plenty of clues. Scientists from many different fields try to piece these clues together to come up with possible explanations. Darwin, himself, looked at many different lines of evidence as he constructed his theory. He considered biogeography (how organisms were distributed over the Earth's surface). He also looked at comparative anatomy (how species resembled each other) and embryology (how organisms develop). Darwin also examined fossils—the mineralized remains of once-living organisms.

Using the clues from each of these areas, Darwin formulated his theory.

Introduction to Darwin's Theory

To understand this book and the issues involved in the discussion, you'll need to know a few key concepts. We'll introduce them here, and examine them in more detail later on. In the *Origin of Species*, Charles Darwin formulated a theory with two main claims.

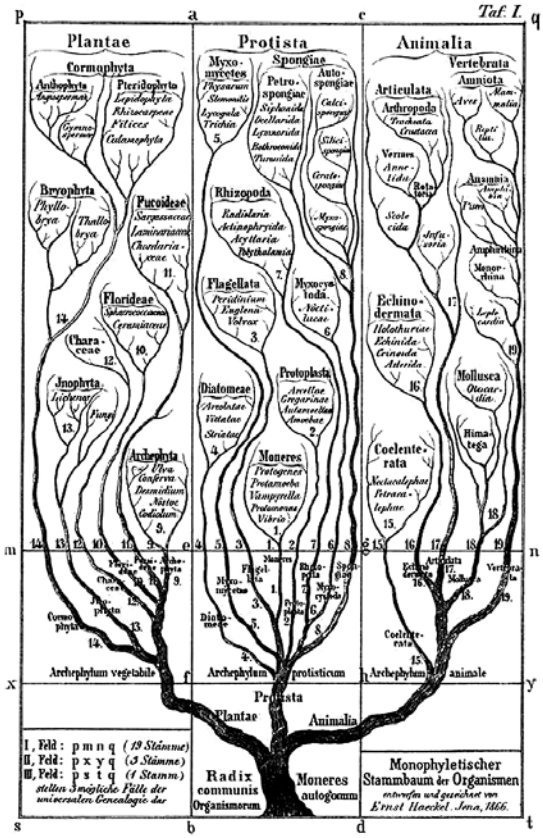


Figure i:3 The tree of life representing life's history, drawn by Ernst Haeckel. *Public Domain.*

The first claim became known as the Theory of Universal Common Descent.[3] This is the idea that every creature on Earth is ultimately descended from a single common ancestor somewhere in the distant past. This theory paints a picture of the history of life on earth—a picture of a great branching tree. Darwin envisioned this "Tree of Life" beginning as a simple one-celled organism that gradually developed and changed over many generations into new and more complex living forms. The first one-celled organism represented the root or trunk of the Tree of Life; the new forms that developed from it were the branches.

The theory's second main claim has to do with the biological process he thought was responsible for this branching pattern. Specifically, Darwin proposed a mechanism that he thought could cause existing living organisms to change, and cause new living forms to arise. Darwin called this mechanism *Natural Selection*, and argued that it had the power to produce fundamentally new forms of life. How could it do that?

Charles Darwin observed that individuals within groups are not exactly the same. Cows from the same herd are not exactly alike. Even puppies in the same litter are not exactly alike. In other words, Darwin observed that organisms *vary* in their traits. Occasionally, these variations between individuals play a huge role in determining which members of the group survive, and which do not.

For example, suppose that sea levels rise dramatically. During high tides, salt water flows into a nearby marsh that previously contained

* Sometimes called "differential survivability and differential reproduction," which is what you should call it when you're trying to impress your parents with how much you're learning.

More Likely To Survive = More Likely To Reproduce

- Variations arise at random.
- Nature "selects" the adaptive (or successful) ones.
- Organisms with the adaptive trait survive and reproduce.
- The offspring are likely to inherit these successful adaptations.
- Inherited adaptations eventually cause populations to change.

only fresh water. Salt is deadly to most plant life, but some plants can tolerate levels of salinity (saltiness) that would kill other organisms. In the new salty environment, the salt-tolerant individuals will probably leave more offspring in the next generation than the non-salt-tolerant (i.e., dead) plants will. The offspring of these salt-tolerant plants are likely to inherit the salt-tolerance trait, which they will likely pass on to their offspring.

Over time, Darwin argued, this process (more likely to survive = more likely to reproduce*) can cause permanent changes in species, and can eventually cause new living forms to arise.

Together, the ideas of Universal Common Descent and natural selection form the core of Darwinian evolutionary theory. They were first spelled out in detail in the *Origin*, and can be found in any biology textbook.

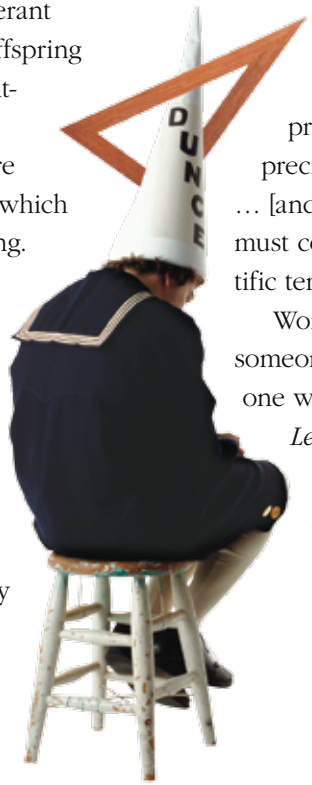
But Darwin's theory itself has evolved a bit since 1859. Darwin (and other biologists of the 19th century) did not understand *how* genetic traits were passed from one generation to the next. In the early decades of the 20th century, biologists learned about the mechanisms of *heredity* (i.e., how traits descend from parents to offspring), and about *mutations* (randomly-arising changes to genetic material, a special kind of variation). The modern evolutionary theory called neo-Darwinism reaffirms the ideas of Universal Common Descent and the creative power of natural selection, and it incorporates this newer knowledge about heredity and mutation that Darwin lacked. Neo-Darwinism is the version of the theory we will examine in this book.

Defining Some Terms

Before we go any further, we have to get a few definitions out on the table. As we look more closely at Darwin's theory, we're going to see that some important terms mean different things to different people. This can be a problem. As the 1990 California Science Framework states, "The process of teaching science requires a precise, unambiguous use of language … [and] …Scientists, teachers, and students must communicate the definitions of scientific terms and use them with consistency."[4]

Words must be defined clearly. When someone uses the same word in more than one way, it's called "equivocation."

Let's look at a humorous example of how equivocation can lead to a faulty conclusion:



To be "obtuse" means to be stupid. Some triangles are obtuse. Therefore, some triangles are stupid.