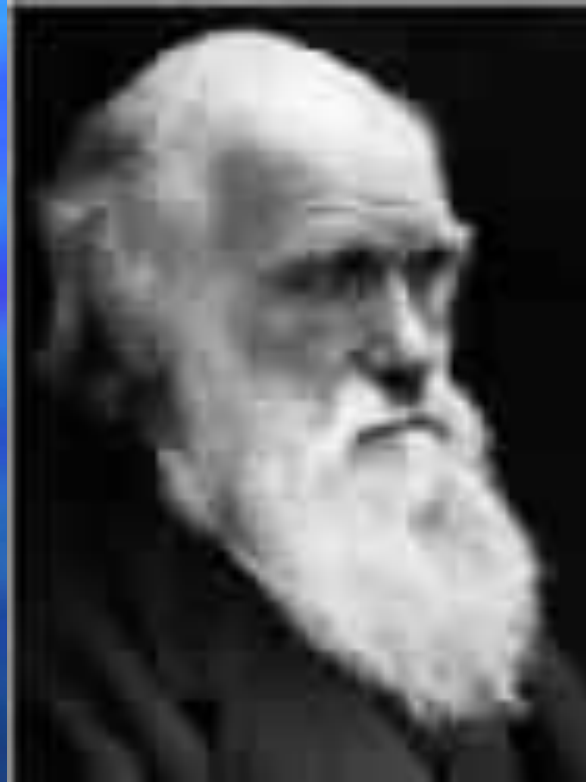


Evidences Supporting Darwin's Theory of Evolution Through Natural Selection





“Nothing in Biology makes sense except in the light of evolution.”

- Theodosius Dobzhansky



Darwin's Theory of Evolution

Charles Darwin set sail on the **HMS Beagle** for a cruise around the world in 1831. On his voyage he discovered the vast diversity of life. As a result of his observations he wrote *On the Origin of Species* (1859).

DARWIN'S CONCLUSIONS

1. All living things are related.
2. One species can gradually change into new species.
3. Species change by the process of Natural Selection.

TYPES of EVIDENCES

Fossil Record

**Comparative
Embryology**

*Comparative
Anatomy*

**Biomolecular
Record**

FOSSIL RECORD

Fossils- preserved remains of ancient organisms. They can be formed in ice, amber, etc. Most often formed in sedimentary rock.



Sedimentary Rock
rock that forms when grains of eroded rock and other materials are carried to the bottom of a body of water and build up under pressure into layers.

FOSSIL RECORD

Fossil Record- collective history of the Earth's organisms. It shows that organisms have changed over time.

FOSSIL RECORD

How are fossils dated?

Relative Dating

- technique to determine the age of fossils relative to other fossils in different layers of rock.

FOSSIL RECORD



The Strata of Olduvai Gorge

FOSSIL RECORD



A fossilized bone is discovered at Olduvai Gorge

FOSSIL RECORD

What is the problem with relative dating?

You don't know the **actual** age of the fossil!!

FOSSIL RECORD

Radioactive Dating

Technique that determines the age of a fossil by measuring the rate of radioactive decay of a radioactive element.

FOSSIL RECORD

Radioactive Dating

This method is based on the **half life** of a radioactive element.

Half Life

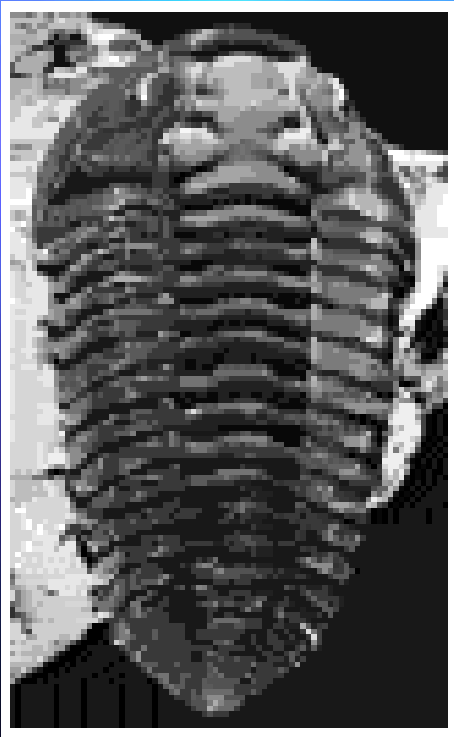
The time that it takes for one-half of a radioactive element to decay.

FOSSIL RECORD

Half Life

Example:

If the Half Life of a
radioactive element
= 1000 years

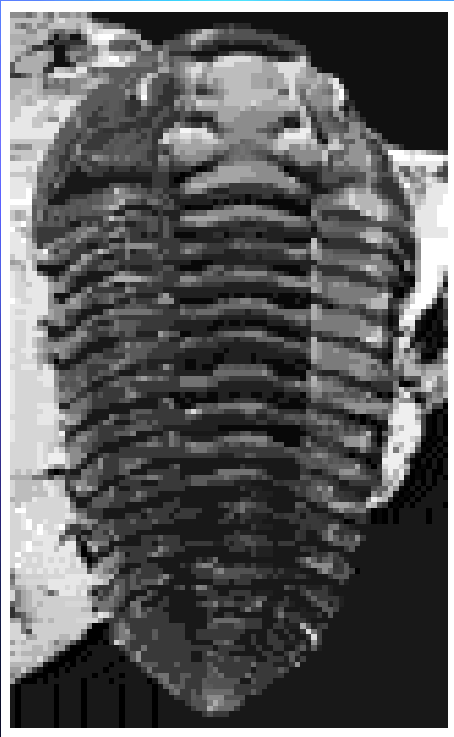


FOSSIL RECORD

Half Life

Example:

And the amount of the radioactive element detected is 0.002 % in 1 kg of fossil



FOSSIL RECORD

Half Life

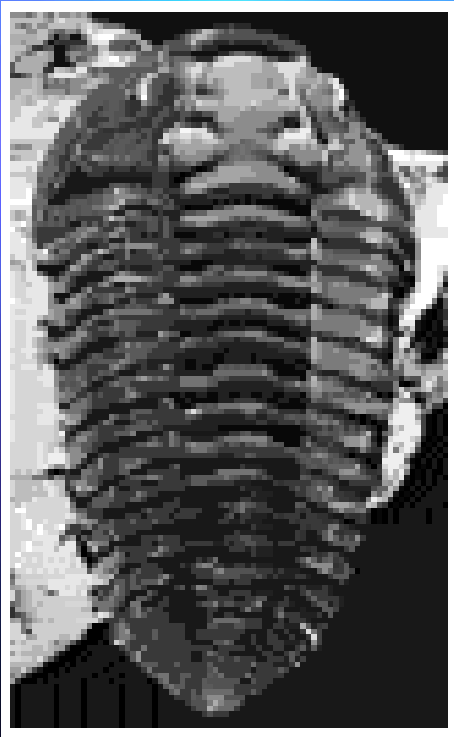
Example:

How old is the fossil?



Age of Fossil	Amount of radioactive element per Kg	Number of half lives
0 yr	0.008 %	0
1,000 yrs	0.004 %	1
2,000 yrs	0.002 %	2
3,000 yrs	0.001 %	3

FOSSIL RECORD



Half Life

Example:

2000 yrs old!

(It's really 500, 000, 000 yrs old – but you get the idea??)

FOSSIL RECORD



Radioactive Dating of
the Fossil Found at
Olduvai Gorge and
Reconstruction of the
Skull

FOSSIL RECORD



Radioactive Dating and Reconstruction of the Skull

“Without evolution to tie it all together, biology is little more than stamp collecting.”



