Natural History Lecture Notes

WEEK 1:

Course Objective:

- To gain insights into the challenges all living things face, and the remarkable diversity of solutions used to solve them
- to develop an appreciation and respect for ALL LIVING THINGS

What is Natural History?

- **Natural History is nature**
    - **living, breathing, dynamic animals…**
    - People often assume that “animals” means “mammals”, but its not. “Mammals” are a type of animal
    - Owls use their face on the ground to pick up noises
    - Snakes must shed their skin, and before this happens the eye becomes milky and cloudy
    - Frogs, snakes, turtles are amphibians/herpitiles, (herps for short) commonly the short form for reptiles and amphibians
    - One fly immune to carnivorous plants water, flesh fly
    - Freshwater sponge is an example of a colonial animal, since they are grouped together.
    - **Natural history is also living, dynamic plants**
    - **Natural History is the interaction between plants and animals.**
    - Insects don’t see the colour red but hummingbirds do, so they are the only pollinator for cardinals
    - Story is more than the picture ie. bird eating fruit on a plant, and then shitting out the seed somewhere else. The plant is actually using the animal.
    - **Interactions between animals and animals as well as plants and animals**
    - Parasites generally don't kill their hosts, but parasatwites* do.
    - **Natural History is the REAL WORLD. It is the only reality show.**
    - **Natural History is the OBSERVATION of living plants and animals- FLORA AND FAUNA- and their interactions. It is an OBSERVATIONAL SCIENCE.**
    - **Someone with a general interest in Natural History is a NATURALIST (not a nature photographer) (respect and admiration for the natural history)**
    - Being a naturalist allows you to see the world around you, and it provides you with a lot of opportunities because not a lot of people can do it

Component 1: Staying Alive

- How do they protect themselves against getting eaten by something else?

#1 DEFENCES:

- One line of defence is what the animal looks like: APPEARANCES
- ie . camouflage (concealment, the animal is hidden from view in some way)

- Might also involve being motionless in order to remain camouflage
- Animals resemble their background AND they are motionless (so cryptic behaviour as well as appearance)
- Grasslands (fields, meadows) have vertical lines. (this is the dominant trait). If an animal wants to blend in they should have vertical lines. When these animals (ie. birds) are motionless, then they blend in with their surroundings.
- **The whole process of having your appearance match the background your in is called BACKGROUND MATCHING (ie. the American Bittern*** which is a marsh bird and uses vertical lines to blend in) *******
- Different habitats have different patterns.
- Forests: light and dark parts to them. Dapple or speckled patterns might be more common in order to blend in (ie. Ruffed Grouse- light and dark areas all over their feathers) (ie. Spruce Grouse- dappled patterns with dark and light spots) (Background Magic)
- Fawn white tailed deers-only have spots when they are babies to blend in with forest floor.
- Animals on bark would have patterns to match the bark
- One of his favourite animals: FROGS, ie. tree frogs blend in with the bark.
- Gray tree frogs are not always grey, they can change their colour to match their background. This is one of the only animals that can do this.
- **Whenever you have an animal that is imitating something else, its mimicking it. (ie. a bark mimic from the frog)**
- **Animals associated with tree trunks often bare a similar pattern, and they are mimicking it.**
- Is there a difference between mimicry, background matching, and camouflage?
    - Sometimes they are one in the same, sometimes one is a type of the other. Slightly different concepts.
- **If a habitat changes through the seasons ie. snow, then they need to vary their appearance. (ie. snowshoe hare (aka. Varying hare)**
- **Seasonal colour change* in order to match their habitat.**
- **Colour patterns can be used for concealment **1:11:56) (listen again)**
- **Many songbirds have eyelines and eye stripes for concealement**
- If there is not a solid shape for a head, then it's harder to see than if it was a solid mass
- **This is called DISRUPTIVE PATTERNS (in conjunction you need cryptic behaviour staying motionless)**
- Ie. Killdeer have distinctive breast bands, that help the bird hide. These breast bands break up the shape of the head when the bird is sitting on the nest, making it tougher to see.
- Ie. a canadian goose has a chin strap as a disruptive pattern, it separates the body from the shape of the head, making it less noticeable.
- Ie. loons have a disruptive pattern. (necklace)
- Also can be called patterns of disruption
- **Leopard frog: coincident disruptive coloration (look up def)**

- **Coincident disruptive coloration or coincident disruptive patterns are patterns of disruptive coloration in animals that go beyond the usual camouflage function of breaking up the continuity of an animal's shape, to join up parts of the body that are separate.**
- **Dayfly Moths: join their wings together to make a continuous pattern of line and dark (Group Coincident Disruptive Coloration)**
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#2 DEFENCES:

- **Shape**
- Some butterflies have a shape that resembles dead leaves. When the wings close, the pattern beneath looks like a leaf (angle winged butterfly- angles that resemble leaves, and differential colouration)
- **Angled winged butterflies are a good example of animals that use body shape for camouflage ******
- **Masquerade is when the body shape of an animal is modified into something that resembles the background. (shape as well as colour)**
- For these butterflies, it's also a bit of dead leaf mimicry.
- Datona? moth also look a rolled/hollow/dead leaf. This is masquerading.
- Stick bugs is another example of masquerading! They are twig mimicry as well. They are called "walking sticks".
- Tree-hopper bugs resemble thorns on trees. This is thorn mimic.
- Animals body structure resembles the structure of a plant/tree etc.
- Some moths (ie. bird dropping moths) resemble animal excrement. That's a form of bird dropping mimic!
- Some caterpillars are bird dropping mimics as well
- Adding camoflouge can also be done, on top of changing shape or colour
- Ie. camouflaged looper- this caterpillar adds petals to its body to be more camouflage
- Sometimes animals can also make material to help them camouflage. Sometimes you might notice something that looks like spit on plants. This is a spittlebug. This is the young version of another bug.
- Clumps of white wooley material on branches, under these filaments of white there are bizarre animals hiding. They secrete this wooley like substance. Therefore they are called, "Wooly Aphids". They have body guards on top of their masquerade, carpenter ants.
- Scarlet lily leaf beetle- the babies have these sacs around their bodies so the poop stays in the sac. They are covered in excrement. This is when they are larvae. When leaves fall down, they stick on top of it. This is also masquerading.

So what about water?? You can't have a body shape that matches water.

- **Bicolouration offers Background Matching in two directions**

- ie . whirligig beetles. Whirligigs are bicoloured, they are black from above and white from below
- Bicolouration is another form of camouflage
- **One group of aquatic insects has a dark underside and a white upper surface**
- **Why is this?? Why is it the opposite?? They swim upside down!! They are called backswimmers.**
- White tailed deer are also dark above and light below. When they are standing still and the sun is shining on them the upper part of the body will shade the belly.
- If the upper part shades the lower part, they become less visible. If not, they would be more visible. **This is called COUNTER-SHADING or SELF SHADOW CONCEALMENT.**
- **A shadow from above makes them appear one solid colour and have beaver taless depth dimension to them.**
- Even wolves, bunnies etc. have pale bellies. This helps with camoflouge
- *******Underwinged moth- they blend in with the background with their wings closed, and underneath they have bright colours.
- **This is called STARTLE PATTERNS! Hidden until their needed.**
- **Plan a) background matching! Plan b) startle patterns!**
- Not all of them would have the same pattern, otherwise no animal would be surprised by it
- **Sphinx Moth- startle patterns in the shape of eye spots! Eye spots will really startle another animal until the moth can hide.**
- IO Moth- beautiful eye spot startle patterns.
- Gray tree frogs- bark mimics, they resemble bark. But if plan A FAILS, when they jump they have bright yellow under their legs which could be a startle pattern (colour)
- Ring-necked Snake- and red-bellied snake- dark on the top, but bright colours on the underside. What would the function be? A startle pattern.
- **Giant Swallowtail caterpillar- looks like bird poop. But it also has a plan B, it shoots a coloured structure out of its slot on its face, looking like a snake tongue. This is a STARTLE STRUCTURE (an osmetarium)!! Then the predator leaves it alone. There is also a chemical on them that smells really bad.**
- Do beavers have a defence? They slap the water with their tail! This beaver tail slap is a **STARTLE SOUND!** It warns its comrades that danger is present, but it also scares the threat. Beaver tail slaps are just like snowflakes, they are all different.
- If it's really alarmed, the head goes down first, and the tail is used as leverage. So here there are two water events, water being thrust up, and then the tail slapping the water down.
- Morning doves have a whistling sound that perhaps is a startle sound.
- **Ruffed grouse take off with an explosions of wing sound. This is also a startle sound!!**
- **STARTLE PATTERNS are hidden until needed**
- **EYED ELATER *********. It's a beetle with big eyed spots. They are always visible, so do tiger swallowtail caterpillars. They are always visible. So does the common**

green garner (dragonfly). THESE AREN'T STARTLE PATTERNS. So what is the purpose?? INTIMIDATION! Predators are deceived into thinking the animal is larger than it is. Some eyespots are always visible.

- **Click beetles is another name for them, they can click themselves back into position when they are caught on the**
- **Startle patterns can also be called distraction patterns,** because maybe the bird or predator tries to grab this part of the body that is less important. It distracts the attention of the predator to that part of the body. **(so first reason is startle, second is distraction)**
- **Distraction pattern: they can deflect predators attack to a non-vital part of the body (also called deflection patterns)**

Distraction:
Disruptive
Deflective:
EXAMPLE: Underwinged moth

- **First line of defence: background matching (looks like bark)**
- **Second Line of Defence: startle/distraction patterns when it opens it's wings.**
- **Third Line of Defence: deflection?**

WEEK 2

RECAP:
First line of defence: camouflage
Second line of defence: startle the predator

Some butterflies have eyespots. Lots of butterflies have these spots. If the predator goes after these spots, there are after bite marks at those spots. So eyespots can deflect the attack to a non vital body part. (this is a deflection pattern)

- Some butterflies have tails eg. hairstreaks
- Associated with these tails are pretty bright colourations
- What are these tails for/
- These tails can look like antennae on a "head"
- Now if a bird came along and grabbed the head of that butterfly by its TRUE head, it would be fatal. The butterfly would be dead. But if this bird is fooled into thinking the tail at the back is the head of the butterfly, the butterfly can escape. Tailless but still alive.
- These tails are also distraction/deflection structures.
- THEREFORE, fake antennae and fake heads can serve as deflection or distraction structures
- ****SWALLOWTAIL butterflies also have "tails" that may act as distraction structures

- ***Five-Lined Skink- interesting tail, bright blue. Slightest touch on the tail and the tail breaks off the body and starts jumping around on the ground, as if it was alive. It will regrow a NEW tail. Also a distraction/deflection structure.
- The ability to break off part of the body and grow it again is called autotamy

- PHYSICAL defence can consist of BODY ARMOUR
- Really hard outer surfaces that are hard to get through
- Example: millipedes, they curl up and protect their soft inside
- These shells are normally made of calcium
- Snails also have those shells, when under attack they can pull inside the shell
- A lot of beetles have really hard body armour, when they are under attack they pull their legs underneath
- Clams (bivalves) are animals with body armour. They have shells.
- Turtles! Their body plan has not really evolved over time, and that is because they have a wonderful body plan. Turtle shells are body armour.
- Blanding turtle is unique because its partially hinged and they can start to close the shell. This offers more protection
- There are two parts of the shell:
    - The Carapace: the upper part
    - The Plastron: bottom part
- You can roughly get an age on turtles by counting the rings on shell
- There are always drawbacks to each adaptation: no defence is perfect!
    - ie . otter eating turtles because they have incredible canine teeth
- One turtle is different, cannot withdraw into shell, does not have a plastron, and has an aggressive defence
    - Snapping turtles!!
- Snapping turtles: cannot fully withdraw into shell! Therefore there defence is to snap at whatever is attacking them. They also have sharp claws. They can live to be 100. They lay 30-60 eggs a year but most get dug up or destroyed. They have a hard time having young produce successfully. Having older turtles is important.

- **Sometimes soft structures can offer protection as well**
- **Ex. Eastern tent caterpillar silk tent**
- These caterpillars work collaboratively, they spin a web out of silk to go around them. This is protection because very few animals want to bite through this.
- They leave during the night to get food when the birds aren't as active and come back during the day
- As well, they themselves have lots of soft hair on their bodies and many birds don't like eating things with hairs because it's unpleasant to eat
- If you see a big web at the end of summer, you are seeing a fall webworm silk tent
- These webworms enclose leaves within their tent and eat those leaves. So they stay in the safety of this protection.

