Science of Biology

Chapter 1

Properties of Life

Living organisms:

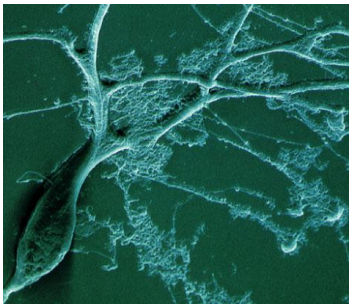
– composed of cells
– complex & ordered
– respond to their environment
– can grow & reproduce
– obtain & use energy
– maintain internal balance
– allow for evolutionary adaptation

Levels of Organization

Cellular Organization

atoms → molecules → organelles → cells

Cell: the basic unit of life



Levels of Organization

Organismal Level

tissues → organs → organ systems → organism

Levels of Organization

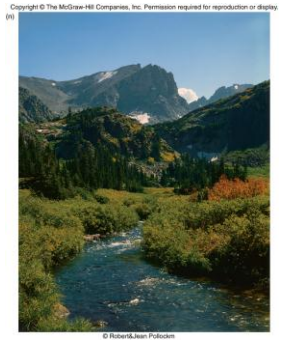
Population Level

ecosystem

community

species

population



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Levels of Organization

Each level of organization builds on the level below it but often demonstrates new features

Emergent properties: new properties present at one level that are not seen in the previous level

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Nature of Science

Science

1) aims to understand the natural world through observation & reasoning

2) begins with ***observations***, therefore, much of science is purely descriptive

3) uses both deductive & inductive reasoning

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Nature of Science

Deductive reasoning

uses general principles to make specific predictions

Inductive reasoning

uses specific observations to develop general conclusions

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Nature of Science

Scientists use a systematic approach to gain understanding of the natural world

Scientific Method

-Observation

-Hypothesis formation

-Prediction

-Experimentation

-Conclusion

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The Nature of Science

Hypothesis:

a possible explanation for an observation

Hypothesis:

-must be tested to determine its validity

-is often tested in many different ways

-allows for predictions to be made

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Nature of Science

Experiment

-tests hypothesis

-must be carefully designed to test only one **variable** at a time

-consists of a **test experiment** & a **control experiment**

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Nature of Science

If the hypothesis is valid, the scientist can predict the result of the experiment.

Conducting the experiment to determine if it yields the predicted result is one way to test the validity of the experiment.

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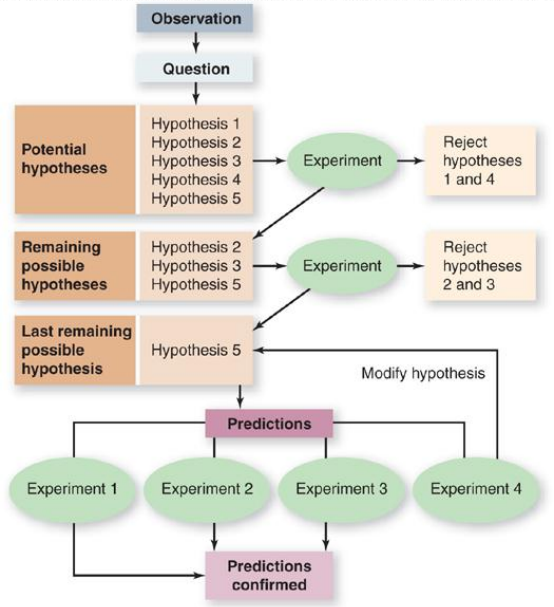

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Nature of Science

Scientists may use

reductionism - to break a complex process down to its simpler parts

models – to simulate phenomena that are difficult to study directly

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Nature of Science

Scientific **theory:**

- -is a body of interconnected concepts
- -is supported by much experimental evidence & scientific reasoning
- -expresses ideas of which we are most certain

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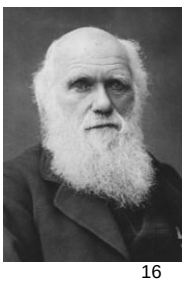
Charles Darwin

