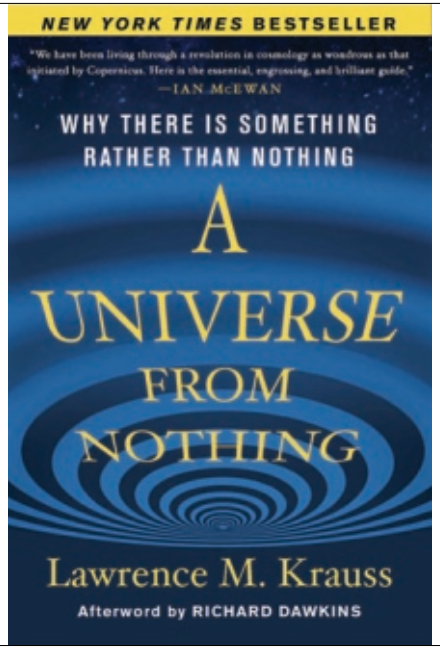
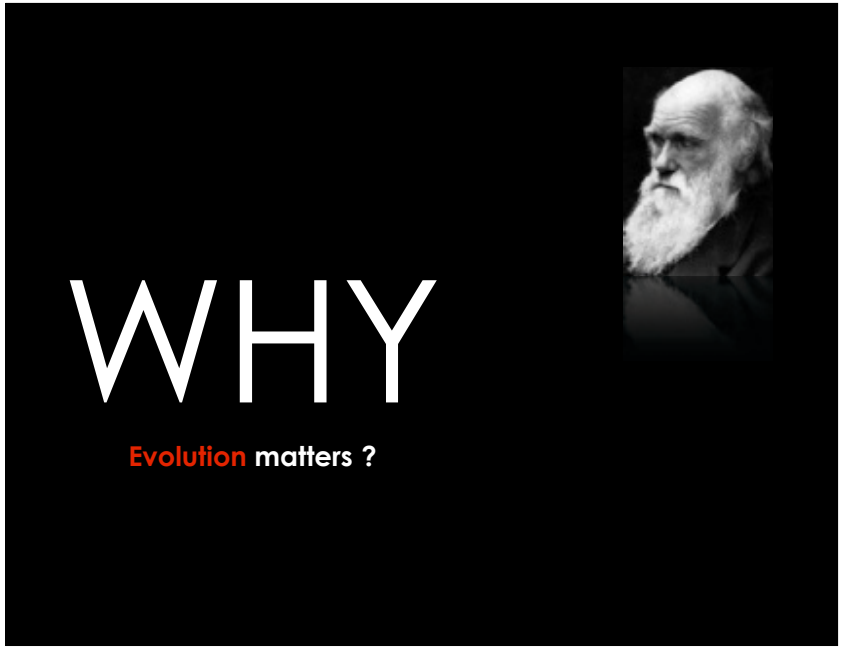




Evolution

In the last class we have covered:

Evolution: Fact or theory?

Part 1: How was evolution discovered?

Part 2: What is the evidence for evolution?

Part 3: How does evolution work?

Part 4: Darwin observations

Evolution

In this class we will cover:

Evolution: Fact or theory?

Part 1: How was evolution discovered?

Part 2: What is the evidence for evolution?

Part 3: How does evolution work?

Part 4: Darwin observations

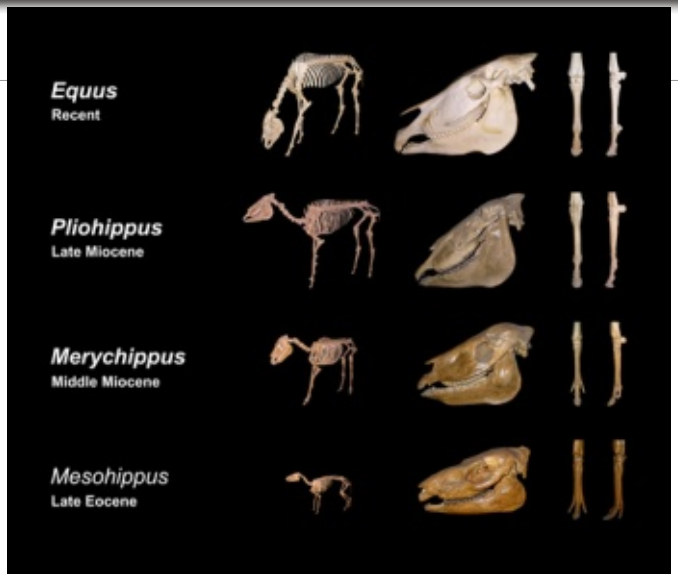
Evolution

Nothing in biology makes sense except in the light of

EVOLUTION

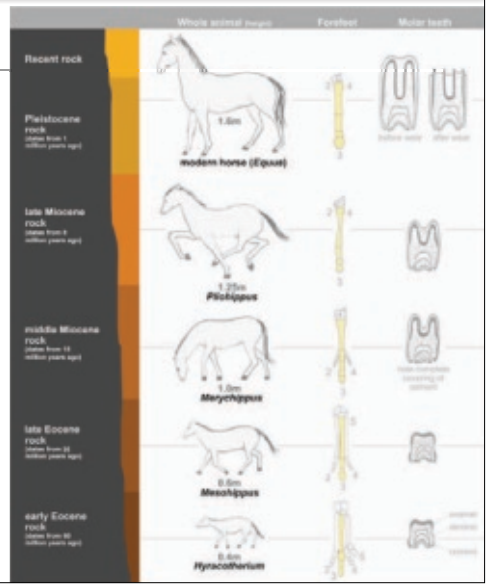
Evolution • What is the evidence for evolution?

Evolution • What is the evidence for evolution?



Evolution • What is the evidence for evolution?

Fossil record



Evolution • What is the evidence for evolution?

Fossil record

Anatomy of modern forms suggests order of evolution

Fish → Mammals → Amphibians → Reptiles

Evolution • What is the evidence for evolution?

Fossil record

Anatomy of modern forms suggests order of evolution

Fish → Mammals → Amphibians → Reptiles X

Evolution • What is the evidence for evolution?

Fossil record

Anatomy of modern forms suggests order of evolution

Fish → Amphibians → Reptiles → Mammals ✓

Fish → Mammals → Amphibians → Reptiles X

Evolution • What is the evidence for evolution?

