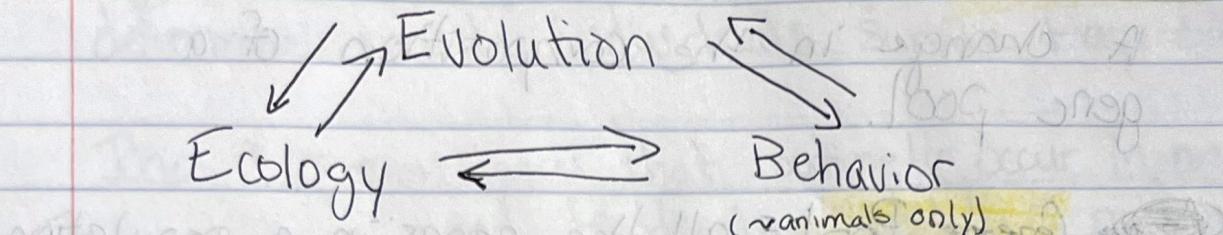


# Biology (8/28/23)



## Ecosystem Services

(things we get for free from ecosystems)

- oxygen
- water supply
- soil
- wood + fibers
- Water purification
- element cycling
- UV shield
- wild genetic material
- climate moderation
- flood prevention
- air purification
- pollination
- recreation
- inspiration

What is evolution & how does it work?

outline

Evolution - 3 circumstances & 2 consequences  
Observations of evolution Evidence of past evolution.  
in progress.

- artificial selection: intentional
- artificial selection: unintentional
- beak depths of Galapagos finches
- gickle back armor
- fossils
- molecular homologies
- anatomical homologies
- convergent evolution
- species diversity on archipelago's

## Evolution: definition

A change in the composition of a gene pool.

~~Gene Pool~~ Gene Pool = all the genes in a population of a species.

Gene = a unit of heredity

Population = a group of members of the same species with opportunities to interbreed.

Theory of Evolution explains:

1. how species change
2. how new species arise.

Selective Breeding - Picking preferred traits and breeding those animals. Don't breed the ones that have undesired traits.

"Artificial" Selection - people determine which individuals reproduce.

Charles Darwin: called evolution "Descent with Modification"

Natural Selection: natural, ecological processes determine which individuals survive & reproduce.

The 3 circumstances that routinely occur in nature lead to the inevitability of natural selection, which in turn results in evolution.

1. More are born than the environment can support.
2. Individuals are not identical
3. Some of the differences are heritable.

2 consequences of those 3 circumstances

1. Individuals best suited to the environment are most likely to leave offspring (natural selection)
2. Because only the reproducers leave genes in the next gen., the composition of the gene pool changes (evolution happens)

Tons of Evidence for Evolution

Some of the real-time evidence:

- Artificial Selection

- intentional artificial selection

- unintentional artificial selection

- Natural Selection

- Beak depths of Galapagos finches

- Armor of stickleback fish

Bio. (9-6-23)

Zoologians no ptions no message

Molecular Homology: Amino acid Sequences.

Human sequence most similar to similar species.

Convergent Evolution: dissimilar organisms (without a recent common ancestor) subjected to similar selective forces develop similar adaptations.

Historical evidence consistent with evolution by natural selection

fossils

molecular homologies

Anatomical homologies

Convergent homologies

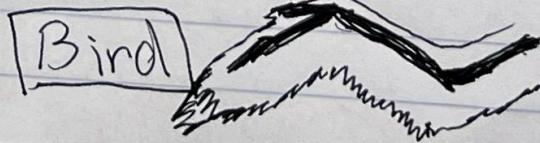
Species diversity on archipelagos

Study carefully:  
different aspects of the  
same pair of species can  
provide examples of  
both.

Anatomical homologies:  
bone structure (distant,  
non-flying ancestors)



Convergent Evolution:  
Wings (Skin vs. feathers  
- more recent evolution)



## Species diversity on archipelagos

(Ch. 11 pg)

Galapagos habitat variation:  
different ecological circumstances (selective forces)  
on different islands led, eventually, to enough evolution  
to give rise to different species.

