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

think

notes & studying

Feyman 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 on 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
- rewrite ~~notes~~ 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 precedes Darwin
- age of the earth integral in early evolution conversations
Galapagos Isles: 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

"acts on individual organisms but shapes an entire species"

- 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
3a. **mutation** = a change in DNA; new alleles; can have (+), (-) or no effect (neutral mutation) w/ varying degrees
3b. 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 (intensity) directions from a common point

convergent evolution: similar traits evolve independently in species that do not share common ancestry
- same predator 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 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 e/ generation
- "artefact of human activity" Dr RS
- "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
- doesn't have to be the predator/prey situation
- mechanism of evolution
- due to what circumstances does n.s. occur?
  - i. competition — 3 Circumstances
  - ii. individuals not identical ⟶ natural selection → evolution
  - iii. some variation heritable (only needs 1/3, not 3/3)

wouldn't actually lead to evolution if there wasn't a genetic difference

individuals vary genetically is four enough

i. 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
- noted in genes (how is this different from the one above)

2 Consequences of these 3 Circumstances

1. individuals best suited to environment (fit) most likely to leave offspring (natural selection)
2. because only reproducers genes passed on, composition of gene pool changes (evolution)

maybe revise notes and get his feedback during office hours

- there is still room for bad luck in ecology; fit organisms can still die before reproduction, chance exists

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

Some of the real time evidence:
- look for evidence for hypothesis being wrong, not for reasons they're right
- try to reject hypotheses. If you can't, it's apt to be right
unintentional artificial selection:
- pugs ~~BBK~~ 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

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

Observations of evolution in progress:
unintentional artificial selection - may produce a superbug
- 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)

reactivity

ex 1

no office hours on 08/31

1) some more questions on 08/30 readings Google doc, [redacted]
- maybe come in Wed. office hours

Q* - how does bacteria even mutate if they reproduce asexually?
- taking antibiotics gives advantage to the antibiotic resistant bacterium; useless 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 analagous to superweeds example
- taking all your antibiotics doesn't ensure all ~~antibiotic~~ bacterium 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 thr 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 mainlands
- lots of different examples of evolution w/ the G.F. because 16 initial cases drew a lot more researchers (less front load effort for researchers)
- wider variety of finch species
- "evolves back and forth" w/ weather cycles; short-term

Geospiza fortis

/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 (form formerly underwater volcanoes); different islands vary a lot as in biotic presence, differ in age etc
- finches seed-eating birds; strong bill to break seeds open
- how well its bill works massively determines fitness
drought on island:
i. few seeds available one large (for whatever reason)
- only big bills can bust it open
ii. small bills can't eat
iii. small birds don't survive/long-bills survive
↓ ——— 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; response 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 reverse on the slide
make sure you can explain each piece of historical evidence of evolution by natural selection
"there's a reason for every slide .. → 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 intermediates
- gradual sequences

anatomical homologies
- descent from common ancestor
- "legacy of structure modified by different environments"
- how does this prove common ancestry? could it just be a sensible way for animals to be organized?
- ~~vestigial analogies~~ vestigial homology
- whales have hipbones 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 homology
- amino acid sequences of humans most similar to organisms (logically) similar to humans
  - due to descent from a common ancestor
  - recency determines similarity - more time for evolution to occur w/ common ancestor → more differences
- more similarity means more recent common ancestor

09/06

convergent evolution
- dissimilar* related* species evolving predictably due to shared environmental* pressures
- not unrelated species becoming ~~non-related~~ related
- similar selective forces → similar adaptations
- whale (mammal) descended from land mammal but shark (fish) have similar overall shape (convergent evolution)
- similar ≠ the same
- can convergent species occur across ~~species~~ geography if selective pressures are the same?
- → answer: yes!
- humans & octopus have common ancestor @ some point but dissimilar
- look similar but different development
- convergent evolution
- how are environmental pressures the same? are we thinking

how exactly do we quantify something as dissimilar if its relative since all are c.a.?

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 shark and mammal are similar
-ce → similarity but ab → same → same structure from same ancestor, similar
① similar features from similar pressures
sn: 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 on archipelagos (sn: evolution doesn't result in perfect form, it's the form that worked for survival in the past, could very well be better)
House Finch (seed-eating birds w/ big heavy bills)
G.I. long (for a finch) way offshore 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 (GI) would be rare too, even that too far and very unlikely that finches flew to GI to begin w/ but sn: unlikely events happen all the time
GI 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

~~beaks evolved quickly~~

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 wrie answering a question, are we answering like wrie 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 if not common knowledge
  ex- would 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 → evolution
- microevolution (pop change over time) and macroevolution (new species)
population genetics discussed in terms of allele frequencies
- genetic change → 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 can extinct allele frequencies (chance)
- occurs alongside natural selection
founder effect - event causing change in gf 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)
- ↑ heritability, ↑ evolution
genetic variance - diversity of alleles + genotypes
inbreeding depression - inbreeding ↑ diseased offspring (greater chance of shared recessive deleterious alleles)
GTD Try 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

different

by chance very different from before
founder effect also if physical barrier causes subsets of individ leave
gene flow: flow of alleles in and out of a population due to
migration of individ as gametes
- some pops have more gf than others
- plants spread pollen
- can intro new genetic variation
mutations
- "species evolve because of mutations accumulating over time"
- intro novel genotype & phenotype variance
- harmful sorted 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 closer
- wouldn't def of pop bounds un dermine this?
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 population vary across an ecological gradient
- more gene flow b/ 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 individ 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 individ on one end of the phenotype

disruptifying selection
- more distinct phenotypes more fit than the intermediate
- increases genetic variance (bad)

frequency-dependent selection
positive fds (fauns common) or negative fds (fauns rare)
↳ decreases genetic variation ↳ increases genetic variance
↳ changes direction depending on allele frequencies

