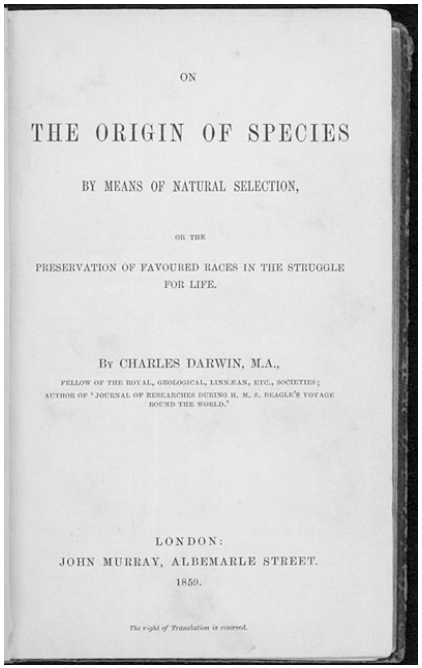

ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNÆAN, ETC., SOCIETIES; AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.

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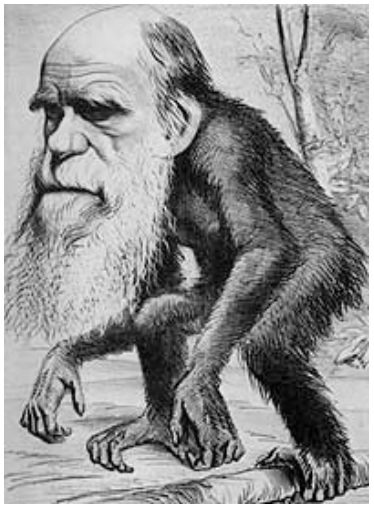
. . . and *On The Origin of Species By Means of Natural Selection* was published in December 1859, and rapidly became a best-seller.



Cartoon in *The Hornet* magazine, 1871

And it sparked some rather strong reactions in public opinion. . .

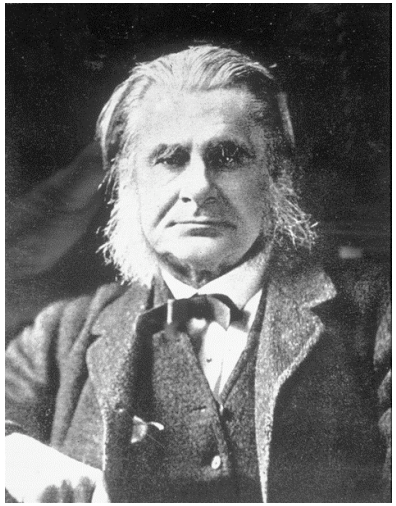
Cartoon in *Punch* magazine, 1862

As you might expect, the public's reaction was rather strong. . .

Darwin hadn't actually said anything directly about human evolution, but it didn't take long for people to realize that natural selection had some very unflattering implications!

Cartoon in *The London Sketchbook*, 1874

And things *really* heated up when Darwin *did* publish his views on human evolution, in his books *The Descent of Man* (1871) and *The Expression of the Emotions in Man and Animals* (1872)!



Darwin himself was too ill to defend his ideas in public speeches and debates and newspapers and such, but Thomas Henry Huxley (1825-1895) publicly promoted and defended "Darwinism" so actively that he became known as "Darwin's Bulldog" (although privately he disagreed with Darwin about some of the details. . .)

. . . the English philosopher Herbert Spencer (1820-1903) took evolution as a philosophy of universal progress, which he applied to the entire universe. (And by the way, *he* coined the phrase "survival of the fittest" — not Darwin!) . . .

. . . the German biologist Ernst Haeckel (1834-1919) was known as "Darwin's Apostle to Germany" for his enthusiastic popularization of the idea. . .

The monumental greatness of Charles Darwin, who surpasses every other student of science in the nineteenth century by the loftiness of his monistic conception of nature and the progressive influence of his ideas. . .

— "Charles Darwin as an Anthropologist" (1869)

. . . American botanist Asa Gray (1810-1888), a member of Darwin's "inner circle", accepted evolution but always believed that God directed it. . .

