

Evolution by Natural Selection (Ch. 24)

I. Introduction: Theory of Evolution by Natural Selection

- A. Darwin's evidence
- B. Darwin's theory

II. The Patterns of Evolution

- A. Have species changed through time?
- B. Are species related?

III. The Nature of Natural Selection and Adaptation

- A. Selection Acts on Individuals, but Evolutionary Change Occurs in Populations
- B. Evolution Is Not Progressive
- C. Not All Traits Are Adaptive

I.A. Darwin's evidence

Fig 22.1

5. While Darwin proposed natural selection as the mechanism of evolution, he didn't know how heritability occurred.

Question 5

Category	Count	Percentage
13 or origig	10	10%
21 or ee	15	15%
37	48	48%
40 or tag	12	12%
53 or 01 tag	5	5%

1. Geological time

James Hutton

Scottish geologist, 1795
Geological gradualism
Present earth formed in past by the same processes that act currently
Long periods of time

Charles Lyell

Scottish geologist, 1830
"Principles of Geology" text
Incorporated Hutton's gradualism into this widely read book
Darwin had a copy with him on the Beagle

2. Population growth & struggle for existence

Thomas Malthus

English political economist
1798 - Essay on human condition as related to overreproduction and limited resources

- Species have great powers of potential reproduction
- Populations would increase exponentially if all individuals survived and reproduced

3. Heritability & artificial selection



Campbell & Reece, Fig 22.11b Vegetables selected by humans from "wild kale".

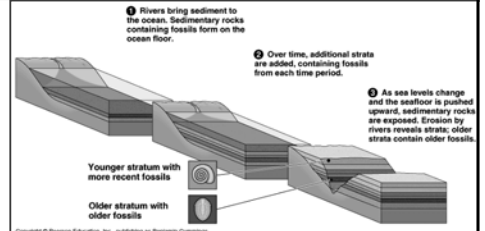
4. Fossil record

a) 110-Million-year-old ammonite shell (b) 50-Million-year-old bird tracks (c) 20,000-Year-old sloth dung



Georges Cuvier

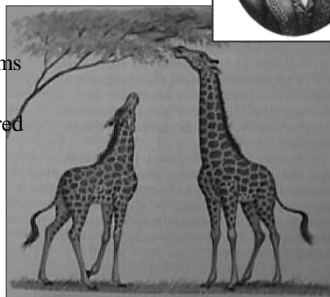
Figure 23-2 Biological Science, 2/e © 2005 Pearson Education, Inc.



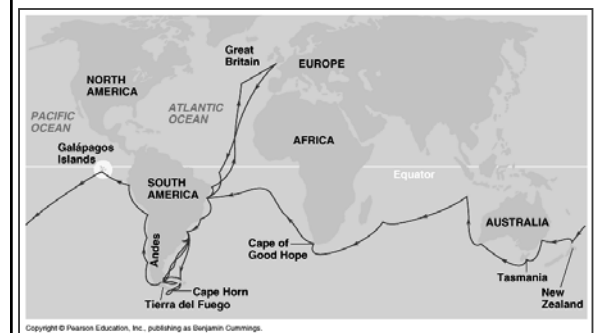
Jean Baptiste Lamarck

French invertebrate natural historian, 1809

Evolution of life forms
Use / disuse
Inheritance of acquired characteristics



Voyage of the Beagle 1831-1836



C&R, Fig 22.5

Alfred Wallace

British naturalist, 1858

Letter from Malaysia with article to review and send to Lyell

Developed a theory of evolution similar to the one Darwin was working on



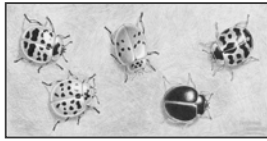
B. Darwin's Theory of Evolution by Natural Selection:

Evolution = a change in the genetic characteristics (allele frequencies) of a population over time.

Natural Selection

4 steps:

1. Variation: traits differ among individuals in a population.



2. Heritability: trait differences are passed on to offspring.



Natural Selection:

4 steps:

3. Differential reproduction: Only some individuals within a generation survive to reproduce, and of those,

4. not all produce same number of offspring (**Darwinian fitness**).

→ Traits of those with most reproduction dominate in subsequent generations of a population and cause it to evolve.