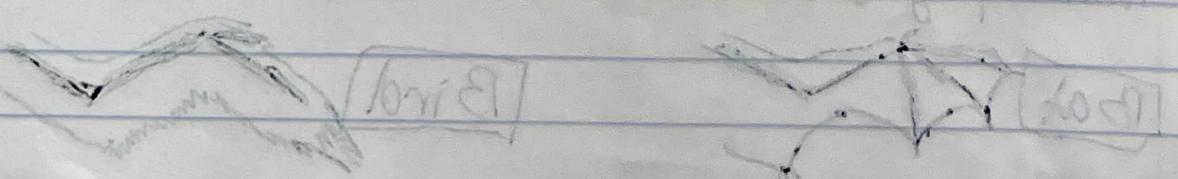
An inconceivable amount of time for evolution to occur. (billions of years)

Inconceivable # of opportunities for beneficial genetic changes

independent evolution  
different environments  
some being more  
hostile than others

inherent plasticity  
without environmental  
constraints there would  
be greater genetic variation

genetic variation  
greater genetic variation  
leads to greater variation



# Biology (9/11/23)

## Modes of Evolution

### Next Level of Understanding Evolution

- Mutations
- inbreeding depression
- Common patterns of evolution
- gene flow
- genetic drift

### Outline

Basic genetics of inheritance involving 5 steps

Fitness - formal definition

Processes that alter allele frequency

Relationship between fitness and survival

(survival of fittest leads to adaptation)

("survival of the fittest" = "survival of the fittest")

= survival of the fittest = survival of the fittest

survival of the fittest in humans and non-humans

survival of the fittest in evolutionary terms

and over time

Population: a group of individuals of the same species with opportunities to interbreed.

Species: a set of individuals with the potential to interbreed in nature.

Gene: a unit of heredity made of DNA

Allele: a variant of a gene - e.g. a length of DNA that codes for a particular trait, such as black hair

### Fitness

The relative contribution an individual makes to the gene pool of the next generation.

"Survival of the fittest" - (not the strongest individuals but the best suited to the environment.)

Processes that alter allele frequencies

("alter allele frequency" = "cause evolution")

- Mutation

• Creates new alleles = new genetic varieties = new possibilities

- Evolution by natural or artificial selection  
• adapts populations to current conditions

- Gene flow

- Genetic drift

## Mutation - a change in a DNA Sequence

- mutations occur randomly, not because they would be beneficial or for any other reason
- mutations often create new genetic variants
- Any specific mutation is extremely unlikely
- most mutations are inconsequential or harmful (random change to functional system)
- Rarer, beneficial mutations enable populations to develop genetic diversity + adapt to new circumstances

## The problem with mutations for individuals

- Two copies of most genes - one from each parent
- Thus 2 alleles - same or different
- Phenotype = the expression of an individual's genotype. (genotype = individual's complete set of alleles)
- Natural Selection acts upon phenotype, not genotype
  - One allele may be dominant over another, recessive to another, or related in a more complicated manner
    - (Dominant does not mean selected for.)

## Finches SimLab

### Ex. 1

Smallest beak:  $\frac{\text{depth}}{\text{width}} = 9.75$  Largest beak:  $\frac{\text{depth}}{\text{width}} = 13.3$   
 $8.50$   $6.75$

7.1. Over the years the finches composition changes from having a little bit of every size beak to a lot of them having bigger beaks

7.2. Yes the beaks got bigger over time

8. Selection Strength: .05

Average B-depth: 11.5

9.1 Average B-depth: 12.1

9.2 It increased by .6

10. Selection Strength: .15 or higher

Average B-depth: 11.5

11.1 Average B-length: 12.0

11.2 B-length increased by 1.1 over 100 generations

11.3 Yes, the beaks get bigger faster



(2. Beak sizes stayed around the same  
Beak sizes got smaller but slowly

**Ex. -2**

Wet      Dry  
Optimal beak length:      Optimal beak length:  
**10 mm**      **14 mm**

3.1 What is the Average Beak Depth?

11.5

3.2 What is range of beak depths?

9.75 - 13.3

3.3 Difference between largest v.s. smallest beak?

3.55 mm

4. Dry

4.1 Average Beak Depth: 12.7

4.2 Range of beak depths 6.00 - 14.00

4.3 difference between biggest v.s. smallest beak: 8mm

4.4 How composition has changed?

beaks got bigger

## 5. Wet

5.1 Composition actually turned out similar to  
in part 3.D

6.1 Did population evolve an average beak depth  
Well adapted for rainy conditions  
The beak depth got smaller

7.1 Is it possible to drive them to extinction  
yes, turn selection strength up all the  
way and switch between Dry + Wet.