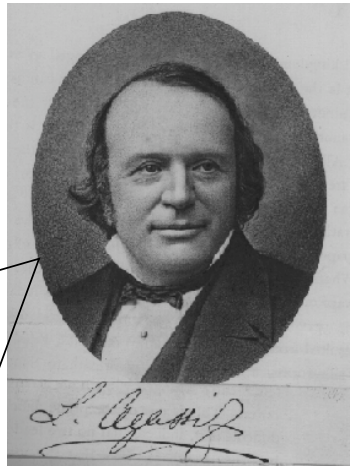
. . . the evolutionist may say with the apostle: "Howbeit that was not first which is spiritual, but that which is natural, and afterward that which is spiritual." Man, "formed of the dust of the ground," endowed with "the breath of life," "became a living soul." Is there any warrant for affirming that these processes were instantaneous?

— "Natural Science and Religion", 1880

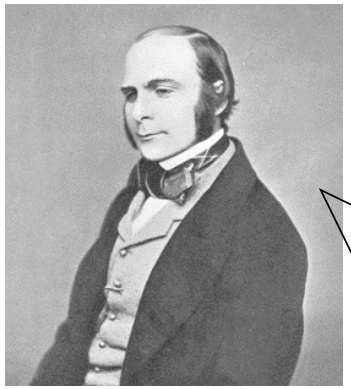
. . . while the Swiss-American scientist Louis Agassiz (1807-1873), carrying on the tradition of natural theology, opposed evolution for the rest of his life!

. . . all these facts in their natural connection proclaim aloud the One God, whom man may know, adore, and love; and Natural History must in good time become the analysis of the thoughts of the Creator of the Universe. . .

— "Essay on Classification" (1859)

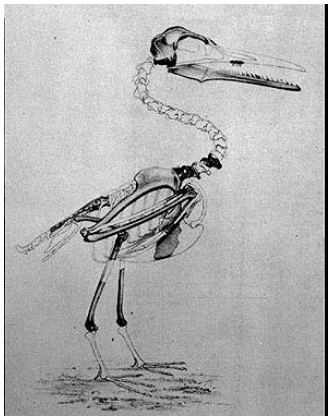


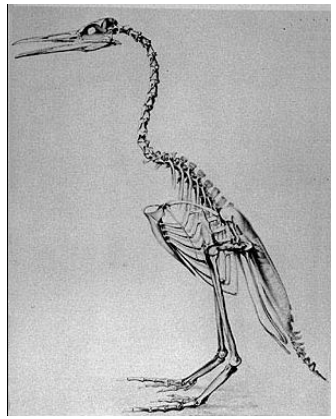
Darwin's cousin Francis Galton (1822-1911), one of the founders of modern statistics, thought that humans should apply artificial selection to themselves to "improve the species"—an idea he called *eugenics*.



I have no patience with the hypothesis occasionally expressed . . . that babies are born pretty much alike, and that the sole agencies in creating differences between boy and boy, and man and man, are steady application and moral effort.
— *Hereditary Genius* (1869)

Soon after *The Origin of Species* was published, yet more evidence began to accumulate that supported *some* form of biological evolution. This included *Archaeopteryx*, found in Germany in 1862, that showed many reptilian skeletal traits, but also had impressions of feathers forming wings. . .





. . . and then Othniel C. Marsh (1831-1899), professor at Yale University, collected vast numbers of fossils from the American West— including these toothed bird skeletons, found in Kansas, that filled a gap between *Archaeopteryx* and modern birds.

There was also the discovery, in 1858 and 1859, in both England and northern France, of stone tools, clearly made by humans—but definitely associated with the bones of extinct animal species. This drove a big stake through the heart of Cuvier's catastrophism—extinct animals were supposed to have been wiped out by catastrophes before humans had existed!

And even the discovery—first in 1844 in Gibraltar, then 1856 in the Neander River valley of Germany, and then at more and more places in Europe—of bones that looked human-like, but not entirely. The brows were too large, the skull vault was too long and low, the mid-face was too broad and projecting, and there was no chin. Could these be—gasp! choke! —

human ancestors???

Objections. . .

- By about 1870, the idea of evolution through *some* kind of natural process, which science could study objectively, was accepted by almost all scientists who studied the matter.
- BUT. . . Darwin's idea of natural selection was *not* widely accepted for about another 50-60 years.
  - Julian Huxley (Thomas's grandson) called this "the eclipse of Darwinism"
  - So why the eclipse?

