Genetics and The Modern Synthesis: Crash Course History of Science #35

Crash Course: History of Science
https://youtube.com/watch?v=aax12eYKd4s
https://nerdfighteria.info/v/aax12eYKd4s

===== (00:00) to (02:00) =====

By the end of World War II and the beginning of the Cold War, physics had been revolutionized. Again. Much as Newton had done in 1666, Einstein did in 1905. But once again biology was late to the paradigm shifting party. Remember how Darwin and Mendel lived around the same time, but everyone forgot about Mendel until 1900? And even then biologists saw Darwinism and Mendelism as two competing grand theories about how life works? The Darwin and Wallace people thought that traits blended and they studied big populations of species in the wild and in fossils, while the Mendelians studied roses or flies in labs, and they saw that some traits aren't blended, but jump around according to Mendel's Laws. And meanwhile, the eugenicists studied variation in human populations for... creepy reasons. Well it's time to bring these threads together into a new paradigm for biology. One that accounts for change over time and species through exacting quantitative analysis on different real world populations.

[title sequence]

Medicine changed a lot after 1900 due to the discovery of different therapies, like antibiotics. Likewise, biology changed a lot as scientists combined different ideas from natural selection to statistics in new ways. The results is a framework called the Modern Synthesis, or Neo-Darwinism. And even today, biologists mostly work within it. Basically the modern synthesis uses Mendelian inheritance - Mendel's rules - to explain how Darwinian natural selection works in real time.

So Darwin and Wallace's big ideas about change over long epochs across vast continents provided a solid theory for different researchers to use when designing studies in quantitative and population genetics, and when trying to make sense of their results. What did the Modern Sysnthesis look like as it happened?

===== (02:00) to (04:00) =====

From 1928 to 1942, different people applied one theory across a bunch of forms of empirical science, gluing them together. Hence, synthesis. They also published influential books that knit together Darwinism with Mendelism, such as English ecological geneticist E.B. Ford's 1931 classic, *Mendelism and Evolution.*

Now, there were too many modern synthesizers to shout-out in one episode, but you've met a couple of them before. American geneticist and embryologist Thomas Hunt Morgan for example directed the Fly Room at Columbia from 1911 to 1928, which we visited in 25. Morgan trained a lot of biologists who contributed to the modern synthesis by exploring where genes are physically located on the chromosomes of fruit flies, members of the species *Drosophila melanogaster.* Fly Boys also created databases of different alleles, or versions of a gene. For example, they figured out that the dominant allele controlling the color of flies' eyes makes it red, but recessive alleles exist for brown or white eyes. In fact, the Fly Room scientists could inbreed flies with specific traits until these mutants were pretty much new species. But this didn't prove how species were created in the wild.

Maybe using artificial selection, scientists were doing something that Darwin and Wallace's proposed mechanism - natural selection - didn't do. Or did in a different way. One of Morgan's students, Ukranian-American geneticist Theodosius Dobzhansky, resolved this frustration by studying flies similar to the lab's *Drosophila.* Traveling from Canada to Mexico, Dobzhansky demonstrated that natural groups of flies have the same levels of genetic variation as mutants in labs. In fact, Dobzhansky showed that in the wild variations are inherited pretty much as Darwin would have predicted, and most mutations aren't good or bad, which is why variation is so high. He joined the world's laboratory of genetics, the realm of experimentation and field naturalism, the realm of observation. Dobzhansky published his landmark book, *Genetics and the Origin of Species,* in 1937, which established evolutionary genetics as a discipline.

===== (04:00) to (06:00) =====

In his book, Dobzhansky defined evolution as "the change in the frequency of an allele within a gene pool", which is pretty much how we teach it today.

Darwin's natural selection, a culling of certain alleles from a population and allowing others to reproduce, is one of the main drivers of the evolution of species. Along with completely random mutation, and some other forces called gene flow and gene drift. Dobzhansky also spent much of his career trying to convince people not to think of humans like inbred mutant flies. Human "races" and not genetically defined, but socially constructed. The biological features that people have associated with different races have changed over time, and the boundaries between those races have been redrawn. Dobzhansky was one of the many scientists who hoped that people would read about human genetics and suddenly change their view on human difference. Theo gave that a good try and turns out, we need more than just science.

Dobzhansky was not the only biologist who turned to statistics as a tool for describing variation in living things. Starting around 1918, English statistician Ronald A. Fisher made numerous contributions to statistics and genetics, culminating in his banger, *The Genetical Theory of Natural Selection,* in 1930. He showed statistically that what looks like continuous natural selection is actually the result of combined changes to many different genes. Fisher's work provided much of the foundation for biostatistics, or how to apply statistics to biology, including using statistical concepts to understand the results of experiments. Unfortunately Fisher was also a massive eugenicist who insisted that racial differences in humans mattered genetically. So, sort of the opposite of Dobzhansky.

English scientists, socialist organizer, and consummate dapper dresser J.B.S. Haldane also helped pioneer biostatistics, and a bunch of other stuff. In a 1915 paper, Halding published the first genetic linkage maps for mammals, showing the order and relative distance of genes in guinea pigs and mice, and later chickens. This was a big step, moving from flies to mice.

