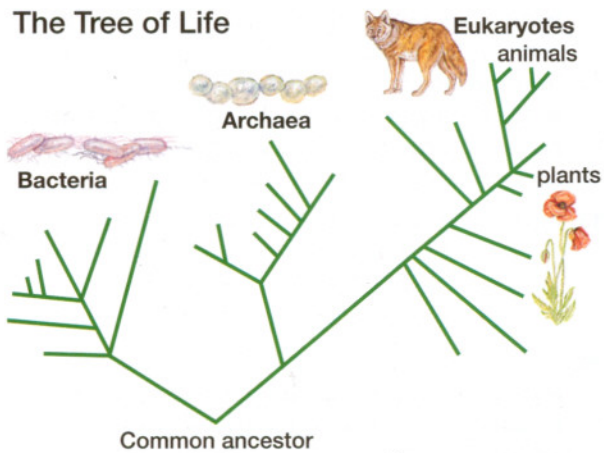
Searching for the Common Ancestor

Background

Until recently, most evidence from the fossil record and DNA analysis pointed to a common ancestor for all life on Earth. The prevalent thought among scientists was that this common ancestor gave rise to three branches of life: bacteria, archaea, and eukaryotes (which are shown in the diagram below). The length of the branches reflects the degree to which the DNA of each lineage has diverged from the common ancestor; the longer the line, the earlier this divergence. Today, new ideas are emerging about whether there was one common ancestor or several. There is no consensus on this question, but there is no doubt that the history of life on Earth has been dominated by microbial life. Multicellular eukaryotes such as animals and plants actually occupy only a few "twigs" at the end of the eukaryote branch. Most of the diversity of life is microbial, and new species continue to be discovered.



The ideas of mutation, adaptation, and natural selection fit well with the ways in which plants and animals recombine and transmit their genes through reproduction. The primary difficulty with applying the same mechanisms of evolution that apply to multicellular eukaryotes to bacteria and archaea is that these organisms replicate in very different ways. Bacteria, for example, can carry genes on plasmids, which are pieces of DNA that are separate from their main chromosomes. They can transfer these plasmids to other bacteria, even those from different species. Also, when bacteria die, their DNA leaves the ruptured cell walls and can be picked up by other bacteria.

All of this "gene swapping" and mixing has made scientists rethink the idea of a common ancestor. As life emerged, perhaps mutations happened at an astounding rate because the mechanism for copying and proofreading DNA was still in its infancy. (Today, proofreading enzymes limit mutations, but three billion years ago these proofreaders were either not present or were very unsophisticated.) Genes may have moved freely between microbes and very possibly, there was not one common ancestor but a fluid matrix of genes moving from organism to organism. So, in the early history of life, genes were not just mutating — they were also mixing and multiplying. Eventually, these "wandering genes" became more complicated and specialized, and DNA was replicated more accurately. From this mix of life, the three main branches of life eventually emerged. In this revised idea of early evolution, even after the branches diverged there were still examples of mixing and fusion between the branches. For example, we now know that cell mitochondria and chloroplasts share their DNA with certain bacteria. They are essentially symbiotic bacteria, living inside a host organism's cells. This example of evolution by fusion (or symbiotic evolution) shows how evolution can happen in other ways than through mutation, adaptation, and natural selection. (Change can happen through fusion rather than by the gradual accumulation of mutations to DNA). Ancestral mitochondria, for example, merged over time with early eukaryotes, and two species fused into one, thereby creating a new genome. From this point, natural selection continued to shape their evolution. This relationship provides an important evolutionary link between prokaryotes and eukaryotes.

Challenge

Research, design, prepare, and present a report on the new ideas and research pertaining to the common ancestry of living organisms. Choose one of the following ideas to focus your project:

ASSESSMENT

After you complete this project,

- **Assess your research skills during the development of your presentation. Did your skills improve?**
- **Assess your understanding of how new technological advances (such as the ability to analyze DNA sequences) affect ideas about evolution.**

- Early life was a fluid matrix of genes moving between organisms rather than a linear, steady change of one common ancestor over time.
- DNA changed over time and eventually became more complicated and specialized, until it was copied much more accurately. Ultimately, this resulted in the three branches of life emerging from the "soup" of mixing microbes.
- Symbiotic evolution, such as that of cell mitochondria and chloroplasts, is another way of creating new genomes.

Describe how the ideas have changed over the past few decades as our understanding of microbiology and technologies have advanced. Prepare a report based on your research. Then prepare a presentation, in one of the following forms:

- an oral, video, or computer presentation;
- a poster display that presents the ideas graphically; or
- a chronological time line that leads to current hypotheses.

Materials

Gather the necessary aids for researching and preparing your report and for your presentation (for example, visual display materials, overhead projector, computer, and so on).

Design Criteria

A. Working individually or in a small group, choose one idea listed in the Challenge. Explain how ideas have changed in recent decades and include information on the scientists who are developing these ideas.

B. Include scientific ideas that support and refute the idea(s) you present in your project.

C. Include your own research as well as information you have learned in this unit (and in relevant earlier chapters in the textbook).

D. Include a revised "Tree of Life" based on your research. (Note: You do not need to show exact relationships — just the general "look" of a revised tree.)

E. Include a brief description of new technologies that have helped to support the new ideas you present in your project.

F. Include a statement on the value of presenting new and sometimes controversial ideas in scientific discussions.

Action Plan

1. Choose a format for your report and a method for presenting your report.
2. Develop a plan to find, collect, and organize the information you will need. This could include defining the key words you will use for research in the library or on the Internet.
3. Review necessary background material from Biology 11 (for example, review the biology of bacteria, archaea, and viruses) and Biology 12.
4. With your teacher, decide on the method you will use for assessment. You could create an assessment rubric, for example.
5. Obtain your teacher's approval for your outline and your action plan. Make modifications as necessary.
6. Prepare your written report.
7. Present your report to the class.

Evaluate

1. Using the rubric you have prepared (or other assessment tool), evaluate your own work and presentation. How effective do you think they were?
2. Evaluate the presentations of other members of your class. Did they introduce ideas that you did not? If so, list these ideas.
3. How did working on this project help you think about what you have learned in this unit?
4. Scientific ideas are sometimes interpreted as being absolute fact, but in reality they often change as new ideas emerge. Describe some of the ways scientists presenting new ideas use to try to support their work.
5. Give an example of how new technologies and scientific techniques change our understanding of processes such as evolution.