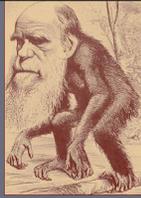


19th Century Reactions to Darwin



"Ignoramus, in hoc signo laboremus"

We are ignorant; so let us work (Charles Darwin)

"Not one subject in the universe is unworthy of study." (Karl Pearson)

Supporters of Darwin

- ▶ **Joseph Dalton Hooker** (1817-1911): London—Botanist, Kew Gardens
- ▶ **Alfred Russell Wallace** (1823-1913): Co-discoverer of natural selection
- ▶ **Thomas Henry Huxley** (1825-1895): London—comparative anatomy
- ▶ **Asa Gray** (1810-1888): Harvard—proposed reconciling evolution and theology: "Evolutionary Teleology"
- ▶ **Ernst Haeckel** (1834-1919): Jena—author of the phylogenetic law: ontogeny recapitulates phylogeny
- ▶ **August Weismann** (1834-1914): Freiburg—rejection of inheritance of acquired characteristics; only germ line cells figure in procreation



Huxley: Darwin's Bulldog

"I finished your book yesterday... Since I read von Baer's Essays nine years ago no work on Natural Science I have met with has made so great an impression on me & I do most heartily thank you for the great store of new views you have given me... As for your doctrines I am prepared to go to the Stake if requisite... I trust you will not allow yourself to be in any way disgusted or annoyed by the considerable abuse & misrepresentation which unless I greatly mistake is in store for you... And as to the curs which will bark and yelp - you must recollect that some of your friends at any rate are endowed with an amount of combativeness which (though you have often & justly rebuked it) may stand you in good stead - I am sharpening up my claws and beak in readiness." (Thomas H. Huxley to Charles Darwin, November 23, 1859)

Huxley, however, did not accept natural selection as the sole or primary mechanism of evolution

Wilberforce vs. Huxley



Confrontation at
British Association,
June 30, 1860

Wilberforce: Bishop
of Oxford, VP of
British Association
and Council
Member of the
Geological Society



Looks more bitter in hindsight

- ▶ *Supposedly* Wilberforce challenged:
“If anyone were willing to trace his descent through an ape as his grandfather would he also be willing to trace his descent similarly on the side of his grandmother?”
- ▶ *Supposedly* Huxley responded:
If there were to be an ancestor whom I should feel shame in recalling, it would rather be a *man* -- a man of restless and versatile intellect -- who, not content with success in his own sphere of activity, plunges into scientific questions with which he has no real acquaintance, only to obscure them by an aimless rhetoric, and distract the attention of his hearers from the real point at issue by eloquent digressions and skilled appeals to religious prejudice.”

Wilberforce’s published review

- ▶ Darwin did not have sufficient proof from the fossil record for existence of *any* transitional forms
- ▶ Practical breeders had never produced a new *species* by selection
- ▶ Selection could only “fine tune” adaptations, but could not create anything new
- ▶ In addition, he quipped that Darwin “showed our unsuspecting cousinship with the mushrooms.”

Darwin and Church of England

- ▶ Darwin was buried in Westminster Abbey:
 - "I think that the interment of the remains of Mr. Darwin in Westminster Abbey is in accordance with the judgment of the wisest of his countrymen...It would have been unfortunate if anything had occurred to give weight and currency to the foolish notion which some have diligently propagated, but for which Mr. Darwin was not responsible, that there is a necessary conflict between a knowledge of Nature and a belief in God." Bishop of Carlisle, Harvey Goodwin, in a memorial sermon on the Sunday following the funeral
 - The Times: "The Abbey needed Darwin more than Darwin needed the Abbey."



Darwin's Scientific Opponents



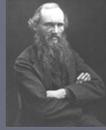
- ▶ **Louis Agassiz (1807-1873):** Harvard
 - Opposed whole idea of transmutation
 - As specialist in fossil fish, accepted extinction
 - All forms result of creation according to God's plan
 - All variants are "separate species"
- ▶ **Richard Owen (1804-1892)**
 - Idealist morphologist (archetypes)
 - Accepted transmutation but not selection
 - Variation due to "innate tendency to deviate from the parental type"

John Herschel



- ▶ Son of William Herschel, one of the discoverers of Uranus.
- ▶ Himself took up astronomy and quickly achieved prominence
- ▶ *A preliminary discourse on the study of natural philosophy* (1830)—major influence on Darwin
 - Science aims to find not just *empirical laws* but *true causes*; "causes recognized as having a real existence in nature and not being merely hypotheses or figments of the mind."
- Objected to Darwin:
 - ▶ Complex adaptations cannot arise from *chance* variation
 - ▶ Labeled Darwin's theory the "Law of Higgeldy-piggeldy"

