Molecular and Genetic Evidence

How could a chicken be related to dinosaur ancestors? Evolution is the process of biological change by which descendants come to differ from their ancestors. Multiple lines of evidence support the idea that evolution has occurred. This evidence comes from fields such as molecular biology, developmental biology, and paleontology, just to name a few. All of this evidence helps to strengthen our understanding of evolution.

Hands-On Activity

Piecing Together Evidence

In this activity, you will receive pieces of "evidence" about a picture in order to make observations, inferences, and predictions about it.

MATERIALS

- picture cut into strips

PROCEDURE

1. Using the three strips that your teacher has provided, write down all observations and inferences that you can make about this picture.
2. Record observations, inferences, and a prediction for each remaining strip of "evidence" that you receive from your teacher.

ANALYZE

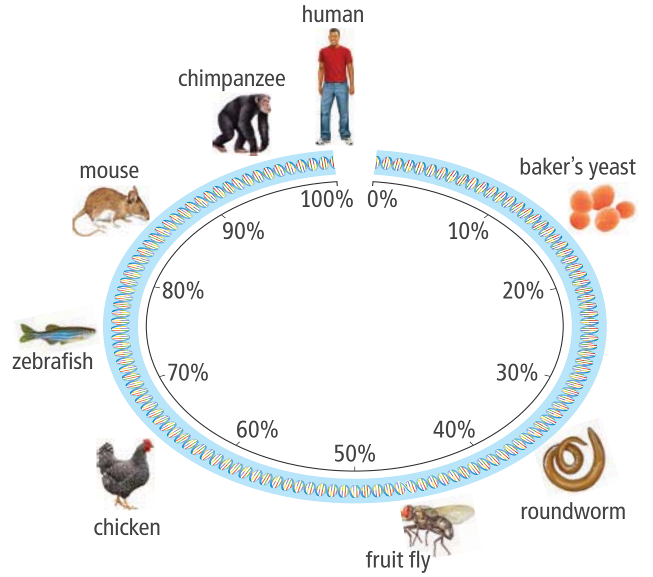
1. What type of evidence might evolutionary biologists find that would let them see the big picture of a species' evolutionary past?

Molecular Similarities

All living things on Earth share DNA as their genetic code. We all have the same four basic nucleotides that make up our genome. Through DNA sequencing technology, scientists can compare the genetic codes of different species. In general, the more related two species are, the more similar their DNA will be. The differences in the nucleotide sequences in the genomes of various species are smaller than you might think. For example, your genome is about 88 percent identical to that of a mouse. That may not be too surprising considering mice are mammals, too. However, this might come as a bit of a surprise: Did you know that your DNA is about 47 percent identical to that of a fruit fly?

Analyze How do patterns in DNA support the claim that living things share a common ancestor?

FIGURE 2: Many of our genes are shared by other organisms.



Explore Online

Hands-On Activity

Predicting Evolutionary Relationships Analyze similarities in a protein common to bacteria and eukaryotes. Then use the results of your analysis to draw conclusions about similarities among species.

Sequences of DNA nucleotides known as pseudogenes also provide evidence of evolution. Pseudogenes are genes that no longer function but are still carried along with functional DNA. They can also change as they are passed on through generations, so they provide another way to determine evolutionary relationships.

Similarities among cell types across organisms can also be revealed by comparing their proteins. A unique set of proteins is found in specific types of cells, such as liver or muscle cells. Computers are used to search databases of protein sequences and look for homologous, or similar, sequences in different species. Cells from different species that have the same proteins most likely come from a common ancestor. For example, the proteins of light-sensitive cells in the brain-like structure of an ancient marine worm closely resemble those of cells found in the vertebrate eye. Vertebrates are animals with a backbone. Invertebrates, like arthropods and worms, have no backbone. This resemblance in proteins shows a shared ancestry between worms and vertebrates. It also shows that the cells of the vertebrate eye originally came from cells in the brain.

Engineering

FIGURE 3: Scientists often study model organisms such as the zebrafish to learn more about human disease.

Using Model Organisms to Study Human Diseases

Because we share common ancestry with other species, many human genes also exist in other organisms such as zebrafish, fruit flies, and mice. This fact, along with their rapid life cycles, makes these organisms ideal models for the study of shared genes. Zebrafish have 70 percent of the same genes as humans, and they have bodies that are almost as transparent as embryos. This feature allows for a better view of what is happening inside of their bodies. Zebrafish can also regenerate their spinal cords after injury, which makes them a promising model organism for studies on spinal cord injuries.