- **Therefore, physical defense can be soft hairs as well**
- **Sometimes these soft hairs can modified into stiffened (stiff) spines**
- **Then if you grab the caterpillar its not soft anymore, its prickly**
- **Generally, longer hair caterpillars are soft, and shorter are spiky.**
- **Ie. woolly bear caterpillar. They also roll into a ball when under attack to protect the soft underparts**
- Some mammals use hair for a defence mechanism as well: porcupines!
- **Mammals can use stiff hair for defence**
    - **Ie. porcupine**
- **Porcupines have many quills on their body, especially around their head, and especially the tail**
- **Quills are modified guard hairs.**
    - Mammals have two types of hair, they have guard hairs (the long hair on outside) next to the skin they have underhair thats wooly for warmth.
- **Porcupines can NOT shoot quills thats a myth**
- Quills have overlapping scales (almost like pine tree)
- About 20,000 quills on a porcupine on average
- As soon as a quill penetrates something, it comes right out very easily
- Quills also have antibiotics on the quill
    - Sometimes they can impale themselves, so maybe they are there for their own benefit?
    - Could be that younger animals watch their mom and dad learn not to mess with porcupines then they don't
- Some animals have poison on their spines...

CHEMICAL DEFENCES

- **Hairs+Poison= Poison Spines**
- **These are defences involving chemicals**
- Io Moth Caterpillar **
    - Long injector spines
    - These spines, when they impale something, inject toxins in that seriously burn
- Are these animals camoflouged? NO
- Animals that tend to have a chemical defense tend to advertise it
- **Poisonous caterpillars are usually brightly coloured**
- Animals that are brightly coloured tend to have some sort of nasty defence
- Ie. milkweed tussock caterpillars *
- Anything with the name milkweed or associated with feeding on milkweed is generally able to store poison from the plant in their body. So they don't have poisonous spines but they contain the chemicals and they are brightly coloured.
- **Giant Leopard Moth has Poison Spines**
    - It doesn't look bright until its attacked and when it rolls up it reveals red

- Animals usually advertise their toxicity: These are “warning colourations”
    - **Aka. Aposematic colouration********
- **Wasps have stingers (ie. yellow jackets) they are brightly coloured.**
- **Red Eft Salamander is brightly coloured (red) and is toxic**
- **Milk weed beetle is another example**
- **Notice how in nature the warning colours are often red or yellow, orange sometimes too. Very bright, vibrant colours.**
- **Warning Colouration= Aposematic Colouration**
    - **Means don’t touch!!**
- **Ladybugs manufacture their toxins**

- Some animals that are active at night still have a chemical defence
- Ie. skunk
- Skunks are black and white (a warning colour visible at night!!!)
- Porcupines are night active, they have white base on their quills, so they still have warning colours.
- It makes them more visible, not invisible
- ** Black and White, Aposematic at Night!!
- ** Colour in day, keep away!!

- Some animals like ladybugs can manufacture their toxins, but some (most) cannot.
- **Other animals obtain chemicals by eating plants that contain them**
- **Ie. Monarch Caterpillar**
    - **They eat milkweed**
    - **They Sequester Cardiac Glycoside (terpenoid) poison from milkweeds**
    - **They store it in their body**
    - **Any animal that eats milkweed does that.**
- **Milkweed Tussock moth caterpillars also sequester cardiac glycosides from milkweed**
    - When an animal eats a source and maintains the characteristics in its body (the poison) it’s called sequestering
    - So the animal is sequestering their defences from the plant that creates it
    - Only a few can actually eat those plants safely
- **Black swallowtail caterpillars sequester toxins from Water Hemlock**
    - They eat one of the most poisonous plants in north america (water hemlock)
    - If you pet a black swallowtail, these orange horns pop out of its head
    - **This is called osmetarium**

- Fire flies are not flies. They are beetles!
- **Photuris fireflies SEQUESTER steroidal toxins…**
    - The females acquire this by eating male photinus fireflies

    - So the male photinus fireflies fly around, photinus females sit up on a branch somewhere and watch
    - When they see one they like, they blink and the male and female photinus mate
    - So these Photuris go and fly in and sit there and blink. So the males go thinking its for love, but they actually get eaten.
    - **This is called AGGRESSIVE MIMICRY**
        - **When something uses mimicry to obtain a meal.**
- **Sawfly Larvae**
    - They can excude these droplets of toxins which are terpenoids from plants
    - So chemcials can be released through different body parts
- Blister Beetle
    - Play dead and then these drops excude from their leg joints
    - These drops are a chemical called cantharidin (a type of terpenoid)
    - This is used as an aphrodisiac

- Some animals have injector systems ie. yellowjacket wasps
    - They have a stinger on the end
    - This is a defence for other animals

- Skunks
    - Sulphur alcohol release opening

- Bombardier beetle
    - Hot quinone gas
    - They shoot out a burning cloud of gas
    - They can't store it inside their bodies, they store the ingredients in different chambers with thick walls, when they are attacked it mixes and pops out
- To review briefly, animals that have a chemical defence that is quite strong, usually advertise it through their colouration. This is called aposematic colouration.
- "Animals armed with chemical weapons often bear aposematic colouration. Aposematic colouration allows a predator to learn and avoid that colour pattern"
- "Once bitten, twice shy"
- Bumble bees probably gain safety from this concept, because predators might confuse them with yellow jackets, which they have learned not to eat.
- When a group of unrelated animals are all defended and bear similar appearances= mimicry
    - Mullerian Mimicry- all the animals that look alike (aposematic and brightly coloured) and they all have a chemical defence or strong defence (all valid advertisements) but they all share an appearance.
    - They all gain protection from this
- Milkweed beetles and milkweed bugs are another example of mullerian mimicry
    - Same colours, same poison from milkweed

- Monarch butterflies maintain the poison that monarch caterpillars sequester from the plant
- Monarch caterpillars sequester cardiac glycosides from milkweeds
- The cardiac glycosides are passed onto the butterfly stage
- Monarch butterflies are thus armed chemically
- The Viceroy looks very similar to a monarch butterfly. The Viceroy mimics a monarch butterfly in appearance
- The monarchs are poisonous but the Viceroys are generally edible
- Since the poisonous animal is the monarch, the monarch is called the “Model”
- The Viceroy (which looks like it) is called the “Mimic”
- This is called Batesian Mimicry******
- Batesian Mimicry is different than Mullerian Mimicry because the Viceroy is not poisonous, just the Monarch is *****
- In Mullerian mimicry, all the animals that look alike have a strong defence.
- In Batesian you have a cheater (mimic)
- If they all look alike, and they are all toxic (its mullerian) if one is harmless and one is not (Batesian)
- If they are brightly coloured, that’s also aposematic colouration
- If it includes their appearance, then its aposematic colouration as well, not just the mimicry element
- Another example, Hover Fly’s look just like bumble bees.
- Bumble bees sting, and hover flys are harmless
- Honey bee strings, hover fly is harmless (also look alike)
- Bald-face hornet (stings)--> hover fly is harmless (some look like them too) these flies also have two toned wings to appear that they have more wings (same as bee or hornet)
- Some of them also pretend to buzz!
- How to tell them apart?
    - Count the wings (4 wings is a wasp, 2 wings is a fly)
- Wasps in particular have MANY mimics
    - His fave: Raspberry Crown Borer (a moth!)
- However, a consideration:
    - One bad experience out of many good ones, it wont deter you.
    - Same for batesian mimicry, if models were rare and most were harmless, the animals wouldn’t learn.
    - In nature you tend to find the batesian models are more common than the mimics***
- **THEREFORE: (considerations)**
    - **Number of models > number of mimics**
    - **Models and mimics must occur at the same time of the year**

Lecture 4

Batesian Mimicry: but there are considerations!
Number of models> number of mimics
Models and mimics must occur at the same time of year (ie. monarchs and viceroys)

American Toads have the toxin BUFOTALIN in skin glands (not brightly coloured)
But they have a BEHAVIOURAL defence too. What do they do when they are cornered?
They puff up and appear larger than life. This is called bluffing (when you appear to be a larger animal than you are)
******Hog nosed snakes also bluff: they bluff by looking larger than they are**
But if the hog nosed snake plan A (bluffing) fails, plan B is to play dead!
Playing dead: thanatosis
Blister beetles will also do this. They play dead and chemicals ooze out. So blister beetles and hog snosed snakes are two great examples of animals that play dead.
Virginia opossums also play dead.

Behavioural Group Defence

- **White-tail deer- they gather together in really big numbers. Where they gather is called a yard**
- **In winter, white tail deer YARD. this can be called yarding.**
- **How does a large number of deer provide protection?**
    - **Safety in numbers**
    - **As a deer, you are less likely to be eaten if only 1/20 is eaten**
    - **The odds are increased of any one surviving an attack**
- **Birds also look for safety in numbers and gather in large groupings**
- **A group of birds is called a flock. So FLOCKING is a bird group defence.**
- **So yes, safety in numbers. But also there are more eyes to look for threats (both deer and birds)**
- **Flocking might serve to:**
    - **Visually confuse predators (ie. a hawk attacks and then 100 birds fly in the air)**
    - **For each flock member lower the odds of being caught (safety in numbers)**
- **Murmuration**
    - **The patterns birds fly from light to dark**
- **Group defence can be aggressive**
    - **Ie. wasps. If you go by a wasp hive, if one wasp sees you and think your dangerous, you have the whole hive coming at you**
- **Yellowjacket wasps (social wasps)**
    - **ATTACK PHEROMONES summon the troops**
- **Bird behavioural defence can also be aggressive**
    - **ALARM CALLS summon other birds to join the attack**
    - **This is called MOBBING. The birds are forming a mob, and the mob is attacking a large bird of prey trying to drive it away making the area safer**
    - **So mobbing is an aggressive behaviour done by birds as a defence**

- **Mobbing owls during the day is a pre-emptive defence for the night.**
    - **Scare them away before the night comes, because they eat smaller birds while they are sleeping**
    - **Happens before the attack would occur.**
    - **The owl is totally harmless to those birds during the day**
- **Some animals have BODY GUARDS**
    - **Eg. carpenter ants guarding aphids**
    - **Aphids suck the sap out of trees**
    - **Carpenter arts guard them, and the aphids give them a small drop off of honey dew.**
    - **It's a mutualistic association, the aphid gets protection from the body guard, and the carpenter ants get food.**
    - **Aphids are generally brown/green and guarded**
    - **One type of aphid is bright yellow and they don't have body guards. These aphids are poisonous because they eat milkweed. They don't need body guards, they have warning colouration to warn of their toxicity.**
    - **Oleander aphids do not use ants as body guards**
    - **Body guards are a form of behavioural defence**
- **Some behavioural defences seem odd**
    - **Eg. eastern cottontail rabbit.**
    - **They run away, and expose a big white tail. The white tail is prominently displayed. WHY?**
    - **White tail deer do this as well.**
    - **This is called a "white flag"**
        - **Many predators rely on surprise. Wolves only catch deer about 10% of the time they attack.**
        - **The white flag lets the predator know that the animal KNOWS they are there. So they should give up. They won't be able to surprise them with an attack.**
        - **So the reason? FLAGS ADVERTISE AWARENESS**

VIGILANCE

- in order for any defence to work the animal must know there is danger present
- Vigilance is being alert and looking for danger.
- They scan the environment in various means/ways
- There are 3 main ways animals might detect danger.
    - 1. Sounds (hearing)
    - 2. Sight (looking)
    - 3. Smell
- Adaptations for scanning:
    - Auditory (ears) ie. rabbits.
    - Visual (eyes)
    - Olfactory (nose)

- Large ears (external pinnae) capture sound
    - Ears pivot to scan all directions
- Why aren't beavers ears larger?
    - Beavers swim a lot. So adaptations can't go across the board for all animals.
    - Big ears would cause drag in the water and wouldn't be good for energy conservation
- Not only mammals have ears for hearing, a number of insects also have ears
    - Eg. tiger moths also have "ears"- membranes on thorax
    - Membranes that pick up sound vibration when they are flying around from bats
    - When they hear bats vibrations, they dive down to the ground.
    - Eg. Lacewings have ears at the base of their wings
    - Eg. mantids (praying mantice) have one "ear" in front of hind legs on the underside of the abdomen
    - So a number of insects have so called ears, which are membranes for hearing sounds.
    - Snakes have no ears, but they sense vibrations. They can feel vibrations of animals walking towards them
    - Snakes also have an enhanced power of smell/taste
    - They use their tongue to taste the air
    - Snakes have forked tongues. Why?
        - Inside the mouth, in the roof of the mouth, is a double entery chamber. Its a chemistry lab. It pulls off scents off the tongue. It will tell the snake which side the animal is on. It will tell them which way to go.
    - Scents are analyzed in the Jacobsons Organ
- Moose, aside from large ears to hear, also have an excellent Olfactory sense
- Mammals in general that use smell generally have longer snouts.
- An enlarged snout houses more sensory cells and a Jacobson's Organ
- Especially during the mating season, moose can use their tongue to pick up airborne scents
- Foxes don't grin- they expose the roof of the mouth, they have certain posture. An example of...
- Mammals expose the Jacobson Organ by FLEMEN
    - It is a posture to enhance the ability of the mouth to scence the scents in the area around.
- The third is scanning VISUALLY
- Eg. snowshoe hare.
- Eyes on the side of the head provide larger view of the surroundings
- Mallards can see 360 degrees around them.
- Each eye has a field of view, how much of the eye is seen
- If you look out of one eye or another eye, there is a large overlap in the middle.
- This gives you depth perception
- If you have eyes on the side of your head, there is less overlap. This gives you less ability to have binocular vision or depth perception/judge distance.

