

An Introduction to Evolutionary Biology

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Week 2 Lecture 10

Evidence for evolution 4: Objections to evolution

So, in the last few discussions, We looked at some of the evidence that scientists have for believing that evolution has indeed occurred on this planet. Now, the point to be noted here is that what we looked at is by no means all the evidence that is available to scientists. It is just a small subset. And therefore, before we proceed further, I would like to give you two references for anyone who wants to dive deeper into the subject. So, the first reference is this very famous book by Jerry Coyne called Why Evolution Is True. This is a book that is written primarily for a non-technical audience and therefore, You know, even if you are not in the field of biology, you can actually have a look at it; it's fascinatingly written with very nice language.

If you are in the field of biology and want to have a slightly more detailed technical look, check out the references for yourself. Then the primary recommendation that I have is Douglas Theobald's 29-plus evidences for macroevolution. So, this is the link for that particular thing, for that particular website. It is a very detailed website.

The point to be noted is that these two references are only for diving deeper into the subject. So, if you are not planning to, you know, do that, and if you only want to have sufficient information for the exams, Then our previous discussion should be enough. Whatever information is given in these resources is only for your personal edification. So, now with this huge amount of evidence that is available to prove evolution, one would think that evolution is done and dusted. Everybody should believe in it, but unfortunately, that is not really true, and there are various societies all over the world where some people, not everybody, and most importantly, not the scientists, but the non-scientists, Many of them end up coming up with all kinds of objections to evolution. Now, these objections, a huge fraction of them, are coming from the so-called creationists. or their close cousins, the so-called intelligent design people. So, these are people who believe that evolution has not occurred. And somewhere there is a supernatural force; call it God, call it the designer, or call it the supreme being, or whatever.

And the objections they come up with many times are simple word plays. Many a time, they

are simple, you know, coming out of a lack of understanding of the basic process of science. But the point is that they refuse to die. And one of the reasons that they choose to die is that sometimes, not always, but sometimes, some of the objections are couched in highly scientific language. And therefore, for people who have not looked into the topic, it looks as if it is very convincing.

So, of course, there are many, many books on this particular topic. Forget about articles; there are thousands of articles on various aspects of these objections. There is one resource to which I would like to guide you, which is again this talkorigins.org. So, if you go there, they have a very, very comprehensive list of the various objections that people often cite against evolution.

What they also do is give you the rebuttals to those objections. And so basically, why scientists think that those objections are wrong, and most importantly, both for the objection. And for the rebuttal, they mostly also give you the corresponding references. So, you can actually go into the primary literature and satisfy yourself. That whatever objection has been given, the way the objection has been put and the way the counter has been put is reasonably good.

Now, the point is that in this particular site there are hundreds of objections that are listed. Out of which, for the sake of this course, we are going to consider only five. Now, of course, you might ask why only five, and there are a couple of reasons for that. Number one is, as I am telling you, the number of objections on this website numbers in the hundreds. And therefore, we do not really have time to look at all of them in the context of this course.

Second, the counter to some of those objections will require you. To have a certain amount of knowledge about the process of evolution, you need to know something about natural selection. Something about mutation, something about genetic drift, and so on. And that is something that we are going to take up only in the later parts of the course. And that is why those objections will be dealt with when we reach the corresponding position, you know, the corresponding part in the syllabus.

Now, what I have done is, as I said, I have picked up only five just to give you a sample of the kind of objections that are there. and some of these are also the ones that you often come across, you know, during your regular course of You know, what you find in popular literature, newspapers, and so on. So, the first objection I am sure most of you have heard is that evolution is just a theory and not a fact. Now, in order to understand why this particular objection does not really make sense, You have to first appreciate what the meaning of the word theory is. So, now in our day-to-day life, when we talk about the word theory, what we typically mean is what scientists call conjectures.

So, suppose there is, you know, a police inspector who is investigating a crime, and the person says that. I think that the butler has committed the crime. Now, in this particular

case, what the inspector means is that they have an educated guess. Or sometimes it is not even an educated guess; it is just, you know, a gut feeling, a hunch. But when they use it, they say we have a theory about that, and in scientific parlance, this usage of the word "theory" is not correct.

