## *Becoming Human*

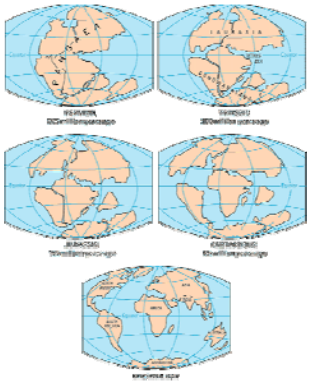

## *Human Evolution*


(A) Pan troglodytes, chimpanzee, modern
(B) Australopithecus africanus, STS 5, 2.6 My
(C) Australopithecus africanus, STS 71, 2.5 My
(D) Homo habilis, KNM-ER 1813, 1.9 My
(E) Homo habilis, OH24, 1.8 My
(F) Homo rudolfensis, KNM-ER 1470, 1.8 My
(G) Homo erectus, Dmanisi cranium D2700, 1.75 My
(H) Homo ergaster (early H. erectus), KNM-ER 3733, 1.75 My
(I) Homo heidelbergensis, "Rhodesia man," 300,000 - 125,000 y
(J) Homo sapiens neanderthalensis, La Ferrassie 1, 70,000 y
(K) Homo sapiens neanderthalensis, La Chappelle-aux-Saints, 60,000 y
(L) Homo sapiens neanderthalensis, Le Moustier, 45,000 y
(M) Homo sapiens sapiens, Cro-Magnon I, 30,000 y
(N) Homo sapiens sapiens, modern

## *Objectives*

- How old is the universe? How old is the earth?
- What is evolution? How does it differ from natural selection?
- Who was Darwin? How does Natural Selection work?
- How do humans differ from apes?
  - Skeleton, organs, culture
- Why was *Homo erectus* so successful as an early hominid?
- Be able to *briefly* trace the cultural development within Great Salt Lake Region

## *Carl Sagan's Universe Calendar*



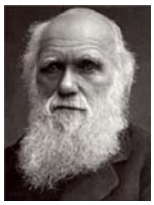
24 days = 1 billion years

1 second = 475 years

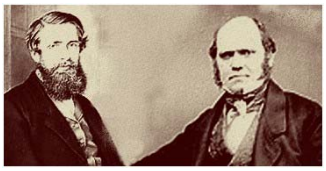
http://www.youtube.com/watch?v=g2qezQzfqIY

## Theories of Evolution

- Charles Darwin and Alfred Russle Wallace, 1850s
  - "Any one whose disposition leads him to attach more weight to unexplained difficulties than to the explanation of certain number of facts will certainly reject my theory"
  - *On the origin of species*, 1859



Charles Darwin

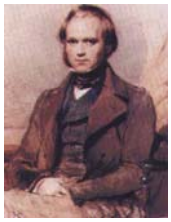


## Darwin's Travels



## Evolution vs. Natural Selection

**Charles Darwin**
*Evolution & Natural Selection*

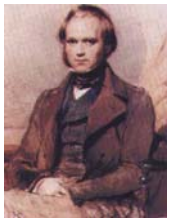


Charles Robert Darwin

1809 - 1882

**Evolution**: Is the process of change in the inherited traits of a population of organisms from one generation to the next (processed at the level of the genes).

**Charles Darwin**
*Evolution & Natural Selection*



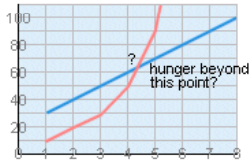
**Natural Selection**: Is the process by which favorable heritable traits become more common in successive generations of a population of reproducing organisms and unfavorable heritable traits become less common, due to differential reproduction of genotypes.

## Before Darwin

- Geologists and paleontologists had made a compelling case that:
  - Uniformitarianism: the assumption that the natural processes operating in the past are the same as those that can be observed operating in the present.
  - life had been on Earth for a long time.
  - it had changed over that time
  - and many species had become extinct.

## Influences on the Theory

- Thomas Malthus published a book in 1797 called Essay on the Principle of Population in which he warned his fellow Englishmen that most policies designed to help the poor were doomed because of the relentless pressure of population growth. A nation could easily double its population in a few decades, leading to famine and misery for all.
  - Species cannot reproduce to their full potential because there is struggle for existence. In this struggle for existence, survival and reproduction do not come down to pure chance. Some traits help produce more offspring.




