Final Exam Outcomes

Lecture 14 – Why Sex?

Post Lecture

1) Examples of genetic exchange/ recombination without reproduction, and of reproduction without genetic exchange/ recombination

- Asexual reproduction is reproduction without genetic exchange/combination
  - Results in offspring having identical genetics to their parents
  - Asexual reproduction is uncommon in plants and animals, but most organisms reproduce asexually
- Transfer of genetic material between two bacteria (e.g. plasmids) is genetic exchange without reproduction

2) How recombination contributes to population genetic variation

- Recombination **does not** create new alleles
- Rather creates new combinations at multiple loci
  - Can result in offspring that have more beneficial mutations; gives them a better fitness and over time their genotype will become more common in populations
- The individuals that "hit the genetic lottery" are more fit than other individuals, so their genotypes will become more common over time through selection

3) Meanings of monoecious, dioecious

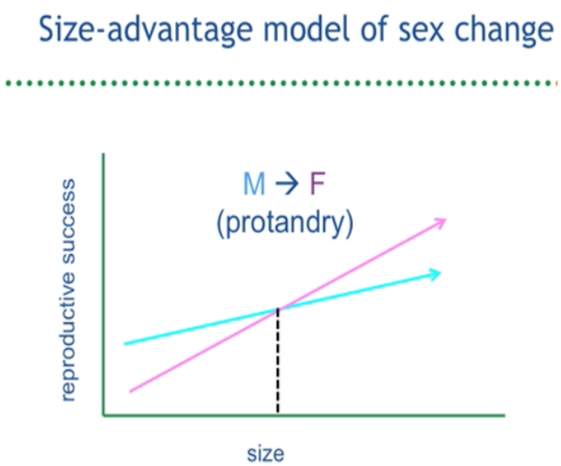
- Monoecious – organisms that have both male and female reproductive parts in the same individual (hermaphrodites)
  - E.g. flowering plants have the stamen and anther in their flowers
  - Every individual is both male and female
  - Can be sequentially or simultaneously monoecious
- Dioecious – species whose male and female reproductive parts are in different "houses"; two different individuals must mate to combine the male and female gametes
  - Humans are dioecious

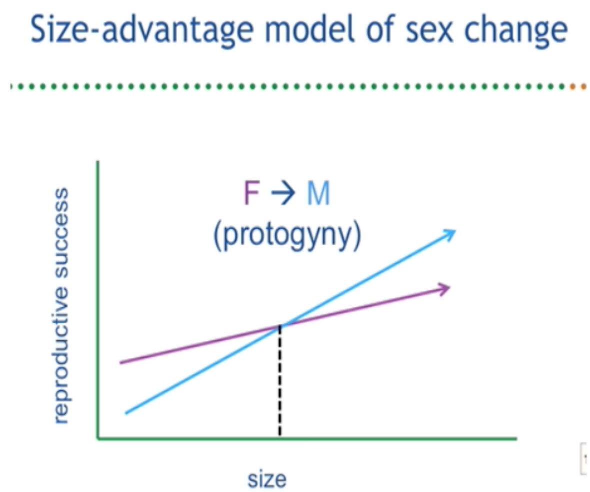
4) Difference between sequential and simultaneous monoecy

- Simultaneous monoecy – since birth you are both male and female; have both reproductive systems your whole life
  - E.g. plant species that have flowers which produce male and female gametes
- Sequential monoecy – Once you reach a specific size you turn from male to female or from female to male
  - Coral reef fish show this behavior; all are born female then when individuals reach a certain size they switch from female to male
  - Clownfish are the opposite; they all start male then turn female later on
  - **Protandry** is when males switch to females
  - **Protygyny** is when females switch to males

5) Examples and predictions of size-advantage model of sex change

- Size-advantage model of sex change – depending on your size, it may be more beneficial to be either a female or a male
- For example in coral reef fish, more beneficial to be a female when you're small, and more beneficial to be a male when you're large
    - When an individual becomes the largest size in a population they make the switch over from female to male (this is called protogyny)
- Can graph the relationship. The point where the graph crosses is the optimal time to switch from male to female or vice versa





6) Examples and predictions of adaptive sex ratio manipulation

- Adaptive sex ratio manipulation is when one sex has an advantage over the other if the mother is of high social standard
    - Red deer produce more males if the mother is healthy; unhealthy mothers produce more females
    - Male baboons leave their groups and females stay. A healthy mother would be more likely to produce females than males; an unhealthy mother would be more likely to produce males so that they can leave the group

7) Reason why most populations have 1:1 sex ratios

- Example of negative frequency-dependent selection
- When one sex becomes rare it has a selective advantage over the other due to the other sex being more common; can find mates and reach a frequency of 50%
- Sexes stabilize at 1:1 ratios

8) Prevalence of sexual vs asexual reproduction in animals, plants and other forms of life

- Most forms of life reproduce asexually, only few reproduce sexually
    - Plants and animals reproduce primarily sexually
    - Isogamy (equal-sized gametes) appeared first, then anisogamy (unequal gametes) developed later on
- Asexual reproduction in animals developed evolutionarily recently

9) Costs of reproducing sexually as opposed to asexually

- Sexual reproduction requires lots of energy to find mates, compete against other males, etc. Also meiosis passes only half of your genome to offspring while asexual reproduction passes on your entire genome
    - Also decreases your fitness such as when males attract mates through singing; this attracts predators which may lead to death
- Only females produce offspring, in that sense males are a dead end
    - Investing energy to raising males in populations when they can't even reproduce
    - Reproduction would be more efficient in an all female population
- Summary cost of reproducing sexually: cost of mating, cost of meiosis, and cost of males

10) Benefits of reproducing sexually as opposed to asexually

- Vast majority of mutations are deleterious. In asexual reproduction there is no way of getting rid of these deleterious mutations due to them being continuously passed on to offspring
- Sexual reproduction allows recombination to produce offspring that don't have deleterious mutations
    - These offspring have a selective advantage so their genotype may become more common over time in a population
    - "Rubies in the rubbish"
- Sexual reproduction **does not** remove harmful mutations in a population; just recombines them to give rise to individuals with few harmful mutations who will have a selective advantage and be more fit than individuals with many mutations
- Asexual reproduction makes populations more prone to extinction due to buildup of mutations; no way of getting rid of them in populations