Kenneth Miller,

Professor of Molecular and Cellular Biology

Brown University

Ken Miller's Evolution Resources Page:

<http://www.millerandlevine.com/km/evol/>

EMBRYOLOGY

Similarities

In Early

Development



In 1998 we rewrote page 283 of the 5th edition of Prentice-Hall **Biology** to better reflect the scientific evidence. It is NOT based on Haeckel's 1874 drawings. Our books now contain accurate drawings of the embryos made from detailed photomicrographs: Authors - Ken Miller & Joe Levine



Fish embryo



Chicken embryo



Pig embryo

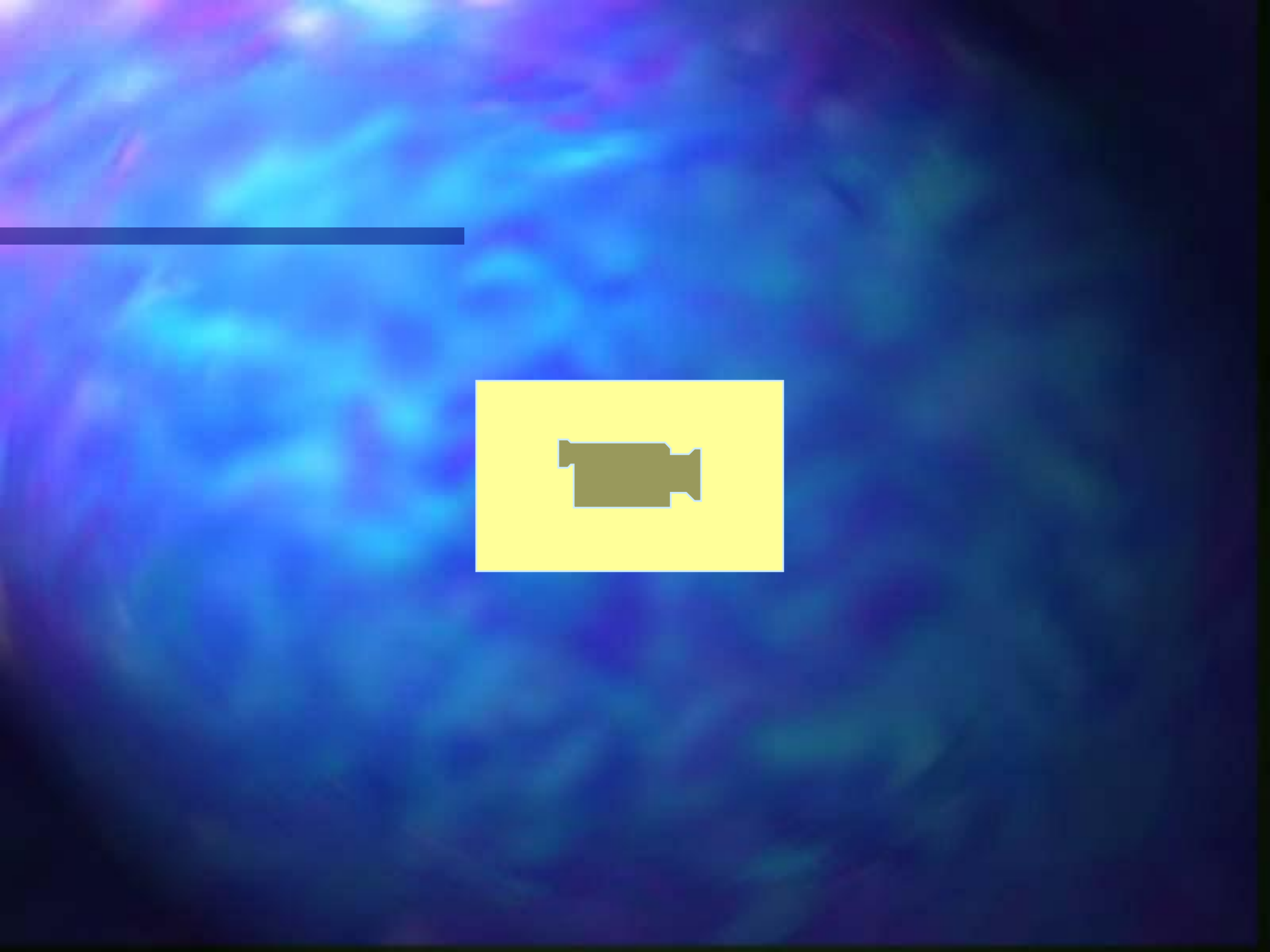


Human embryo

These photographs are absolutely accurate and have been taken at similar stages of development.

EMBRYOLOGY

Let's take a closer look at the similarities found in vertebrate embryonic development...



COMPARATIVE ANATOMY

Homologous Structures:

Parts of different organisms that have developed from the same body parts of a common ancestor.

COMPARATIVE ANATOMY

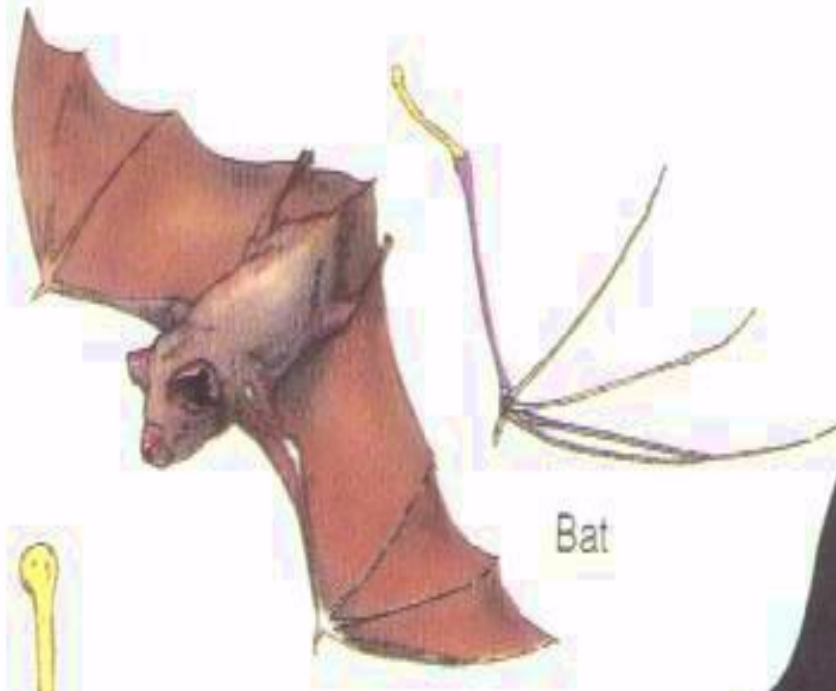
Homologous Structures are a result of:

Divergent Evolution:

- A species experiences environmental selective pressures
- Individuals of a species may respond to this pressure in different ways, and through natural selection vary significantly from each other.
- Eventually, these forms will differ enough to be called different species. They will still retain similar structures to the common ancestor – these structures are **homologous**.



