

- read syllabus and article on
08/25 before next class

- download copy of
biology textbook

08/23:

evolution, behavior, ecology

my initial definition of evolution: the reaction of an entity - organism or species - to an environmental stimulus over time

" " natural selection: the favoring of certain traits ~~over~~
over others by the natural environment

- fit to its environment

what is confusing, unclear, or seems impossible about evolution?

- naturally some religious competition in my eyes

Why these topics in the first semester?

organisms don't always become better adapted to the environment
because the environment changes too

- species go extinct when they can't evolve as fast as the environment
changes

most schools do cells and molecular biology in the first semester

- helps you to understand everything else; w/o that, you just have
a lot of facts

- this is the why of biology

- the modern how is evolutionary history

- so much medical insight to be gained by knowing we evolved to
be hunters/gatherers

- don't use humans as your example to try and understand the
biological process (culture and ego)

think

notes & studying

Feynman technique

- write what you know about topic by hand
- explain to a younger person (appropriately)
- notice what you can't explain
 - follow up and then repeat

Notes

- don't dictate but paraphrase everything the professor says. They won't say anything that they think is useless.
- leave space at front for additions and leave back empty for later
- improve your notes w/ others after class
- work together to ID main points, their relations, and how they relate to points in previous classes. Shouldn't be laundry list of material
 - write these down on blank spaces.
- use readings to learn about the topics y'all don't understand
- transfer ~~assess~~ in new notebook (w/ blank pages at front); develops
 - "Do not transfer anything you do not understand"
 - write in complete paragraphs; write out explanations in your words
- add outline of the day in beginning of book ↴
- Keep up day by day!
- a list of topics and subtopics w/o any explanation
 - to study, look at the outline and see what you can do. Use that to guide your test prep.

read before 08/28 class

ch. 18 Evolution and the Origin of Species

All organisms evolved from a different species, and evolution is ongoing

Evolution is the rationale for all biologic processes and drives current curiosity

18.1 Understanding Evolution

- evolution as a science preceeds Darwin

- age of the earth integral in early evolution conversations

Galapagos form: similar organisms on different islands with some distinct differences

Alfred Wallace and Charles Darwin independently thought of natural selection simultaneously

natural selection (survival of the fittest): the more prolific reproduction of individuals with favorable traits that survive environmental change because of those traits

- the how of evolution (adaptive evolution ... other types?)

① most traits of an organism are inherited

② competition for resources in every generation (from Malthus)

③ observable genetic variation; characteristics that compete better will be passed to progeny → descent w/ modification: "change in populations over generations"

- nongenetic variation not contribute to evolution b/c not inheritable

④ **mutation** = a change in DNA; new alleles; can have (+), (-) or no effect (neutral mutation) w/ varying degrees

⑤ **sexual reproduction** = unique mixing of parent DNA → unique combo

adaptation a heritable trait that helps an organism's survival and reproduction in its present environment

- genetic variation over time contributing to fitness

- favorability ← environmental conditions (not static); directions can shift

divergent evolution evolution in diverse (interesting) directions from a common point

"acts on individual
organisms but shapes
an entire species
over time"

convergent evolution similar traits evolve independently in species that do not share common ancestry

- same predicted destination, different journeys (group of tourists)

homologous structures same overall construction / synonymous parts in different species

vestigial structures unused structures w/o function (appendix)

analogous structures similarities not due to a close evolutionary relationship just common reaction to environment

- ex. many arctic animals white b/c arctic is white, not because of common ancestry

Misconceptions

- scientific "theory" ≠ common usage "theory"

- an individual organism cannot evolve

- evolution not about the beginning of life

- evolution not intentional, just logical outcome

- the variation must already be present to be selected for

Evidence:

- fossils

- anatomy + embryology (homologous + vestigial structures)

- biogeography (like mainland / island similarities)

- molecular biology: similarity in DNA similarity in ancestry

artificial selection: evolution driven by decisions of people (whether intentional or not); people determine which individuals reproduce and/or survive

- generation by generation; the preferable selected after each generation
- "artefact of human activity" Dr PS
- "descent with modification" Darwin
- modern fruits + vegetables great example of artificial selection
- most of what we eat is a product of intentional a.s.

natural selection: natural, ecological processes determine which individuals survive and reproduce

wouldn't actually lead to evolution
there won't be genetic difference

- don't have to be the predator/prey situation

- mechanism of evolution

- due to what circumstances does n.s. occur?

i. competition ii. 3 Circumstances

individuals < ii. individuals not identical \rightarrow natural selection \rightarrow evolution

vary genetically iii. some variation heritable (only needs $1/3$, not $3/3$)

ie. fewer offspring; more born than environment can support

- not enough resources for all to survive; don't all survive to reproduce

ii. individuals aren't identical

- some differences genetic; not all differences genetic

iii. some of the variation among individuals is heritable

↓ - worked in genes (how is this different from the one above?)

2 Consequences of these 3 Circumstances

maybe revise

1. individuals best suited to environment (fit) most likely to leave offspring (natural selection)

during off. 2. because only reproducing genes passed on; composition of gene pool changes (evolution)

i. there is still room for bad luck in ecology; fit organisms can still die before reproduction, chance events

- over time, probability is truer
- "Evolution doesn't occur so that anything"
- evolution not on purpose & it's a result, not a goal - the consequences of evolution are not "whys" for evolution

Some of the real time evidence:

- look for evidence for hypothesis being wrong, not for reasons they're right
 - try to reject hypothesis. If you can't, it's apt to be right
- unintentional artificial selection:
- pug bkt does this mean yielding unintentional effects or we didn't know we were selecting? or both?
 - pugs have trouble breathing. modern crops must be babied on a farm.

Why would a physician make you keep taking antibiotics even when you're feeling better?

08/30 Lecture

- reactions
- don't develop the potential to evolve because of exposure to environmental pressure; relies on genetic variations that just happen to occur
 - we don't write articles on unknown mutations (a lot)

no office hours
on 08/31

Observations of evolution in progress:

unintentional artificial selection → may produce a superbug

- Ex 1
- antibiotics are for bacteria
 - not enough antibacterial in your system to kill all the bacteria; leaving just a few over, they'll reproduce exponentially still
 - why do some survive and some not? →
 - bacteria aren't genetically identical (news to me)

some more questions on 08/30 readings Google doc, ~~please ask~~

- maybe come in Wed. office hours

(Q) ~~K~~ - how does bacteria even mutate if they reproduce asexually?

- taking antibiotics gives advantage to the antibiotic resistant bacterium; unless w/o bacteria
- evolution involves trade offs; genes that contribute to fitness in one way typically detract from fitness somewhere else
- pretty much an inherent cost to mutated advantages
- pre antibiotic, the bacteria compete with each other
- antibiotic example analogous to superweeds example
- taking all your antibiotics doesn't ensure all antibiotic bacteria are gone (answer to question)
- resistance doesn't mean 100% resistance

ex 2 Why do commercially-harvested fish become reproductively mature at smaller sizes than previously?

- commercial fishers kept bigger fish and returned smaller fish
- net fishing removes more big fish; fish left to reproduce are the ones small enough to fit t/ the net
- again, relies on the leftovers just happening to mature at smaller size
- unintentional artificial selection

ex 3 Changes in beak depths of Galapagos finches following drought

- 400 miles offshore, not on a migration path, not visible from mainland
- lots of different examples of evolution w/ the G.I. because it's initial cases drew a lot more researchers (less front load effort for researchers)

*Geospiza
fantis*

- under variety of finch species
- "evolves back and forth" w/ weather cycles; short-term

/ environment changes

evolution that frequently changes direction

- islands far from mainland tend not to have many species b/c difficult for species to get there

- GI volcanic (from formerly underwater volcanoes); different islands vary a lot \Rightarrow in biotic presence, differ in age \Rightarrow

- finches eat eating birds; strong bill to break seeds open

- how well its bill works mainly determines fitness
drought on island:

i. few seeds available one large (for whatever reason)

- only big bills can burst it open

ii. small bills & can't eat

iii. small birds don't survive / long-bills survive

\downarrow evolution

next generation from large-billed parents mostly

natural selection example (due to natural)

why / how does it switch back? How do small bills even

have an advantage over large bills?

evolution not a goal; react to conditions of environment

ex 4

Armor of 3-spined stickleback - ocean vs lake populations

- lake have less and less armor over time

- nowhere to hide in ocean so armor necessary

- lake pops have places to hide; being more mobile
helps them to hide in the lake

- occurs due to already existing mutation

break until 2:21

do the review on the slide

make sure you can explain each piece of historical evidence of
evolution by natural selection

'there is a reason for everything ...' \rightarrow next page

- ask if will be doing
office hours on Wednesday,
September 6, 2023

evidence of past evolution

fossils

- sequential change in fossils w/ sensible intermediate stages

- gradual sequences

anatomical

- descent from common ancestor

homologies

"legacy of structure modified by different environments"

- how does this prove common ancestry? couldn't it just be a sensible way for arms to be organized?

~~vestigial structures~~ vestigial homology

- whales have hip bones with no limbs → descent from ancestor that did have legs

"evolution doesn't make things perfect", not ecologically expensive for whales to have hip bones - will be very gradually lost; vestigial things don't get lost very fast since they're neither advantageous or disadvantageous

molecular

homologies

09/06

amino acid sequences of humans most similar to organisms (logically) similar to humans

- due to descent from a common ancestor

- more similarity means more recent common ancestor

- lineage didn't

dissimilate

- moves smoking

isolated species evolving predictably due to shared environment

- more time

(relatively) mental pressures

- in evolution

how exactly - not unrelated species becoming ~~more~~ related /

to same b/ common ancestors

descentarily - similar selective forces → similar adaptations

→ more differences

something as - whale (mammal) descended from land mammal but shark

dissimilar if (fish) have ~~similar~~ ^{is not related to} overall shape (convergent evolution)

its relative - similar ≠ the same

since all g - can convergent species occur across ~~global~~ geography if

are c.a.? selective pressures are the same?

→ answer: yes!

- humans & octopus have common ancestor @ some point but dissimilar

- look similar but different development

- convergent evolution

10 - how are environmental pressures the same? are we thinking

way back or?

Bat/bird

be able to distinguish b/ the two
- anatomical homologies: bones in the wings

- wings: convergent evolution (common ancestor had a front leg, not wing) but similar in the way a shank and mammal are similar

- e.g. → similarity but ah → same ^{similar} same structure from same ancestor
↳ similar features from similar pressures

sm: he will send old questions via email

- know definition of evolution and natural selection but generally knowing the meaning is enough

- mix of MCQ and SAQ

- anything discussed in class (review nonbio stuff too!)

species diversity (sm: evolution doesn't result in perfect form, it's the an archipelago form that worked for survival in the past, could very well be better)

House Finch (seed-eating birds w/ big heavy bills)

G.I. (Galapagos Islands) (far off shore of Ecuador)

- finch doesn't fly there from mainland on purpose

- one finch species on mainland in Ecuador (more land area)

- 13 finch species in G.I. (less land area, volcanic islands of different ages)

- going b/ the islands (G.I.) would be rare too, even that too far and very unlikely that finches flew to G.I. to happen w/
but sm: unlikely events happen all the time

G.I. habitat variation

- islands different from each other + different environmental pressures

- two individuals surviving in different environments are different!