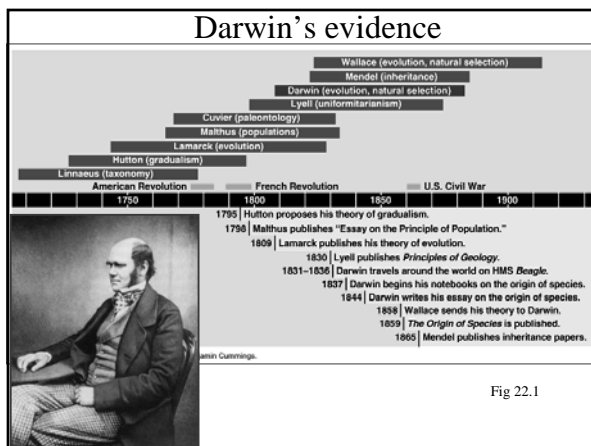
- An **adaptation** is a heritable trait that increases an individual's fitness in a particular environment relative to individuals lacking that trait.

Evolution by Natural Selection = “descent with modification”

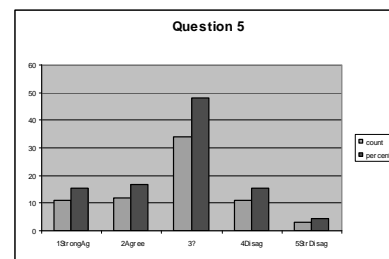
Species change through time

Species are related

These patterns contradicted the “theory of special creation”.



5. While Darwin proposed natural selection as the mechanism of evolution, he didn't know how heritability occurred.



II. The Pattern of Evolution

A. Have Species Changed through Time?

1. Fossil record
2. Extinction
 - Many fossils provide evidence for **extinct** species unlike any known living organisms.
 - Darwin interpreted extinction as evidence that species are dynamic and can change.

3. Transitional Forms

- Extinct fossil species are typically succeeded, in the same region, by similar species.
- Darwin interpreted this pattern as evidence that extinct forms are the ancestors of modern forms and that species change over time.

Living species "succeed" fossil species in the same region.



<http://www.ucmp.berkeley.edu/mammal/xenarthra/xenarthrafr.html>



Fossil sloth

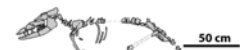


Present-day sloth

Figure 23-3a Biological Science, 2/e
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(Figure 23.3a)

Transitional forms during the evolution of whales



50 cm

Pakicetus, about 50 million years old



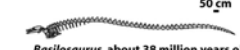
50 cm

Ambulocetus, about 49 million years old



50 cm

Rhodocetus, about 47 million years old



50 cm

Basilosaurus, about 38 million years old

Figure 23-3b Biological Science, 2/e
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- Many **transitional forms** have been discovered with traits that are intermediate between older and younger species (Figure 23.3b).

And even modern whales have hips...

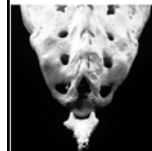
4. Environmental Change

- Earth's topography and environment have changed drastically over time.
 - plate tectonics
 - geologic uplift (oceanic fossils in mountains)
 - glacial/interglacial cycles

5. Vestigial Traits

- functionless structures that are similar to functioning structures in related species.

The human tailbone is a vestigial trait.



Human coccyx



Capuchin monkey tail (used for balance, locomotion)

Goose bumps are a vestigial trait.



Human goose bumps



Erect hair on chimp (insulation, emotional display)

23.4

6. Current observations

a. Drug & pesticide resistance

Campbell & Reece, Fig 22.12
Evolution of resistance to insecticides in insect populations

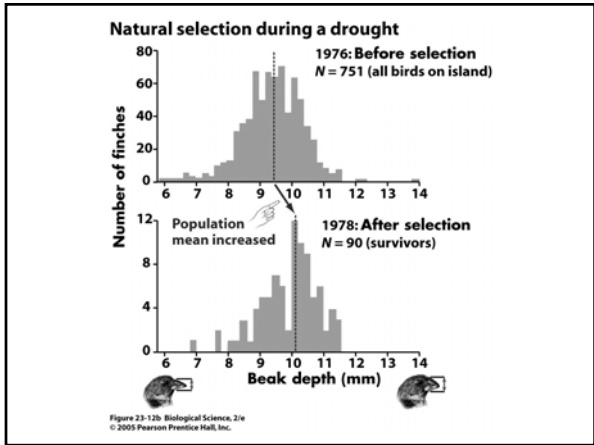
See also Tuberculosis example in your book

b. Galápagos Finches

Why Are Beak Size, Beak Shape, and Body Size Changing?

Work of Peter & Rosemary Grant

Figure 23-13 Biological Science, 2/e
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B. Are Species Related?