Objections sustained. . .

- The Earth couldn't be old enough for slow, plodding natural selection to have produced the entire diverse spectrum of living things.
- Favorable variants couldn't be selected for, because interbreeding would "wash out" variation in the population.
- Darwin had no explanation for where variation comes from, or how it can be inherited.
- Natural selection seemed too random— "the law of higgledy-piggledy", as one detractor called it—not a good scientific law with predictive value

Fleeming Jenkin
(1833-1885)

A Scottish engineer and economist—he invented supply and demand curves, and helped develop underwater telegraph cables—Jenkin also pointed out a serious flaw in the theory of natural selection. coming from what he called "blending inheritance".

Fleeming Jenkin's "blending inheritance" problem

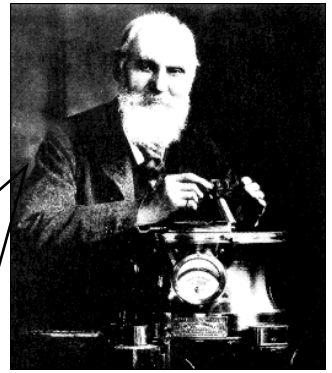
- In a population of organisms, "favorable variants" do sometimes occur—but whom do they mate with?
- They can only mate with normal individuals—and their offspring will be a blend of parental characteristics, and won't completely show the favorable trait that one of their parents had.

"Blending inheritance", continued

- Over generations, the favorable trait will become fainter and fainter (like a drop of red paint mixed into a bucket of white paint).
- Any favorable variation would soon be "swamped out" by interbreeding with members of the population that don't have it.
- Therefore, natural selection has nothing to work with.

Sir William Thomson, Lord Kelvin
(1824-1907)

The limitation of geological periods imposed by physical science. . . does seem sufficient to disprove the doctrine that transmutation has taken place through 'descent with modification by natural selection.'

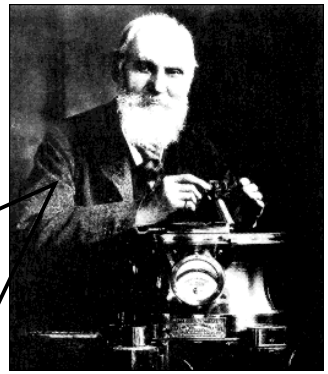


Kelvin's reasoning went like this:

- The Earth has internal heat (as shown by volcanoes, the heat in deep mines, etc.)
- A warm body in cold space must radiate that heat away to space, at a rate governed by the laws of physics.
- For the Earth to be at its current temperature and losing heat at its current rate, it must have been molten recently—too recently for Darwinian evolution to have had any effect.

The Earth must have solidified only about 20 million years ago—and life must be even younger.

But I think we may with much probability say that the consolidation [of the earth] cannot have taken place less than 20,000,000 years ago, or we should have more underground heat than we actually have, nor more than 400,000,000 years ago, or we should not have so much as the least observable underground increment of temperature.
—"On the Secular Cooling of the Earth", 1864

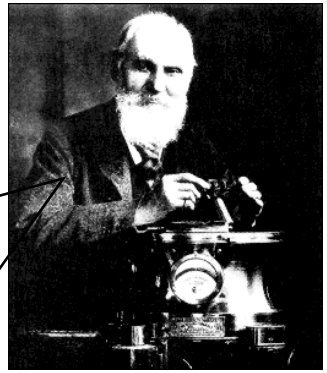


Although he was a great physicist, Kelvin's track record was not always perfect. . .

"X-rays will prove to be a hoax."

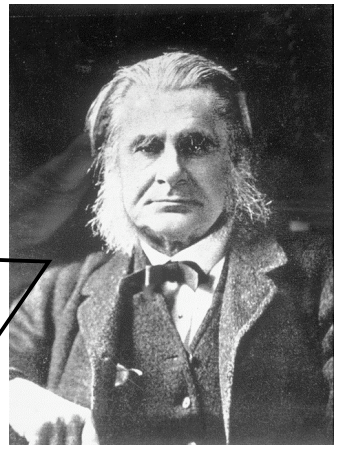
"Radio has no future."

"I can state flatly that heavier-than-air flying machines are impossible."

