Part V

The Darwinian Revolution

Chapter 12

Introduction

12.1 Readings and Homework

- Darwin Selections: pp. 3-13, 23-40, 44-49, 61-81, 285-87

IMPORTANT NOTE: *Except otherwise noted, the following course notes are a reproduction of Prof. Schmaus Course notes.*

12.2 The Road to Evolution: Scientific influences

12.2.1 Natural Theology and the problem of the fixity of species

In the beginning of the 19th century, people thought of **biological species as fixed and eternal**. This view, I think, has less to do with the Bible, which is silent on this question, than with the **Natural Religion** tradition.

1. Indeed, we do not find people even debating the question before Natural Religion became popular some time around the 17th century.

2. The thought was that if God designed species, he would have made them the best they could be, so why should they change?

Ironically, it was the very tradition of Natural Religion that led to the demise of the belief in the fixity of species

1. in the 18th century, Natural Religion came to be associated with the **detailed and exhaustive study of nature**, including the comprehensive classification of living things

2. **Linnaeus** was part of this natural religion tradition

a. the great classifier who bequeathed to us the binomial system saw himself as studying God's plan

b. in the beginning he regarded species as fixed

c. however, towards the end of his career, he came to doubt the fixity of species

(1) he couldn't help but notice how closely related the species of the same genus were

(2) leading him to wonder whether they had a common ancestor

D. the study of **embryology and development** also led people to question the fixity of species

This was also the time where the idea has arisen that the Earth could have an history – geology.

12.2.2 Erasmus Darwin (Darwin anthology, p. 33)

A. the grandfather of Charles Darwin

B. a physician

C. came to believe in the **mutability of species** because of

1. changes undergone by animals during embryonic development; e.g.

a. caterpillar into butterfly

b. tadpole into frog

2. changes brought about through **domestication**, **hybridization**

3. **monstrous births**

4. **structural similarity** among vertebrates

D. Erasmus Darwin also recognized the significance of:

1. biological **adaptations** such a protective coloring

2. artificial and sexual **selection**

3. **vestigial** organs

E. **Erasmus Darwin's theory of evolution**

1. organisms seek to satisfy wants and desires due to "lust, hunger, and danger" (33)

2. as a result of their exertions, new irritations, sensations, volitions, and associations – that is, habits – stimulate and direct the development of their organs

3. these "improvements" are then handed down to successive generations

12.2.3 Lamarck (Darwin 34, 44-9)

A. developed an **evolutionary theory** similar to that of Erasmus Darwin

B. **notion of species**:

1. working in the Paris Museum of Natural History on the classification of invertebrates, he encountered great difficulty in distinguishing species from varieties of species

2. concluded that there is no difference and that species could be transformed into new species

C. according to Lamarck's theory, **two factors** were at work in evolution

1. all living organisms are **striving to improve** themselves and achieve higher levels of complexity (Darwin, 46)

a. no species ever go extinct

b. new simple organisms constantly arise through spontaneous generation

c. if this were the only factor at work, all the animal species could be arranged in a progressive series

d. the effects of the **environment** on animals creates anomalies (47, q.v.)

2. Like Erasmus Darwin, Lamarck also believed that **animals' felt needs led to new habits and thus new organs that satisfied these needs** (Darwin, 34-5, 45, 47-9)

a. thus adapting the animal to the environment

b. these new organs, the effects of use and disuse, could then be inherited (Darwin, 44-5)

c. Lamarck's theory relied on **subtle fluids** to explain these changes (Darwin, 45)

1. parts of the organism that were used a lot would attract more of this fluid and would increase in size and complexity

2. parts that were not used much would not attract this fluid and would degenerate

D. as the second part of the theory could not apply to plants or even to the lowest animals, **he really did not have a unified theory of evolution**

E. for these and other reasons, his theory was not accepted by other scientists such as Cuvier

12.2.4 Cuvier (Darwin, 35)

A. Cuvier held a **more prestigious position** in the same museum as Lamarck, working on comparative anatomy of vertebrates, while Lamarck worked on invertebrates

B. Studying the rock layers around Paris, he was struck by the fact that some contained **fossils** of salt-water animals, others contained fossils of fresh-water animals, and some had no fossils at all

C. He explained these facts as due to a **series of catastrophes** on the scale of Noah's flood, with new species created by God after each catastrophe

1. unlike Lamarck, then,

a. he allowed for species to go extinct

b. but he did not allow them to mutate or change

2. after each catastrophe, God created more complex, more advanced creatures

3. hence, the younger the layer of rock, the more the fossils in it resembled living animals