William Thompson



Lord Kelvin (1824-1907): University of Glasgow

- Britain's most famous physicist
- Calculated heat radiation from earth's surface
- Based on cooling earth theory maintained that the longest time for earth to have been habitable is 200,000 years
- Not nearly long enough for evolution by natural selection
- ▶ Darwin took Thompson seriously: wrote to Wallace in 1869: "Thompson's views on the recent age of the world have been for some time one of my sorest troubles."
- His response was to ask: What could speed up the process of evolution?
 - ▶ One possibility to which he appealed: inheritance of acquired characteristics

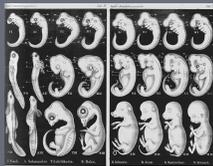
Fleeming Jenkin



- ▶ Not a biologist: an engineer who helped develop underwater telegraph cables and invented supply and demand curves
- ▶ Focused on blending inheritance: if offspring are blends of the traits of their parents, within a very few generations variability will be eliminated.
- ▶ Darwin's response was to ask: What could enhance variability in a population?
 - Open to the possibility that inheritance of acquired characteristics could enhance variability

Ernst Haeckel (1838-1919)

"I established the . . . view, that 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... *'ontogenesis is a brief and rapid recapitulation of phylogenesis*, determined by the physiological functions of heredity (generation) and adaptation (maintenance)."



Haeckel, E. 1899. *Riddle of the Universe at the Close of the Nineteenth Century*.

Gastraea



- ▶ All multi-celled organisms go through stages of becoming globular masses, which hollows out and becomes a gastrula with two layers: ectoderm and endoderm.
- ▶ Proposed a common origin of multi-celled organisms from a species he named *Gastraea*.
- ▶ Mechanism for developing more complex organisms:
 - Compress the developmental pathway of extant organism
 - Add new trait on to the end of the development process

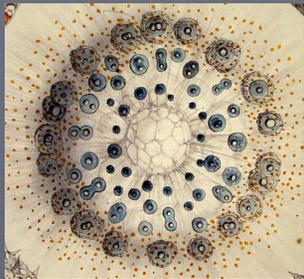
Jellyfish

- ▶ Described species of jellyfish in 1866 and included in *Kunstformen der Natur, Art Forms in Nature* (1902)
- ▶ Named the species shown in the center *Desmonema Annasethe*, after his first wife, Anna Sethe, who had died years earlier. He commented that the streaming tendrils reminded him of her flowing blond hair.

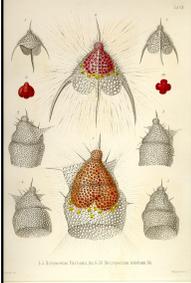


Radiolarian

- ▶ Haeckel investigated these tiny, single-celled organisms in northern Sicily after finishing his medical degree in 1860. They absorb silica from the ocean and produce highly baroque, glassy skeletons. Different patterns characterize different species.
- ▶ That year he also read *On the origin of species*

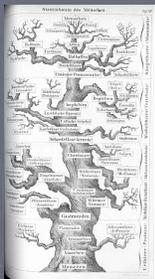


Haeckel to Darwin

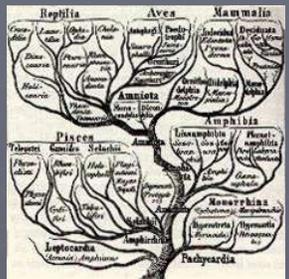


- ▶ Saw similarities among the radiolarian as evidence of common history
- ▶ Sent his 1862 monograph *Radiolaria* to Darwin
- ▶ Darwin replied that the images “were the most magnificent works which I have ever seen, & I am proud to possess a copy from the author.”

Haeckel's Representation of Phylogeny

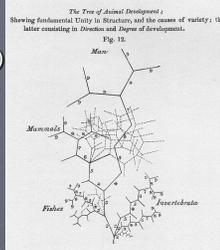


- ▶ Developed the idea of representing descent relations as a tree



Haeckel vs. Ernst von Baer

- ▶ Von Baer had noted in 1828 that the embryos of related species are extremely similar—all organisms go through stages in which they are very similar
- ▶ Subsequent development results in species specific traits (specialization)
- ▶ Development of higher life forms do not go through the *adult* form of lower life forms, but only the *embryonic* form of lower life forms.
- ▶ Von Baer never accepted evolution, although Darwin utilized von Baer's ideas



