Evolution & systematics

Lecturer: Monica Mwale

Module: Introduction to evolution and the principles of systematics

SAIAB: Second Floor

Course Description

This course will explore evolution and the theory and procedures of modern systematic analysis with emphasis on fishes. The course will introduce some fundamental terms and give a review of the historical development of taxonomy. The main topics to be considered will be:

1. **Evolution:** Early history of systematics and Species concepts: e.g. Linnaeus, Darwin & Mayr.
2. **Systematics:** Nomenclature, taxonomy, classification, phylogeny, biodiversity, historical biogeography, evolutionary biology.
3. **Characters and character-states:** homology, coding, kinds (morphological, molecular, behavioural, physiological).
4. **Phylogeny**: basic concepts, lineage, last common ancestor, sister groups, monophyletic vs paraphyletic, in-group and out-group.
5. **Fish systematics**

Evolution - Charles Darwin

Charles Darwin
- medical school dropout; earned a theology degree
- botany professor nominated him to be a naturalist on a voyage to South American (1831-1836), *HMS Beagle*

– **Collected many animals and plants**

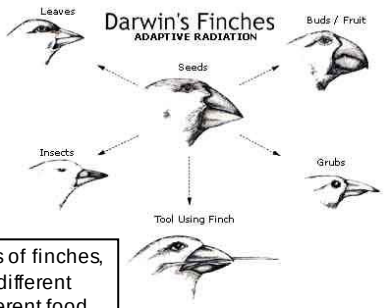
– **What did he see?**

• Geological consistency throughout the world

• Adaptive radiation on islands

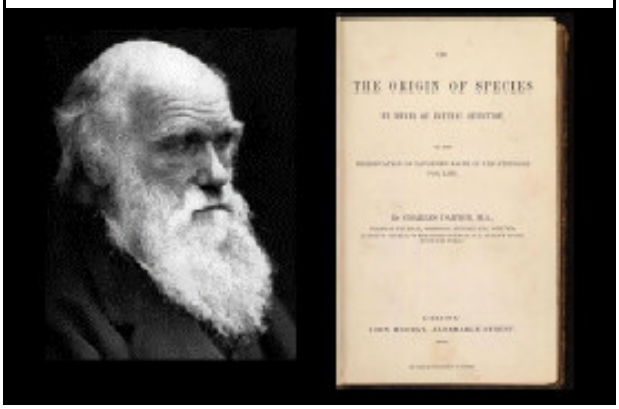
• Conversations with plant and animal breeders -realised differences among individuals that are passed onto offspring.

Illustrates the way the finch has adapted to take advantage of feeding in different ecological niche's



- 14 species of finches, adapted to different niches (different food sources)

Darwin's theory of evolution by natural selection



Darwin's theory of evolution by natural selection

• ***Observations***
– Species have great potential fertility
– But populations are generally stable
– Food resources are limited

• ***Inference 1***

There must be a struggle for survival among individuals, with a small number reproducing

Darwin's theory of evolution by natural selection…

- ***More observations***
  - Individuals are **NOT** identical
  - Variation is **heritable**: from parent to offspring

- ***Inference 2***

Those individuals with 'best' characteristics are most likely to survive

- ***Inference 3***

Natural selection will produce marked changes in a populations and lead to new species

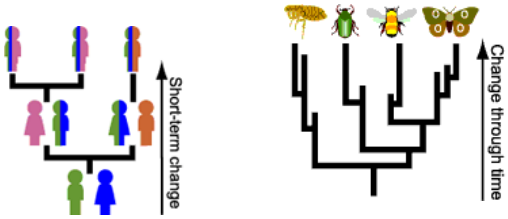
Evolution

What is evolution?

Evolution is a scientific theory

that <u>populations change</u> over a no. of generations. changes are produced at the genetic level as organisms' genes <u>mutate</u> and/or <u>recombine</u> in different ways during **<u>reproduction</u>** and are passed on to future generations.

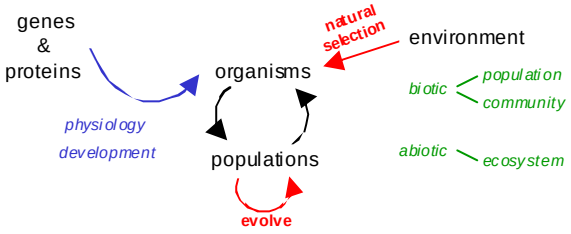
Descent with modification



Through the process of descent with modification, the common ancestor of life on Earth gave rise to the fantastic diversity that we see around us today.