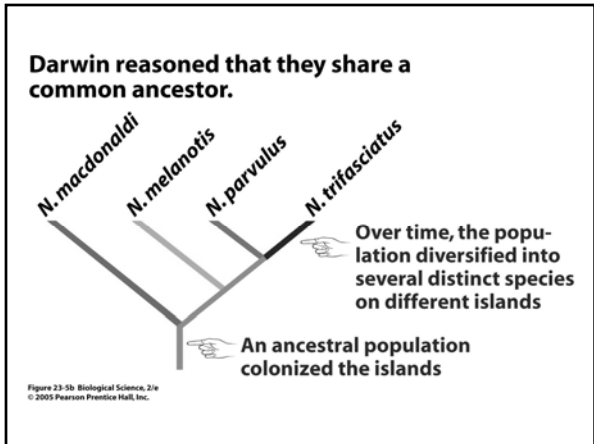
1. Island radiations

Similar mockingbird species on different Galápagos islands

Galápagos Islands

N. parvulus
N. melanotis
N. trifasciatus
N. macdonaldi

Figure 23-16a Biological Science, 2/e
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2. Homologies

a. Structural homologies

- similarity of morphological traits

Humerus
Radius and ulna
Carpals
Metacarpals
Phalanges

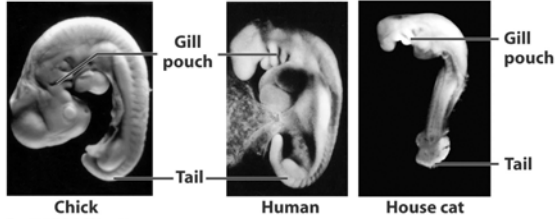
Turtle Human Horse Bird Bat Seal

Figure 23-6 Biological Science, 2/e
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23.6 - limb structure in vertebrates.

b. Developmental Homologies

- similarity in embryo morphology and/or pattern of tissue differentiation.



23.7 - all vertebrates have gill pouches and tails early in embryonic development

c. Genetic Homologies

- similarity in the DNA sequences of genes from different species → Structural homologies and developmental homologies.

Gene: Amino acid sequence (single-letter abbreviations):
Aniridia (Human) LQRNRTSFTQEQIEALEKEFERHYDPVFARERLAAKIDLPARIQVWFSNRRRAKWRREE
eyeless (Fruit fly) LQRNRTSFTNDQIDSLKEKEFERHYDPVFARERLAGKIGLPEARIQVWFSNRRRAKWRREE

Only six of the 60 amino acids in these sequences are different. The two sequences are 90% identical.

Figure 23-8 Biological Science, 2/e
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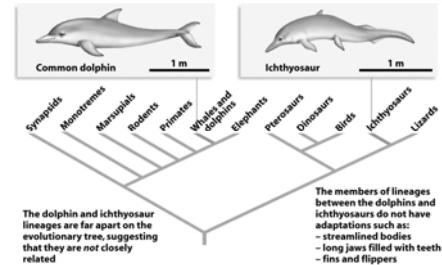
d. Homology vs. Analogy

- **Homology** = similarities due to common descent.
- **analogous traits** or **convergent traits** - similar traits that are *not* inherited from a common ancestor.

Analogous traits

- similar environment, similar selection pressures
- traits aren't shared among other relations

Analogous traits: Similarities result from convergent evolution.



Homologous traits: Similarities are inherited from a common ancestor.

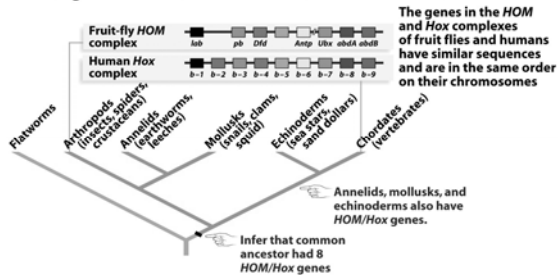


TABLE 23.1 Evidence for Evolution

Prediction 1: Species Are Not Static, but Change through Time	Prediction 2: Species Are Related, Not Independent
<ul style="list-style-type: none"> • Many species have gone extinct. • Fossil species frequently resemble living species found in the same area. • Transitional forms document change in traits through time. • Earth is ancient; environments and landscapes have changed through time. • Vestigial traits are common. • Populations and species can be observed changing today. 	<ul style="list-style-type: none"> • Closely related species often live in the same geographic area. • Homologous traits are common and exist at three levels: <ol style="list-style-type: none"> 1. structural (morphological traits) 2. developmental (embryonic structures and processes) 3. genetic (gene structure and the genetic code)