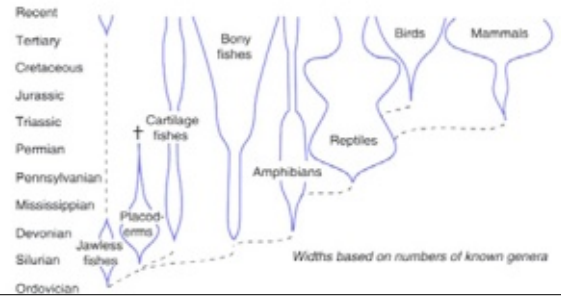
Fossil record

Anatomy of modern forms suggests order of evolution

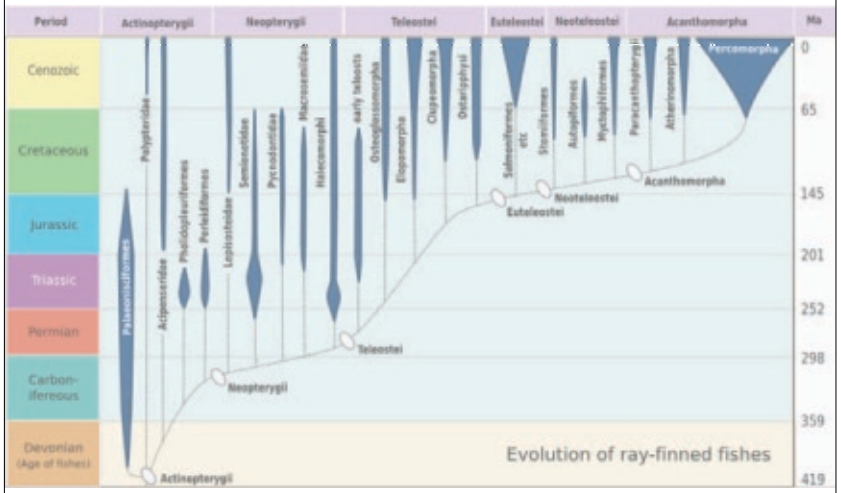
was: Fish → Amphibians → Reptiles → Mammals

and not: Fish → Mammals → Amphibians → Reptiles

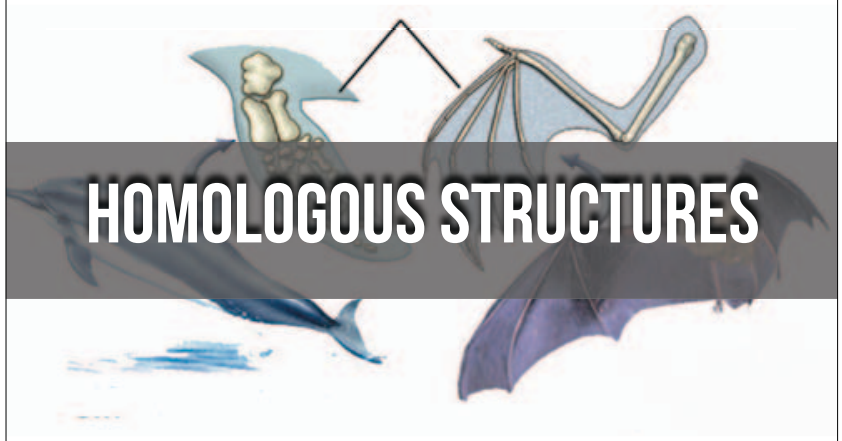
(b) **Order of main vertebrate groups in fossil records**



Evolution • What is the evidence for evolution?



Evolution • What is the evidence for evolution?



Evolution • What is the evidence for evolution?

Analogy vs Homology

Similar due to inheritance

Homologous

Evolution • What is the evidence for evolution?

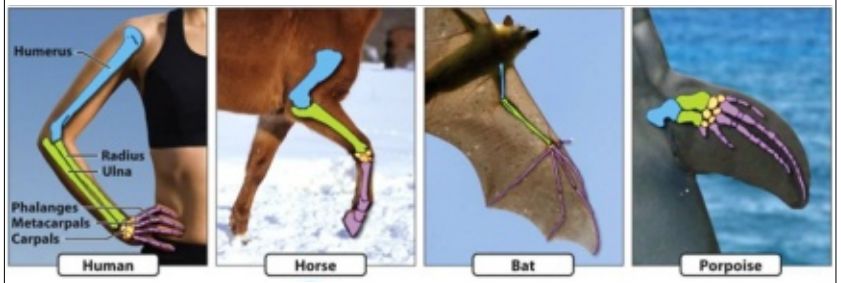
Analogy vs Homology

Similar due to... uh...other factors

Analogous

Evolution • What is the evidence for evolution?

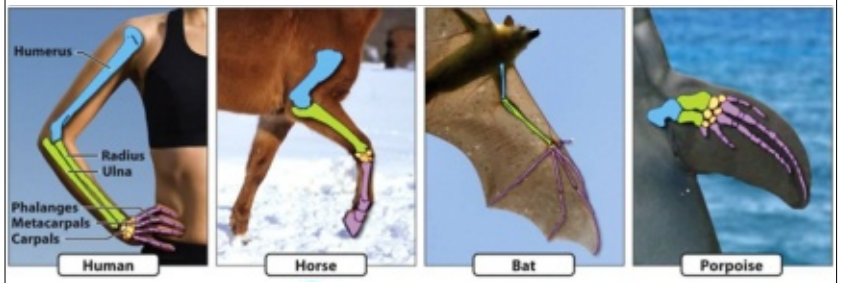
Comparative anatomy — **Bones**



Evolution • What is the evidence for evolution?

Comparative anatomy — **Bones**

Homologous Structures ***(Pentadactyl Limbs)***



Evolution • What is the evidence for evolution?

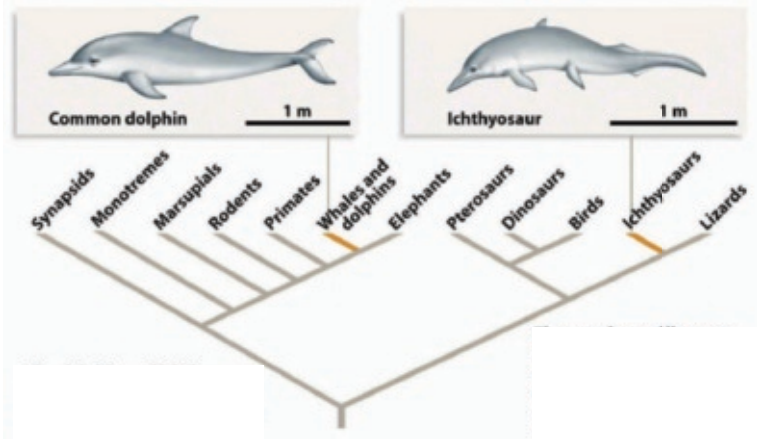
Ichthyosaurus

Evolution • What is the evidence for evolution?

Dolphin

Evolution • What is the evidence for evolution?

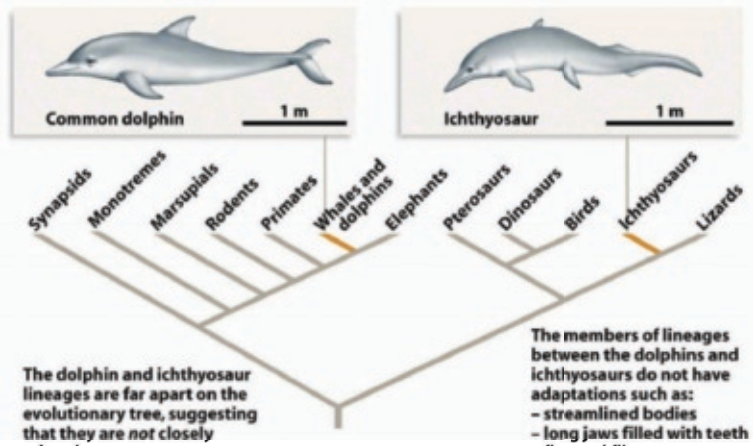
Analogy vs Homology



Evolution • What is the evidence for evolution?