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 ∨∨ sexual dimorphism

some traits ↑ sexual success w/o survival success - sometimes selects for sexually beneficial traits that detract from survival
- = handicap principle (those that survive w/ unfavorable sexual handicap are unusually good)

trait signals male's quality

good genes hypothesis - impressive trait may signal genetic superiority

n.s cannot make a perfect organism; can only select not create
- limited by genetic variance, mutations, & gene flow
- net effect of alleles often reduced, less intensity of n.s.

- work on simulation (due on 11:59 on Wednesday)
  - don't have to design the experiment at the end
- revise two 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 or population, but some species have lots of populations

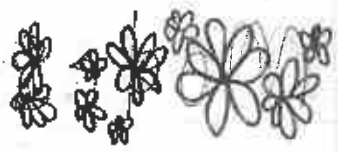
gene: a unit of heredity made of DNA
- affects some feature of an organism

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 more 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 ≠ strength

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



1. 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
- not that many mutations are actually beneficial; not all mutations matter; random change to functional system may become common if its selected for
- more genetic diversity = more capability for evolution/capacity to adapt to new circumstances

the problems with mutations for individuals
- don't want to expose yourself to mutagens (cuts yourself up when getting mutated)
- 2 copies of most genes (one from e/ parent) thus 2 alleles - same or different

genotype: individual's complete set of alleles
phenotype not solely genetically determined (eg. aging) nutrition, etc.
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) no acts on phenotype (affected by genotype)
- don't necessarily blend
- dominant ≠ more fit

09/13

~~so are mutations dominant or recessive or does it depend? what are the genetics of mutation?~~

☐ print WBs
☐ start Sim 4

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 noted on (its 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
- were all carrying harmful recessive alleles (heterozygous)

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 rare, recessive, harmful alleles will be passed on homozygously (carriers having children → 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 p~~ from the population perspective because...
the same that are beneficial
new genetic material only from mutations
list of genetic diversity → 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 - get denser on this increases fitness

1. mutation (random, doesn't happen because it's selected for - usually leaves set of offspring better adapted to parents than other offspring) generation pg
doesn't matter)

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 GI 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) disruptive selection (rare)
- both extremes favored over intermediates
- African black bellied seedcracker
- ~~best of both worlds~~ absolutely not

watch video before class

OH: 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?
- ie; I know theories are pretty solid, but are there any words between hypothesis and theory?

q. I understand science ~~is 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?
ie. 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 4) 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 a relevant concept. ie. it exist 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 phenomena

usually the females are choosier about mates because usually the female invests more energy + time into the reproduction (post conception); 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
- sn: 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 are 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 choosier 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 arise that would make females not choose them (and be successful because of the if, would not arise b/c of the 'if')

offspring will have low fitness if females bad at choosing for

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 100 000 00% separate, same 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 ever disadvantageous?
- gene flow is random, doesn't happen on purpose
- genetic diversity from gene flow ~~not~~ doesn't always persist (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've decreased to a small pop ~~life of endangerment~~ (bottleneck) (almost die offs - only a few survive
- little genetic drift in large populations
- not all times when most of pop dies = founder effect
- has to be random event not related to natural selection

~~world of~~
- see examples on slides

creatures continually + constantly subjected to selection pressure
- why doesn't this decrease genetic diversity? ~~DNA~~

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 heterozygotes better than either homozygote
- one sickle cell allele protects against malaria (+) but two are very harmful (-) - sometimes hetero has diff. phenotype than homo dom - not always dom + recess

4) not all genetic variation affects individual fitness

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 were creating a problem

Q gene regulation problems (epigenetic processes) interfere w/ fitness
don't get it - turn on and off 4) ÷

- download lab documents to smartphone & read before class on Friday

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

speciation

→ 09/20 lecture

formation of new species

so far we've been talking about small evolutionary changes

~~independent~~ 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've made up

gene pools have to stay separate for speciation

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

population w/ opportunity to interbreed

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

# of pops vary among species

- 2 different species cannot produce fertile offspring (ie mule)
- this definition can't always be applied
- separate species are reproductively isolated ~~from different~~ (also relevant to two populations of the same species) gene flow b/ pops means they're not reproductively isolated
- cannot just go by appearance to differentiate b/ 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 confuse/say isolated populations and actual separate species - does it even matter? - eh 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 error 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 to/ gametes
typically not interbreeding b/ species in the wild
- hybrids in nature suggest descent from common ancestor
(interbreeding species) — distribution same across geography
typically homogenous (?) gene pool for geographically continuous
species because of free gene flow
allopatric processes < dispersal - a few members of a species move to a new geographic area
vicariance - natural situation physically separates 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 organism
(create several new species) → founder species
- different orgs of one pop e/ find a niche in a new area
aneuploidy - error occurs during cell div (2n+1 or 2n-1 chromosomes)
- diploid (2n)
- polyploidy (4n), tetraploid (org w/ 4n, can self pollinate)
allopolyploid gamete from two dif species combine
conjunction
species 1 → normal gamete
species 2 → polyploid gamete
first mating → polyploid gamete
self pollinate → second mating
high rate of polyploidy in plants
temporal isolation - difference in breeding time
behavioral isolation
gametic barriers