Population Increase
- Geometric or exponential growth

Food Supply
- Arithmetic growth

## Selective (artificial) Breeding

This Chihuahua mix and Great Dane show the wide range of dog breed sizes created using artificial selection.

http://www.dailymotion.com/video/xdyjed_the-story-of-oliver-the-humanzee_animals

## Variation is Key!


http://www.youtube.com/watch?v=-CBNK8UbI38

## Principles of Natural Selection

**There is variation in traits:**
*For example; some beetles are green & some are brown.*

**There is differential reproduction:**
- *Environments cannot support unlimited population growth (Malthus) – Not all individuals get to reproduce to their full potential.*

**There is heredity**
- *Traits have a genetic basis.*

**The more advantageous traits allow more offspring.**

If you have **variation, differential reproduction,** and **heredity**, you will have *evolution* by *natural selection*.

## Sources of variation

- Genetic Drift
- Mutation

## Genetic Drift

- ***Genetic drift*** is one of the basic mechanisms of evolution.
- There is no direction or selection in genetic drift, it is simply about luck. If an individual leaves more offspring simply by chance, that is genetic drift.

- Genetic drift depends strongly on small population size since the law of large numbers predicts weak effects of random sampling with large populations.
- By definition, genetic drift has no preferred direction

## Mutations

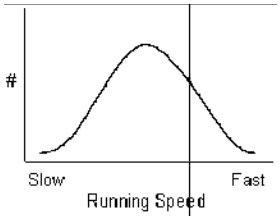
- In biology, mutations are changes to the nucleotide sequence of the genetic material of an organism.
- Mutations can be caused by copying errors in the genetic material during cell division.
- Mutations create variation within the gene pool. Less favorable (or *deleterious*) mutations can be reduced in frequency in the gene pool by natural selection, while more favorable (*beneficial* or *advantageous*) mutations may accumulate and result in adaptive evolutionary changes.

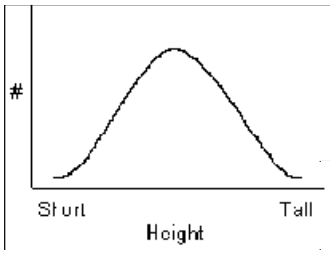
## Facts necessary for Natural Selection to operate

1. Variation exists between individuals of same spp.
2. Every population produces excess offspring
3. Not all individuals survive to reproduce
4. Among all individuals competing for resources, only those individuals best able to obtain resources will survive and reproduce
5. If characteristics are inherited, favored traits will be more frequent in the next generation

## Variation

Individuals are not all identical. For example, if running speed were measured, some individuals would likely be able to run faster than others but most individuals would probably be intermediate.




## Some variants are "favored"

Some individuals are bound to be favored. You would expect that more of the faster ones would survive and reproduce than the slower ones.

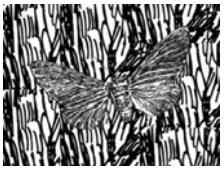
## Traits Are Heritable

Those individuals that survive to reproduce better will pass their genes to the next generation. As a result, the population will change from one generation to the next.

- Natural selection will favor traits that allow individuals possessing those traits to leave more descendants.
- The environment that the organisms inhabit shape the evolution that occurs.
- Ultimately natural selection operates only by differential reproductive success.

## Classic Example

**Industrial Melanism in the British Peppered Moths**



**Polluted Forest**

Near Birmingham, 630 moths were released. Of those 493 were dark and 137 were light.

Of the moths marked and released, 149 were recaptured: 131 were dark and 18 were light.

| | Dark-colored moths | Light-colored moths |
|---|---|---|
| Released | 493 | 137 |
| Recaptured | 131<br>27% (131/493) | 18<br>13% (18/137) |

Kettlewell concluded that **dark-colored** moths were twice as likely to survive in the **polluted forest**.

*From Kettlewell, 1955, p. 302.*

## Unpolluted Forest

Near Dorset, 984 moths were released. Of those, 488 were dark and 496 were light.