Lecture 15 – Sexual Selection

Post Lecture

1) How environmental stability influences whether sexual or asexual reproduction is favoured

- In stable environments it is better to reproduce asexually (buying many copies of the same ticket; you know that your genotype is already very successful so no point in giving rise to a different genotype)
- In unstable environments it is better to reproduce sexually (hedging your bets; more chances to have offspring that can adapt better to certain environments)

2) Lottery principle and Red Queen principle as environmental (short-term) benefits of sex

- Lottery principle: buy many copies of the same ticket, or hedge your bets?
    - In an unchanging environment, you should make many copies of the same ticket (asexual reproduction)
    - In a changing environment, you should hedge your bets (sexual reproduction); increases chances of success
- Red Queen principle: "It takes all the running you can do, to stay in the same place"
    - Metaphor for co-evolutionary arms race for the evolution of two species
    - Parasites are more likely to infect common genotypes of hosts; negative frequency-dependent selection
    - Hosts with a rare genotype have a selective advantage

- The greater the selection pressure of the parasites, the greater the advantage of reproducing sexually
- Beneficial to rapidly produce different genotypes to combat the evolution of the parasites

3) How sexual reproduction places different selective forces on males vs. females

- Sexually dimorphic traits – traits that are produced by one sex but not the other (e.g. tail of a peacock in males)
- These traits are favoured by sexual selection, but can reduce survivorship
  - Females are attracted to these traits; however, so are predators
- Females may not necessarily have these sexual selective forces in some species
- Sexual selection is done by the species that invests more in parental care (e.g. females invest more energy to produce gametes and also to raise offspring; so they will want to select for a higher quality male)

4) Distinction between intrasexual selection and intersexual selection

- Intrasexual selection: selection between two males who directly compete for a female (e.g. fighting with horns); **direct competition**
- Intersexual selection: **indirect competition** between two males caused by females choosing specific traits, such as flashy tail feathers or beautiful songs
- In some species intrasexual and intersexual selection occurs simultaneously
  - Bower birds: Females attracted to blue and hate the colour red (intersexual); sometimes males sabotage other males by destroying or putting red feathers in their nests (intrasexual)

5) Why males usually compete for access to females (rather than vice versa)

- Maximizing fitness is different for males and females
  - Male fitness increases by maximizing the number of females they mate with (offspring quantity)
  - Females can only produce limited quantities of offspring so they can only maximize fitness by making sure that the males they mate with are high quality (offspring quality)
  - Thus females are very picky about mates; so males have to compete between one another for access to a female mate
    - Females are the ones that do sexual selection on males

6) Which sex has higher potential fitness

- Males have a higher potential fitness than females
- Fittest male in a population almost always produces more offspring than fittest female
- Males invest less in parental care than females so they care about offspring quantity
- Females invest more in parental care; they need offspring quality
- Therefore males have much higher potential fitness (can produce many offspring)

7) Which sex has higher average fitness

- Both males and females have equal average fitness

- Every offspring has one male parent and one female parent
- Males have a higher potential fitness but for every big winner there's always some big losers
    - Lots of variation around the average fitness for males
    - Males invest less in parental care

8) Relationship between sexual selection and parental investment
- Whichever sex invests more in parental care, that becomes a limiting resource for the sex that invests less
- High investing sex is usually females, low investing is females
- The sex that invests more in parental care selects their mates more carefully (focus on offspring quality, not quantity)
- Reasons to be choosy:
    - Direct benefits (attractive males are good dads)
        - Can provide food, protection, or access to good territory to a female
    - Indirect benefits (attractive males have good genes)
        - Don't provide any direct benefits to the female; however they can improve the survivorship or attractiveness of an offspring

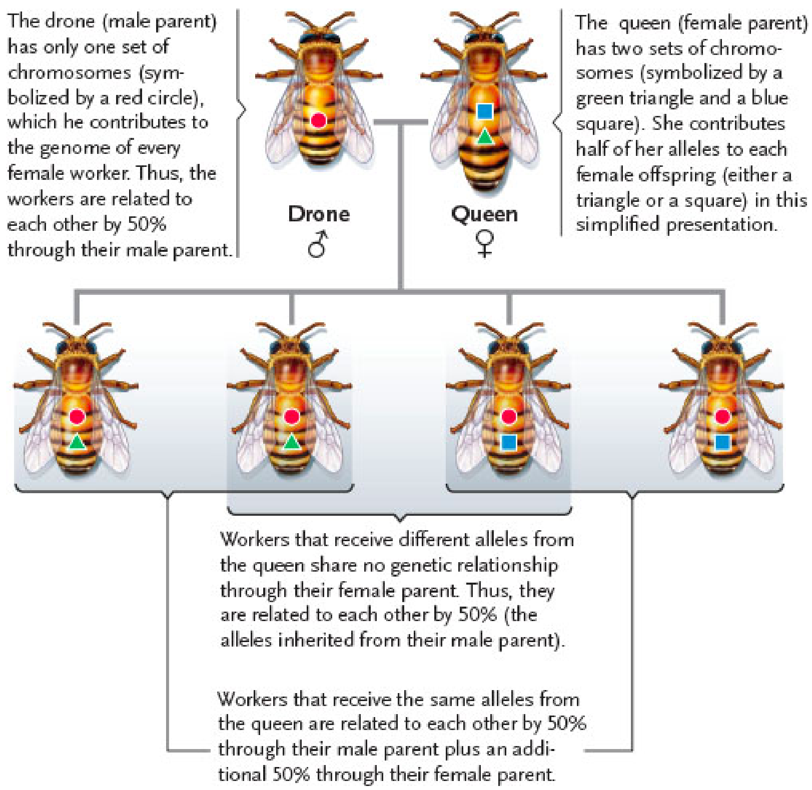
Lecture 16 – Cooperation and Conflict

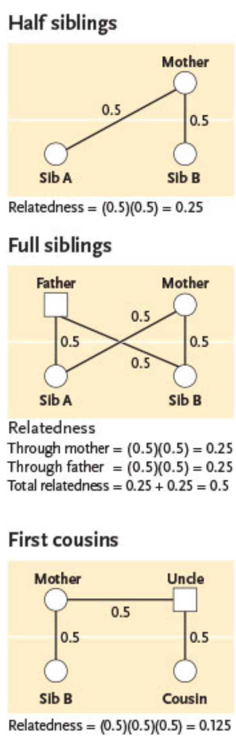
Pre-Lecture Readings

1) advantages and disadvantages of living in a group
- Advantages of living in groups:
    - Groups of predators cooperating together are more efficient in hunting; capture prey more effectively
    - Groups of prey may be able to detect predators better in group
        - Can also disperse the predators so no individuals in groups are at less risk of being attacked than if they were alone
- Disadvantages of living in groups:
    - Costlier to live in groups; increased competition for food
    - Can also spread diseases and parasites more rapidly

