Darwin and Natural Selection: Crash Course History of Science #22

Crash Course: History of Science
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If you only remember one name in the entire history of modern biology, it should be… two names.

Because the first biologists were a pair of freaky intellectual twins, just like Newton and Leibniz. But with more barnacles and monkeys.

Let's meet Charles Darwin and Alfred Russel Wallace. [INTRO MUSIC PLAYS] In the early 1800s, England was already moving away from the traditional way of thinking about life, which was then called "natural theology." In this belief system, the living world was created by a kindly but hands-off God. And there were four aspects of Creation: One, there was a divine Creator. But simply believing in God didn't prevent you from asking how life works.

Two, there were species that didn't change, ever. This idea was known as the fixity of species. But keep in mind, the French had already worked out that species do change over time and go extinct.

They just hadn't figured out how. The third aspect of natural theology was a short creation, in which the world was only about six thousand years old. But geologists had pushed the age of the earth back to millions of years.

And the fourth idea was the one that was still contentious in 1800—a perfect design for each species. The idea went: if God made, say, a turtle, he knew what he was doing. Even if that turtle was stupid or ugly, it was still a designed-by-God original, and there wasn't too much sense trying to understand the mechanism, the how, of that design process. (

Note: we here at Crash Course love turtles! There are no stupid ugly turtles!) Today, natural theology is associated with philosopher William Paley, perhaps because he wrote a book in 1802 called... Natural Theology. This book influenced a young scholar named Charles Darwin. But wanted to understand the "how." Young Chuck originally wanted to become a physician, but he hated the sight of blood. So he went to Cambridge to study beetles but skipped a lot of lectures. He earned Gentleman's Cs and graduated at twenty two with no direction in life, just a huge collection of beetles. Which, to be honest, is more than I had. So Chuck's family did what any rich family with a beetle-obsessed son would do: they sent him to South America on a ship with a cute name: The HMS Beagle.

Chuck was seasick the entire five years. But the voyage was more than worth the lost lunches: it turned Darwin from a mere collector into an extraordinary theorist. For one, the voyage gave Darwin time to read the geological theories of Charles Lyell and think about gradual change over long ages. Wouldn't it be nice to like get on a boat with a couple of books and just think for 5 years, and puke a lot? Near Concepción, Chile, Darwin saw a volcano and felt an earthquake: he got to live through Lyell's theory of how geological changes happen! The voyage also gave him lots of opportunity to collect and compare fossils. For instance, Darwin found fossils of a species that looked like a giant sloth, one like a giant capybara, and one like a giant armadillo.

And Darwin thought, what if these giant creatures did not just coincidentally look like modern animals, like sloths, rodents, and armored mammals, but were actually ancestors of them? But the main thing the voyage did was give Chuck access to hundreds of specimens from similar-looking species that lived close to each other, but in slightly different environments. The most famous examples, of course, come from the Galapagos Islands off the coast of Ecuador, home to land and marine iguanas, diverse mockingbirds and thrushes, tortoises by the dozen, and—say it with me—finches! Like beetles before and barnacles later, finches became an absolute obsession for Chuck. He had to catch them all. Lucky for him, the people who lived near the Galapagos even explained to him that the different species seemed to vary according to island. This turned out to be one in a number of clues that would lead Chuck to developing the theory of evolution by natural selection.

When he got back to London, Darwin wrote up his meticulous field notes. He published the Zoology of the Voyage of HMS Beagle in volumes from 1838 to 1843. This alone made Darwin a serious naturalist. His generous sharing of specimens made him not only a member of the London scientific world, but a leader in it. He sent specimens to naturalists including John Gould, who helped Darwin confirm that his finches were actually different species, and not just varieties of one species. Major clue! And then Darwin read the Essay on the Principle of Population by a cranky reverend named Thomas Robert Malthus.

Malthus argued that population increases geometrically, but food only increases arithmetically: the logical result must be famine. This was the final clue—a relationship between the environment and the reproduction of populations. Darwin reasoned that living beings compete over resources, and only the most fit for a given region survive. It's as if nature selects them. Hence his choice of the term "natural selection," for the primary mechanism of evolution. Compare this to natural theology: there's no Creator involved. Species aren't fixed. The process takes aeons. And design—what design? Useful traits emerge over time.

At the same time that he was solving the biggest problem facing the study of "what is life?", Darwin was also busy performing Victorian gentleman-ness: he married his cousin, Emma Wedgwood, in 1839. He had babies and moved to a manor in Kent. He got REALLY into billiards. But, what Darwin was not doing? Publishing a complete theory of evolution. What was Darwin's next move? Pigeon fancying. He bred pigeons in order to understand artificial selection, or how humans design organisms. Because breeding pigeons is a lot faster than watching finches change over millennia. And then? Eight years studying barnacles. He worked on his theory, writing to his friends for advice about it. But he didn't publish it.

