

The Lead-up to *On the Origin of Species*

Epigenesis vs. Preformationism

- Historically there has been a close conceptual relation between formation of species and development of individual organisms:
 - Both involve the creation of organized systems from something that appeared less organized
- Historically there were two competing perspectives on development:
 - Epigenesis: mechanical causal processes combined to create new organisms
 - Challenge—inconceivability of reliably making complex forms in this way
 - Preformationism: All organisms preformed in the initial creation
 - Development consisted of the growth of a hidden seed that contained all the complexity of the organism
 - Theorists differed over where the seed existed—female egg, male sperm, in the soil

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Species and classification

- History of classification systems, usually focused on practical objectives (plants as medicines)
- The 17th and 18th centuries were a period of exploration, with explorers bringing back to Europe many specimens of life found elsewhere
 - Researchers recognized a need to organize these
- The Swede Karl von Linné (Linnaeus: 1707-1778) was himself an explorer and sought to develop a *natural* system of classification



Linnaeus' task

- Desiderata of a classification system
 - Provide a definition of what a species is (i.e. a theoretical "species concept")
 - Show the relationships between species
 - Provide a method of classifying any given specimen
- Assumptions
 - Essentialism—each species has an essence, set down in the type specimen
 - Species are separately created
 - Each species has a place in the economy of nature

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Discussion Question

If you were Linnaeus, what would you make the essence of the human species, homo sapiens?

Wisdom, as the name suggests

Featherless biped, as Aristotle taught us

Having human DNA

None--humans like other species have no essences

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Linnaeus's System

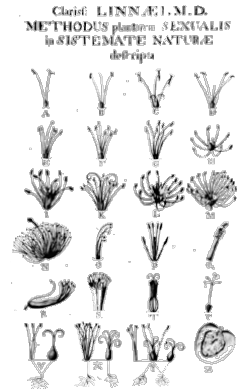
Linnaeus extended the species-genera relationship to higher levels: genus, order, family, kingdom

He tried to create a rational basis for identifying similarities

in plants, used sex organs (number & arrangements of pistils, stamens) as the major basis for grouping

Not always perfect:

- grouped conifers such as pines, firs, and cypresses as well as a few true flowering plants, such as the castor bean, in the Class Monoecia (separate male and female "flowers" on the same plant), Order Monadelphia (multiple male organs joined onto one common base)
- grouped algae, lichens, fungi, mosses and other bryophytes, and ferns together as plants that lacked obvious sex organs in the Class Cryptogamia, or "plants with a hidden marriage."



Linnaeus on Transformations and Transmutations

Species could undergo *transformations* (change of traits) but not *transmutations* (formation of new species) through:

Hybridization

Selection

(these could act separately or together)

These processes could generate *varieties*, "*races*" or subspecies, *but not new species (essences)*

Active Debate on Transmutation

The late 18th century/early 19th century was a period of active debate over whether species could change into other species

Against: George Cuvier: The parts of organisms work together so intimately that changing one trait required changing all the others: "Give me one bone, and I can reconstruct the entire organism"

Similarities between organisms explained by the Creator's use of a common set of bauplans that the Creator modified in making each species

For: Geoffroy St. Hilaire argued for a common origin of all vertebrates, with different organs arising as variants of a common structure

Debated Cuvier (whom he had brought to Paris!) at the French Academy 8 times in 1830 as to which is primary—function (Cuvier) or form (Geoffroy)



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Jean Baptiste Lamarck, Chevalier de Lamarck (1744-1829)

- While working at the Paris Museum of Natural History, found it difficult to differentiate species from mere varieties
- In *Philosophie Zoologique* (1809) proposed a mechanism for improvement of species



Animal seeks to improve some characteristic
Changes it makes in its lifetime are passed to offspring
Inheritance of effects of use and disuse

Giraffe: brought to France from Africa during Napoleonic campaigns of 1798-1799

- Striving to eat from branches stretched neck
- Physiological fluids from neck change germ plasm
- Changed germ plasm passed to offspring



Lamarck on Species Progression

- Species gradually change into improved species
Ascending a ladder from the lowest form to the highest
- Then why are there still "lower" species?
Spontaneous generation
- Although a foremost naturalist, he quickly fell from creditability:

The Church condemned his writings as "atheistic", as God had no explicitly stated role

Opposed by naturalists for proposing a mechanism of transformation with no empirical support

Idea of organisms "striving for perfection" rejected as ludicrous

Became associated with "inheritance of acquired characters" and ridiculed for giraffe example

Discussion Question

What makes the idea of inheritance of acquired characteristics ludicrous?