2) meaning of dominance hierarchy, kin selection, altruism, reciprocal altruism, eusocial, haplodiploidy
- Dominance hierarchy: some individuals in groups dominate over others (i.e. alpha male)
    - Dominance can be **absolute** (one individual has dominance over every resource) or **relative** (certain individuals have dominance for certain resources, while other individuals have dominance for other resources)
- Kin selection: Individuals are more likely to help close relatives survive because they share some of their alleles and so their alleles would propagate and be passed on to the next generation of offspring
- Altruism: doing something that enhances the situation of another individual
    - Increases the fitness of the recipient but decreases the fitness of the actor
- Reciprocal altruism: Individuals helping nonrelatives if they are likely to return the favour in the future; both individuals can benefit

- o Favoured by natural selection as long as individuals that do not reciprocate are denied future aid
- Eusocial: thousands of genetically related individuals, most of them sterile workers, who work together for the benefit of a single queen to ensure her reproductive success
- Haplodiploidy: Male drones are haploid, female queen bee is diploid. Sex is determined genetically
    - o Male workers hatch from unfertilized eggs (100% related) and females are combination of alleles from mother and father (50% related). Combination of male and female workers = 75% relatedness between them





3) calculate degree of relatedness between two individuals, given the type of relationship (parent-offspring, cousins, etc)

- Parent-offspring are 50%, half siblings are 25%, cousins are 0.125%, etc.

4) identify why haplodiploidy can favour high levels of cooperation in social insects

- Sex determined in eusocial insects by haplodiploidy
- Workers related to each other by 75%
    - o Half workers related to each other by 50% and half related by 100%, average = 75%
    - o All worker offspring from queen bee mating with just one male will receive same set of alleles from male parent (50% degree of relatedness among them)
    - o Like other diploid organisms, workers are related to each other by an average of 25% through their female parent
- 75% is a higher degree of relatedness than would have been achieved by having workers be fertile rather than just the queen bee
- Favours cooperation in insects because workers will devote their lives to caring for their siblings (queen's other offspring) because a few of these siblings (those carrying 75% of

the workers' alleles) may become future queens and produce enormous numbers of offspring themselves

Post Lecture

1) Whether a particular social behaviour represents cooperation, competition, spite or altruism

- If both the actor's fitness and the recipient's fitness increases, it is cooperation
- Altruism – actor's fitness decreases but recipient's fitness increases
- Selfishness – actor's fitness increases but recipient's fitness decreases
- Spite – both actor's and recipient's fitnesses decrease

	Actor fitness increases	Actor fitness decreases
Recipient fitness increases	Cooperation	Altruism
Recipient fitness decreases	Selfishness	Spite

2) Why "altruistic" and "spiteful" behaviours are both difficult to reconcile with natural selection

- Both altruistic and spiteful behaviours do not increase the actor's fitness
    - o These behaviours should therefore be eradicated through natural selection
    - o Not favoured by selection due to individuals having less fitness
- Traditional explanation for altruism: sacrifice the fitness of the individual for the overall good of the population
    - o Not a satisfactory explanation; selection would weed out traits that are good for the group at the expense of the individual
    - o Also selfish individuals that are introduced into altruistic groups should have a huge selective advantage; this does not explain why altruism persists
- Spiteful behaviours are also difficult to reconcile because they decrease the fitness of both the actors and the recipients; doesn't occur in nature because natural selection works against it

3) How kin selection theory explains the persistence of helpful behaviour

- Kin selection theory: individuals are more likely to help close relatives survive because they share some of their alleles; these alleles would then be able to be passed on to the next generation of offspring
- Can be used to explain altruism
- Although the direct fitness of the actor may be reduced, their indirect fitness is increased because they are helping those with similar alleles to them
- If the benefit to the actor's indirect fitness outweighs the cost to the actor's direct fitness, the behaviour is favoured by kin selection
    - o i.e. if their inclusive fitness is positive, then the behaviour is favoured

4) Situations in which kin selection does, or does not, favour helping non-descendant relatives

- Helpful behaviours persist if $rb>c$
    - o r is degree of relatedness; b is the benefit to the actor; c is cost to actor

- E.g. would lay down your life to save two brothers or 8 cousins because brothers are related by 0.5; cousins are related by 0.125 so if you save 2 brothers or 8 cousins then theoretically all your alleles could be maintained to the next generation
- Specific example of helping non-descendant relatives: adult ground squirrels screeching to warn young squirrels when there's a predator
  - This decreases the fitness of the adult but increases fitness of young squirrels
  - Direct fitness of the adult may be reduced but their indirect fitness is increased
- In an example of helping your brother:
  - From your perspective, you would help him if b>2c
  - From your mom's perspective you should help him if b>c
  - From your brother's perspective you should help him if b>c/2

5) Meaning of direct fitness, indirect fitness, inclusive fitness

- Direct fitness – the lifetime reproductive success of an individual
- Indirect fitness – helping relatives survive to pass on some of your alleles; would not have otherwise survived without your help. This is kin selection theory.
- Inclusive fitness – the sum of the direct and indirect fitness

