EVOLUTION

• CHANGE OVER TIME

REVIEW

We now know that.....

• our *DNA* or GENOTYPE determines our physical characteristics or PHENOTYPE

We also know that....

• changes in our genotype are called MUTATIONS and these changes result in changes in our physical characteristics.

We'll now learn ...

• what determines whether or not these changes or MUTATIONS in our *DNA* are HELPFUL or HARMFUL to an organisms and its survival.

"Bummer of a birthmark, Hal."

Explain WHY you think the mutation that caused the birthmark in Hal will be helpful or harmful?
(**HINT**: *Think...will this mutation most likely be passed on to Hal's offspring?*)

MAIN IDEA

MOLECULAR GENETICS (DNA) and EVOLUTION help explain the amazing similarities and differences among living things.

"Teaching biology without evolution is like teaching math without prime numbers."
- Rita Calvo

EVOLUTION IS A UNIFYING PRINCIPLE FOR BIOLOGY

"GOOD" MUTATIONS vs. "BAD" MUTATIONS

- GOOD mutations result in ***beneficial*** changes in an organisms physical characteristics. These *beneficial physical changes* or ADAPTATIONS allow an organism to better adapt to its NATURAL SURROUNDINGS.

- Better adapted organisms survive long enough to REPRODUCE and thus pass on these beneficial GENETIC changes or *mutations* to their offspring through SEXUAL REPRODUCTION.

- BAD mutations result in ***damaging*** changes in an organisms physical characteristics. These *harmful*, sometimes LETHAL *mutations* makes the organism LESS FIT to survive in its NATURAL SURROUNDINGS.

- These organisms do NOT survive long enough to reproduce and thus do NOT pass on these harmful changes to their offspring. When the organism DIES, the bad *mutation* DIES with them. When ALL the organisms carrying the *harmful mutation* die, the species becomes EXTINCT.

So.....

* An organisms NATURAL SURROUNDINGS or ***environment*** determine whether a *mutation* is good or bad.

- The same *mutation* may be ***GOOD*** in one environment or ***BAD*** in another.
  EXAMPLE: *The sickle-cell mutation in West Africa.*

I. SUPPORTING EVIDENCE FOR THE THEORY OF EVOLUTION

THEORY - EXPLANATION BASED ON FACTS THAT APPLY TO A BROAD RANGE OF PHENOMENA

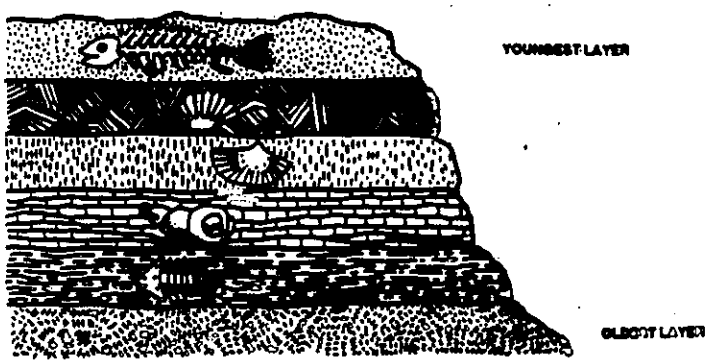
A. FOSSILS

- any trace or remains of an organism that has been PRESERVED by natural processes.
- FOSSILS provide the strongest evidence of organic evolution. (*living*)

EXAMPLES:
(1) AMBER / ICE
(2) BONES / PETRIFICATION
(3) MOLDS / CASTS / IMPRINTS

1. CALCULATING THE AGE OF FOSSILS

a) Relative Dating - DETERMINES THE ORDER IN WHICH EVENTS OCCURRED.



- the deeper down fossils are found in the STRATA or *layer of rock*, the OLDER they are.
- upper layers of rock or STRATA contain more COMPLEX and relatively *newer* organisms than the lower layers.

b) **Radioactive Dating** - DETERMINE HOW LONG AGO AN EVENT OCCURRED

- Through the fossil record, scientists have discovered that the earth is around 3.5 - BILLION years old.

B. COMPARATIVE CYTOLOGY

- this process involve COMPARING the CELL STRUCTURE of living things.
- remember the Cell Theory: "ALL LIVING THINGS ARE MADE OF CELLS.
- the following organelles are found in **ALL** living things :

CELL MEMBRANE — RIBOSOMES

CYTOPLASM — NUCLEUS (DNA)

C. COMPARATIVE BIOCHEMISTRY

- this process involve COMPARING the CHEMICALS that make up living things.
- DNA and RNA are found in **EVERY** living thing.
- since many different organisms have similar genetic make ups or *DNA*.... many different organisms produce similar PROTEINS.