- EYES ON THE SIDE, MAKE THE VIEW WIDE
- Eyes on the front allows for more overlap, more ability to judge distance, but this means behind them they cant see (blind spot)
- EYES ON THE FRONT, HELP YOU HUNT.
- Eye placement is affected by other aspects of an animals natural history
- Beaver- eye, ears and nose are in a straight line, all along the surface of the water
- A beaver has all of its sensory organs near the top of its head
- The eyes of a Wilson's Snipe are on the upper rear of its head
- Why do they need to see above them?
- They feed by sticking their head in the mud and they feed at night. So there heads are pointing down, so if they want to watch behind them, or in the sky for owls coming at them, then they need eyes up top.

American Bittern

- When alarmed, American bitterns put their bill in the air and freezes (background matching)
- But when the bill is in the air, it still wants to be able to see danger
- American bitterns eyes are placed near the base of the beak
- Then it can face the danger coming toward it, even when background matching
- It can still see forward with binocular vision
- So why are the eyes there?
    - To allow the bittern to see ahead while its bill is pointing up
- Remember, no adaptation is perfect. It has to turn its head to keep its eye on you. It will keep turning.
- There is a draw back, it can't see behind itself.

Animals that are night active must have special eyes to be able to see and look around for danger.

- Large eyes can help. The larger the eyes, the more light it can gather, ie. eastern whipperwhill
- They also have eyes with lots of RODS in the retina
- Rods are sensory cells.
- Rods activate under low light conditions
- So these animals have lots of rods.
- Cones require lots of light. Rods require only a small amount of light so send impulses to the brain
- Animals that are night active have a special reflective layer behind the eye (ie. flying squirrel)
- Therefore, nocturnal animals display EYESHINE
- That layer of cells that reflects light forward again is called Tapetum Lucidum
- Different animals have different colours of eyeshine

More eyes allows for more complete vigilance.

- Animals that travel in groups such as deer (yarding), have more eyes to look for danger.
- This is another reason white-tailed deer YARD in winter
- Same with birds who flock.
- Recall that flocking offers two advantages; one of which is more eyes THUS better vigilance.
- BUT two types of flock can be seen
- One kind of flock has one type of bird in it. (ie. Canada Geese) (ie. Waxwings)
- Key is, some birds have “single species flocks”
- Some birds travel in “mixed species flocks”
    - Ie. Warblers, but different warblers eat food in different ways,
    - So they aren’t competing against eachother.
    - Same with if there is just LOTS of food (ie. fruits), then there can be mixed species flocks.
    - Benefits are the same for both flock types!!
        - More eyes to watch for danger, and they are not competing heavily for food if they are in a single species flock but its plentiful, or a mixed species flocks but they feed in different ways.
        - Fruit or corn field is in huge quantites, so the same types of birds can be in single species flocks because they aren’t competing for it.

Lecture 5

Plant Defences

- Plants are constantly under attack, but they are rooted to the ground. They cannot run away
- All plants are food for something, yet plants flourish.
- They have been very successful at developing a wide array of defences
- When you see a plant defoliated you see a battle lost
- When you see a plant untouched, you see a war temporarily won
- Many plants have PHYSICAL DEFENCES ****
- ARMOUR
- Trees and other woody plants have external ARMOUR
    - This is BARK!
    - Seeds can be protected inside HARD COATS
    - Acorns have extremely tough coats
- SPINES
    - Spines= modified leaves
    - Eg. thistles
    - Spines are modified leaves
- PRICKLES
    - Prickles are epidermal outgrowths, like hairs
    - Eg. blackberries and raspberry plants have lots of prickles
    - Prickles are epidermal outgrowths

- THORNS
    - Hawthorns are an example of this “prickly” defence (3 kinds)
    - Modified branch, using aprt of their structure to cause pain
    - Thorns are modified branches
- Do physical defences work? YES. animals know to avoid them.
- Plants can also have SOFT defences
- Plant hairs are called TRICHOMES
- Hairs are meant for the insects that would eat the plants. They are a physical barrier. Insects cannot walk through these hairs. It’s an obstacle.
- Mullein
- Its leaves are down flat on the ground and the leaves are covered in trichomes
- Stinging nettles- have trichomes, and when you touch them they break your skin and inject chemicals in
- Glandular Trichomes- because there are glands on the top that release chemicals
- A glandular trichome is a combination of physical (piercing) and the chemical aspect
- GLANDULAR TRICHOMES- PHYSICAL + CHEMICAL
- Water Smartweed- in the water the leaves have no trichomes, but if a drought occurs, a dam breaks etc, and the plants are suddenly stuck in mud, when this happens, they start growing trichomes on their leaves. Since they produce them on demand, it is called inducible.
- INDUCIBLE DEFENCE - is not there all the time, only produced when necessary
- STRUCTURE of the plant can also serve as a deterrent
- Structural elements such as CELLULOSE, HEMICELLULOSE, and PECTIN, make plant tissues hard to digest
- The animal must break them down physically first. This takes a lot of effort and then they really can’t digest it.
- Plant tissues have structures inside to make them strong.
- These are called STRUCTURAL ELEMENTS of a plant.
- Other support parts include
    - LIGNIN: gives leaves stiffness, nuts and cherry pits their hardness
- STRUCTURAL ELEMENTS are DIGESTIBILITY REDUCERS which simply means they reduce the ability of the animal to digest them
- SILICA is found in HORSETAILS
- GRASSES are also full of SILICA

- Other digestibility reducers are not structural elements
- TANNINS are ASTRINGENT
- This is a drying agent. It sucks out the moisture, making it harder to digest.
- This exists for different reasons, but one is defence
- The common term is a PLANT SECONDARY METABOLITE

- CALCIUM is also used as a deterrent

- ARUM plants have calcium oxalate crystals in their leaves
- If they are eaten, they burn the mouth (and they can tear apart digestive tracks)
- One type of **ARUM** plant is SKUNK CABBAGE.
- JACK IN THE PULPIT, is also an **ARUM**
    - It is well endowed with CALCIUM OXALATE CRYSTALS

MAJOR Groups of Chemicals

1. TERPENOIDS
    - Milkweeds are full of terpenoids.
    - The ones in milkweeds are called cardiac glycosides
    - Monarch butterflies exploit these plants for their own benefit, they have obviously evolved a solution
    - Terpenoids taste bitter
    - Terpenoids do NOT contain NITROGEN (KEY DIFFERENCE)
    - Terpenoids are major group of plant CHEMICAL TOXINS
    - New pine cones have RESIN. This resin is a terpenoid
    - Therefore, RESINS contain terpenoids
    - So resins are sticky
    - Another plant defended by TERPENOIDS is POISON IVY
    - The resin in poison ivy is UROSHIOL
    - This is CONSTITUTIVE DEFENCE (there all the time)

2. ALKALOIDS
- Toxins that contain NITROGEN are called alkaloids (key difference)
- ASTERS are defended by ALKALOIDS
- These leaves are almost always untouched
- BUTTERCUPS also contain alkaloids
- Alkaloids interfere with digestion by BINDING TO DIGESTIVE ENZYMES; some are sugar mimics
    - Body tries to load them in and it doesn't work probably
- They taste nasty
- These are defences that are not created on demand, these are CONSTITUTIVE DEFENCES. They are there all the time.

Other toxins are produced on demand…

3. HYDROGEN CYANIDE (HCN)
- Hydrogen Cyanide (HCN) is INDUCIBLE
- This cannot be there all the time, it would kill the plant. The ingredients are stored separately, when an animal eats it, it combines the chemicals creating HCN and thus making it toxic (inducible)
- Black cherry plants are an example

- Many ferns have HCN defence
- BRACKEN also contains HCN
- It is strongly defended, can be deadly

Some chemicals disrupt digestion by INTERFERING WITH DIGESTIVE PROTEINS

- A wounded leaf sends out WOUNDED HORMONES (chemical signals through internal structure/airborne to tell them they need to get ready for an attack, and then they make more hormones)
- An example is a potato plant
- PROTEINASE INHIBITORS prevent PROTANAISE from doing their job

Some plants produce INSECT GROWTH HORMONES

INSECT GROWTH HORMONES

- Moulting Hormone= ecdysone
    - Caterpillar. As it grows larger it gets moulting hormones
- Juvenile Hormone
    - Later in life
- As each stage as it grows larger from larva on
- Once it transforms from adult stage, then it loses the juvenile hormones, it allows the animal to go from juvenile stage to adult stage
- Combo of two hormones, but lack of juvenile allows it to transition to adult stage.
- Some plants are full of moulting hormones, so if an animal eats those it gets an overdose of moulting, so it might change too quickly to adult before its ready to transition
- Rock Polybody (a fern) is loaded with MOULTING HORMONES
    - If an animal eats those, it is getting an overdose of moulting hormones
    - These moulting hormones are called ECDYSONES
    - Plants can make perfect copies of these hormones
    - PHYTOECDYSONES, means the plant made them
    - The body will transform too quickly and the insist will die.
- BRACKEN FERN, is LOADED with PHYTOECDYSONES
    - Insects mature too quickly and die
    - Premature death

So most important, too much of moulting hormone can make an animal mature top quickly, and the other thing that is important is juvenile hormones importance, juvenile hormone makes it stay in a juvenile stage. If juvenile hormone is still present, this is also important. Moulting makes them advance, juvenile keeps them juvenile.

- Balsam Fir (local tree) contains PHYTOJUVENILE HORMONE

- If a caterpillar ate this, it would never mature, it would never grow up.
- So they can't be adults who reproduce and lay eggs on the plant
- Insects that eat a plant with phytojuvenile hormones do not mature
- Population control

REPRODUCTIVE HORMONES

- Mess up an animals reproductive system
- They produce PHYTOESTROGENS
- Eg. red clover, sheep eat them and then have miscarriages.

PHOTOTOXINS

- Very nasty side effects
- They make the skin/or cuticle (insect) very sensitive to sunlight
- Eg. St. John's Wort

Sometimes plants advertise their defence

- MUSTARDS advertise their defence (GLUCOSINOLATES- warning odor)
- They have warning colour and warning odour
- Aposematic colouration and aposematic odour
- Plants use aposematic colours too
    - Eg. blueberries.
    - They taste bitter when they aren't ripe (terpenoids)
    - They want their mature fruits with seeds to be eaten so they get pooped out and grow elsewhere. They also want to advertise when they ARE ready to eat, and discourage when they are not.
    - Once the plant is ready for transport (ie the berries), the plant will shut down the terpenoids and produce sugars that make the berry sweet.
    - The colouration is done deliberately, to tell animals it is ready to eat.

When a plant is under attack (ie. a leaf being bitten) an alarm is sent to other parts to prepare themselves

- Chemical Messengers = Phytohormones (jasmonic acid and/or ethylene and/or salicylic acid) travel through the plant, initiating biochemical responses.

In summary of plant defences…

- The two major categories are physical (outter or inner structures) and chemicals (terpenoids,alkaloids, reproductive chemicals)

Challenge 1: staying alive and not being eaten by something else. This is the first challenge plants and animals face.

Challenge 2: ENVIRONMENTAL STRESS

- Temperature extremes
- Sub Zero Temperatures
- What happens when temperatures fall below zero?
    - Water turns to ice
    - And expands
- If water inside an animal's body freezes, it will expand and they will die. So how do they survive?