18.3 reconnection and speciation rates

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

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

reinforcement fusion 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 everything.
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

print flowers + trees workbook

Speciation

→ 09/15 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/ 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 (e) 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 individual fitness
- I didn't know that my quiz answers majorly reflected that, but this specific verbiage is kind of new to me

Hawaiian archipelago
- 1) each islands have very different environments
- 2) islands far enough away from each other for birds to interbreed not likely

archipelago 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, b/ adaptations to new environment)
ie one Asian bird → 54 Hawaiian honeycreepers
- crazy to me how the different Galapagos Islands have such different environments - to understanding how the magnitude of these differences occurs necessary?

- to hinclune a qualifies 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 (Cryptus beetles)

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
phylogenetic tree, hypothesis of genetic past (can change as time (and data))
- nested 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/ >2 lineages

rotation at branch points does not change the information" use for family
systematics - the field organizing + classifying orgs based on evolutionary relationships
better show of relationship than physical similarity
branch length not related to time unless stated
three domains: Bacteria, Archaea, Eukarya
- then kingdom > phylum > class > order > family > genus > species (also subspecies)
- each level's specific name for an organisms 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)

gene transfer among common bacteria mechanisms:
1) transformation
2) transduction: a virus transfers the genes
3) conjugation: hollow tube (pilus) transfers genes between organisms

gene transfer agents (GTAs) transfer random genome segments from one prokaryotic species to another
genome fusion: when symbiotic prokaryotic species become endosymbiotic

HGT has formed web of life model over tree of life, ring of life also in the mix
theme: limitations of models + scientific advances
★ question: how to thrive at all w/i the scope of our class?
what do I actually need to know for the purposes of this class here?

27.4 Evolutionary History of the Animal Kingdom

Q what specific fossil listing 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 some wipes the slate

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 (~1/2 all species disappear from fossil record)
- there are lesser extinction events

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

Fri 3:15 10/27

09/27 Lecture (Wednesday)

speciation

formation of new species

- find time for group to office hours before the test
- email Dr Richardson about chem follow up
- two Smalls due Fri (one extra credit)

exam one week from today! OCT 4

understand how skewed sex ratios affect genetic diversity (forest Sims)

extant 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

caterpillar → butterfly

gene regulation

- 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

most genes affecting development negatively affect development

mutations

but some are good

evolution can't always little by little and thousands of years

intermediate not always necessary

Look at these examples again

~~mutations~~ often mutations can be massive

small genetic change can cause massive phenotype change

kind of like domino effect, large ramifications

upshot:

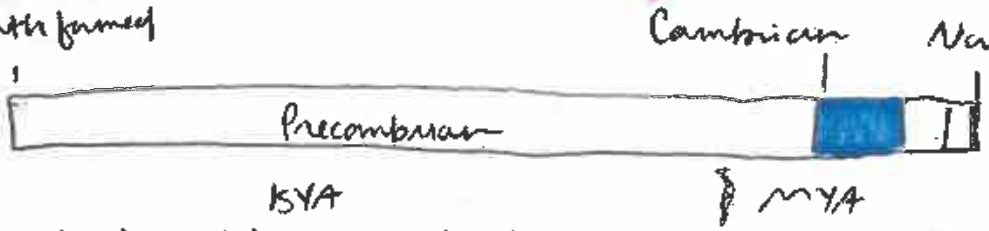
this will be on the second exam

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
- ½ the same genes as a banana - why/how?
- perform the same critical function
- evolution doesn't seem to fix what isn't broken
- importantest 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: Bactria, Archaea, Eukarya
figure 1.17 / proximity → closeness/relatedness via DNA
- animals and plants diverge at the same point?
~~[illegible] the difference between Archaea and Eukarya in the [illegible]~~
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/t cells and work
Archaea have been around the longest
Eukarya have nuclei, others don't
Bactria & Archaea DNA is circle w/ two ends
- how are 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 working with what we have evidence of on the timeline

540 mya Cambrian explosion

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

today/Archaea exist in "harsh" environments

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

Bacteria have peptidoglycan in cell 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)

these daughter organisms/ chromosomes enclosed inside the membranes of cell nuclei (eukaryotes) arise?

"prokats are a taxonomic hurdle people"

chromosomes not loose in the cell

Endosymbiont hypothesis for the origin of Eukaryotes

- bacteria eats another bacteria doesn't get digested, lives on,

then split further
- there are coral with cells living inside their cells
- coral bleaching (look at this data)
- chloroplasts + mitochondria similar in size to bacteria (how does this support ET) thought the absorbed bacteria was the nucleus)
- chloroplasts + mitochondria circular like bacteria
- chloroplasts + mitochondria have cyanobacterial DNA sequences and then DNA is archaea like bacteria
- compelling evidence that eukaryotes are from bacteria (and we know bacteria are from/archaea)

LAB 09/29

BIOLOGY

tends to be more text (which is based from data) than in chem labs

introduction usually ends with hypotheses ~~and the rest~~ in the results

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

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

magnitudes, 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 screwed 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

~~[illegible]~~

look at the axes first

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

Graph 1 1. The independent variable (photon fluxdensity) varied between 0 and 2000 $\mu mol\ m^{-2} s^{-1}$ for Amaranthus Palmeri and between 0 and about 1500 for Euphorbia fuhrerii. The net photosynthesis varied between below zero and almost 60 for Amaranthus palmeri and between below zero $\mu mol\ m^{-2} s^{-1}$ less than

the low zero topic

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

Graph 2: 1. Magnitude of ≥10 μg/dL decreased to elimination ~~both~~ decreasing from 88% prevalence from 1976-1980 to 0% in 2011-2014; ≥5 μg/dL decreased from 100% from 1976-1980 to 1% in 2011-2014.

why did they look at children aged 1-5?

