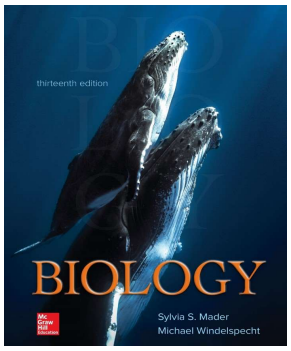
Darwin and Evolution



Biology

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Michael Windelspecht

Chapter 15
Darwin and Evolution
Lecture Outline

See separate FlexArt PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes.

15-1

Outline

15-2

15.1 History of Evolutionary Thought

Prior to Darwin

- The view of nature was determined by deep-seated beliefs held to be intractable truths rather than experimentation and observation.
- Biologists had slowly begun to accept various ideas of **evolution** (species change through time).

Evolution is the unifying principle of biology.

- Explains the unity and diversity of life
  - Similarities between living things reflect recent common ancestry.
  - Dissimilarities between living things reflect ancient common ancestry.

15-3

Darwin and Evolution

History of Evolutionary Thought (1)

Mid-Eighteenth Century Influences:

- Taxonomy matured during the mid-eighteenth century.
  - Linnaeus believed in the fixity of species.
    - Each species had:
      - An ideal structure and function, and
      - A place in the *scala naturae* (a sequential ladder of life)
    - He developed the binomial system of nomenclature.
      - System of classification for living things
  - Count Buffon:
    - A French naturalist
    - Wrote a 44-volume catalog of all known plants and animals
    - Provided evidence of descent with modification
    - Suggested mechanisms including environmental influences, migration, geographic isolation, and the struggle for existence

15-4

History of Evolutionary Thought (2)

Late Eighteenth Century Influences:

- Cuvier:
  - First to use comparative anatomy to develop a system of classifying animals
  - Founded the science of **paleontology**
  - Proposed **catastrophism**
    - Local catastrophes in the past had caused Earth's strata to have a new mix of fossils.
    - After each catastrophe, the region was repopulated by species from surrounding areas.
    - The result of the catastrophes was change appearing over time.

15-5

History of Evolutionary Thought (3)

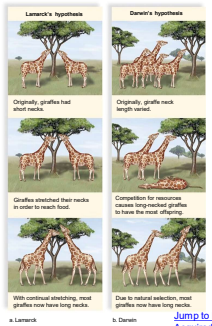
Late Eighteenth/Early Nineteenth Century Influences:

- Lamarck:
  - First biologist to:
    - Propose evolution
    - Link diversity with environmental adaptation
  - Concluded that more complex organisms are descended from less complex organisms
  - Proposed the **inheritance of acquired characteristics** – Lamarckianism
- Malthus:
  - Economist who studied the factors influencing the growth and decline of human populations
    - He related famine, war, and epidemics to the problem of populations outstretching their limited resources.
    - Darwin used Malthus' principles to formulate his idea of natural selection.
- Charles Lyell:
  - Earth is subject to slow but continuous cycles of erosion and uplift.
  - He proposed **uniformitarianism**, which states that rates and processes of change are constant.

15-6

Darwin and Evolution

Lamarck's Inheritance of Acquired Characteristics



Jump to Lamarck's Inheritance of Acquired Characteristics Long Description

15-7

15.2 Darwin's Theory of Evolution (1)

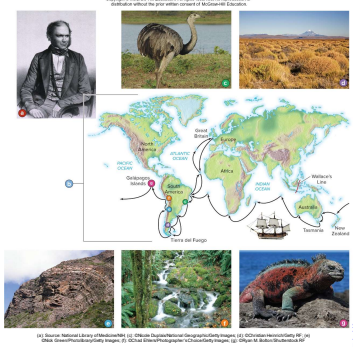
Geological observations consistent with those of Hutton and Lyell

Biogeography:

- Biogeography is the study of the geographic distribution of life forms on Earth.
- Darwin saw similar species in similar habitats.
- He reasoned that related species could be modified according to the environment.
- Living forms could be descended from extinct forms known only from the fossil record.

15-8

15.2 Darwin's Theory of Evolution (2)



Jump to 15.2 Darwin's Theory of Evolution (2) Long Description

15-9

Darwin and Evolution

Darwin's Theory of Evolution (1)

Biogeography is the study of the range and geographic distribution of life forms on Earth.

Darwin compared South American animals to those with which he was familiar.

- Instead of rabbits, he found the Patagonian cavy in the grasslands of South America. The Patagonian cavy has long legs and ears but the face of a guinea pig.

Did the Patagonian cavy resemble a rabbit because the two types of animals were adapted to the same type of environment? Both animals ate grass, hid in bushes, and moved rapidly using long hind legs. Did the Patagonian cavy have the face of a guinea pig because of common descent with guinea pigs?