- not one species / island different directions of evolution

- more than one on an island kind of just happens

slide 42 → are any of these species more or less related to the ancestral finch? does amount of divergences relate to amount of relatedness to ancestors? does it even matter?
- resume at 2:25

~~bacteria can't reproduce~~

bacteria can mutate

mutations are evidence that biological processes aren't perfect

QUIZ #1 on MONDAY
09/11

ESSAY EXAMPLES

- When you write an answer that includes a technical term from the class, define the term to demonstrate you know its meaning
- When we're answering a question, are we answering like we're explaining it to a professor (you) or to someone with zero knowledge? Who is our audience?
- Explain your reasoning. Finish your thoughts
- complete sentences
- do not use the root of a word to define a word
- examples are often helpful in explaining
- think before you write
- define terms of not common knowledge
if we define something like bacteria? probably common knowledge of its semi-meaning but not exact definition
- avoid vagueness

2:22-2:30

ch 19 The Evolution of populations

19.1 Population Evolution

blending inheritance was the theory before natural selection

- but genes found to have particulate nature, passed discretely

modern synthesis: natural selection + genetics \rightarrow evolution

- microevolution (pop change over time) and macroevolution
(new species)

population genetics discussed in terms of allele frequencies

- genetic change \rightarrow phenotypic change

natural selection affects allele frequency (=genetic change)

gene pool: sum of all alleles in a population

genetic drift - allele frequencies change w/ no advantage over initial
allele frequencies (chance)

- occurs alongside natural selection

founding effect - went causing change in f_1 in an isolated part of the
population (?) that isn't typical

19.2 Population Genetics

polymorphisms (circumstances 2, 3)

population variation - distribution of phenotypes

heritability - the part of phenotype variation from genetic
variance (among individuals in a population)

- \uparrow heritability, \uparrow evolution

genetic variance - diversity of alleles + genotypes

inbreeding depression - inbreeding \uparrow disease offspring (greater
chance of shared recessive deleterious alleles)

GDP by chance some orgs have more children

small populations more susceptible to genetic drift

larger population = buffered effects of chance

bottleneck effect - natural events kill large portion of pop can
magnify genetic drift

survivors solely determine genetic variation which is maybe

by chance very different from before

founder effect also if physical barriers arises or lots of indols leave
gene flow: flow of alleles in and out of a population due to
migration of indols or gametes

- some pops have more of than others

- plants spread pollen

- can intro new genetic variation
mutations

- "species evolve because mutations accumulate over time"

- intro new genotype & phenotype variance

- harmful weeded out by n.s., beneficial spread

- silent don't affect population variation but maybe genetic variation
nonrandom mating

- natural selection selects traits preferred by females for mating
assortative mating - one wanting to mate w/ one similar to
themselves

physical location - mate with those close

- wouldn't def of pop kinda un define tho?
environmental variance

environment can affect phenotype (not heritable)

- what about temp dependent sex determination
geographical variation

- can lead to differences in phenotypic variation

- cline: a species populations vary across an ecological gradient

- more gene flow b/w clines, less difference and vice versa

19.3 Adaptive Evolution

natural selection = adaptive evolution

- not all evolution is adaptive !!!!

- n.s acts on entire organism, not indol alleles (takes all factors
into account)

are there other
elements on other
planets?

evolutionary (Darwinian) fitness)

- relative fitness; fitness only matters as it compares to other organisms of the same population

stabilizing selection: if N.S. prefers average over extreme phenotypes

directional selection:

- often response to change in environment

- selects indts at one end of the phenotype

diverting selection

- more distinct phenotypes more fit than the intermediate

- increases genetic variance (back)

frequency-dependent selection

positive Fds (favors common) or negative Fds (favors rare)

↳ decreases genetic variation

↳ increases genetic variance

changes direction depending on allele frequency

sexual selection

- sexual dimorphism (especially present in animal populations)

- more variance in male reproductive success than females

- strong selective pressure on males to obtain mates

- some species sex-role reversed so vv sexual dimorphism

some traits ↑ sexual success w/o survival success - sometimes

selects for sexually harmful traits that distract from survival

- = handicap principle (those that survive w/ unfertilizable sexual handicap are unusually good)

good genes hypothesis - imperfections may signal genetic superiority

N.S. cannot make a perfect organism; can only select not break

- limited by genetic variance mutations, & gene flow

- net effect of alleles often reduced, less intensity of N.S.

trait signals
males quality

- work on simulation (due on 11:59 on Wednesday)
 - don't have to design the experiment at the end
- revise bio notes from today

modes of evolution

→ 09/11 lecture

- print off workbook
- print off periodic table

MUTATIONS, INBREEDING DEPRESSION, COMMON PATTERNS OF EVOLUTION, GENE FLOW, & GENETIC DRIFT

natural selection is not the only mechanism of evolution, but it is the most important

population: a group of individuals of the same species with opportunities to interbreed (offspring able to reproduce)

- species: the potential to interbreed (would if they had opportunity)
- in nature; members of same species not necessarily same population
- some species have only one sp. population, but some species have lots of populations

gene: a unit of heredity made of DNA

- affects some feature of an organism

allele - a variant of a gene - e.g. a length of DNA that codes for a particular genetic trait

- variant of alleles on same gene → different effect

- natural selection concerned mainly w/ alleles, not genes

fitness: the relative contribution an individual makes to the gene pool of the next generation

- most fit individual leaves the most viable offspring

- sn: not on test / what is natural and what is desirable are not always the same thing

- more copies of their allele make it to the next generation

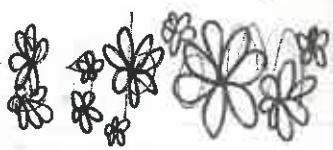
- highest fitness tends to be what survives best

- fittest ≠ strongest

Processes that alter allele frequencies (cause evolution)

- 1) mutation (new allele = new genetic varieties = new possibilities)
- 2) evolution by natural or artificial selection (adapts population to current conditions)
- 3) gene flow
- 4) genetic drift (chance change in allele frequency)

- go back through WB and make full sentences



- mutation - a change in the DNA sequence
 - random
 - mutations occur randomly (not because it may be beneficial)
 - create new genetic variants (only case where new happens)
 - any specific mutation is extremely unlikely increases fitness
 - not that many mutations are actually beneficial; not all mutations matter; random change to functional system may become common if it's selected for
 - more genetic diversity \rightarrow more capability for evolution / capacity to adapt to new circumstances
 - The problems with mutations for individuals
 - don't want to expose yourself to mutagens (care yourself up when getting mutated)
 - 2 copies of most genes (one from each parent) thus 2 alleles - same or different
 - genotype: individual's complete set of alleles nutrition, etc.
 - phenotype: not solely genetically determined (e.g. aging)
 - natural selection acts on phenotype, not genotype
 - any measurable part of an individual
 - out of the two alleles, one may be dominant (expressed in phenotype) and the other recessive (or something more complicated) it acts on phenotype (affected by genotype)
 - don't necessarily blend
 - dominant \neq more fit
 - ~~so are mutations dominant or recessive or does it depend? what are the genetics of mutation?~~

09/13

- print WB
- dominant mutant - expressed; affects phenotype
- recessive mutant - typically only expressed if homozygous
- dominant harmful alleles rapidly eliminated quickly
 - selected against with only one copy (hetero or homo)
 - recessive harmful alleles do not affect heterozygotes

and thus aren't noticed (it acts on phenotype, not genotype)
so they accumulate in heterozygous individuals

- only harmful when homozygous
- here's a reason evolution doesn't lead to perfect organisms
- we're all carrying harmful recessive alleles

inbreeding depression - reduction of fitness due to mating between closely related organisms (among the same species)

- how related is always a relative term in biology
- most mutations are harmful or have no consequence
- does mutation happen on the allele scale or gene scale? allele
- inbreeding increases the chance non, recessive, harmful alleles will be passed on homozygotously (carries having children \rightarrow harmful phenotype)
- deleterious recessive alleles are common but don't affect fitness in outbred populations
- Hapsburg chin
- became fashionable for German shepherds to have short back legs
- why is this included here?
- is this artificial selection or inbreeding or both?

the importance of mutations to populations

- not good on the individual level but valuable for the population from the population perspective because...

the same that are beneficial

new genetic material only from mutations

lot of genetic diversity \rightarrow capability to survive/respond to environmental change. The alternative is extinction "potential to adapt"
genetic + phenotypic variation from mutations

break until 2:20

maladaptive - selected against) (adaptive - increases fitness

1. mutation (random; didn't happen because it's selected for - usually leaves set of offspring with better traits)

adapted to parents' generation
than other offspring

II. natural selection (not random, adaptive)

III. gene flow (not usually adaptive)

- distinction between populations can be hard to determine

- individuals (+ their alleles or gametes) move between populations

IV. genetic drift (not usually adaptive)

V. artificial selection (not usually adaptive)

- usually don't have to survive on their own

common patterns of evolution by natural selection

nonrandom

1) directional (natural) selection

- one extreme phenotype is selected for (does this assume binary traits, either/or?) quantitative phenotypes address this but what about something more qualitative?)

- look at graphs in slides

↳ does it being a bell shaped curve mean there was a long period of stabilizing selection in the past?

- length of G1 finch beaks varying with seasons is directional selection

- doesn't necessarily have to go into the same direction for a long period of time. the direction can change and change often

- long-term: directional selection doesn't tend to go on forever

2) stabilizing selection

- intermediate phenotypes selected for; highest fitness in intermediate phenotype

3) diversifying selection (rare)

- both extremes favored over intermediate

- African black bellied seedcracker

- best of both worlds absolutely not

watch video before class

OTL: M 3-4:30
W 10-11:30
Th 2:00-3:30

09/15

Scientists seek evidence that an idea is **wrong**

theory: a hypothesis that explains a lot and has survived many attempts at being proved wrong

hypotheses must be testable - potentially falsifiable - able to be supported ~~or~~ wrong with evidence

Scientific thinking - open-minded perspective based on evidence

Science based on inductive reasoning - extrapolating from specific to general; inherently limiting

- this is why stats is so important

q. is there terminology for the different degrees of certainty?

- i.e., I know theories are pretty solid, but are there any links between hypothesis and theory?

q. I understand science ~~so~~ not seeks to find evidence supporting that an idea is wrong (critical, not affirmative) and that we use words like consistent and supports rather than proves - what more should I be understanding?

q. are proposed explanations scientific?

i.e. we don't talk about the beginnings of life. Can we even talk about them scientifically given lack of empirical evidence?

q. is "social sciences" a misnomer?

modes of evolution

09/18

(1) sexual selection - behavior and morphology

- mate choice is an aspect of natural selection - must be suited for survival and for reproduction/mating (when mating is or relevant concept. ie it isn't for bacteria)

- birds not the only weird sexual selection thing

African long-tailed widowbird

- no survival fitness with long tail beyond being attractive to mates

- something that survives and doesn't reproduce is not fit

- animal phenomenon

usually the females are choosier about mates because usually the female invests more energy + time into the reproduction (post copulation); at the very least, gestating

- female fitness more at stake because they have less chance for reproduction (ie males can mate a lot a lot a lot but female goes out of commission for a while)

- evolutionary selective incentive

- sm: we can't really understand what animals can perceive

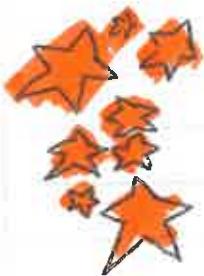
- female unconsciously choosing - it's instinct

- fit of offspring among individual males is super variable

her contribution to the next generation; her offspring one her genetic contribution - there is no fitness of an individual if their offspring don't reproduce, must produce fit offspring exceptions where males raise the young - then males are chosen and when only one or a few males mate

- especially where females are good at getting away from males (only the 'best' males able to get to female to mate)

if the long tail were even too long, a random mutation could arrive that would make females ^{not} choose them (and be successful because of the if, wouldn't cause b/c of the if)
offspring will have low fitness if females bad at choosing + no



QUIZ:

Wednesday,
September 20th

mate choice very contributive to evolution

- probably less directional changes with this one since it's based in instinct?
- mate choice must lead to high fitness or otherwise the alleles causing mate choice will be deleterious and rooted out

gene flow - alleles moving from one population to another

- populations not totally absolutely 100% separate, some potential for movement
- changes frequency of source and destination populations
- critically important in preventing inbreeding depression in small pops
- greater genetic diversity + greater capacity for evolution
- is genetic diversity an disadvantage?
- gene flow is random, doesn't happen on purpose
- genetic diversity from gene flow ~~but~~ doesn't always prevent (new alleles may be deleterious and be rooted out)

genetic drift - chance change in allele frequency, not adaptive

random - potentially important in small populations

- when a few individuals of a species colonize a new area (founder effect)
and when they're decreased to a small population of ~~of endangerment~~ (bottleneck)
(almost die off)
- little genetic drift in large populations
- only a few survive
- not all times when most of pop dies = founder effect
- must be random event not related to natural selection
- ~~most of~~
- see examples on slides

creatures continually & constantly subjected to selection pressure

- ↳ why don't they decrease genetic diversity? ~~die off~~

5 reasons why natural selection doesn't eliminate genetic variation

- 1) diploidy (recessive alleles hidden in heterozygotes)
- 2) the environment changes so selection pressure changes

- 3) sometimes heterozygous better than either homozygote
 - one sickle cell allele protects against malaria (H^+) but two are very harmful (H^-)
 - sometimes hetero has diff. phenotype than homo dom
- 4) not all genetic variation affects individual fitness
 - not always S dom
 - + recessive
- 5) mutations

evolution does not create perfect organism

NO!

evolutionary trade-offs (can't prioritize both if they are in conflict)

natural selection can only act upon existing genetic variation

- creatures constrained by their past evolution

mutations random, not adaptive

lag between evolution (response) and environment (selective forces)

- extinction b/c they can't evolve as fast as we're creating a problem

Q gene regulation problems (epigenetic processes) interfere w/ fitness

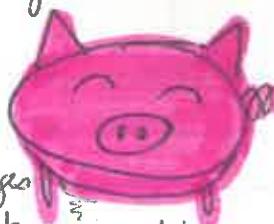
don't get it - turn on and off

↳?

