

We biologists, and I'm sure all of you, are astounded by the amount of biodiversity that exists on this planet. And we want to understand how it happened and how organisms are related to each other. This can be done for some organisms through the fossil record, but most organisms don't leave fossils. And so, another way has emerged which is to sequence the genomes of organisms and then compare them to one another, and those that have more similar genomes get grouped into some closer groups than those that have more dissimilar genomes. The result of that is the kind of diagram we have here, where all of the organisms on the planet today group into three major radiations called the bacteria, the archaea and the eukaryotes. Looking at these genomes and how these organisms are set up, we discover that they're all very similar to one another in important ways. They all have DNA as a genetic material. They all have the same kinds of ribosomes and protein synthesis and membranes and so on. You can take a gene from a bacterium and put it in a human and it works just fine and vice versa. So the inescapable conclusion from all of this data is that there was, back in the day, a single kind of common ancestor to all of modern life. This is not to say that ancestor was the first cell. There were doubtless many preceding cells that were less complex. But once this quite complex universal common ancestor came into being, that template was used by all life. So, let's look over here at the bacteria. The bacteria seem simple, but, in fact, they do very important things. Many of them take nitrogen out of the air and fix it into molecules that are then used by organisms to make their amino acids and their nucleotides that contain nitrogen. They... a number of them do photosynthesis, as we've already seen, and a number of them, all of them are involved in taking up detritus from previous organisms and metabolizing it and then becoming food sources for all the rest of the food chain. So if there were no bacteria on the planet, life would grind to a halt in a few months. Our group is called the eukaryotes, and by the same kind of reasoning with genome sequencing, it's very clear that there was a most recent common ancestor to all of the eukaryotes. This ancestor had tamed a bacterium and had it become part of itself. This bacterium is now called a mitochondrion and it does respiration for all eukaryotic organisms. The eukaryotes also have similar kinds of nucleus and similar kinds of sex. So, the idea is very firmly established of a most recent common ancestor to eukaryotes. So what happened next? Let's first look at the ones that do photosynthesis. All of them derived from a eukaryote that took up a second bacterium, this time a cyanobacterium, tamed it to become its chloroplast that does photosynthesis. So, all of the green organisms that you're familiar with derive from that event. Some of these organisms that are in this pathway are called the red algae because of their pigments. And about 300 million years ago, some other eukaryote snarfed up a whole red alga and tamed it to become a different kind of alga that now is in all of these radiations over here. Included in these groups are organisms like the diatoms and the dinoflagellates that are major oxygen evolvers in the ocean and the basis for much of the marine food chain for fish all the way up to whales. In this group also are organisms like plasmodium, the organism that gives rise to malaria, that once was an alga back in the day, has lost its chloroplast and is now white but makes a living as a parasite. Now, most of these organisms that we've thought about are single-celled. They are organisms just as one cell. But a number of times during evolution, the idea of becoming multicellular arose. It happened with the fungi, think of the mushrooms. It happened, of course, with the plants, think of trees. And it happened with all of the animals. And the difference between a multicellular and a unicellular organism is that the multicellular organism takes the job of being alive and partitions it out to different kinds of cells, all of which are responsible for the organism as a whole. So, in our bodies, we have livers that are doing one things and muscles that are doing another and brains that are doing something else. All of those functions that a multicellular organism does are, in fact, in some simple form, carried out by single-celled organisms. So, it's fun to think of a single-celled organism as a one-man band and a multicellular organism as more like an orchestra, with different instruments taking care of different functions. If we step back from this, we see that all of these organisms that evolved from common ancestry are now on the planet today in complex ecosystems sharing the planet with one another, giving each other food and sustenance and oxygen and so on. And these ecosystems, while they can evolve, while the organisms inside that inhabit the ecosystems have evolved and will continue to evolve, evolution is a very, very slow process. And one of the things that is of concern to me and many others is that the presence of the human has very much altered many of these ecosystems in many ways. And we are concerned that the consequences down the road will be catastrophic.