Analogy vs Homology

Analogous traits: Similarities result from convergent evolution.



The dolphin and ichthyosaur lineages are far apart on the evolutionary tree, suggesting that they are *not* closely related

The members of lineages between the dolphins and ichthyosaurs do not have adaptations such as:
- streamlined bodies
- long jaws filled with teeth
- fins and flippers

Evolution • What is the evidence for evolution?

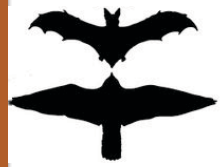
Birds and bats wings (flying ability) are analogous or homologous?

Evolution • What is the evidence for evolution?

Bird and bat **wings** structure are analogous

they have **separate evolutionary origins**, but are superficially similar because they have both experienced natural selection that shaped them to play a key role in flight.

Analogies are the result of convergent evolution

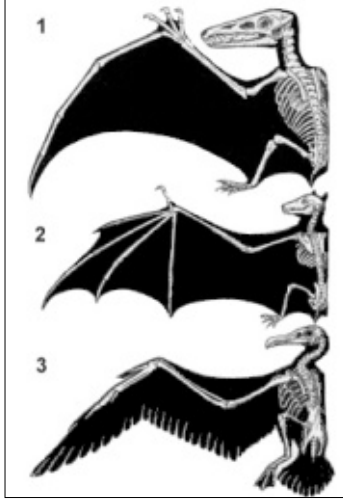


Evolution • What is the evidence for evolution?

However, wings have a bone structure which are **homologous** as forearms.

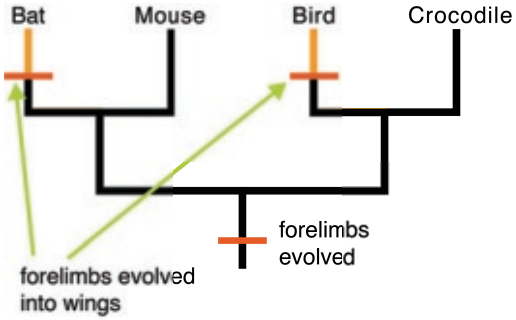
Evolution • What is the evidence for evolution?

Wings analogous, forearms homologous



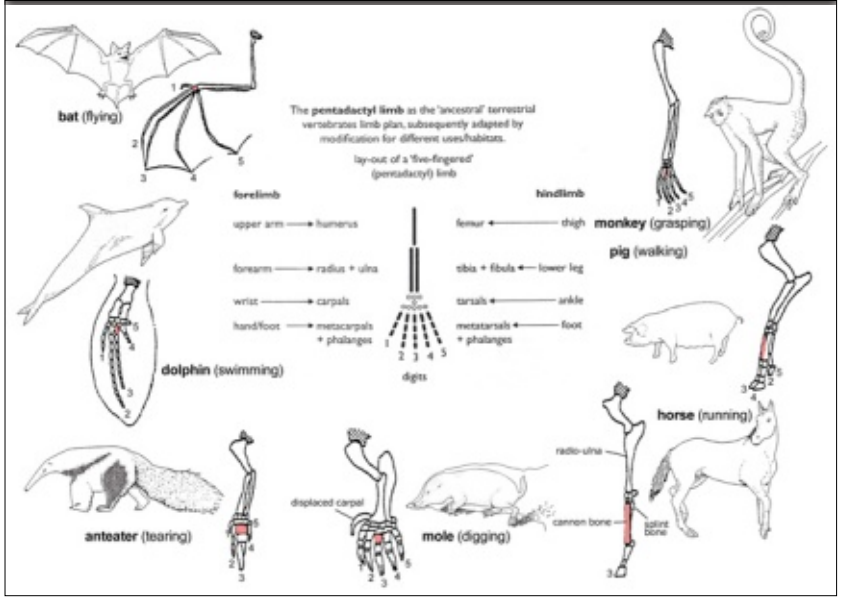
The wings of pterosaurs (1), bats (2) and birds (3) are **analogous** as **wings** (their last common ancestor did not have wings), but **homologous** as forearms.

Evolution • What is the evidence for evolution?



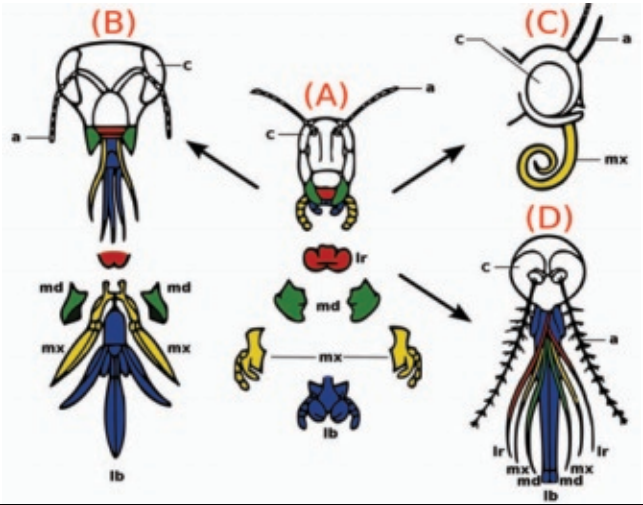
Bird and bat **forelimbs (structure)** are homologous.
Birds and bats **did not inherit wings** from a common ancestor with wings, but they did inherit forelimbs from a common ancestor with forelimbs.

Evolution • What is the evidence for evolution?

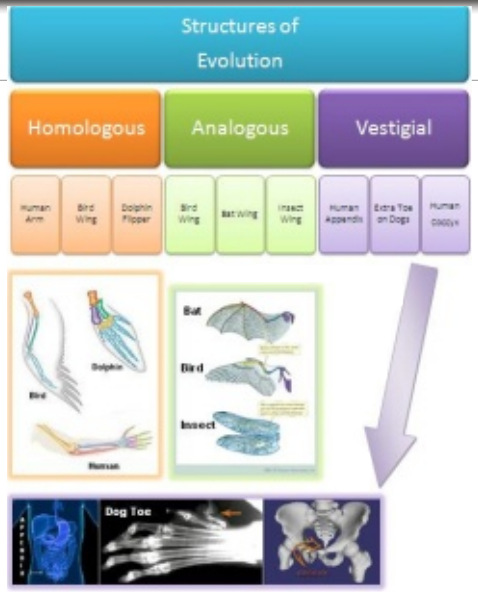


Evolution • What is the evidence for evolution?