Lecture 6

Challenge 2: Environmental Stressors

Temperature Extremes

Subzero Temperatures

- Water inside plants and animals can turn to ice and this can be lethal
- When temperatures plunge below freezing it can affect some animals more than others
    - Ie. Frogs and turtles do not do well in the cold
- Ectotherms (formally known as cold blooded)
    - Internal body temperature is mostly controlled by the external temperature around them
        - In other words, the environment controls their body temperature
- Endotherms
        - Internal body temperature is mostly controlled by themselves

Solutions to Dealing with Subzero Conditions:

Two different types of animals…

For animals that stay active

- Solution A: dress for the occasion
- Mammals grow more hair
    - Two types of hair
    - Guard Hairs: grow longer and thicker
    - Undurfur: the fur closes to the skin, dense underfur traps body heat

- Birds grow bulkier feathers
    - Birds have two coats of feathers as well
        - Contour feathers are on the outside
        - Down feathers underneath

- Animals also add extra layers on the inside
    - Mammals have two types of fat
        - Subcutaneous fat: for insulation= warmth (under the skin)
        - Internal Brown Fat for burning for warmth (using for energy)

- Birds tend to have one type of fat but it's a little different
    - Birds add subcutaneous fat for fuel (it is not used for warmth)
    - They do indirectly, because they burn that fat as fuel in the cells, and this gives off heat

- Birds also tend to SHIVER to generate heat
    - Shivering is an important means of thermogenesis (Whenever heat is generated by the body)

- Colour can provide warmth.
    - What colour is the warmest in cold temperatures?
    - The most northern owl in the world is the snowy owl. And this bird is white
    - The most northern grouse in the world is Ptarmigan (also white)
    - The most northern fox in the world: arctic fox
    - PALE colours retain body heat better
    - GLOGER'S RULE: animals in the north tend to be paler in colouration than animals in the south, and this is a means of staying warmer
    - Snowshoe hares gain 27% in the coats insulation value by being white

- What shape is the best for the cold?
    - ALLENS RULE: Smaller Extremities
        - Big ears, long legs, long tail: NOT GOOD (all those body parts lose heat)
        - Most northern deer in the world: Woodland caribou.
        - Very different shape than typical deer. Extremities of an animal tend to be a bit smaller as you go north (aka. SMALLER extremities) (Allens Rule)
        - BERGMANN'S RULE: Lower surface area: volume ratio
            - The volume means the amount of matter in the animals body
            - Surface area is the total area covering the animal
            - If its 10:1, that's a bad ratio is you want to retain body heat

- This rule is that as you go farther north you tend to have a lower surface area to volume ratio (So the numbers are closest together)
- 10:1 is bad, 2:1 is good
- Animals farther north tend to have a lower surface area to volume ratio SA:V
- Higher the number, ratio isn't good (more surface area than volume)

- What are three important principles that allow animals to live further north than other animals?
    - Gloger's Rule
    - Alan's Rule
    - Bergmann's Rule

- Other Info
    - Bushy tail, allows them to cover their face (less hair on face)
    - Mouse shape is bad for the cold (long tail, big ears)
    - Meadow vole has better shape

- How do beavers stand on ice?? Their tail/feet has no protection??
    - Countercurrent Heat Exchanger
    - Rete Mirabile or Wonderful Net
    - Found in the legs of beavers, tail of beavers, feet of ducks etc.
    - Blood going down to the feet is cold. How does this help the bird?
        - Less body heat is being lost
        - They save energy by having colder tails (can't go below zero though or it would freeze)
        - Most northern gull in the world: Ivory Gull
        - Colour, body shape, extremity size, rete mirabile
        - Tucking extremity under a wing can also help keep them warm

- How an animal breathes in winter also conserves energy and heat? fox
    - Countercurrent vessels in snout

- Where a bird sleeps can be important
    - Choice of roost site
        - Coniferous trees offer more warmth

        - When they are covered in snow that adds even more insulation
        - Woodpeckers stay inside cavities overnight
        - Small owls go inside cavities too
        - So do black capped chickadees
        - Mammal that sleeps in cavities is a squirrel

- Huddling
    - Flying squirrel and voles HUDDLE
        - So they are in cavities but also in groups of 7-10
        - So do raccoons (A few of them)

- Some Animals Build their own Shelter
    - Muskrat lodge
        - Just plant material
    - Beaver lodge
        - Always has sticks in it
        - Lodges and dams are not the same
        - Add mud for insulation
        - Snow also helps insulate lodge
        - If there is a natural chimney, beavers are inside “hole” or chimney

- Small Animals Find Warmth Under Snow
    - Subnivean space (under the snow by the ground is much warmer than above the snow)
    - Latent heat coming up from ground, and pressure (compact) from snow above

- Some Birds also find Warmth in the Snow
    - Ruffed Grouse
        - Flies up in the air and then dives down into the snow
        - Ruffed grouse snow bed

- What is the Danger of Being in the Subnivean Space?
    - Freezing rain
    - Humans tramping down on them

- On cold days animals can bask in the sun
    - Basking is a behavioural means of getting through cold winters

    - Basking can be done while sleeping

- Chickadees can lower their internal body temperature
    - On cold nights black capped chickadees lower their body core temperature by 12 degrees Celsius
    - When doing this, they enter a deep sleep called TORPOR
    - How does this help them survive?
        - Takes less energy to reduce the body heat being lost
    - How does this conserve energy?
        - Shivering as important means of thermogenesis

TWO: Then you have ectotherms…

- For most animals, body temperature below zero is fatal
- Snakes are ectotherms
    - They survive by going below the frost line and becoming dormant
    - Dormancy = behavioural freeze avoidance
    - Northern water snake leaving its hibernaculum

- All adult turtles and most hatchlings escape subzero temperatures by going to the bottom of ponds and lakes
        - So do many frogs (not all)
        - American toads dig down beneath the frost line
        - As do many salamanders

- But many insects survive winter above the frost line!!
    - Go dormant and use antifreezes:
        - Glycerol = Cryoprotectant
        - They use compounds like glycerol.
        - This preserves life.
        - They put it in their system and go dormant, and then they don't have their water freeze inside them
        - Ie. The wooly bear

- Insects usually overwinter in sheltered sites
    - But some not as adults

- Many overwinter as eggs.
    - The adults die with the subzero temperatures and the eggs survive
    - Preying mantid
    - Ootheca (egg case)
        - There is no water in the egg and no antifreeze is added
    - Walking sticks also overwinter as eggs

Lecture 7

Some Insects Overwinter in the Larva Stage

- In the case of moths, they stay as caterpillars (ie. wooley bear)
- If they stay as caterpillars, they have to stop their liquids from freezing or they'd die
- Therefore, many produce antifreeze
    - Glycerol
- Because it protects their lives, it is called a **cryoprotectant**
    - Anything that helps protect life is a cryoprotectant
- There is a term for when an animal survives sub zero conditions…
    - Its an ectotherm so normally it would freeze, but by Glycerol it remains liquid.
    - TERM: When no ice forms inside the body: SUPERCOOLING
- The liquids inside are below zero but no liquid is freezing

Some Adult Insects can Survive the Winter as well

- Angle-Winged Butterflies spend winter in the adult (butterfly) stage

Many Moths Overwinter as Pupa in a Cocoon

- If they do, they are generally inside cocoons
- Some pupa are in the ground or under rocks
- Essentially, they are spending the winter inside a protective case (cocoon)

Goldenrod (plant)

- There are swellings on them
- Goldenrod Gall
- This one is called by a fly, (a goldenrod gall fly)
- A gall is just abnormal plant growth around the egg of an insect
- Inside is a.... Goldenrod gall fly grub

Goldenrod Gall Fly Grub

- It is frozen but ALIVE
- They can have ice inside their bodies and survive
- They can control internally where the ice forms
- They put glycerol inside the cells so the cells remain liquid
- But between the cells they have little proteins they create that attract ice around them, called nucleating sites or nucleating proteins

- Therefore, there are cryoprotectants inside the cells and ice nucleating sites between them
- Freeze Tolerance: they are tolerating being frozen. The animal surviving the condition has ice inside its body.
    - The key thing is the ice is never inside the cells, or the animal would die.

Supercooling and freeze tolerance are different. *

What does a wooly bear do in winter?
- It super cools

No ice in system?
- Super cools

But no solution is perfect!
- Downy woodpeckers and black-capped chickadees extract grubs from goldenrod galls
- Grubs that make smaller galls have a better chance of surviving
- Medium sized galls have better survival rate

Other Insects Survive the Winter as Adults
- Female mosquitos, wasps, bumble bees

Not all Herps Avoid Freezing Temperatures
- Nucleating proteins direct ice formation between cells
- Ice forms inside body but NOT inside cells
- Grey Tree Frogs stay near the soil's surface and freeze!
- Over half their body water turns to ice.
- They pump glycerol into the cells
- Freeze tolerant frog
- Wood frogs are also freeze tolerant
- Spring peeper frogs are also freeze tolerant
- Chorus frog are also freeze tolerant.
- All 4 are freeze tolerant frogs, they all stay inside the soil.
- No ice inside the cells, just around the cells.
- These are the first frogs you see in spring

Like most turtles, snapping turtles are NOT freeze tolerant and they can NOT super cool.
- Snapping turtles often spend winter in a dormant state where a stream enters a lake
- This is called Behavioural Freeze Avoidance

Snapping Turtles

- Snapping turtles lay eggs in late spring
- Hatchling snapping turtles head for the water where they spend winter in a dormant stage

Painted Turtles

- Painted turtles also lay their eggs in the ground
- But some hatchling painted turtles stay in the ground all winter
- Thus, Hatchling Painted Turtles are freeze tolerant
- BUT, only as hatchlings
- They have glycerol inside the cells, and allow freezing between cells.

Endotherms have different strategies for conserving energy in subzero temperatures

- A lot of mammals enter a state of sleep, where they can lower their body temperature and heart rate to reduce demand for energy
- Aka. some enter DORMANCY.
- There are different levels of dormancy
- Racoons are winter active on warm winter days. They do not fully hibernate
- Racoons undergo LETHARGY
- Lethargy is usually done in a sheltered den
- Porcupines are another example
- Chipmunks undergo longer periods of torpor= HIBERNATION?
- (torpor= mental or physical inactivity; lethargy)
- Prof argues its not fully hibernation.
- They store food all summer long
- In winter, they awaken every few days, have a snack, go to the bathroom, and back to sleep.
- So they have a low heartbeat, low temperature, but awaken every few days
- Bats undergo a light “hibernation” too
- They maintain a high heart rate, low body temperature and are easily aroused
    - They must be able to respond to colder conditions fairly quickly
    - He thinks this is more torpor
- How do Blackbears spend the winter?
- Low heart rate, high temperature, easily aroused
- So they are not true hibernators
- They sleep in dens
- Bears nest are commonly in American Beeches (they produce beech nuts)
- Bears are still fat in spring! They are still large even after dormancy
- Bears don’t urinate or defecate during winter dormancy
- The TAPPEN is a rectal plug that they form that keeps them from fouling the winter den
- Bears go into a dormant stage but they aren’t a true hibernator

Then there are true or DEEP HIBERNATORS

- Groundhogs: the worlds largest true hibernator
- Their heart rate and body temp goes down to almost zero
- They curl in a ball. (surface area: volume ratio is better)
- Jumping Mice: are also true/deep hibernators

Subzero Temperatures bring two problems for winter active animals.

- The first problem that subzero temeratures bring for winter active animals
    - Maintaining body temperature
- The 2nd problem that subzero temperatures bring for winter active animals
    - Mobility.

Mobility

- They have physical adaptations for this.
- Eg. Moose

Moose

- Have very long legs 2m high at the shoulder
- Special joints- special leg motions
- Allows moose to go through very deep snow with little difficulty

Snowshoe Hares

- Large surface area of feet
- Which feet are the biggest? The hind feet!
- The hind feet come up and go in front of the front feet when they jump
- This is for winter mobility

Northern Animals

- Many northern animals such as Fisher and Marten also have large hind feet

Do Birds have Snowshoes?

- Some do!
- Ie. the Ruffed Grouse
- They grow new ones every year, they do not have them year round
- These are the scales on the sides of the toes
- Ptarmigan have dense feathers around toes

Behavioural Adaptations for Mobility

- Some mammals travel through the subnivean space
- White tailed deer move to a YARD (sheltered area with less snow and more food) where they make trails in the snow
- A BROWSE LINE identifies where White-tailed deer feed in winter

Wolves also have a behavioural adaptation

- They do have big feet
- They walk single file

Otters and Mink

- Have short legs
- They slide on their bellies
- A natural toboggan
- Mink can also use their bodies as toboggans

Conclusion:

- Animals solve the subzero temperature problems in a number of ways
- But not all stay and face the challenges
- What is one major adaptation animals use to avoid this problem?
    - Many others escape subzero temperatures: MIGRATION

Lecture 8:

Besides birds, what other animals migrate?