Served as naturalist on mapping expedition around coastal South America

Used many observations to develop his ideas

Proposed that evolution occurs by **natural selection**



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Voyage of the *Beagle*

Charles Darwin

evolution: modification of a species over generations

-"descent with modification"

natural selection: individuals with superior physical or behavioral characteristics are more likely to survive and reproduce than those without such characteristics

natural selection:

differential survival & reproduction

Darwin's Evidence

Similarity of related species

- Darwin noticed variations in related species living in different locations

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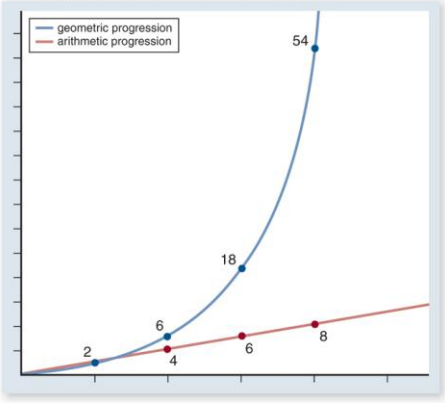
Darwin's Evidence

Population growth vs. availability of resources

-population growth is geometric

-increase in food supply is arithmetic



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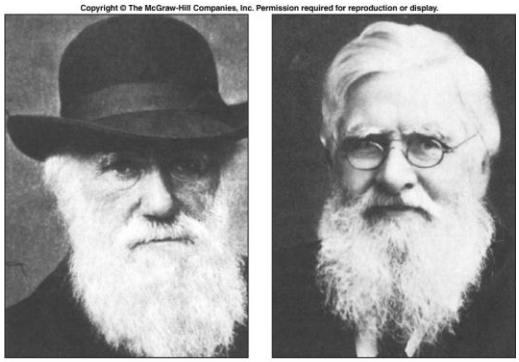
1859: Theory of Evolution by Natural Selection



A Charles Darwin 1881 B Alfred Russel Wallace 1895

Theory of Evolution by Means of Natural Selection*

1) organism show variation which is passed on to offspring[1]
2) organisms produce more offspring than can survive
   "struggle for existence" from Thomas Malthus essay
3) some organisms have selective adaptations for survival*
4) surviving organisms reproduce & pass on these advantageous adaptation to their offspring*
5) new species thus can evolve

*natural selection: differential survival & reproduction

[1]weakest part of theory since variation could not be explained

Darwin's Evidence

Population growth vs availability of resources

- Darwin realized not all members of a population survive & reproduce

-Darwin based these ideas on the writings of Thomas Malthus

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Post-Darwin Evolution Evidences

- 1) Fossils
- 2) Homology
  - -- anatomical
  - -- embryological
  - -- biochemical
- 3) Molecular

Post-Darwin Evolution Evidences

Fossils: remains of the past

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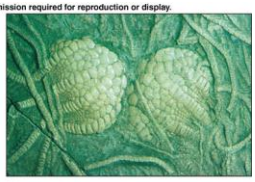

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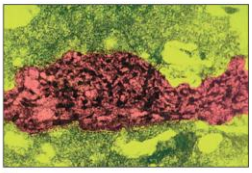

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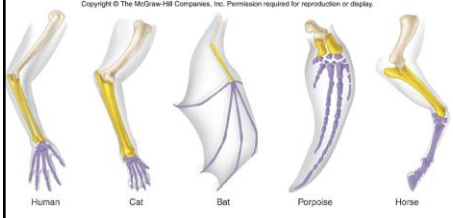
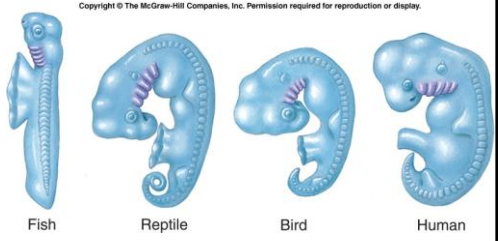
Post-Darwin Evolution Evidences

