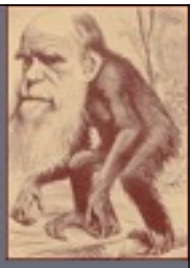
19th Century Reactions to Darwin



"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)

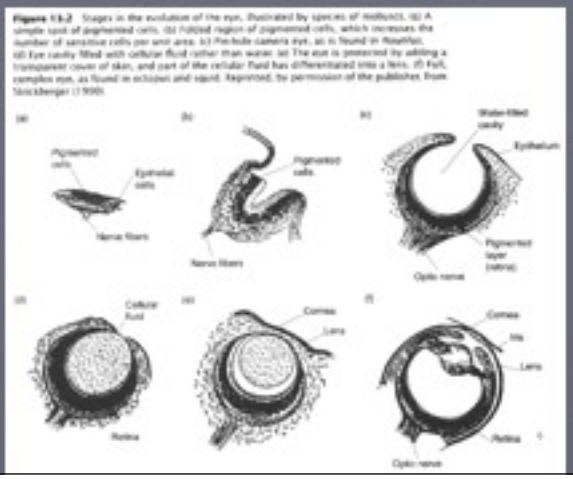
Darwin: His Own Critic

- In the course of the *Origin* Darwin considered a number of possible objections to his view--for example:
  - Why, if species have descended from other species by insensibly fine gradations, do we not everywhere see innumerable transitional forms?
    - Short answer: the fossil record is imperfect
  - (How) is it possible that an animal having, for instance, the structure and habits of a bat, could have been formed by the modification of some animal with wholly different habits?
    - Short answer: through a long history of gradual change

How Could Natural Selection Create Something As Complex as the Eye?

- "To suppose that the eye, with all its inimitable contrivances for adjusting the focus to different distances, for admitting different amounts of light, and for the correction of spherical and chromatic aberration, could have been formed by natural selection, seems, I freely confess, absurd in the highest possible degree."
  - Yet reason tells me, that if numerous gradations from a perfect and complex eye to one very imperfect and simple, each grade being useful to its possessor, can be shown to exist; if further, the eye does vary ever so slightly, and the variations be inherited, which is certainly the case; and if any variation or modification in the organ be ever useful to an animal under changing conditions of life, then the difficulty of believing that a perfect and complex eye could be formed by natural selection, though insuperable by our imagination, can hardly be considered real."

Evolution of the eye



Eye and telescope

- "It is scarcely possible to avoid comparing the eye to a telescope. We know that this instrument has been perfected by the long-continued efforts of the highest human intellects; and we naturally infer that the eye has been formed by a somewhat analogous process. . . . If we must compare the eye to an optical instrument, we ought in imagination to take a thick layer of transparent tissue, with a nerve sensitive to light beneath, and then suppose every part of this layer to be continually changing slowly in density, so as to separate into layers of different densities and thicknesses, placed at different distances from each other, and with the surfaces of each layer slowly changing in form. Further we must suppose that there is a power always intently watching each slight accidental alteration in the transparent layers; and carefully selecting each alteration which, under varied circumstances, may in any way, or in any degree, tend to produce a distincter image. We must suppose each new state of the instrument to be multiplied by the million; and each to be preserved till a better be produced, and then the old ones to be destroyed."
- In recent years engineers have adopted Natural Selection as a means of creating designs
  - The Genetic Algorithm iteratively generates variants and selects among them

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 History 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

Clicker Question

Huxley begins his essay by talking about time and geology. What is his point?

A. To defend the unitarianism principle that similar processes to those operative today have worked over long aeons in the past to create the formations we see today
B. To show that because of the long time periods operative in geology we simply cannot know how geological formations were created
C. To repudiate the uniformitarian principle and defend the view that geology evidences much larger-scale changes than are operative today
D. To show that continuous changes of the sort operative today could not explain the divergence of life forms

Clicker Question

When he turns to plants and animals, Huxley makes a great deal out of persistent species--species that have remained much the same through recorded time. What is his point?

A. These species are evidence of the Divine creation of original forms
B. These species are the final stage of an earlier process of gradual modification of pre-existing species
C. These species no longer have competitors and hence Natural Selection no longer works on them
D. These species show the limits to the ability of Natural Selection to generate changes in species

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."