So, scientists will simply call this a conjecture. So, if that is the case, what will a scientist call a theory? So, I will be quoting liberally from this particular document, a fascinating document freely available on the web. Again, if you want to understand the nature of science, this is a great place to look. So, coming back to what is a theory? So, in science, a theory is a comprehensive explanation of some aspect of nature that is supported by a vast body of evidence. Now, this last phrase is very important by a vast body of evidence.

If you do not have a vast body of evidence supporting something, you do not really call it a theory in science. As opposed to the normal usage, where just your gut feeling is good enough for you to call it a theory. Now, the other important word in this objection is a fact. What is a fact? Now, normally, a fact is an observation, a measurement, or any other form of evidence. So, both scientists and regular usage converge on this part, but there is another way in which scientists use the term fact.

And that is that scientists also use the term "fact" to refer to a scientific explanation that has been tested and confirmed so many times. There is no longer a compelling reason to keep testing it or looking for additional examples. In other words, if it is, like, you know, one or two steps beyond a theory, When you have a vast amount of evidence, you call it a theory. When the amount of evidence that you have is so large that there is no reasonable doubt left that If the theory is correct, then you can actually end up calling it a fact. And it is in this context that the past and the continuing occurrence of evolution are scientific facts.

We ourselves looked at so many different strands of evidence that suggest that evolution has happened, right? And as I told you, we just looked at a small subset; I have already given you the list to a much longer set, right? So, in that context, evolution has actually been accorded the status of a scientific fact. And because the evidence supporting it is so strong, scientists no longer question. Whether biological evolution has occurred and is continuing to occur. Instead, they investigate the mechanisms of evolution, how rapidly evolution can take place, and related questions. So, these latter questions are also the kind of things that we are going to investigate during our time as part of this course.

So, to put it in a nutshell, in the context of science, evolution is both a theory and a fact, okay. It is not that it is a theory, not a fact; the way scientists define the terms, evolution is both a theory and a fact. Objection number 2: This is a very common objection that the fossil record lacks transitional fossils. Why is it an objection? Because Darwin said that all organisms evolve from pre-existing organisms over large amounts of time. And therefore, the argument goes that for all existing lineages, you should have an unbroken chain of fossil forms which should show you what those transitions are. If that is not there, then that is

proof that that kind of evolution did not even occur. What is the problem with this? As we have already seen, fossilization is a very rare process with very specific requirements. Therefore, one cannot really expect to find every single transitional form in every lineage. It is just not going to happen.

In spite of this, there are several transitional forms that have been unearthed by scientists. Some of these examples we have seen already. So, for example, we have already looked at Archaeopteryx, which is a transitional form between theropod dinosaurs and birds. We have not looked at it, but a very important fossil form that has been discovered is that of Tiktaalik. So, you know that at some point, fish came out of the water and went onto the land, conquering it.

So, that is when the tetrapods, you know, all those who have four limbs, were developed, and this is a very major transition. The fossil called Tiktaalik actually has properties of bony fishes; for all practical purposes, it is a fish. but it has four limbs, which the fossil evidence suggests it should have been able to use to lift itself up on. You know hard surfaces, which obviously are the prerequisite for walking on the land. So, we have the Tiktaalik, and then, as we already saw, we have transitional forms in several lineages.

For example, the horse, the whales, and, as we are going to see later in this course, also the humans. So, the property of transitional fossils that very much exists is important. And there are enough fossils in the fossil record to prove that transitional forms did exist at some point on this planet. So, again, this objection does not really hold much water. Now, we come to the third objection, which is actually a very old objection.

Nowadays, it is couched in a new term called irreducible complexity. So, the objection is simply that biological systems exhibit irreducible complexity. Irreducible complexity could not have evolved, and this proves that there has to be a designer in evolution. Now, what is irreducible complexity? So, if you remember when we were talking about the evolution of ideas in biology, Then one of the people that we looked at was William Paley and his watchmaker analogy. So, what was Paley saying? Paley was saying that if you find a watch and look inside it, you will see that there are many highly precise components that are communicating with each other, which are interacting with each other in a very very precise way such that you get a proper time accurate time.

