

Topic 5 Evolution & Biodiversity

5.1 Evidence for Evolution

Essential idea: There is overwhelming evidence for the evolution of life on Earth.

Understandings

- 5.1.U1 Evolution occurs when heritable characteristics of a species change.
- 5.1.U2 The fossil record provides evidence for evolution.
- 5.1.U3 Selective breeding of domesticated animals shows that artificial selection can cause evolution.
- 5.1.U4 Evolution of homologous structures by adaptive radiation explains similarities in structure when there are differences in function.
- 5.1.U5 Populations of a species can gradually diverge into separate species by evolution.
- 5.1.U6 Continuous variation across the geographical range of related populations matches the concept of gradual divergence.

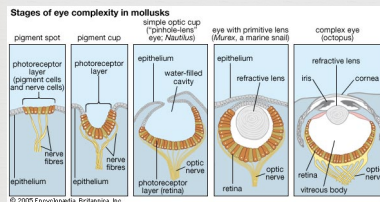
Nature of Science

- Looking for patterns, trends and discrepancies: there are common features in the bone structure of vertebrate limbs despite their varied use.

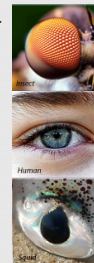
I. Evolution in Summary

- A. Evolution occurs when heritable characteristics of a species changes-

The evolution of the eye took millions of years...



learn.genetics.utah.edu



I. Evolution in Summary

The eye is not a perfectly designed organ....

EVIDENCE

Scars of Evolution

The vertebrate eye, far from being intelligently designed, contains numerous defects that attest to its evolutionary origin. Some of these flaws degrade image quality, including an inside-out retina that forces light to pass through cell bodies and nerve fibers before hitting the photoreceptors ❶; blood vessels that sprawl across the retina's inner surface, casting undesirable shadows onto the retina ❷; nerve fibers that gather together to push through a single opening in the retina to become the optic nerve, creating a blind spot ❸.

nature.com

I. Evolution in Summary

B. Evolution is the cumulative change in the heritable characteristics of a population.

1. Cumulative change – small changes that occur over many generations
2. Heritable characteristics – gene-controlled factors, not those that are acquired during one's lifetime
3. Population – not an individual of a species

Pearson Education; Reynolds Science

I. Evolution in Summary

...but, evolution is only a *theory*...

What makes something a...

<p>FACT?</p> <p><i>"Any observation that has been repeatedly confirmed and accepted as true; scientific observation that has not (yet) been refuted."</i></p>	<p>THEORY?</p> <p><i>"A set of statements or principles devised to explain a group of facts or phenomena. Most theories that are accepted have been repeatedly tested by experiments and can be used to make predictions about natural phenomena."</i></p>
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Despite the strength of evidence there is still widespread disbelief of evolution among some groups.

Evidence for Evolution

"It's only a theory!"

The **scientific method** is based on a system of **making hypotheses and testing them** through rigorous collection of **empirical evidence** (can be measured and recorded).

TOK

i-Biology; bioknowledgy.com

Evidence for Evolution

The **scientific method** is based on a system of **making hypotheses and testing them** through rigorous collection of **empirical evidence** (can be measured and recorded), **peer-review of data**, statistical analysis, **replication** and finally acceptance.

"It's only a theory!"

highest level of certainty in science
theory
accepted
corroborated unquestionably
repeated
corroborated
not corroborated (evidence does not support hypothesis)
formulate new hypothesis

TOK

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Real science is **evidence-based**. If a theory is proven wrong through good scientific evidence, the scientific community will re-think the theory. This is how science advances.

The **theory of evolution** has stood the test of generations of scientific research and testing and evidence collection and gets **stronger with each new set of data**.

In the following sections, you will look at some examples of evidence for evolution: fossil records, homologous structures and selective breeding.

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i-Biology; bioknowledgy.com

Evidence for Evolution

Fossil record

Gradual lineage evolution
Rock strata with fossils

Homologous structures

Comparative DNA

Selective breeding

http://www.bbc.co.uk/schools/ks3/hs/hs/science/images/bio_dogs.gif

Vestigial structures

Large Intestine
Cecum
Appendix

<http://www.nlm.nih.gov/MEDLINEPLUS/ency/imagepages/1128.htm>

Observable changes

Bacteria
reproduction
Variation
reproduction
antibiotics

Reproduction: bacterial conjugation, binary fission, budding
Antibiotics: penicillin, streptomycin, tetracycline
Reproduction: population growth

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i-Biology; bioknowledgy.com

II. Evidence from Fossils

A. Fossil record provides evidence for evolution- How do fossils form?

geology.com

II. Evidence from Fossils

B. Types of fossils:

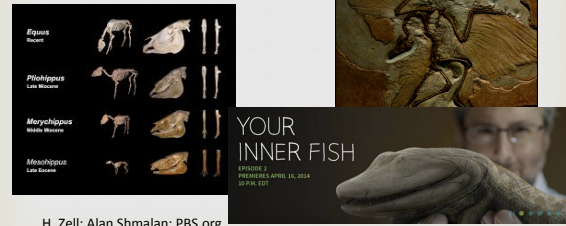
1. Direct (body fossils) – remains of body parts/ structures such as teeth, bones, shells, leaves, hair, etc.
2. Indirect (trace fossils) – remains of how organisms lived such as footprints, tracks, tooth marks, burrows, tools, etc.



greaterancestors.org; discoveringfossils.co.uk; swallowaquatics.co.uk

II. Evidence from Fossils

3. Transitional fossils – show the links between groups or species by exhibits **traits common to both** the ancestral group/species and its derived descendant group/species.