Evolution is a unifying theme in biology

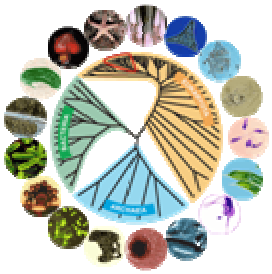
connects all levels of biological organization



Evidence of Evolution Concepts

1. Diversity of life

Extant organisms look and behave in a manner, which can be exactly expected given an **<u>evolutionary genesis</u>**



e.g: Diversity of fishes




Evidence of Evolution Concepts

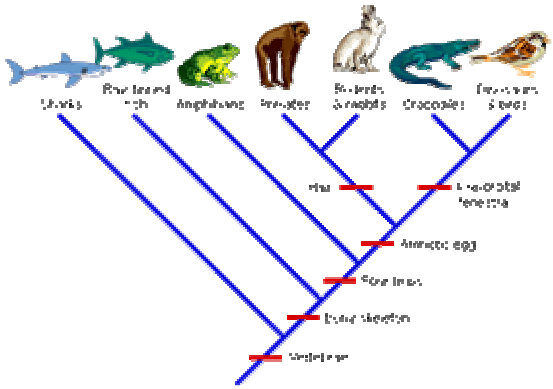
1. Diversity of life

2. Homology

- Organisms bear numerous **shared characteristics** that in total are undeniably strong evidence for the existence of **relatedness.**

- Form is linked to function

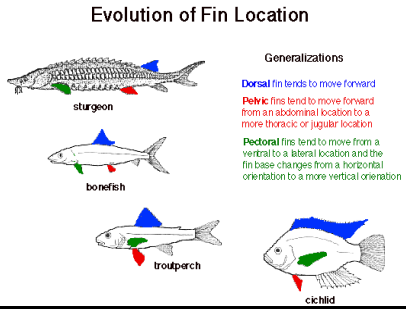
The History of Life: Looking at the Patterns



SIMILARITIES

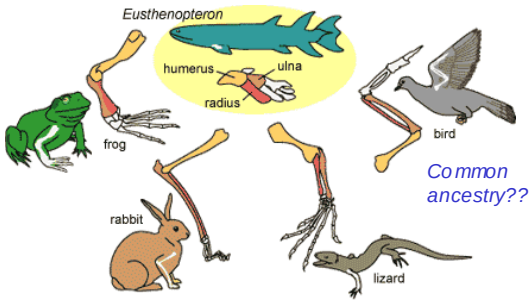
Homology – Form is linked to function

b. Functional morphology (e.g. fins in fishes)



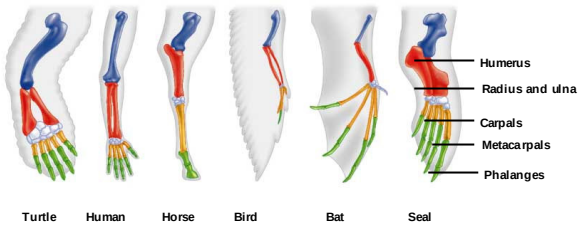
C. Comparative anatomy

Different forelimbs all share the same set of bones - the humerus, the radius, and the ulna



Structural homology

e.g. Similarity in limb structure among mammals

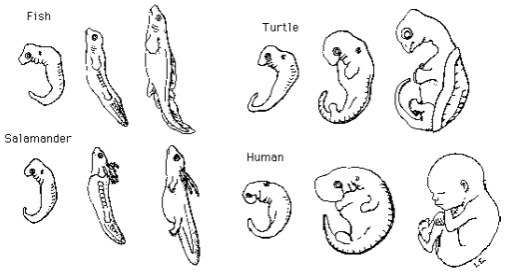


c. Developmental biology

Comparative embryology

The limbs of all tetrapods develop from limb buds in similar ways.

- vestigial traits



d. Cellular and Molecular evidence

-DNA sequences of all organisms have same the same 4 nucleotide bases (AGTC)

Biochemical homology

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D26150 cow     GACTTCTGAATATATTTGAAAACTGAACAGTTTCAACCAAGCCGAAGCAT
U67922 sheep   GACTTCTGAATATATTTGAAAACTGAACAGTTTCAACCAAGCTGAAGCAT
U29185 human   GACTCCTGAATATTTTTCAAAACTGAACAATTTCAGCCATGTCTGAGCTT
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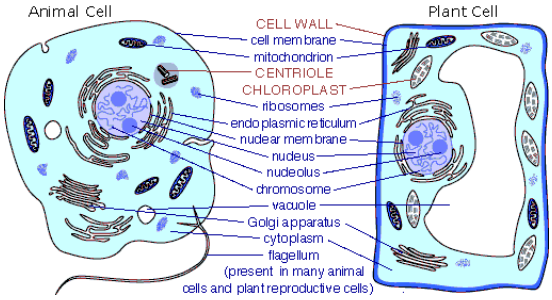
The cellular level