- download lab documents to smartphone
- had before class on Friday

- tell him you're missing → ask him about WD
- go to off on Monday to ask about how much detail is necessary in quizzes / how can I write more effectively

2> 09/20 lecture



Speciation

formation of new species

so far we've been talking about small evolutionary changes
in different populations of same species undergoing evolution in different selective pressures for long enough (separate environments) may speciate

or one species evolves massively over time until it's a new species

don't get too hung up on definition of species, it's a concept we're made up
gene pools have to stay separate for speciation

- sometimes same species don't recognize their ability to mate → opportunity to interbreed

species group of individual organisms that have the potential to interbreed # of pops
[and produce fertile offspring under natural circumstances] vary among species

- 2 different species cannot produce fertile offspring (ie mule)

this definition can't always be tested

- separate species are reproductively isolated ~~are different~~ (also relevant to two populations of the same species) gene flow b/w pops means they're not reproductively isolated

cannot just go by appearance to differentiate b/w species
another way biologists distinguish species:

1) morphology or 2) genetics (unique DNA sequences)

- universally the same across species and universally different

• among other species, not necessarily the most obvious, not necessarily every difference (look at slide six)

- sometimes confusingly - isolated populations and actual separate species
- does it even matter? (is not really)

origin of new species

allopatric - two populations are physically separated; different environments means different selective conditions meaning differences in evolution

in plants, sometimes reproduction can create a new species in one generation

^{allopatric}
speciation requires a long period of reproductive isolation
sympatric speciation - two populations become isolated even
though they occur in the same area

18.2 Formation of New Species

hybrid - infertile cross between two species

sexually reproducing organisms can only pass on DNA +/ gametes
typically not interbreeding b/c species in the wild

- hybrids in nature suggest descent from common ancestor
(interbreeding species)

distribution same across geography
typically homogeneous (²) gene pool for geographically continuous
species because of free gene flow

allopatric  dispersal - a few members of a species move to a new geographic area
processes vicariance - natural situations physically separate organisms

- the further the distance, the more likely speciation
- probably more difference along latitude than longitude (I think)

adaptive radiation - many adaptations from single part of cym
(creates several new species)  founder species

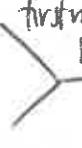
- different orgs of one pop e/ find a niche in a new area

aneuploidy - even occurring at \pm (2n+1 or 2n-1 chromosomes)

- diploid (2n)

- polyploidy (4n), tetraploid (org w/ 4n, can self pollinate)

(allotetraploid gamete from two dif species combine)

confining  species 1 → normal gamete  first mating self pollinate

species 2 → polyploid gamete  polyploid  second mating

high rate of polyploidy in plants

temporal isolation difference in breeding time

behavioral isolation genetic barrier

18.3 reconnection and speciation rates

hybrid zone - two closely related species continue to interact and reproduce

- speciation reinforcement of hybrids are less fit (how can a hybrid have any fitness if it cannot reproduce)



reinforcement limits stability

gradual speciation - like a ramp

punctuated equilibrium (doesn't exclude gradualism)

- like a staircase

~~rate of~~ changes in environment determine speciation rate

09/15 Reflection

1) Feynman technique, but I didn't actually explain it to a separate person, just myself.

2) Pretty much, yeah. I imagined I would need to do some specific research or targeted review, but I was satisfied in my ability to explain anything.

3) answered in second sentence of (2)

4) I was confident yes!

5) I was not at all intentional about blocking out time specifically to study.

6) more intentionality in scheduling and listing objectives but I was pretty comfortable with my readiness and maintain that having taken the quiz even without receiving a grade yet. A bad grade would definitely undermine my confidence though.

very little method in my studying for this test

speciation

27/09/25 lecture
(Monday)



Factors that increase the likelihood of allopatric speciation:

- 1) diff selective pressures in diff locations (will evolve differently)
 - virtually no gene flow between populations (very small amount of gene flow can make two "populations" indistinguishable)
- 2) many different populations, not just two
 - this is not rare
 - species have certain specific habitat requirements
 - just easier to study with island barriers
- 3) initial allele frequency differences b/t populations
 - ex. deer larger at higher latitudes and smaller closer to equator
 - the two different pops have diff allele frequencies for size (part #1 too)
 - founder effect can cause this factor (\hookrightarrow I was right about temp reg :P)
 - inbreeding depression can apply to individual, not only population; not only relevant at population level, really referring to individuals/fathers
 - I don't know that my quiz answer mostly reflected that, but this specific linkage is kind of new to me

Hawaiian archipelago

- each islands have very different environments
- islands far enough away from each other for birds to interbreed not likely

Archipelagos often sites of adaptive radiation (= from one species to many as a result of ~~different~~ adaptation to different selective pressures, lots of allopatric speciation, many species resulting, +/ adaptations to new environment)

i.e. one Asian bird \Rightarrow 54 Hawaiian honeycreepers

- crazy to me how the different Galapagos Islands have such different environments - is understanding how the magnitude of these differences occurs necessary?

99

- is timeline a qualifier at all for adaptive radiation? is it just kind of relative what we call adaptive radiation since all life is a product of evolution from a common ancestor?
- 800 cichlid species in Lake Victoria example
 - when water levels go low, became isolated populations - adaptive radiation, now all in one lake
- sympatric speciation "harder to study and for animals, probably not very important"
- not a physical barrier but don't interact
- harder to know they didn't speciate somewhere else and then end up here (*Cyphocheilus hectelles*)
- nondisjunction of chromosomes during meiosis
- don't need to know the nitty gritty of meiosis

20.1 Organizing Life on Earth

phylogeny = evolutionary history, provide info on shared ancestry

can change over time (and do)

phylogenetic tree, hypothesis of genetic past

- not all trees do show a common ancestor
- ? - branch point: where a single lineage evolved into a distinct new one
- basal taxon: lineage that evolved early from the root (common ancestor) but remains unbranched
- sister taxa: two lineages stemming from the same place
- polytomy: branch w/ 3+ lineages

resolution at branch points does not change
the information "use for simly"

systematics - the field organizing & class-

ifying orgs based on evolutionary relshps

not branch pt

keeps track of relationship than physical similarity

branch length not related to time unless stated

three domains: Bacteria, Archaea, Eukaryota

- then kingdom, phylum, class, order, family, genus, species

- each kind's specific name for an organism's classification = taxon

20.3 Perspectives on the Phylogenetic Tree

limitations to classic model: genes transferring b/t unrelated species
horizontal gene transfer (HGT)

- occurs in ~~some~~ prokaryotes, also some in Eukaryotes

- gene transfer other than parent to offspring (vertical gene transfer)
genetransfer among common bacteria mechanisms:

1) transformation

2) transduction: a virus transports the genes

3) conjugation: hollow tube (pilus) transports genes between organisms

gene transfer agents (GTAs) transfer random genome sequences from one prokaryotic species to another

genome fusion: when symbiotic prokaryotic species become endosymbiotic

HGT has furnished web of life model over tree of life, ring of life also in the mix

theme: limitations of models + scientific advances

★ question: how is this at all w/i the scope of our class?

what do I actually need to know for the purpose of this class here?

27.4 Evolutionary History of the Animal Kingdom

Q what specific fossil history do I actually need to know?

Cambrian explosion - rapid diversification of animals, most rapid evolution of new animal phyla + animal diversity ever
- trilobite from this time

new ecological niches → adaptation of existing species

environment changes → new niches speciation and diversity

mass extinction seems to upset the state

47.1 Biodiversity Change +/ Geological Time

speciation and extinction equilibrium = # of species on planet

birth & death rates of macroevolution

of species on earth change as these change

five mass extinctions (?) all species disappear from fossil record

- there are lesser extinction events

more than likely, a portion of this will not be on the test

→ 09/27 lecture (Wednesday)

Speciation

formation of new species



- find time for going to office hour before the test
- email Dr Richardson about chem followup
- two Sunlis due Fri (one extra credit)

EXAM one week

from today! OCT 4

understand how skewed sex ratios affect genetic diversity (for next Sunli 4)
extinct means not extinct; they live now

- Q hybridization: two species cross and produce fertile (?) offspring
keep in mind there is some tension and fuzziness with speciation
- mechanisms that prevent hybridization
 - behavioral isolation
 - ex. the meadowlarks
 - they have different songs and only respond to the song of their own species
 - is this assortative mating culminating in speciation?
- temporal isolation
- most animals aren't fertile year round
- major changes due to evolution of genes that regulate development
- development: single-celled organism (zygote) → maturity
- gene regulation caterpillar → butterfly
- for instance, cancer is unregulated cell division
- not all genes are active all the time
- cells in finger could make liver cells, only certain genes being activated (all the genetic info is in all the cells)
- genes controlling gene regulation can cause big change
- mutations
- most genes affecting development negatively affect development
- but some are good

evolution isn't always little by little over ^{thousands} of years
intermediates not always necessary

look at these samples again

mutations of tiny mutations can be massive
kind of like domino effect, large ramifications

small genetic change can
cause massive phenotype change

Upshot:

History of Life

09/27 Lecture

all species made of the same stuff, didn't evolve from completely separate biochemicals

sequence similarities among fundamental genes

- conserved among species

- have the same genes as a banana - why / how?

 - perform the same critical function

 - evolution doesn't seem to fix what isn't broken

 - important set of genes not modified because no alternative has ever worked better

- some of our mitochondrial genes identical to some bacterial genes

- supports evolution & gradual genetic change

 - no better way to explain this than one single common ancestor

3 Domains of Life: Bacteria, Archaea, Eukaryon

figure 1.17 / proximity → closeness/relatedness via DNA

- animals and plants diverge at the same point?

~~that RDP has differences between bacteria and eukaryotes in the DNA~~

figure 20.16

horizontal gene transfer (HGT)

- we have been saying reproductive isolation means stopped gene flow

- HGT really most relevant in early single celled organisms

- may have happened a lot w/o being recognized

- genetic engineering: artificial gene transfer

- not impossible for genes to move b/w cells and work

Archaea have been around the longest

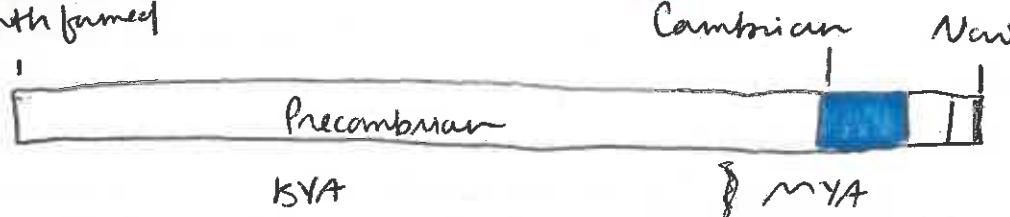
Eukaryon have nuclei, others don't

Bacteria & Archaea DNA is circle w/ two ends

- have one genetic sequences so similar when the literal shape of DNA is so different

I didn't realize there were photosynthetic prokaryotes

4.5 bya Earth formed



cyanobacteria (blue green algae) but not actually algae ~~first~~ first put oxygen in the atmosphere - made an oxygenated atmosphere, which is necessary for many later organisms

Lack of fossil evidence doesn't mean it didn't happen, we just weren't looking with what we have evidence of on the timeline

540 mya Cambrian explosion

- adaptive radiation to the max, but how?
- many of these aren't still alive today

Today's Archaea occur in "harsh" environments

- methanogens (generate methane in decomposing areas w/ no oxygen - didn't decomposition generate oxygen?)
- halophile (salty environments) thermophile (very hot environments)

Bacteria have peptidoglycan in all walls (Archaea don't)

Cyanobacteria are bacteria by cyanobacteria?