7.2 Since beak depth has no effect on survival  
When faced with Dry Spells or wet spells they  
cannot immediately evolve to survive such conditions  
evolution takes time

- Q1 Why are birds discussed called Darwins Finches
- Q2 A Medium ground finch's ability to survive often ~~determines~~ depends on its beak size primarily because
- Q3 Which statement best describes the pattern of natural selection on beak sizes of birds from North wing to South America
- Q4 What can happen to our virtual finch population if environment changes from wet conditions to dry conditions too rapidly
- Q5 What happened to beak depths in the finch population when selection on beak depth was eliminated (selection strength) and mutation rate for alleles determining beak depth was greater than zero
- Q6 The correlated traits exercise shows?

Q7 In the Mountains & Valleys ex which of the following parameters had the largest influence on whether the finch population evolved a bimodal distribution

Q8 The final ex., Large & small seeds showed that?

Q9 Under which of the following conditions is a population most likely to evolve a bimodal distribution

Q10 In the lab, which of the following factors made it more likely that similar individuals would mate with each other

Our  
Wednesday

## Biology (9/18/23)

### Sexual Selection - Mate choice

- one sex ~~is~~ is generally (in most species) choosier about mates **Usually Females (Why?)**
  - Female fitness depends more on genotype of individual offspring than does male fitness - because females cannot reproduce as often
  - If a male makes a bad mate choice he can mate again - **little impact of one bad choice on fitness**

### Exceptions

In species where males raise young, males are the choosier sex

In other species only or ~~one~~ a few males mate. **Females have no choice**

What would happen to alleles that cause females to choose poorly?

**Offspring would have lower fitness**  
**Alleles that ~~lead~~ led to such ~~bad~~ choices would be selected against**

- Mate choice criteria (of wild species) **Must** lead to high fitness or alleles that lead to those choices would have been selected against

→ snail  
↓  
↓ / /

(E&I 2010) p. 10, 8

## Processes that alter allelic frequencies

- Mutation
- Natural Selection
- \* - Gene Flow
- Genetic drift

\* movement of genes from one population to another

Gene Flow critically important to prevent inbreeding depression in small population

Genetic Drift. Chance change in allele frequency - individuals

Genetic Drift can be important in very small populations but chance changes in allele frequencies are unlikely in large populations

## Population Bottlenecks

- Almost all individuals die, population regrows

## founder Events

- A few ind. found a new population in a new location

mutation ~~70%~~ random variation

natural Selection kind of random

Gene Flow not random

Genetic Drift random

Creatures are continually subjected to selection pressure

5 reasons why natural Selection does not eliminate genetic variation

Diploidy = 2 alleles for most genes so recessive alleles are "hidden" in heterozygotes (not selected against)

Variable Selection Pressure (different alleles favored in different times and places)

Heterozygotes sometimes have higher fitness than either homozygote

Neutral variation (variation with no fitness consequence)

Mutations continually add new variants

Evolution Does NOT lead to perfect organisms

- Natural Selection Involves trade offs (faster/stronger)
- Natural Selection can act only upon existing genetic variation
- Mutations occur randomly, not because they would be adaptive
- Delay between when Selective forces change and when allele frequencies change. Natural Selection always playing catch up
- Gene regulation problems (epigenetic Processes) interfere with fitness

### Some imperfections of humans

- Pharynx used for both breathing & eating
- We can't synthesize vitamin C
- ectopic pregnancies
- babies heads too big

Fitness - The relative contribution an individual makes to the gene pool of the next gen

"Survival of the fittest"

(not the strongest individuals, but rather the individuals best suited to the environment)

Processes that alter allele frequencies ("alter allele frequency" = "cause evolution")

- Mutation (creates new alleles = new genetic varieties = new possibilities)

- Evolution by natural or artificial selection  
adapts populations to current conditions

- Gene Flow

- Genetic Drift

Mutation - a change in a DNA sequence

- occur randomly, NOT b/c they'd be beneficial!

- Create new genetic variants

- Any specific mutation is extremely unlikely

## Speciation 9/20/23

formation of new species

### Outline

- Species definition
- Species identification
- Origin of new species
  - Allopatric Speciation
  - Sympatric Speciation
- Mechanisms that prevent hybridization between species
- Major changes due to evolution of genes that regulate development

A species is a group of individual organisms that have the potential to breed and produce fertile offspring under natural circumstances.

If members of 2 ~~different~~ different species breed they do not produce fertile offspring.

Thus, members of separate species are reproductively isolated.