6) Why interests of parents may conflict with interests of their offspring

- Parent-offspring conflict: occurs before birth. The fetus and the mother disagree as to how many nutrients the fetus should get
  - Fetus's demand for nutrients are higher than what is deemed appropriate by the mother
  - Fetus secretes hormones to increase mother's BP and blood sugar levels; over time the mother reduces sensitivity to these hormones so the fetus secretes more of them
  - Can be fatal to the mother and consequently to the fetus if BP and sugar levels rise too much
- This occurs due to the differences in relatedness between the fetus and the mother as well as the fetus and its siblings
  - Mother and fetus have 0.5 degree of relatedness, but the relatedness between this fetus and every other sibling is also equal to 0.5
    - Thus mother gives some nutrients to the fetus but has to save some for other offspring
- **Monogamous species**: mate for life with a single partner
- **Promiscuous species**: both sexes have multiple mating partners
- Parent-offspring conflict is **greater in promiscuous species** because the degree of relatedness between offspring is less (0.25)
  - Makes fetus more "selfish" to their own needs; demands even more nutrients from the mother because they don't foresee the needs of their siblings

Lecture 17 – Cooperation and Conflict 2

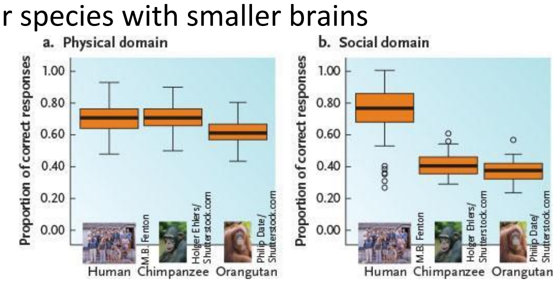
Pre-Lecture Readings

1) Meaning of cultural intelligence, ultimatum game, rational maximizer

- Cultural intelligence – large brain size enables us to perform cognitive tasks more efficiently and quickly than our close relatives (especially social related tasks)
- Ultimatum game – proposer is offered a sum of money or food, and they can decide whether or not they will share it with the responder or not. If the responder accepts whatever they are proposed, both individuals get to keep what they have. If the responder declines what they are proposed, neither individual gets anything
- Rational maximizer – Show little sensitivity to fairness or the interests of others.

2) Similarities and differences between humans and closely related species (eg chimpanzees) in cognitive ability, "cultural intelligence", response to the "ultimatum game", and the value of fairness

- Cognitive ability: large brains of humans allow us to perform more complex cognitive tasks more rapidly and efficiently than other species with smaller brains
- Cultural intelligence: although humans, chimps, and orangutans performed relatively equally in physical tests, the two year old humans were more advanced in the social world



- Ultimatum game: chimps are rational maximizers. They will accept any offer that they are given because it will always be better than receiving nothing at all. Meanwhile humans are more sensitive to the needs of others, and they value fairness more. Humans typically reject offers less than 30% because they want equal rights basically

3) Relative risk of child abuse in families in which not all the adults are genetically related to all of the children

- Children whose parents are not genetically related to them (stepchildren) are 40 times more likely to suffer from child abuse
- Humans have some genetic trait that makes it more difficult to invest in children that aren't their own, particularly if they take care of their own genetic children

Post Lecture

1) How mating system affects intensity of parent-offspring conflict

- Monogamous mating systems have less intense parent-offspring conflict
- Offspring in monogamous systems are more closely related to their siblings than offspring in promiscuous systems
    - In promiscuous systems fetus is more "selfish" to their own needs because they don't foresee the needs of their future siblings

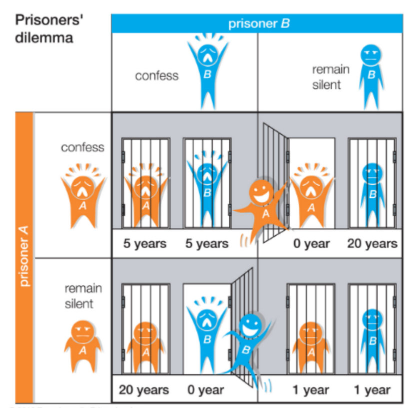
2) Conflict hypothesis for how different interests of maternally vs paternally derived alleles influence embryonic growth

- Vast majority of genes have one allele from dad and one from mom; both expressed
- ~1% of protein producing genes in mammals have one allele that is expressed and the other is silenced (called genomic imprinting)

- Most of these genes regulate embryonic growth; some are located in the brain and are related to social behavior
- Loci with maternal expression downregulate embryonic growth; loci with paternal expression upregulate embryonic growth
- Conflict hypothesis for genomic imprinting: which allele is imprinted (silenced) and which is expressed, reflects conflicting interests of maternally vs paternally derived alleles
    - o Maternal alleles would make more sense to save energy for future offspring; thus demands less resources from the mother as an embryo
    - o Paternal alleles would try to extract as many resources as possible from the mother; this increases the chances of paternal alleles being preserved
- This concept is more applicable in promiscuous systems where one offspring may not have the same father as another; even with the same mother
    - o Less relatedness between offspring

3) Why the interests of uniparentally transmitted genomes can differ from those of biparentally transmitted genomes
- Nuclear genomes are inherited biparentally (from both mother and father)
- Other genomes are inherited uniparentally
    - o Mitochondrial DNA is inherited maternally
    - o Chloroplast DNA in plants can be either inherited maternally or paternally depending on the species
- From the point of view of a mtDNA gene in a plant, it would be a waste to invest in male function. It would make more sense to invest only in female function because mtDNA is passed on maternally; thus the only way to pass on mtDNA is to invest in female function

4) Conditions that favour or disfavour cooperation between non-relatives, in the Prisoner's dilemma



- Prisoner can make a choice to cooperate or defect; objective is to minimize own jail time
- In cases where the game is only played once the rational choice would be to defect since it would minimize jail time (0 or 1 year)
- However, when the game is played repeatedly with the same person, then cooperation may be favoured
- Your decision in one round influences the consequences of the next round
- You rub my back I'll rub yours (reciprocal altruism)
- Thus cooperation is disfavoured when the game is played once. Cooperation is favoured when the game is played several times repeatedly with the same individual

Lecture 18 – Life on Earth

Pre-Lecture Readings

1) How the relative position of fossils in sedimentary rock strata (higher vs lower) reveals their relative age