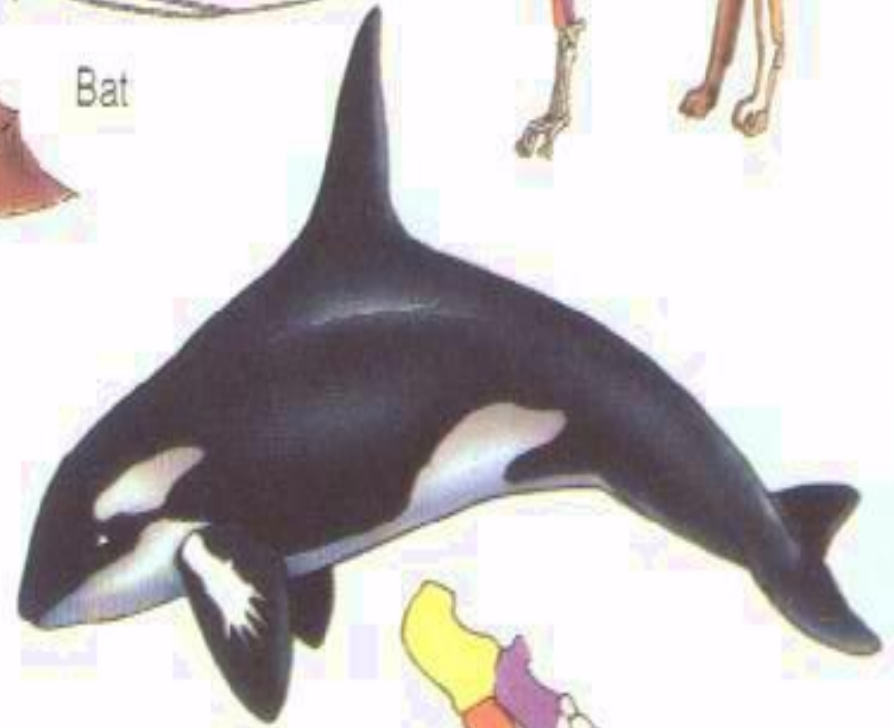
Human



Bat



Dog



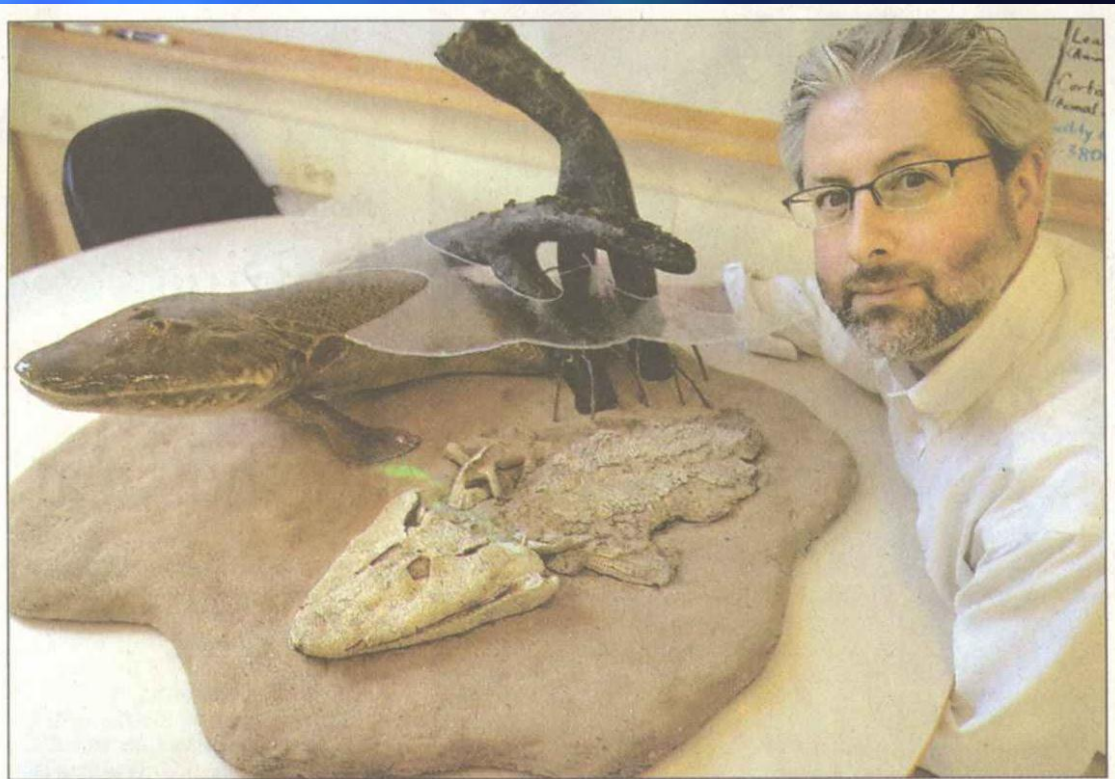
Whale



COMPARATIVE ANATOMY

The discovery of
Tiktaalik
(*Tiktaalik roseae*)
or “Large Shallow
Water Fish”

<http://tiktaalik.uchicago.edu/> (to learn
more about the discovery)



Tribune photo by Milbert O. Brown
University of Chicago scientist Neil Shubin co-lead the expedition that found the fossil Tiktaalik in frozen river sediments on Ellesmere Island in the Canadian Arctic.

‘It represents the transition from water to land—the part of history that includes ourselves.’

—Neil Shubin, U. of C. scientist

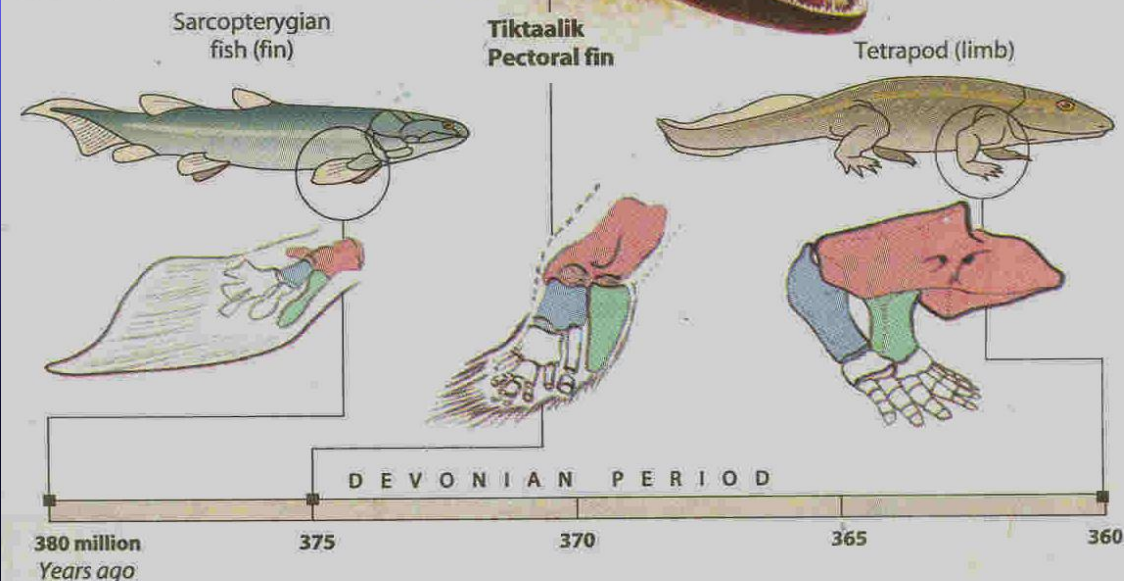
A link between sea creatures and land creatures

The pectoral fin bone structure of the newly discovered fossil Tiktaalik roseae offers the best evidence yet of fins evolving into limbs.

EVOLUTION TIMELINE

Bone key

- Humerus (upper arm)
- Radius (lower arm)
- Ulna (lower arm)



Fin and limb illustrations by Kalliopi Monoyios, University of Chicago

Sources: Nature, National Geographic, University of Chicago, Macmillan Illustrated Encyclopedia of Dinosaurs

Chicago Tribune

Ellesmere Island
Discovery site

NUNAVUT

CAN.

U.S.

Illustration by
Shawn Gould ©
2006 National
Geographic

This transitional form:

- has an extremely flattened body with eyes on the top of its head, suggesting it spent a lot of time on the bottom, looking up
- has shoulders that are not connected to its skull, giving it a functional neck.
- has ribs exactly like those of its contemporary tetrapods which were used to support the body and aid in breathing (it had lungs)