In practice - it is often impossible to test whether two individuals can breed & produce Fertile offspring so...

Species identified on basis of

- **morphology** (unique features or combinations thereof)

or

- **genetics** (unique DNA sequences)

Suggest unique features implies reproductive

isolation

Morphological features that do not vary from individual to individual within a population and distinguish populations with those features from other populations (of closely-related species)

In some cases biochemical data, such as DNA sequences, must be used to identify species with any certainty.

"bar coding species"

Thus, 2 methods for distinguishing species

1. Reproductive Isolation
2. Distinctive morphological or biochemical features.

Problems with these methods

#1 often cannot be tested

#2 can confuse long-isolated populations  
and actual separate species

How do new species arise?

-1 Separate populations experience different selective conditions that favor different alleles

• changes accumulate until 2 populations of one species become 2 different species

or

-2 Much rarer but common in plants:  
reproduction "error" produces a new species in one generation

For 2 populations to diverge into separate species they must be sufficiently reproductively isolated that their gene pools can diverge

Biology 9/25/23

How did you study for the quiz?

I went over notes as well as reviewed all power point slides.

Was that how you intended to study?

No. I was hoping to get to study with a friend and make flash cards.

If not, what was the difference?

I didn't have enough time.

Were you confident that you were ready for the exam?

No I had a lot of anxiety before and after.

Have you identified any ways to improve your methods for studying and learning? Looking at slides is useful for memorizing but not for when you need to explain in other ways. I need to practice explaining the topics.

Would you change your procedure for next time?

If so, how?

I'll start earlier and use more methods than memorization. I will also make sure to understand the material.

## Speciation

cont.

EEB1221P 1/2018

If there is substantial gene flow between populations, they will not diverge genetically.

Allopatric Speciation - Speciation involving geographic isolation

Sympatric Speciation - two populations become isolated even though they occur in the same area.

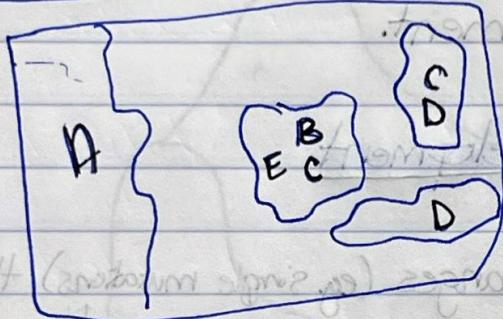
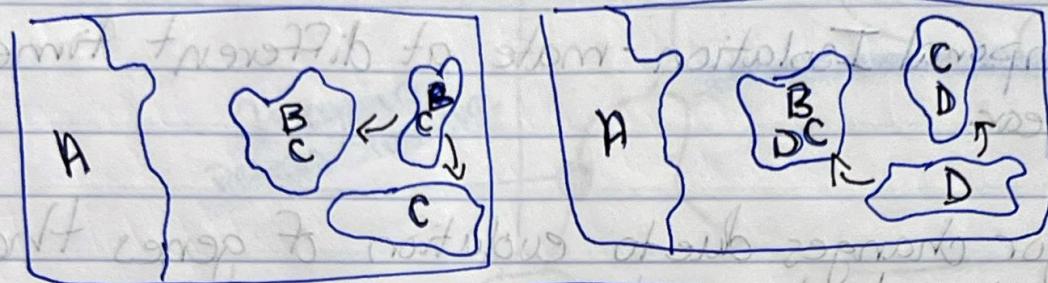
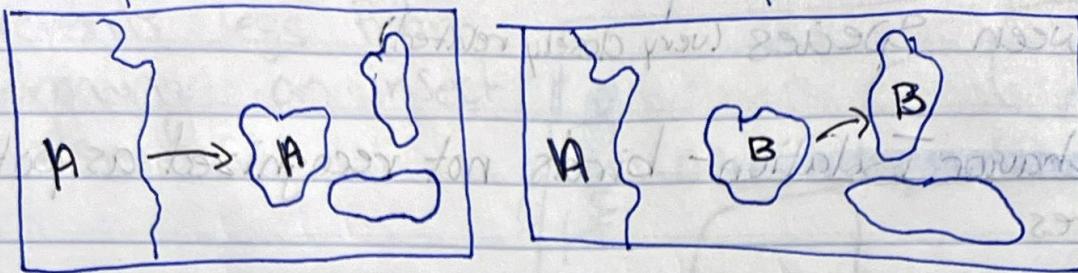
Factors that increase likelihood of Allopatric Speciation

- 1) Different selective pressures in different locations
- 2) Many different populations
- 3) Initial allele frequency differences among populations.