EXAMPLE: *insulin from horses was used for treatment in humans who suffer from diabetes.*

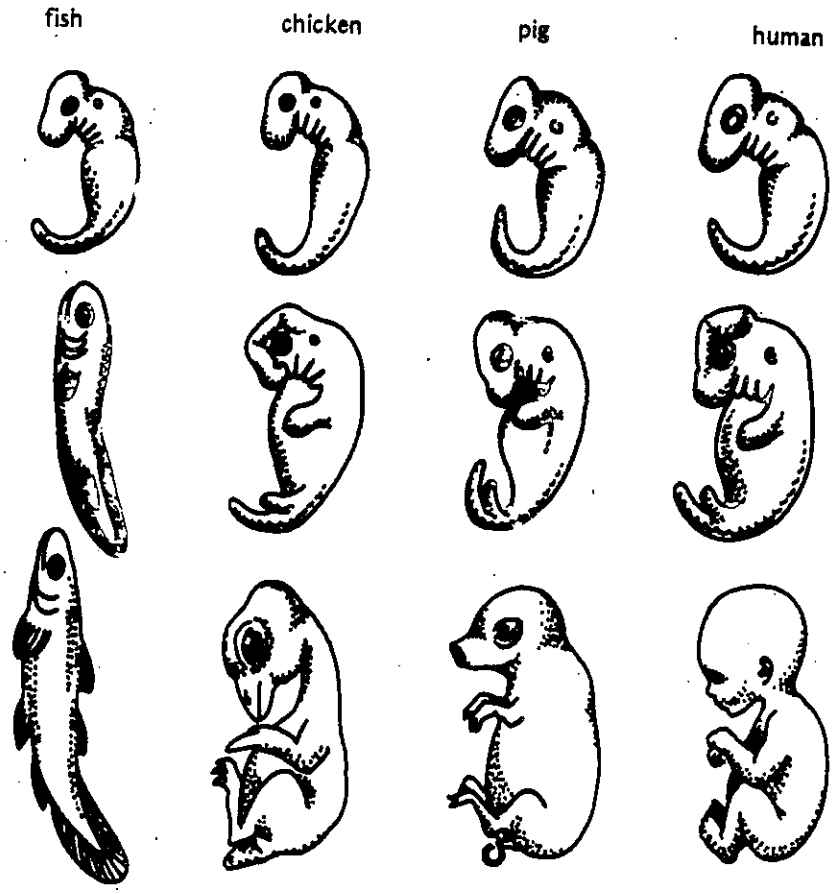
*** Human DNA is 98.5 % the same as chimpanzee DNA ***

D. COMPARATIVE EMBRYOLOGY

- this process involve COMPARING the EMBRYO development of living things.

- during the early stages of development, EMBRYOS of many different members of the animal kingdom (*vertebrates = animal with backbones*) are SIMILAR.

EMBRYO COMPARISONS:



FOUR VERTEBRATES EMBRYOS AT THREE STAGES OF THEIR DEVELOPMENT:
The similarities in the early stages of embryo development suggest common ancestry.

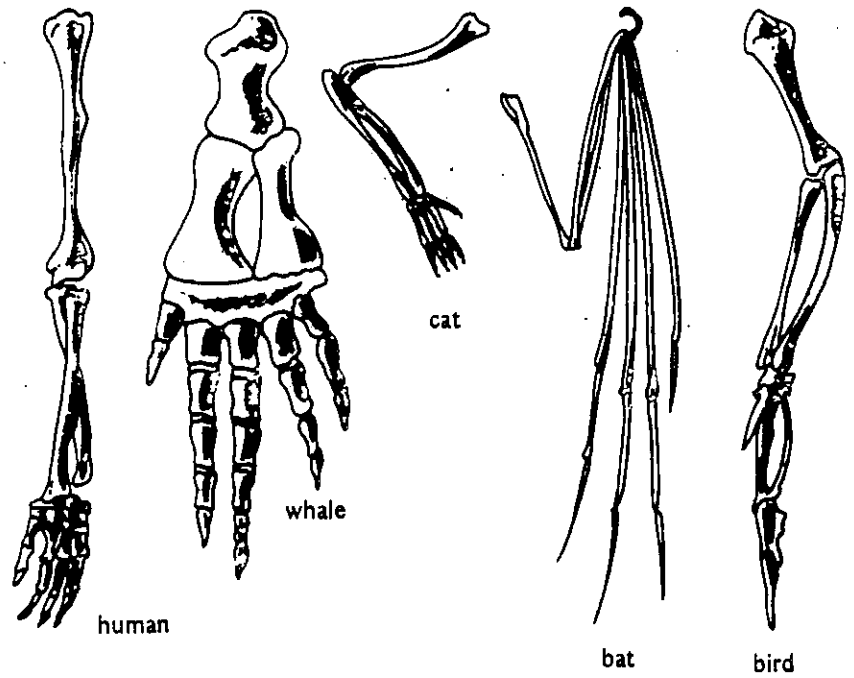
E. COMPARATIVE ANATOMY

- this process involve COMPARING the ANATOMICAL structures that make up living things.