Natural Selection and Biometrics

- ▶ Whereas many of those who embraced Darwin on the transmutation question in the late 19th century rejected or were dubious as to whether natural selection was **the** vehicle of the generation of new species,
 - It was so embraced by a group of investigators who came to be called “Biometricians”
 - They especially emphasized the gradualness of evolution
- ▶ Key to natural selection is the existence of variation on which selection can occur
 - The biometricians developed the statistical tools for characterizing the variability in traits that provided the raw material for selection



Galton and the Development of Biometrics

- ▶ Francis Galton, like his cousin Charles Darwin, was sent off to study medicine, but after his father died in 1844 he was left with “a sufficient fortune to make me independent of the medical profession.”
- ▶ Like Darwin, he choose to travel, traveling up the Nile to Khartoum, and then, in 1849, set out for south west Africa, exploring Damaraland, and writing *Tropical South Africa* on his return
- ▶ After the *Origin*, Galton turned his attention to intelligence, its variability and its heritability.

Regression to the Mean

Studies with peas:

- Larger peas give rise to larger offspring, but very large peas do not give rise to ones as large as themselves
- Likewise with smaller peas
- Reversion to the mean
- Very interested in the heritability of traits by humans—height, weight, visual acuity, “talent and character”

Diameter of Parent Peas (100 of each)	Mean Diameter of Offspring Peas
21	17.26
20	17.07
19	16.37
18	16.40
17	16.13
16	16.17
15	15.98

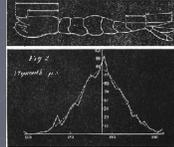
Raphael Weldon



- ▶ “. . . the questions raised by the Darwinian hypothesis are purely statistical, and the statistical method is the only one at present obvious by which that hypothesis can be experimentally checked.”

Some remarks on variation in plants and animals, 1894

- ▶ In 1890 study of shrimp, measured traits such as length of various parts
 - First demonstration that the traits in a wild population were distributed normally



Controversy Brewing

- ▶ William Bateson was highly critical of a paper Weldon submitted to the Royal Society
- ▶ Weldon wrote to Pearson:
 - “the contention ‘that numbers mean nothing and do not exist in Nature’ is a very serious thing, which will have to be fought. Most other people have got beyond it, but most biologists have not. Do you think it would be too hopelessly expensive to start a journal of some kind?”
- ▶ Weldon and Pearson then together created *Biometrika*

Biometrika



- ▶ *Biometrika* will include (a) memoirs on variation, inheritance, and selection in animals and plants, based upon the examination of statistically large numbers of specimens (this will of course include statistical investigations of anthropometry); (b) those developments of statistical theory which are applicable to biological problems; (c) numerical tables and graphical solutions tending to reduce the labour of statistical arithmetic; (d) abstracts of memoirs, dealing with these subjects, which are published elsewhere; and (e) notes on current biometric work and unsolved problems.

Karl Pearson

- ▶ Pearson reported that the first thing he could remember was sitting in a high chair sucking his thumb. Someone told him to stop sucking it, and added that unless he did so, the thumb would wither away. He put his two thumbs together and looked at them for a long time. "They look alike to me," he said to himself. "I can't see that the thumb I suck is any smaller than the other. I wonder if she could be lying to me."

Pearson

- ▶ "It was Galton who first freed me from the prejudice that sound mathematics could only be applied to natural phenomena under the category of causation. Here for the first time was a possibility - I will not say a certainty - of reaching knowledge as valid as physical knowledge was thought to be, in the field of living forms and above all in the field of human conduct."
- ▶ Met Weldon when Weldon was appointed to University College, London in 1890
 - Weldon pressed him on mathematics:
 - ▶ How does one describe asymmetrical, double-humped, and other non-Gaussian frequency distributions?
 - ▶ How does one derive best values for the parameters of such distributions?
 - ▶ What are the probable errors of such estimates?
 - ▶ What is the effect of selection on one or more of the correlated variables?

Pearson and Statistics

- ▶ Accepted view (from Adolphe Quetelet) that all distributions could be represented as normal
 - Pearson investigated skewed distributions and developed curves for asymmetric distributions
 - True variability different than chance variation among errors
 - Coined the term "standard deviation"
 - Developed the χ^2 test for goodness of fit between curve and actual distribution
- ▶ Developed tools for analyzing correlations both in actual populations (ρ) and in samples (r)
 - And for testing the significance of correlations in samples

Pearson and Eugenics

- ▶ Welfare of the nation required "high pitch of internal efficiency" achieved by "insuring that its numbers are substantially recruited from the better stocks."
- ▶ After Galton's death, Pearson named the first Galton Professor of Eugenics