2. The prevalence of lead levels of both ≥10 μg/dL and ≥5 μg/dL in children age 1-5 saw substantial ~~decreases~~ and consistent decreases from 1976 to 2014 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 ~~gaps~~ cath that there is gaps in the data

- should use a consistent 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, in "The magnitude matters" which predicted a consistent decrease followed by a stable increase

The data pretty consistently decrease and then increase ever since

"lot of choices 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)

this 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 regional 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 skewed across species and vary within a species. But, a trait always and only present in one set of ~~organisms~~ populations or a population and never present in another population is compelling evidence for the existence of two different species (ie. a trait always present - good basis 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

modes of evolution

I feel pretty good about this one

- should I have multiple examples for e/ selection

- examples for stabilizing

disruptive selection

evolution basics

I feel pretty good about this too

Chapter 18 Textbook Questions

p 484

1. 2n+1 4. b 7. d
2. human 5. d 8. a
3. b 6. a 9. dispersal vs vicariance? → relocation to new region ? physical division resultant of an environmental change
10. b
11. ~~autopolyploid vs allopolyploid?~~ → ~~source of extra chromosomes~~
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. Human 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's not going to ask what a certain subdiscipline is?

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

12. a cline is a gradual geographic variation across an ecological gradient
- example: size of deer increasing at higher latitudes (further from equator)

22. 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 (turned-nose)	Haplorrhines (dry-nosed)
- generally nocturnal	- generally diurnal
- smell	- sight
- smaller size + brain	- anthropoids
- can make vitamin C	- cannot

primates generally produce one offspring / pregnancy, carry themselves upright
New World and Old World monkeys underwent separate adaptive radiation
humans + chimpanzees diverged from common hominoid 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 forms
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 prokaryotic?
- endosymbiont hypothesis
- thought to have happened ~1.5 BYA
- chloroplasts and mitochondria similar in size to bacteria (so there not a vast size range for bacteria) also not that impressive as a cell
- chloroplasts + bacteria + mitochondria all reproduce by splitting
- chloroplasts + mitochondria have their own circular DNA
- unique from nucleus DNA?
- chloroplast DNA similar sequencing as cyanobacteria

more compelling of the reasons

don't need to know the more detailed timelines from the book
don't 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

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 radiation / 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 $CO_2 \rightarrow O_2$
- 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 CO_2 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 (compare w/ dates on dragonfly slide, makes sense)
- the largest mass extinction was Permian - Triassic 250 mya (98% of species or less)
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 modest 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 wetness 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
- location of continent affect how water moves around the planet
2. tectonic plate movement can also cause massive volcanism

- ash blocks the sun → cools and plants can't photosynthesize

B. asteroids

- lot of good evidence for asteroids @ different times and especially for dino extinctions
- Rampino 2017 American Scientist
- these events have huge implications for what comes later
- most compelling evidence for past mass extinctions
- Tanzania event (some asteroids smaller than others)
- tremendous amount of forest fires → ash in air → cooling → carbon in wood then carbon in atmosphere → warming → melting snow and ice → less reflective → warming

how asteroids set off climate changes - lots of regional impacts where it hits but effects resound 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

no ecologist knows exactly how all the parts work (doesn'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

hunters aren't driving anything extinct now

- Hagerman manages the land to offer a migratory haven for birds

hole nesting birds

- holes found in dead trees, which humans tend to cut down

Costa Rica fog trees x Costa Rica wasps / fog trees

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

define endemic — species most affected by pollution are riven species

how statistics work

lab: Friday, October 13th

magnitude tells how much above the pattern
- there was more Grass in Field A than in Field B
- yeah but how much? → magnitude
data usually varied in bio (more factors than in physics) (like Reed'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 comparison, just describing something
e.g. mean, σ, variance, n
↳ looking for a statistically significant result
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
lots more things affect our lizard's value than what affects how fast a ball falls
- doesn't mean you're manipulating all of them but just inherent variation
we are 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
is 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

IMPORTANT DISTINCTION

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

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

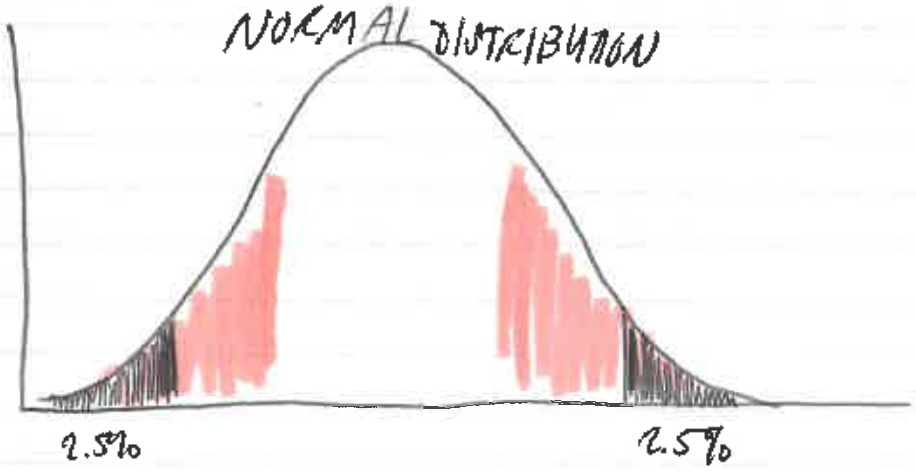
Random processes can certainly generate patterns