D. his **reasons for rejecting the transmutation** of species included:

1. the absence of intermediate forms

2. the fact that organisms from the oldest tombs in Egypt resembled living organisms

3. his observation that animals could be classified according to four distinct body plans and hence did not reflect a linear progression from simplest to most complex, as in Lamarck's theory (Darwin, 35-6)

a. radiata: starfish, jellyfish

b. articulata: worms, insects

c. mollusca: snails, octopus

d. vertebrata

E. for Cuvier, the correlation of the parts of an animal together with the way they adapt the animal to its environment was evidence of their having been designed and created that way

12.3 The road to Evolution: Methods in Science

THE FOLLOWING TWO SUBSECTIONS ARE NOT FROM PROF. SCHMAUS

12.3.1 Charles Lyell (Darwin, 36)

Darwinism is not only a set of scientific theses: it is also a set of philosophical principles about scientific method. Darwin's philosophical views on scientific method is one important reason for his tremendous influence.

Darwin embraced A. Lyell's methodology as exposed in the *Principles of Geology*:

- **natural causes**: Complete account of changes on the earth, encapsulating in general laws and search for the natural causes
- **uniformitarianism**: same laws at work in the past as now
- **gradualism**: changes on earth surface occurred over long periods of time – against Catastrophism
- **actualism**: search for causes that are actually at work and can thus be studied experimentally
- **evidence**: introduction to and criticism of Lamark's ideas about the transformation of species into another for lack evidential support

Important: Lyell's philosophical ideas (on the nature of science) influenced Darwin as much as other's scientific ideas. His aim is **to take on Lamarck's ideas, but follow Lyell's principles as far as scientific methodology is concerned.** That is to say, to give an account of the slow, gradual transformation of the species through natural causes still at work and which thus can be actually empirically studied.

12.3.2 Darwin and philosophy of science

- Philosophy of science is a newborn at the time in England

  - Hershell *Preliminary Discourse on the Study of Natural Philosophy*: importance of evidence

  - Whewell

  - Mill

- Contradictory accounts:

  - Tradition is: Baconian method: induction – no speculation

- The problem is that no scientific observation is possible without an hypothesis in mind

- back and forth from observation to theorizing and observation again

- **The main problem of scientific methodology is the proper ratio between speculation and observation.**

  - Observation alone obviously does not allow to construct any theory.

  - Speculation alone allows for all kinds of systems, which may be coherent but lack evidential support.

- New approaches in philosophy of science:

  - modern physics = mathematical physics, deterministic laws of nature

  - Darwin "introduced the concepts of probability, chance, and uniqueness in scientific discourse" (23)

  This was really new and will be problematic in the eyes of Darwin's contemporaries.

12.3.3 Influences from political philosophy and economics

(From Prof. Schmaus)

1. reading Quetelet may have introduced him to population thinking,

   a. that is, to thinking about species as populations of diverse organisms that vary with respect to some mean

   b. rather than as copies of an ideal type

2. Adam Smith on laissez-faire capitalism: economic trends can arise as unintended consequences of individual interactions

3. but most importantly, Malthus's *Essay on population*

   a. for Malthus, population increased in a geometric and subsistence only in an arithmetic ratio (Darwin, 37 q.v., 39-40)

   1.) this law pervades animal kingdom

   2.) thus, as de Beer suggests, Malthus unwittingly puts humans on the same level as animals

b. as early as 1838, Malthus's work suggested to Darwin the idea of a struggle for existence, in which favorable variations would be preserved and unfavorable ones destroyed

12.4 Charles Darwin

12.4.1 Early Life

- A. was born into a wealthy, unconventional, and free-thinking family 1809
- B. Even as a child had a great **interest in nature**
- C. first went to University of **Edinburgh** to study medicine

  1. to follow in the footsteps of his father and grandfather

  2. while there, he came to know Dr. **Robert Grant**, who was defending Lamarck's evolutionary hypothesis even before Lyell made it well known in England

  3. then decided against medicine as a career

- D. then in 1828 went to Cambridge to study for the **ministry** instead

  1. as Mayr points out, this was entirely reasonable as **all the naturalists in England at that time were ordained ministers**, including the professors at Cambridge, including (Darwin 24):

  a. John Henslow, the botanist

  b. Adam Sedgwick, whom Darwin accompanied on geological field trips

  2. **Paley's *Natural Theology*** was required reading there

  a. Darwin almost knew it by heart (Darwin, p. 5, q.v.)