- Sedementary rock that is lower is older; fossils deposited in these strata are therefore older species
- Younger species are deposited in higher strata

2) Ways in which fossils can form

- Fossil skeletons formed when dissolved minerals enter spaces b/w bones and solidify
- Plant fossils are moulds or impressions; footprints can also be fossilized when stepping in mud
- Early humans or animals have been frozen or mummified to become fossilized
- Droppings and gastroliths can also be fossilized
- Petrified forests and trees fossilized by minerals

3) Reasons why the fossil record is incomplete

- 3 reasons: few organisms fossilize completely, some organisms are more likely to fossilize than others, and natural processes such as erosion can destroy fossils
  - Thus some fossils may be missing from the fossil record

4) Importance of animal skeletons to the fossil record

- Animal skeletons led to an increase in fossil abundance
  - Skeletons are more likely to be preserved (minerals entering spaces between bones and solidifying)

5) Approximate age of the first living things, the first eukaryotes, and the first multicellular eukaryotes, based on fossil evidence

- Stromatolites (layers of bacteria) date to 3.5 bya
- Oxygenic photosynthesis by blue-green prokaryotes and plants led to increase in atmospheric oxygen 2.5 bya
- Earliest unicellular eukaryotes came up just over 2 bya
- Multicellular eukaryotes 1.2 bya
- History of life is **not gradual**; bursts of life come up (e.g. 600 mya an explosion in diversity of groups of species marked the beginning of the Cambrian era)

Post Lecture

1) Most recent common ancestor (MRCA) for a given group(s), given a phylogenetic tree.

- MRCA occurs at nodes in a phylogenetic tree
- LUCA is the descendent of **all** living things on earth right now

2) Why the idea that “humans are descended from chimps” is inaccurate.

- Humans are not descended from chimps; rather, we shared a common ancestor with chimps and bonobos some time ago that didn’t exactly look like humans, chimps, or bonobos – rather shared some features that are common to all three groups

3) Why some traditional groupings of organisms ("reptiles", "fish") do not reflect evolutionary relationships

- Traditional systematics classify the reptilia taxa together but exclude birds (i.e. include turtles, lizards, crocodiles but not birds)
- However some reptiles are more closely related to birds than they are to other reptiles
- Same concept with fish; some fish are more closely related to us than they are to other fish
- Therefore traditional groupings do not always accurately reflect evolutionary relationships
- Look only at morphological characteristics which may not reflect relationships

Lecture 19 – Phylogeny

Pre-Lecture Readings

1) What types of traits are useful in determining evolutionary relationships

- Phylogenies show the evolutionary histories of groups of organisms; they are formal hypotheses that represent evolutionary relationships between organisms
- Before Linnaeus phylogenies were classified based on morphological characteristics
- Over time more traits were being used to determine evolutionary relationships
    - o Patterns of behaviour, chromosomal anatomy, details of physiology, morphology of subcellular structures, cells, and organ systems
- These additional traits started being studied over the past 50 years
- Homologous, analogous, ancestral, and derived characters indicate evolutionary relationships between different organisms

2) Meanings of mosaic evolution, ancestral character, derived character

- Mosaic evolution: Different characters evolve at different rates. Some characters evolve slowly while others evolve more rapidly
- Ancestral characters: characters that are present in distant common ancestors
- Derived characters: characters that are present only in the MRCA
    - o Useful because once established they persist in all the species' descendants; they are markers for evolutionary lineages
    - o Derived characters are only classified in comparison to other organisms; you determine what is the ancestral state then whatever species is different then that species would have the derived character

3) Whether ancestral or derived characters are more useful in determining evolutionary relationships

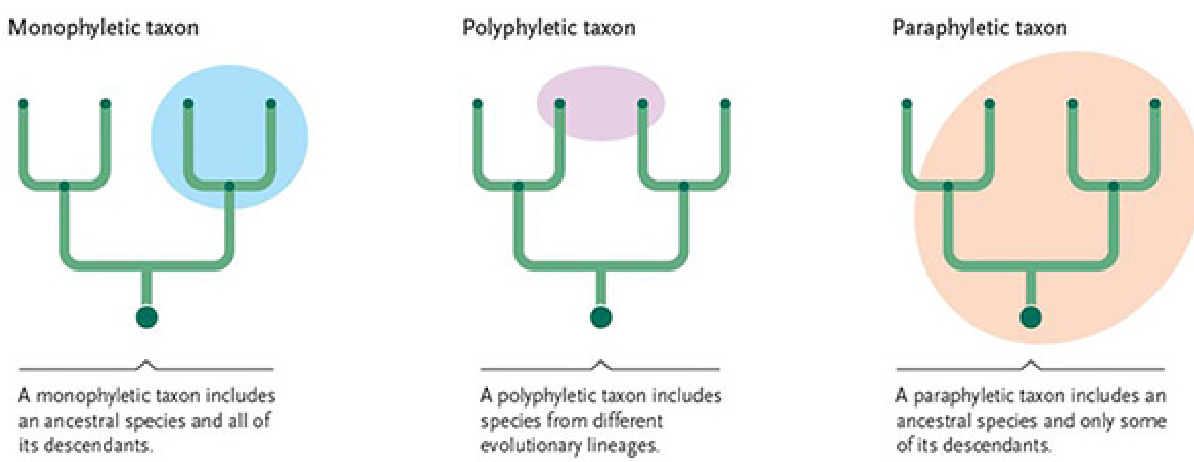
- Derived characters are more useful in determining evolutionary relationships
- Once established, they persist in all the species descendants
- Unless they are removed from the species by being lost or replaced over time, they can be used as markers for that species and the entire evolutionary lineage

4) Ways in which cladistic systematics differs from traditional evolutionary systematics

- Traditional evolutionary systematics uses phenotypic similarities and differences to infer evolutionary relatedness
    - Places together groups of species sharing ancestral and derived characters
    - Reflects both evolutionary branching and morphological divergence
- Cladistic systematics ignores morphological divergence
    - Morphological divergence: microevolutionary changes in the morphological structure of an evolutionary lineage; results in similar traits in a wide variety of species
    - Reflects only evolutionary branching
    - Place species that share derived characters in a group; called a clade
    - Ancestral characters are excluded from analysis