- enabled formation of stratospheric ozone layer
- ozone at the ground level is harmful to living things
- ozone in the stratosphere blocks UV
- CFCs damaged stratosphere → increased UV getting to us
- benefitted stratosphere best example of international climate action
- made it so anything could live on land (otherwise way too much UV on the earth)

How did organelles/chromosomes enclosed inside the membranes of cell nuclei (eukaryotes) arise?

"prokots are a taxonomic hodge podge"

chromosomes not loose in the cell

Endosymbiotic hypothesis for the origin of Eukaryotes

- bacteria eat another bacteria don't get digested; live on,

then splits further

- there are corals with cells living inside their cells
- coral bleaching (look at this data)
- chloroplasts + mitochondria similar in size to bacteria (how does this support it? thought the absorbed bacteria was the nucleus)
- chloroplasts + mitochondria divide like bacteria
- chloroplasts + mitochondria have prokaryotic DNA sequences and then DNA is arachnid-like bacteria
- compelling evidence that eukaryotes are from bacteria (and we know bacteria are from Archaea)

LAB 09/29

BIOLOGY

tends to be more fact (which is based from data) than in chem lab
introduction usually ends with hypotheses
hugely relevant if you're going to be a bio major or something similar
defensible - 'yeah you can say that based off of those results'

3 features of data to describe in results sections of laboratory reports

- not a literal description of the figures - takes some practice to realize what to say and how to say it

magnitude,
patterns, and
surprises

- 3 clear things in the data you didn't expect to see, don't get to ignore data points that seem wrong - can't say "somebody sneaked up" if you don't have clear evidence - don't dismiss as wrong or invalid there are always trends and they could very well be random variation

- be very careful to distinguish between what you know and what you think you know



~~label things & check their things~~

look at the axes first

dependent variable still called the dependent variable even if found experimentally not to be

(photosynthetic rate)

Graph 1 1. The independent variable varied between 0 and 2000

$\text{mmol m}^{-2} \text{s}^{-1}$ for Amaranthus Palmeii and between 0 and about 1500 for Euphorbia pulcherrima. The net photosynthesis varied between below zero and almost 80 for Amaranthus palmeii and between below zero and $\text{mmol m}^{-2} \text{s}^{-1}$ less than

2. don't need fancy statistics to clearly tell pattern

EF increase and then level out; Ap increased and looks like it may eventually level out

1. There is a substantial difference in the ranges (magnitude = how much higher)

3. no basis to find anything surprising - don't have to say there's nothing surprising if there is not anything surprising

sthe law
genetic
topics

Graph 2: 1. Magnitude of $\geq 10 \mu\text{g}/\text{dL}$ decreased to ~~elimination~~ and both decreasing from 88% prevalence from 1976-1980 to 0% in 2011-2014; $\geq 5 \mu\text{g}/\text{dL}$ decreased from 100% from 1976-1980 to 1% in 2011-2014.

why did they look at children aged 1-5² → 2. The prevalence of lead levels of both $\geq 10 \mu\text{g}/\text{dL}$ and $\geq 5 \mu\text{g}/\text{dL}$ in children age 1-5 saw substantial ~~decrease~~ and consistent decreases from 1976 to 2011 with initial decreases being the largest in magnitude and the size of the decrease becoming smaller in magnitude over time —————— pretty strong pattern

only use the term skewed if you expected normal distribution not a surprise but good ^{catch that} gaps there are gaps in the data

should use a constant interval

Graph 3: this one has data and model results

There was an overall but consistent decrease in total ozone, which was not consistent with the model's projection, "The magnitude matters" which predicted a constant decrease followed by a stable increase

The dots pretty consistently decrease and then increase everytime "lot of chaos when making a graph" thinks its a mistake to connect the dots

not as firm or clear as the other graphs (part of the point)

the graph should go to zero (scaling issue)
this magnitude is biologically significant
there is a surprise around 2015

BIO 115 Exam Prep

Speciation

→ The definition of species is naturally imperfect as nature is not driven by biological definitions. However, there are generally two definitions of a species; the first distinguishes different species based on an ability to interbreed with one another and produce fertile offspring ^{in natural conditions}. Therefore, according to this definition, members of the same species can interbreed and produce fertile offspring; members of different species may interbreed but produce sterile offspring. The other definition of species is

which is very much related to species identification.

→ Similarity or dissimilarity in appearance is not ~~an automatic~~ a reliable means of species identification. Traits can be shared across species and vary within a species. But, a trait always and only present in one set of ^{populations or a population} individuals and then present in another population is compelling evidence for the existence of two different species (i.e. a trait always present - god blessed of writing)

origin of new species ✓

- need more examples of sympatric speciation
- mechanisms that prevent hybridization

- I think there are three but I don't very well remember

I feel pretty good about this one

- should I have multiple samples for selection

models of evolution

- example for stabilizing disruptive selection

evolution basis I feel pretty good about this no

Chapter 18 Textbook Questions

p 484



- | | | | | |
|-----------|--------------------------------------|-----------------------------|--------------------------------|-------|
| 1. 2n+1 | 4. b | 7. d | relocation to new region | |
| 2. fusion | 5. d | 8. a | physical division resultant of | |
| 3. b | 6. a | 9. dispersal vs vicariance? | an environmental change | |
| 10. b | 11. autopolyploid vs allotetraploid? | source of other chromosomal | changes | |
| 12. a | 13. c | 14. d | 15. a | 16. c |

21. why do island chains provide ideal conditions for adaptive radiation to occur?

- lots of niches because different environments

24. what do both rate of speciation models have in common?

- both include the same four factors affecting allele frequency

25. Fusion will occur if there is no difference between the fitness level of the hybrids and the non-hybrids. Being forced to occupy the same niche in the same area will result in either

Chapter 19 Textbook Questions

p 503

he is not going to ask what a certain subdiscipline is?

~~population genetics is the study of how selective forces change the allele frequencies in a population over time~~

12. acline is a gradual geographic variation across an ecological gradient

- example: size of deer increasing at higher latitudes (further from equator)

12. males w/ handicaps that survive must have good genetics

- example: male peacock tail feathers

29.7 the evolution of primates

all primates descended from tree dwellers

- rotating shoulder joint, big toe separate from other toes (except in humans), and thumbs separate from fingers, stereoscopic vision

Strepsirrhines (furred - nose) Haplorhines (dry - nosed)

- generally nocturnal
- smell
- smaller size + brain
- can make vitamin C

- generally diurnal
- sight
- antecedents
- cannot

primates generally produce one offspring / pregnancy, carry themselves upright

New World and Old World monkeys underwent separate adaptive radiations

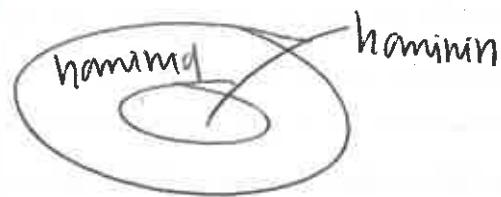
humans & chimpanzees diverged from common hominid ancestor ~ 6 MyA

- hominin: species that evolved after this divergence (closer to humans than chimpanzees)

- humans bipedal, larger brains, fully opposable thumbs
relatively few hominin fossils

more than one hominin species alive at once historically

not all hominins ancestral to humans (some species died out)



this will be on the second examination

History of Life (cont.)

→ October 11th lecture

How are eukaryotes thought to have evolved from prokaryotes?

- endosymbiotic hypothesis
- thought to have happened ~1.5 BYA
- chloroplasts and mitochondria similar in size to bacteria (as there not a vast size range for bacteria) also not that impressive on its own
- chloroplasts + bacteria + mitochondria all reproduce by splitting
- chloroplasts + mitochondria have their own circular DNA

more

compelling

of the reasons
dont need to know the more detailed timelines from the book
dont need to memorize the exact years listed on his timeline
but do need to grasp the timeframe, so it's worth looking at and remembering the timeline

Cambrian explosion more precisely dated than other events on timeline

Timeline of life

fossils don't normally form - rare event

Burgess Shale (Alberta, Canada) most famous site for fossils from that period
the times of periods are set by the fossils

explosion is a lot of adaptive radiations / a lot of speciation from a few ancestral organisms

Conditions on the planet have been very different at some times in the past

- the atmosphere is now 20% oxygen, used to be 0% oxygen
- atmospheric oxygen from photosynthesis $\text{CO}_2 \rightarrow \text{O}_2$
- has been more oxygen in the past

- insects have holes in their body for gas exchange, not lungs; how far on scale that works on depends on how much oxygen is in the atmosphere
- more oxygen in atmosphere in the past meant massive insects
- how much CO₂ in atmosphere has also been different

now there has been net speciation, but in the past there have been mass extinction events (I worded this poorly)

don't need to memorize names and dates except for the Cretaceous - Tertiary mass extinction 65 mya (dragonfly slide, makes sense)

- the largest mass extinction was Permian - Triassic 250 mya (98% of ~~species~~ species or levels) sixth one now being caused by us

- going extinct faster now than at normal background rates
marine species more likely to fossilize than land species

Cambrian explosion b/ pre Cambrian and Paleozoic

species can adapt to moderate changes but not usually large changes
all of the mass extinctions thought to be associated w/ change in climate (temperature or moisture), which is caused by several factors (including natural ones) caused by plate tectonics

1. movement of continents alter ocean circulation patterns
- can be very different climates across the same latitudes
- think about EC vs WC waters even at same latitude, cold by Cali, warm by Carolina

- do we need to know mechanics of currents?

- oceans have huge potential to move heat around the planet

- locations of continent affect how units move around the planet
2. tectonic plate movement can also cause massive volcanism

- ash blocks the sun \rightarrow cooler and plants can't photosynthesize
- B. asteroides*
- lot of good evidence for asteroids at different times and especially for done extinctions
- Ramprasa 2017 American Scientist
- these events have huge implications for what comes later
- most compelling evidence for past mass extinctions
- Tunguska event (some asteroids smaller than others)
- tremendous amount of forest fires \rightarrow ash in air \rightarrow cooling \rightarrow carbon in wood
then carbon in atmosphere \rightarrow warming \rightarrow melting snow and ice \rightarrow less reflective \rightarrow warming
- has asteroids set off climate changes - lots of regional impacts where it hits but effects resonant across globe
- "Grizzly bears are like golden retrievers now."
- why are there golden retrievers? artificial selection
- why would there still be grizzly bears in the future? it depends on the decisions we make - if we don't intentionally keep them around, will unintentionally wipe them out

background extinction rate between mass extinctions

10/16 CIRCUMSTANCES THAT MAKE SPECIES ESPECIALLY SUSCEPTIBLE TO EXTINCTION

(no ecologist knows exactly how all the parts work (don't mean they EXTINCTION) know nothing either)

some species are much more susceptible to extinction than others
niche not where a species lives but the function it fulfills
humans aren't doing anything extinct now

Hagaman manages the land to offer a migratory haven for birds
hole nesting birds

- holes found in dead trees, which humans tend to cut down
Giant Sequoia trees x Giant Sequoia warps / big trees

big trees particularly valuable to people (cities along big rivers)

defining Pandemic - species most affected by pollution are river species

how statistics work

lab: Friday, October 13th

magnitude tells how much about the pattern

- there was more grass in Field A than in Field B

- yeah but how much? \rightarrow magnitude

data usually varied in two (more factors than in physics) \rightarrow mice Reet's physics lab example

The question is: is this a pattern or is it just random variation?