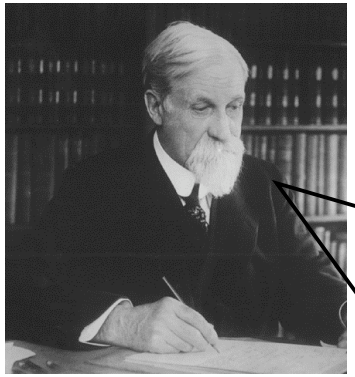


"Darwin's Bulldog," Thomas Henry Huxley, countered by arguing that the physical data weren't good enough to calculate anything definite. . .

Mathematics may be compared to a mill of exquisite workmanship, which grinds you stuff of any degree of fineness; but nevertheless, what you get out depends on what you put in; and as the grandest mill in the world will not extract wheat-flour from peascod, so pages of formulae will not get a definite result out of loose data.



. . . and American geologist T. C. Chamberlain made this statement, which turned out to be eerily prophetic!



What the internal composition of the atoms may be is yet an open question. It is not improbable that they are complex organizations and the seats of enormous energies. Certainly, no careful chemist would affirm either that the atoms are really elementary or that there may not be locked up in them energies of the first order of magnitude.

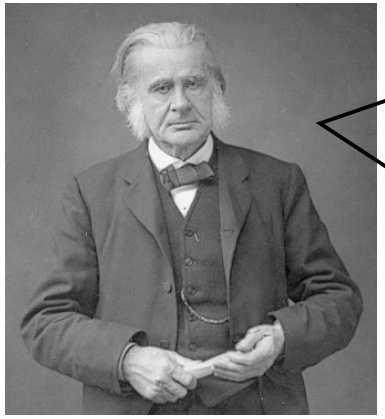
But Jenkin's, Kelvin's, and others' objections supported the rise of alternative evolutionary theories.

- directed variation—natural selection may work, but organisms don't vary randomly. Something (God? an undiscovered law of nature? *Both?*) causes purposeful change over time
- Neo-Lamarckianism—a revival of Lamarck's ideas about the inheritance of acquired characters
- saltation—species are not formed gradually, but in sudden bursts of change—possibly in only one generation
- orthogenesis—species evolve because of some sort of "internal drive" that has nothing to do with the environment

The astronomer J. W. Herschel believed that evolution was guided by intelligence, acting through natural laws. . .

An intelligence, guided by a purpose, must be continually in action to bias the direction of the steps of change—to regulate their amount—to limit their divergence—and to continue them in a definite course. . . On the other hand, we do not mean to deny that such intelligence may act according to law (that is to say on a preconceived and definite plan).

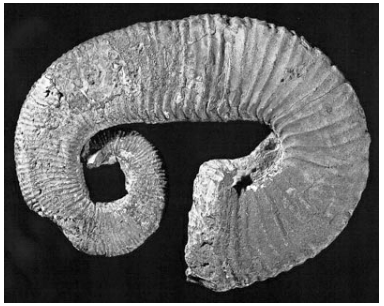
Saltationists believed that lineages could change by "leaps" instead of gradually. Thomas Henry Huxley was of this view—as he wrote in a letter in 1894:



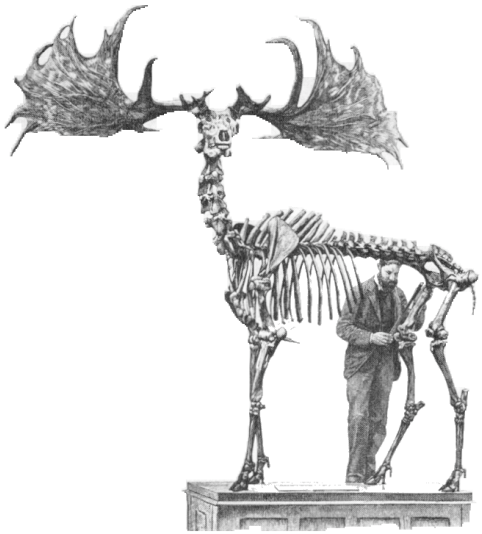
I see you are inclined to advocate the possibility of considerable "saltus" [Latin, "leap"] on the part of Dame Nature in her variations. I always took the same view, much to Mr. Darwin's disgust, and we used often to debate it.