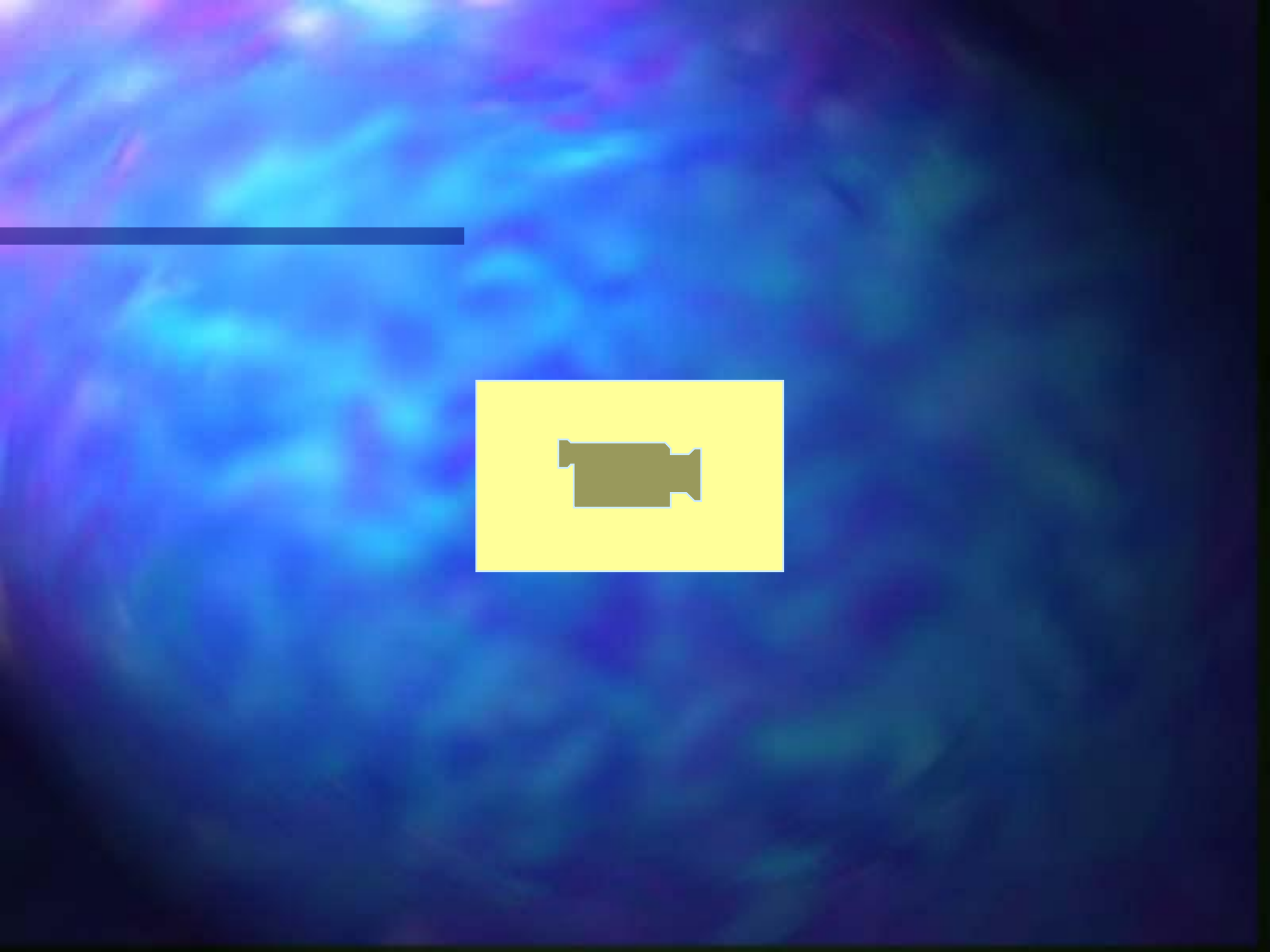


(artist's model)

COMPARATIVE ANATOMY

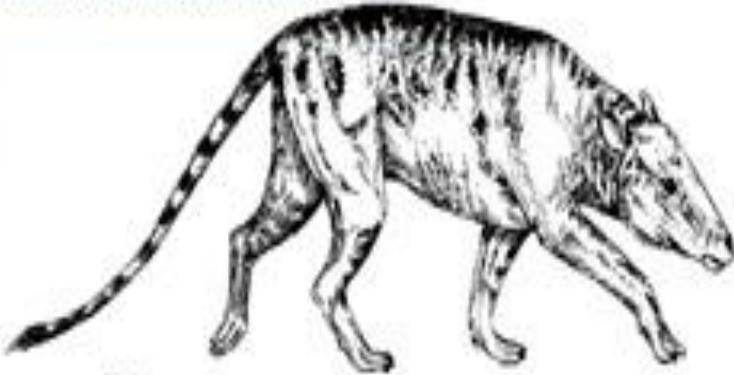
An Application of the Evidences
of the Fossil Record and
Homologous Structures:

Where did whales come from??

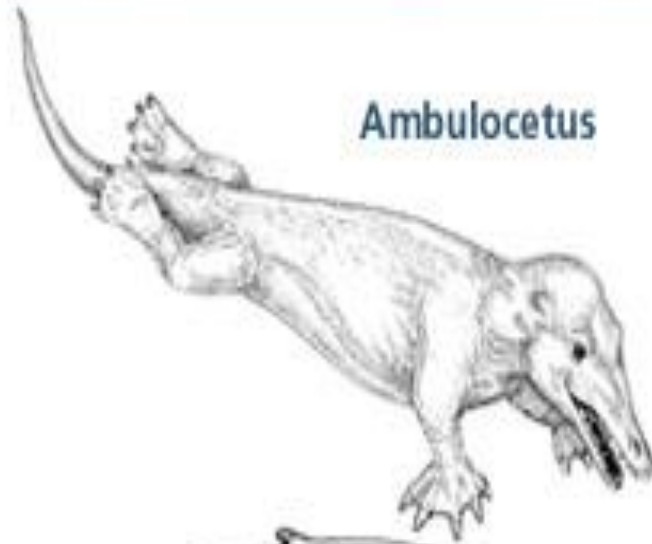


COMPARATIVE ANATOMY

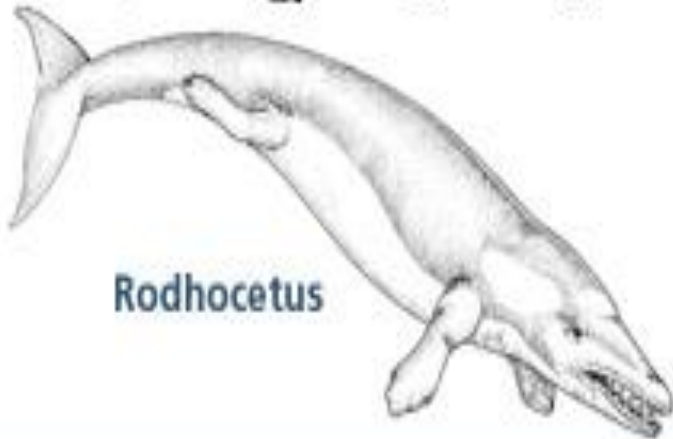
Mammalian land ancestor



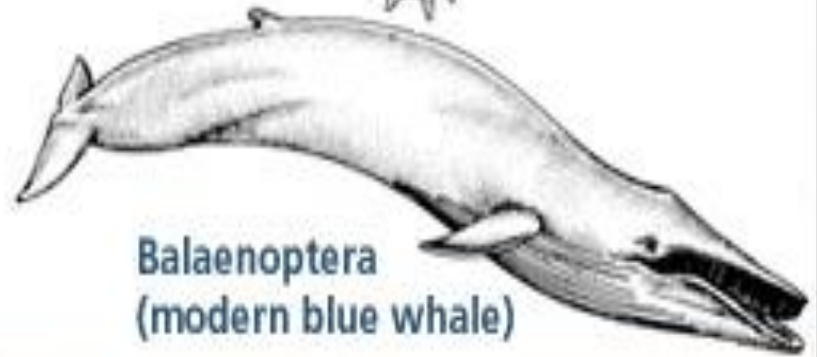
Ambulocetus



Rodhocetus



Balaenoptera
(modern blue whale)



Modern whales trace their ancestry to land mammals that evolved into species progressively more adapted to the water.

<http://www.indiana.edu/%7Eensiweb/lessons/whalekiosk.html>

(Great interactive tutorial on whale evolution and supporting evidence!)

COMPARATIVE ANATOMY

Vestigial Organs

- Ex: snake “legs”, human appendix and coccyx
- Structures that serves no useful purpose in an organism.

COMPARATIVE ANATOMY

Analogous Structures:

Similar structures in organisms with different ancestry.

COMPARATIVE ANATOMY

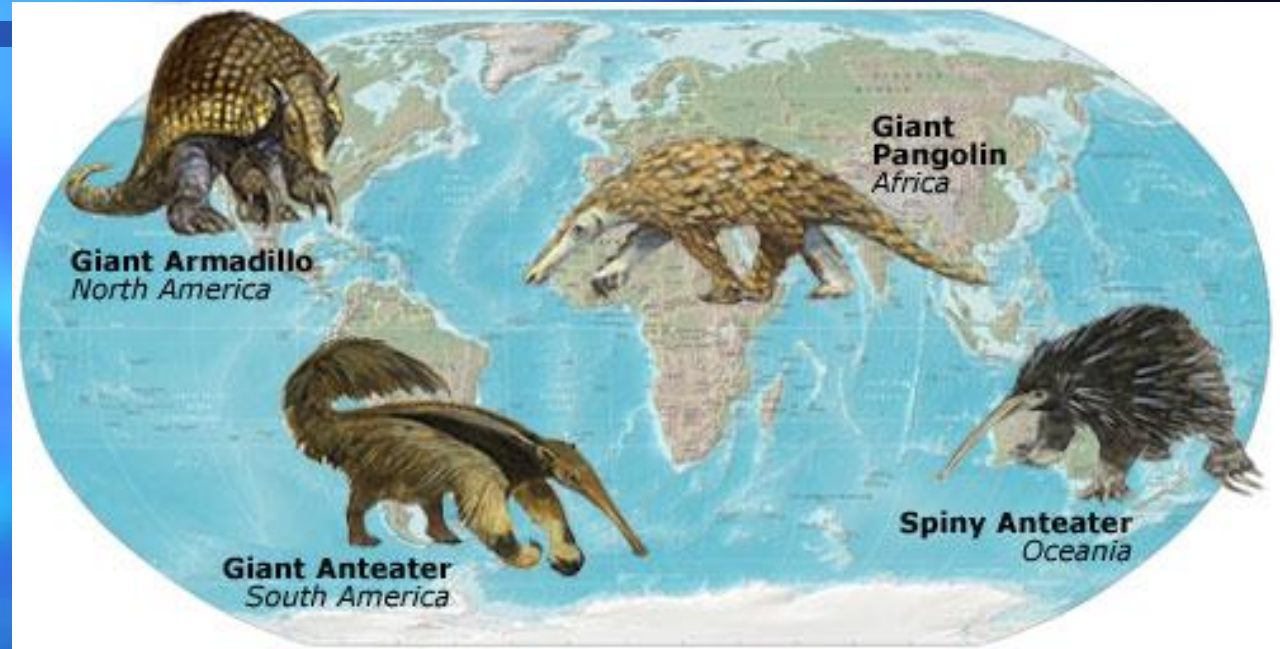
Analogous structures are a result of:

Convergent Evolution:

- Organisms from unrelated, or not closely related, ancestral lines that exhibit similar evolutionary changes.
- Caused by similar environmental, selective pressures that result in natural selection favoring a similar feature.
- Result in similar-looking body plans or structures

COMPARATIVE ANATOMY

Examples:



These animals are NOT closely related by ancestry, they all evolved the "tools" necessary to subsist on an ant diet: a long, sticky tongue, few teeth, a rugged stomach, and large salivary glands. In each case, evolutionary adaptations allow them to exploit a food niche of ants and termites, but the developments occurred **independently**, through **convergent evolution**.

Examples:

These animals have vastly different ancestries – However, the pairs are found in unrelated, yet similar habitats and have developed adaptations to live successfully in similar niches.

Placentals



Flying squirrel
(*Glaucomys*)



Ground hog
(*Marmota*)



Anteater
(*Myrmecophaga*)



Mole
(*Talpa*)



Mouse
(*Mus*)

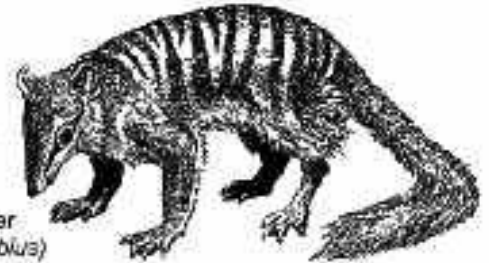
Marsupials



Flying phalanger
(*Petaurus*)



Wombat
(*Phascogale*)



Anteater
(*Myrmecobius*)

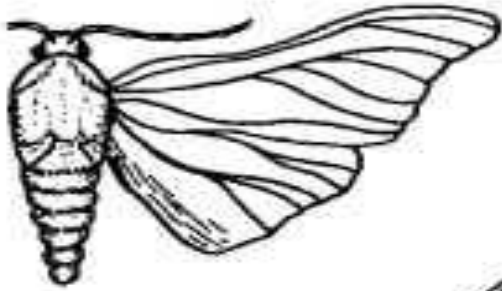


Mole
(*Notoryctes*)



Mouse
(*Dasyurus*)

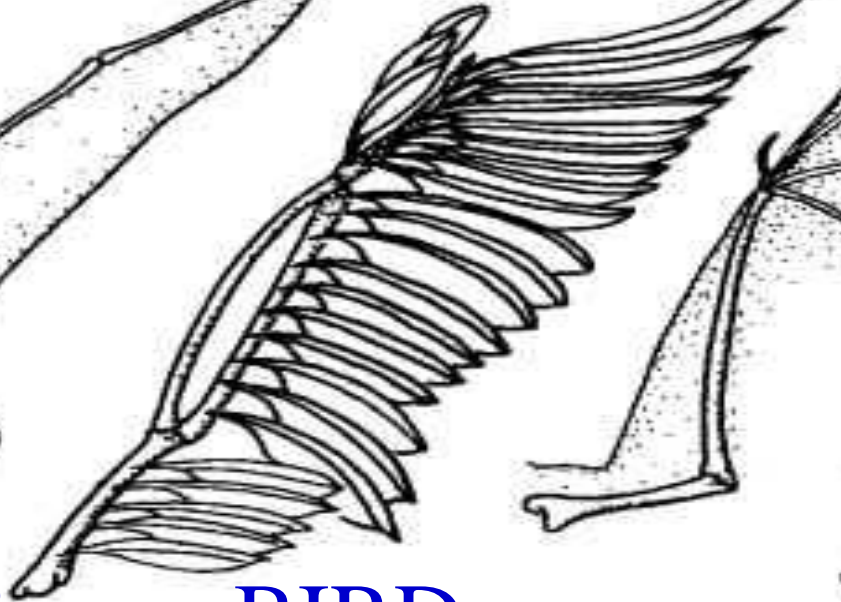
COMPARATIVE ANATOMY



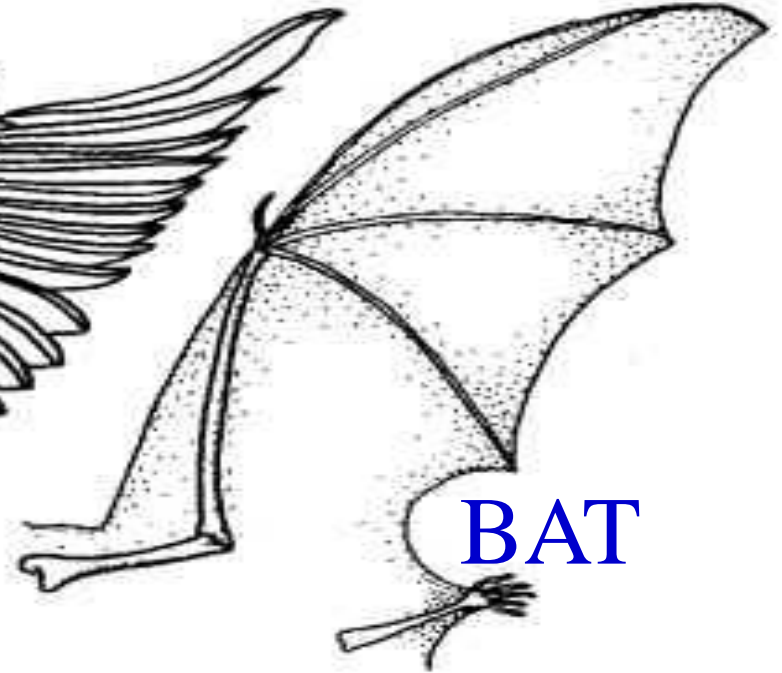
INSECT



PTEROSAUR



BIRD



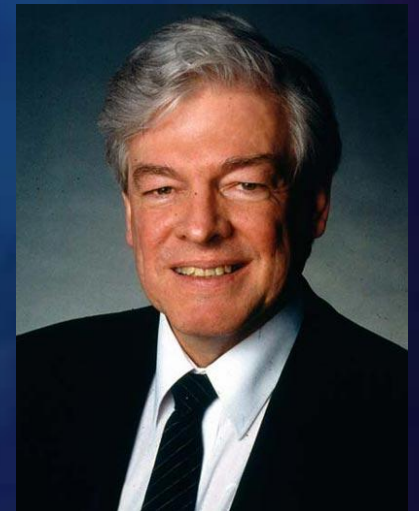
BAT

9/4/95

Another example of **convergent evolution**. Wing structures – from organisms with differing ancestries that all developed to perform the same function as a result of natural selection.