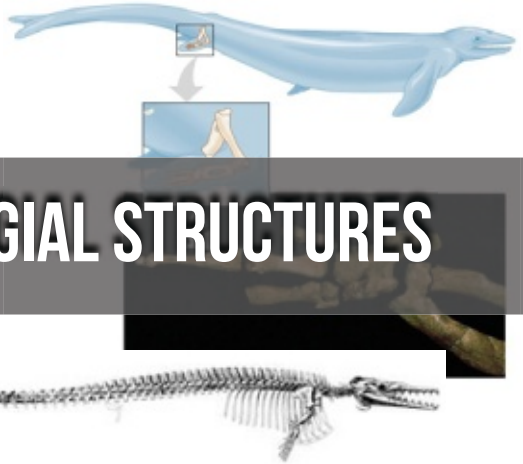
Comparative anatomy



Evolution • What is the evidence for evolution?

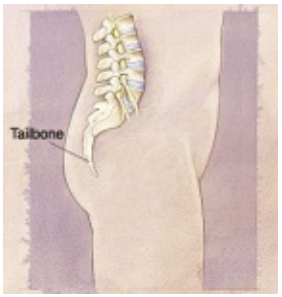


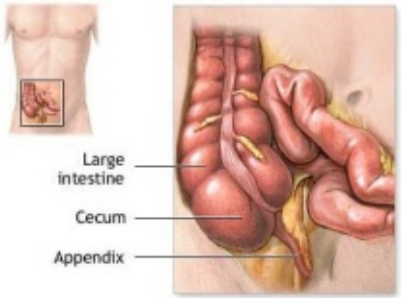
Evolution • What is the evidence for evolution?



VESTIGIAL STRUCTURES

Evolution • What is the evidence for evolution?





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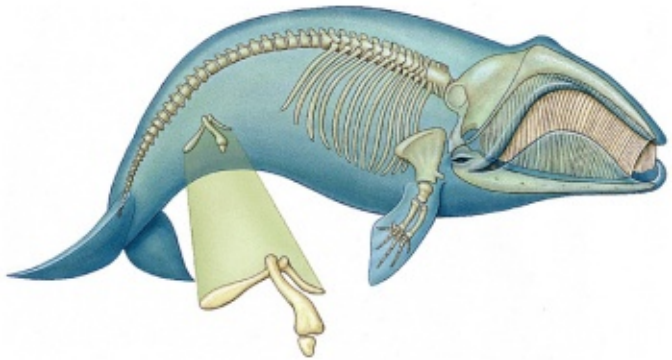

Evolution • What is the evidence for evolution?

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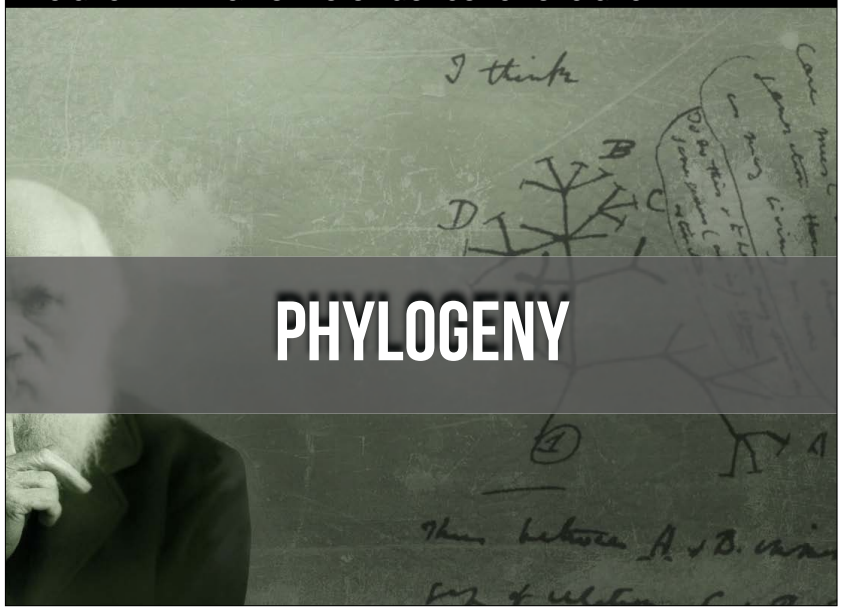

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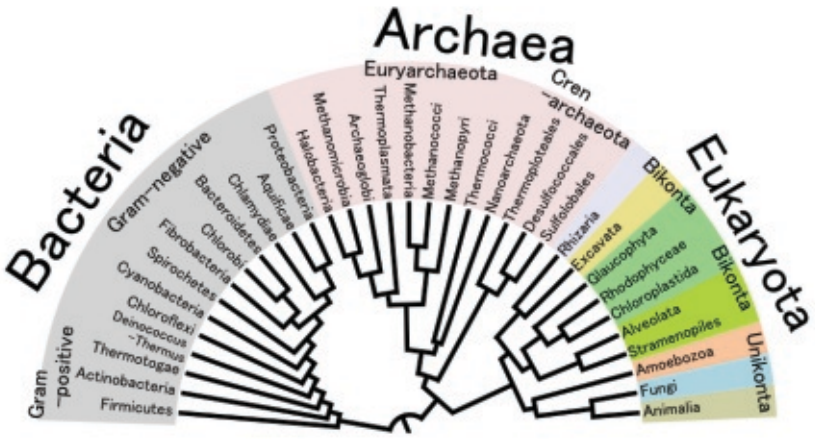
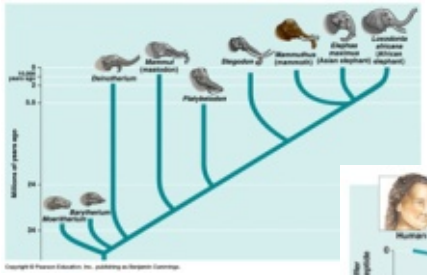
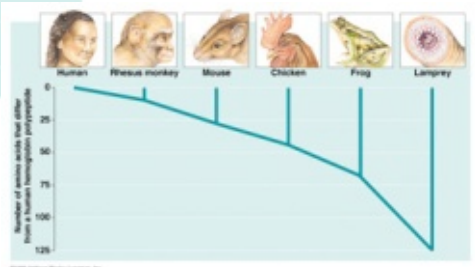


Evolution • What is the evidence for evolution?

Phylogeny



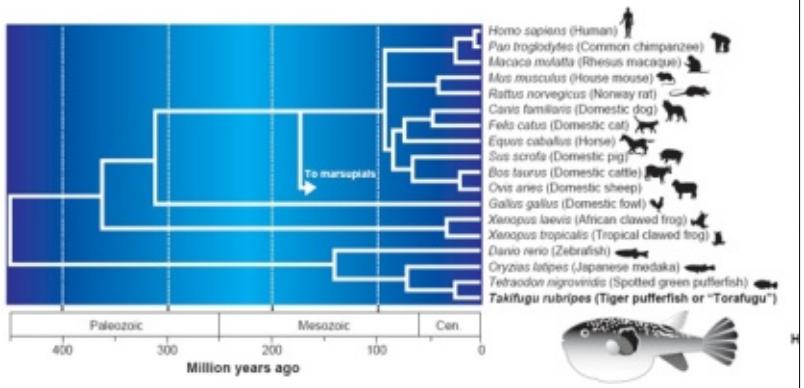
Quanto mais antigas são as espécies, maiores diferenças morfológicas exibirão.