15-10

A Glyptodont and a Giant Sloth

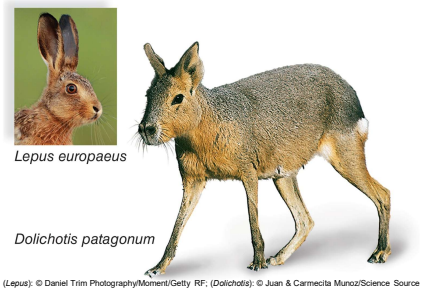
a.Glyptodon

b.Mylodon

Jump to A Glyptodont and a Giant Sloth Long Description

15-11

The European Hare and the Patagonian Cavy



Lepus europaeus

Dolichotis patagonum

(*Lepus*): © Daniel Trim Photography/Moment/Getty RF; (*Dolichotis*): © Juan & Carmecita Munoz/Science Source

15-12

Darwin and Evolution

Darwin's Theory of Evolution (2)

Galápagos Islands

- Tortoises
  - Darwin observed that tortoise neck length varied from island to island.
  - He proposed that speciation on islands correlated with a difference in vegetation.
- Finches
  - Darwin observed many different species of finches on various islands.
  - Significant variety in beaks
    - Ground-dwelling finches have beaks adapted to eating seeds and tree-dwelling finches have beaks sized according to their insect prey.
  - He speculated that they could have descended from a mainland finch species.

15-13

Galápagos Tortoises

a. b.

a: © Kevin Schafer/Corbis; b: © Tim Laman/National Geographic/Getty Images

Jump to Galápagos Tortoises Long Description 15-14

Darwin's Theory of Evolution (3)

Natural selection and adaptation:

- Members of a population have heritable variations.
- More individuals are produced in each generation than the environment can support.
- Organisms compete for available resources.
- Some individuals have adaptive characteristics.
  - Favorable traits that result in increased survival and reproduction which causes organisms within a population to differ in their reproductive success.
- Natural selection can result in a population adapted to conditions in the local environment as the environment changes.
  - An increasing proportion of succeeding generations will have favorable characteristics.

15-15

Darwin and Evolution

Variation in a Population

© Lisette Le Bon/SuperStock

15-16

Darwin's Theory of Evolution (4)

Darwin emphasized that individuals from a population vary in their:

- Functional characteristics
- Physical characteristics
- Behavioral characteristics

He proposed that these variations:

- Occur randomly
- Can be harmful, helpful, or neutral
- Are essential to the natural selection process
- Allow adaptation to the environment over time

15-17

Darwin's Theory of Evolution (5)

Fitness is the relative reproductive success of an individual.

- The most-fit individuals in a population capture a disproportionate share of resources.
- Interactions with the environment determine which individuals reproduce the most.
- Example: Among western diamondback rattlesnakes (*Crotalus atrox*) living in a dark environment, the most fit are black; but among those living in a light environment, the most fit are light.
  - Background matching helps an animal avoid being captured.

Adaptation

- Change that helps a species become more suited to its environment
- Product of natural selection

15-18

Darwin and Evolution

Darwin's Theory of Evolution (6)

Artificial selection

- A breeder chooses which traits to perpetuate and selects the plants and animals that will reproduce.

All dogs are descended from the gray wolf.

- They began to be domesticated between 18,800 and 32,000 years ago.
- The process of diversification led to extreme phenotypic differences.
  - The wolves under domestication were separated from other wolves.
  - Each human tribe selected for whatever traits appealed to them.

15-19

Artificial Selection of Animals

(wolf): ©Nicholas James McCollum/Moment Open/Getty RF; (bulldog): ©Willee Cole/Getty RF; (whippet): ©Daniela Jakob/123RF

15-20

Darwin's Theory of Evolution (7)

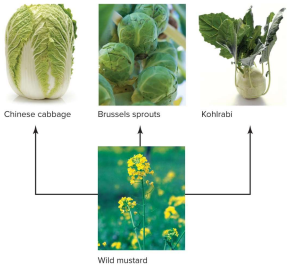
Artificial selection in plants:

- The following vegetables are derived from a single species, *Brassica oleracea*:
  - Chinese cabbage
  - Brussel sprouts
  - Kohlrabi
- Darwin described artificial selection as a model by which to understand natural selection.

15-21

Darwin and Evolution

Artificial Selection of Plants



(cabbage): ©Jiang Hongyan/Shutterstock RF; (brussels sprouts): ©Anne Murphy/Moment/Getty RF; (kohlrabi): ©Foodcollection RF; (mustard): ©Medioimages/PunchStock RF

Jump to Artificial Selection of Plants Long Description

Darwin's Theory of Evolution (8)

Darwin's natural selection hypothesis was based on:

- Observation of tortoises and finches on the Galápagos Islands

Darwin's Theory of Evolution (9)

Each of the 13 species of Galápagos finches has a beak adapted to a particular way of life.