H. Zell; Alan Shmalan; PBS.org

II. Evidence from Fossils

C. Issues with the fossil record:

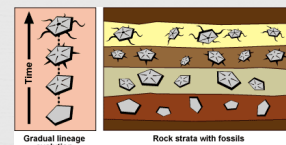
1. There are gaps in the fossil record
 - a. Special circumstances are required for fossilization to occur
 - b. Only hard parts of an organism are preserved
 - c. Fossils can be damaged so that only fragments remain to be discovered



evolution.berkeley.edu

II. Evidence from Fossils

- B. As layers of sedimentary rock are put down, fossils are made.
 1. New layers of sediment are added on top of the old layers, thus generally older fossils are found in deeper layers.
 2. Fossils can also be dated by this technique



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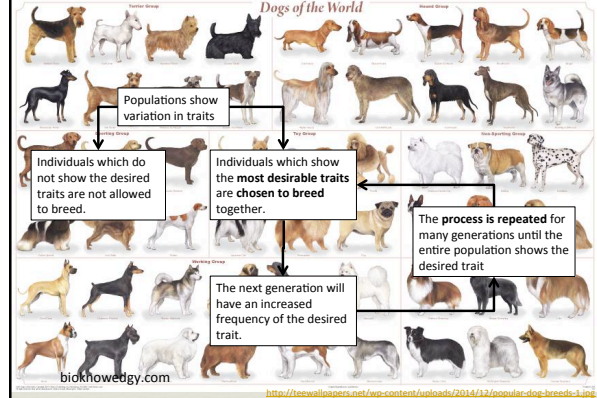
III. Evidence from Selective Breeding

- A. Selective breeding of domesticated animals shows that artificial selection can cause evolution-
1. Humans deliberately breeding organisms for particular traits has caused changes in many species. Examples: breeding of dogs for racing, cows for milk or meat, crops for increased yield or pest resistance.



National Geographic; petwave.com; UC Davis

How does artificial selection work?

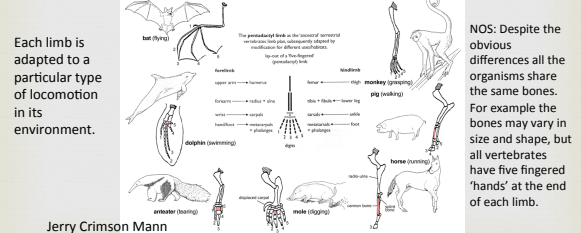


IV. Evidence from Homologous Structures

- A. Evolution of homologous structures by adaptive radiation explains similarities in structure when there are differences in function-
1. Homologous structures – structures that are similar in shape in different types of organisms and may have different functions.
 2. Adaptive radiation – the process by which organisms diversify from an ancestral species in to new forms
 3. Comparative anatomy – studying the similarities and differences in the anatomy between species that may show common ancestry

IV. Evidence from Homologous Structures

- B. The pentadactyl limb in vertebrates is a homologous structure that has undergone adaptive radiation to fit the needs of organisms in different niches, and shows common ancestry




Jerry Crimson Mann

V. Speciation

A. Populations of a species can gradually diverge into separate species by evolution-

1. The evolutionary definition of a species – a group of individuals that can potentially interbreed and produce fertile offspring

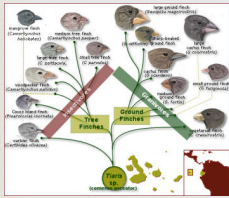
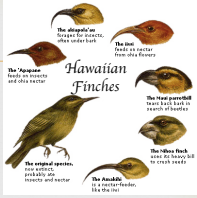



What other definitions of species are there?

hdfinewallpapers.com

V. Speciation

Examples of Speciation

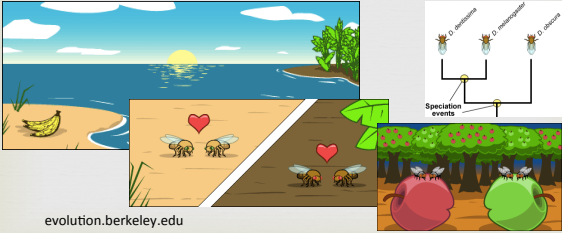




bioweb.uwlax.edu; bio.miami.edu, Roger D Hall

V. Speciation

B. How do new species form?

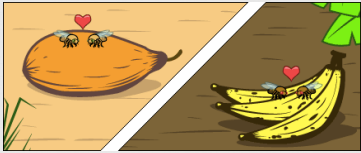
1. Two population must be separated physically (allopatric speciation) or utilize different resources (sympatric speciation) reducing gene flow



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V. Speciation

2. Over many generations, the two populations will diverge as the result of living under differing conditions. Genetic difference may accumulate as they try to survive (natural selection).



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3. If the two populations meet again they are unlikely to reproduce due different reproductive isolating mechanisms (behavioral, temporal, and mechanical).

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VI. Evidence from Patterns of Variation

3

A. Continuous variation across the geographical range of related populations matches the concept of gradual divergence-

Which of these birds belongs to the same species? Which are from different species?

U.S. Fish and Wildlife Service

VI. Evidence from Patterns of Variation

3

- ☞ The Red Grouse and the Willow Ptarmigan were at one time classified as two separate species.
- ☞ The current scientific consensus is that they are both members of the **same species** (*Lagopus lagopus*).
- ☞ It is a common problem in classification to determine when two populations of one species to have sufficiently diverged to become two separate species.
- ☞ Populations will gradually diverge over time and it is natural to see continuous variation across a geographical range.
- ☞ The greater the geographical separation and the longer the populations have been separated the **greater the divergence**.

U.S. Fish and Wildlife Service