5) Recognize monophyletic and non-monophyletic groupings (taxa), given a phylogenetic tree

- Monophyletic taxa: a group of organisms derived from a single ancestral species
- Polphyletic taxa: species from separate evolutionary lineages; do not share a RCA
- Paraphyletic taxon: includes an ancestral species and only some of its descendants



6) Difference between homologous and homoplasious traits

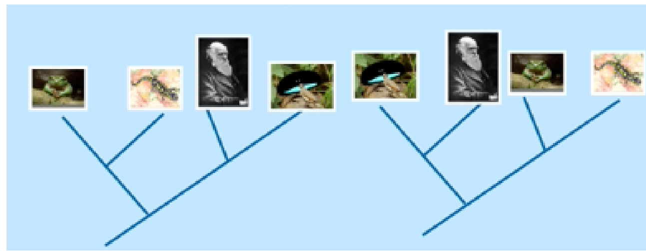
- Homologous traits are characters that are similar in their evolutionary history but not necessarily in their function
    - Reflect genetic similarities and common ancestry between species
    - Come from comparable embryonic structures
- Homplasious traits: also known as analogous characters; they are different characters that serve the same function, but not present in common ancestors
    - Excluded in genetic analysis; genetic ancestry is not shared
    - E.g. wings of birds, bats, insects, and pterosaurs all serve the same function
    - However the surfaces of bird wings are homplasious with bats and pterosaurs (birds are feathered and bats/pterosaurs have skin wings)

Post Lecture

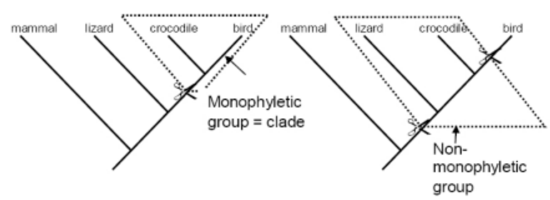
1) Relatively close and relatively distant relatives, given a phylogenetic tree

- Close relatives have a more recent common ancestor

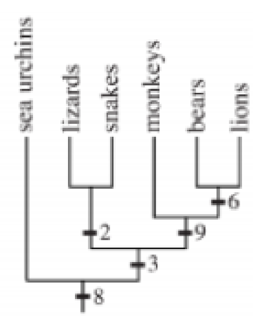
2) Whether or not two phylogenetic trees convey the same information
- Can rotate phylogenies around nodes (axes). This doesn't change the information of the phylogeny however; sequence of speciation would still be the same
- Basically just look at the relatedness between different species (when they share a common ancestor). The species must be related to one another in the same manner in order for two phylogenetic trees to be the same
- The two trees shown here convey the same information!!



3) Monophyletic and non-monophyletic groupings, given a phylogenetic tree
- A monophyletic group has a single ancestral species with all of its descendants
    - Polyphyletic groups have different evolutionary lineages (MCRA is further down in evolutionary history)
    - Paraphyletic groups have an ancestral species with only some of its descendants
- On a phylogenetic tree, a rule of thumb is to make "cuts" on the phylogenetic tree
    - If a group can stay together with one single cut, then it is monophyletic
    - If it takes two or more cuts to group species together, then that group is not monophyletic



4) Meaning of synapomorphy, symplesiomorphy, autapomorphy; and know which of these is considered informative in cladistic analysis



- Synapomorphy is the only one that is useful for cladistics analysis
    - **Synapomorphy:** traits that are both *shared* by a group of organisms, as well as *derived* from a recent common ancestor
    - Trait 6 is a synapomorphy because it is shared by lions and bears and it is also relatively recent in evolutionary history
- **Symplesiomorphy** are not useful for cladistics analysis. They are traits that are *shared* by two or more groups but are *ancestral*
    - Trait 8 is not useful because it is an ancestral trait that is shared between vertebrates and invertebrates; not derived
    - Doesn't allow us to differentiate between monkeys, bears, and snakes
- **Autopomorphy** are traits that are *unique* to one single group; they are *derived* within that group

- If bears have a trait that no other species have then that trait is not useful to determine evolutionary relatedness between species

5) Traits that are probably derived vs probably ancestral, given a phylogenetic tree and a suitable outgroup

- If a trait is present in the outgroup and ALL of the ingroup, then that trait is most likely ancestral
- If trait is present in the outgroup but only some of the members of the ingroup, then the most likely explanation is that having the trait is the ancestral state
- If the trait is absent in the outgroup, but present in SOME of the ingroup then the most likely explanation is that the trait is derived
- If the trait is present in the outgroup, but NONE of the ingroup then it becomes difficult to tell whether or not the trait is ancestral or derived
  - Reason for this is that there are two equally likely possibilities here for ancestral or derived
- Traits that are present in ALL of the ingroup but none of the ingroup then it is also just as likely that it is either a derived trait or an ancestral trait

Lecture 20 – Phylogeny Part 2

Pre Lecture Readings

1) Distinction between parallelism and convergence, and how both of these differ from homologous similarities

- Tendency among organisms living under the same conditions to develop similar body forms
  - Can be parallel or convergent evolution
- **Convergent evolution** is referring to phylogenetically more distantly related organisms
- **Parallel evolution** is referring to more closely related organisms
- Homologous traits are characters that are similar in their evolutionary history but not necessarily in their function
  - If two distantly related species share homologous traits, then that is an example of convergent evolution. If two closely related species share homologous traits, then that is parallel evolution

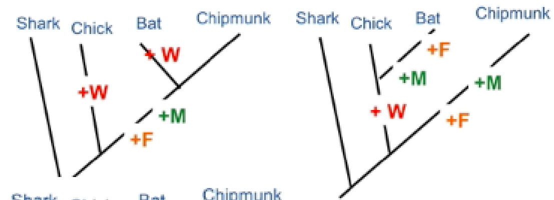
2) Whether carnivorous plants have likely evolved once or multiple times, and thus whether this trait is homologous or homoplasious