- A heavy beak is suited to a diet of large seeds.
- The beak of the warbler-finch is suited to feeding on insects.
- A longer, somewhat decurved beak and the split tongue of the cactus-finch are suited to probing a cactus for seeds.

a. Large, ground-dwelling finch
b. Warbler-finch
c. Cactus-finch

a: © Miguel Castro/Science Source; b: © Celia Mannings/Alamy; c: © Michael Stubblefield/Alamy RF

Jump to Darwin's Theory of Evolution (9) Long Description

Darwin and Evolution

Darwin's Theory of Evolution (10)

Peter and Rosemary Grant are observing natural selection as it occurs in finches on Daphne Major.

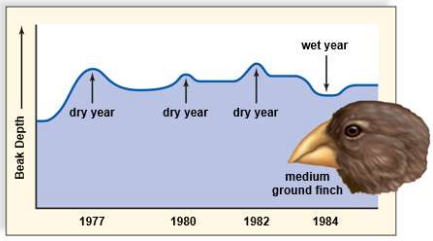
- The beak size of the medium ground finch adapts to the weather.

Other observations of natural selection

- Changes in the shells of marine snails are due to hunting by crabs.
- Changes in the beak length of the scarlet honeycreeper are due to a new food source.
- Industrial melanism
- Bacterial resistance to antibiotics

15-25

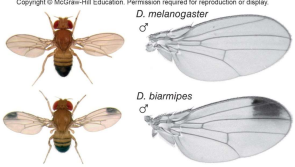
Evolution in Action (1)



Jump to Evolution in Action (1) Long Description

15-26

Evolution in Action (2)



a.

Jump to Evolution in Action (2) Long Description

b.

(all): © Nicolas Gompel and Benjamin Prudhomme

15-27

Darwin and Evolution

15.3 Evidence for Evolution

Fossil evidence

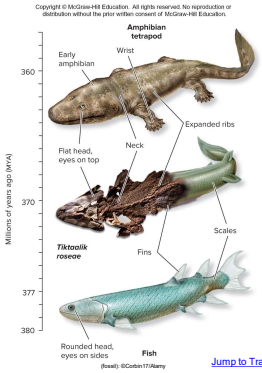
- **Fossils** are the remains and traces of past life. Traces include trails, footprints, or preserved droppings.
- Fossils record the history of life from the past.
- They document a succession of life forms from the simple to the more complex.
- Sometimes the fossil record is complete enough to show descent from an ancestor.

Transitional fossils are a common ancestor for two different groups of organisms.

- They allow us to trace the descent of organisms.

15-28

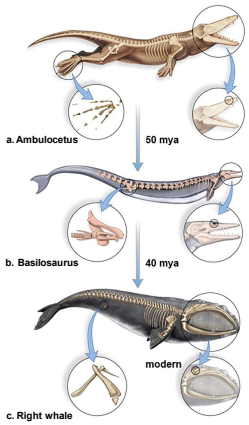
Transitional Fossils



Jump to Transitional Fossils Long Description

15-29

Anatomical Transitions During the Evolution of Whales



Jump to Anatomical Transitions During the Evolution of Whales Long Description

15-30

Darwin and Evolution

Evidence for Evolution (1)

Biogeographical Evidence:

- Biogeography is the study of the range and distribution of plants and animals throughout the world.
- Biogeographical distributions are consistent with the hypothesis that related forms of life evolved in one locale and then spread to accessible regions.
- A different mix of plants and animals would be expected whenever geography separates continents, islands, seas, etc.
  - Marsupials (mammals in which females have an external body pouch where there young complete development) evolved from egg-laying mammal ancestors.
  - Today they are endemic to South America and Australia.
    - When Australia separated and drifted away from other landmasses, the marsupials diversified into many different forms.

15-31

Biogeography

Sugar glider, *Petaurus breviceps*, is a tree-dweller and resembles the placental flying squirrel.

The Australian wombat, *Vombatus*, is nocturnal and lives in burrows. It resembles the placental woodchuck.

The Tasmanian wolf (now extinct) was a carnivore that resembled the American wolf.