~~but~~ not exactly as predicted because of that random variation

2:20

p = .05

p = .50



the results in these 2.5% ranges statistically significant because unexpected

nothing right about the p-value cutoff, just convention

will 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

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 → Type II Errors: false negative experiment doesn'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 $p \geq .05$ 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 affect the dependent variable

human evolution

October 16th

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

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

- tarsiers and humans the same amount of related to prehensile
- 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 swim 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

larger 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 posture & evolution
- not using hands 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
observed

trying to interpret changes in selective forces from changes in fossil records

make list of all readings
- review readings

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/ 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 diff species
- may be asked why he doesn't require us to memorize the details of graphs like the one on page 10 of the PowerPoint

2:22
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
are all very closely related
races 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 & 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/ an area and the interactions w/i + among species

- heterospecifics → 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 matter 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 water occurs when winds blow along surface water 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 around it

denser water sinks ↓, bottom water moves to replace it ↑

migration increases species distribution

- migrate to areas of different temperature

hibernation - survive cold estivation = survive hot and dry

torpor (lowered metabolic 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 rainforest - 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

subtropical deserts very dry, low annual precip and little monthly variation in rainfall
- low species diversity
- mostly annual plants - water-conserving adaptations and nocturnality & burrowing

chaparral - most rain in winter, summers are dry & plants are dormant during the summer - shrubs - fire common — shrubs

temperate grassland prairies & steppes, hot summers & cold winters
- specific growing seasons - further from equator than savannas, savannas have more trees & less rain & tropical or subtropical
- few trees
- dense vegetation and fertile soil - controlled burns for maintenance

temperate forests mid latitude, defined growing seasons due to temp variation but consistent precipitation, deciduous trees (seasonal leaf loss)

C

- less NPP than tropical ent and less diversity
- rich soil from leaf litter
- evergreen
boreal forests taiga, coniferous trees, cold + dry winters w/ cool, short, wet summers, snow more precip 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 not enough growth b/c lots of sunshine, little precip and little variation and little evaporation b/c cold, plants low to grow, low diversity, low NPP (low above ground biomass), all perennially frozen = permafrost → roots can't go deep and decay is slow

44.4 aquatic biomes

light distinguishes ↳ stratification, currents
water absorbs light
↳ thermal properties of water

open water = pelagic realm
benthic zone = shoreline - ocean floor
- high biogenic thermal stratification
photic zone - photic zone (light penetrates)
- aphotic zone (most of ocean) → scarce minerals
oceans relatively uniform in composition
- physical diversity (different zones)
- abyssal very cold, high pressure, low nutrients
intertidal zone - b/t high + low tide, closest to land, tidal ebb and flow
neritic zone - intertidal → continental shelf, photosynthesis
coral reefs skeletons of coral organisms → reef
mutualistic relships with algae cryptic fauna planktivores
estuaries freshwater meets ocean, diluted saltwater
- salinity varies with seasonal rainfall and tides
- halocline
lakes + ponds temp - thermal stratification
phytoplankton eaten by zooplankton
nitrogen + phosphorous 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 sun, photosynthesis from algae on rocks a accumulation
that fall into the water no phytoplankton
width of channel ↑, current slows, sedimentation ↑, phytoplankton & nutrient
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 waterflow - no waterflow

445 # 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
milankovitch cycles → slight changes in Earth's orbit affect climate
solar intensity ↑ temp ↑ - changes in solar intensity
volcanic eruptions - gases released generally cool (blocks sun)
greenhouse gases trap heat from sun → greenhouse effect ↑
human activity → CO_2, methane ↑ / burning of fossil fuels, deforestation, agriculture
melting of clathrates (frozen chunks of ice and methane @ bottom of ocean) → release methane as temps warm
- positive feedback loop
human extinction caused w/ increase in temperature
melting glaciers ↑ sea level