Of the moths marked and released, 96 were recaptured: 34 were dark and 62 were light.

| | Dark-colored moths | Light-colored moths |
|---|---|---|
| Released | 488 | 496 |
| Recaptured | 34<br>7% (34/488) | 62<br>13% (62/496) |

Kettlewell concluded that **light-colored** moths were twice as likely to survive in the **unpolluted forest**.

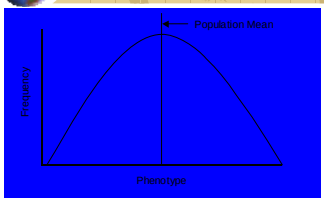
*From Kettlewell, 1956, p. 295.*

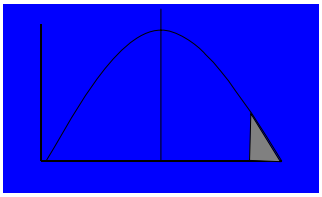
D. Fitness

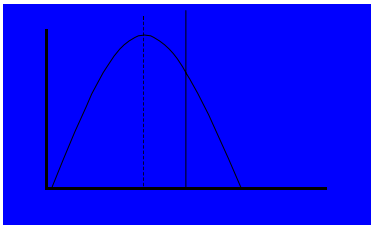
Two definitions-

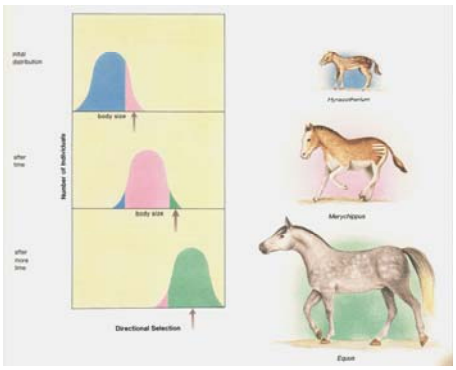
1. Absolute fitness – the measure of an individuals genotype present in the next generation
2. Relative fitness – the measure of an individuals genotype relative to everyone else in the population. How does an individual stack up?

## Directional Selection

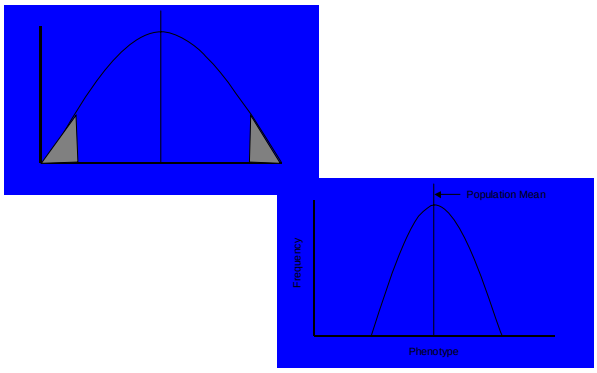


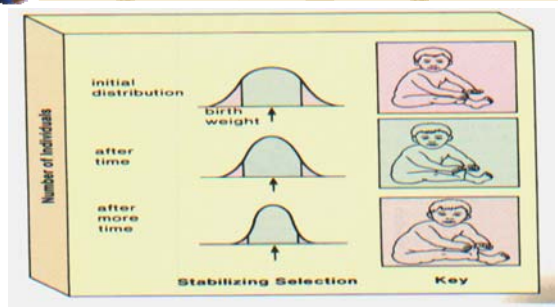





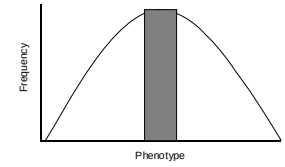


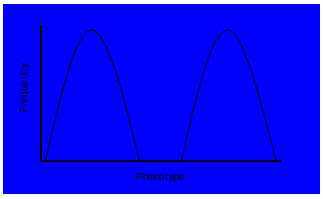

## Stabilizing Selection




## Disruptive Selection



## Point to Ponder

Support or reject the following statement with a rationale for your decision.

Adaptation will eventually always produce the "best" or "optimal" phenotypes.