And it is impossible to conceive that the watch can work. In the absence of all those very precise components interacting in such a precise way. And therefore, the presence of such an intricate mechanism proves that there has to be a watchmaker. There has to be somebody who thought through the entire process, designed each component separately, and put them together. It is inconceivable that such an intricate mechanism can arise on its own.

So, this is what is known as an argument by incredulity; this is something that could not have happened because I cannot imagine it. Now, what is an example of this kind of complex

structure in biological systems? Well, there are thousands and thousands. But the one example that caught everybody's fancy, including that of Charles Darwin, was the eye. Now, this is the cross-section of a human eye. Now, I do not know if you have ever come across this diagram or not.

If you have not, it does not really matter. All you want to see over here is the fact that there are so many parts that are there in the eye. All these parts need to be there in a particular orientation. They need to communicate with each other, and they need to support each other. Then and only then can the eye do its primary function, which is, you know, seeing. Of course, you also need the brain, but the primary function is gathering the light and communicating all those signals to the brain.

That function can only be done if all these, you know, subparts of the eye are functioning properly. So, people ask the question of how exactly an eye, just like a watch, can be put together or come into being through completely natural phenomena. So, why should you know that is why the eye is considered an example of evidence against evolution? Now, let me put it in the precise words in which intelligent designers put them. So, what I am doing is quoting from the work of this person called Michael Behe who is supposed to be one of the most famous proponents of intelligent design? So, I am giving you the arguments in his words so that you can understand them more precisely. So, what Behe says is: An irreducibly complex system cannot be produced directly by numerous successive slight modifications of a precursor system. Because any precursor to an irreducibly complex system that is missing a part is, by definition, non-functional. So, this is exactly the watchmaker's analogy. If you have a system such that the removal of even one part will make the system non-functional, then that system is what we call an irreducibly complex system.

Now, such a system cannot possibly arise by natural selection. Why? Because natural selection can only choose systems that are already working. Then, if a biological system cannot be produced gradually, it would have to arise as an integrated unit in one fell swoop for natural selection to have anything to act on. So, this part is a direct objection to Darwin's contention that any complex part could have arisen. And this is, I mean, here Behe is actually quoting Darwin. Darwin said that it could have arisen through numerous successive slight modifications of a precursor system.

And Darwin says that if one can show that there exists a system that could not have arisen this way, then that will be taken as very strong proof against the process of evolution by natural selection. And what people like Behe are saying is that structures like the eye, and they, of course, have some other examples also. Structures like the eye could not have arisen through such a process simply because you know what good a half an eye is. If you do not have one small thing, then the entire structure fails, which basically means that the structure could not have arisen except by some kind of divine intervention. Now, how does one counter that? Now, in order to understand the counterargument to this, you have to understand what the implication of an irreducibly complex system is.

So, if a structure is indeed irreducibly complex, That essentially means you cannot find a simpler structure doing a similar function, right? Or you, for that matter, cannot find a simpler structure doing any function. Because the whole idea is that if one component goes, the entire structure fails. But if that is the case, the implication of that is that if you look at the animal kingdom, You should not be able to find eyes that are any simpler than the eye that I showed you, correct? Now, is this statement correct? Do we find other kinds of eyes in the animal kingdom? And it turns out that the answer is an overwhelming yes. If you start looking at eyes, you can find eyes at all levels of complexity across the animal kingdom. Each one of them gives some degree of benefit to the organism.

So, there are some eyes that are very simple, which are just like, you know, a cell with a few pigments. which is simply light-sensitive, which simply tells you whether the light is there or if the light is not there. And then there are slightly more complicated systems, which tell you which direction the light is coming from. And then there is a slightly more complicated system, which shows you that you know. A very vague and unfocused image of the eye—sorry, of the object—but it shows you something.