Zebrafish have been used as a model organism for research on many human diseases, including muscle, kidney, heart, and nervous system disorders. Scientists use genetic manipulation techniques to induce mutations in the fish. By experimenting with mutant, or variant, forms of genes in this model organism, scientists can make predictions about how similar genes will function in humans. For example, a strain of mutant zebrafish called *breakdance* has been used for studies on arrhythmia, or abnormal heart rhythm, in humans.

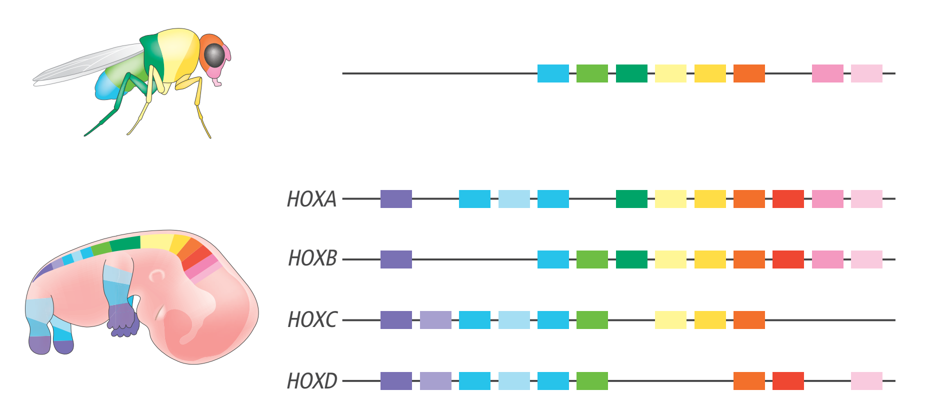
In addition to sharing much of our genetic material, zebrafish also have eyes that are similar to the human eye in many ways. Several zebrafish mutants have been identified that display eye defects and visual impairment. These mutants have helped scientists better understand how different genes are involved in eye disorders. For example, two mutant strains called *grumpy* and *sleepy* have been vital in the study of certain disorders that affect the optic nerve.

Analyze Make a list of criteria and constraints a researcher would need to consider when choosing a model organism for a human disease study. Include factors related to the organism's development and life cycle, the genetic basis of the disease being studied, and any ethical considerations.

Homeobox Genes and Body Plan Expression

As an animal develops, its genes guide the formation of organs and the arrangement of body parts. If we have much of our DNA in common with other organisms, such as mice or birds, why then does a bird's body plan look so different from our own? From a very early stage, certain types of homeobox genes, called *Hox* genes, help to guide the process that results in the development of an organism's characteristic body plan. The process begins by instructing embryonic cells where in the body they will be located—head, midsection, or tail. From there the genes define the location and number of eyes and limbs, the location of the gut, the development of a wing instead of a leg, and so forth. If a mutation arises in these genes, drastic changes can occur in the body plan of the animal. Scientists think that random mutations in these genes over time account for the incredible diversity of body types seen today.

FIGURE 4: Differences in fruit fly and human body plans arise from variations in *Hox* genes.



Analyze When do duplication mutations usually occur? In which type of cells would these mutations have to occur to be passed down from parents to offspring?

Collaborate Analyze the model of *Hox* genes in fruit flies and humans. Write your answers to the questions below, and then discuss your answers with a partner.

1. What patterns do you see in the similarities and differences between *Hox* genes in humans and in fruit flies?
2. How do your observations support the claim that humans and fruit flies share a common ancestor?

Vertebrates have multiple sets of the same *Hox* genes that insects and other arthropods have. For example, the *Hox* genes that direct the organization of the vertebrate body plan are actually just different versions of the *Hox* gene that directs the body plan in fruit flies and other insects. The difference suggests that over time, mutations have caused the original *Hox* gene to be copied repeatedly, forming a series of similar genes along a chromosome. Mutations in these genes are typically duplications, and with each duplication, the developing organism may show slightly different traits.

Explain *Archaeopteryx* is seen by some experts as a link between reptiles and birds. What types of cellular or molecular evidence might a scientist study in order to determine the evolutionary relationship between the chicken and modern reptiles?