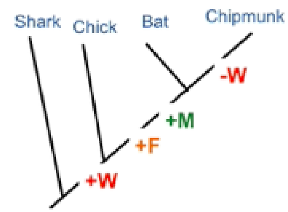
- In some places with lots of water/sunlight, nitrogen for plants can be short in supply
  - Plants trap insects to directly (or indirectly) obtain nitrogen
- Insectivorous plants catch insects in sticky traps, snap traps, and pitfall traps (pitchers)
  - Flypaper traps appear in at least 5 evolutionary lines and pitchers at least 3 times
- Carnivorous plants do not share a close common ancestor – this is a case of convergent evolution
- Therefore this trait is homoplasious (analogous trait) since it evolved multiple times in evolutionary history

Post Lecture

1) How the principle of parsimony informs outgroup analysis and helps identify the most likely phylogeny

- Principle of parsimony: the simplest explanation is most likely to be correct
- Use parsimony to determine the most likely phylogeny: the one that requires the least number of evolutionary steps is the correct tree
- Tree on left is more parsimonious since the total number of evolutionary steps is less
- Can also have alternative arrangements:





2) Traits that are, and are not, synapomorphies (given a suitable outgroup and a distribution of traits)

- Synapomorphies are **shared, derived** traits
- If a trait is present in the outgroup but only some members of the ingroup then it is most likely ancestral – this represents a symplesiomorphy; not useful
- If the trait is not present in the outgroup but present in some members of the ingroup then it is most likely derived – therefore it is shared and derived; synapomorphy
- Outgroup:
  - Shark: No milk. No fur. No wings. No beak.
- Ingroup:
  - Chicken: No milk. No fur. Wings. Beak
  - Bat: Milk. Fur. Wings. No beak
  - Chipmunk: Milk. Fur. No wings. No beak
- In the above example, beaks are autapomorphy since they are unique and derived; not useful. Milk, fur, and wings and synapomorphies since they are shared and derived.

3) Which phylogeny is more parsimonious, given a suitable outgroup and a distribution of traits

- The phylogeny with the least number of evolutionary steps is the most parsimonious.

4) Distinction between homology and homoplasy

- Homology – traits that are shared by two species due to common ancestry
- There's a difference between similarity and relatedness: similarity most of the time would reflect relatedness, but not always. Homologies reflect relatedness.
- Can sometimes be fooled by homoplasies; not all similarities are homologies
  - Can have convergence or divergence
- Convergence: two or more origins of a trait due to it being good in a particular environment; this is a misleading similarity and doesn't show that the species are not actually closely related
- Divergence: another source of homoplasy; two or more species look very different from each other due to different environmental conditions but they are actually closely related

- There's lots of sources of homoplasy and ideally you should avoid convergent evolution of traits for constructing phylogenies since homoplasies are misleading
- To tell differences between homology and homoplasy you must look beyond superficial similarities; look at whether the trait follows the same developmental process
  - If the developmental process of wings for example is different then that indicates independent evolving

5) Most likely phylogenetic tree of a group of organisms, given a suitable outgroup and a matrix of traits

- Most likely phylogenetic tree is the one with the least evolutionary steps

<u>Lecture 21 – Species Concepts and Speciation</u>

Pre-Lecture Readings

1) Criteria used by the morphological, biological and phylogenetic species concepts to define species

- Morphological species concept:
  - Uses visible anatomical characteristics to classify species; individuals of one species share measurable traits that distinguish them from other species
- Biological species concept:
  - Emphasizes genetic *cohesiveness* (same species experiences gene flow) and also genetic *distinctness* (populations of diff species cannot exchange information)
  - If two populations interbreed naturally and produce fertile offspring under natural conditions, they are part of the same species
- Phylogenetic species concept:
  - Use morphological and genetic sequence data to construct evolutionary tree; phylogenetic species share recent evolutionary history
  - Applicable to any group of organisms including extinct and asexual

2) Weaknesses/limitations of these different species concepts

- Morphological species concept:
  - Wide variety of traits could represent one species
  - Cannot distinguish closely related species that look nearly identical
  - Tells us little about evolutionary processes that produce new species
- Biological species concept:
  - Not applicable to asexually reproducing or extinct organisms
- Phylogenetic species concept:
  - Difficult to apply to all forms of life since not all species have detailed evolutionary histories

3) Distinguish between pre-zygotic and post-zygotic isolating mechanisms and recognize examples of each

Timing Relative to Fertilization	Mechanism	Mode of Action
Prezygotic ("premating") mechanisms	Ecological isolation	Species live in different habitats
	Temporal isolation	Species breed at different times
	Behavioural isolation	Species cannot communicate
	Mechanical isolation	Species cannot physically mate
	Gametic isolation	Species have nonmatching receptors on gametes
Postzygotic ("postmating") mechanisms	Hybrid inviability	Hybrid offspring do not complete development
	Hybrid sterility	Hybrid offspring cannot produce gametes
	Hybrid breakdown	Hybrid offspring have reduced survival or fertility

- Prezygotic: ecological, temporal, behavioural (signals b/w mates), mechanical, gametic (sperm and eggs incompatible)
- Postzygotic: hybrid inviability (die as embryos or at a young age), hybrid sterility (develop but are sterile), hybrid breakdown (F1 generation is fertile but F2 has reduced survival or fertility)

Post Lecture

1) Which species concept (morphological, biological, phylogenetic) is being used, given 'real world' examples

- Happy face spiders – under MSC they are all different species since they look different
- Under BSC they are all the same species since they interbreed
- With PSC, many groupings categorized as "subspecies" by BSC are monophyletic so they would be recognized as species by PSC
    - Radically shakes up what we currently consider to be species
    - Song sparrows; 20 different species in North America under PSC but only 1 species under BSC

2) Whether coming into secondary contact is required for speciation to occur

- Allopatric speciation is speciation that occurs when populations of the same species become geographically isolated from one another, preventing genetic interchange
    - What was originally one population separates to distinct populations and diverges; genetic drift can fix different alleles in two populations
- Secondary contact is **not required** for speciation to occur
    - If two populations do come into secondary contact we can use BSC to see if they breed with each other; won't be able to tell without secondary contact but speciation can still occur

3) Ways in which secondary contact can affect speciation

- In some cases populations don't have time to diverge enough from one another; if they come into secondary contact then you have **species collapse** – any speciation that has begun stops
- If two populations have been diverging for long periods of time then they become partly or completely reproductively isolated from each other