Homology: similarities





Anatomical Homology

Embryological Homology

Biochemical Homology: genetic mechanisms (DNA, RNA, codons) & metabolic pathways (enzymes, proteins)-- present in primitive, single-celled, common ancestor: inherited by successive organisms, eventually leading up to higher organisms

Post-Darwin Evolution Evidence

Fossil record

- New fossils found all frequently
- Earth older than previously believed

Mechanisms of heredity

- Early criticism of Darwin's ideas resolved by Mendel's theories for genetic inheritance

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Post-Darwin Evolution Evidence

Comparative anatomy

- **Homologous structures** same evolutionary origin, but different structure & function

- **Analogous structures** similar structure & function, but different evolutionary origin

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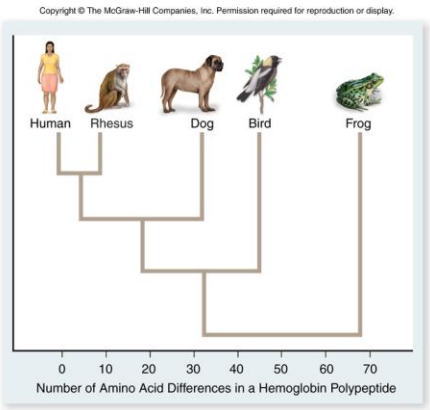
Post-Darwin Evolution Evidence

Molecular Evidence

- Increased understanding of DNA & protein structures led to development of more accurate **phylogenetic trees**



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Unifying Themes in Biology

Cell theory

- All living organisms are made of cells, & all living cells come from preexisting cells

Molecular basis of inheritance

- DNA encodes genes which control living organisms & are passed from one generation to the next

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Unifying Themes in Biology

Structure & Function

-Proper function of a molecule dependent on its structure

-Structure of a molecule can often reveal its function

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Unifying Themes in Biology

Evolutionary change

- Living organisms have evolved from same origin event→ diversity of life is result of evolutionary change

Evolutionary conservation

- Critical characteristics of early organisms are preserved & passed on to future generations

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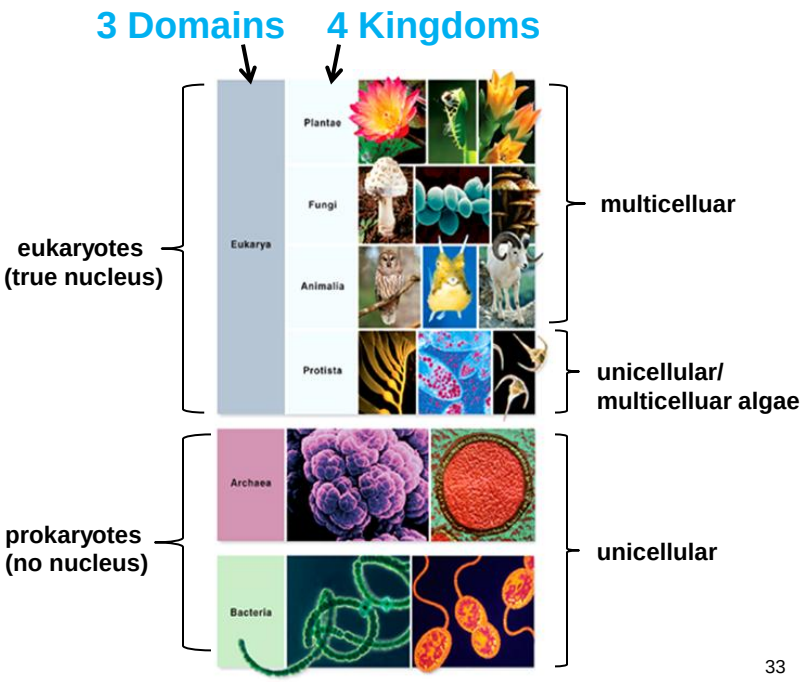

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Unifying Themes in Biology

Cells - information processing systems

- Cells process information stored in DNA as well as information received from environment

Emergent properties

- New properties present at one level of organization not seen in previous level

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