**1. Gene flow and mutation**

Mutations are always occurring, generating variation in the population. Most mutations are detrimental no adaptive.

**2. Environments continuously changing**

Environments are not constant, thus traits that have a fitness at one point in time might not at another.

**3. Adaptation is always a compromise**

Organisms have a limited amount of time and energy available. There are trade-offs between adaptations.

The wing of a Loon is ideally suited for swimming bu not so well for flying.

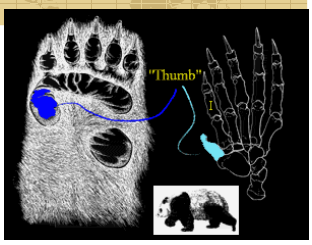
**4. Historical constraints**

Historical constraints are always present because organisms have a history and change in small increments.

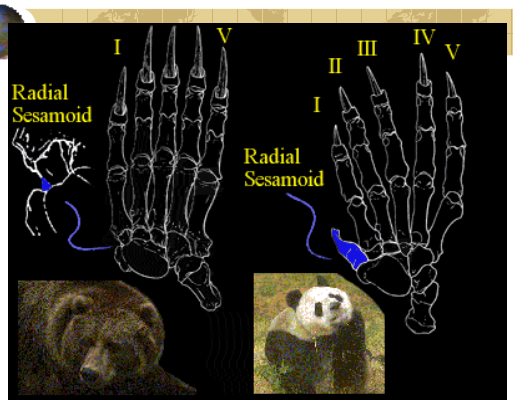
"Panda's Thumb Principle"

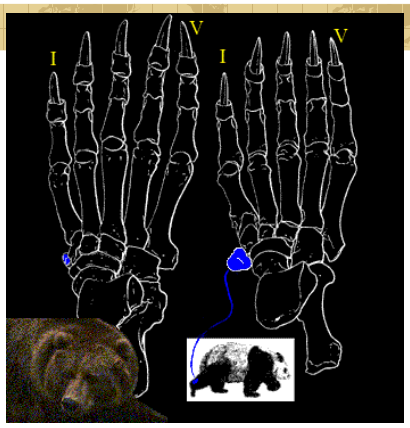
How many claws are there?

5


**Radial sesamoid bones** form in the bits of connective tissue that cross joints.



Why both tibial sesamoid and radial sesamoid enlarged?

Likely an artifact of the history of the Giant Panda.

Original function - reduce chance of tears in the tendons

Subsequent function - enlarged to serve as tree climbing aids in giant panda ancestors

The radial sesamoid was then co-opted to help the panda grip bamboo.

**1. Evolution operates at the level of**

**a. populations**
**b. phenotypes**
**c. individuals**
**d. characters**

**2. Which of the following is <u>not</u> necessary for natural selection to operate?**

**a. variation between individuals**
**b. production of excess offspring**
**c. random mating**
**d. heritability of traits**

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d. heritability of traits

## II. Macroevolution

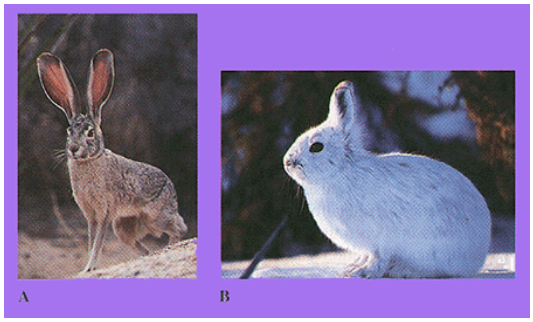
A. Definition
- refers to the large-scale patterns, trends, and rates of change among groups of species.

- Origins of new organismal structures and designs
- Evolutionary trends
- Adaptive radiation
- Phylogenetic relationships of species

**Large-scale variation among populations**

**Allen's rule: The size of extremities (limbs, tail, ear, etc.) increases from colder to warmer climates in the same species or in closely related species.**

Figure 42-4 ALLEN'S RULE: EXTREMITIES, TEMPERATURE, AND EVOLUTION.
According to Allen's rule, animals living in cold climates tend to have shorter extremities (tails, limbs, ears) than animals living in warm climates. This is illustrated by (a) the arctic fox (*Alopex lagopus*) with its short tail, ears, and legs, and (b) the desert fox (*Vulpes chama*) with its longer tail, ears, and legs. These characteristics have obvious adaptive value: body heat is retained more efficiently by short extremities and is dissipated more efficiently by large extremities with their greater surface areas.