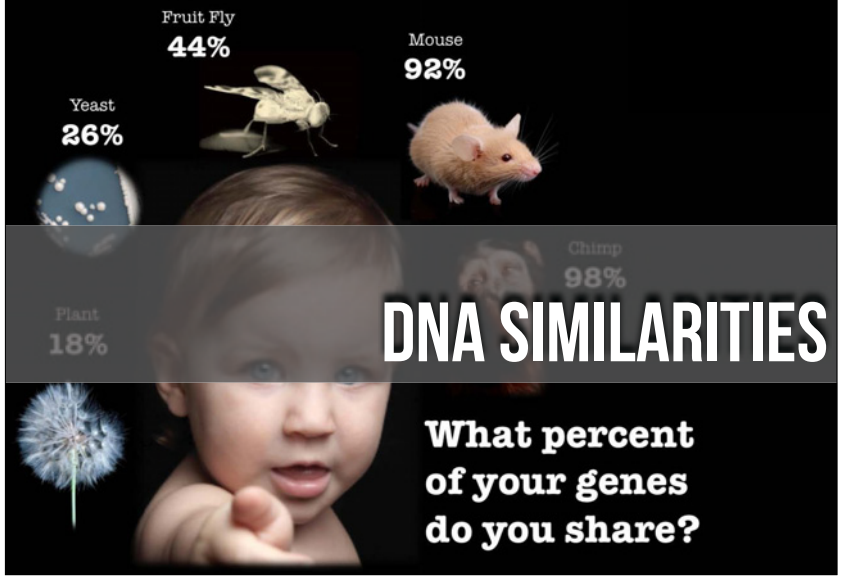
Diferenças moleculares são proporcionais à proximidade dos organismos

Evolution • What is the evidence for evolution?

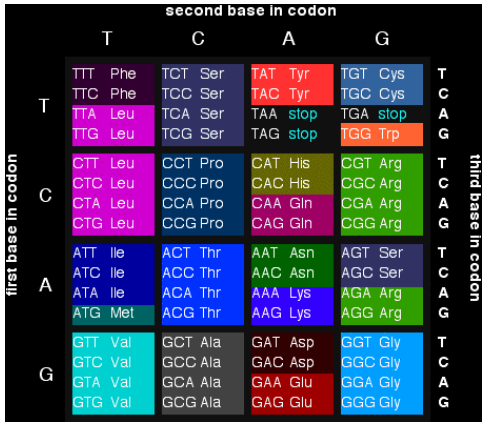
Phylogeny



Evolution • What is the evidence for evolution?



Evolution • What is the evidence for evolution?



Porque é que o código genético é universal? Ou existe uma limitação química, ou o código representa um "acidente" histórico. (Homologia molecular)

Evolution • What is the evidence for evolution?

DNA

Evolution • What is the evidence for evolution?

Evolution • What is the evidence for evolution?

Direct observation

For example, allowing only organisms with certain traits to breed, humans have created many different varieties from one species.

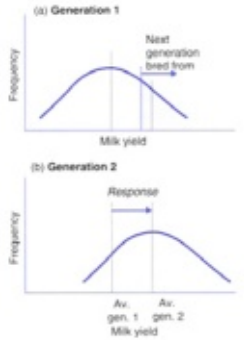
- Traças (*Biston betularia*) - duas variantes: clara, escura.
- Antes de 1900, as árvores cobertas de liquenes eram cinzentas claras: as traças claras eram mais comuns.
- Com a revolução industrial a poluição matou os liquenes e as árvores ficaram mais escuras: as traças escuras passaram a ser mais comuns.
- Mais tarde com a diminuição da poluição, as árvores voltaram à cor normal e as traças claras substituiram as escuras.
- A sobrevivência das traças depende da predação pelas aves – predadores visuais.

Evolution • What is the evidence for evolution?

Direct observation - experimental

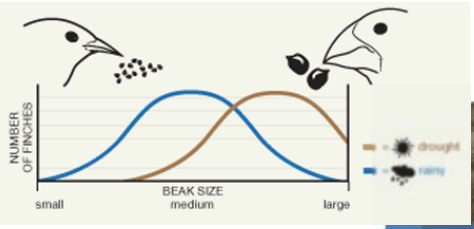
A geração 2 surge a partir de um cruzamento de indivíduos da geração 1 que produzem uma quantidade de leite acima da média.

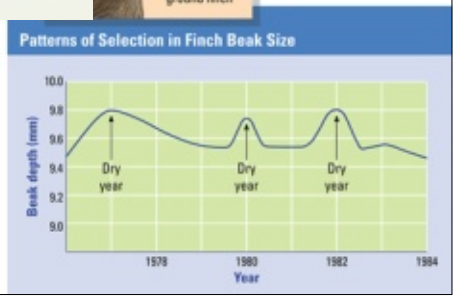
Observa-se um desvio da média de produção de leite da 1ª para a 2ª geração.



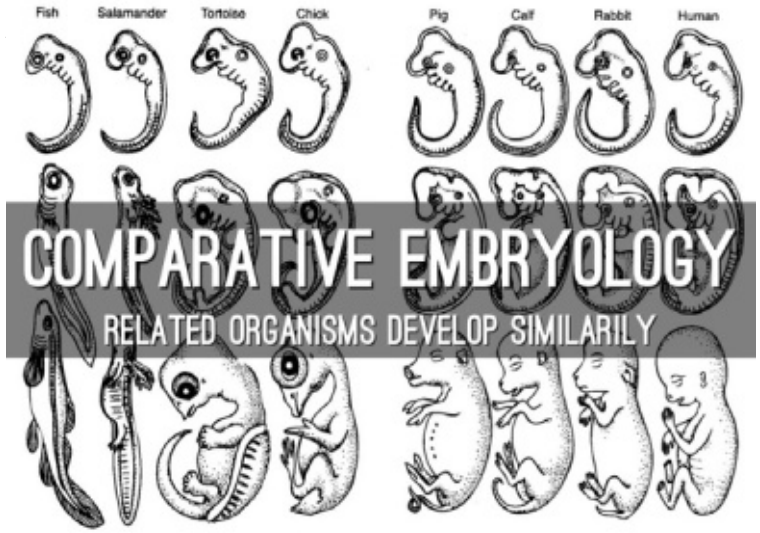
Evolution • What is the evidence for evolution?

Direct observation - new species





Evolution • What is the evidence for evolution?



COMPARATIVE EMBRYOLOGY

RELATED ORGANISMS DEVELOP SIMILARILY

Evolution • What is the evidence for evolution?

Embryonic development

- Morfologia (forma do corpo) é determinada pela taxa de crescimento de certos tecidos em alturas chave do desenvolvimento.
- Espécies proximamente relacionadas desenvolvem-se de forma semelhante.
- Diferenças fundamentais (peixes vs mamíferos) requerem alterações prematuras no desenvolvimento.
- Diferenças superficiais requerem alterações menores mais tarde.
- O desenvolvimento embrionário reflecte a história da evolução.