Sometimes patterns are due to chance

How do we conclude if there is a pattern in data?

key characteristic of science is that it seeks to prove its hypothesis wrong

- doesn't make sense to go "I don't know, let's start over"

statistical tests determine whether or not patterns are statistically significant

- useful data but not perfect measure

- stats are not a be-all, end-all

* be able to explain the three questions on the title slide

- tool to enable critical thinking

descriptive vs. experimental statistics

↳ no hypothesis or \rightarrow looking for a statistically significant result

comparison, just defining or describing something

e.g. mean, variance, N \rightarrow e.g. regression, analysis of variance, Chi-square test,
Kruskal-Wallis test, paired t-test

(all test for statistically significant relationships)

2 Categories of experiments:

1) experiments w/ highly repeatable results (still has a narrow range)

2) experiments with substantial replicate-to-replicate variation w/ treatments

1 is not a better experiment than 2

lot more things affect our heart rate than what affects how fast a ball falls

- doesn't mean you're manipulating all of them but just inherent variation

no one arguing about patterns in category 1 (no need for statistical tests)

do need statistical tests for category 2

why there's a pattern in the data is a different question

Excel always gives you line of best fit (not an indicator of a good pattern)
it's not a pattern if taking a point away changes the pattern
All conventional statistical tests calculate the likelihood of obtaining

- statistically significant if less than a 5% chance of getting that pattern

* all a statistical test can tell you is how often you can get that much pattern with chance alone

p-value = the probability of obtaining at least as pronounced or pattern in data on the basis of random variation

- p-value is not the probability that the data are due to chance

Random processes can certainly generate patterns

* not exactly as predicted because of that random variation

2.10

$p = .05$

$p = .50$



The results in these 2.5% ranges are statistically significant because they are unexpected.

Nothing right about the p-value cutoff, just convention

We don't say it was random variation but that we have no reason to believe it wasn't random variation

- can't know for sure

- p-value doesn't mean it wasn't random, means we have reason to believe it wasn't

IMPORTANT DISTINCTION

problems with statistics: - Type II error

- drug that gives $p = 0.07$, can't say that's statistically significant

Type I Errors:

unlikely events occur randomly but statistical tests will suggest unlikely random data are consistent with the hypothesis of one variable affecting another

false positive is an example of a type I error, don't need to remember which error is type I but remember the error

If a study isn't designed well \rightarrow Type II Errors: false negative experiment didn't detect effect

p-value cutoff guarantees many "Type II" errors

What are the pros and cons of other p-values

- very low p-value, lots of Type II errors

- very high p-value, lots of Type I errors

.05 is not correct, it's convention, and a pretty low #

- more worried about Type I error than Type II errors

- build off of statistically significant results ; research builds on research

- if you're looking for a hazard, Type II errors are especially bad

- easy to say it's not hazardous but that doesn't mean it's not

if $p > .05$ conclude no evidence of a relationship not no relationship

if $p < .05$ don't conclude proof (could be a Type I error) conclude "... consistent with the hypothesis that independent variable affects the dependent variable"

human evolution

October 16th

HUMAN ANCESTRY: PRIMATES, MONKEYS & APES, HUMANS, MODERN HUMANS

only primates have both binocular vision + grasping fingers/feet
relatedness doesn't matter on how recently it branched off
↳ to a common ancestor

- tarsiers and humans the same amount of related to Ardipithecus
 - relatedness to a common ancestor discussed in terms of time (not generations)
- lemurs, lorises, tarsiers only in Madagascar
- been left alone because you can't farm there
- fossil evidence (when we see more than one kind) used to construct these trees

DNA sequencing

- some genetic variation is neutral
 - molecular clock: look for # of DNA differences used to estimate how recently a divergence occurred
 - assumes neutral DNA changes accumulate at a constant rate
- all these big apes are endangered

bigger eyes → active at night

savanna: some trees, spread out from one another though

gorillas live on the ground

chimpanzees do go in trees

many primate species were adapted to living in trees but then the climate changed and they had to go on the ground

- human ancestors became bipedal - shows you a lot about nature of evolution
 - not among tools if you're swinging through trees
- you can see a lot further if you're bipedal - can't see well if you're just crawling on the ground
- trying to interpret changes in selective forces from changing in fossil records

make list of all meetings
review readings



2:22

tool use thought to stimulate selection for larger brains
gorilla can't walk around as upright as we can (+ we don't need to)
more fossils will get found? - cause our diagrams to be refined, not thrown away
systematists

- harder to distinguish b/w species when you have few fossils to go off of
 - lumpers and splitters (seems kinda arbitrary to me)
- we mated w/ Neanderthals and are still dif species
- may be asked why he doesn't require us to memorize the details of graphs like the one on page 10 of the Pownall
creatures that eat more plants have larger jaws
arguable to call these different species
(first ones all in Africa and then spread to other places)
- know the order of magnitude if not specific dates/years
 - get the point; variety of populations, some genetic exchange, hard to say what is and isn't a species

Genetic Structure of Modern Human Populations
we're all very closely related

race is not a term used in biology - genetic similarity too large even across different areas

95% of variation is w/i population, only 3-5% outside the population



ch 44 ecology of the biosphere

44.1 the scope of ecology

ecology: the study of the interactions of living organisms with their environment

organisms < populations < communities < ecosystem < biosphere

organismal ecology: interested in adaptation

population ecology: ? conspecifics?

biological community - all the species w/ in an area and the interactions w/ i & among species

- heterogeneity → different species

- interactions: predation, parasitism, herbivory, competition, & pollination

mutualism: +/+ heterospecific interaction

ecosystem ecology: all the biotic & abiotic components of an area

44.2 biogeography

= geographic distribution of living things + abiotic factors + distribution of manner abiotic factors that affect their distribution

endemic species: naturally found only in specific geographic area

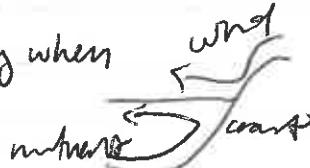
usually restricted in size

- nonendemic species = generalists

ocean upwelling = rising of deep ocean waters occurring when

winds blow along surface waters near a coastline

- nutrients in bottom ↑



spring and fall turnover - recycle nutrients and oxygen from bottom to top of lake - in response to air temp and wind changes

- caused by formation of thermocline: layers of water w/ temps significantly different from those above it

deeper water sinks ↓, bottom water moves to replace

migration increases species distribution

- migrate to areas of different temperature

hibernation - survive cold estivation = survive hot and dry
topsoil (low heart rate)

organisms have adaptations to retain water

inorganic nutrients (nitrogen + phosphorous?) → distribution

- soil?

net primary productivity = all carbon fixed per year - carbon oxidized during cellular respiration

- measured from above-ground biomass

44.3 terrestrial biomes

temperature and precipitation → distinguish terrestrial biomes

what details about biomes should I know?: basic characteristics

tropical wet forest - plants w/ broad leaves that fall & replace t/o year

- no seasonal loss of leaves - constant daily amount of sunlight

- temp & sunlight stable, year-round plant growth

- annual rainfall variable (wet + dry months even but dry months aren't that dry)

- high NPP, high species diversity

- epiphytes (plants grow on other plants)

Savanna grassland w/ scattered trees, usually hot

grass

- long dry season - fire common → plants have root systems to recover

tropical desert very dry, low annual precip and little monthly variation in rainfall



- low species diversity

- mostly annual plants - water conserving adaptation and耐旱性 (xerophily) & burning

chaparral - most rain in winter, summers are dry & plants are dormant

during the summer - shrubs - fire common

shrub

temperate grassland

prairies & steppes, hot summers & cold winters

- specific growing seasons

- further from equator than savannas,

- few trees

summer has more trees & less rain & tropical or subtropical

- dense vegetation and fertile soil - controlled burns for maintenance

temperate forest mid latitude, defined growing seasons due to temp

variation but consistent precipitation, deciduous trees (seasonal leaf loss)

- less NPP than tropical wet and less diversity
- rich soil from leaf litter
- boreal forest** evergreen taiga, coniferous trees, cold + dry winters w/ cool, short, wet summers, snow insulates ground w/ little evaporation
less energy needed to warm a needle like leaf than a broad (deciduous leaf)
more acidic soil with less nitrogen (less leaf litter)
- NPP lower than temperate, less diversity**
- arctic tundra** very short growing season but rapid growth b/c lots of sunshine, little precipitation and little evaporation
b/c cold, plants low to ground, low diversity, low NPP (low above ground biomass), soil perennially frozen = permafrost → roots can't go deep and decay is slow

- 44.4 aquatic biomes** light distinguishes ↓ stratification, animals
- water absorbs light
 - open water = pelagic realm
 - bottom** - photic zone (light penetrates)
 - aphotic zone (most ocean)**
 - realm** relatively uniform in composition
 - physical diversity (different zones)
 - intertidal zone - b/c high + low tide, desert to land, tidal flats and flow
 - neritic zone - intertidal → continental shelf, photosynthesis
 - coral reefs** skeletons of coral organisms → reef
 - mutualistic relationship with algae
 - estuaries** freshwater meets ocean, diluted saltwater
 - salinity varies with seasonal rainfall and tides
 - halophytes
 - lakes + ponds** temp - thermal stratification
 - phytoplankton eaten by zooplankton
 - nitrogen + phosphorus determine phytoplankton growth
 - algal bloom from too much + bad ↑ turbidity ↓ photosynthesis + oxygen

rivers and streams continuously moving

source water - usually cold, low in nutrients & clear, narrow
channel = width of river or stream) channel → faster current → low silt
- energy input from plants photosynthesise from algae on rocks accumulation
that feed into the water no phytoplankton ↘
width of channel ↑, current slows, sedimentation ↑, phytoplankton &
warmer ↑

wetlands soil either permanently or periodically saturated with water
wetlands shallow

emergent vegetation - roots in soil with tops of plants out of water
marshes, swamps, bogs, mudflats, salt marshes

→ slow steady infiltration 'no runoff'

4.5 climate and the effects of global climate change

all biomes affected by global conditions (ie climate)

climate - long term, predictable atmospheric conditions of an area

- weather - short-term

historical evidence of Earth's past climate:

- antarctic ice cores

millankovich cycles → slight changes in Earth's orbit affect climate

solar intensity ↑ temps ↑ - changes in solar intensity

volcanic eruptions - gases released generally cool (block sun)

greenhouse gases trap heat from sun → greenhouse effect

human activity → CO₂, methane + burning of fossil fuels,

deforestation, agriculture

melting of clathrates (frozen chunks of ice and methane c bottom
of ocean) → release methane as temps warm

- positive feedback loop

Pearman extinction coincided w/ increase in temperature

melting glaciers ↑ sea level

ecology-intro-biomes

lecture: October 18th

"just surviving is an evolutionary dead end"

- there's not as strong of selective pressures at post reproductive age
get energy + nutrients from food - need enough to survive + reproduce
need to not get eaten or succumb to the environment

natural selection - natural (biological) processes determine which individuals
reproduce and which don't

must be able to tolerate the environment (physical + chemical conditions)

studying ecology: helps to understand natural selection and environmental
do we owe anything to future generations? do we owe any - problems
thing to other species - is that an injustice issue?