  b. as de Beer points out, Paley's work consists of a huge catalogue of facts about adaptation (Darwin, p. 39)

  c. this work thus turned out to be very useful for evolutionary science, contrary to Paley's more theological purposes

  3. Darwin also acquired an interest in the **philosophy of science**

  a. he learned from **William Whewell**, a Cambridge professor, that **a successful theory must integrate a wide variety of facts**

b. also read **John Herschel**'s work on the philosophy of science while at Cambridge

– alluded to in opening paragraph of the *Origin*: "that mystery of mysteries, as it has been called by one of our greatest philosophers" (Darwin, p. 95)

4. also read Alexander **Humboldt**'s account of his voyages, and acquired desire to take a voyage to study natural history

12.4.2 Voyage of the *Beagle*

How Darwin got on a boat

- A. set sail on a voyage of exploration and map making in 1831 and returned five years later
- B. was arranged by Henslow and Darwin's uncle Josiah Wedgewood for Darwin to go along as naturalist and gentleman companion to **Captain FitzRoy** (Darwin 25)
- C. **read Lyell**'s *Principles of Geology* while traveling around South America on the *Beagle*

  1. found much to confirm Lyell's uniformitarianism, if not his steady-state theories

  2. went on to use Lyell's idea of the rising and subsiding of the earth's surface to develop a successful theory of coral reefs

12.4.3 Evolution of Darwin's ideas

D. Darwin **still believed in the fixity of species** when he set sail at the age of 22

E. However, he was **struck by two kinds of facts** in his studies of South America:

1. **relations of fossil to present living beings**

   a. such as armadillos and glyptodonts, sloths and megatheriums

   b. "law of succession of types:" that there is a close resemblance among animals inhabiting the same area over time

2. **distribution of living beings**

   (a) natural theology explained that species were designed for the environment they inhabited

   That is to say, natural theology takes it that there is one specific kind of species for one specific kind of environment.

   (b) but this account could not explain the fact that there are often **no sharp boundaries** between similar species

   1.) e.g., different species of rhea, a large flightless bird of South America

   2.) in fact, sometimes the territories of closely related species overlapped, and they were forced to compete with each other

   (c) this observation may have led Darwin to think about nature in terms of **competition** between closely related forms, rather than in terms of a benevolent design in which there is a "balance of nature"

   So: different kinds of environment are inhabited by similar kinds of species when the regions are close

   (d) Darwin also came to be convinced of evolution through his study of how **physical barriers like oceans** affect geographical distribution

   1.) adaptation alone could not explain the fact that similar environments that were widely separated had different life forms

   2.) for example, the rhea of South America, the African ostrich, the emu of Australia, and the cassowary of New Guinea and Australia inhabit similar environments, yet are very different

   3.) such facts also raise problems for the idea that God designed animals to be suited to their environments

   So: Similar environments are inhabited by different kinds of species when they are widely separated.

   (e) the study of the distribution of species on oceanic islands proved to be especially important

Galapagos Islands

1. **the species on oceanic islands resemble but are not the same as those on nearest continent**, suggesting migration and transmutation

(Darwin, 69)

a. physically, these islands are like the Cape de Verde Islands off Africa (78)

b. yet the life forms on the Galapagos resemble those in the Americas while those on the Cape de Verde Islands resemble those in Africa

2. **in fact, he learned that the giant tortoises actually differed from island to island** (78)

a. same was true for lizards, mockingbirds (79)

b. suggests that they had evolved in different directions on each island after their arrival

3. **scarcity of life forms**

a. there were very few mammal species – one mouse he thought indigenous, and a rat descended from ship born rats (70)

b. certain species, such as frogs, were entirely lacking. He speculated that this is because their eggs could not travel in sea-water (72)

c. he found several species of lizards, but these are reptiles, which lay eggs with shells

d. he remarks that he knows of no other place where the reptiles outnumber the mammals (77-8, q.v.)

4. **he also noticed that the islands were populated by related species of finches** (see picture on p. 71)

a. what struck him was the gradation in the size of their beaks (Darwin, 70-71)

b. it suggested to him that, due to lack of birds on the islands, one original species had been modified in different ways (71, q.v.)

c. unfortunately he kept no records of which islands each kind was from (79)

12.4.4 Back home in England: toward publication

Gathering evidence

A. begins to organize his collection and consult other scientists

B. Bird collection

1. in 1837, the ornithologist John Gould showed him that the mockingbirds he had collected on three different islands in the Galapagos were three different species, which led Darwin to think about **the role of geographical isolation in speciation**

2. somewhat later, he learned that some of the species of finches he had collected there were restricted to certain islands