Island chains are often sites of adaptive radiation.

- isolation from mainland
- Small founder populations.
- Different selective pressures on different islands
- Infrequent movement from island to island

## Adaptive Radiation on island chain



## Sympatric Speciation

- Speciation without geographic isolation
- Possibly Common, difficult to detect
- Ambiguity of "geographic" isolation?

Sympatric speciation due to nondisjunction of chromosomes during meiosis - common in plants

Mechanisms that prevent hybridization between species (very closely related).

Behavior Isolation - birds not recognized as potential mates

Temporal Isolation - mate at different times of year.

Major changes due to evolution of genes that regulate development.

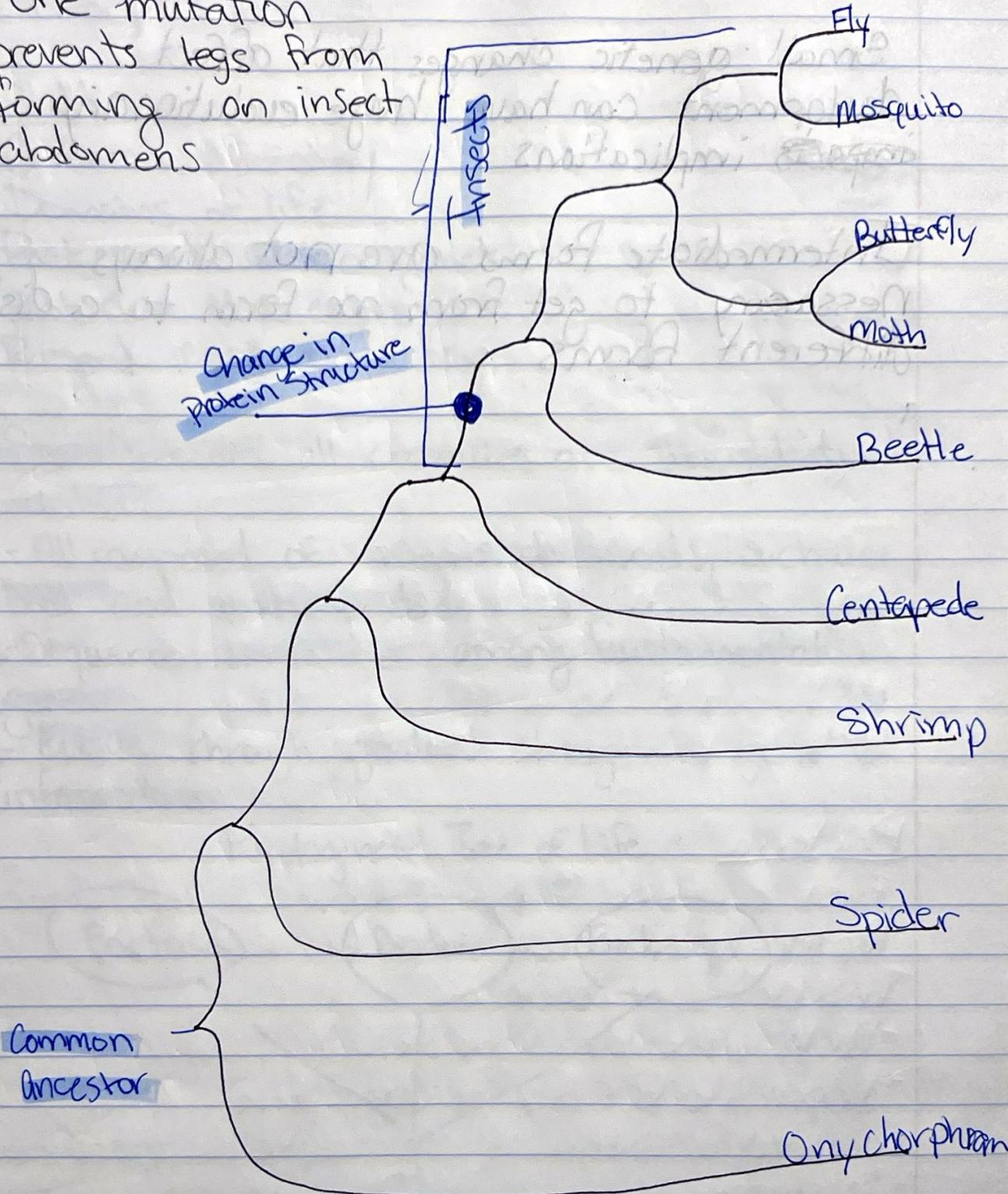
### Evolution of Development

- Small genetic changes (e.g. single mutations) that affect the development of embryos can cause tremendous morphological changes.
- In other words, a small genetic change sometimes causes a major phenotypic change.