Evolution • What is the evidence for evolution?

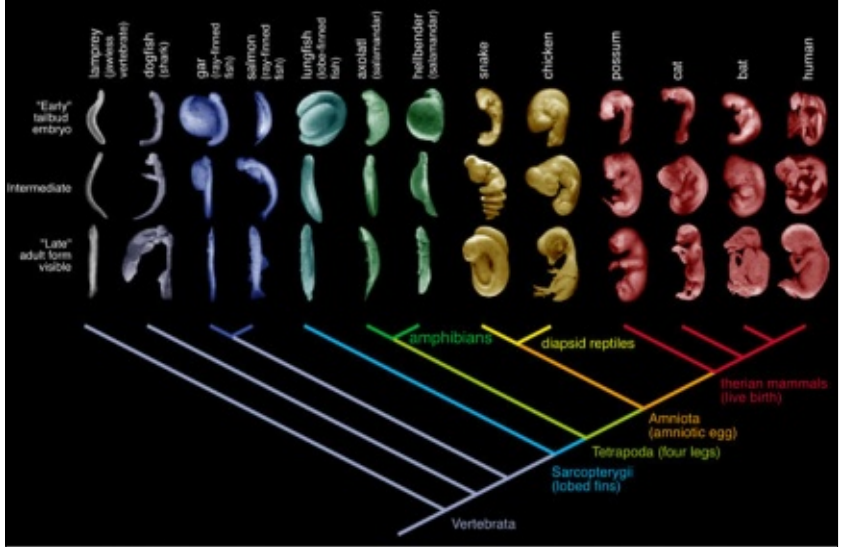
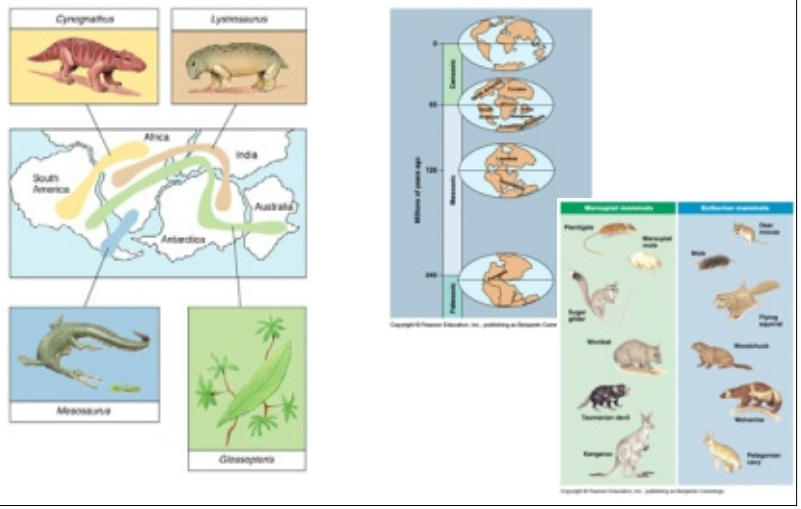


Figure 8. Developmental sequences of various vertebrates shown in phylogenetic context. Note the shared similarities of some closely related taxa, particularly the amniotes

Evolution • What is the evidence for evolution?

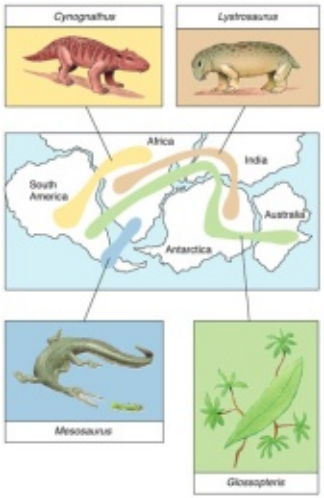
Evolution • What is the evidence for evolution?

Biogeography



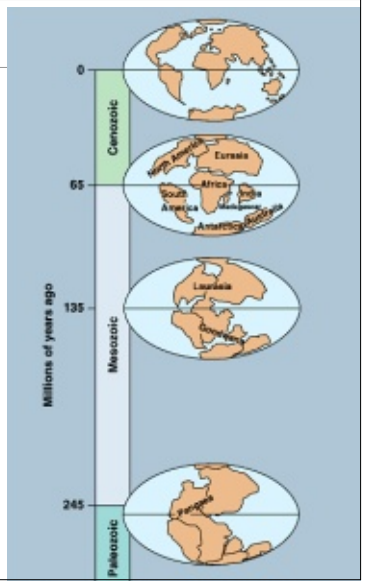
Evolution • What is the evidence for evolution?

Biogeography



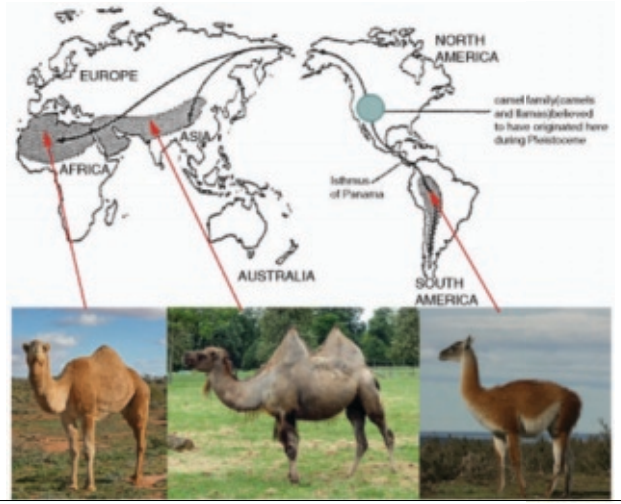
Evolution • What is the evidence for evolution?

Biogeography



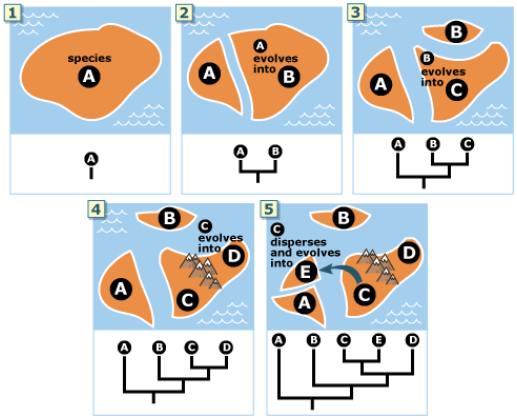
Evolution • What is the evidence for evolution?

Biogeography



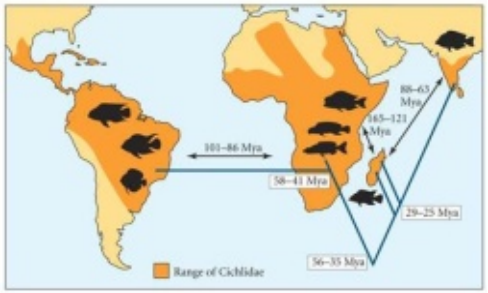
Evolution • What is the evidence for evolution?

Biogeography - Distribution of species on oceanic islands



Evolution • What is the evidence for evolution?