3. **thinking about the birds of the Galapagos, Darwin began to regard the distinction between species and variety as vague and arbitrary**

D. collected information from plant and animal **breeders**, learned how they **exploited random variations**

12.4.5 Publication?

F. published *Journal of Researches* 1839

1. includes an account of the voyage of the *Beagle*

2. republished as *Voyage of the Beagle* 1845

3. even this contains some speculation about the transformation of species, especially the birds and reptiles on the Galapagos Islands as we have just seen

4. he also speculated on the development and inheritance of mental habits in animals, in order to explain the fact that birds on oceanic islands were not afraid of humans while birds from the continents inhabited by people were (Darwin, 81)

G. had worked out the theory of evolution by natural selection in his notebooks of 1842 and 1844, which he had shown to Joseph Hooker, the botanist, as early as **1844** (Darwin, 286)

H. occasion of the publication of the *Origin* (1859):

1. Darwin hesitated to publish for a long time

a. according to some scholars at least, his reluctance probably stemmed less from any doubts about his theory than from his unwillingness to disturb people and cause controversy

b. others may point to Darwin's extreme carefulness and his desire to amass enough facts to make a persuasive case

c. for instance, he spent eight years on his two-volume study of barnacles

2. Alfred Russell Wallace forced his hand in 1858 by sending him a paper in which he had been working out similar ideas (reprinted on pp. 61-4)

a. Wallace had similarly been stimulated by his studies of South America and the islands of what we today call Indonesia

b. like Darwin, Wallace

1.) also found the distinction between varieties and species unclear (Darwin, 61)

2.) described a struggle for existence (Darwin, 62)

3.) He argued that if some variety had an advantage in this struggle over the rest of the species, it would replace it (Darwin, 63)

3. Lyell and Hooker arranged for Darwin and Wallace (Darwin, 286)

a. to jointly present papers describing the new theory at the Linnaen Society meeting in London in 1858 (Darwin, p. 6)

b. and to publish extracts from their work

4. Darwin conceived the *Origin* of 1859 as an "abstract" of a much longer work – hence the lack of footnotes, references, etc.

12.5 Conclusion: "the gentlest of revolutionaries" (4)

Darwin ended up with a revolutionary theory, but he remains the gentlest of revolutionaries. He was extremely cautious: amass evidence and does not want to publish before Wallace's letter forces him to.

It should not be forgotten that he also contributed to:

- botany
- the theory of classification
- and many other sciences

12.5.1 "What is at stake is no less than a worldview" (7)

For the Church and the conventional believers, Darwin's theory of evolution is a challenge. But it was even more than that. Darwin's theory was to change completely the world view of the western world.

- Of course, the theory denies any privileged status to humans among other natural being – all natural beings descend from a common ancestor.
- Darwin's theory of evolution is at odds with one of the beloved idea of the time: fixity of species.
- The theories of a special status of the human species and of the fixity of species were part of the more general view that nature is the product of the benevolent design of God.

- Darwin replaces it with "struggle", "war" and "survival". Quite a change. – Cf. Quotations of Whewell and Darwin p.5

- That said, the most challenging feature of Darwin's theory might be that evolution is "a self-regulating mechanism" (14). The way the world is is explained by an internal, purely mechanistic process. No need for further explanation!!!

12.5.2 The Darwinian Effect

- Victorian era and science: industrial revolution and Empire – steam machine, railroad, steamship. "Science makes things happen"

- Huge effect: in any domain of knowledge, people try to introduce some elements of evolutionary theory

- Many critics – geology teacher Sedgwick

- Circle of supporters: Lyell (no open endorsement according to Lennox), Hooker, T.H. Huxley (Darwin's Bulldog) and naturalists, among which Wallace of course

- An important distinction: Darwinism is not Darwinisticism (Morse Peckham), the latter being an application of Darwin's principles to a domain to which they were not supposed to be applied (Typically, sociology, economics or politics).

- Such application contrasts with the extreme caution that Darwin displays in his writings about evolution.

- Note, however, that Darwin is "guilty" of some Darwinisticism when he denies intellectual abilities to women.

- But nothing in comparison to Social Darwinism – especially in the US

  - Herbert Spencer: the wealthiest is the fittest.

  - Laissez-faire economics: the state should not interfere with the natural selection of the fittest, which naturally, thence necessarily, leads to progress, to "the establishment of the greatest perfection and the most complete happiness".

- Use the Theory of Evolution as a rationalization of the huge social and economical discrepancies that were the result of the industrial revolution.