2 genes determines whether a bird's foot is webbed.

A single mutation prevents armor formation in sticklebacks

One mutation  
prevents legs from  
forming on insect  
abdomens



Only chelophaean

Small genetic changes that affect development can have huge evolutionary implications

Intermediate Forms are not always necessary to get from one form to a distinctly different forms

# History of life

## Outline

Common Ancestry

Domains of life

Past conditions on planet

Historical Mass extinctions

Present Mass extinction

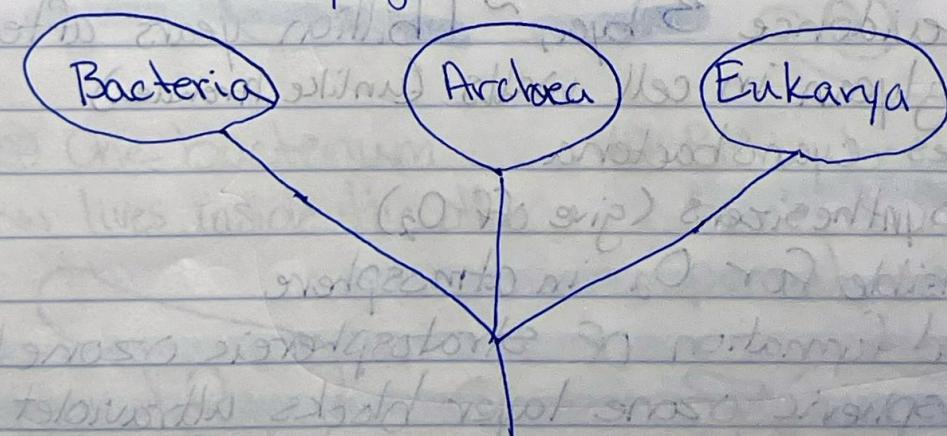
Some reasons all creatures are thought to be related:

- All composed of same biochemicals, such as DNA and amino acids.

- Sequence similarities among fundamental genes

- Evolve through gradual changes in genetic information.

## Phylogenetic Tree of Life



# 3 Domains

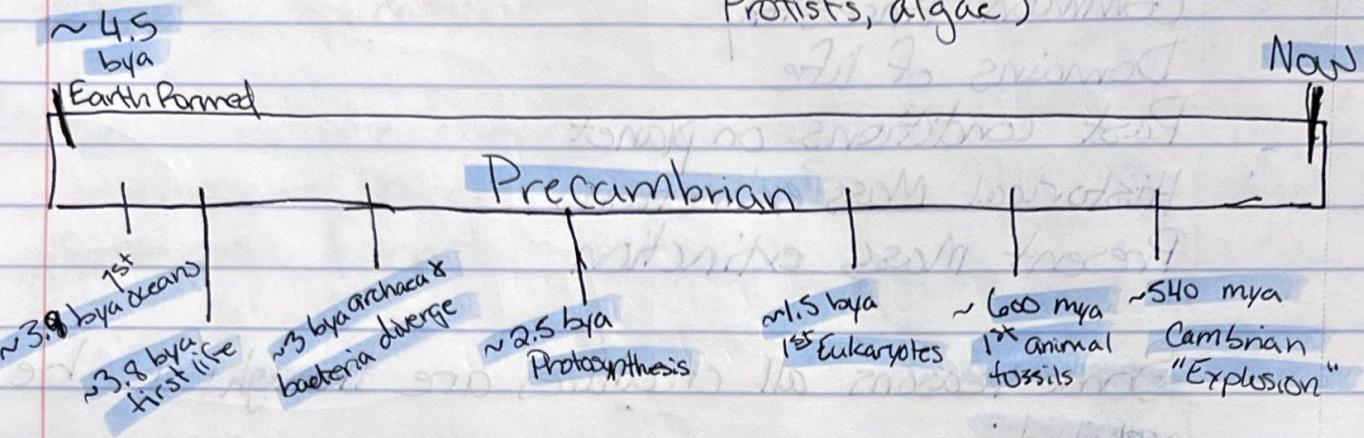
Bacteria

Archaea

Eukarya

Prokaryotes - no nuclei (archaea + bacteria)