Darwin wanted to wait until he had incontrovertible proof. Then in 1858, Darwin received a letter from one Alfred Russel Wallace. Wallace had also discovered natural selection. He sincerely wrote to Darwin for advice: would he be interested in, uh, an evidence-based theory explaining how organisms evolve? Darwin's mentor, Lyell, told him that he had no choice now. So Darwin and Wallace published a joint letter in the Journal of the Proceedings of the Linnean Society of London. And then Darwin wrote a compelling, five hundred-page book detailing his theory. In one year.

In 1859, On the Origin of Species by Means of Natural Selection, or just "the Origin," debuted as a modest edition of twelve hundred copies but soon became a smash hit. It was a scientific bestseller, intended for a wide audience. No footnotes! The book explained how "descent with modification" or "transformism" actually works. In any population of the same species, you can see a natural variation in traits: some finches have longer beaks; some have shorter beaks. Over time, small changes in the environment add up, favoring some traits over others. Natural selection modifies the population: the fittest survive and reproduce, passing on their traits. Say, the long beaks get to more food and survive when food becomes scarce. Unfit species die out. Populations diverge into new species!

Darwin's writing, influenced by Malthus, shifted away from a harmony of nature and toward a competition for resources—a war. But Darwin's theory wasn't perfect. In fact, he included a chapter on the "difficulties" facing natural selection. These included a lack

of transitional forms in the fossil record: how do we get from fish to amphibians? Even more basically, where do variations come from? How are they passed on from one generation to the next? We have answers to these questions today—stayed tuned!—but Darwin didn't, and he admitted as much. This was… refreshing. He didn't claim to be a genius. He didn't bash earlier theories. The Origin didn't even mention God, much less where humans come from. Instead, Darwin focused on what he knew: variation in beetles, finches, pigeons, barnacles, and fossil animals. His theory, backed by so much evidence, accounted for how new species evolve. Even more importantly, Darwin united many branches of natural history into a single synthetic theory and proposed a bunch of clear and important questions for future research. In fact, Origin marks a kind of evolution of natural history, which was focused on observation and description, into biology, which is more focused on testing theories about living things. Darwin's skill as a writer is one reason his name eclipsed Wallace's. Another is that my dude was rich! Like, born rich, invested well, married rich… He was doing all right. And Wallace? Introduce him, Thought Bubble.

Al was born to a family with money problems. He quit school at sixteen to work surveying canals with his brother. And at twenty, he quit surveying to teach. Wallace read Malthus. He also read Darwin's details of his American voyage and became a lifelong fan. Wallace met Henry Walter Bates in 1844. They became science besties and decided to figure out how evolution works in order to apply that knowledge to human society and save people from greed and individualism. Wallace and Bates went to the Amazon from 1848 to 1852 to collect specimens for museums in London. And he was super successful… until he set off back to England. His boat, brimming with specimens, caught fire and sank. Wallace watched from his lifeboat as all of his hard work—his carefully trapped and cataloged monkeys and his parrots—sank into the dark waves. He was not rescued for ten days. But, like Galileo after his trial by the Inquisition, Wallace never gave up. In debt, Wallace decided to continue collecting more specimens to pay the bills, this time in Southeast Asia in 1854. He sent specimens back regularly, developing a brilliant reputation. And Wallace was doing a more than collecting: traveling from island to island across what is now Indonesia, Malaysia, and Singapore, he observed that different environments seem to produce different populations of organisms… perhaps even new species. While sick in bed in 1858, Wallace suddenly recalled the essay on populations by Malthus, and an entire theory clicked into place. In his words: A "self-acting process" meant that, for any species, "the fittest would survive." The colleague he thought would most appreciate this wild new theory? A slightly older naturalist in London… Thanks Thought Bubble.

After the joint paper with Darwin, Wallace continued working in Southeast Asia until 1862. He published his major work, The Malay Archipelago, in 1869. Wallace observed that there is a sort of invisible line—"Wallace's line"—in Indonesia: to the west, species resemble those in Asia. To the east, they resemble those in Australia. In fact, Wallace invented the discipline of biogeography, or the study of plants, animals, and geological formations together. So, between them, Darwin and Wallace were reaching a lot of people with their ideas. And it's true that some people with conservative religious values were outraged at the public acceptance of a Creation that had no elegant design, just random variation. But the reaction to natural selection was mostly acceptance. Darwin's writing, and the depth of his and Wallace's evidence, settled the matter for many readers.

In fact, in some ways, Darwinism was accepted too easily. Darwinism quickly became equated with the term "survival of the fittest," which was coined in 1864 by biologist Herbert Spencer and appeared in the fifth edition of Origin. This term isn't a bad summary of natural selection, in terms of animals and plants. But it was increasingly applied to human society, as "social Darwinism," in a way that Darwin and Wallace would not have approved of.

An Industrial Revolution has just brought radical change to England. A new class of capitalists saw themselves as more "fit" to govern the world than the nobles they replaced or the workers they controlled. Next time—Darwin's cousin, Frank Galton, will try to apply Chuck and Al's theory to society. Yes, it becomes strange, and even tragic. So be sure to come back.

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