



ScienceWatch – Darwin’s Big Idea

“I have called this principle, by which each slight variation, if useful, is preserved, by the term of Natural Selection.” - C. Darwin, 1859

My 100th article written under the *ScienceWatch* banner discusses evolution by natural selection—Darwin’s big idea.

The idea seems simple enough. Over time species will evolve. Some will die out while new ones will arise. The changes are due to an ongoing process whereby traits favoring survival are preserved and unfavorable ones are weeded out. Darwin called the process *Natural Selection*, coining the term in his earth-shattering book, *The Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*, published in 1859.

Darwin’s theory of evolution by natural selection became famous among scientists because it explained the overwhelming diversity of the living world in a simple, elegant way. It remains central to everything we know about biology today. Without it biology is merely a collection of disconnected facts, a set of descriptions.

It also became infamous overnight because it flew in the face of established religious beliefs on how living beings were created. Unfortunately, many still refuse to accept it. Barely 40% of Americans in a recent poll think evolution by natural selection is correct. By contrast, upwards of 70%-80% of western Europeans agree with the theory. One argument espoused by deniers is that “it’s just a theory”. However, in science a theory is not a hunch, but an explanation backed by abundant observation and where gaps in knowledge are not seen as grounds for doubt, but points for future understanding.

Darwin’s theory is even more universal than Newton’s theory of gravity. When we throw up a ball it always comes down. However, gravity does not work at subatomic levels. When we look at life we see evolution; all the diversity of life is descended from a common ancestor, through a process of mutation and natural selection over 3.8 billion years. But unlike gravity, there are no exceptions to natural selection, even at the molecular level.

When Darwin published his big idea genetics was completely unknown. But nothing we have learned since then contradicts him. Natural selection explains everything we are learning about life today. For example, food crops genetically engineered to produce toxins that kill insect pests can result in insects resistant to the toxin. This is because natural selection will favor those few individuals that are resistant and they will increase, eventually making the genetically-engineered plant useless. To combat this, farmers plant some non-engineered, non-toxic plants alongside the modified ones, so that the sensitive trait remains in the insect population. Similarly, natural selection explains results from all other branches of modern biology.

Darwin had no idea what natural selection was acting on. Now molecular biology tells us that traits are controlled by genes, stretches of DNA. Mutations are changes in DNA and they are the raw material for evolution by natural selection. Mutations occur by chance, but natural selection acts in a relentless, directed fashion, constantly favoring traits (genes) that work and eliminating those that don't.

A new branch of biology, known as *Evo-Devo*, short for Evolutionary Developmental Biology, shows us that Darwin is at the cutting edge of biology even today. Using the tools of molecular biology *Evo-Devo* answers the important question of how an egg gives rise to a complete organism. It combines the approaches of two groups of scientists—evolutionary biologists, who study how organisms have evolved to form new species, and developmental biologists, who investigate the way genes control the development of organisms. Their findings show that vastly different organisms share the same genetic blueprint.

For example, in the 1980's scientists isolated the genes (only 8) that control the development of the lowly fruit fly from egg to adult. These genes work by making proteins that bind to DNA and turn on other genes. The same “master genes” control development in other organisms including us. They lay out the basic body plan by setting up the head-tail, back-front, and left-right organization, directing where structures will go as an embryo develops. This means that the development of complex body parts like limbs, eyes and hearts, long thought to have evolved in different ways in different organisms, is controlled by the same genes. *Evo-Devo* supports Darwin's assertion—the tree of life he drew in *The Origin of Species*—that all life is connected.

Darwin's finches continue to help fine tune his theory. Darwin assumed that the accumulation of changes needed to form a new species would take many—perhaps millions—of years. However in 1972 a new theory called *Punctuated Equilibrium* said changes could occur much more rapidly. Now we know speciation can happen in just a few generations. Darwin found 13 species of finches when he visited the Galápagos, but recently the formation of a new hybrid species was observed. In just four generations the hybrids began breeding exclusively among themselves—the hallmark of a new species— and they have been doing so for the past eight years (see *-Darwin's Finches: Thirteen Species and Counting*, ScienceWatch, March 2010 or at www.HRAS.org).

Darwin would be pleased to know that his 19th century big idea is explaining 21st century facts. As the famous geneticist Theodosius Dobzhansky said, “Nothing in biology makes sense, except in the light of evolution”. That will be true into the 22nd century and beyond.

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