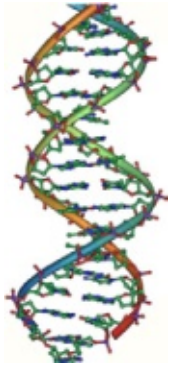
Biogeography



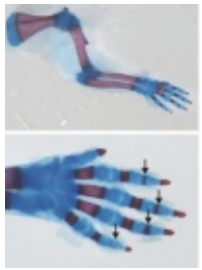
Evolution • What is the mechanism for evolution?

Evolution • What is the mechanism for evolution?

All in the Genes (or almost all….)



Genotype



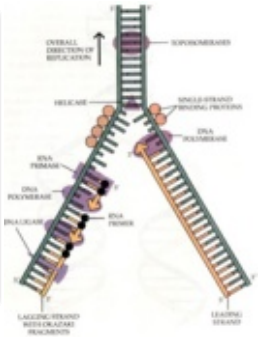
Phenotype

- The genetic make-up of an organism is known as its genotype.
- An organism's genotype and the environment in which it lives determines its total characteristic traits i.e. its phenotype.

Evolution • What is the evidence for evolution?

DNA

Watson and Crick and their model of DNA

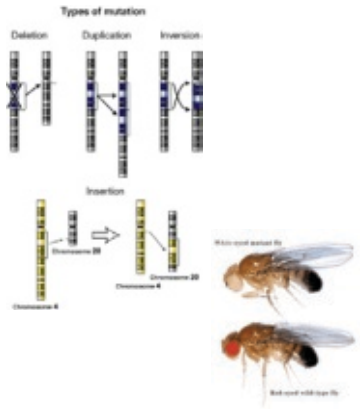


DNA replication

- The double-helix structure of DNA was discovered in 1953.
- This showed how genetic information is transferred from one cell to another almost without error.

Evolution • What is the mechanism for evolution?

Mutation



Types of mutation

- However, occasional mutations or copying errors can and do occur when DNA is replicated.
- Mutations may be caused by radiation, viruses, or carcinogens.
- Mutations are rare and often have damaging effects. Consequently organisms have special enzymes whose job it is to repair faulty DNA.

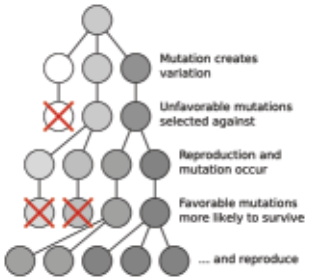
Evolution • What is the mechanism for evolution?

Mechanism: Variation

- Nevertheless, some mutations will persist and increase genetic variation within a population.
- Variants of a particular gene are known as alleles. For example, the one of the genes for hair colour comprises brown/blonde alleles.

Evolution • What is the mechanism for evolution?

Natural Selection

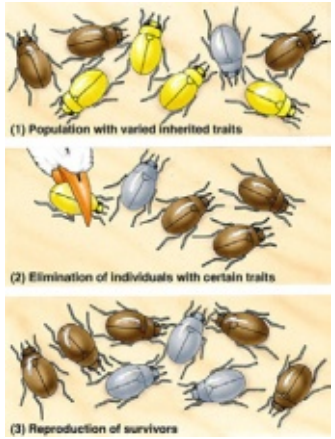


Selection of dark gene

- Mutant alleles spread through a population by sexual reproduction.
- If an allele exerts a harmful effect, it will reduce the ability of the individual to reproduce and the allele will probably be removed from the population.
- In contrast, mutants with favorable effects are preferentially passed on

Evolution • What is the mechanism for evolution?

Natural Selection



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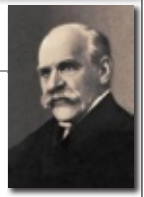
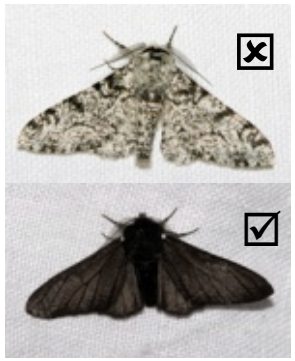




Haldane and the peppered moth

- The Peppered Moth is an example of Natural Selection in action discovered by Haldane
- During the Industrial Revolution the trees on which the moth rested became soot-covered.
- This selected against the allele for pale colour in the population (which were poorly camouflaged from predators) and selected for the dark colour allele.

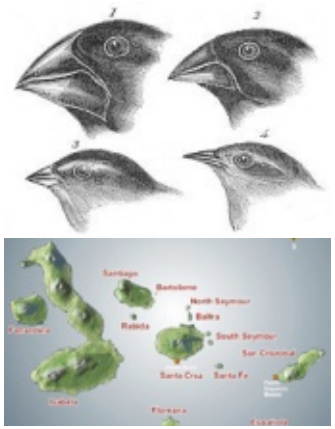
Evolution • What is the mechanism for evolution?

Dogs are wolves

- The dog is another example of how selection can change the frequency of alleles in a population.
- Dogs have been artificially selected for certain characteristics for many years, and different breeds have different alleles.
- All breeds of dog belong to the same species, ***Canis lupus*** (the wolf)

Evolution • What is the mechanism for evolution?

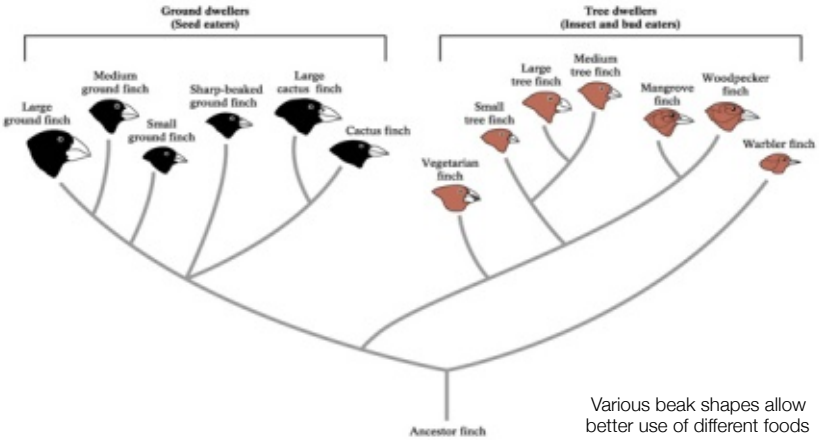
- However, if two populations of a species become isolated from one another for tens of thousands of years, genetic difference may become marked.
- If the two populations can no-longer interbreed, new species are born.
- Darwin's Galapagos finches are an example of this process in action.



Galapagos finches

Evolution • What is the evidence for evolution?

