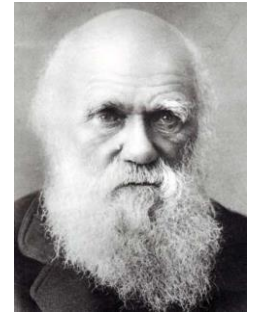


## CHAPTER 22- Darwin's Theory

Theodosius Dobzhansky~ "Nothing in Biology Makes Sense Except in the Light of Evolution"

**EVOLUTION** = a change over time in the genetic composition of a population

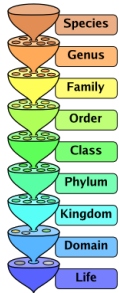
- = change in allele frequency
- also refers to the gradual appearance of all biological diversity



### IDEAS THAT INFLUENCED DARWIN:

**ARISTOTLE**- Anti-evolutionist- saw species as fixed (unchanging)

- all living forms could be arranged on a ladder of increasing complexity (*scala naturae*)



### CAROLUS LINNAEUS

- Taxonomy = science of grouping and naming organisms
- Nested hierarchy classified organisms using similarities/differences in characteristics
- Binomial nomenclature (*Genus species naming*) D, K, P, C, O, F, G, S
- Anti-evolutionist - saw species as fixed

**GEORGE CUVIER**- Father of Paleontology - Anti-evolutionist

- **CATASTROPHISM**-mass extinctions/repopulations explain changes in fossil record
- Extinction possible

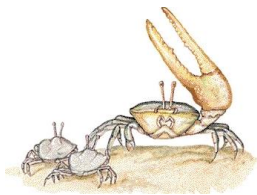
### JAMES HUTTON-

- Earth is **MILLIONS NOT THOUSANDS** of years old
- **GRADUALISM** = profound change is cumulative result of slow but continuous processes

**CHARLES LYELL**- Geologist

- **UNIFORMITARIANISM** (incorporated Hutton's gradualism)-
- Geological processes that have shaped Earth over millions of years are still happening
- Darwin read Lyell's book *Principles of Geology* on the *Beagle*

If earth can change, why can't slow processes over long periods of time also produce changes in living organisms?



**JEAN BAPTISTE LAMARCK** - One of first to suggest "life has changed over time"

- published a theory of evolution before Darwin (1809) to explain fossil record
- **"Use and disuse"**
- body parts that get used become larger and stronger; Unused parts become smaller
- **"Inheritance of acquired characteristics"**
- modifications acquired during the life of an organism could be passed to offspring

Giraffes stretch for food → Their necks elongate → Longer necks are passed to offspring

NO EVIDENCE that acquired traits are inherited without changing DNA, but... what about epigenetics?

- Appears some "acquired traits" may cause changes in genes
- EX: Remember video: grandparents diet impacting grandchildren's health

### THOMAS MALTHUS

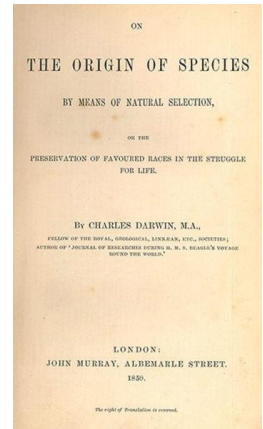
- Human suffering (disease, famine, homelessness, war) = consequence of overpopulation
- If resources are scarce, some organisms will not survive

### WHAT DARWIN DIDN'T KNOW

- MENDEL's genetic experiments were published AFTER *Origin of Species* was published
- VARIATION in population due to MUTATIONS in GENES and GENETIC RECOMBINATION

## DARWIN'S THEORY = Revolutionary;

- accepted view at time = living things were created once and were unchanging
- Returned from voyage on Beagle (1831-1836) and spent 20+ years studying/writing;
- Didn't publish his ideas because he knew they were radical
- Reluctantly published when Alfred Russel Wallace wrote essay with same ideas
- *On the Origin of Species by Means of Natural Selection*- published 1859
- At first rejected/ridiculed;
- Evidence for evolution has been/continues to be overwhelming
- Evolution is "universal theory linking all biological concepts"