we depend on oxygen w/ a fairly specific range of concentration

- too much and too little both bad

geological processes regulate amount of oxygen in atmosphere

soil product of food web interacting with food chain + climate

those in the future depend on us making progress in today's
ecological problems

can't make water at the quantities we use it - comes from ecosystem

these problems get unintentionally worse w/o intervention

almost no one is running around trying to damage an ecosystem

we can't not damage ecosystems at all

"life support potential of the planet"

concerns over global scale environmental degradation 'til recently

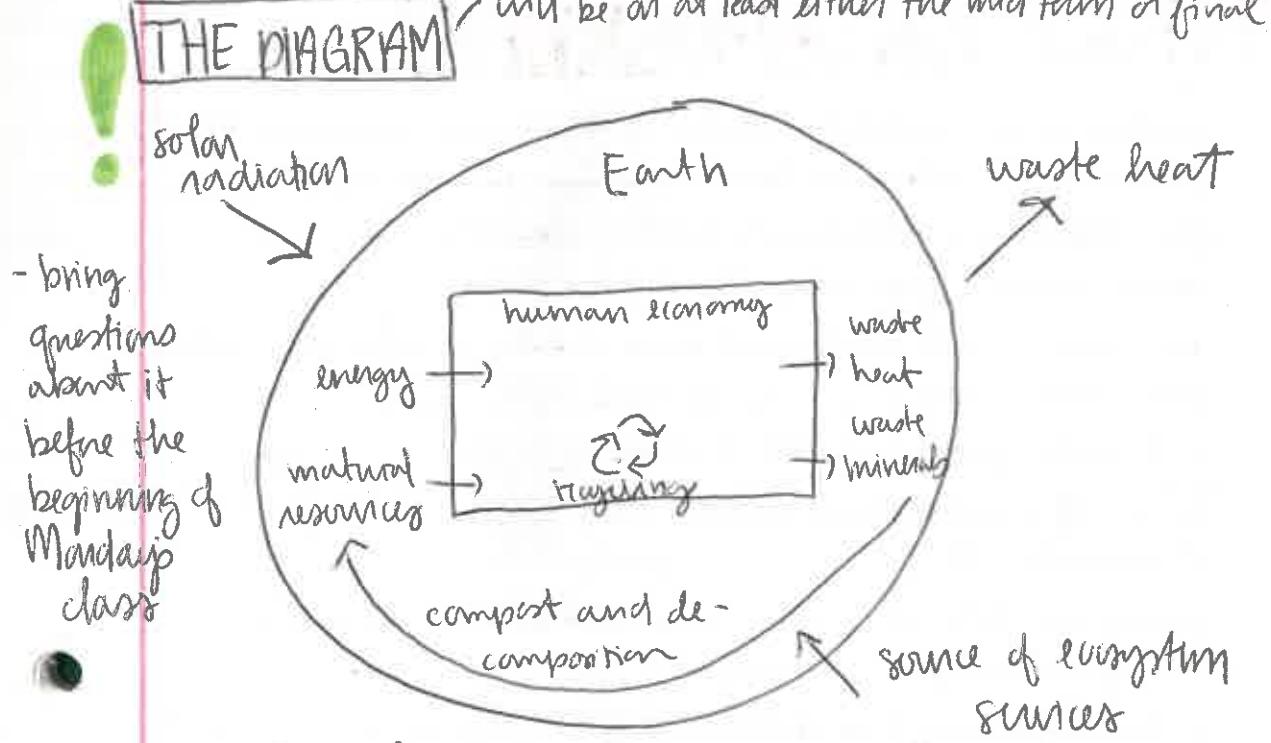
can't just stop oil because we're dependent on oil, but we need to
switch as fast as we can

Tar Sands oil (Alberta)

ECOSYSTEM SERVICES: oxygen, water supply, soil, wood
and fibers, food, water purification, element cycling, UV shield,
wild genetic material, climate moderation, flood prevention, air
purification, pollination, reiteration, inspiration
(no one inventing cars / computers)



THE DIAGRAM



ecological view of how the world works
materials is another word for nutrients
"elements don't go in and go out"
"economy" = the things people do
just seems like such an exhausting everyday calculus (side note)
the box isn't a physical barrier
can only get away w/ energy \rightarrow waste heat of the energy is renewable

e 45.1 POPULATION DEMOGRAPHY

demography - statistical study of population dynamics over time
life tables → life expectancy of individuals w/i a population
population size (N) and population density
body mass ↓, pop density ↑ and vice versa

quadrat - random samples to make guesses about entire population
mark and recapture can guess entire population size

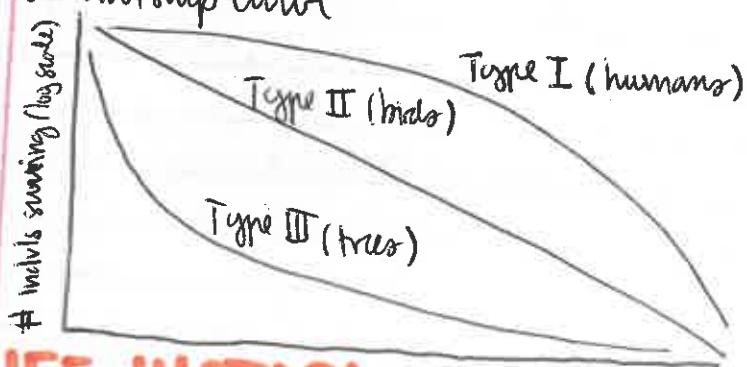
$$\frac{\# \text{ marked first catch} \times \text{total } \# \text{ second catch}}{\# \text{ marked second catch}} = N$$

- imperfect method

- species dispersion patterns - spatial relationships b/w members of a pop
- uniform, random, or clumped
- more telling than population density

life tables: divide into age and sexes, may include mortality rate
Mortality rate = $\frac{\# \text{ of indivs dying}}{\# \text{ indivs surviving}} \times 1000$

survivorship curve



45.2 LIFE HISTORIES AND NATURAL SELECTION

species life history → series of events over its lifetime

- affect life table

- genetically determined and shaped by the environment + natural selection
all species have an energy budget

fecundity: potential reproductive capacity of an individual w/i a pop

(no one inventing cars / cars / etc.)

fecundity inversely related to amount of parental care in animals

- remember the energy budget - energy trade off / evolutionary fitness

- plants w/ low fecundity \rightarrow energy rich, high yield seeds and v.v.

different energy strategies - dif. org. species reach reproductive ages at different times

semelparity: species reproduces once and then dies

- causes debated ex. bamboo

iteroparity: species reproduce repeatedly during their lives

45.3 ENVIRONMENTAL LIMITS TO POPULATION GROWTH

Malthus \rightarrow exponential growth

- ex: bacteria - accelerating population growth rate (\uparrow # of organisms added in each generation) \rightarrow J-shaped growth curve

$$\frac{dN}{dt} = bN - dN = (b-d)N \quad \frac{dN}{dt} = rN \quad r=0 \rightarrow \text{zero population growth}$$

different species have different intrinsic rates of growth increase (bacteria > human)

- maximal growth rate = biotic potential or r_{max}

exponential growth only possible w/ unlimited resources

- "struggle for existence" \rightarrow competition for limited resources

logistic growth model

carrying capacity (K) = max # an environment can support

$$\frac{dN}{dt} = r_{max} N \frac{(K-N)}{K} \quad \text{pop growth slows @ higher } N \text{ values}$$

\rightarrow S-shaped curve - exponential, \downarrow growth rate, levels off

phenotypic variation \rightarrow intraspecific competition N_T , comp?

45.4 POPULATION DYNAMICS AND REGULATION

K varies (often higher in summer than in winter) natural events can alter K

of the population

density-dependent factors - density affects growth rate and mortality

density-independent factors

mostly biotic - predation, intr and intraspecific competition, levels of waste, and disease

- denser pop tend ↑ mortality rate (more comp ↑, ↓ reproductive rate)

- low prey density ↑ mortality in predator

ex. giant intestinal roundworm

- denser pop of parasite, lower fecundity of worm

parasites smaller

typically abiotic - weather, natural disasters, pollution

- dense pops better able to recover than sparse pops after natural disaster/harsh winter/etc

K -selected species

selected by stable, predictable environments

- just close to K (intra comp is high)

- few offspring, longer generation time

parental care, immaturity at birth

- plants (how long it remains on parent plant)

this theory didn't account for age-specific mortality

demographic-based models being developed, incorporating pop age structure and mortality factors with r - and K -selection

r -selected species

- large # of small offspring

changing environments

- self-sufficient at birth

- low energy content offspring in plants

- less competition and less longevity

45.5

HUMAN POPULATION GROWTH

we have ↑ K (agriculture, etc) and these technologies have changed the earth (depletion of ozone, climate change) which will affect K
human pop growing exponentially but still below basic potential

human growth rate predicted to slow

humans able to overcome density-dependent growth regulation
age structure - proportion of a population at different age ranges

- remembers the demographic transition model from APHUG
one-child policy in China

pop growth → endangerment of natural environment

45.6 COMMUNITY ECOLOGY

all pop in same habitat = community

- species diversity is on community level
predation and herbivory

- cycling of lynx and hare) - more than predation affects prey pop levels

- some plants have mechanisms to defend against herbivory

- herbivory → seed distribution for plants (mutualism)

species are not static - evolutionary forces

- mechanical defenses: thorns on plants or hard shells on turtles

- chemical defenses: toxicity

- camouflage: avoid detection by blending in w/ surroundings

- aposematic coloration: warning coloration

- Batesian mimicry: harmless species imitates warning color of harmful species

- Mullerian mimicry? - same coloration

- Emoleyan/Mertensian mimicry - deadly prey mimics less dangerous one
competitive exclusion principle → two species cannot occupy the
same niche in a habitat - different species cannot coexist in a community
if they are competing for all of the same resources

- arched evolution creates resource partitioning

- symbiosis - close interactions b/ individuals of different species over an
extended period of time, impacting the abundance and distribution of
the interacting populations

commensalism = +/0 ex. nest and tree

mutualism = +/+ fruits/protazoa (digest cellulose)

parasitism = +/-

- parasite = organism that lives in or on another living org and derives nutrients from it

communities: structure (demographics) + dynamics (change over time)

foundation species - greatest influence on structure, usually primary producers; may physically benefit environment (ex: coral skeletons lived in by other species)

biodiversity: species richness and relative abundance (species evenness)

- greatest species richness typically greater nearer the equator

relative species abundance - # of individuals in a species relative to the total # of individuals in all species

- foundation species typically have the highest relative abundance

keystone species - their presence key to maintaining biodiversity

environmental disturbances affect community dynamics

primary succession - land first colonized by living things

secondary succession - part of an ecosystem is disturbed and remnants of the previous community remain

pioneer species

equilibrium state = climax community

ecology - intro - biomes

the rivets are to the airplane what species are to an ecosystem
 ecosystem is a human construct to talk about the interactions in the environment
 we don't know how many rivets the plane can lose and still be okay
 - we don't test that lol - we don't know for sure which are the worst to lose
 - same w/ species & ecosystem with full certainty - only some predictability
 - have to be hopeful that we haven't damaged them to crash point
 ecology - the study of the distribution and abundance of organisms (very narrow)
 everything that affects and the consequences of those distributions + abundances
 population has increased a lot - growth rate starting to flatten though

Herman Daly's Guidelines for Sustainability

↳ ecological economist - understood economy was in the box, dependent on environment

1. renewable resources should not be depleted faster than they are regenerated

2. waste should not be produced faster than they are assimilated (made harmless)

- car makes its weight in air pollution every year, literally burning gas

- plants assimilate CO₂ (make it nonproblematic O₂)

3. nonrenewable resources should not be depleted faster than substitutes are developed

- harder to know if you're breaking this rule than the other two

violations of each rule:

1.

2. greenhouse gases, persistent organic pollutants,

3. fossil fuels, various metals, phosphorus

- phosphorus is mined from rocks now - 1/2 of known P was in Morocco

- before, we got phosphorus from islands of bird poop - literally mined away

- throwing away food → making it P useless as you mix it w/ other trash

present activities aren't sustainable because they degrade ecosystem services.

We depend on ecosystem services.

readings from 10/23-25 not on exam
changing deadline on two simulations

10/25

BIOMES

"biome + ecosystem almost synonymous on land"

- ↳ assemblage of plants associated w/ certain climate
- = ecosystem = community

slide 32: total transformation of our vegetation - are we a new biome?

- historically, this was tall grass prairie, blackland prairie
- the reason 1-35 is where it is is because there is fertile soil
- it's really not that easy to replace ecosystems services

slide 33: Boreal forest

slide 34: tropical rainforest

climate → plants → animals

slide 35 - distribution of biomes

- is mountains a biome?

different species across biomes but similar b/c convergent evolution

precip and temp → climate (longly)

slide 36 These lines are not exactly there

Why does temp & water availability (precip) vary around the planet?