ecology - intro - biomes

lecture: october 18th

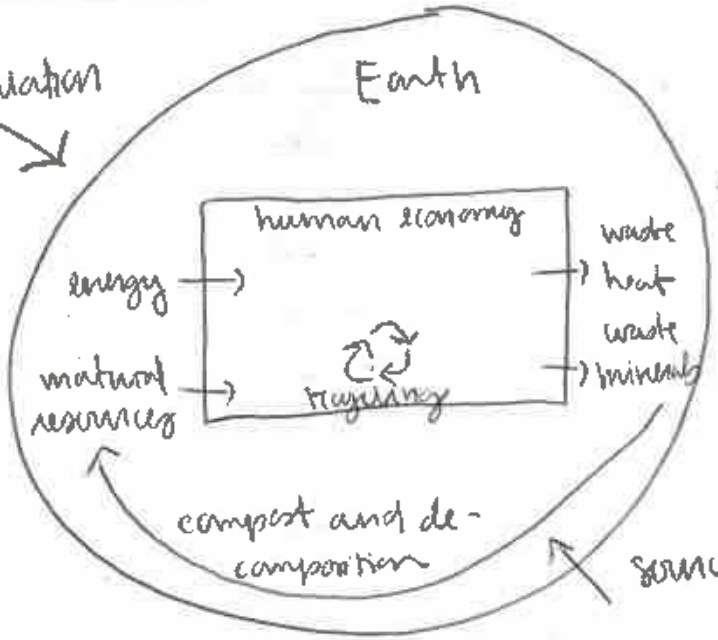
"just surviving is an evolutionary dead end"
- there is not as strong of selective pressures at post reproductive age
get energy + nutrients from food - need enough to survive + reproduce
need to not get eaten or succumb to the environment
natural selection - natural (ecological) processes determine which individ reproduce and which don't
must be able to tolerate the environment (physical + chemical conditions)
studying ecology: helps to understand natural selection and environmental problems
do we owe anything to future generations? do we owe anything 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"
consciousness of 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 fiber, food, water purification, element cycling, UV shield, wild genetic material, climate moderation, flood prevention, air purification, pollination, recreation, inspiration
- no one intentionally causes/contributes.

THE DIAGRAM

will be on at least either the mid term or final

- bring questions about it before the beginning of Monday's class



ecological view of how the world works

materials as another word for nutrients

"elements don't go in and go out"

"economy" = the things people do

just seems like such an exhausting energetic calculus (side note)

the box with a physical barrier

can only get away w/ energy → waste heat if the energy is renewable

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

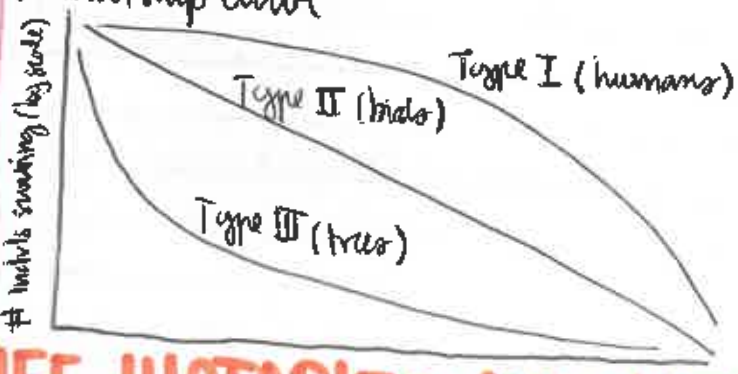
$$\frac{\#\text{ marked first catch} \times \text{total }\#\text{ second catch}}{\#\text{ marked second catch}} = N$$

- imperfect method

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

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

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 interesting cuss / complete.

fecundity inversely related to amount of parental care in animals
- remember the energy budget - energy trade off / evolution any fitness
- plants w/ low fecundity → energy - rich, high yield seeds and vv
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 → exponential growth
- ex: bacteria - accelerating population growth rate (↑ # of organisms added in each generation → J-shaped growth curve

$\frac{dN}{dt} = bN - dN = (b-d)N$ $\frac{dN}{dt} = rN$ r=0 → 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" → competition for limited resources

logistic growth model
carrying capacity (K) = max # N an environment can support
$\frac{dN}{dt} = r_{max} N \frac{(K-N)}{K}$ pop growth slows @ higher N values
→ S-shaped curve - exponential, ↓ growth rate, levels off

phenotypic variation → intraspecific competition NT, 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, inter and intraspecific competition, levels of waste, and disease

- denser pop tend ↑ mortality rate (more comp ↑, ↓ reproductive rates)
- low prey density ↑ mortality in predator

ex. giant intestinal roundworm

- denser pop of parasite, lower fecundity of worm

~~females 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	r-selected species
selected by stable, predictable environments	- large # of small offspring
- exist close to K (intra comp is high)	- changing environments
- fewer offspring, longer gestation, long-term parental care, ↓ mortality C birth	- self-sufficient at birth
- plants (live long, ↓ turnover on parent plant	- low energy content offspring in plants
	- less competition and less longevity

this theory doesn't account for age-specific mortality

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

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 biotic 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
- remember 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 an 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 defense: 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 imitate warning color of harmful species
- Mullerian mimicry ? - same coloration
- Emsleyan / 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
- avoided if 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 = +/+ termites/protozoa (digest cellulose)
parasitism = +/-
- parasite = organism that lives on 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 is 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

10/23

2nd lecture

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 one 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)
- can makes its weight in air pollution every year, literally burning gas
- plants assimilate CO_2 (make it nonproblematic O_2)
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, phosphorous
- phosphorous is mined from rocks now - 1/2 of known P was in Morocco
- before, we got phosphorous from islands of bird poop - literally mined away
- throwing away food → making its 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

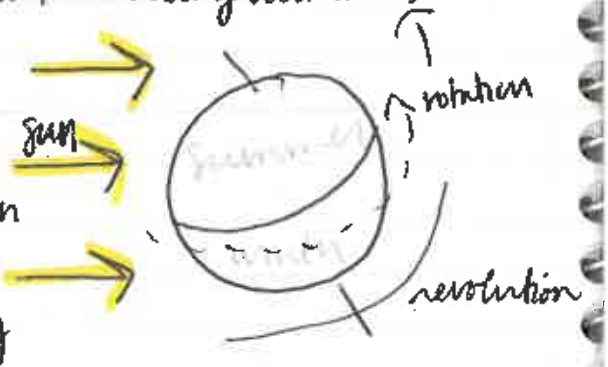
slide 32: total transformation of our vegetation - are we a new biome?
- historically, this was tall grass prairie, blackland prairie
the reason I-35 is where it is because there is fertile soil
- it's really not that easy to replace ecosystem services