Orthogenesists claimed that a species or group had to evolve along a predetermined track. The extinct coiled cephalopods called *ammonites* evolved a number of strangely coiled species before dying out— orthogenesis claimed this showed "senescence" (aging) of the lineage.

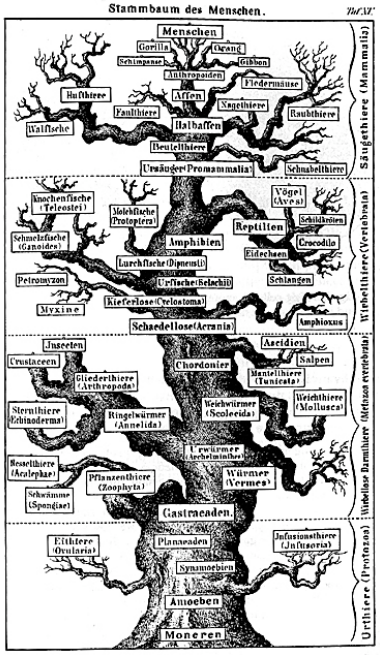
typical ammonite



heteromorphic ammonite



Thus did orthogenesists explain the "Irish elk": One lineage of deer was on some sort of "track" to evolve bigger antlers over time, even though huge antlers were *not* adaptive! The Irish elk died out about 10,000 years ago, when its antlers became so large that it couldn't lift its head. Supposedly.



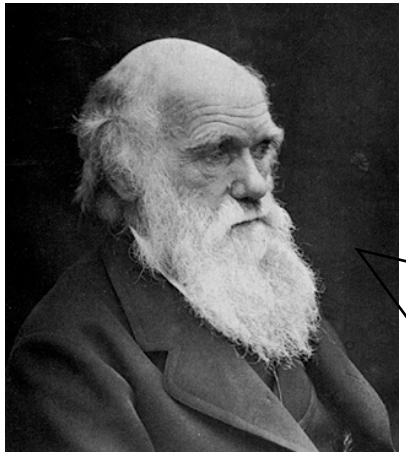
Meanwhile, as we've seen, over in Germany, Ernst Haeckel (1834-1919) was popularizing evolutionary ideas, drawing up elaborate "family trees" showing how evolution had progressed.

(Notice, of course, that humanity [*Menschen*] is at the very top of Haeckel's Tree, comfortably above the apes [*Affen*] and everything else. . .)

But Haeckel reasoned thus—using logic that makes more sense from a Lamarckian perspective:

- Evolution adds changes (especially acquired, Lamarckian changes) to the adult stages of the life cycle
- Previous adult stages would have to be pushed backwards in developmental time
- Embryonic development is therefore a record of an organism's past evolutionary history
- *"Ontogeny recapitulates phylogeny"* —Haeckel's "Biogenetic Law"
  - What Haeckel actualy said was "The rapid and brief ontogeny is a condensed synopsis of the long and slow history of the stem (phylogeny). . ."

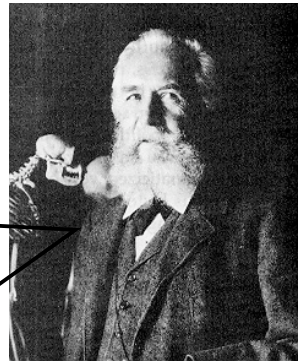
Darwin himself had never ruled out Lamarckian evolution— and he showed increased acceptance of Lamarckianism later in his life. Darwin was no strict "Darwinian"!



I think there can be no doubt that use in our domestic animals has strengthened and enlarged certain parts, and disuse diminished them; and that such modifications are inherited.
— *Origin of Species*, 6th edition (1872)

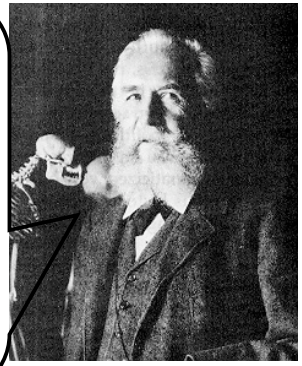
Nevertheless, natural selection does not give the solution of all our evolutionary problems. It has to be taken in conjunction with the transformism of Lamarck, with which it is in complete harmony.