HOMOLOGOUS STRUCTURES - PARTS OF DIFFERENT ORGANISMS THAT HAVE SIMILAR STRUCTURE AND EMBRYOLOGICAL DEVELOPMENT, BUT HAVE DIFFERENT FORMS AND FUNCTIONS.

EXAMPLES: *The forelimbs (forearms) of a human, whale, cat, bat and a bird.*

ANATOMICAL COMPARISONS:



HOMOLOGOUS STRUCTURES - Although these organs of locomotion (movement) function in different ways, they appear to have developed from the same original structure. They are all made up of the same type of bones and are attached by tendons and ligament in similar fashon. The whale flipper is actually MUCH larger than the other limbs.

II. *Theory of Natural Selection*

A. Charles Darwin (1859)

- Wrote book *The Origin of Species* describing his theory of NATURAL SELECTION.
- *Natural Selection* states that the process of EVOLUTION is controlled by NATURE.

MAIN IDEA

According to Darwin, nature selects which organisms survive. Which organisms survive depends upon which possess the necessary biological adaptions to succeed in their environment. Success is measured by which organisms reproduce and pass on their genetics information (DNA) to the next generation. Those organisms that are not as successful in ***"that"*** environment often die without leaving any offspring. When all the organisms ***"less fit"*** to survive in ***"that"*** environment die, the species becomes ***extinct.***

Evolutionary Success -----> Reproduction
(passing on DNA)

HOWEVER...

IF THE ENVIRONMENT CHANGES....
....some traits not beneficial may become so - or vice versa.
EXAMPLES: *Asteroid ----> Dinosaurs?*
Industrial Revolution ----> Peppered Moth

B. Darwin's Theory of Natural Selection

Necessary elements vital to the Theory of Natural Selection include:

1. **OVERPRODUCTION**
   - a species produces MORE offspring than can possibly survive.

   EXAMPLE: *Fish and frogs produce millions of eggs, but by the next year, the populations of both species is about the same as the previous year.*

2. **COMPETITION** (*large number of organisms+ limited resources = competition*)
   - Organisms COMPETE for each of the following resources:

     ANYTHING an organism NEEDS to live!

     (a) SPACE - SHELTER
     (b) FOOD - WATER
     (c) LIGHT (PLANTS)
     (d) SEX - FINDING A MATE

3. **SURVIVAL OF THE FITTEST**
   - The individuals who survive are the ones who win the daily competitions for the LIMITED natural resources found in the environment. Those individuals that win are better adapted to their natural environment.

4. **VARIATIONS** (*mutations*)
   - Due to crossing over of DNA that occurs during MEIOSIS and the union of haploid gamates at FERTILIZATION, sexually reproducing organisms show VARIATIONS from one generation to the next.
   - Genetic variations **HELP** or **HARM** individuals in their struggle for survival.

   THEORY WEAKNESS: *In 1859, Darwin didn't know what DNA ---> genes ---> chromosomes were, therefore, he could not explain the genetic basis for variation.*

5. **REPRODUCTION**
   - The best adapted individuals survive and reproduce, passing on the favorable variations to their offspring.

6. **SPECIATION** ---> evolution of a new species over **LONG** periods of time.

III. Examples of Evolution in Modern Times

A. Peppered moth (*Biston betularia*)

1. *Change in Nature*: POLLUTION caused by INDUSTRIALIZATION
   - Prior to 1850, light-colored moths blended in well with the trees.
   - After 1850, the pollution covered the trees turning them black.
   - Through NATURAL SELECTION, more DARK moths survived and reproduced than LIGHT moths.
2. *Result:* Over TIME, the dark-colored moths outnumbered the light-colored moths in the woods surrounding MANCHESTER, ENGLAND.

B. Insect Resistance to Pesticides (DDT)

1. *Change in Nature:* The spraying of CHEMICALS used to kill insects.
   - All organisms (insects) effected by the poisonous chemicals are killed.
   - Those organisms (insects) IMMUNE to the poisonous chemicals survive.
   - Through NATURAL SELECTION, more pesticide RESISTANT insects survive than non-resistant insects.
2. *Result:* Over TIME, all the insects will be RESISTANT to the pesticide.

C. Bacteria Resistance to Antibiotics

1. *Change in Nature:* The introduction of an ANTIBIOTIC into the human body.
   - All bacteria effected by that ANTIBIOTIC are killed.
   - However, there is a chance, due to a GENETIC MUTATION, that some of the bacteria are IMMUNE to the antibiotic and RESISTANT to its harmful effects.
   - Those bacteria RESISTANT to the antibiotics survive.
   - Through NATURAL SELECTION, more antibiotic RESISTANT bacteria survive than non-resistant bacteria.
2. *Result:* Over TIME, all the bacteria will be RESISTANT to the antibiotic.

In all three cases, the changes in the environment did NOT cause the beneficial mutation or change in DNA, it had only acted as a selector for those organisms who had already had the beneficial gene(s).