallen flat."

There are certain core evolutionary principles that no scientist seriously questions. Everyone agrees that natural selection plays a role, as does mutation and random chance. But how exactly these processes interact – and whether other forces might also be at work – has become the subject of bitter dispute. "If we cannot explain things with the tools we have right now," the Yale University biologist Günter Wagner told me, "we must find new ways of explaining."

In 2014, eight scientists took up this challenge, publishing an article in the leading journal Nature that asked "Does evolutionary theory need a rethink?" Their answer was: "Yes, urgently." Each of the authors came from cutting-edge scientific subfields, from the study of the way organisms alter their environment to reduce the normal pressure of natural selection – think of beavers building dams – to new research showing that chemical modifications added to DNA during our lifetimes can be passed on to our offspring.

The authors called for a new understanding of evolution that could make room for such discoveries. The name they gave this new framework was rather bland – the Extended Evolutionary Synthesis (EES) – but their proposals were, to many fellow scientists, incendiary.

New trends

In 2015, the Royal Society in London agreed to host New Trends in Evolution, a conference at which some of the article's authors would speak alongside a distinguished lineup of scientists. The aim was to discuss "new interpretations, new questions, a whole new causal structure for biology", one of the organisers told me. But when the conference was announced, 23 fellows of the Royal Society, Britain's oldest and most prestigious scientific organisation, wrote a letter of protest to its then president, the Nobel laureate Sir Paul Nurse.

"The fact that the society would hold a meeting that gave the public the idea that this stuff is mainstream is disgraceful," one of the signatories told me. Nurse was surprised by the reaction. "They thought I was giving it too much credibility," he told me. But, he said: "There's no harm in discussing things."

Traditional evolutionary theorists were invited, but few showed up. Nick Barton, recipient of the 2008 Darwin-Wallace medal, evolutionary biology's highest honour, told me he "decided not to go because it would add more fuel to the strange enterprise". The influential biologists Brian and Deborah Charlesworth of the University of Edinburgh told me they didn't attend because they found the premise "irritating". The evolutionary theorist Jerry Coyne later wrote that the scientists behind the EES were playing "revolutionaries" to advance their own careers. One 2017 paper even suggested some of the theorists behind the EES were part of an "increasing post-truth tendency" within science. The personal attacks and insinuations against the scientists involved were "shocking" and "ugly", said one scientist, who is nonetheless sceptical of the EES.

What accounts for the ferocity of this backlash? For one thing, this is a battle of ideas over the fate of one of the grand theories that shaped the modern age. But it is also a struggle for professional recognition and status, about who gets to decide what is core and what is peripheral to the discipline. "The issue at stake," said Arlin Stoltzfus, an evolutionary theorist at the IBBR research institute in Maryland, "is who is going to write the grand narrative of biology." And underneath all this lurks another, deeper question: whether the idea of a grand story of biology is a fairytale we need to finally give up.

Broken dream

Behind the current battle over evolution lies a broken dream. In the early 20th century, many biologists longed for a unifying theory that would enable their field to join physics and chemistry in the club of austere, mechanistic sciences that stripped the universe down to a set of elemental rules. Without such a theory, they feared that biology would remain a bundle of fractious sub-fields, from zoology to biochemistry, in which answering any question might require input and argument from scores of warring specialists.

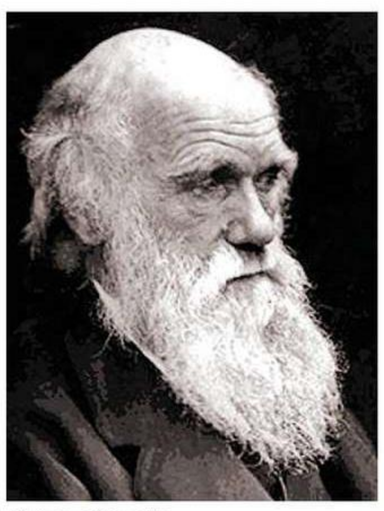
From today's vantage point, it seems obvious that Darwin's theory of evolution – a simple, elegant theory that explains how one force, natural selection, came to shape the entire development of life on Earth – would play the role of the great unifier. But at the turn of the 20th century, four decades after the publication of On the Origin of Species and two after his death, Darwin's ideas were in decline. Scientific collections at the time carried titles such as The Death-bed of Darwinism.

Scientists had not lost interest in evolution, but many found Darwin's account of it unsatisfying. One major problem was that it lacked an explanation of heredity. Darwin had observed that, over time, living things seemed to change to better fit their environment. But he did not understand how these minute changes were passed from one generation to the next.

At the start of the 20th century, the rediscovery of the work of the 19th-century friar and father of genetics, Gregor Mendel, started to provide the answers. Scientists working in the new field of genetics discovered rules that governed the quirks of heredity. But rather than confirm Darwin's theory, they complicated it.