And then, through various grades of complexity, evolving grades of complexity, you finally get to the human eye. which actually forms a very nice and accurate representation of the object you know on the retina and then takes it to the brain. So, the fact that all these simpler systems exist and that all these simpler systems are still functional in terms of vision or in terms of some other job that actually provides very strong evidence in favor of evolution and not the other way around. So, to give you a slightly better understanding of how to find eyes at all levels of complexity, Instead of me talking about it, I will guide you to this video called The Evolution of the Human Eye by Joshua Harvey.

This is the link to that video. So, what I recommend is that you do not go to the video right now. You just look at this; you just take part in our discussion right now. And once the discussion is over, you can go and look at this video to gain some understanding for yourself. Convince yourself that you can actually have eyes of different levels of complexity, which basically implies that.

A. Irreducible complexity can arise through natural selection and. B. Whatever these people show as irreducibly complex organs in most cases, Well, in all the cases that scientists are aware of, the complexity is not at all irreducible. There are simpler forms possible, simpler forms that are still performing a function for the organism. So, basically, irreducible complexity is, according to the proponents of intelligent design, the biggest hurdle in front of evolution.

But if you look at it in some detail, you will realize that irreducible complexity is not at all an issue. It does not really disprove evolution in any way. Then we go to what again; in many places, you will come across this one. Evolution violates the second law of thermodynamics,

the law of entropy. How does it do that? So, according to the creationists, the second law of thermodynamics states that the total entropy which is a measure of how much disorder there is in a system, The total entropy of an isolated system that is not at equilibrium can only increase over time, right? And their argument is that.

Evolution implies the development of increasingly complex and ordered living organisms from simpler forms. which means that the entropy in the system is decreasing and therefore, evolution contradicts the second law. And, of course, the second law of thermodynamics is a fundamental law of physics, and because Evolution violates the second law of thermodynamics; evolution cannot possibly happen or could not have happened. Now, this particular objection has actually been looked at and thoroughly debunked by the physicists more than by the biologists.

So, I will quickly tell you what the debunking is. I mean this is basically stemming from a lack of understanding of thermodynamics. So, if you look at the statement of the second law, it applies to closed systems. In other words, it is applicable only to those systems where there is neither inflow nor outflow of energy. Now, we understand that the Earth is not such a system. On Earth, we are getting, you know, sun rays; we are receiving energy in various forms.

In the form of sun rays, we are emitting an enormous amount of heat into space. So, for all practical purposes, in reality, we are an open system. Therefore, the second law of thermodynamics about entropy increasing does not even apply in our system. But then one can argue that Earth might be an open system, but the universe is not.

The universe can be thought of as a closed system. So, is evolution leading to a reduction in entropy at the universal level? Great question, but the problem is that if you look at the universe, we know that the total entropy needs to increase. But that does not mean that locally entropy cannot decrease. As a matter of fact, there are several examples all over the world where in the natural systems, where you know a local decrease in entropy is happening all the time. So, for example, if you take some water and put it in the refrigerator and it freezes, it goes from a liquid state to a solid state. Entropy has decreased, but does that mean it is violating the second law of thermodynamics? No.

Similarly, if you take a single-cell zygote that forms an embryo, and then the embryo at some point becomes a baby, And then at some point, the baby develops to become a full-fledged adult. In all these cases, what is happening? There is an increase in orderliness, but is that violating the second law of thermodynamics? Absolutely not, because in all these cases the total entropy of the universe can be increasing. It is due to the action of energy that you are able to locally reduce the amount of entropy in the system. But as I said, the total amount of entropy in the universe has to be increasing. So, now the question that many people ask is, is this what is happening to the Earth? Can we really say that the total amount of entropy increasing in the universe due to the Earth is Let us say it is larger than the total amount of

reduction in entropy due to evolution.

Now, obviously, this will require you to measure the entropy reduction due to evolution. It will require you to measure the entropy increase in the universe due to the Earth and so on and so forth. All of those are obviously very, very difficult quantities to measure, but you can make some educated guesses. And you can come up with, you know, an order of magnitude back-of-the-envelope calculation. So, that is the kind of calculation that physicists have done, and these calculations suggest, and I am quoting from the paper.