Eukaryotes - cell nuclei (fungi, animals, plants, protists, algae)



## The earliest Cells: Archaea

Age of Earth: 4.5 billion years

First life occurred: 3.8 bya, descendants still around

Archaea + Bacteria diverge 3 bya

Today's Archaea occur in "harsh" environments

## Bacteria

First evidence 3 bya, ~1 billion years after Archaea

Peptidoglycan in cell walls (unlike Archaea)

Includes cyanobacteria

- Photosynthesizers (give off O<sub>2</sub>)
- responsible for O<sub>2</sub> in atmosphere
- enabled formation of stratospheric ozone layer
- Stratospheric ozone layer blocks ultraviolet light
- no life on land until the ozone layer formed
- So, we owe our lives to pond scum. (real) (lol)

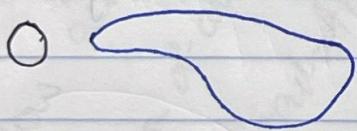
Prokaryotes (organisms whose cells lack nuclei, archaea, bacteria) had the planet to themselves for more than 1 billion yrs.

Eventually the first eukaryotes arose  
(organisms with chromosomes enclosed inside the membranes of cell nuclei)

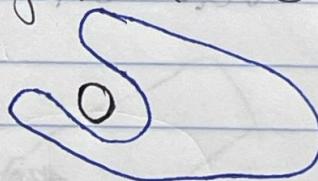
Prokaryote (Archaea, bacteria)  
Eukaryotes (everything Else)

Endosymbiotic hypothesis for origin of Eukaryotes

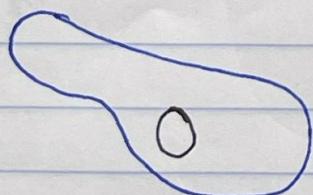
1) Start w/ 2 independent bacteria



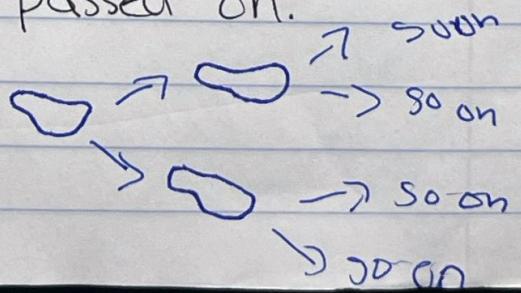
2) One bacterium engulfs the other



3) One bacterium now lives inside the other



4) Both bacteria benefit. So bacteria passed on.



## Evidence

chloroplasts + mitochondria are similar in size to bacteria

Chloroplasts + Mitochondria reproduce by splitting, like bacteria.

Chloroplasts + Mitochondria have their own circular DNA, like bacteria.

Chloroplast DNA include sequences very similar to cyanobacterial DNA.

4.5 bya ??

evolution is a change in the gene pool

## Human Ancestry

Primates

Tarsier      Monkey      Us (humans)

All primates have ~~binocular vision~~

1. binocular vision

2. Grasping fingers & toes

(No other mammal has both)

Primate evolutionary tree

65 mya Mammals called archonta give rise to primates.

36 mya Some primates become diurnal - monkeys with opposable thumbs

25 mya First apes

5-10 mya Climate cools, African forests replaced by Savanna & grasslands

4-5 mya Tool use

2 mya Brains get larger - presumably because of selection for intelligence due to potential to use tools.

~~genes~~

Neanderthal genes live on in modern humans

*Homo naledi* - Found in S. Africa in 2015,  
has characteristics of both *Australopithecus*  
& *Homo*

### ~~Common all fossil record~~ Immediate Ancestors of humans

- 5 bya: Hominids split from apes
- 4.5 bya: "Lucy" - truly bipedal, survived 2m yrs.
- 2.1 mya: *Homo erectus* in Africa, Europe, & Asia
- 500,000 ya: *H. neanderthalis* in Africa
- 300,000 ya: *H. Sapiens* in Africa & Middle East
- 100,000 ya: *H. neanderthalis* in Europe & Siberia
- 200,000 ya: (2019 Nature Report, *Apidima 1*)
- 28,000 ya: *H. neanderthalis* still in Europe

### Genetic Structure of Modern Human Pop.

"Within-population differences among individuals account for 93 to 95% of genetic variation; differences among major groups constitute only 3 to 5%."