Anyone can see that offspring generally lack the abilities their parents acquired

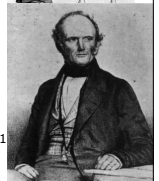
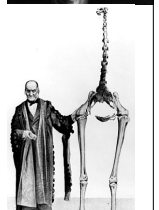
There is no mechanism by which it can happen

We know that sperm and eggs are not affected by what happens in the rest of the organism

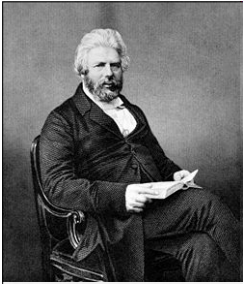
It isn't ludicrous--it happens

The Debate Extended to England

- Erasmus Darwin, Charles' grandfather, defended transmutation in a manner similar to Lamarck: wants and desires ("lust, hunger, and danger") result in habits, which are then inherited
- Richard Owen defended a view in which all vertebrates were derived from the same archetype
Introduced the distinction between homology and analogy
 - Homology: same parts due to common archetype
 - Analogy: similarity due to conditions of existence
- Charles Lyell, a geologist, advocated uniformitarianism: there were no causes in the past that are different from those operative today

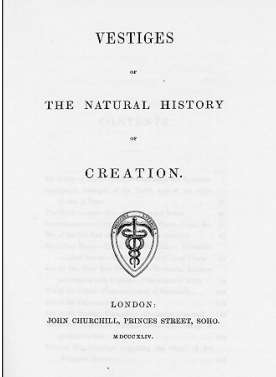


Applied not just to rocks, but to the arising and extinction of species



Vestiges of the Natural History of Creation (1844)

- Published anonymously by Robert Chambers, whose family owned *Chambers Encyclopedia*
- Proposed sequence of geological epochs punctuated by catastrophes
- A few species survived and radiated out to form many new groups in the next epoch
- Roundly condemned, including by Darwin
- Made Darwin and others skittish about espousing evolution



Charles Darwin

- Darwin born into upper middle class
- Left medical school since he couldn't stand the sight of blood
- Became interested in biology and went on field trips in Scotland, where he became impressed with the power of geological forces to shape terrain
- Went to Cambridge to become a country parson, but instead became interested in botany and natural history
- Graduated in 1831 with "Poor Degree"

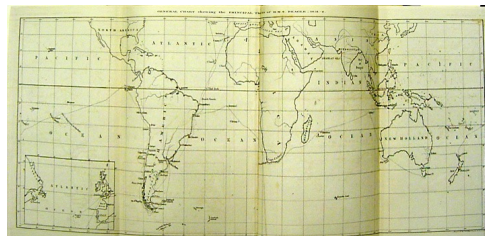


The Beagle

- Set sail on December 26, 1831 as companion to Captain Fitzroy
- Purpose: to obtain information on
 - Weather, ocean currents, ocean depths, especially around east and west coasts of South America
 - Gather military and commercial information as to who is trading where, especially the French, who were making moves into South America



H.M.S. Beagle in the Strait of Magellan



Clicker Question

What is the central topic in the first two chapters of *On the Origin of Species*?

That new species originated via Natural Selection

The laws of heredity--how specific traits are passed from parent to offspring

The occurrence of variability in both domesticated and wild species

Demonstrating that true species always breed pure--never exhibiting new traits

Pigeons

Why is Darwin so obsessed with pigeons?



Primrose and Cowslip

Are they varieties or different species?

Where their habitats grade into each other, they generate intermediate forms

Primrose growing along the edges of woodlands



Cowslips growing in pastures



Where they collide, an intermediate form appears



Clicker Question

What is a major reason Darwin emphasizes so strongly the variation in both domestic and wild species?

He is showing that we need to cleanup the practice of taxonomy to distinguish true species

He is arguing that investigators should focus on essential, not accidental traits

He is calling into question the distinction between species and varieties

He is arguing for replacing the notion of species with that of variety

Variation under nature

"I [will not] here discuss the various definitions which have been given of the term species. No one definition has as yet satisfied all naturalists; yet every naturalist knows vaguely what he means when he speaks of a species."

Variability in both unimportant and important characteristics, including internal ones:

"I should never have expected that the branching of the main nerves close to the great central ganglion of an insect would have been variable in the same species; I should have expected that changes of this nature could have been effected only by slow degrees: yet quite recently Mr Lubbock has shown a degree of variability in these main nerves in *Coccus*, which may almost be compared to the irregular branching of the stem of a tree"



Varieties and incipient species

- ✦ Difference between species and varieties is not sharp: What one researcher identifies as a species, another identifies as a variety:
 - ✦ "From these remarks it will be seen that I look at the term species, as one arbitrarily given for the sake of convenience to a set of individuals closely resembling each other, and that it does not essentially differ from the term variety, which is given to less distinct and more fluctuating forms. The term variety, again, in comparison with mere individual differences, is also applied arbitrarily, and for mere convenience sake."