The decrease in entropy required for evolution is so small that it is negligible compared to the entropy throughput that would occur. Even if the Earth were a dead planet or if life on Earth were not evolving, The reduction in entropy would be so small that no measurement would ever detect it. So, that basically suggests that if you look at the throughput of entropy, How much reduction is happening on planet Earth? And how much is increasing in the universe because of all the heat, etc., that we are emanating? We, as in the planet Earth, are emanating into the universe. The amount that we give out, which basically means the amount by which Earth increases the entropy of the universe, is Way orders of magnitude greater than the amount by which entropy reduces due to the evolutionary process.

So, to put it simply, the second law of thermodynamics has no problems whatsoever with evolution. That brings us to our fifth objection. This is the one that most people end up seeing most of the time in newspapers. Or you know, for that matter, certain YouTube shorts, which is that. No one has ever observed evolution, macroevolution, or speciation; therefore, evolution cannot be correct.

I mean that I have not observed my great-great-grandfather, but saying that my great-great-grandfather did not exist. Simply because I have not observed my great-great-grandfather is probably not a great argument. However, let us look at this head-on; let us see what exactly this is trying to say. So, the counter to this actually depends on how you think about evolution. Whether you are thinking about evolution in terms of microevolution, The kind of evolution that is, you know, defined as a change in trait values. or you are thinking in terms of the generation of new species. Now, if you think in terms of microevolution, Then there are tons of examples of observing that kind of evolution in the scientific literature. We talked about the industrial melanism case ourselves. We ourselves have seen how the COVID virus has evolved, you know, going from one strain to another in front of our eyes. We have seen antibiotic resistance evolve in bacteria before our eyes over the last four or five decades. So, observing evolution in terms of changes in trait values, there are, you know, an enormous number of examples.

What about evolution in terms of the formation of new species? Now, it turns out that there are again an enormous number of examples available over there. So, we have already looked at the case of the primrose, *Primula kewensis*. We are going to look at a few more cases as this particular course progresses. However, for those of you who want to have a list right

away, I strongly recommend that you look at that particular link. It is a dated one; I think it was compiled in 2005 or something like that, 2005 or 2008, somewhere in that zone.

But even then, you are going to find a massive list over there of all the known cases of speciation on this planet. I mean in the scientific literature. So, to put it simply, evolution and speciation, whichever way you look at it, have been observed again and again and again in the literature. We really cannot say that anyone has ever observed those processes. So, that brings us to a very fascinating question, which is whether the evidence for evolution is so overwhelming, So why is it that a subset of the population—and when I say population, I mean the general population—still refuses to accept it? Now, here the phrase "general population" is key, because if you look at scientists, Scientists overwhelmingly accept that evolution has occurred on this planet.

There is no doubt about that. What scientists still quibble about is, for example, when we discussed extended evolutionary synthesis and all that, you know. What are the mechanisms by which it happened, and whether this mechanism is more important or that mechanism is more important? Nobody in the scientific world questions whether evolution has taken place. But if you look at people who are not trained as scientists, it is a small subset of that. Well, I should not say a small subset; different subsets of that actually still end up objecting to it.

Now, why that is so, answering that question actually goes beyond the domain of science. It goes into the domain of culture, sociology, politics, and so on and so forth. One of the things that we know is that there is a lot of variation across countries and religions. So, many people think that individuals do not believe in evolution because of their religious beliefs. Why is that? Because most religions have their own theories about how organisms came to be, that is where the tension lies.

Very interestingly, it is not as black and white as that. Why? Because if you look at the religions of the world, many religions, or at least many subsets among the main religions, They have actually explicitly put out statements saying that there is nothing in evolution that contradicts our teachings. So, for example, if you look at the Roman Catholic Church, it has explicitly said that there is nothing. There is nothing in our teaching that contradicts evolution. Interestingly, there are sects in Islam that have also simply announced, straight away announced that there is nothing in the teaching that contradicts evolution. If you look at the situation in India, in which, for obvious reasons, we are greatly interested, then it is very interesting.