## DARWIN'S THEORY:

**NATURAL VARIATION**- "Each individual is unique"

**ADAPTATION**-characteristic that helps an organism be more suited to its environment/survive and reproduce

**OVERPRODUCTION** of offspring results in more offspring than can survive

**STRUGGLE FOR EXISTANCE**-Organisms must compete for food, space, mates

**NATURAL SELECTION** also called "**SURVIVAL OF FITTEST**"

- Individuals that are best adapted to their environment will survive and reproduce

- Inherited favorable characteristics become more common from one generation to the next

**FITNESS** = measure of organism's reproductive success (greater number of offspring that carry your genes)

**DESCENT WITH MODIFICATION**-organisms have descended from a common ancestor;

**EXTINCTION** occurs when previous adaptations are no longer suitable to a changed environment

\* \* \* \* **IMPORTANT TO REMEMBER>>> POPULATIONS evolve NOT INDIVIDUALS** \* \* \* \*

## MYTHS:

**Evolution is like a climb up a ladder of progress; organisms are always "getting better"**

"Best" depends on environment; A trait that is beneficial in one environment may be detrimental in another

**Evolution is a "theory" so it's a "hunch" or "opinion"**

**THEORY** = broad explanation that can be used to make predictions and generate new hypotheses  
and is supported by large body of evidence

**Evolution gives organisms the traits they "need"**

Organisms don't "get what they need" from natural selection

Traits some individual organisms already have are selected for

**EVIDENCE FOR DARWIN'S THEORY**



**ARTIFICIAL SELECTION-** "If we can pick & change organisms' traits, why can't nature?"  
 Nature provides differences; humans choose useful traits  
 Ex: broccoli/ cauliflower share same ancestors;  
 dogs; increased milk production in modern cows; Butterball turkeys

**FOSSILS-**

Fossils at the lowest level = oldest; younger layers as you move upward

**FOSSIL RECORD SHOWS SEQUENTIAL CHANGES**

- ~ a succession of organisms have populated Earth throughout time.
- More than 98% of organisms that once lived are now extinct
- prokaryotes appear before eukaryotes;
- single celled appear before multicellular;
- invertebrates appear before vertebrates;
- fish < amphibians < reptiles < birds < mammals
- Cambrian Explosion- around 530 million years ago
- rapid appearance of most major groups of complex animals
- Similar rapid increase in species of land plants 400 million years ago



**TRANSITIONAL FOSSILS** = "in between"  
 -organisms with intermediate characteristics  
 - show relatedness of species

Ex: *Tik taalik* = has both fish/amphibian characteristics  
*Archeopteryx* = shares bird/reptile characteristics



**BIOGEOGRAPHY**-study of the distribution of organisms

- Related organisms are found living close to one another

**DIVERGENT evolution (=ADAPTIVE RADIATION)**

- closely related species become different as move into new environments
- EX: Galapagos finches/tortoises

**CONVERGENT evolution**- different organisms that share similar habitats become more alike

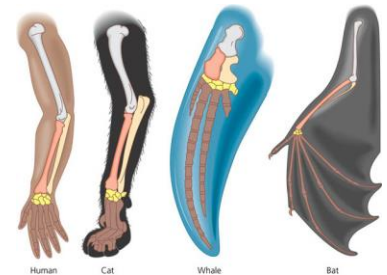
Ex: whale and sharks have similar body shape

**COMPARATIVE ANATOMY-**

**HOMOLOGOUS STRUCTURES-** evidence of divergent evolution (shared common ancestor)

- body parts with similar structure but not necessarily same function
- share same embryonic origin

Ex: bird wing, human arm, whale flipper



**ANALOGOUS STRUCTURES-** Evidence of convergent evolution

- Different structures with similar function in different species

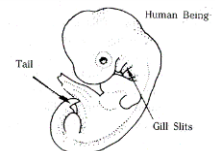
EX bird wing and butterfly wing



**VESTIGIAL ORGANS-** evidence of divergent evolution

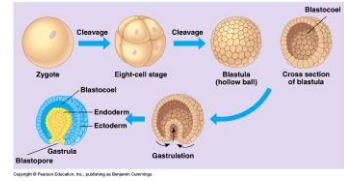
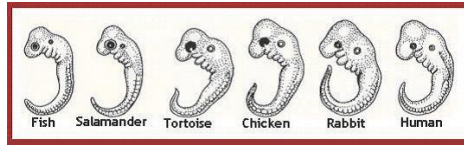
- remnants of structures that had functions in ancestors but are no longer essential/function changed

