Evolution myths: Evolution is just so unlikely

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By weeding out harmful mutations and assembling beneficial ones, natural selection acts like an "improbability drive" that can, given enough time, produce results that appear utterly impossible at first glance

In a recent TV special shown in the UK, called *The System*, a mother with big debts was persuaded to borrow even more money to bet on a horse race. Having been sent correct predictions of six previous races, she believed illusionist Derren Brown really had come up with a foolproof system for predicting the outcome of races.

In fact, the producers of the show started by sending different predictions to nearly 8000 people. After each race, those sent predictions that turned out to be wrong were eliminated and another set of varying predictions sent to the remaining participants. What appears utterly extraordinary at first – sending someone correct predictions of the winners of six races – seems very ordinary as soon as you understand that thousands of people got wrong predictions.

Confronted by the marvels of the living world, many people jump to the same conclusion to the woman in the programme: they cannot be the result of chance alone. But what we don't see are all the failures: the countless numbers of creatures that died in the egg or in the womb, or hatched or were born with terrible defects, or fell victim to predators or disease because of some weakness.

In the wild, most individuals die long before they get a chance to reproduce. The living organisms on Earth are the result not just of six rounds of selection, as in the TV programme, but of trillions. This, not chance, is the crucial factor in evolution.

Three steps to evolution

To understand evolution, you need to appreciate three things. Firstly, that quadrillion-to-one chances actually happen all the time. Secondly that, while mutation is random, which mutations survive often is not. And thirdly, given enough time, the accumulation of one beneficial mutation after another can produce amazingly complex systems. Natural selection can be seen as a kind of improbability drive that – given enough time – makes the apparently impossible extremely likely.

If you pick even the simplest creatures alive today and calculate the odds of getting their genome by randomly shuffling DNA sequences, you'll find they are pretty astronomical. Even matching the sequence of the simplest virus is stupendously unlikely.

Does this prove evolution is impossible? Try this: get a pack of cards, shuffle it well and spread it out so you can see the sequence. Now try to generate the same sequence by shuffling another pack.

Done it yet? The universe might end before you succeed. If shuffles are truly random, the chance of generating any particular sequence of 52 cards is 1 followed by 68 zeroes – and yet such an incredibly unlikely event happens each time any pack is shuffled.

Shifting genes

In all living creatures, the "pack of cards" is constantly being shuffled. Damage to DNA or mistakes in replicating it generate random mutations, ranging from changes in single "letters" to duplications or deletions of huge chunks of DNA. The vast majority will be either harmful or neutral – only a few will be beneficial. But as the card example shows, even if all beneficial mutations are highly unlikely, this doesn't mean they cannot happen.

In fact, the odds of a beneficial mutation occurring are higher than you might think. One recent study of the *E. coli* gut bacterium puts the rate as high as 1 beneficial mutation for every 10,000 new bacteria.

That might not sound like much but populations of many simple organisms can number in the trillions, with new generations appearing every hour or less. Do the sums.

What really matters, though, is what happens after mutations appear. That's when natural selection kicks in. Each new organism's life is essentially a rigorous testing process. Those with a harmful mutation will tend to die out, while those with a beneficial mutation that gives them a competitive edge will thrive and produce more descendants. This means that beneficial mutations will become more common in a population, while harmful mutations disappear.

This process happens over and over again. If individuals with one beneficial mutation thrive and multiply, eventually another beneficial mutation will occur in one of them. Over time individuals with both beneficial mutations will come to dominate a population, making it likely for yet another beneficial mutation to appear in one of them…

Benefits of sex

What's more, in species that can swap genetic material, for instance by reproducing sexually, beneficial mutations that occur in separate individuals can be combined in their descendants. In this way, natural selection can create the astonishing organisms we see around us, the result of countless trillions of beneficial mutations slowly assembled over billions of years (see *Mutations can only destroy information*).

It's true that how the process got underway in the first place is still something of a mystery. We won't begin to know just how likely or unlikely the origin of life was until someone manages to get life to evolve from scratch in the lab or discovers life that originated

independently, perhaps on another planet. What is clear, however, is that as soon as the first primitive entities capable of replicating themselves emerged, further evolution was inevitable.

And the more evolution there is, the faster it may become. In fact, evolution might produce "evolvability". For instance, as organisms evolve systems that can cope with a wide range of environmental conditions, further evolution might become more feasible – an idea backed by recent experiments showing evolution can be speeded by varying the environment.

Such ideas remain controversial. What is indisputable is that while the end results of evolution might appear utterly impossible, once you understand the way in which natural selection can collect and distil the results of chance events, there's nothing impossible about it at all.

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