A 2018 survey across 12 states suggested that 68.5 percent of the population accepts evolution. This was not a very big survey; you know the sample size was relatively small. But still, you know there are other surveys around the same time that give you roughly similar figures. And if you look at how you know why this amount, the number is so high, and if you look at how various religions in India.

Various philosophies in India have actually tackled the question of evolution. You find that, by and large, there has been an acceptance of evolution by the philosophers of India. So, for example, you know people who believe in the traditional Samkhya school of philosophy. In particular, they find a lot of concepts that are congruent with, you know, the modern evolutionary theory. Specifically, Swami Vivekananda and Swami Sri Aurobindo both incorporated evolution into their philosophies.

So, the second reference by Gosling, you know, traces that very nicely. And people have suggested that the concept of the Shavatara or the concept of reincarnation. All these suggest that changes are possible in the living world. And this concept of change in the living world is congruent with what Darwin was trying to say that You know organisms change, and therefore, fundamentally, there is no conflict. Now, of course, if you look at the nitty-gritty details, you know the way change is being conceptualized in philosophy. And the way change is being conceptualized in evolution is different, but the fundamental spirit still remains the same.

And that is why there probably has never been a major conflict with evolution in India the way, for example, it has happened in the US. So, now we are still, you know, left with that question that, by and large, if there are no conflicts, Then why is it that so many people refuse to believe in evolution? Now, at this point, I have to go into the realm of hypothesis, because, as I said, you know this is not something. That science can answer; this is something that sociologists need to answer, or, you know, cultural historians need to answer. So, my feeling is that what evolution does is that it unequivocally shows that humans are essentially animals, some kind of an ape and there is biologically speaking, there is nothing that makes us special in the context of the living world.

And that is why many humans who believe that, you know, we as humans are different cannot accept this. They cannot accept that you know we are just apes And that is the reason for which there is a very visceral reaction against the theory of evolution. How can you take away our exalted position? Now, this is actually one of the sets of objections about evolution, the moral objection against evolution that if humans are nothing but animals, if we are just you know modified apes, Then you know why we should behave nicely towards fellow human beings. Excuse me, why should we not behave like beasts? But personally speaking, I think that is completely beside the point. Humanity, as we call it, actually involves a set of nice properties and a set of nice qualities that human beings have evolved. Evolved in a social sense, not in a biological sense, that human beings have incorporated into the context of their civilization.

We believe that being tolerant towards other people, helping other people, and being kind to them is what makes us human. And what makes us human does not necessarily have to be a part of our biology; it can also be a part of our culture, right? And for that matter, if you look at it, things like kindness are by no means solely human properties. There are all kinds of

other organisms that are kind to each other, you know. They are kind, you know, helping their fellow organisms out and so on. Therefore, saying that if you are not special, then you are bad, if you are a beast then you have all the negative qualities of beast that does not really make sense.

So, my personal viewpoint on this is that just because evolution or evolutionary biology tells us that We are very close relatives of the apes; that does not really take away any of our achievements, both moral and otherwise. as well as the socio-cultural achievements that we have gathered as a species over the last thousand years. If anything, it makes those achievements even greater, even more meaningful, because it says that even though we are beasts, Look how nicely we have done; look how we have been able to rise above our mere biology and become organisms. which you know have made a very disproportionate impact on the earth. Now, of course, some can argue that our effect on the earth is really bad, We are really, you know, causing global warming and all that stuff.

But it is undeniable that within a span of about a million years or maybe a million years. Or maybe less human beings have had a massive effect on the earth to an extent that No other group of organisms, to the best of our knowledge, ever has. And that tells us that human beings have a massive capacity for progress. And this is what makes me happy as a human being, even though evolution tells us that we are no different. So, biologically we might not be different, but our culture and our morality are what have made us different.

And there is nothing in evolutionary biology that contradicts these properties we have as a species. So, anyway, with that backdrop, we will now start looking at how the process of evolution works mechanistically. And that is what we are going to start when we meet next week. Thank you.