Why is this significant for Darwin?

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Discussion Question

If one focuses on variation, and allows that with accumulation of variation one might produce new species, what happens to the idea of species having essences?

The idea of an essence is still important--only a change of essence results in new species

The idea of an essence to a species is discredited--as new variation arises, the species change

The whole idea that the natural world is divided into species is threatened--there are no sharp boundaries between species

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Putting Observations Together: Transmutation of species

- ✦ The closer an island was to the nearest mainland, the more the island fauna and flora resembled the mainland forms
- ✦ The closer two islands were in an archipelago, the more similar the fauna and flora
- ✦ Darwin wondered:
 - Could island forms have established themselves as offshoots of mainland forms?
 - Could their similarities and differences be the result of divergence from a common ancestor?
- ✦ Beagle returned to Britain in October 1836
- ✦ In early 1837 Darwin began his Notebook on the transmutation of species (second edition in 1845 entitled Voyage of the Beagle)

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Transmutation Notebooks

- ✦ Descent with modification
- ✦ Notion of divergence from a common ancestor
- ✦ Variation within domestic varieties
- ✦ Variation within natural species
- ✦ Patterns of geographic distribution

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Transmutation: Puzzles and Answers

- Why homology?
 - Adaptations that modify the same inherited body plan
- Why vestigial organs?
 - Parts once common to a whole group not used in current organisms
- Why distinct patterns of geographic distribution?
 - Result of migration and adaptation to new localities
- Why do similar types of animals have similar behaviors? (Humans, dogs, horses “yawn”, but lizards and birds do not)
 - Common ancestry
- Why do older fossils differ more from modern forms than younger fossils?
 - diverged from common ancestor much longer ago than more recent fossils
- Why is there greater similarity of early embryos than of adult forms
 - Species share common ancestral developmental pathways

Which of His Observations Has Darwin Not Yet Explained?

- Organisms are adapted to environments
- Two forms of iguana

Land

Marine—the only sea-going lizard in the world

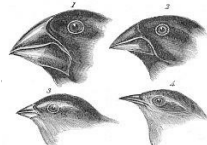
Obvious related but occupy different niches to which each is fitted



On the other hand, Darwin noted that similar niches in different locations occupied by different species, each adapted to the similar niche: the rhea of South America, the African ostrich, the emu of Australia, and the cassowary of New Guinea and Australia

Galapagos: Finches

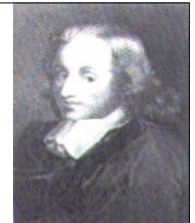
- All the island species were similar to the **one** species found on the mainland
- Major specializations were observed in beak shape and size: Large, medium and small seed and insect-eaters, cactus eaters, Tree-dwelling and ground-dwelling
- Pattern true not just of finches: giant tortoises, lizards, mockingbirds
- In each case, organisms exhibit traits useful in their local environments



1. *Geospiza magnirostris* 2. *Geospiza fortis*
3. *Geospiza parvula* 4. *Certhidea olivacea*
Finches from Galapagos Archipelago

Major question: How did they become adapted?

William Paley (1743-1805)



- “In order to pass the B.A. examination, it was, also, necessary to get up Paley's *Evidences of Christianity*, and his *Moral Philosophy*. . . The logic of this book and as I may add of his *Natural Theology* gave me as much delight as did Euclid. The careful study of these works, without attempting to learn any part by rote, was the only part of the Academical Course which, as I then felt and as I still believe, was of the least use to me in the education of my mind. I did not at that time trouble myself about Paley's premises; and taking these on trust I was charmed and convinced of the long line of argumentation.” Charles Darwin. *Autobiography*

Watchmaker Argument

- ▶ “when we come to inspect the watch, we perceive. . . that its several parts are framed and put together for a purpose, e.g. that they are so formed and adjusted as to produce motion, and that motion so regulated as to point out the hour of the day; that if the different parts had been differently shaped from what they are, or placed after any other manner or in any other order than that in which they are placed, either no motion at all would have been carried on in the machine, or none which would have answered the use that is now served by it. . . . the inference we think is inevitable, that the watch must have had a maker -- that there must have existed, at some time and at some place or other, an artificer or artificers who formed it for the purpose which we find it actually to answer, who comprehended its construction and designed its use.
- ▶ “Every observation which was made in our first chapter concerning the watch may be repeated with strict propriety concerning the eye, concerning animals, concerning plants, concerning, indeed, all the organized parts of the works of nature.”