- Insects:
    - Monarch Butterflies: go to mexico
    - Common Green Darner (Dragonfly): go to capecod
- Mammals:
    - A few bats, including Red Bats do

Birds that Migrate

- Most songbirds migrate
- Why migrate?
    - Their food supply is directly related to subzero temperatures because songbirds generally feed on insects
    - So finding this in the winter is very difficult
    - Therefore they migrate because their food supply is not available because of subzero conditions
- Sandpipers migrate
- Why Migrate?
    - They feed on invertebrates in the mud primarily (by the water)
    - In winter, you can't probe your bill in the mud
- So the food supply is affected by the subzero conditions, and therefore they migrate
- So by leaving they solve two problems:
    - Food
    - Subzero temperature
- Geese and Duck migrates

- Scarlettanigers: fly to brazil

Birds that stay for wintertime

- Woodpeckers (their food supply is unchanged)
- The vast majority head south

What is the world's most famous migrating bird?

- Arctic Tern
- Arctic to antarctic 20,000km roundtrip each year
- Right now they are ex world champion
- Newly crowned champion: Red Knot!

They must have fuel for their flight. What is the fuel that powers a birds flight?

- FAT
- What kind of fat?
    - Subcutaneous fat
- Sandpipers stopover at good feeding areas to fatten up before migrating (they are called stopovers)
- Sandpipers
    - They double their body weight in ten days
    - Why?
        - They can fly longer distances without having to stop
        - They fly non stop for thousands of kilometers

Most Songbirds only add about 10% additional weight

- Why?
    - They only fly between 300 and 500 km before refueling and continuing their journey
- Most songbirds migrate only at night. Why do they fly at night and not during the day?
    - Fewer predators!
    - More calm at night (less wind)
    - It's also cooler at night
    - So its calmer, cooler and safer.

Blue Jays

- Migrate during the day

Hawks and eagles

- Flapping is an energy powered flight
- But if you soar on air currency, this is zero energy
- This air currency is only available during the day

- These are thermal air currents
- Hawks and eagles and vultures soar up on a thermal
- Then glide down to the next thermal
- And then soar up on it and so on.
- This is called THERMAL HOPPING
- THERMALS:
    - Thermals provide lift
    - Thermals are created by sunshine
    - Especially when the heat is near water
    - Differential heating creates currents
- These birds who do soar have adaptations for it
    - Slotted wing feathers for extra lift
    - Bigger wingspan, the more wing for air to act on.
    - They also spread the end of their wings like fingers

Swallows Migrate in the Daytime

- They feed as they migrate
- They are fast fliers and burn up a lot of fuel when they move
- They eat flying insects and need to feed as they migrate

Hummingbirds also Migrate in the Daytime

- They have a hard time putting on body fat
- They feed as they fly
- They hover when they drink nectar
- Hovering is more expensive
- They eat on the fly

* Sandpipers fly both by day and night *

How do Birds find their way?

- Daytime migrants navigate by the sun, landforms and other visual cues
- Nighttime migrants navigate by the moon, and constellations are used as compasses
- However, are these visual aids visible every night?
    - No, they can be obscured.
    - Therefore, visual aids cannot be 100% relied upon
- All birds that are migrating using electromagnetic field
- Both diurnal and nocturnal migrants use the Earth's Magnetic Field
- How do these birds detect this field?
    - Rhodopsin is a retinal photopigment

Why do Geese fly in a V-shaped Flock?

- To conserve energy
- It provides free lift

Studying Bird Migration

1) Ringing the Birds

- Adding tags to the birds
- They capture the birds, and they record the number on the ban
- Songbirds and most birds, are caught in very fine nets called mist

2) Today there is a better technique: Geolocators

- Geolocators: they measure the ratio of light to dark, it is fed to a satellite.
- Small little tags that give off a signal
- Another technique is Towers called motus towers: if a bird flies within a certain distance it picks up a signal from their transmitter
- Their movement and information is tracked
- Therefore, Motus is a coordinated hemispheric tracking system
- Motus towers rely on nanotags.
- Prof butchered this section so look in textbook ***
- Radio transmitters provide information too (feed signal to satelites)
- Conclusion:
    - Variety of means of following birds of migration now
        - Involve use of radio transmitters
        - Nanotags
        - Geolocators

Migration is a Complex Solution Adaptation to Solve Environmental Stresses

- But, NO solution is perfect

Drawbacks to Migration

- Only half of all the birds that migrate return the next year.
- Half die

Subzero Temperatures also Pose Problems for Plants

- Water becomes… ice
- Ice inside their cells kills plants

Solution 1: Many plants go dormant in the soil under the snow

- Plant has already dropped all seeds into soil, and died and then the seeds are under the soil for winter

Solution 2: Plants become COLD HARDY

- Cold hardy means they can survive in subzero conditions

- How?
    - Excess water is withdrawn and evaporated from leaves
    - Water is drawn out of the cells, which increases solute concentration
    - Protective sugars added to cells increasing solute concentration
        - They don't add antifreeze (glycerol)
        - They add sugar with the same general effect (lowering freezing temperature)
- Increases flexibility of cell membranes
    - Allow ice to form between cells
- Animals have freeze tolerance, plants have cold hardiness

Are plants just naturally cold hardy?

- Plants become cold hardy through acclimation
- The process of getting ready to become cold hardy

There are two stages of Acclimation…

1) The first stage of acclimation is triggered by a change in the PHOTOPERIOD
    a) The photoperiod is the ratio of dark to light in a 24 hour period
    b) Ie. winter the days are shorter
    c) They have cells that react to the change in light over time
    d) PHYTOCHROMES - light sensitive photopigments
        i) Causes cells to go dormant
        ii) Makes plants more responsive to low temperatures
2) Second stage is triggered by cold (but not sub-zero) temperatures (10 degrees to 0 degrees)

Some trees are able to survive (are cold hardy) to -80 degrees celcius

Some trees retain their leaves

- Retaining needles creates new problems: damage by solar radiation
- Solution: xanthophyll pigments (special pigments to protect them)
- Enable chlorophyll to use sun's energy to create heat, not to photosynthesize

Skunk Cabbage has an unusual adaptation for the cold

- It turns up the heat!

Coniferous trees retain their leaves (deciduous trees do not)

- They have needles
- Desiccation is another problem they would face (can't lose all water)
- Calm sunny days are the worst
- More heat to absorb the leaves

- Conifers retain their leaves so size and shape is very important
    - Leaf surface area tends to be small
    - They also have little pores (stomata) and they close their stomata
    - They also have thick cuticles (retains water inside the cells)
    - Hairs on underside of leaves

Rock Polybody is an evergreen fern
- They have poor SA:V ratio. So how do they survive?
- It reduces leaf surface area by rolling them up

Deciduous Trees have Big Leaves with a Large Surface Area
- They change colour
- Chlorophyll- break down at the end of summer
- Green mask vanishes and the other colours appear
- Then the tree goes dormant and the leaves fall off
- So the fall colours are part of the whole process of trees getting ready for subzero conditions

Red Maple
- Male vs. female
- Females turn yellow!
- Males turn red!
- Red is not actually present in the leaves- leaves produce anthocyanins

Leaf Loss
- Leaf loss helps solve a second problem associated with subzero temperatures
- Deciduous trees lose their leaves, and it's a way to stop trees from desiccating during winter months
- What could the other problem be with having big leaves on the tree in winter time besides desiccation?
- The weight of snow!

How about coniferous trees?
- They don't lose their needles but they don't capture as much snow.
- Some shapes shed snow
- Short branches with small needles
- The boreal forest is dominated by spindly and spire-shaped (point) trees
- Balsam Fir have a spire shape
- Black spruce are spindly
- BUT, no solution is perfect (aka icestorms)

Not only extreme cold is a problem for living things.
Too much heat can also be a problem.

PLANTS ARE JUST AS COMPLICATED AS ANIMALS WHEN SOLVING SUBZERO TEMPERATURE CONDITIONS

Lecture 9: Environmental Stressors- EXTREME HEAT

Excessive Heat

Plants
- Excessive heat can cause desiccation (the moisture they have inside is drying out)

How do plants resolve this problem?
- In extreme heat, plants:
    - Reduce leaf surface area by CURLING the leaves
        - Adaptation that prevents water loss
    - Close the stomata to keep in water

Animals
- On hot days, many animals:
    - Seek cooler sites/become less active (behavioural heat avoidance)
    - Get rid of excess body heat
        - Heat can be shunted to body parts with a greater surface area
        - Ie. in dragon flies they send liquids containing heat to abdomen
        - Dragonflies also reduce their surface area that faces the sun by assuming a position called the OBELISK (point it upwards- looks like standing on their head)

Tiger Beetles
- Live in hot places
- When it is really hot on the sand they raise their bodies up by STILTING

Ducks
- Countercurrent heat exchanger
- The Rete Mirabile is bypassed and more blood is shunted to the extremities

Beavers
- By diverting more blood through the tail, 90% more heat is lost than when the rite mirabile is in operation
- It is a great surface area of the body to lose heat through on hot days

Honey bees
- Honey bees are social insects that work together to air cool their hive

- They fan their wings and make hot air leave the hive and cool air come in
- In the hive, honeybees use their wings to fan the colony
- This is called behavioural cooling
- Bees also use evaporative cooling
- They produce a drop of liquid and rub it over their bodies

Red Fox
- Panting is a form of evaporative cooling
- Using evaporation of water to help you cool down

Birds
- Birds also pant, allowing more air to pass over the respiratory surface

Turkey Vulture
- They use evaporative cooling by excreting on their legs
- The liquid on their legs evaporates and cools them down

Mourning Doves
- They employ an even more dangerous strategy
- Allow their internal body temperature to rise to 45 degrees celcius
- What's it called if your temperature rises above normal?
- Hyperthermia!
- By matching or exceeding the heat around them, so the flow of heat is outward not inward
- Not many do this because it's a dangerous game.

Challenge #3: Nutrition

Plants can make their own food
- Need raw ingredients

Animals cannot make their own food
- Solutions:
    - 1. Eat plants (herbivory)
    - 2. Eat other animals (predation)

Some animals eat dead plant material
- This is called detritus
- If you eat dead plant material you are a detritivore
- Eg. milipede eating pine pollen

The First Way Animals Get Nutrition: Animals Eating Plants

Some animals have food delivered to them

- Clams are filter feeders
    - They are filtering the food out of the environment passing by them
- Blackflies
    - Black flies as adults are not filter feeders but as larvae in the water
    - Black fly larvae filter feed with elegant Labral Brushes
- Larger animals also filter feed
    - Dabblers or puddle ducks
    - Swans
        - They use a special tool on the bill called a lamellae (it's like a siv)
    - Northern Shoveler (prof likes this duck)
        - Huge bill
    - Tongues also help filter the food from water (Northern shoveler, a puddle duck)

All plant foods require feeding adaptations

NECTAR: 2 main adaptations for Nectar

- Nectar requires a long **proboscis**
    - Ie. insects, butterflies, moths etc.
- Hummingbirds have a really long beak
    - This is to access the nectar
- Hummingbird have a long tongue that acquires the nectar
- At the base of the tongue, lies a structure called the HYOID Horns (Hyoid Apparatus) that allows the tongue to extend passed the beak
- This is called an **extensible tongue**

SAP:

- Stylets (the piercing mouth part on insect that sucks up sap)
- Many True Bugs suck plant juices
- Aphids are sucking bugs
    - Use their stylets to puncture the plant on the outside and the sugars flow into them
- Yellow bellied sap sucker

PLANT TISSUES:

- One problem? Tough structural components

OVERCOMING PHYSICAL DEFENCe OF PLANT TISSUE

Problem #1: Ingestion of plant tissue

- This is called ingestion when you are taking the plant material into your system
- Slugs and snails break off plant tissues with a RADULA
    - Radula is used to break down plant tissue to ingest it
- Caterpillars have modified MANDIBLES
    - Used for shearing
- Some caterpillars eat leaves from the inside and it creates a blotch
    - So this caterpillar is called a Leaf Blotch Miner
- Mammals use modified teeth eg. beevers
- Different types of teeth for different purposes
    - Incisors (the equivalent of mandibles on caterpillars and radulas on snails)
    - Why are beavers teeth orange? They have iron particles (strengthen)
    - Beaver incisors also never stop growing and they self sharpen

- Moose have only lower incisors so they rip off plant tissues
- What helps them break down the food once it's in their mouth?
    - The cheek teeth (molars and premolars collectively)
    - So once the incisors snip of the material then the cheek teeth go to work to grind it down into smaller particles
    - Large CHEEK TEETH grind up the food
    - Cheek teeth grind the food and are powered by the large Masseters
- In herbivores, in general, the masseters (power cheek teeth) are very large and the temporalis (power incisors) is small
- Mandibles, radula, and cheek teeth all perform the same function but arise from different orgins
    - What's the term for things that do the same function but arise from different orgins?
    - ANALOGOUS STRUCTURES****
    - They do the same thing but they are not the same tool *****
- Spruce Grouse
    - Ruffed grouse have no teeth
    - What is the analogous structure in a bird that would grind up the plant material?
- Analogous to the radula, mandibles and cheek teeth is the GIZZARD (eg. turkey or grouse)
    - It's all muscle and inside there is a hard lining called the cuticle

After Ingestion comes a second problem… digestion.