— "Charles Darwin as an Anthropologist" (1869)

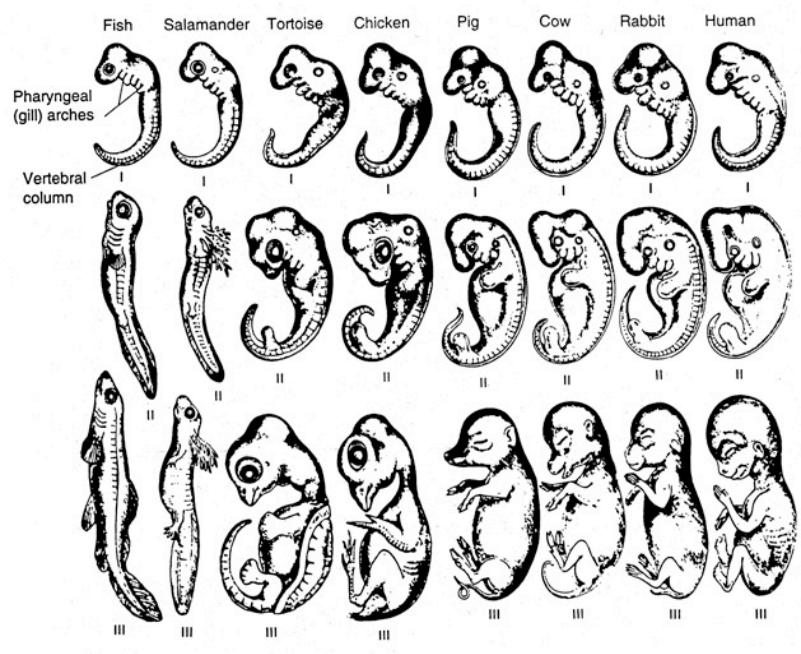


This is easier to envision if you're a Lamarckian—and Haeckel believed in Lamarckianism as well as Darwinism!

. . . this history of the embryo (ontogeny) must be completed by a second, equally valuable, and closely connected branch of thought— the history of race (phylogeny). Both of these branches of evolutionary science, are, in my opinion, in the closest causal connection; this arises from the reciprocal action of the laws of heredity and adaptation. . .



The idea wasn't original with Haeckel, or even with the evolutionists. But Haeckel demonstrated this link with a now-infamous set of diagrams showing the embryonic development of various vertebrates. . .



Yeah,

BUT. . .

Beginning in 1895, physicists discovered and began to study a strange new phenomenon: *radioactivity*. Here's Marie and Pierre Curie with their great discovery, the new, rare, and highly radioactive element *radium*.

Natural radioactivity in the Earth maintains the Earth's temperature. The Earth isn't cooling down, as Kelvin had thought, because it has an internal source of heat!

Kelvin, who was in his eighties at the time, never really accepted radioactivity, which annoyed his colleagues. . .

The weight of years and the almost unanimous opinion of his younger colleagues against him have not deterred him from leading a lost cause. . . . atomic disintegration is based on experimental evidence, which even its most hostile opponents are unable to shake or explain in any other way. . . .
— Letter to *Nature*, 1906

Frederick Soddy (1877-1956)

As for "blending inheritance": the answer had been worked out by this man—but nobody paid much attention at the time.

. . . the constant characters which appear in the several varieties of a group of plants may be obtained in all the associations which are possible according to the laws of combination, by means of repeated artificial fertilization.
— "Experiments in Plant Hybridization", 1865

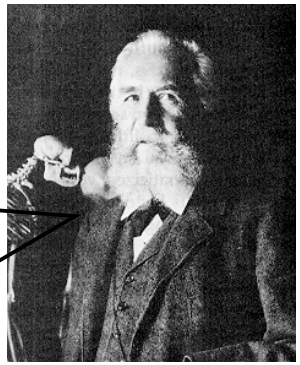
Check it out at MendelWeb. . .