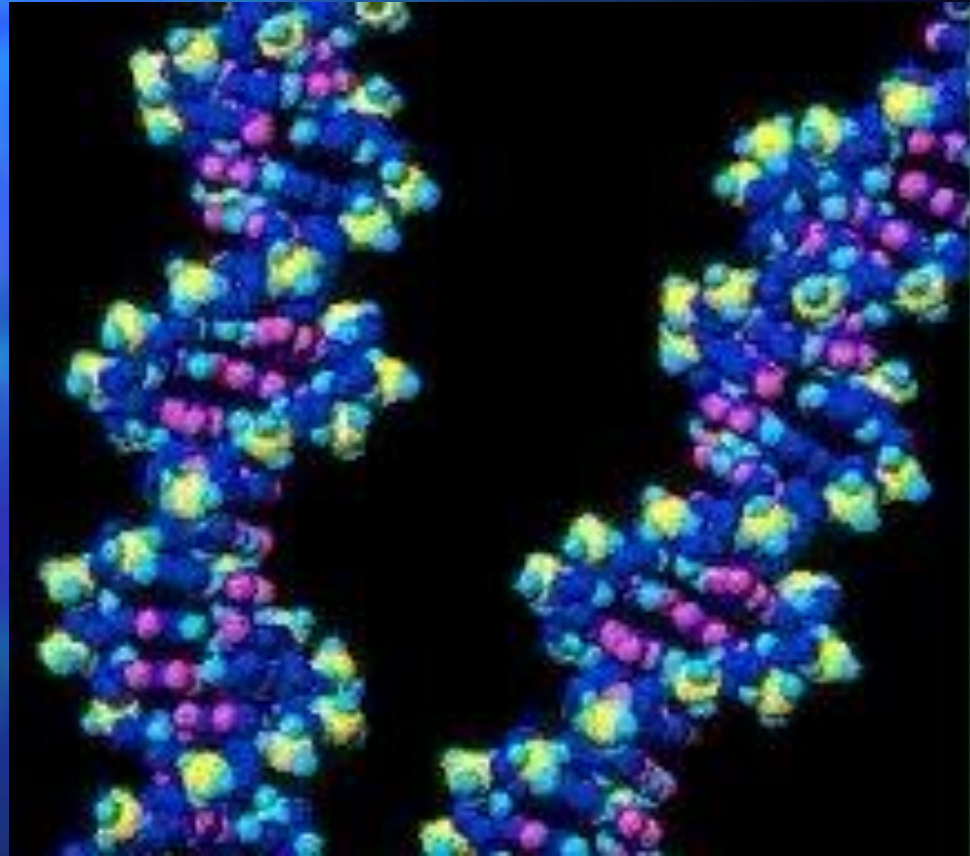
“The theory of evolution remains the only well-established scientific explanation for the rich diversity of life on Earth.”

- Robert D. Martin, PhD
Anthropology Department
The Field Museum, Chicago



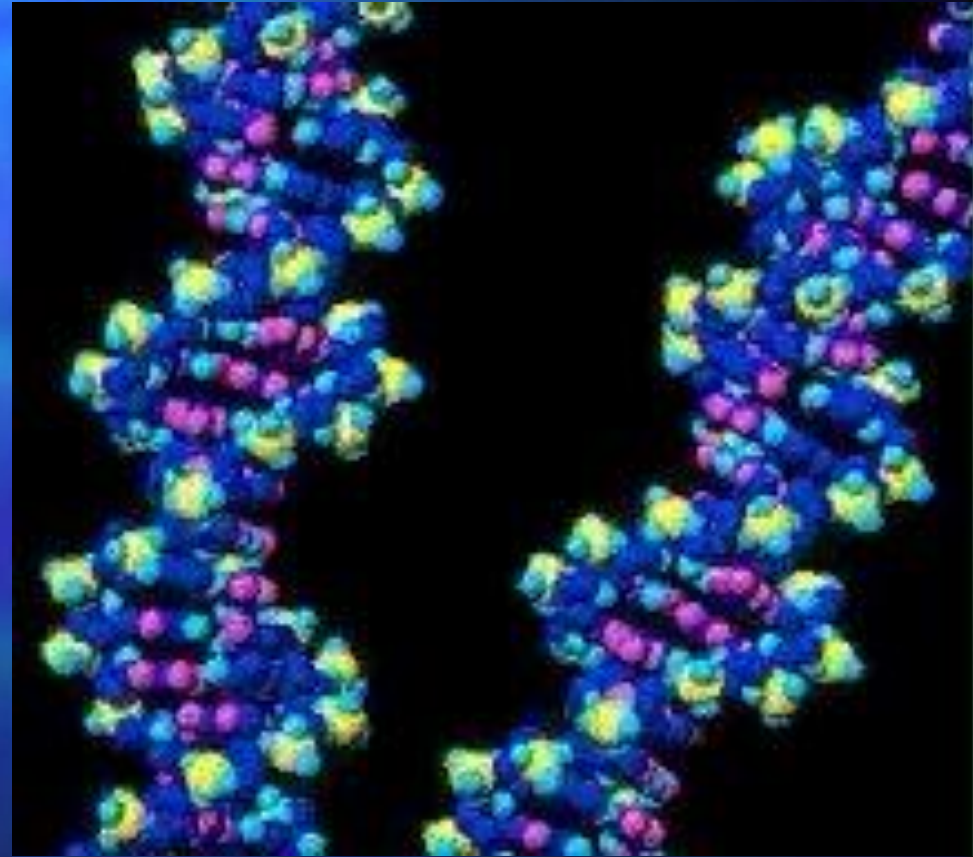
BioMolecular Evidence

All organisms
use DNA or
RNA as their
genetic
material.



BioMolecular Evidence

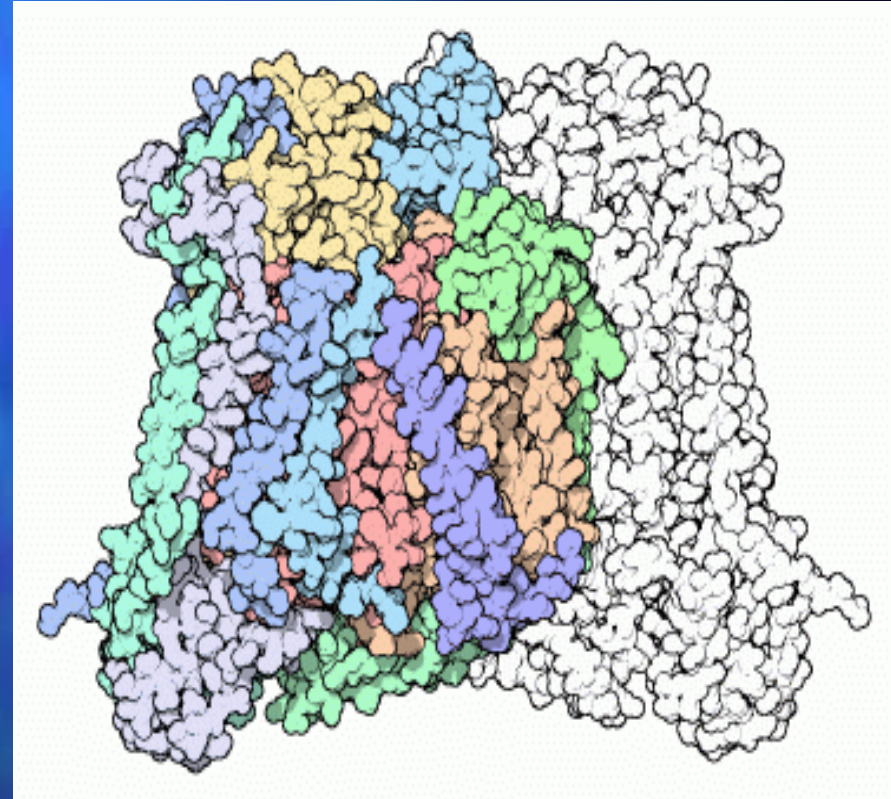
Genetic Code is
UNIVERSAL
Ex: CCC codes
for proline....in
ALL organisms



BioMolecular Evidence

Common proteins
in **all** living cells

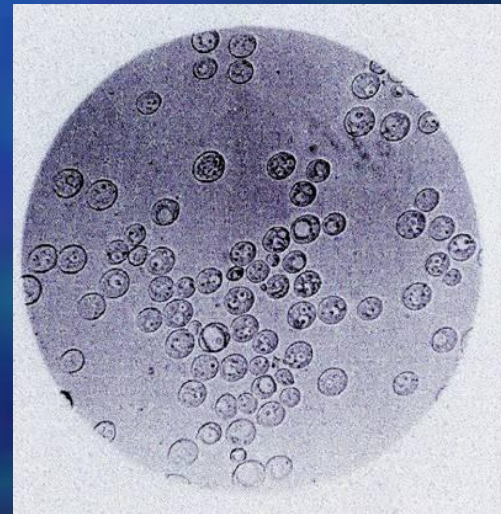
Ex: cytochrome C
helps to release
energy in the
mitochondria