Problem #2: Digestion

- Slugs and snails produce digestive enzymes
- But caterpillars don't produce the enzymes!
    - They waste a lot!

        - But caterpillars do not face a shortage of food, they can keep eating and waste most of it.
- Can moose afford to eat 10x its body weight per day like a caterpillar?
    - No way.
    - How do they break their food down without enzymes?
    - They get help from BACTERIA
    - They bring their food back up and then chew it again and swallow again and the bacteria goes back to work
    - Food is processed twice: This is called rumination (they rechew the cud)
    - There is a symbiotic relationship between the bacteria and the moose
    - The moose get its food digested for it, and the bacteria get food/home
- Social hares and rabbits do not have a rumen
    - They have sacs called caecum (plural: caeca) (an extension of the intenstines where the bacteria is)
    - They eat their droppings twice
- Beavers also eat their droppings!
- COPROPHAGY: a term for when an animal eats its droppings

Lecture 10:

Porcupines
- Don't eat their droppings but…
- There digestive tract is about 26% of their total weight
- So they have lots of surface area in their intestines to break down food

Ruffed Grouse
- Devour plant tissues
- They have Grouse Caeca as well to break down the plant tissue
- They also have the Gizzard

FRUIT:
- Frugivore: name for an animal that just eats fruit. You are an obligate fruit eater.
- Most fruit eating birds are not obligate fruit eaters

Waxwings
- Waxwings are fruit specialists
- They get little red markings on their wings that are wax like structures on the feathers
- They swallow the fruit whole, and some of this fruit is large, so this requires an adaptation
- The adaptation is large gapes (aka wide mouth): an adaptation for swallowing fruit whole
    - They must eat and process food very quickly

- They also have adaptations inside their stomachs for breaking down and processing the food
    - Small Gizzard: the pit is removed but they are not breaking it down and everything is processed (almost like a conveyor belt to the intestines)
    - Short Intestines: fruit is easy to break down and they want to pass it quickly so they have room for more

Blackbears
- Love blueberries!
- They try to fatten up before they go into winter dormancy
- Just like the waxwings, they don't want the seeds and pass them out

Seed Dispersers
- Animals that eat fruit and pass out the seeds are called SEED DISPERSERS

Seed Predator
- Seed eaters are SEED PREDATORS
- They kill and destroy the seeds
- Seeds of plants have defences and the animal must get through them

Seed Specialist
- American Goldfinches have fine bills for fine/small thistle seeds

SEED PREDATORS

Evening Grosbeak
- Cracking Seeds: Two hard plates and powerful jaws and they can crack seeds
- Sharp point in bill and top of bill they have a groove, they roll it back and forth to cut off the seed coats

Finches
- Seed predators and various types have different sizes of bills to access different kinds of seeds

Crossbill
- They have bills that cross over each other
- Its an adaptation to access seeds
- They eat seeds from pine cones
- Adaptation: crossed mandibles for accessing seeds and prying scales open
- Adaptation: long extensible tongue to get grit for the gizzard (hyoid apparatus)

Red Squirrel

- They love cones but they do not have mandibles
- Red squirrels bite off the cone scales with their incisors
- Very sharp and very strong and have enamel reinforced with iron

Mallards

- Also eat tough/large seeds
- They use their gizzard

Not all birds that eat seeds have a gizzard though

- Blue jays and chickadees will use their bills to hack open the case and get the seed inside it

Besides the Physical Defence that plant structures have, plant structures have a second major obstacle

- Plants also have CHEMICAL defenses to overcome

OVERCOMING CHEMICAL DEFENCE OF PLANT STRUCTURE

Sequestering

- Some herbivores sequester the toxins
- Mostly small herbivores like caterpillars and beetles
- Some sequester some of the chemicals but avoid most of the chemicals
- Some beetles that eat milkweed tissues have an amazing way of getting rid of some of the toxins in that plant
    - VEIN DRAIN: they go and cut and sever a vein of the leaf to isolate a part of the plant before they devour it

How do larger herbivores deal with toxins?

- Some herbivores use enzymes to neutralize the toxins
- The enzymes belong to a category of MFO's (Mixed Function Oxidases)

Two Categories of Herbivores

- Specialists (eg. Monarch caterpillars eat only milkweed)
- Generalists (eg. Beavers eat a large variety of plants)

Certain animals look for different types of nutrition at different times of the year in order to get a balanced diet

- Moose:
    - Winter: Balsam Fir = very low in sodium

- Summer: Aquatic plants= High sodium content
- Therefore, in summer they switch to aquatic plants to devour plants for hours and get the sodium out of them
- They can store the sodium in their rumen so they have a reserve until next year
- One of their favourite plants for sodium is called “Water Shield”
    - Water shield had 500x more sodium than land plants
- * sodium is stored in the rumen
- Moose in northern areas also drink/eat the road salt that has melted away into little roadside ditches or muddy puddles
- Road salt = sodium chloride

The Second Way Animals Get Nutrition: Eating Plant Eaters

Advantages to eating animals instead of plants

1. More return for the effort (proteins already packaged)
2. Easier to digest (avoid difficult plant structures/chemcials.

Disadvantages to eating animals instead of plants

1. Can be hard to find
2. Often prey is well protected
3. They fight back

What is called when an animal eats other animals? PREDATION!
What is the animal called that does this? PREDATOR
When an animal has been eaten? DEPREDATED
It has been depredated.

Some animals eat from the inside when the animal is alive

- This is called PARASITOID

Some animals eat other animals in part from the outside

- This is called PARASITES
- There are parasites on the outside and inside of the body
- Eg. ticks causing lyme disease

Some animals eat dead animals

- This is called SCAVENGERS

Predation

- Predation simply means capturing, killing and eating a prey item
- Before a meal is enjoyed a predator must first:
    - Locate the prey
    - Capture the prey

- Immobilize the prey

Eyesight

Hawks (Diurnal Birds of Prey)

- If you are using your eyes to look for prey, you must have vision that is improved
- **Enhanced Vision**
- Hawks have incredible vision
- Adaptations for their eyes:
    - Large eyes collect more light
    - Large number of CONES for visual acuity (cones are for sharp coloured day time vision)
    - Hawks in their retina have millions of cones to be activated by light coming in
    - Hawks also have eyes that magnify what they are looking at
    - Hawks eyes magnify image 2-3 x
    - Frontal placement of eyes for depth perception (overlap of fields of view creates depth of field perception)
        - This is how you determine how far away something is
        - It is also called binocular vision by some people
    - Retinal pits called fovea contain millions of sensory cells
        - Central Fovea: they are more in the middle of the eye
            - Help the animal search better for movement
            - Central= search fovea
        - Temporal Fovea: they are more frontal
            - Following the prey and locking onto it
            - Temporal= pursuit fovea

Owls (Nocturnal Birds of Prey)

- Adaptations for nocturnal hunting
    - Huge eyes to gather light
    - Eyes contain lots of rods with glycogen
        - 300x more rods than cones
        - Less precise vision but more sensitive vision
    - Globular shape to gather light and magnify without loss
    - Frontal placement of eyes
        - More frontally placed the eyes are, the smaller the field of view visible, you cant scan much of the environment and you cannot see behind you
    - Problem: large blind area
        - How do they compensate for this?
    - Solution: Can turn head 270 degrees

Frogs

- Frogs are visual hunters
- Large eyes
    - More visual input
- Can swallow food with their eyes

Tiger Beetles

- Tiger beetles have large compound eyes
- Huge eyes, but insect eyes are called compound eyes
- There are multiple eyes and they were together to create one image of the environment
- Daytime hunter

Ground Beetles

- Ground beetles are the nocturnal counterparts of Tiger Beetles

Dragonflies + Damselflies = Odonates

- Dragonflies are visual hunters
- Damselflies
    - Damselflies are also visual hunters
    - Smaller than dragonflies
- If you add dragonflies and damselflies together there is a big order of insects called: ODONATES (“the toothed ones”)
- Odonates have large compound eyes
- Each eye is a compound eye with many individual components (ommatidium)
- Ommatidium is a sensory component part of the eye
- As many as 28,000 OMMATIDIA per eye, each with 6 or 7 sensory cells
- Very sharp, powerful vision

Specialized eyes for hunters at the water's surface.

- Eg. whirligigs can see above and below the water at the same time

Predatory Eyesight Conclusion: it all depends where the animal hunts to determine how the eyes are adapted to the environment. The key thing is, most predatory animals have very large eyes for greater sensory input.

Simple Eyes

- Spiders:
    - Spiders have 8 eyes
    - They are not compound eyes, their eyes are called simple eyes.
    - Only one component to each eye
    - Some spiders are strictly visual hunters, so their eyes must adapt accordingly

Spiders that Hunt Visually

- Jumping Spiders
    - 2/8 eyes are huge and they are the ones primarily used for hunting prey
    - All eyes work, that means they can scan their environment with the other eyes
    - Two front eyes: Anterior Median Eyes (AME)
    - Big pair of eyes have the ability to change where they are looking
        - Spiders cannot rotate their eyes.
        - They move their retinas, so the eyes on the front are looking in different directions
        - Jumping spiders move their retinas to change their field of view
- Crab Spiders
    - Crab spiders are also visual hunters
    - Goldenrod crab spider: can change its colour from white on a white flower to yellow on a yellow flower

Biology Lecture 11- predators and prey

Crab Spiders:
- Are visual hunters
- Use their eyes to look for motion
- They have 8 eyes
- They are simple eyes (other insects have compound)
- The Golden Rod Crab Spider can change its colour from yellow to white ** (he thinks its an interesting spider) (it can do what most other spiders cannot do)

Grey Tree Frog:
- Can also change its colour from brown to grey to green

Eyes:
- Therefore, eyes are a very important part for many predators in terms of scanning for prey

Next Sense: Hearing

Large Ears:
- One adaptation that many animals, particularly mammals have for hearing is simply large ears
- Red Fox:
    - Can turn them around
    - Large Pinnae (external pinnae is external ears)
- Eastern Wolf
    - Large ears are important
- Not Just mammals hunt by sound, other animals do too.

Owls:

- Can hunt entirely by hearing their prey
- Owls ears are hidden, they have feather tufts that look like ears
- They have big openings on the side of the skill, they do not have large external pinnae like mammals do
- Hearing is an owls most developed sense
- Hunt by hearing
- Owls actually hear with their faces (an assisted system)
- Facial disks: rings of the feather on the face of the owl and they form a circle. These collect sound and move it towards the ear openings which are hidden under the feathers. They capture sound, they focus sound, and they drift the sound to the ear openings. They can magnify sound to some degree.
- 2 Disadvantages/Obstacles to this adaptation:
    - Short beak/bill: Why does it not stick out? It would block sound waves. By compensation for the facial disk structure, they are short raptorial bills.
    - Therefore, ONE: Short, down-curved bill prevents interference with sight and hearing.
    - Facing forward, can't hear that well. They turn their head around to focus.