Ex: whale hipbones, human tail/cecum; skink legs



**EMBRYOLOGY**- similar developmental patterns seen in all vertebrates

Ex: zygote → blastula → gastrula;  
tail/pharyngeal pouches in humans



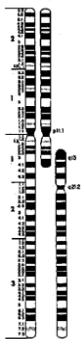
**MOLECULAR BIOLOGY**-

**UNIVERSAL genetic code/cell machinery** in all living things

	Horse	Chicken	Tuna	Frog	Human	Shark	Turtle	Monkey	Rabbit
43	Glu	Gln	Glu	Gln	Glu	Gln	Glu	Gln	Gln
44	Ala	Ala	Ala	Ala	Ala	Ala	Ala	Ala	Ala
45	Pro	Glu	Glu	Ala	Pro	Gln	Glu	Pro	Tyr
46	Phe	Phe	Tyr	Phe	Tyr	Phe	Phe	Tyr	Phe
47	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr
48	Asp	Asp	Asp	Asp	Asp	Asp	Asp	Asp	Asp
49	Lys	Lys	Lys	Lys	Lys	Lys	Lys	Lys	Lys
50	Asn	Asn	Asn	Asn	Asn	Asn	Asn	Asn	Asn
51	Lys	Lys	Lys	Lys	Lys	Lys	Lys	Lys	Lys
52	Met	Met	Met	Met	Met	Met	Met	Met	Met
53	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr
54	Ala	Ala	Ala	Ala	Ala	Ala	Ala	Ala	Ala
55	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr
56	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr
57	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr
58	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr
59	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr
60	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr
61	Glu	Glu	Asn	Glu	Gln	Glu	Glu	Glu	Glu
62	Glu	Asp	Asp	Glu	Glu	Glu	Glu	Asp	Asp
63	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr
64	Met	Met	Met	Met	Met	Met	Met	Met	Met
65	Met	Met	Met	Met	Met	Met	Met	Met	Met
66	Ala	Glu	Glu	Glu	Glu	Ala	Glu	Glu	Glu
100	Lys	Asp	Met	Lys	Lys	Lys	Lys	Lys	Lys
101	Ala	Ala	Ala	Ala	Ala	Ala	Ala	Ala	Ala
102	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr	Thr
103	Asn	Ser	Ser	Ser	Asn	Asn	Asn	Asn	Asn
104	Glu	Lys	Lys	Glu	Lys	Lys	Lys	Lys	Lys

**AMINO ACID/DNA COMPARISON**

- Closely related species have more similarities  
EX: human/chimp cytochrome C = identical
- More differences in more distantly related species
- Can track shared mutations over time  
EX: hemoglobin; cytochrome C, pseudogenes)
- Essential genes are conserved (little variation) between different organisms  
EX: **HOX GENES**- control embryonic development



**HUMAN CHROMOSOME #2** -Humans have one large chromosome (#2) chimps don't have

- Chimps have two smaller chromosomes humans don't have
- Banding pattern matches;
- Human chromosome #2 has telomeres in middle; and extra inactive centromere
- Suggests it formed by fusion of two smaller chimp chromosomes

**VESTIGIAL GENES (PSEUDOGENES & ENDOGENOUS RETROVIRUSES)**

- Remnants of shared mutations found in related organisms
- Genetic code similar to functional genes but have lost function due to mutations
- Many intron sequences = nonfunctional pseudogenes  
EX: gene mutations for vitamin C production in primates; smell receptors in humans
- Remnants of retrovirus infections



**SEE IT HAPPEN**

- Emergence of new viruses diseases (HIV; Ebola; Bird flu, H1N1);
- Drug resistant HIV virus; Antibiotic resistant bacteria (MERSA); Pesticide resistant insects
- Peppered Moth data-
  - population became darker as industrial pollution increased in England;
  - lighter when anti-pollution laws went into effect
- Endler and Reznick Guppy experiments (1980's) - changes in populations happened within 11 years
- Age and size at sexual maturity change depending on predators
  - Small killifish eat juvenile guppies; Large pike-cichlids eat adult guppies
  - Guppies in populations with pike-cichlids begin reproducing at a younger age and are smaller at maturity than guppies in populations preyed on by killifish
  - Moving guppies to pools with different predators changes size and age of maturity in population
  - Changes are heritable