**Bergmann's rule: The body size of organisms within species (or in closely related taxa) increases from warmer to colder climates.**

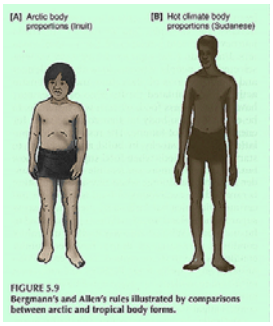
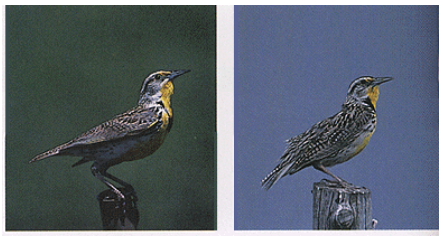


FIGURE 5.9
Bergmann's and Allen's rules illustrated by comparisons between arctic and tropical body forms.

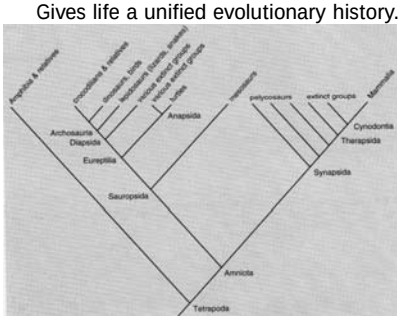
**Accumulation of genetic differences that manifest themselves in the phenotype may lead to the formation of clines, races and eventually new species.**


A. Similarity between species

## B. Common Descent

History of life can be depicted as a branching tree called a Phylogeny

Gives life a unified evolutionary history.




## *Definitions*

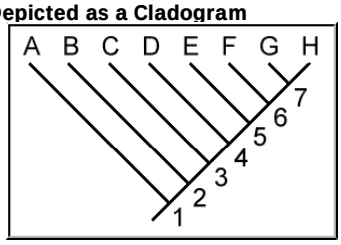
**Taxonomy**- Branch of biology concerned with identifying and naming organisms

**Classification**- The assignment of organisms based on their evolutionary relationships to other organisms

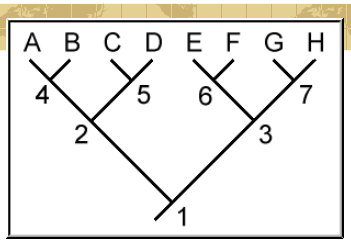
**Phylogeny**- Evolutionary history of organisms

**Phylogenetic trees show the order in which lineages split.**

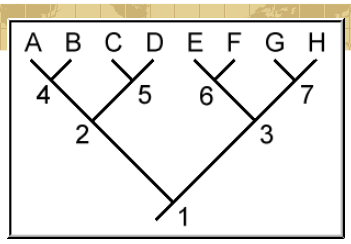
**Depicted as a Cladogram**




Groups G and H are most closely related, while group A is the most distant. Clades are represented by numbers 1 through 7.




Groups A and B are more closely related to each other than to any other group, as are C and D, E and F, and G and H.




**Which clade is more closely related?**

**A. 5 and 6**

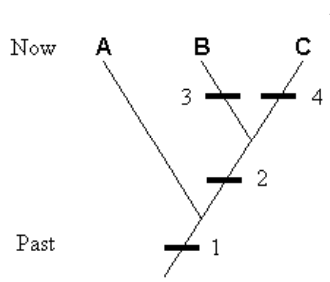
**B. 4 and 5**

**C. 6 and 7**

**Darwin described evolution as descent with modification. He recognized that closely related species are likely to be similar → They share traits.**

