When listening to David Dubal's program "The Piano Matters" last week, I was astonished to hear David reading, at the end of the show, an excerpt by the British writer Gerald Brenan attacking evolution. Brenan expressed skepticism that "the huge variety of living species, each of them of a fantastic complexity, has developed solely through the operation of natural selection working on chance mutations", especially since as Brenan correctly notes, "most mutations are harmful."

These comments reflect multiple misconceptions that I believe merit a response. I am a physicist, not a professional biologist, but I pay attention to developments in biology. Because my colleagues and I at the Institute for Advanced Study consider biology to be a very important branch of science, we have added an active group in biology to the existing particle physics and astrophysics groups in the Institute's School of Natural Sciences.

To begin, Brenan's excerpt ignores both the fact that large populations are involved in natural selection, and the mathematics of compound interest. If in a population of a million bacteria one thousand have harmful mutations, and one has a very advantageous mutation, the progeny of that one will take over in ten or twenty generations. We see this all the time with populations of germs developing resistance to antibiotics. There is plenty of evidence that the same mechanism is in play for larger animals, and plants, as well.

Moreover, the fact that mutations have a random element does not imply less efficacy in natural selection. Random processes have the advantage of testing possibilities without the bias of preconceptions. So chance mutations can uncover advantageous evolutionary pathways that a designer would miss. In fact, in computer science this has been put to use in so-called "genetic algorithms", in which random mutations of a computer code can produce more efficient codes, embodying short-cuts that are beyond what the best program designer can produce.

Brenan's excerpt was written over thirty years ago, and a great deal about evolution has been learned since then. Thirty years ago, the evolutionary tree, showing the order in which various life forms developed over the last few billion years, was partly based on a study of plant and animal physiology, and partly based on a study of the fossil record and geology. Now, this information has been supplemented by the decoding of the genomes of many species, and this information reinforces that obtained from the fossil record. Life forms that are far apart on the evolutionary tree have genomes that differ more than life forms that are closer.

As one example, around thirty four percent of the mouse genome maps to identical sequences, in a jumbled order, on the human genome, whereas fully ninety five percent of the chimpanzee genome maps to an identical sequence in the human genome. This difference reflects the fact that the last common ancestor of the chimp and humans lived roughly five million years ago, whereas the last common ancestor of humans and mice lived around seventy five million years ago. The commonalities and the changes reflect two other misconceptions in Brenan's remarks. Nature did not have to invent all living creatures independently from scratch; many structures are conserved as one goes up the evolutionary tree. But the change in ordering of sequences on the chromosomes reflects another process, DNA recombination, that along with mutations plays an important role in producing the variability of populations that is acted on by natural selection.

Later on in the excerpt, Brenan objects that biologists are "obsessed by mechanical explanations". Over the last thirty years, we have discovered that cellular processes – the reading of genetic information by an amazing object called the ribosome, the motors with microscopic rotors that produce cellular energy, and the fibers that make our muscles contract – are in fact microscopic mechanical devices operating at the molecular level. The cells in our bodies are biochemical, and biomechanical, machines.

Dubal ends his reading of the excerpt with the comment, “Ah, sweet mystery of life.” Looking back over the history of science, many things that were considered mysterious in the past are now well understood as natural phenomena, and it is the expectation of scientists that this will continue in biology just as it has in physics, chemistry, and geology. But understanding need not remove our sense of wonder at the universe.

I am a particle physicist, and people in my field are working to find a unified explanation for all observed physical phenomena, from quantum theory to gravitation and cosmology. Such a theory will underlie our current “standard model” of particle physics, which in turn already underlies all of chemistry and biology. However, success in finding a “theory of everything” will not eliminate all mysteries. Suppose in ten or twenty years, taking an optimistic view, or in a few hundred years, taking a more pessimistic one, we find the underlying equations of the universe. That still won’t answer the question of why this set of equations isn’t just an abstract possibility, rather than being physically realized in the universe in which we live. The “why” of existence is to me the ultimate mystery. To my mind this is the place, not the mechanics of the cell or the details of evolution, where the boundary between physics, metaphysics, theology, and religion resides.