Reproduction appeared to remix genes – the mysterious units that programme the physical traits we end up seeing – in surprising ways. Think of the way a grandfather's red hair, absent in his son, might reappear in his granddaughter. How was natural selection meant to function when its tiny variations might not even reliably pass from parent to offspring every time?

Even more ominous for Darwinists was the emergence of the "mutationists" in the 1910s, a school of geneticists whose star exponent, Thomas Hunt Morgan, showed that by breeding millions of fruit flies – and sometimes spiking their food with the radioactive element radium – he could produce mutated traits, such as new eye colours or additional limbs. These were not the tiny random variations on which Darwin's theory was built, but sudden, dramatic changes. And these mutations, it turned out, were heritable.



Charles Darwin

Gregor Mendel

Julian Huxley

The mutationists believed that they had identified life's true creative force. Sure, natural selection helped to remove unsuitable changes, but it was simply a humdrum editor for the flamboyant poetry of mutation. "Natura non facit saltum," Darwin had once written: "Nature does not make jumps." The mutationists begged to differ.

Theological schism

These disputes over evolution had the weight of a theological schism. At stake were the forces governing all creation. For Darwinists especially, their theory was all-or-nothing. If another force, apart from natural selection, could also explain the differences we see between living things, Darwin wrote in On the Origin of Species, his whole theory of life would "utterly break down". If the mutationists were right, instead of a single force governing all biological change, scientists would have to dig deep into the logic of mutation. Did it work differently on legs and lungs? Did mutations in frogs work differently to mutations in owls or elephants?

In 1920, the philosopher Joseph Henry Woodger wrote that biology suffered from "fragmentation" and "cleavages" that would be "unknown in such a well-unified science as, for example, chemistry". The divergent groups often feuded, he noted, and it seemed to be getting worse. It began to seem inevitable that the life sciences would grow more and more fractured, and the possibility of a common language would slip away.

Just as it seemed that Darwinism might be buried, a curious collection of statisticians and animal breeders came along to revitalise it. In the 1920s and 30s, working separately but in loose correspondence, thinkers such as the British father of scientific statistics, Ronald Fisher, and the American livestock breeder Sewall Wright, proposed a revised theory of evolution that accounted for scientific advances since Darwin's death but still promised to explain all of life's mysteries with a few simple rules.

In 1942, the English biologist Julian Huxley coined the name for this theory: the modern synthesis. Eighty years on, it still provides the basic framework for evolutionary biology as it is taught to millions of schoolchildren and undergraduates every year. Insofar as a biologist works in the tradition of the modern synthesis, they are considered "mainstream"; insofar as they reject it, they are considered marginal.

Despite the name, it was not actually a synthesis of two fields, but a vindication of one in light of the other. By building statistical models of animal populations that accounted for the laws of genetics and mutation, the modern synthesists showed that, over long periods of time, natural selection still functioned much as Darwin had predicted. It was still the boss. In the fullness of time, mutations were too rare to matter, and the rules of heredity didn't affect the overall power of natural selection. Through a gradual process, genes with advantages were preserved over time, while others that didn't confer advantages disappeared.

Modern synthesis

Rather than getting stuck into the messy world of individual organisms and their specific environments, proponents of the modern synthesis observed from the lofty perspective of population genetics. To them, the story of life was ultimately just the story of clusters of genes surviving or dying out over the grand sweep of evolutionary time.

The modern synthesis arrived at just the right time. Beyond its explanatory power, there were two further reasons – more historical, or even sociological, than scientific – why it took off. First, the mathematical rigour of the synthesis was impressive, and not seen before in biology. As the historian Betty Smocovitis said, it brought the field closer to "exemplar sciences" such as physics. At the same time, writes Smocovitis, it promised to unify the life sciences at a moment when the "enlightenment project" of scientific unification was all the rage.

In 1946, the biologists Ernst Mayr and George Gaylord Simpson started the Society for the Study of Evolution, a professional organisation with its own journal, which Simpson said, would bring together the sub-fields of biology on "the common ground of evolutionary studies". This was all possible, he later reflected, because "we seem at last to have a unified theory capable of facing all the classic problems of the history of life and of providing a causalistic solution of each."

This was a time when biology was ascending to its status as a major science. University departments were forming, funding was flowing in, and thousands of newly accredited scientists were making thrilling discoveries. In 1944, the Canadian-American biologist Oswald Avery and his colleagues had proved that DNA was the physical substance of genes and heredity, and in 1953 James Watson and Francis Crick – leaning heavily on work from Rosalind Franklin and the American chemist Linus Pauling – mapped its double-helical structure.