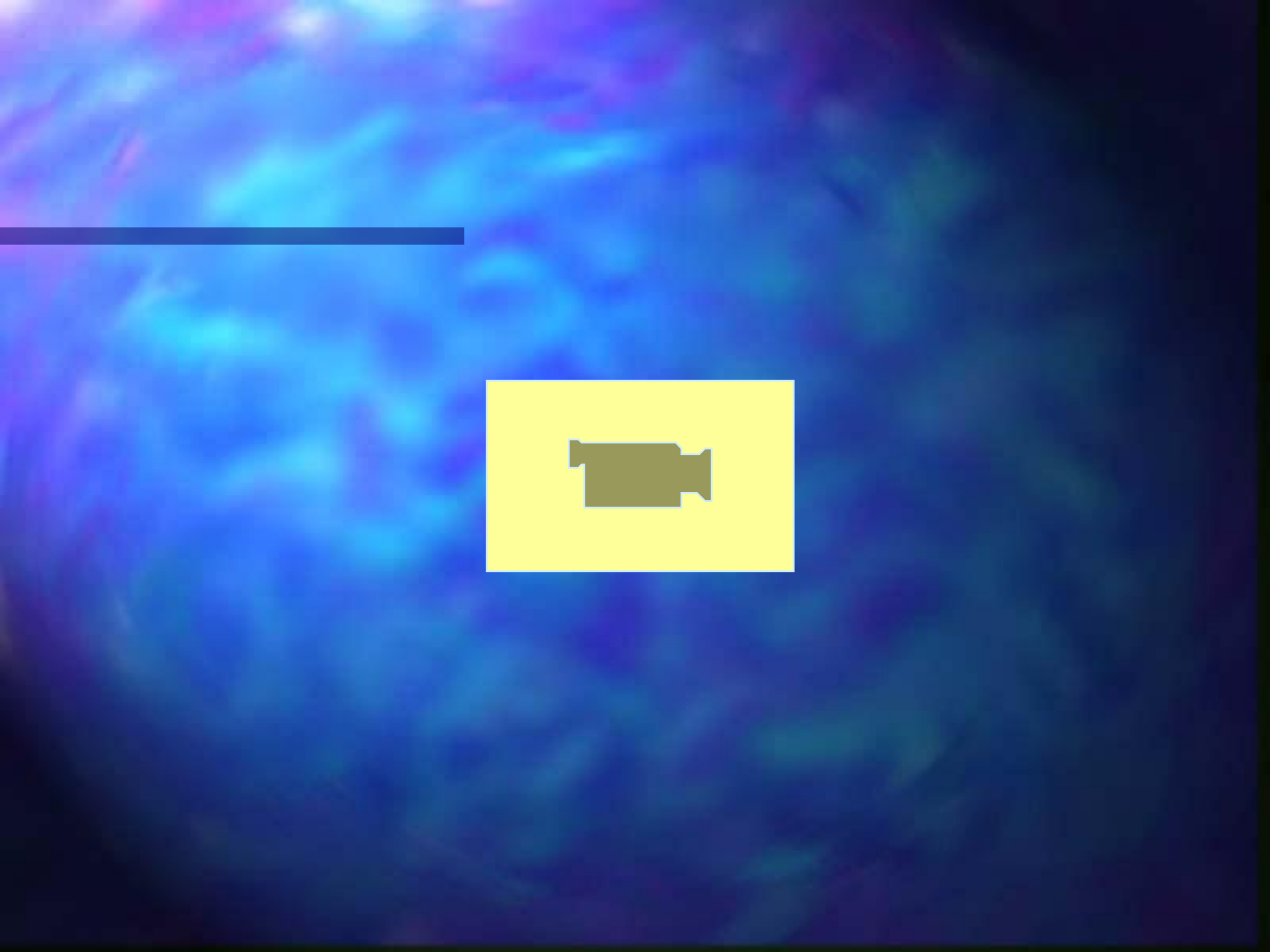


BioMolecular Evidence



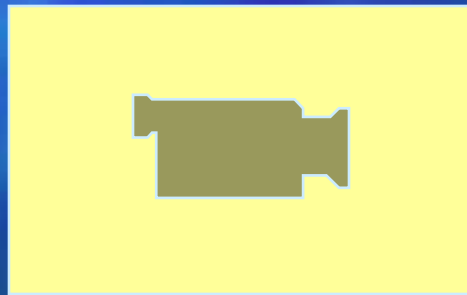
What could
humans possibly
have in common
with Yeast?

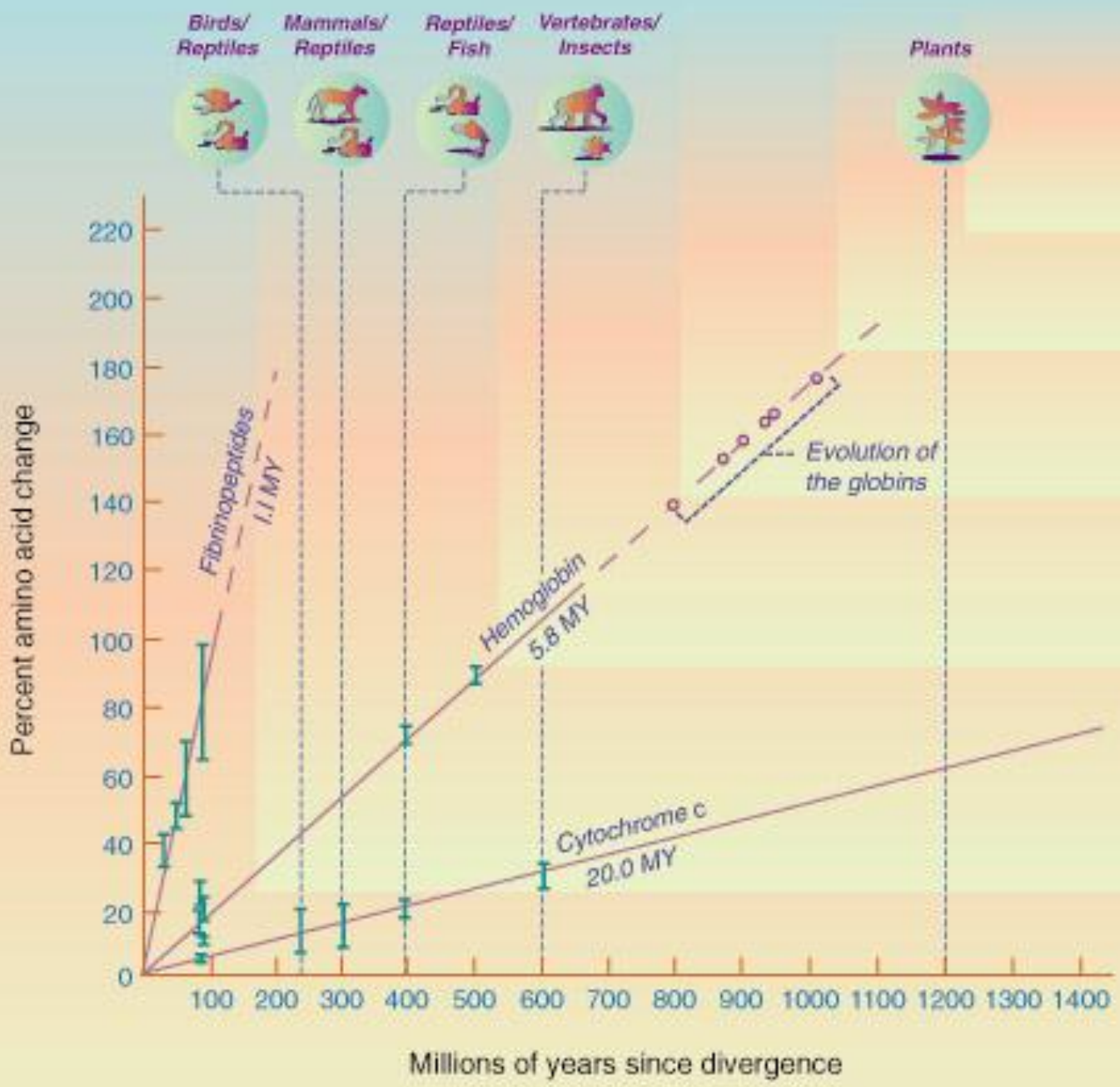




BioMolecular Evidence

Comparing Amino Acid
sequences and DNA supports
descent w/ modification





BIOGEOGRAPHY

The distribution
Of modern
organisms and
fossils
supports “descent
with modification.”