Owl Modification for Hearing:

- They have special modifications for hearing things precisely
    - 1. Wide heads → horizontal sound separation
        - This means that if the animal sound is coming from one side, it arrives at one ear opening first (sound takes time to travel). So the separation means they can tell which way its coming from.
    - 2. Asymmetrical ear canals→ vertical sound separation
        - Because they are offset, one is higher than the other. They can tell if it is above or below.
    - This allows them to have cross hares. Horizontal and vertical. Then they can tell where things are and locate them. (3 millionths of a second they can distinguish)
    - Some owls are day time hunters
        - For them, things are more symmetrical because they have eyesight.
        - The ones that are completely nocturnal are the most offset
    - Therefore: Asymmetrical ear openings in position and shape with wide separation = auditory crosshairs for accurate pinpointing of sounds

Owl Adaptation for Silent Flight

- Denser air carries sound better
- There is also less wind
- This makes it easier to hunt, but also, the prey can then hear the owl unless the owl as adaptations to make it silent
- 1. Low Wing Loading:

    - Large wings carry small, light bodies
    - Heavier load, you would have to flap more, and this would make noise.
    - Owls can just glide and soar.
- 2. Fringe on leading edge of wing helps give silent flight
    - This breaks up the air flow making it quiet
    - But this means they must fly slowly (so this is a draw back)
- 3. Silencers on owl wings called pile.
    - When the feathers slide they don't make a sound

Bats:

- Not only do they hear sound, they produce sound to find prey
- They send out high pitched frequency signals to find prey in the area
- Echolocation: using sound to locate
- Called ultrasounds because we cannot hear them
- Shaking keys can help locate bats.

Shrews:

- Use ultrasound and echolocation

Sense of SMELL: Olfactory

- Adaptation: Elongated Snout
    - More sensory cells to enhance olfactory sense
- Adaptation: Vomeronasal organ
    - Jacobsons organ for snakes
    - Vomeronasal organ (more for mammals) (mass of sensory cells for detecting odours in the air)
    - They expose by a posture called flehmen
- Adaptation: track at dusk
    - A lot of animals hunt when the sun starts to go down or at dusk
    - Mammals do this because there is a scent trail at this time
    - Scent trails are easier to track at dusk
    - Ground is still warm, but the air is getting colder.
    - The cold air is holding the warm air next to the ground so it is being tracked
    - If an animal walks around, their odour is trapped there.
    - So predators put their nose to the ground (ie. fox, coyote, wolf etc.)
    - The way to call by feigning as an injured animal is called squeaking
- Snakes also use scent
    - Snakes analyze scents with Jacobsons organ

- Forked tongue is like asymmetrical ears on the owls head, it allows them to discriminate where the scent is coming from
- In terms of hunting tools: the snakes tongue and the owls wide head are analogous structures (allow the pinpointing of an animal)

Touch/Tactile senses
- Some animals find their food by touch

Racoons:
- Raccoons have touch-sensitive front paws
- They put their paws in the water to try to find food.
- Their front paws are loaded with sensory cells. This is tactile senses.
- Animals that use a tactile sense have a modified brain for analyzing what they are touching
- The front paws are the ones they use for tactile sense
- Tactile paws are crucial for sensory information

River Otter:
- Whiskers are sensory structures
- They are called vibrissae (sensory hairs)
- When the hair touches things, they send nerve signals
- Typically around the mouth
- This us for animals that have hair
- Cats group (mountain lions, lynx, fox)

Birds:
- Birds have modified feathers like whiskers
- Birds have a similar feature called rictal bristles
    - Ie. whipperwhil
- Hair like feathers that have sensory cells at the base of them
- They are analogous to the vibrissae on mammals
- Example; fly catchers and raptors

Star Nosed Mole
- Star nosed moles have eimer's organs in their nose protuberances
- Eimers Organs: tactile bulbous outgrowths of the epidermis; the 22 protuberances on a star nosed moles nose collectively contain 25,000 Eimer's organs
- This nose is very important for them, they dig tunnels underground
- They have tactile sense on their paws too

Sandpipers:
- Long bills for sticking in the mud
- Sandpipers have Herbst Corpuscles in the bills tip

- Little organ in the bill tip with the sensory cells
- Tactile
- Herbst Corpuscles: a pressure-sensitive group of cells associated with tactile sensory perception

Ducks:

- Ducks have a bill tip organ
- They have a bill tip organ called a Nail
- Tactile

Woodpeckers

- Woodpeckers have Herbst Corpuscles in the tips of their tongues

Rattle Snakes

- Sensory cells
- Rattle snakes have an infrared heat sensor in the pit on their face
- Infrared is heat given off by mammals
- The heat pit lies between the eyes and nostrils and can detect changes as small as 0.001 degrees celsius

Techniques to find Prey:

1. Active Searching
    a. Moving around
    b. Foxes, wolves and coyotes do this
    c. Some spiders actively search- one is called wolf spiders because of their behaviour
    d. Tiger beetles also search and capture
2. Wait and Ambush
    a. Praying mantids let their prey come to them
    b. The Golden Rod Crab spider changes colour to match the flower it is waiting on (white on white flowers and yellow on yellow flowers)
3. Traps
    a. Spider webs
    b. There can be up to 7 kinds of silk on one web
    c. Different spiders build different webs and some don't (ie. jumping spiders don't build traps, wolf spiders don't build traps, crab spiders)
    d. Orb weaver spiders build spectacular webs (circular rings) (females)
    e. Orb weaver webs are Flight Intercept traps
    f. The best time to see spider webs is early in the morning
    g. Sheet web spider webs build webs that look messy

h. Two types of silk in this web, vertical are not sticky, the bowl shaped part is sticky, so it knocks them into that
i. The vertical strands are called Knock Down Strands
j. The bottom part is called the Capture “Sheet”
k. Bowl and Doily Spider (one of the sheet web spiders)
l. Funnel Weavers usually build webs on the ground
m. They hide in the funnel at the back end
n. Therefore those are the 3 main groups using webs as traps
o. Silk strands of spider webs must stay moist to be elastic, otherwise they would become brittle
p. So they absorb moisture from the air (dew drops)
q. Therefore, webs are Hygroscopic

Spider Web Facts

- Spider silk has a tensile strength half that of steel! (the strength you can pull it before it snaps)
- Webs contain 6 or more types of silk
- Spiders recycle silk from broken webs
- To build a complex orb web takes… 20 minutes
- Argiope: the type of spide. visible and build a special structure in the middle of the web that are obvious. One theory is that it stabilizes the web and it’s called the Stabilimentum. It’s also a lure though, ultra violet colour that insects can see to attract them

Spiders are not the only animals that make traps.

- Pit-Fall Trap:
  - Ant-lion larvae dig little cone traps in the sand for insects to fall into and they jump out and pull them into the sand to eat them
- Mole tunnels can also be considered traps
- Aggressive mimicry: using your body to attract your meal to you. Ie. Photuris fireflies
- Alligator Snapping Turtle and Angler Fish use aggressive mimicry to attract prey

BIOL Lecture 12- using tools to capture prey

Aggressive mimicry- when animals use part of their body to attract another animal to eat it (alligator snapping turtle and angler fish)

Capturing Prey:

- Once an animal locates prey, it must be captured. There are many tools that they use to do so.

Bird Tools: (birds of prey)

- Talons
    - Ie. falcon
    - Strong toes equipped with talons to scoop up prey
    - They also have sharp claws on the end called talons
- Modified Feet
    - Eg. Ospreys (kind of large hawk)
    - Osprey have special feet for catching fish
    - Osprey have muscular toes and massive talons, and their bill has a huge meat-hook tip
    - Ospreys also “hover” over their prey (stay in one spot in the air and flap wings)
    - Therefore, they eat fish on the surface
    - Two problems with grabbing fish
        - They are under the water
        - They are slippery
    - Sharp “scales” on underside of toes = sharp projections for holding slippery fish
    - Osprey turn the fish around so it points head first
    - Most toes have fixed toes, but ospreys have a toe they can flip around, making it easier to turn something
    - The outer toe is Reversible. (a reversible toe)
    - Owls also have a reversible toe!
- Beaks/Bill
    - beaks/bill can also be used to catch prey
    - Eg. Great blue heron, Common loon, Snowy egret, Mergansers)
- Modified Tongues
    - Loons used modified tongues with barbs on it to keep fish in their mouths and to
- Modified Bills
    - Mergansers are commonly called fish ducks because they are fish specialists
    - They have narrow bills for capturing fish and holding them (no lamellae)
    - They have jagged teeth-like beaks (not actually teeth but serrations all along to hold slippery fish)

Mammals:

- Use canine teeth to catch prey (modified incisors powered by the temporalis muscle)
    - If you are a canine who captures prey, you would have a large temporalis muscle
- Cheek teeth are used to grind up plants (powered by the masseter muscles)

Bugs:

- Use modified mandibles to catch prey (beetles)
- Tiger beetles use modified mandibles to grab and tear apart

Animals that use their tongue to capture prey:

- Frogs use tongues to catch prey (tongue flick)
- Toad tongue flick
- Salamanders use their tongues too
- Frogs eyes help them swallow their prey
- Woodpeckers also capture prey with their tongue
    - It must be extensible.
    - To extend their tongue they use hyoid horns muscles

Legs:

- Crab spider is an example
- praying mantid have specialized Raptorial Legs (front)
- When they see prey it unfolds and snaps on them and the spines help them hold it in place

Canines killing tactics:

- Different groups of mammals with canines.
- Therefore canines can be used in different ways
- Wild dogs, weasels, wild cats are examples of groups
- Fox or coyotes (smaller wild dogs)
    - They hunt smaller prey
    - Use “shake and break” to kill their prey once catching
- Bigger wild dogs (ie. wolves)
    - They tackle bigger prey they hunt socially
    - They hunt socially and use the “slash and shock” to rip holes in the prey to make it weaker

Other animals killings tactics:

- Weasels
    - bite into the cranium and penetrate the brain case to kill
- Cats
    - bite into the neck vertebrae to kill
    - They break the neck by biting this vertebrae
- Eagles, Shrikes
    - Raptorial bills (eagles, shrikes) their hooks are called meat hook tips
    - They kill with their bill
- Bird hawks (Accipiters)
    - kill with their talons (birds that kill birds)
    - They have long toes with talons
    - They stand on top of the prey still alive, and moves around its toes and squeezes until the talon punctures the heart or lung of the bird (squeeze to puncture a vital organ)

- Snakes (garter, water etc.)
    - Many snakes swallow their prey while it's alive (ie. garden snakes, water snakes)
    - They need a specialized mouth to do so: unhinge jaws
    - Allows a much larger opening to bring inside it much larger prey
- Snakes (grey rat, milk)
    - Some snakes kill their prey first by wrapping around it and squeezing
    - squeeze their prey to death (constricting)
    - Gray rat snakes and milk snakes are constrictors
    - Other examples are anacondas and the pythons are constrictors
- Snakes (rattle snakes)
    - Some snakes kill with poison (toxins)
    - Venom = injected toxins
    - Also inject digestive enzymes
    - The prey dies, but while its dying, the enzymes are digesting it prematurely. So part of the digestion is done outside the body
    - Massasauga rattlesnake is an example
- Crab Spider and Assassin Bug
    - crab spiders and assassin bugs inject toxins and enzymes
    - Robber flies- inject toxins and enzymes
    - They stab
    - Toxins to kill, enzymes to digest
- Short tailed shrews
    - Short tailed shrews also have a venom bite (only north American mammal with a venomous bite)

Indigestible parts:

- Spiders / crab spiders
    - slurp out inside
- Birds
    - pluck feathers and then tear chunks of meat
    - This is called selective feeding when it chooses parts it wants to eat
- Bears
    - They pull the hide off the outside (they skin their prey)
- Fisher
    - Hide of a porcupine left behind? It's a porcupine specialist (the fisher)
    - Fishers skin porcupines
- Wolves
    - Also selectively feed but they also eat small bones
    - They crunch them up in their teeth and swallow them and just leave the big bones behind
    - They pass indigestible pieces through their body
    - Wolf and coyote droppings are always wrapped in hair and brought out in the droppings
    - And this is called Wolf Scats
- Owls
    - Owls swallow small prey whole
    - About 12 hours later, they poop but they don't pass the bones

- Unlike wolves, owls cough out bones and fur known as pellets
- A pellet is coughed out

Setbacks of hunting prey:

1. Prey fight back (ie. moose fracturing a wolf skull)
2. Chasing it is dangerous (ie. Hawk with a pierced wing from branch)
3. Pollution from poisons (ie. pesticides) (poison accumulated through the food web into a higher dose, this build up is called bioaccumulation) (ingestion of toxins = bioaccumulation) (Botulism is the biomagnification or bioaccumulation of toxins that begin in the water originally and get passed up the food chain into the birds eating the fish)
4. Human prejudice (a lot of people don't like predatory animals) (ie. killing wolves) (you can kill coyotes whenever you want- no regulations)
5. The NUMBER ONE PROBLEM FOR PREDATORS IS: Starvation

Fact:

- Peregrine falcons were almost driven to extinction because of DDT (pesticides meant to kill bugs but were passed up the food chain. Egg shells were thinned and behaviour was altered
- DDT was used to kill insects, and they ate it, then songbirds at the insects and so on
- Peregrine falcons were driven to near extinction by DDT
    - It changed their behaviour when nesting (would knock off eggs because they were clumsy)
    - And it changed the egg shell thickness (they would crush them when trying to incubate them)
- Therefore, DDT bioaccumulation in Peregrines resulted in thinner egg shells and behavioural changes (this results in no young produced)

TAKE AWAY ABOUT PREDATORS: predators are a major force in natural selection and evolution. Predation also keeps populations down, and it weeds out those that are less fit. Predators refine the prey species in the process, creating a better fit generation. This leads to evolution.