- climate (long term average) vs weather (daily variation)

- wind and water currents

- amount of sunlight a place gets

- proximity to equator because more

light energy per area near eqn than near the poles (think about why/how)

(it is so much warmer at noon than any other time of day)

- tilt → seasons with varied length of the day

- not as much seasonality at the equator

○ latitudinal patterns in moisture:

○ * practice explaining this to someone else

warmth from sun causes gmt to produce infrared radiation
hits molecules in atmosphere and is absorbed



air warmed from heat given off from the ground because the sun hits
sun doesn't directly heat the air; the sun heats ground which
warms air

- hot air rises (warm gas rises) updraft

~~transferred heat~~

- dry air blowing across something damp gets wetter \rightarrow wet war = fur
- cools as it rises \rightarrow moisture in it condenses \rightarrow rain falls
- won't go up forever - gravity descends as air goes north or south
- goes down while not holding much moisture \hookrightarrow deserts c 30°N/S
- how come it rises more before shifting direction closer to the equator?
- more air coming behind it, so it doesn't go straight down
- hard to appreciate how big updrafts
- wind tends to blow ~~south~~ or southeast or northwest
- don't need to be able to explain Coriolis effect
- updraft gets weaker as you move toward poles because of difference in
intensity of sunlight

thank you
for info about ocean conveyor off the oceans or off land toward ocean?
you are and
for being so
good to me

damp dry

- direction of wind as it goes over the ocean
- in general, proximity to ocean makes winter warmer and summer
cooler than if inland (water has higher specific heat than land;
ocean deeper than land surface)

rain shadow effect

- air has to go up to pass mountain range
- altitude has an effect on temps of air
- modern people have altered the vegetation
watch YouTube video at the end

ecology introduction - homes end of warm 2 carriage

don't write the lab w/o carefully looking at the handout
review the updated lab on Moodle

6

MIGHAR43 3d5 130, 132 ^{cm.} ✓ 13.500 ✓ 14.250 ✓ 11.230
MIGHAR61 1d1 160 148 ✓ 12.000 ✓ 12.500 ✓ 12.000 ✓ 12.500

~~Group 12~~

Group 12 - TXMHC112 check radius measurements

$r_1: 108.0$ $r_2: \cancel{108} 114.0$ $r_3: 116.2$ $r_4: 141.0$

reread what a praline is

Review Period

10/30

- HGT - just know that it happened. don't need to know the mechanics or the consequences
- be able to define it

figure 23.5 2 (b) human evolution), slide 10

- don't have to memorize the details because they shift around
 - should know from million year timescale; separate lineages from Lucy, including the *Homo* genus but not all ancestral to humans
 - know that some of them went extinct relatively recently
 - know the magnitudes
- common ancestor: how many generations since, not # of divergences
- most similar ≠ most closely related
 - ↳ most similar in genetic sequencing (can't tell genetic similarity w/o knowing the genes)

relatedness among modern species determined by how recent a common ancestor was shared

- cyanobacteria* were photosynthetic but did not have chloroplasts
- chloroplasts came after eukaryotes

if the book has a more detailed timeline, ignore it

all mass extinctions (5) between Cambrian explosion and now)

the primates most similar to the early ones are the prosimians

- there's been more evolutionary change in our lineage than in the lemurs but w/e the same amount of time removed

Lucy is after the split from chimpanzees

diversity of life / diversity has gone up generally, but sharp drops during periods of mass extinctions (the increase not necessarily steady)

Hadley cells air mass and how it moves is determined by pressure gradients

- make sure you're able to connect this to latitudinal patterns

45.7

behavioral biology: proximate and ultimate cause of behavior

inherent behaviors

behavior: change in activity of an organism in response to a stimulus

inherent behavior: strong genetic component, independent of environmental influence

learned behavior: from environmental conditioning

reflex action → the difference?

- ↳ kinesis - klinokinesis, orthokinesis
- ↳ taxis - toward or away from a stimulus
 - phototaxis, chemotaxis, geotaxis
- ↳ fixed action pattern - keeps going even when stimulus is removed
- ↳ migration
 - obligative (innate) and facultative (learned)
- ↳ foraging
- ↳ mating behavior
- ↳ signals: communication b/ animals
 - pheromones
 - songs
 - courtship displays
 - aggressive displays
 - distraction displays
- ↳ altruistic behavior (lower fitness of indiv but increase another's)
 - worker bees, only queen reproduces
 - meerkats have sentry at entrance of colony
 - wolves bring meat back to pack
 - lemurs take care of children that aren't theirs
- ↳ kin selection (increase fitness of those related to you)
 - indirect increase in individual fitness
- ↳ intrasexual selection + intersexual selection (competition for mates)
 - monogamy, polygynous, polyandrous (rare)

Learned

- habituation - stops responding to a stimulus after repeated exposure
 - stimulus not associated w/ anything positive or negative
- imprinting - attach to first adult they see
- conditioned behaviors - associative, stimulus does have consequence
- classical conditioning - conditioned response to conditioned stimulus
 - Pavlov's experiment
- operant conditioning - conditioned behavior gradually modified by its consequence as animal responds to stimulus
 - can be induced to do things they wouldn't normally do
- cognitive learning - abstract thought capabilities

physiological ³ population ecology

does the abundance of non-human species matter?

what determines if those abundances increase or decrease?

- even bacteria abundance (think ebola, COVID, etc.)

ex: COVID not as virulent now than it was then (makes you less sick than it initially did)

- if it's super virulent, can't spread as easily (natural selection selects for intermediate / lower virulence)

- COVID not out to kill you just out to reproduce

- epidemiology + public health / population ecology critically important

- this is an interesting field to me, maybe ask him about it during Q&A one day

what affects/determines if those abundances increase or decrease?

- high juvenile mortality (die before they get chance to reproduce)

- ex. polar bear moms don't have enough energy to reproduce and/or raise children, population declines

- different for type (Type I, II, III) of species

- oak have high juvenile mortality but produce so many acorns it doesn't matter

- climate change

- disrupts dispersal

- natural disasters

- not having any predators

nobody knows the consequences of 50% of amphibians dying
(like nitrates on a plane)

physiological niche: the set of physical and chemical conditions required by an organism

- species tend to occur only in certain biomes

- will elaborate on this definition later

- niche for an organism has a lot of dimensions - hard to define all the niche requirements (73 variables, N-dimensional niche)
- species can't live in habitat that doesn't meet its niche requirements
 - natural selection is ecological processes. this causes evolution, this difference can change ecological processes, even if minuscule.
 - adaptations make niche boundaries wider
- life history adaptation - Type I, II, and III species
- seeds can be dormant for years, germinate later + grow
 - morphological - how it's made, its water parts it's made of
 - behavioral - turtle sunbathing
- physiological - salmon go from freshwater to saltwater back to freshwater
- how is physiological different from morphological?
 - species live only in places they originated or places they get to
 - different species have different dispersal potentials
 - e.g. zebra mussels only a problem here after they got here (but we met their niche requirements even before they got here)
 - species don't live everywhere that meets their niche requirements
 - why might dispersal be selected for?
 - all species have some dispersal abilities? they differ in degree
 - in: "It's hard to get to know somebody if they never say anything" - P.J. meaningful for references (why raising hand in class is good)
 - want offspring to get to place w/ less competition
 - ex. trees can't grow right underneath parent tree (too shady)
 - avoid inbreeding
 - not doing it for the sake of species - how does this fit w/ altruism?
 - mutations good for species (ex. if less reproduction was good) but not good for individual not passed down
 - parent's habitat becomes uninhabitable
 - new habitat has better reproductive success

DRAFT

Population

- dispersal on individual level, not the species level (though indiv dispersal has ramifications for species)
- dormancy - dispersal in time rather than space
 - Daphnia, reproduce sexually when conditions are bad - dormant daphnia
 - adaptation to survive times/places that don't meet niche requirements
 - dormant organisms often undergo physical dispersion too
 - is this comparable to human eggs being in grandma or only dormant if fertilized?

population growth and regulation

deer/frozen lake example

- per capita: per individual (sometimes per female, etc.)
- doubling time uniform in theoretical exponential growth
- paper folding example
- population growth insight realizes necessity of natural selection
 - ex. some organisms have to evade predators constantly
 - what keeps bacteria from reproducing unchecked?

competition

carrying capacity (K): pop size an environment can support

- tall spindly trees competing for light
- what does K of bacteria type stuff look like?

intraspecific competition - competition among indvl of same species

interspecific competition - among indvl of two or more species

- diff tree species diff colors / don't understand relevance here

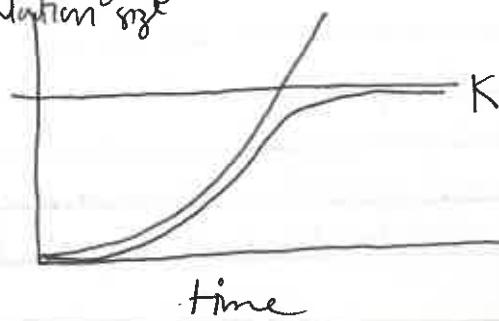
competition regulates population size

- system dynamics (something changing in amount due to interaction of factors) population size

- masks regulated COVID ex.

- stop epidemics + regulation

regulation: to increase when low and decrease when high



- to push a system back toward equilibrium
- ex. HVAC regulates; heating/cooling affects temp. of room
- our bodies regulate our temperature
- density dependent (organisms per area)
- per capita population growth rate depends on pop. density
- only density dependent processes can regulate population size
- competition happens because of population density
- predation can happen b/c of population density (?)
- predator goes to where prey density is highest
- competition reduces per capita growth rate
- pay careful attention to units (addresses them in answers too)
- population regulation/per capita measurements are what matters
- how many individuals are born, how many die, how many move in, and how many move out
- immigration/emigration typically not a big deal in wild populations
- other processes (density independent) can affect but not regulate pop. sizes
- biological interactions are most often density dependent
- competition more relevant if pop is dense
 - ~~not that~~ lack $< 0 \rightarrow$ decreasing
- per capita growth rate $> 0 \rightarrow$ growing $\rightarrow / 0 \text{ and } + \rightarrow$ decreasing
- knowing something is regulated doesn't mean we know it is regulated
- regulation isn't perfect, means it won't get too too too far away from equilibrium / how it's regulated + the tightness with which it's regulated different question
- if a pop is low in certain area, predators will go looking somewhere else \rightarrow prey pop grows \rightarrow predators go to prey and get eaten \rightarrow prey pop decrease $\rightarrow \dots$
- parasites spread more easily in dense pops disease w/s
- I feel like there's some nuance to this? is parasitism regulating?
- Bubonic Plague didn't affect long term population growth (same for nonhumans)
- I wonder if this is the only time our pop. went down? in history

11/08 lecture

4.1 Ecology of Ecosystems

ocean ecosystems most common (~70% of surface) - shallow oceans, deep ocean, deep ocean surfaces

- phytoplankton perform 40% of Earth's photosynthesis
freshwater forest (1.8%)

environmental + human disturbances in ecosystems

equilibrium - all org.s in balance w/ environment + e/ other
measurments
resistance - ability to remain in equilibrium despite disturbance
of changes in ecosystem

resilience - speed at which equilibrium is recovered

- ecosystem can lose its resilience \rightarrow destruction

food chain - primary producers < primary consumers < ... consumers
trophic level (linear)

energy limits length of food chains

- 2nd law of Thermodynamics (tendency toward entropy)

products - nonlinear, more holistic, made of food chains

- grazing food web (typical)

- detrital food web - orgs that feed on dead organic matter (decomp.)
at the bottom

mesocosm: partition of natural ecosystem for experimentation

microcosm: laboratory environment

4.2 Energy Flow in Ecosystems

photynthesis chemosynthesis digestion

autotrophs

sunlight

inorganic molecules

mostly bacteria in places w/o sunlight

net primary productivity

trophic level = $\frac{\text{production} \text{ C present trophic level}}{\text{production} \text{ C previous trophic level}} \times 100$

transf. efficiency = $\frac{\text{production} \text{ C present trophic level}}{\text{production} \text{ C previous trophic level}}$

- can't have unlimited amount of energy transfer
net production = $\frac{\text{net consumer productivity}}{\text{efficiency}} \times 100$

assimilation

energy content available to next trophic level

biomass of present trophic level after accounting for energy loss

cold-blooded use less energy than warm-blooded - low NPE

biomagnification - ↑ concentration - have to eat more to generate heat
of persistent toxic substances up the food chain

e.g. DDT, PCBs, heavy metals

POPULATION ECOLOGY 11/08

- humans have artificially increased $K_{\text{ing way}}$ / depleting a "one-time inheritance" of natural capital
- exceeding K requires depleting that resource can't be used again
- wedding ring example + trust fund interest example
- can use resource in a way that it's recyclable or in a way that's not recyclable
- maintaining human pop has consequences though
- did physiological ecology refer to adaptations?