4) Whether prezygotic or postzygotic isolating mechanisms tend to be more costly

- Postzygotic isolating mechanisms are more costly
    - Specifically, hybrid sterility is the most costly – the female wastes parental care on growing offspring to adulthood but the offspring would never provide her with grandchildren

Lecture 22 – Human Evolution

Pre-Lecture Readings

1) Competing theories about where modern humans (Homo sapiens) evolved, and which is best supported by available evidence

- **African emergence hypothesis**: early hominin descendants came out of Africa
  - 100-200 thousand years ago, homo sapiens arose in Africa and drove other species to extinction; migrated to Europe and Asia
- **Multiregional hypothesis**: populations of archaic humans spread through Europe and Asia by 500,000 years ago; H. sapiens evolved from descendants of early dispersals
  - Geographically separated populations have evolutionary differentiation but gene flow prevents reproductive isolation; maintain them as a single species (sapiens)
- Genetic data supports African emergence hypothesis; work on Y chromosomes of men confirms that all humans are descendants of a single migration out of Africa

2) How different species concepts resolve (or do not resolve) the question of whether Homo sapiens, neandertals and Denisovans were all members of the same species

- Homo sapiens interbred with both Neanderthals and Denisovans; so under BSC they are not 3 separate species
- Under PSC, distinctions are not clear enough to determine
- Also not enough morphological evidence to apply MSC

Post Lecture

1) Conditions necessary for reinforcement to occur

- Reinforcement occurs when two populations come back together through secondary contact **and** have become postzygotically isolated (risk of low fitness hybrids)
  - Result is that selection would favour fast evolution of prezygotic isolation mechanisms
  - Females would be more fit if they mate assortatively
- Secondary contact can result in two outcomes:
  - If it occurs relatively early then you get species collapse
  - If it occurs relatively late then you get reinforcement; populations become prezygotically isolated

2) Arguments for and against the idea that human are no longer evolving.

- Arguments for:
  - Tremendous amount of selection is still going on in the developing world
  - Gene flow is stronger; there's more connectivity now than in the past
- Arguments against:
  - Genetic drift is weaker now than it was before; much bigger population size
  - Mutations: males over the age of 40 have had more opportunity to have mutations in sperm; not many fathers over 40 now but in the past there was

3) Evidence for recent evolution in humans.

- Selective sweep: if an adaptive mutation increases in frequency, adjacent stretches of DNA come along for the ride
- Recently favoured SNPs will have little variation in surrounding sequence (called linkage disequilibrium); everyone has similar sequence of DNA around the SNP
- HapMap project found that there are lots of SNPs that have been favoured over the past 40,000 years (selective sweeps); about 100x more evolution occurred
- Recently selected SNPs often vary geographically
- Not a fine temporal scale; we want to know if we are still evolving right now
- Evidence from study of Massachusetts women shows that natural selection is operating on reproductive success; shorter, higher BMI, earlier puberty and later menopause

4) Costs of large brains.

- Energetic costs: brains weigh 2% of the body mass but use 20% of its energy
- To have a big brain you need a big head; this leads to difficulties in childbirth

5) Possible advantages of large brains as proposed by the "utility hypothesis" vs. The "mating mind hypothesis"

- Utility hypothesis: having a big brain allowed ancestors to survive better
    - Develop language for hunting expeditions; use tools more effectively
        - Don't actually need to be this smart to accomplish tasks of survivorship
        - Seems wasteful and extravagant for natural selection
- Mating mind hypothesis: use big brains to make jokes, music, art, etc.
    - Increases mating success; better for sexual selection

Lecture 23 – Evolutionary Arms Races

Post Lecture

1) Mutualistic, competitive and antagonistic relationships between species, given 'real world' examples

- Mutualistic: form of cooperation between species, for example between plants and pollinators or humans domesticating animals or plants
- Competitive: two species fighting for access to the same resource, such as water or prey. Both species would be better off if the other one wasn't around.
- Antagonistic: one species benefits from an interaction while the other suffers. Predator-prey interactions are examples of antagonistic relationships, or host-parasite interactions

2) Factors that advantage one side or the other in an evolutionary arms race

- Speed of evolution: one species may take fewer generations to evolve certain traits, allowing it to get ahead of the other species in terms of evolutionary advantage
- Size of population: if one species' population is larger than the other species, it will have an advantage due to it being more likely to produce beneficial mutations to outcompete the other species

- Differences in selection pressure: if one species has a higher selection pressure than the other species, then it will be at a disadvantage. Life-dinner principle.

3) Meaning of 'life-dinner principle'
- Road runner vs. coyote. The road runner has a higher selection pressure acting on him than the coyote does; his life is at stake while only the coyote's dinner is at stake. The road runner has to win the evolutionary arms race every single time but the coyote only has to win it sometimes.

4) Difference between prudent-parasite hypothesis and trade-off hypothesis, in terms of the evolution of virulence
- Prudent-parasite hypothesis: selection prefers parasites becoming less and less harmful over time. This predicts a decrease in the virulence of the virus
    - Viruses that have high virulence probably haven't been affecting hosts for very long; Ebola has only recently infected humans which is why it's so dangerous but AIDS has been infecting for longer which is why it's less dangerous
- Trade-off hypothesis: viruses must balance the costs of being virulent with the benefits of being virulent. If the virus is more virulent, then it will be able to colonize new hosts much more effectively. However, surviving as long as possible in a single host would favour less virulence

5) Factors that influence the optimal virulence of a given host/parasite relationship
- Parent-offspring transmission (vertical transmission) favours less virulent parasites
- Surviving as long as possible in a single host favours less virulence
- High density environments for hosts favours high virulence

6) Costs and benefits of being highly virulent (from the point of view of the parasite)
- Costs: kills the host too soon, not being able to infect other hosts
- Benefits: allows transmission to be more effective

7) Why improving equipment for survival does not always translate into 'winning' an evolutionary arms race
- If both species are evolving at the same time then neither species actually has an advantage over the other
- If you compare the success of lions now to their success a long time ago they're actually less successful now despite being faster