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 (largely)

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 equator than near the poles (think about why/how it's 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 ground 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) updrafts
~~increased heat~~
- dry air blowing across something damp gets wetter ↗ wet mean = hot
- cools as it rises + moisture in it condenses + rain falls
- can't go up forever - gravity does work on air - goes north or south
- goes down while not holding much moisture L) closer to 30° N or S
- how come it rises more before shifting direction closer to the equator?
- more air coming behind it, so it can'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
global ocean convergence — damp off the ocean or dry off land toward ocean?
- 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 temp of air
modern people have altered the vegetation
watch YouTube video at the end

ecology introduction - homes end of exam 2 coverage

thank you Jesus for who you are and for being so good to me

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

cm.

MIGHBR43 3of5 130, 132 r1 3.500 r2 [illegible] r3 [illegible] r4 11.230
MIGHBR61 1of1 160 148 r1 [illegible] r2 [illegible] r3 [illegible] r4 [illegible]

Group 12 - TXSHC112 check radius measurements
r1: 108.0 r2: ~~[illegible]~~ 114.0 r3: 116.2 r4: 141.0

reread what a pvalue is

test: november 1st

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 (16 human evolution), slide 10
- don't have to memorize the details because they shift around
- should know four 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 were 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 rises and how it rises 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

innate behaviors

behavior: change in activity of an organism in response to a stimulus
innate 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 indv but increase another's)
- worker bees, only queen reproduces
- meerkats never 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
↳ intersexual selection + intrasexual selection (competition for mates)
- monogamy, polygyny, polygandrous (rare)

learned

habituation - stops responding to a stimulus after repeated exposure } non associative
- 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

11/06 lecture

physiological & 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 OH one day
what affects / determines if these 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 rivets 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 miniscule.
-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
-sm. "It's hard to get to know somebody if they never say anything" - PJ
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
-parents habitat becomes unsuitable
-new habitat has better reproductive success

dispersal

- dispersal on individual level, not the species level (though indv 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

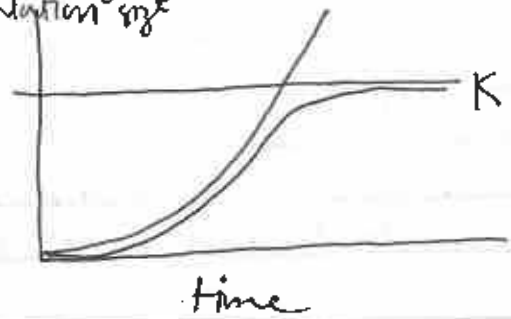
deer/frozen lake example
- per capita: per individual (sometimes per female, etc.)
- doubling time uniform in theoretical exponential growth
- paper folding example
- population growth in might realizes necessity of natural selection
- ex. some organisms have to evade predators constantly
- what keeps 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 indvls of same species
interspecific competition - among indvls of two or more species
- diff tree species diff colors / don't understand relevance here

competition regulates population size
- ecosystem dynamics (something changing in amount due to interaction of factors)
- masks regulated COVID ex.
- stop epidemics b/ regulation

regulation: to increase when low and decrease when high



regulation

- to push a system back toward equilibrium
ex. HVAC regulates; breaking window 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 / address them in answers too)

11/08 lecture

- 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 fast~~ < 0 → decreasing
per capita growth rate $= 0$ → growing ~~b/c 0 and + → decreasing~~

- knowing something is regulated doesn't mean we know it is regulated
- regulation isn't perfect, means it won't get too too far away from equilibrium / how it is regulated + the tightness with which it is regulated different question
- if a pop is low in certain area, predators will go looking somewhere else → prey pop grows → predators go to prey and get eaten → prey pop decrease → ...
- parasites spread more easily in dense pops
- I feel like there's some nuance to this ? disease w/ is parasitism regulating?
- Bubonic Plague didn't affect long term population growth (same for non humans)
  - I wonder if this is the only time our pop. went down?

46.1 ecology of ecosystem

ocean ecosystems most common (>70% of surface) - shallow ocean, deep ocean, deep ocean surface
- phytoplankton perform 40% of Earth's photosynthesis
freshwater rarest (1.8%)
environmental + human disturbances in ecosystems
equilibrium - all org.s in balance w/environment + e/ other
measurements of changes in ecosystem
resistance - ability to remain @ equilibrium despite disturbance
resilience - speed at which equilibrium is recurred
- ecosystem can lose its resilience → destruction
food chain - primary producers < primary consumers < ... consumers
trophic level (linear)
energy limits length of food chains heat
- 2nd Law of Thermodynamics (tendency toward entropy)
food web - nonlinear, more holistic, made of food chains
- grazing food web (typical)
- detrital food web - orgs that feed on dead organic matter (decomposers) at the bottom
mesocosm: partition of natural ecosystem for experimentation
minicosm: laboratory environment