While information piled up at a rate that no scientist could fully digest, the steady thrum of the modern synthesis ran through it all. The theory dictated that, ultimately, genes built everything, and natural selection scrutinised every bit of life for advantage. Whether you were looking at algae blooming in a pond or peacock mating rituals, it could all be understood as natural selection doing its work on genes. The world of life could seem suddenly simple again.

By 1959, when the University of Chicago held a conference celebrating the centennial of the publication of On the Origin of Species, the modern synthesists were triumphant. The venues were packed and national newspaper reporters followed the proceedings. (Queen Elizabeth was invited, but sent her apologies.) Huxley crowed that "this is one of the first public occasions on which it has been frankly faced that all aspects of reality are subject to evolution".

Yet soon enough, the modern synthesis would come under assault from scientists within the very departments that the theory had helped build.

Dissenters

From the start, there had always been dissenters. In 1959, the developmental biologist CH Waddington lamented that the modern synthesis had sidelined valuable theories in favour of "drastic simplifications which are liable to lead us to a false picture of how the evolutionary process works". Privately, he complained that anyone working outside the new evolutionary "party line" – that is, anyone who didn't embrace the modern synthesis – was ostracised.

Then came a devastating series of new findings that called into question the theory's foundations. These discoveries, which began in the late 60s, came from molecular biologists. While the modern synthesists looked at life as if through a telescope, studying the development of huge populations over immense chunks of time, the molecular biologists looked through a microscope, focusing on individual molecules. And when they looked, they found that natural selection was not the all-powerful force that many had assumed it to be.

They found that the molecules in our cells – and thus the sequences of the genes behind them – were mutating at a very high rate. This was unexpected, but not necessarily a threat to mainstream evolutionary theory. According to the modern synthesis, even if mutations turned out to be common, natural selection would, over time, still be the primary cause of change, preserving the useful mutations and junking the useless ones. But that isn't what was happening. The genes were changing – that is, evolving – but natural selection wasn't playing a part. Some genetic changes were being preserved for no reason apart from pure chance. Natural selection seemed to be asleep at the wheel.

Evolutionary biologists were stunned. In 1973, David Attenborough presented a BBC documentary that included an interview with one of the leading modern synthesists, Theodosius Dobzhansky. He was visibly distraught at the "non-Darwinian evolution" that some scientists were now proposing. "If this were so, evolution would have hardly any meaning, and would not be going anywhere in particular," he said. "This is not simply a quibble among specialists. To a man looking for the meaning of his existence, evolution by natural selection makes sense." Where once Christians had complained that Darwin's theory made life meaningless, now Darwinists levelled the same complaint at scientists who contradicted Darwin.

Concentrated bursts

Other assaults on evolutionary orthodoxy followed. The influential palaeontologists Stephen Jay Gould and Niles Eldredge argued that the fossil record showed evolution often happened in short, concentrated bursts; it didn't have to be slow and gradual. Other biologists simply found that the modern synthesis had little relevance to their work. As the study of life increased in complexity, a theory based on which genes were selected in various environments started to seem beside the point.

It didn't help answer questions such as how life emerged from the seas, or how complex organs, such as the placenta, developed. Using the lens of the modern synthesis to explain the latter, said the Yale developmental biologist Günter Wagner, would be "like using thermodynamics to explain how the brain works". (The laws of thermodynamics, which explain how energy is transferred, do apply to the brain, but they aren't much help if you want to know how memories are formed or why we experience emotion.)

Just as feared, the field split. In the 70s, molecular biologists in many universities peeled off from biology departments to form their own separate departments and journals. Some in other sub-fields, such as palaeontology and developmental biology, drifted away as well. Yet the biggest field of all, mainstream evolutionary biology, continued much as before.

The way the champions of the modern synthesis – who by this point dominated university biology departments – dealt with potentially destabilising new findings was by acknowledging that such processes happen sometimes, are useful to some specialists, but do not fundamentally alter the basic understanding of biology that descends from the modern synthesis. In short, new discoveries were often dismissed as little more than mildly diverting curiosities.

Today, the modern synthesis "remains, mutatis mutandis, the core of modern evolutionary biology" wrote the evolutionary theorist Douglas Futuyma in a 2017 paper defending the mainstream view. The current version of the theory allows some room for mutation and random chance, but still views evolution as the story of genes surviving in vast populations. Perhaps the biggest change from the theory's mid-century glory days is that its most ambitious claims – that simply by understanding genes and natural selection, we can understand all life on earth – have been dropped, or now come weighted with caveats and exceptions. This shift has occurred with little fanfare.

The theory's ideas are still deeply embedded in the field, yet no formal reckoning with its failures or schisms has occurred. To its critics, the modern synthesis occupies a position akin to a president reneging on a campaign promise – it failed to satisfy its entire coalition, but remains in office, hands on the levers of power, despite its diminished offer.

– Daily Mail