(sugar glider): ©ANT Photo Library/Science Source; (wombat): ©Marco Tomasini/Shutterstock RF; (Tasmanian wolf): ©World History Archive/Alamy

Jump to Biogeography Long Description

15-32

Evidence for Evolution (2)

Anatomical Evidence:

- Vertebrate forelimbs:
  - **Homologous** structures – all contain the same sets of organized bones in similar ways.
  - Yet they are modified extensively to meet various adaptive needs.
  - Darwin interpreted this as support for a hypothesis of common descent.
- Embryological development
  - All vertebrate embryos have:
    - A postanal tail
    - Paired pharyngeal (throat) pouches supported by cartilaginous arches

15-33

Darwin and Evolution

Evidence for Evolution (3)

Homologous Structures:

- Anatomically similar because they are inherited from a common ancestor
- May be functionally similar or not

Analogous Structures:

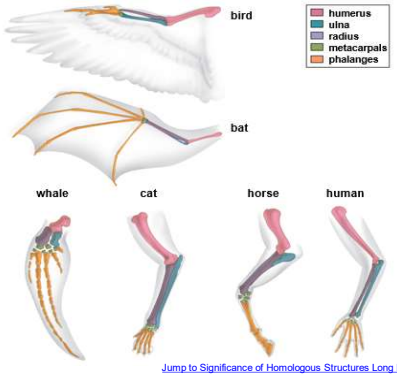
- Serve the same function
- Are not constructed similarly
- Do not share a common ancestor

Vestigial Structures:

- Fully developed anatomical structures in one group of organisms
- Reduced or obsolete function in similar groups

15-34

Significance of Homologous Structures



Jump to Significance of Homologous Structures Long Description

15-35

Significance of Developmental Similarities

Jump to Significance of Developmental Similarities Long Description

15-36

Darwin and Evolution

Evidence for Evolution (4)

Biochemical Evidence:

- All living organisms:
  - Use the same basic biochemical molecules
  - Utilize same DNA triplet code
  - Utilize same 20 amino acids in their proteins
- DNA base-sequence differences:
  - When very similar, suggest recent common descent
  - When more different, suggest more ancient common descent

15-37

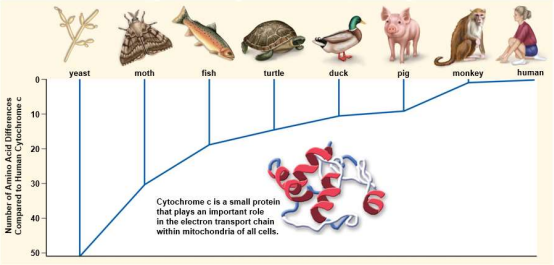
Evidence from Developmental Biology

Homeobox or *Hox* genes:

- Orchestrate the development of the body plan of all animals
- All animals share a *Hox* gene common ancestor.
  - The number and type of *Hox* genes vary among animal groups.
- The variation in *Hox* genes is responsible for the wide range of body plans seen in animals.
  - Example: Changes in the timing and duration of expression of *Hox* genes controlling the number and type of vertebrae can produce the spinal column of a chicken **or** the longer spinal column of a snake.
- Simple changes in gene control have profound effects on the phenotype.

15-38

Significance of Biochemical Differences



Jump to Significance of Biochemical Differences Long Description

15-39

Darwin and Evolution

Criticisms of Evolution

Evolution is no longer considered a hypothesis.

- It is one of great unifying theories of biology.

Misconceptions about evolution

- It is a theory about how life originated.
  - Evolutionists are concerned with how the diversity of life emerged following its origins.
- There are no transitional fossils.
  - Biologists don't expect all transitional fossils to have been preserved, but have unearthed many transitional fossils.
- Evolution proposes that life changed due to random events.
  - Chance is only part of the story; mutation occurs randomly but natural selection isn't random.
- Evolution is not observable or testable. It is not science.
  - Evolution is both observable and testable.

15-40

The Tree of Life Project – Nature of Science Reading (1)

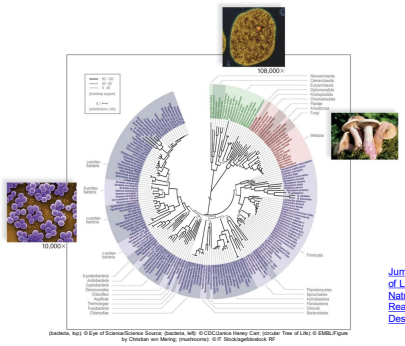
The Tree of Life Project is a collaborative effort to determine how all of life is related and descended from a common ancestor.

It contains hundreds of species from all domains of life and is growing.

It provides support for Darwin's theory of evolution by natural selection.

15-41

The Tree of Life Project – Nature of Science Reading (2)



(bacteria, top): © Eye of Science/Science Source; (bacteria, left): © CDC/Janice Haney Carr; (circular Tree of Life): © EMBL/Figure by Christian von Mering; (mushrooms): © IT Stock/agefotostock RF

Jump to The Tree of Life Project – Nature of Science Reading (2) Long Description

15-42