**Traits inherited from ancestors in distant past should be shared by large number of species.**

**Traits inherited more recently should be shared by fewer species.**

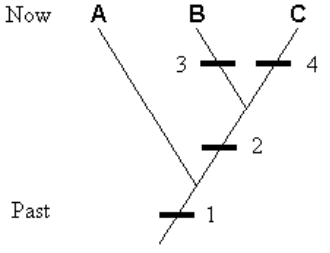



**Ancestral character** - Character or character state present in common ancestor and in all members of the group

## Ancestral traits

Criteria to determine primitiveness:

- Presence in fossils
- Commonness across taxa
- Early appearance in phylogeny
- Presence in outgroup




**Derived character –**

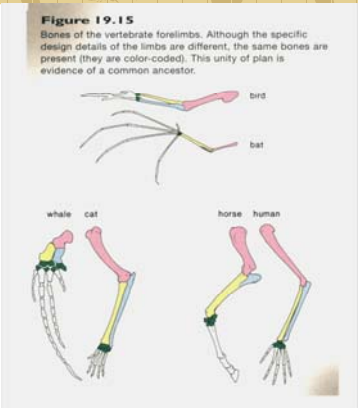
**Character or character state present only in a particular line of descent.**

Sharing of traits indicates they **<u>may</u>** be descendants of a common ancestor.

**Homology** - Character similarity that stems from common ancestry. Characters may differ in structure or function.

Vertebrates → vertebral column

## Morphological Divergence




Traits may be similar but not due to inheritance from common ancestor.

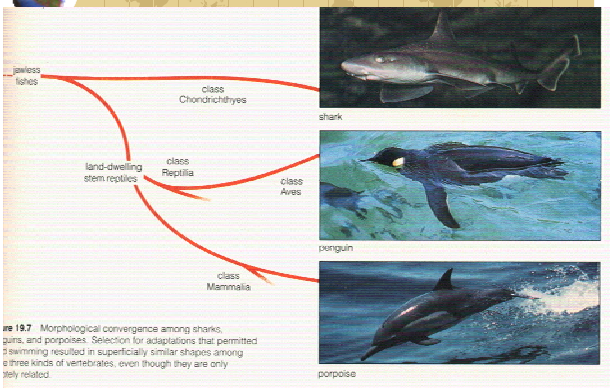
Need to determine how traits have changed during evolution. Not easy task! Evolutionary patterns are complex.

3 processes generate difficulties.

**1. Convergent Evolution –**

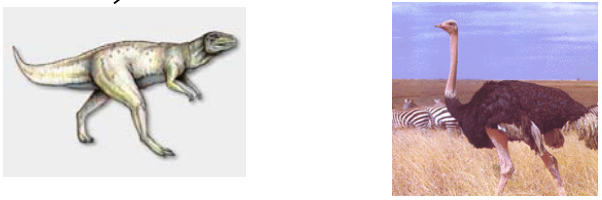
Independently evolved features subjected to similar pressures can become superficially similar.

## Morphological Convergence



1871 - Thomas Henry Huxley compares hindlimb with ostrich 35 unique, shared characters! Concluded – could be closely related.


Harry Seeley – disagreed and suggested similarity due to convergence



**2. Parallel Evolution –**

involves similar developmental modifications that evolved independently, often in closely related organisms (because they are likely to have similar developmental mechanisms to begin with).

In parallelism, the ancestors of the two lineages are similar to each other, and the 'end products' or descendant species are similar to each other, with the same or similar steps along the
way. Hence, the lineages remain 'parallel'.

Convergence - ancestors are 'unrelated' and are dissimilar to each other.
convergence in superficial appearance of the descendant species

Not concerned about the intermediate stages, only the end result.

Thorny devil *(Moloch horridus)* Alice Springs, Australia

Desert horned lizard *(Phrynosoma platyrhinos)*, Death Valley, CA, USA

**3. Evolutionary Reversals –**

A character may revert from a derived state back to an ancestral one.

Most frogs lack teeth on their lower jaw, but the ancestors of frogs did. One frog genus *Amphignathodon,* has re-evolved teeth in the lower jaw.

degeneration of complex structure
looks primitive, actually derived

e.g. Winglessness in Fleas & Lice
Actually 2 different winged ancestors

Dollo's law : complex structures that are lost are unlikely to be regained