All organisms are made of cells



Similarity in form can reveal similarity in function

Don't confuse homology with

convergence – trait adapted to similar function but with a different origin

Evidence of Evolution Concepts

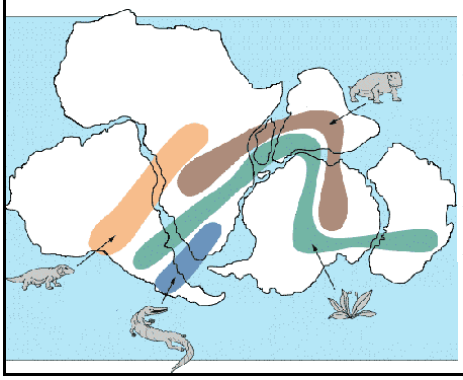
1. Diversity of life
2. Homology
3. **Biogeography**

Organisms are not uniformly distributed
Environments are not homogenous

Ecological levels of organization, such as guilds, faunas, floras, communities, and biotic provinces, have evolved through time.

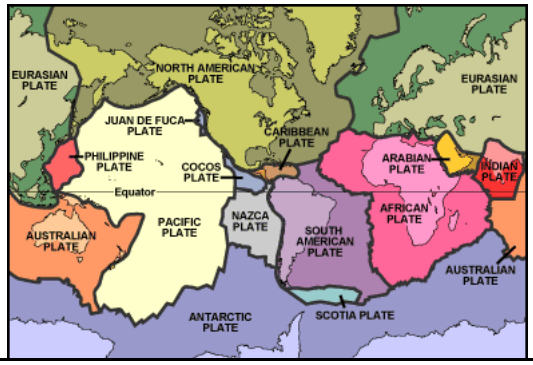
Plate tectonics is the central organising theory of geology and the basis for changes in the distributions of plants and animals through time

Alfred Wegener, a German geophysicist and meteorologist
- fossils and rock types

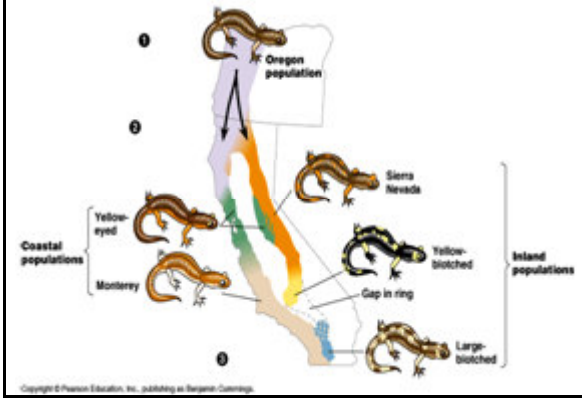


Map showing distribution of fossils on the southern continents.
-Gondwanaland (India, Africa, Australia, S. America & Antarctica)

Continental drift is an explanation for similarities among landforms, sequences of rock formations, and fossil floras and faunas spread across widely separated continents



Local Distribution - Population differences



Evidence of Evolution Concepts

1. Diversity of life
2. Homology
3. Biogeography
4. **Fossil records**

Paleontology

4. Fossil records

— Alignment of rock layers showed common and deep geological history, far beyond the few thousand years sometimes proposed.

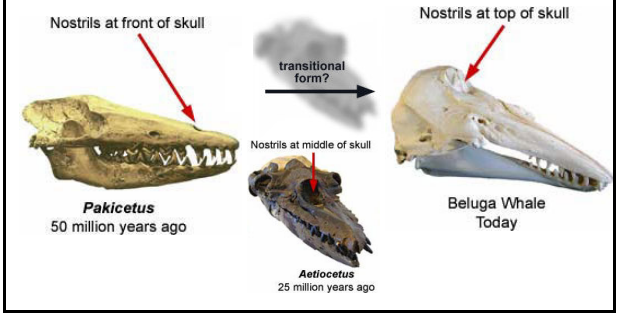
— Succession of fossil-bearing rocks representing sequences of ancient marine and terrestrial environments, gave evidence of many great changes in Earth's surface through time.

— Discovery of fossil animals such as the dinosaur found nowhere on Earth today, demonstrated the reality of extinction (Cuvier, early 19th C.).

— Fossil-bearing sequences through the geologic column showed that faunas become quantitatively more similar to living forms as the present is approached

4. Fossil records

- Provides snapshots of the past
- Shows that life is old and has changed over time.



5. Evidence by example (population genetics models)

The rise of population genetics models (early 20th C.) provided illustrations of how forces of selection, genetic drift, and population size can change the genetic composition of natural populations.