Clicker Question

What view does Wilberforce defend in his review of *On the Origin of Species?*

A. Religion is supported by Revelation and appeals to science can only distort the truth

B. Darwin is a secret atheist and it is the duty of Christians to repudiate him

C. That important facts about humans such as reason and language are incompatible with Darwin's account of the origin of humans from lesser species

D. Darwin is only describing the process by which God is operative in nature--God is the guiding force behind Natural Selection

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

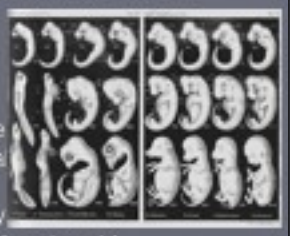
- Darwin took Thompson seriously: wrote to Wallace in 1869: "Thompson's views on the recent age of the world have been for some time one of my sorest troubles."
  - His response was to ask: What could speed up the process of evolution?
    - One possibility to which he appealed: inheritance of acquired 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): A Friend?

"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

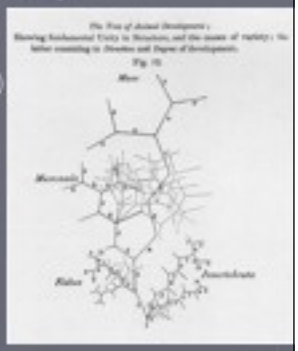
- All multi-celled organisms go through stages of becoming globular masses, which hollows out and becomes a gastrula with two layers: ectoderm and endoderm.
- Proposed a common origin of multi-celled organisms from a species he named Gastraea.
- Mechanism for developing more complex organisms:
  - Compress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

Haeckel's Representation of Phylogeny

- Extended Darwin's 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 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

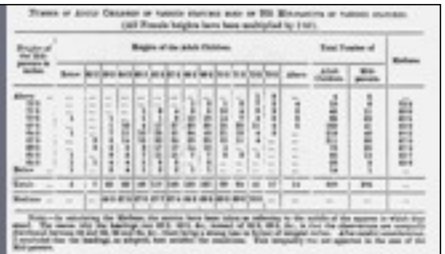
Studies with peas:

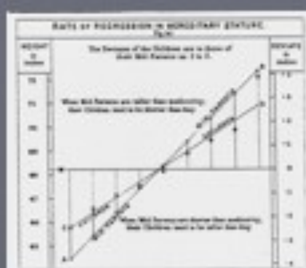
- Larger peas give rise to larger offspring, but very large peas do not give rise to ones as large as themselves
- Likewise with smaller peas
- Reversion to the mean
- Very interested in the heritability of traits by humans—height, weight, visual acuity, "talent and character"

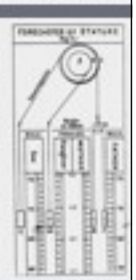
Diameter of Parent Peas (100 of each)	Mean Diameter of Offspring Peas
21	17.26
20	17.07
19	16.37
18	16.40
17	16.13
16	16.17
15	15.98

Galton's studies of height

- Compared the mean height of parents in 205 families (calculated by multiplying the mother's height by 1.08 and averaging that and her husband's height) with the height of 928 adult children (multiplying daughters' heights by 1.08 again).
- Graphed the results comparing expected value (mid-parents) and actual (children)







Galton and Eugenics

- "Eugenics is the study of agencies under social control that may improve or impair the racial qualities of future generations, whether physically or mentally."

SIR FRANCIS GALTON.

SIR FRANCIS GALTON'S WILL.

BEQUEST TO LONDON UNIVERSITY.

THE STUDY OF EUGENICS.

Eugenics Program

"The feeble nations of the world are necessarily giving way before the nobler varieties of mankind: and even the best of these, so far as we know them, seem unequal to their work. The average culture of mankind is become so much higher than it was, and the branches of knowledge and history so various and extended, that few are capable even of comprehending the exigencies of our modern civilization; much less of fulfilling them. We are living in a sort of intellectual anarchy, for the want of master minds. The general intellectual capacity of our leaders requires to be raised, and also to be differentiated. We want abler commanders, statesmen, thinkers, inventors, and artists. The natural qualifications of our race are no greater than they used to be in semi-barbarous times, though the conditions amid which we are born are vastly more complex than of old. The foremost minds of the present day seem to stagger and halt under an intellectual load too heavy for their powers."

"Hereditary Character and Talent" (MacMillan's Magazine, 1864-5)

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."
- "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."

Pearson and Statistics

- The accepted view (from Adolphe Quetelet) was that all distributions could be represented as normal
  - Pearson investigated skewed distributions and developed curves for asymmetric distributions
  - Showed that true variability could be distinguished from chance variation among errors
  - Coined the term "standard deviation"
  - Developed the X^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

Discussion Question

What accounted for the great interest in eugenics amongst biologists (and many others, including Teddy Roosevelt) from the 1860s until the 1940s?

A. Growing awareness of the enfeeblement of the poorer classes in industrialized England
B. Reprots like Darwin's of the savage and degraded forms of life he found in many parts of South America
C. Recognition that breeders have been able to promote great improvements in their stocks than when left to Natural Selection
D. The horrors of putting eugenics into practice (e.g., the Holocaust) were not yet known