August Weismann

(1834-1914)

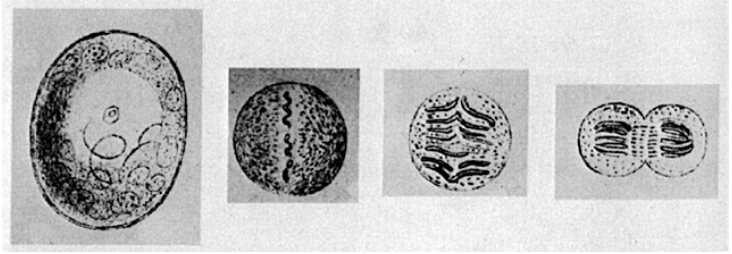
- German biologist who argued strongly against neo-Lamarckian ideas
- "Continuity of germ plasm": The hereditary material in the gametes is set apart from the rest of the body. Lamarckian evolution isn't possible.
- Weismann hypothesized the existence of "intracellular pangenes"— some sort of physical unit of inheritance

Weissman's theory in its entirety is a finely conceived molecular hypothesis, but it is devoid of empirical basis. The notion of the absolute and permanent independence of the germ-plasm, as distinguished from the soma-plasm, is purely speculative. . .



Weissman's support for natural selection was so loud and argumentative that it actually turned people off—such as Haeckel, here venting his spleen. . .

But in 1873, Friedrich Schneider discovered chromosomes—and by 1885, Weismann and others had concluded that the chromosomes *were* the "germ plasm".



". . . there is an hereditary substance, a material bearer of hereditary tendencies. . . contained in the nucleus of the germ-cells, and in that part of it which forms the nuclear thread, which at certain periods appears in the form of looops or rods."
—Weismann, 1887

Hugo de Vries

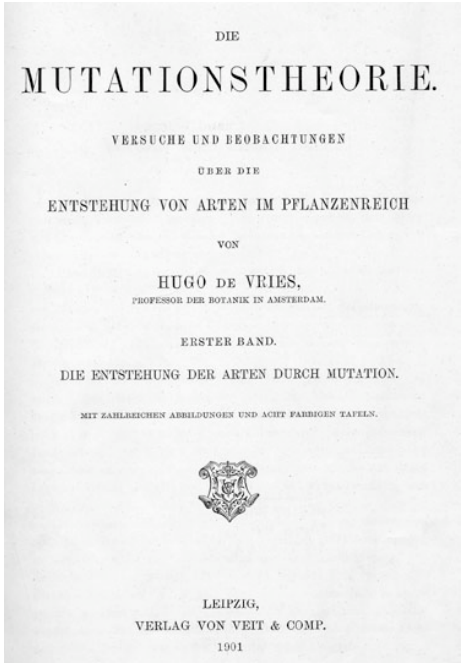
(1848-1935)

Images taken from the University of Amsterdam Biology Library

Working with a species of flower known as the evening primrose, De Vries noticed what he later called *mutations*—sudden changes in color or shape from one generation to the next. He argued that traits must be inherited as units, rather than as blends. . .

The Great Coincidence

- In the first half of 1900, within a few months, *three* scientists independently rediscovered Mendel's work: Hugo de Vries, Carl Correns, and Hugo Tschermak.
- The idea of "genes" as independent particles ultimately disproved Jenkin's "blending inheritance" (though not without a fight—at first it wasn't clear how genes could be responsible for continuously variable traits).



DIE

MUTATIONSTHEORIE.

VERSUCHE UND BEOBACHTUNGEN

ÜBER DIE

ENTSTEHUNG VON ARTEN IM PFLANZENREICH

VON

HUGO DE VRIES,

PROFESSOR DER BOTANIK IN AMSTERDAM.

ERSTER BAND.

DIE ENTSTEHUNG DER ARTEN DURCH MUTATION.

MIT ZAHLREICHEN ABBILDUNGEN UND ACHT FARBIGEN TAFELN.

LEIPZIG,
VERLAG VON VEIT & COMP.
1901

De Vries explained mutations as changes in the "genes" in this book, *Die Mutationstheorie*. De Vries was *not* a supporter of natural selection, however—he was a saltationist, and thought that new species spontaneously appeared by mutations in a single generation. (As we'll see later, he wasn't entirely wrong. . .)

Skipping over a great deal of complex controversies and history. . . by about 1930, Mendelian genetics had joined with Darwinian natural selection to produce a powerful theory known as "Neodarwinism" — or

The Modern Synthesis

The American biologist Thomas Hunt Morgan and his students, working with fruit flies in the 1910s, went on to clinch the case that genes are carried on chromosomes—and to map them. . .

. . . and to complete the link with radioactivity, H. J. Muller showed in the 1920s that mutations could be caused by radiation—they resulted from physical damage to a chromosome.