These models are consistent with observations of population changes in the wild and in laboratories.

5. Experimental evolution

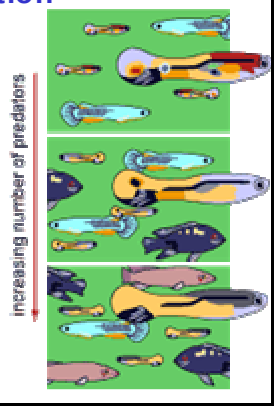
; rapid evolution in nature

1. Artificial selection

Can provide a model that helps us understand natural selection

e.g. Guppy experiment:
Female guppies prefer colorful males for mating purposes.

Predatory fish also "prefer" colorful males



5. Evidence by example…

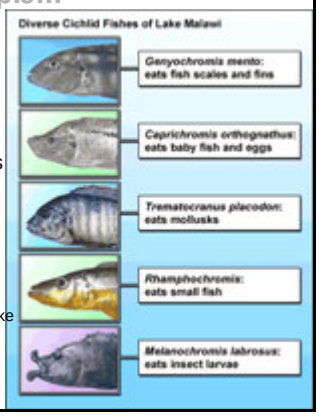
2. Ecology

Can also explain natural selection

e.g. – Lake Malawi cichlids (Adaptive radiation)

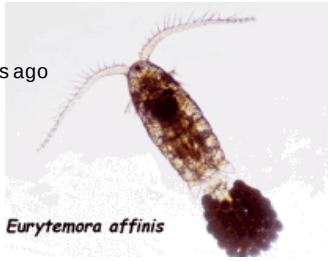
At least 500 endemic species of cichlid fishes

Jaw morphology - has adapted to take advantage of feeding in different ecological niche's



- Experimental evolution; rapid evolution in nature
Selective breeding & direct observation

- marine copepod species
- invaded freshwater 60 yrs ago
- marine populations can't tolerate freshwater
- invaders had to evolve tolerance to freshwater



- Other examples are rapid evolution of antibiotic resistance, pesticide resistance

History of "evolutionary thought" & evidence for evolution

Charles Darwin
- not the first to suggest that evolution has occurred
- amassed the evidence for "descent with modification"
- suggested natural selection as a mechanism

Evidence for "descent with modification"

common ancestry
- homology
- related species
- biogeography

change over time
- vestigial traits
- selective breeding
- direct observation
- fossil record

Evolution may be divided into two types termed:

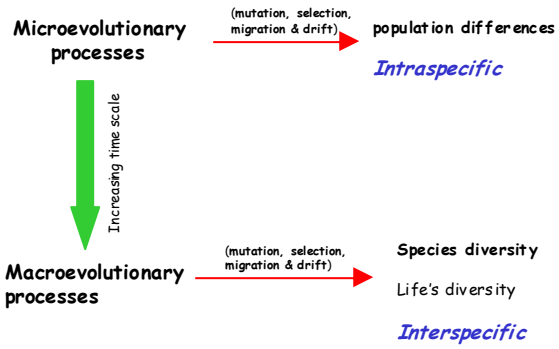
1. Microevolution is change in allele frequency, which occurs within species (i.e., between individual members of individual species, or populations)

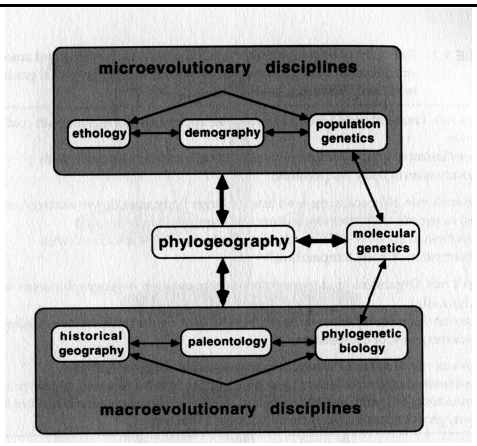
- **e.g. different morph types**

2. Macroevolution

-the processes and patterns that take place between species and larger lineages of organisms and communities in their environments, which also change through time.

-It is thought to occur due to forces similar to those acting within species (**mutation, selection, migration,** and **drift**)





Summary

1. All life forms (species) have developed from other species.
2. All living things are related to one another to varying degrees through common decent (share common ancestors).
3. All life on Earth has a common origin. On other words, that in the distant past, there once existed an original life form and that this life form gave rise to all subsequent life forms.
4. The process by which one species evolves into another involves random heritable genetic mutations (change), some of which are more likely to spread and persist in a gene pool than others.

The central ideas of evolution are that;

- Life has a **history**
- it has **changed over time**
- different species share **common ancestors**

Hence;

Descent with modification