Table 23.1 Biological Science, 2/e
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III. The Nature of Natural Selection and Adaptation

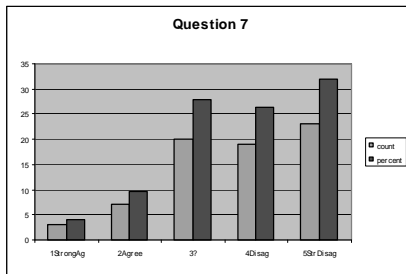
A. Selection acts on individuals, but evolutionary change occurs in populations

- **Acclimation** occurs when an *individual* changes in response to changes in the environment.

- **adaptation** occurs only when a *population* changes in response to natural selection.

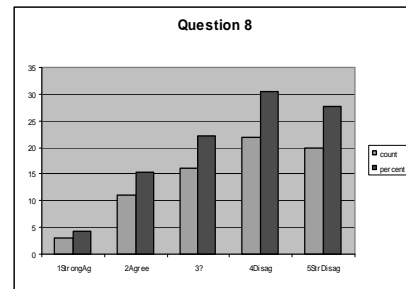
B. Is Evolution Progressive?

7. Dolphins are better adapted to their environment than are alligators because the former are more recently evolved.

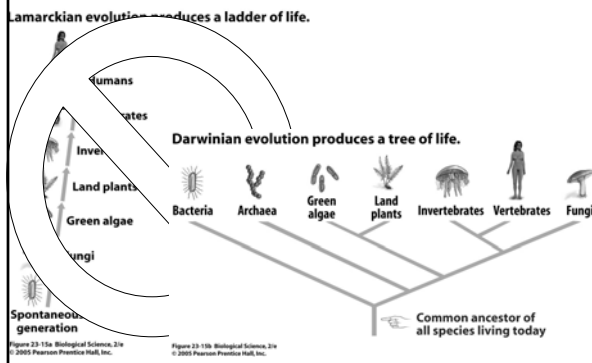


B. Is Evolution Progressive?

8. Evolution favors the development of more complex organisms over simpler organisms.



B. Evolution Is Not Progressive



Evolution does not have goals: Horse family tree

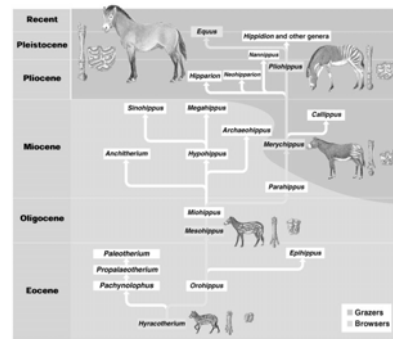
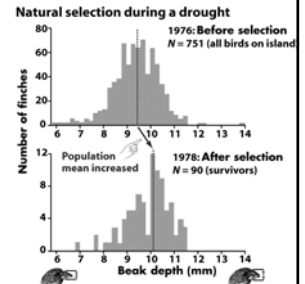


Fig. 24.24

C. Are All Traits Adaptive?

1. Genetic Constraints

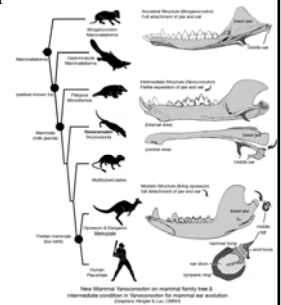
- When selection on alleles for one trait causes a correlated but suboptimal change in another trait, the possible evolutionary outcomes are limited. This type of constraint is called **genetic correlation**.



- Lack of genetic variation can also constrain evolution, because natural selection can work only on existing variation in a population.

2. Historical Constraints

- Because all traits evolve from previously existing traits, adaptations are constrained by history.



KEY CONCEPTS

Evolution is defined as change in the genetic composition of a population over time.

Natural selection occurs when heritable variation in traits leads to differential success in survival and reproduction.

KEY CONCEPTS

Darwinian (evolutionary) fitness is the ability to produce viable offspring.

An adaptation is a genetically based trait that increases the fitness of an individual in a particular environment relative to individuals lacking that trait.

KEY CONCEPTS

Evolution

- Occurs in populations, not individuals.
- Is not goal-directed.
- Does not always lead to optimal traits (is subject to historical and genetic constraints).