46.2 energy flow t/ ecosystems

photosynthesis — autotrophs — sunlight
chemosynthesis — inorganic molecules
digestion
mostly bacteria in places w/o sunlight
net primary productivity
trophic level transfer efficiency = $\frac{\text{production @ present trophic level}}{\text{production @ previous trophic level}} \times 100$

- can't have unlimited amount of energy transfer

net production efficiency = (net consumer productivity / assimilation) x 100

→ 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 heart of persistent toxic substances up the food chain

ex. DDT, PCBs, heavy metals

POPULATION ECOLOGY 11/08

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

→ 45.1-4

LECTURE

(a) 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 of 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, other suffers
- cow eats grass = predation
- what about one plant "takes light" from another

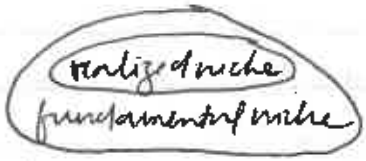
mutualism: both species benefit

commensalism: one species benefits, other unaffected (hard to determine if something is unaffected), has to go both ways

coevolution: reciprocal evolution of ?? species in response to/ 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...
- abiotic works but something missing



where a species actually lives in presence of predators and competitors

~~where a species can't~~

ex of difference (Chthamalus stellatus)
- intertidal zone - partitioning w/ water determines amount of day in water or not
- lots of different niches in intertidal zone
- lots of ecological study (easier than wolf pop in YX)
- close shell in air, open in water + collect zooplankton
- does this count as amphibious? or do they have to move themselves b/ water + land (not just water moving?)

- 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 free release toxins (super sophisticated)

so as not to waste energy on toxin when not necessary

→ 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 naivete

LECTURE 2) 11/13

- ~~finish statistical analysis on tree lab~~
- ~~tell him about library bundle~~
- LAB REPORT FORMAT

community ecology

tree lab:
- see more about p-values in "Probabilistic Reasoning" from his book
- q: so you can't say that in this case the trees visited natural plants more often but that the insignificance of the relationship means nothing can be extrapolated
- TREE LAB DUE DECEMBER 8th, set deadline for yourself
- q: when do OH stop happening as usual?
- put final exams 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 bioregulation?

cyclic abundance
- typically don't see it as clear as hare/lynx because hard to get data and other factors present
- recall chemical defense of plants; some for vegetation the rabbit eats
- produce when hares get abundant and then some
  - lag time in biology
- most predators + preys don'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 suppress 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 @ Yellowstone; wolves wiped out

by people; elk population increases w/o rest of predators; 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 traits 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
- thorns defends shrub from large herbivores
- ants defend against smaller herbivores
- ants dig hole + shelter in thorns
- coevolution always mutualism?
- tree makes ant food
species diversity:
- no one knows all the species in any one community

~~-finish them tomorrow~~
~~-go t/ disease lab~~

- different communities have different levels of biodiversity

beech maple trees:

- invasive species caused beech trees to die t/ beech bark disease
- how will this affect the ecosystem?
- hard to predict consequences
  - non native plankton in Great Lakes → birds getting nutrition
  - plane vine example

ecosystems w/ more species tend to be more stable

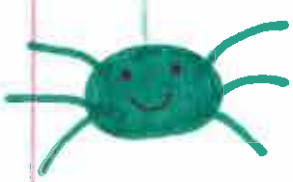
- what does stability mean in this context?
- could I talk about stability in terms of resistance?
- COVID horse/human/giraffe/tiger example

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 increase doesn't really follow for me
  - couldn't it force them to find a niche
- seems like monopoly could happen to me?
- non-native predators
  - prey haven't been selected for in the past to have to get away from those predators (no evolutionary history with it)
  - native predators increase SD because they decrease competition
    - reduce abundance but don't eliminate species
    - prey on abundant prey preferentially
    - good at competing - less good at avoiding predation
- isolation from source of colonists
- hard for organisms to get to far away islands
- how 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 redoing 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
- near and far 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: ~~takes how~~ considers species richness and relative abundance
- some measurements are indices (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 individ / 1 species, 10 species > same SR but different SD
or 100 trees, 91 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 JD^2?

- notice the best competitor for light take a while to get there
some species are faster colonizers and some are better at competitors
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 w/ the conditions?
- sometimes inhibit: invasive grass @ Sneed (how does this happen after burn and primary succession)
historically fires didn't grow here b/c fire + bison 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/ SD, typically higher SD of intermediate
- enough time for a lot to get there
- not enough time for other species to outcompete (ex. trees)
- ~~how does~~ this plays w/ competition @ ↓SD
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 2) 11/15

- check for missing assignments on Moodle
- LOR?
- find time for OH
- come w/ questions

BEHAVIOR

focus on how it helps you understand evolution & ecology

most creatures aren't animals + don't behave

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~~ fitness without it (natural selection drives animal behavior)

- if your child dies (bc no parental care), your genes are gone forever

zooplankton in world's oceans

- at the mercies of currents, can't swim against it
- can decide b/ 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 omit no behaviors
have to study generations to detect genetic basis for behavior
- inbreeding the quick to e/ other and the slow to e/ other
- dk 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

- LAB REPORT - make list of readings

behavior

parus major
- nut bouts poking through milk bottle lids

reasoning
- very sophisticated - requires more potential to learn
- chimp gets bananas from ceiling

living alone vs. living in a group
- most cntr are solitary; hums 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 → different selection → 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 benefit when reciprocated
- reciprocal altruistr will quit doing it if they don't return
- could be kin selection
- fitness = 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