## Human "Races"

Genetic similarities among people from dif. areas.

No biological basis for conventionally identified races.

Criteria for race disti

\* Midterm 2  
next Wednesday \*

## Biomes

Types

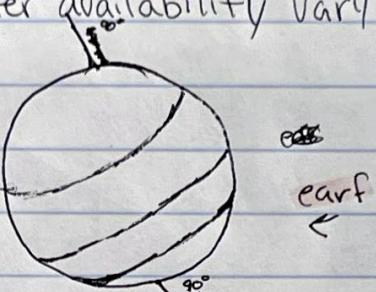
Distribution

Determinants of distributions

Human impacts on distributions

Biome - a type of ecosystem

Why does temperature and water availability vary around the planet?

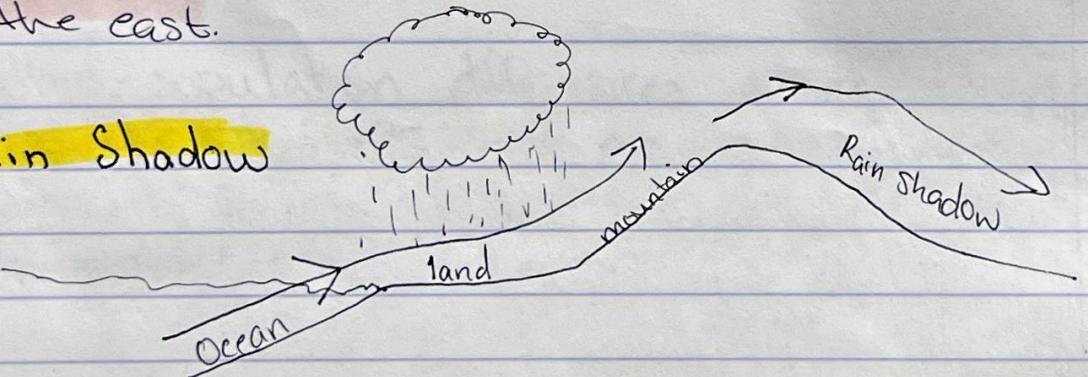


Orbit = Seasons

An air mass moving towards the equator moves more slowly than Earth's surface and is therefore deflected to the west.

An air mass moving toward the poles moves faster than the Earth's surface and is therefore deflected to the east.

Rain Shadow



During the day as warm air rises, cooler air rushes in from the ocean to replace it.

~~Population regulation & cycles~~

~~Population regulation & cycles~~

**Density dependent:** Per Capita population growth rate depends on population density

Only density dependent processes can regulate population sizes.

Regulation occurs only per capita birth rate, death rates, or both vary with population density.

Biological interactions are often density dependent  
eg. competition, predation, parasitism, (B/C of Population Density)

Abiotic factors are not generally density dependent  
eg. extreme weather (This happens Regardless of Population Density)

Current human population is maintained at expense of costs to future.

depleting a "one time inheritance of Natural Capital."

# Phys. & Population Ecology

## Summary

- Species maintain populations only where niche requirements met
- Adaptations broaden niche boundaries
- Some potential habitats are uninhabited due to failure to disperse to those sites.
- Once a population reaches a new site it may grow, but will not grow indefinitely.  
Population sizes tend to be regulated, but sometimes only loosely.
- The human population has grown dramatically, as if not regulated.

# Community Ecology

## Outline:

Types of interactions among species

- Competition
- Predation
- Mutualism
- Coevolution

## Species Diversity

How does species diversity affect ecosystem functioning?

Factors that reduce species diversity

Community: An assemblage of organisms living close enough together to have potential to interact.

## Types of interspecific interactions

- Interspecific competition -  $\geq 2$  species use same limiting resource, one or both suffer
- Predation (including parasitism): One individual benefits other suffers.
- Mutualism - both species benefit.
- Commensalism - One species benefits, other is unaffected

- **Coevolution**: reciprocal evolution of 2 species in response to each other.

### Fundamental vs Realized Niche

**Fundamental niche** - the set of conditions where a species could live in the absence of competitors & predators

**Realized niche** - the sets of conditions where a species actually does live in the presence of competitors.

### Interspecific Competition & realized niches

#### Predation

Selection favors individuals that survive and reproduce  
Selection also favors individuals that obtain sufficient resources

thus

Almost all creatures are routinely at risk of predation or have effective defenses against predators