===== (06:00) to (08:00) =====

Halding's work, like his 1932 book *The Causes of Evolution,* helped establish, with Fisher and American geneticist Sewall Wright, population genetics. This is the study of how genes vary in populations, including models of how different alleles will change in a population over time. Other scientists focused not on gene by gene change, but on whole species. German ornithologist Ernst Mayr came up with the modern biological definition of a species. Not just a bunch of similar organisms, but a group that can only breed with each other. Mayr published *Systematics and the Origin of Species from the Viewpoint of a Zoologist* in 1942, helping establish evolutionary biology as distinct from genetics and the the other life sciences.

Finally, British evolutionary biologist and eugenicist Julian Huxley published *Evolution, the Modern Synthesis* in 1942. This one was

kinda the capstone of the whole Modern Synthesis. It summarized the research uniting evolution and genetics up until World War II. And Julian Huxley coined many terms still used by evolutionary biologists, such as *cline*, or the gradient of some trait - say, some gene - within a population across a geographical range. Fun fact: Julian's little brother, Aldous Huxley, wrote the dystopia *Brave New World* in 1932, which argued that technology might not only not be the solution to the world's problems. It might be a major source of them. And we have to shout out their grandpa, Thomas Henry Huxley, AKA Darwin's Bulldog, who helped make Darwin the most famous scientist of the 19th century. Just a lot going on with the Huxley family.

So the Modern Synthesizers had links back to Darwin himself, and with Julian Huxley's book, the work of figuring the *how* of evolution was publicly announced, a little less than a century after *The Origin of Species.* In the public eye, biology gained credibility. After striving for decades to make their field better resemble physics, biologists were finally using mathematics and massive data sets regularly and convincingly.

===== (08:00) to (10:00) =====

It's important to note that the Synthesizers weren't really a clearly defined group and they didn't always agree with each other. And while their work was transformative and still provides a basis for some day to day work for biologists, not everyone was down with the synthesis in the 40s, and new ideas continue to reshape it today. But still, by 1942 biology had become by its own account, modern.

Notice the Synthesizers were mostly English and American dudes. Dobzhansky was born in the Ukraine, but he immigrated to the US at the age of 27. And while they were meticulously using Mendelian genetics to explain natural selection, their counterparts in the newly powerful Soviet Union faced a different intellectual landscape. Science and technology were strongly prized in the Soviet Union, after all the country had been founded on Marxist principles: there is only one, material world, and whoever controls the means of production - capital and technology - controls the world. After World War II, elite schools pumped out many, highly skilled engineers every year, and Soviet scientists began to win Nobel prizes. They had to catch up on the whole atomic bomb fad for one, but in the life sciences, in stead of competing with the Modern Synthesizers, the Soviets focused on applications: agriculture.

The question facing Societ geneticists was how to improve varieties of wheat and other staples so they could grow longer, even in the harsh environments that made up much of the Soviet Union. ThoughtBubble, show us what happened next.

[entering the ThoughtBubble]

Soviet agronomist Trofim Lysenko rose from obscurity to become the directory of the Soviet Union's Lenin All-Union Academy of Agricultural Sciences, all because he claimed that "wheat subjected to cold would produce a next generation better able to withstand even more cold". This process was called vernalization, and it caught on, along with Lysenko's other ideas for farming, faster than scientists could investigate whether they actually worked.

===== (10:00) to (12:00) =====

So now promoted up to science-boss, Lysenko focused on ideas developing ideas similar to those of Jean-Baptiste Lamarck, the French evolutionary theorist who thought that organisms could inherit characteristics based on their individual experiences. This theory, in which experience mattered more than a competition among inherited genes, was a better fit with Marxism. Lysenko and his yes men also made lots of unscientific claims about agriculture, including that rye could transform into wheat. He also used his power to destroy the careers of geneticists in the Soviet Union - all of them. He had the real scientists fired and replaced with his lackeys. This system of science-purely-for-politic's-sake came to be known as Lysenkoism. Now, all systems of science are political - saying you're "apolitical just means you're for the status quo - but Lysenkoism wasn't even science anymore. It was a pure power play.

So in 1940 the leading Soviet geneticist Nikolai Vavilov arrested. Lysenko took up his post as the Director of the Institute of Genetics. In 1941, Vavilov was put through a sham trial and found guilty of sabotage. Imprisoned, he died of malnutrition in 1943. Thanks, ThoughtBubble.

[exit the ThoughtBubble, back to Hank]

And then, in 1948 Lysenko talked Joseph Stalin into banning population genetics and other types of bourgeois biology entirely. This meant no more artificial selection of crop varietals based on neo-Darwinian science. The Soviet Union, already facing serious food shortages, lost an important tool for fighting famine. Lysenkoism only ended in the 1960s, after Lysenko's Stalin died and three prominent Soviet physicists spoke out against his psuedo-science and political manipulations. But at least thanks to scientists, including Julian Huxley, Nikolai Vavilov's reputation as a great geneticist was finally restored.

[next time]

Next time, another bridge from World War II to the Cold War. It's time to meet Alan Turing and invent the computer.

Crash Course: History of Science is filmed in the Dr. Cheryl C. Kinney Studio in Missoula, Montana. And it's made with the help of all of these nice people, and our animation team is Thought Cafe.

===== (12:00) to (12:34) =====

Crash Course is a Complexly Production. If you want to keep imagining the world complexly with us, we've got a bunch of other shows that you can check out like Nature Leage, Sexplanations, and of course SciShow. And finally, if you would like to keep Crash Course free for everybody, forever, you can support the series at Patreon, a crowdfunding platform that allows you to support the content you love. Thank you to all of our patrons for making Crash Course possible with your continued support.