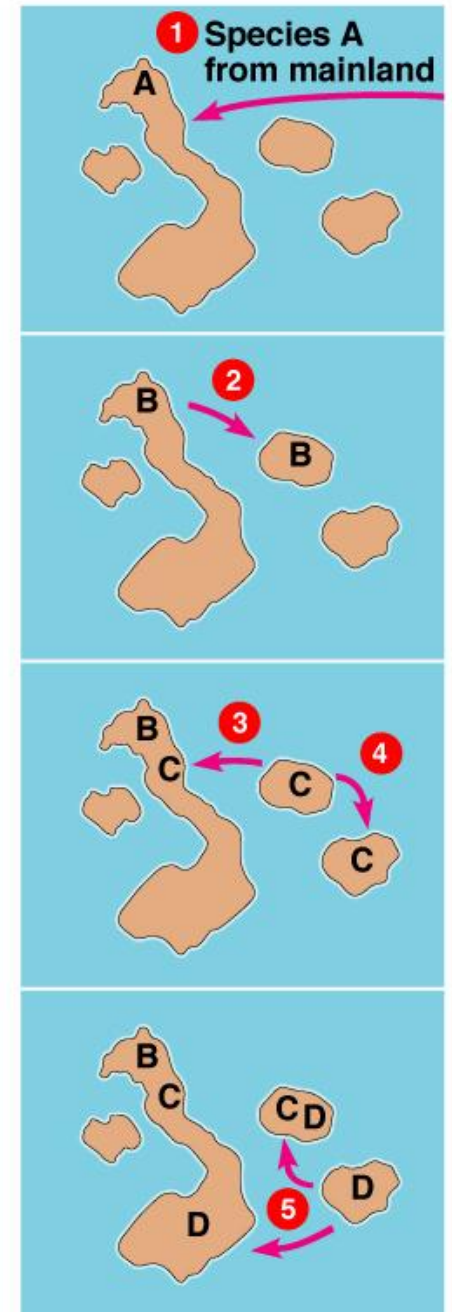
BIOGEOGRAPHY

Darwin observed that the Finch species in the Galapagos Islands more closely resembled those from the mainland (near Ecuador), than those of other islands with similar climates.

BIOGEOGRAPHY

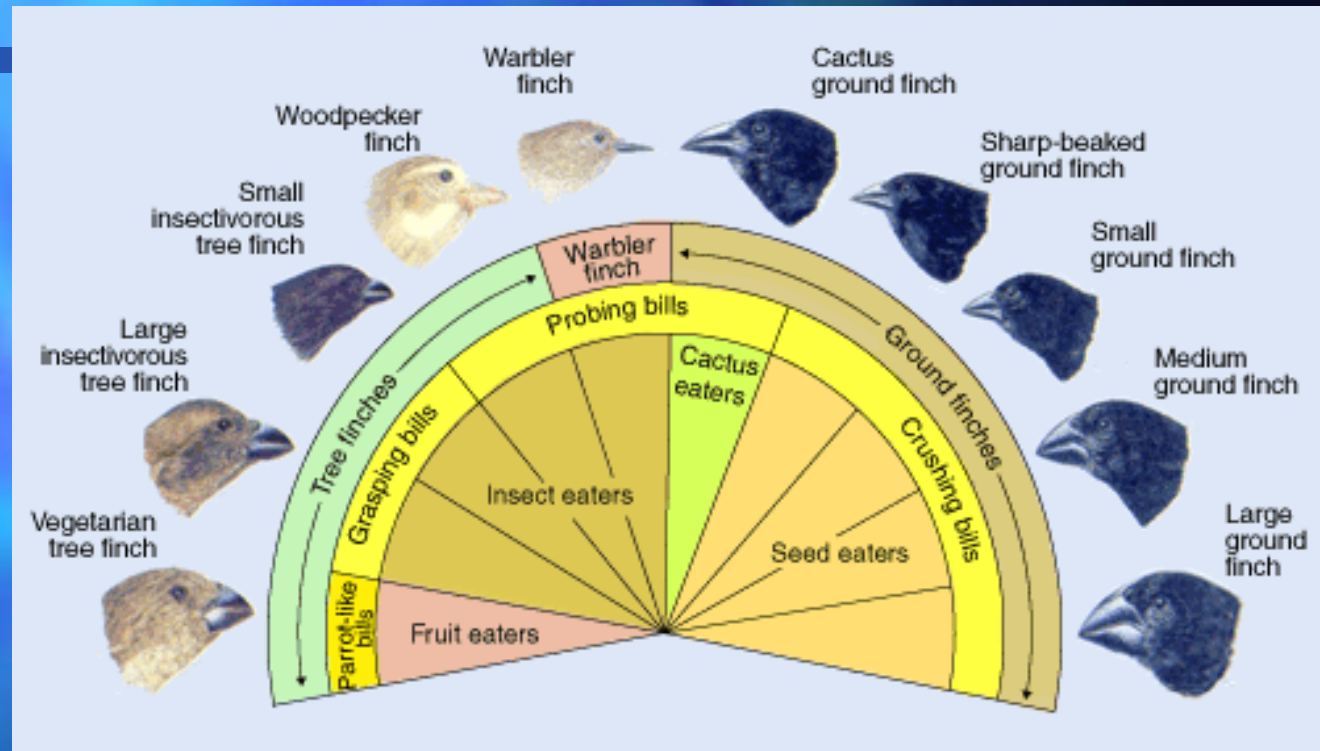
The presence of endemic species of finches on the Galapagos Islands is evidence that supports the theory of evolution.

The ancestral finch (A) was a ground-dwelling, seed-eater. (After the burst of speciation in the Galapagos, a total of 14 species would exist: three species of ground-dwelling seed-eaters; three others living on cactuses and eating seeds; one living in trees and eating seeds; and 7 species of tree-dwelling insect-eaters.)



BIOGEOGRAPHY

This process in which one species gives rise to multiple species that exploit different niches is called **adaptive radiation**.



The ecological niches exert the **selective pressures** that push the populations in various directions. On various islands, finch species have become adapted for different diets: seeds, insects, flowers, the blood of seabirds, and leaves.

BIOGEOGRAPHY

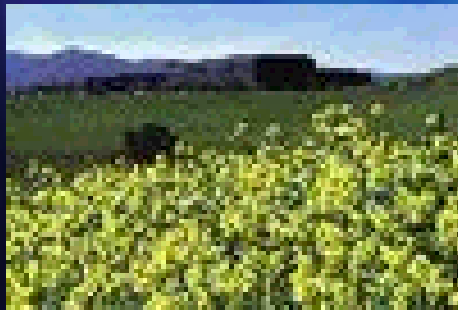
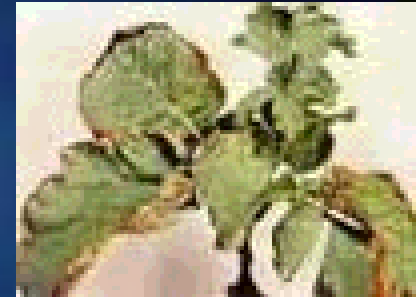
Until about 3 million years ago, North and South America were separated by a wide expanse of water, so mammals on the two continents evolved separately. After the isthmus of Panama formed, armadillos and opossums migrated north, and mountain lions migrated south. These movements are documented in the fossil record.



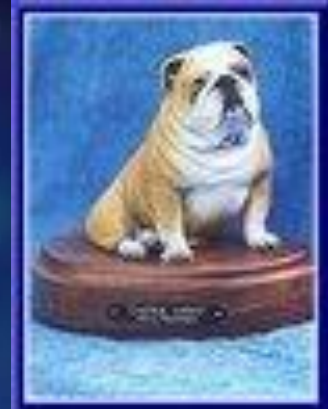
These examples and Darwin's Finches illustrate **Divergent Evolution**. Beginning with a **common ancestor** - separate paths of evolutionary change, shaped by natural selection, lead to variation of forms and structures, and ultimately the formation of **new species**.

Artificial Selection

Plants: These vegetables were “created” through selected breeding of wild mustard plants over hundreds of years: Cabbage, Brussel Sprouts, Kale, Cauliflower, Broccoli, and Kohlrabi.



Artificial Selection



Animals: Selected breeding of dogs over the past 1000 years has yielded Extreme varieties such as Saint Bernard, German Shepard, Bulldog, Yorkshire Terrier, and Chihuahua



“There is a grandeur in this view of life ... from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved.”



- Charles Darwin (1859)

On the Origin of Species by Means of Natural Selection

Evidences for Darwin's Theory

1. Fossil Record
2. Similarities in Embryonic Development
3. Homologous Structures
4. Similarities in Biomolecules
5. Geographic distribution
6. Artificial Selection