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neo-Darwinism

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A term narrowly understood as the synthesis of Mendelian genetics and Darwinian theory and broadly understood as the current paradigm of evolutionary theory.

As this brief definition suggests, neo-Darwinism is a somewhat imprecise concept. It is difficult to provide a single definition since neo-Darwinism can be understood in a variety of ways, given its narrow and broad construals. In the narrow conception, neo-Darwinism is simply the combination or reconciliation of Darwin's theory of natural selection with Mendel's theory of genetics. Under the broad conception, on the other hand, neo-Darwinism is an umbrella term for work done in contemporary evolutionary theory, i.e. how the various fields of biology, from genetics to population biology to paleontology, are integrated with classical Darwinian theory. I will discuss both the narrow and broad usages, since both are necessary for a complete understanding of the concept.

Narrow Usage Prior to the popularization of genetics as outlined by Gregor Mendel, it was thought that traits were "blended," like colors of paint. This theory, however, is incompatible with Charles Darwin's theory of natural selection. Darwin provided three conditions for evolution by natural selection: (1) heredity, (2) variation, and (3) differential reproduction (the ability for organisms to reproduce at different rates, hence some flourish more than others). A theory of blending traits, however, *reduces* variation over time; or, to render it in terms of the metaphor, particular traits or "colors" blend until they produce a gray amalgam. This clearly violates Darwin's second condition, and poses a serious problem for Darwin's overall theory, because without variation, natural selection has nothing to act upon. Therefore, Darwin understood that there must be *particular* traits that are inherited from one generation to the next, allowing for variation in traits to persist. However, Darwin failed to produce a viable alternative to the blending theory that would explain the continued variation observed in nature.

Although Mendel provided an alternative to the blending theory while Darwin was still alive (and sent him a copy), much to history's dismay, Darwin never read it. Mendel's alternative to the "blending" theory is specified by his two laws: the Law of Segregation and the Law of Independent Assortment. The first law states that an individual possesses two copies of one gene: one maternal and one paternal. So, for instance, if my father has brown eyes, he might have two dominant copies of brown, and if my mother has blue eyes, then she must have two recessive copies of blue. I, however, would not have a *blend* of brown and blue eyes; I would simply have brown eyes because brown is a dominant and particulate trait. The second law states that the two gene copies (alleles) separate independently during gamete formation. Or, rather, if my mother has blue eyes and brown hair and my father has brown eyes and blond hair, just because I have brown eyes does not necessarily mean I will have blond hair as well. Mendel's claim is that traits are inherited independently of one another, as particulate traits.

Surprisingly, during Darwin's time, and for some time thereafter, Mendel's theory of inheritance was understood as an *alternative* to Darwinian theory. Darwin's theory focused on the changing probabilities of traits in a population, via natural selection, from one generation to the next, while Mendel's theory seemed to focus on traits remaining static over time (brown eyes will always be inherited as brown eyes). Overlooked was Mendel's idea of mutation, which caused variation; however, he did not integrate that with Darwin's theory of natural selection. Darwin, conversely, had no working theory of inheritance or explanation of the variation he saw in nature to supplement his theory of natural selection. Although Darwin's theory of natural selection doesn't require a *specific* mechanism (just a mechanism) of inheritance, Darwin still proposed "pangenesis" (1868), an error-ridden theory, which held that each and every cell contributed "gemmules" to the reproductive organs in order for traits to be passed on. This theory, however, allowed for heritability of acquired characteristics (as Jean-Baptiste Lamarck argued), and is one of the reasons it is discounted today.

The term "neo-Darwinism" was coined in 1895 by Georg Romanes, specifically to oppose the idea of the heritability of acquired characteristics. For Romanes, neo-Darwinism referred to Weismann's theory of germ plasms (or gametes), which are the essential parts of germ cells. Germ cells are distinct from body cells, because they are inherited. Since only germ cells can contribute to the next generation, acquired characteristics cannot be selected for. Weismann's explanation of inheritance without acquired characteristics is compatible with Darwin's theory of natural selection, and was necessary for Mendel's theory to be revisited at the end of the nineteenth century. It was at that point that the theories of Mendel and Darwin were integrated. Mendel's theory solved Darwin's problem of where much of the variation in nature comes from, by means of genetic mutations, and Darwin's theory explained directed change in nature as adaptations. Current science now regards Mendel's theory as a precursor to modern genetics, and recognizes that natural selection acts on variation at the genetic level.

Broad Usage Neo-Darwinism can also refer to our current paradigm of evolutionary theory, which stemmed in large part from the modern synthesis. The "modern synthesis" is a term coined by [Julian Huxley \(1942\)](#), and refers to a time in science from the mid-1930s to the mid-1940s. Some of the more important contributors include J.B.S. Haldane, Sewall Wright, R.A. Fisher, Gaylord Simpson, Ernst Mayr, T. Dobzhansky, and G. Ledyard Stebbins. It was during the modern synthesis that the field of population genetics developed, which took ideas at the genetic level and fused them with the idea of evolution observed at the population level, driven by natural selection. Before the modern synthesis, it was hard to reconcile genetics with real world examples of natural selection.

An example of this synthesis can be seen in J.B.S. Haldane's general selection model, a mathematical analysis of how certain genotypes change from one generation to the next based on natural selection. His mathematical analysis explains the underlying genetics behind real world examples. For instance, there is the famous example of peppered (melanic) moths that is taught in most population biology classes today. In a normal forest near London around 1848, light-colored moths flourished because they blended in with the light-colored environment. Predators were more likely to eat darker-colored moths that stood out, and therefore the light-colored moth genotype was passed on. However, by 1895, there was an increase in the frequency of dark-colored moths because of pollution from the Industrial Revolution. The dark-colored moth genotype

became more prevalent because they camouflaged with the darker trees and predators ate the light moths that now stood out. Haldane calculated an increase of dark-colored moths, from 2 to 95 percent of the population over the 47 years. This change was so fast, he concluded, that only natural selection could have caused it. This case is wonderful because it shows an easily understood example of adaptation at the population level as well as the underlying genes of the dark- and light-colored moths that were inherited from one generation to the next. Both the theory of natural selection at the population level and the theory of natural selection at the genetic level are consistent. Neo-Darwinism, then, can refer to science after the modern synthesis - we are able to apply genetics to natural populations, whether those populations are communities, species, or clades. In this respect most current research in biology hinges on evolutionary theory in some way, and falls under the term neo-Darwinism.

Criticisms of the Term Neo-Darwinism Ernst Mayr, one of the founders of the modern synthesis, writes that, "the term neo-Darwinism for the [modern] synthetic theory is wrong, because the term neo-Darwinism was coined by Romanes in 1895 as a designation of Weismann's theory" (Mayr, 1984, p. 146). This view, advanced by Mayr, restricts the usage of the term "neo-Darwinism" to its narrow sense, as Romanes originally intended it. However, despite such opposition, the broad construal of neo-Darwinism has seen widespread acceptance and use, especially in popular writings. For example, the *New York Times* journalist and evolutionary biologist Olivia Judson recently wrote that terms such as "neo-Darwinism," or even simply "Darwinism" are misleading for biology. If biologists are working under a neo-Darwinian paradigm, then it can be said of physicists, for example, that they are doing "neo-Einsteinism." Obviously she understands neo-Darwinism to refer to our current paradigm of evolutionary science - otherwise there would not be the distaste. Like Mayr, Judson might agree with calling the modern synthesis just that, and our current paradigm simply "evolutionary biology." Neo-Darwinism, then, would be relegated to its historical usage, a word that reminds us of a period during which Mendel and Darwin's theories were at odds.

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