→ 45.1-4

LECTURE

(e) 11/08

Community ecology

he's not going to ask if something is population or community ecology? mostly an arbitrary difference
pretty hard to put boundaries around a community
only competition if there is a limiting resource

difference?

- ex. two things that breathe oxygen not in competition for oxygen, but limited amount of food is competition
- light a limiting resource for plants

predation (includes parasitism): one individual benefits, others suffers

- cow eats grass = predation

- what about one plant "takes light" from another

mutualism: both species benefit

commensalism: one species benefits, others unaffected (hard to determine if something is unaffected)

coevolution: reciprocal evolution of 2 species in response to each other

- evolve in response to everything in environment, including interactions with other species - example?

- associated w/ codependency I think

fundamental vs. realized niche

↳ where a species can live in the

absence of competition or predation...

↳ where a species actually lives in presence of predators

- abiotic works but sometimes moving and competitors

↳ where a species could

ex of difference (*Chthamalus stellatus*)

- intertidal zone - positioning w/ water determines amount of day in water or not

- lots of different niches in intertidal zone

- lots of ecological study (earlier than wolf pop in TX)

- close shell in air, open in water & collect zooplankton

- does this count as amphibious? or do they have to move themselves b/w water & land (not just water moving?)

realized niche
fundamental niche

- barnacles compete for space (super obvious limiting resource)
- must get enough resources to survive
- selection favors effective predators, so most creatures at risk of predation or have good defense against predation
- a lot of plant material has chemical defenses
 - not necessarily toxic
 - milk + coffee example
 - when caterpillars start chewing leaves, only then does tree release toxins (super sophisticated)

→ 45.6 "Community Ecology"

- know lots of examples of defenses against predation
- milkweed straight up toxic but monarchs can eat them, they sequester the toxins until they're butterflies (→ defense against predation)
- other butterflies mimic monarchs for this reason (Batesian mimicry?)
- only works if others are rare + monarchs popular (frequency-dependent selection)

Brood parasites (lay eggs in other birds nests)

- selected for because you don't have to care for it → potentially very high fitness
- birds not used to brood parasites more susceptible
- but not effective over time - why?
- evolutionary narrative

LECTURE

Community ecology

2) 11/13

- finish statistical analysis on tree lab
- talk about library trouble
LAB REPORT FORMAT

tree lab:

see more about p-values in "Probabilistic Reasoning" from his book
q: so you can't say that in this case the bees visited natural plants more often but that the significance of the relationship means nothing can be extrapolated

TREE LAB DUE DECEMBER 8th, set deadline for yourself

q: when do OT stop happening as usual?

- put final exam & on calendar

class content:

invasive parasite eggs vs native parasite eggs

- no selection yet for diff eggs - selection to look more like host + egg
ecological interaction over generations → selection

how would you expect predator and prey populations to affect each other's abundance?

typically not on same numerical scale (more prey than predator)

- is this an example of homeostasis?

cyclic abundance

- typically don't see it as clear as hawks/lynx because hard to get data and other factors present

- recall chemical defense of plants; same for vegetation the rabbits rats

- produce when hares get abundant and then same

- lag time in biology

- most predators + preys aren't this wildly cyclical

- regulated but not very tightly regulated

- happens when predator really depends on one prey source

- doesn't work when predator affects lots of different things

elk suppresses little trees from growing b/c they eat little trees

- lynx didn't permanently suppress rabbits but elk permanently suppress the trees

wolves natural predators of elk C Yellowstone; wolves wiped out

by people; elk population increases w/o lack of predation; stick around streams - eat all the little trees, stopping reproduction of trees; streams no longer shady; no more beavers making dams; birds disappear from streams; cool-water fish left b/c too cold
↳ "trophic cascade", one species can cause a lot of changes

- how does this relate to idea of a keystone species?

people function as predators sometimes

- people collectively acting unsustainable

- abundance of big fish in the ocean decreased by ~90% due to overfishing

- no one knows the environmental consequences of these things

- animals at top of food web more likely to go extinct

- remember the features that make a species more susceptible to extinction

coevolution: reciprocal evolution of two species

- pollination by hummingbird

- able to reach deep for nectar, pollen gets on face of hummingbird, transported physically across hummingbirds

- short-billed flowers

- long-billed birds have greater chance of success

- flower species benefitted only if bird visits other members of that species

- defense - kind of reminds me of defensive eating

tropical acacia shrub with mutualistic ants:

- ground comparatively barren near these shrubs

- thorn defends shrub from large herbivores

- ants defend against smaller herbivores

- ants dry hole + shelter in thorns

- coevolution always mutualism?

- tree makes ant food

species diversity:

- no one knows all the species in any one community

- finish chem followup
- go to disease WS

- different communities have different levels of biodiversity
beech maple trees:

- invasive species causes beech trees to die +/ heech bark disease
- how will this affect the ecosystem?
- hard to predict consequences
 - non-native plankton in Great Lakes \rightarrow birds getting botulism
 - plane virus example

ecosystems w/ more species tend to be more stable

- what does stability mean in this context?
- could I talk about stability in terms of resilience?
- COVID horse/human/giraffe/tiger example

November 15th

- variety of measures characterize ecosystem function
 - function is better when more species are present
- what can cause an ecosystem to lose species? (w/i ecosystem)
 - competition (does no competition always increase species diversity?) the inverse doesn't really follow for me
 - seems like monopoly could happen to me? \rightarrow couldn't it force them to find a niche
- non-native predators
 - prey hasn't been selected for in the past to have to get away from those predators (no evolutionary history with it)
 - native predators increase SP because they decrease competition
 - prey on abundant prey preferentially
 - good at competing - less good at avoiding predation
- variation from source of colonists
 - hard for organisms to get to far away islands
 - has does this play with adaptive radiation?
- small habitat size
 - limited amount of resources
 - small pops have greater chance of extinction
 - high level predators cannot persist in small habitats



- *look at modified instructions for the lab statistical analysis
- finish draft after reading analysis
- intermediate disturbance hypothesis simulation

- people make habitats small (main reason we make species distinct)
- "to a fish, a lake is an island surrounded by land" + vice versa for snake
- isolation via urbanization/habitat destruction creates habitat islands
- recall distinction b/ species and populations
 - ex: I think a workshop where humans had separate populations might help them empathize w/ need for habitat protection
- mean and fn is relative for each different species (different mobility capabilities)
- are there ecosystems w/o competition for at least certain species?
- is the measure for species diversity the # of species? no!

species richness: # of species

species diversity: ~~too~~ considers species richness and relative abundance

- some measurements are indexes (pulls more than one variable and with different units) and wind chill index, sustainable welfare index

- ex: heat index, ~~accounts for~~ temperature and humidity

- not a right index but an agreed on index in a way to pool them into one value

- new concocted value

- SD considers # of species and their relative abundance

ex. 100 trees, 10 individuals / 1 species, 10 species > same SR but different SD
or 100 trees, 90% of one, 1% of the others, 10 species

- closer relative abundance means greater SD

- no right formula for species diversity

- how does this example play with competition?

different aspects of different levels of biodiversity

SUCCESSION - predictable temporal change in community structure
which species are present and how abundant they are
old fields

annual plants - fast at getting to a place and/or have been there all along

- over time, more species will get there (different methods of dispersal?
different likelihoods)

how is that

different from

JD²

- notice the best competitors for light take a while to get there
- some species are faster colonizers and some are better at competing
- largely a terrestrial plant concept
- affects animal succession but easier to measure plants
- how do early species change conditions?
 - ~~how do early species make it more hospitable? Improve niche conditions?~~
 - sometimes inhibit: invasive grasses @ speed how does this happen w/but un primary succession
 - historically trees didn't grow here b/c fire + human trampling (=disturbances)
 - disturbance: discrete (not continuous) time event and some resources are more available to some individuals
 - typically more light on ground
 - setting back the succession
- IDH has to do w/ JD, typically higher JD of intermediate
- enough time for a lot to get there
- not enough time for other species to outcompete (ex. trees)
 - ~~does this play w/ competition @ JD~~
- plenty of water for trees here, now nothing to prevent them from growing, now outcompeting
- not natural for succession to progress this far b/c humans stopping fires

LECTURE BEHAVIOR

2/11/15

- check for missing assignments on moodle
- LOR?
- find time for OTL
- come w/ questions

focus on how it helps you understand most creatures aren't animals + don't behave evolution & ecology

takes several generations to make monarch migration (no one monarch able to even make the entire trip), go back to one single forest

leatherback turtles lay eggs in one single place

- mind blowing!

birds migrate without being taught where to go

Why do animals behave the way they do?

parent b/c no evolutionary fitness without it (natural selection drives around behavior)

- if your child dies (bc no parental care), your genes are gone forever zooplankton in world's oceans

- at the mercy of currents, can't swim against it

- can decide b/w up and down

- cyclical movement up + down 100m with daylight (sun ↓, moon ↑)

- a lot of moving up + down for an organism the size of the pinhead genetic behaviors must be products of natural selection

- (why we do evolution first)

- talking about natural circumstances

what is our definition of instinctive in biology?

zooplankton go down to avoid being eaten (fish that eat plankton do it by sight)

- surface is where all the food is (bc that's where all the light is)

movement of zooplankton is a widespread, genetic behavior

squirrels going back and forth in the road

- animal behavior can be maladaptive (?) in human-dominated environment

- human disruption can outpace evolution

- genetic behaviors only work for fitness in natural circumstances

- genetic element in behavior + genetically determined

zooplankton might not necessarily know if they're in danger of being eaten

- study questions

proximate: the stimulus of the behavior, the cue

ultimate: why the behavior was selected for

ex. zooplankton proximate: light

cyclical movement ultimate: predator avoidance

creature is just reacting to the environment - don't anthropomorphize

Why do male birds sing?

- attracting female birds or defending territory (female bird attracted to nice territory, genetically determined too)
this is the ultimate cause

- singing is risky

- but what's the proximate cause? they don't sing all the time
- seasonal testosterone thing

- what is the definition of behavior?: does it happen on organismal level?

- pathways of behaviors isn't so obvious

have to study generations to detect genetic basis for behavior

- introducing the quick to el other and the slow to el other

- do what the allele is but know there's a genetic basis

- do know the allele for parental care in mice

instinct vs. learning

- don't worry about different types of learning

- automatic behavior doesn't depend on experience

instinct: characteristic behavior made in response to stimulus never previously encountered

- not altered by experience

learned behavior: behavior modified by experience

- could this ever be instinct?

goose that moves eggs (grey-legged goose)

- won't be tested

These behaviors often not very sophisticated, but if it works, it works

behavior

parus major

- not born poking through milk bottle lids

nesting

- very sophisticated
- requires more potential to learn

- chimp gets bananas from ceiling

living alone vs. living in a group

- most cats are solitary; lions are kind of unique in this way

- default assumption that this is genetically determined

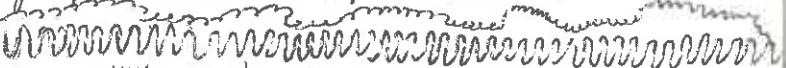
- how do we know when this is a safe assumption?

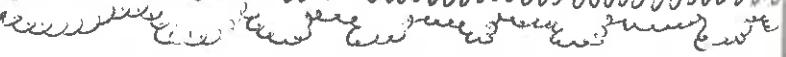
different ecological situation \rightarrow different selection \rightarrow diff. genetic behavior

most animals aren't territorial but some are very territorial

prairie dog sentries

- the noise alerts the rest of the group and the hawk, so how does

it help evolutionary fitness? 

- could be reciprocal altruism 

- very low cost to making the noise but huge benefits when reciprocated

- reciprocal altruists will quit doing it if they don't return

- could be kin selection

kin selection = how many copies of one's genes left in the next population, not # of offspring (inclusive fitness)

reciprocal altruism in vampire bats

- need other bats to stay warm enough

kin selection in Florida scrub jays

- think of it as the alleles being selected for or against, not the individuals