Darwin- Speciation in Galapagos finches



Various beak shapes allow better use of different foods

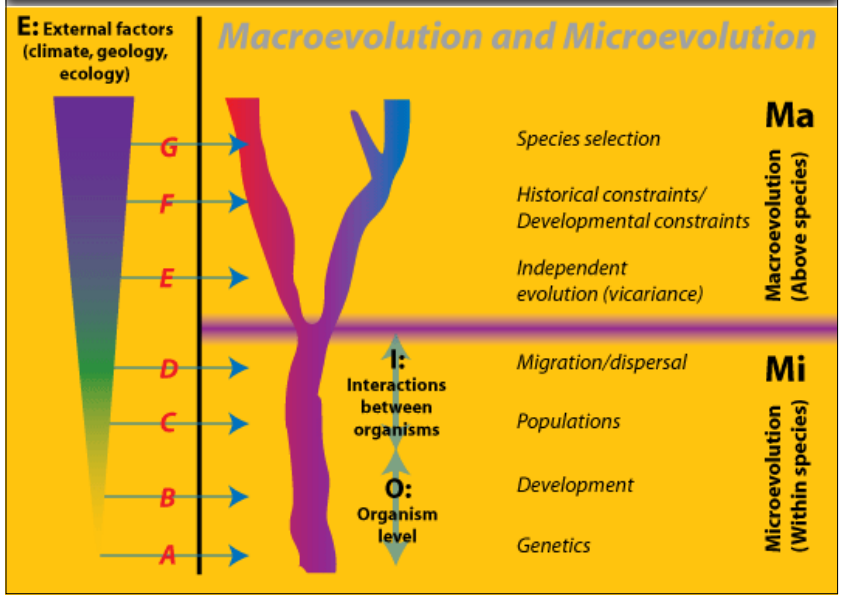
Evolution • What is the mechanism for evolution?

Speciation Today?

London Underground Mosquito

- The mosquito was introduced to the London Underground during its construction around 1900.
- It became infamous in the War for attacking people sheltering from the Blitz.
- Studies indicate several genetic differences from its above-ground ancestors. Interbreeding between populations is difficult suggesting that speciation may be occurring.

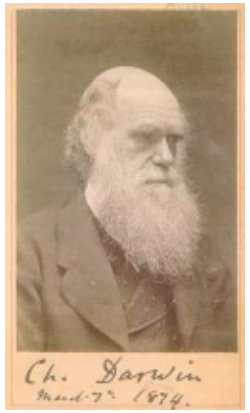
Evolution • What is the mechanism for evolution?



Evolution • What is the mechanism for evolution?

The mosquitos are an example of macro-evolution.
The dogs are an example of micro-evolution.

Evolution • Darwin observations



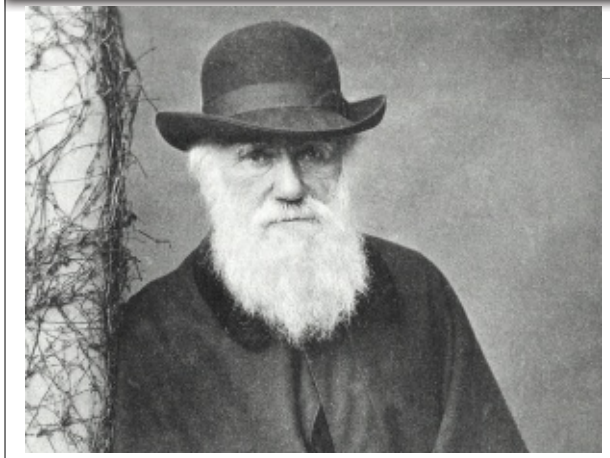
"Neither the similarity or dissimilarity of the inhabitants of various regions can be wholly accounted for by climatic and other physical conditions."

"Neither the similarity or dissimilarity of the inhabitants of various regions can be wholly accounted for by climatic and other physical conditions."

so... what can explain the similarity?

likewise what can explain the dissimilarity?

Evolution • Darwin observations



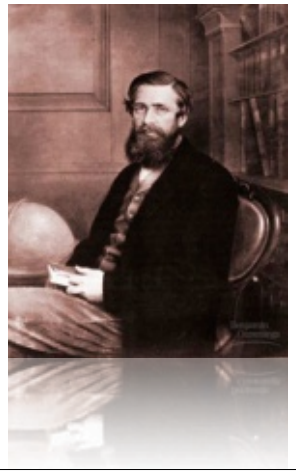
"Barriers of any kind…are related in a close and important manner to the differences between the productions [organisms] of various regions"

Alfred Wallace (1823-1913)

British naturalist, 1858

Letter from West Indies with article to review and send to Lyell.

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



Alfred Russell Wallace (1823-1913)

- Darwin passou 2 décadas a coligir informação, mas estava reluctante em publicar a matéria que sabia que iria gerar grande controvérsia.
- Em 1858, Alfred Wallace submeteu um manuscrito propondo uma teoria idêntica à de Darwin.
- Publicaram conjuntamente em 1858.
- Em 1859, Darwin publicou "The Origin of Species".

As duas maiores contribuições de Darwin

1. Estabeleceu que as espécies surgem através de **evolução de ancestrais comuns**.
2. Identificou o mecanismo da evolução como a selecção natural.

- A reunião de evidências sobre a evolução convenceu numa década a maior parte dos biólogos.
- A sua teoria só se estabeleceu firmemente, após os anos '30, com os avanços no campo da genética.

A revolução Darwiniana

A teoria de Darwin desafiou:

1. A ideia de que a Terra tinha um ambiente constante e uma idade relativamente jovem.
2. A crença de que o mundo tinha sido criado por um criador sábio e benigno.
3. A ideia da imutabilidade das espécies.
4. A ideia da posição única do homem na criação.

"I have called this principle, by which each slight variation, if useful, is preserved, by the term ***Natural Selection***."

Charles Darwin 1809 -1882

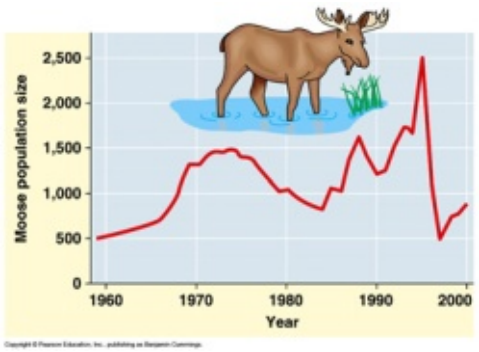
Observation 1

Species have great powers of potential reproduction

Populations would increase exponentially if all individuals survived and reproduced

Observation 2

But populations tend to remain stable over time, except for seasonal fluctuations



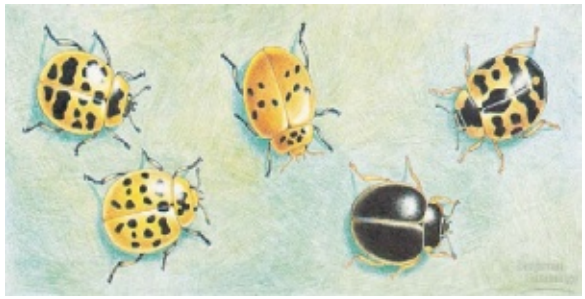
Observation 3

Environmental resources are limited

Discussion in Malthus, "Essay on the Principle of Population" helped clarify this

Observation 4

Individuals in a population vary extensively



Observation 5

Much of this variation is heritable

However, Darwin did not know the mechanism at the time