Lecture 13: Eating Prey from the Inside

- Other animals eat their prey from inside them
- The Host can be either killed or left alive in the process
- The host is the animal that has another animal inside (it is the meal)
- If the animal is killed in the process the animal inside eating it is parasitoids
- Parasitoids: kill their HOSTS

Parasitoids:

- There are a number of types of parasitoids
- Most are insects
- Most are only parasitoids in the larval stage
- Braconid Wasps are parasitoids only in the larval stage
- Braconid wasp cocoons are then on the outside of a caterpillar because they dig their way out
- Tachinid Flies are parasitoids as larvae
- Many Flesh Flies are parasitoids in the larval stage

Parasitoids that Paralyze Prey:

- Thread Waisted Wasps
    - Paralyze prey
    - Bury it in the ground with eggs
- Spider Wasps do this too
- Both thread waisted wasps and spider wasps are parasitoids in the larval stage only
- Digger Wasps (bees) do this too
    - Females dig the holes with hind legs to take prey and put their eggs in
- Cerceris (Digger Wasp)
    - Specialize with jule(?) beetles (including ash bore)
    - Dig with mandibles

Parasitoids: Ovipositors

- Some parasitoids find hosts through visual searching
- When the right host is found, eggs are laid through an Ovipositor
- Ichneumon Wasps
    - Ichneumon wasps are a huge group of Parasitoids
    - They have really long ovipositors because they lay eggs on insects in trees
    - Megarhyssa Ichneumon ovipositors are very impressive (because of size)
        - They can serve as “Drills”
        - They do this to locate grubs of Pigeon Horntails
        - When the egg hatches, the paralyzed Horntail larvae is eaten alive
- Pelecinid wasps lay eggs on June Beetle Grubs in the ground
- Turtle eggs are not immune to parasitoids either

Key point about parasitoids: they kill the host. The host that they are feeding on is killed in the process.

Parasites:

- Parasites: Do not kill the Host
- If they are found on the outside of a host, what kind of parasite would they be? ECTOPARASITE

Ectoparasites:

- Leeches
    - Many leeches (blood suckers) are ectoparasites in all stages
- Ticks
    - Ticks are also ectoparasites in all stages
    - Moose Ticks: a particular kind of tick found on mooses
        - Generally found on moose in the winter
        - Engorged female moose ticks are almost the size of a dime
        - Moose rip of their hair because of it and can become hypothermic
        - Winter ticks is another name for the same species
    - Black-Legged Deer Tick (lyme)
        - If they get on humans, they can transmit a bacterium into you that causes lyme disease if you do not take them off immediately
- Mites
    - Some mites are ectoparasites
    - (ticks and mites are in the same groups of animals together like dragonflies and damselflies)
    - Mites are very tiny
    - They go on dragonflies sometimes
    - Arennurus: a group of mites. Arennurus mites are the ones on dragon flies
- Ectoparasitic flies
    - Migratory Birds
    - Many migratory birds harbour ectoparasites
    - Ectoparasitic flies go on birds
    - The name for this is Flat Flys
- To conclude: mites and ticks are ectoparasites

Obligate Parasites:

- Are Biting Insects Ectoparasites?
    - NO. They are Obligate Parasites * read in textbook

Ectoparasite: Glochidium

- Are Clams Ectoparasites?
    - YES. But not in the “clam” stage.
    - Baby clams are ectoparasites on fish gills.
    - Glochidium (baby clam) are ectoparasites on fish gills.
- How do they find a host?
    - Pocket book clam:
        - Sticks out lure (mantel) and when the host comes by it spews eggs on it and withdraws lure

How do Ticks find hosts?open

- Ticks find hosts by Questing
- Therefore, they need adaptations

Ectoparasite Adaptations

- Haller's organ detects humidity, temperature, and carbon dioxide (allows them to idenitify host)
- Other Adaptations:
    - Mouthparts to cut into host
        - The mouthpart is called a hypostome
        - Barbs on the hypostome
        - They can open or close their barbs (ie. close to detach and open to stay on)
        - Ie. ticks
    - Mouthparts for holding and penetrating
        - Ie. leeches, Lamprey (fish)
    - Anticoagulants to keep the blood flowing
        - Inject chemicals to keep the blood flowing so it won't clot/scab up
    - Flattened body shape to climb through feathers, hair
        - Ie. flat flies, lice
    - Claws to grip
        - Ie. flat flies.
        - There are a different group of flat flies found on bats called bat flies

Ectoparasites: Problems/Obstacles

- Hosts die
- Hosts remove them
- Hosts Groom and Preen (ie. birds using their bill to pick off)
- Herons have a Pectinate Toe (serrated edge to groom through feathers)
- Beavers have a double or "split" toe nail

Some Parasites live INSIDE the host… ENDOPARASITES.

Endoparasites:

- Eg. fly grub inside chip munk or mice
- Cuterebra (a Robust Bot Fly) is endoparasitic only in the larval stage
- Deer have a parasitic BRAIN WORM
    - They produce in the deer, so the deer is the Definitive Host
    - The larvae leave the deer through its droppings

    - A slug or snail then becomes the Intermediate Host when it eats the droppings (intermediate host carries it in the larval stage)
    - Then the snail takes them to leaves, the deer eats the leaves, and they go to the brain
    - One problem: if a moose eats the leaves, this same worm that is harmless to a deer can kill a 1000 pound moose.
    - Moose gets the “Blind Staggers” (maladaptive behaviour like bumping into things)
    - Why does the brain worm only kill the moose?
        - The deer has a long term natural evolutionary history with it
- Robins are the Definitive Host for a parasitic Fluke
    - They leave their droppings in the water, and it goes into an aquatic snail (aquatic snail is the intermediate host)

Endoparasites: Adaptations

- (most) Small Size (cuterebra is an exception)
- Parasitic castration (take the sex drive out of the host) (????)

Endoparasites: Problem

- Intermediate host may not be found
- Wrong host might be entered (ie. brainworms in moose die)
- Hosts can die

Lecture 14: Scavenging and Scavengers

- Some animals eat animals that are already dead
- This feeding strategy is called scavenging
- Those animals are called scavengers

Facultative Scavengers: Part Time Scavengers

- A lot of animals are not full time scavengers
- Eagles are also part-time (FACULTATIVE) scavengers, especially in winter
- Gulls scavenge excessively also but will eat live fish as well
- Common ravens also scavenge but not exclusively
- Ravens are scavengers primarily in winter

Obligate Scavengers: Full Time Scavengers

- Turkey Vultures are full-time scavengers

Adaptations for Obligate Scavenging:

- A featherless head
    - For sticking it into unpleasant places (ie. eyes, mouths, rectums, open guts)
- Huge Raptorial Bill
    - Meet Hook Tip for tearing
- Carrion is detected primarily by smell. Therefore, they have a refined sense of smell.
    - Enlarged nasal chamber (large but also complex chambers, more SA)
    - Large olfactory bulb in brain

Adaptations for Locating Food During Flight

- Flight mode is almost entirely gliding and soaring
- Dihedral (V) wing position… for teetering flight (pg. 125)
- Vultures fly low and they fly slow (looking for odours)
- Communal roosting (group roost together)
    - This is for feeding purposes primarily, following vultures to a food spot
    - Theory- Information Transfer (indirect)

Blow Flies

- Scavengers in the larval form because adults lay their eggs on the carcus
- Most are obligate scavengers as larvae only

Carrion Beetle Larvae

- Female finds carcus and gives out sex pheremone so a male beetle will find her
- They bury the carcus and lay maggots on it
- Some beetles in this group are called Burying Beetles
- Necrophagus: Animals that eat dead things

Predictable Food Shortages

- Seasonal (ie. shortages in winter)
- What are the solutions for this?
    - Dormancy/Hibernation
    - Migration
- Therefore, migration solves a predictable food supply problem

Unpredictable Food Supply

1. Seeds and Nuts
2. Berries and Other Fruit
3. Small mammals

Solutions to the Problem of Unpredictable Food Supply

1. Solution: Move to food rich region when necessary (not always south)
    a. Ie. birds are nomadic(?)
    b. Eg. Bohemian Waxwings move to areas with large fruit crops
        i. If all of a sudden the birds nest there because there is a lot of fruit that is an irruption
        ii. Therefore, these birds are nomadic and irruptive
        iii. They can leave an area entirely and then show up in large quantities in an area they are not usually found
        iv. If they are irruptive, the event of them all arriving is called an irruption
    c. Crossbills are seed specialists (ie. white winged crossbill)
        i. cross bills are nomadic and irruptive as well
    d. Great Gray Owl
        i. Great Gray Owls are highly irruptive
        ii. They are crepuscular: active at twilight (the low light period just before dawn and just after sunset)
2. Solution: kill and store food for later
    a. Shrike
        i. Impale animals they have killed in advance on thorns (modified branches)
        ii. They are saving food for later
        iii. Larder: an area of stored food. They create a larder so they can go there to eat food
    b. Owl
        i. Create Larders as well
        ii. They sit on frozen carcuses to dethaw them

Other Animals Store Food for a Predictable Shortage

1. Scatter Hoarding:
    a. Gray Squirrels create hundreds of solitary caches
        i. They scatter their food in different stored spots
        ii. Ie. nuts are buried in the ground, and they dig them up in the winter
    b. Canada Jay (Gray Jay) do not migrate
        i. They scatter hoard food for the winter
        ii. Thousands of items all stored individually, and usually under the bark of spruce trees
        iii. Canada Jays cache food all summer and fall (best example of scatter hoarding in birds)
        iv. Adaptations for storing food:
            1. Enlarged salivary glands
            2. Sticky saliva

3. Nesting early (need enough time to store food after)
4. Amazing memory; a large Hippocampus provides excellent Spatial Memory

v. A Chickadee's hippocampus grows larger before winter

c. Red Squirrel
   i. Stores food for the winter (winter active)
   ii. They cache the cones on coniferous trees that still have seeds inside them
   iii. They create very big stashes
   iv. They create a number of large stashes called MIDDENS
   v. They dig the cones up in the winter
   vi. In the rocky mountains they create monster middens
   vii. They also will store mushrooms by hanging them on trees and then once they are dry they store them
d. Chipmunks
   i. Expandable Cheek Pouches to carry more at one time to hide food
e. Beavers
   i. Beavers create a Central Cache of branches called a Food Pile (right near lodge)
   ii. Drag trails: trails used to go to the forest and they drag the branches through here
   iii. Top part of the food pill keeps the good stuff below the surface
   iv. Favourite food is poplar (bark)
   v. Beavers break the ice using the back of their heads

Exam Question: Are most animals that scavenge full time scavengers? Are they obligate? No. they are facultative or part time scavengers.

Lecture 15: Plant Nutrition

Are plants any different than animals in terms of nutrition?

- Key Difference: Most plants make their own food. PHOTOSYNTHESIS. (photo means light and synthesis means putting together or making)
- Key Similarity: Plants have nutritional needs just like animals. They cannot make food from nothing, they need to have the basic ingredients.
- Therefore, most plants are autotrophic. This is the term used when plants make their own food.
- But they still need basic ingredients: sun, carbon dioxide, water, nutrients (nitrogen, phosphorus, calcium)
- These ingredients that they have to have are not available in the same quantity everywhere. There are certain habitats where some of these things are very hard to find

Bogs

- By nature bogs are **nutrient poor.**
- This means that things like phosphorus and nitrogen are very scarce in that habitat
- True bogs are formed by rainfall
- Two important points: bogs are low in nutrients and therefore the plants that grow there must have special adaptations
- Dominant plants are the most common plants growing there, dominant plants are those that are very common in bogs
- The most common plant in a bog is a Heath plant

Heath Family (Ericaceae)

- How do they live in a bog with no nutrients
- They get by with a little help from their friends
- Heath Plants have fungal partners
- the fungal partners are on their roots and there are long threads that come out of the fungus and these threads go through the bog mat and form a larger area of nutrient uptake. They expand the area of nutrient uptake.
- In return, the fungus gets sugars that the plant manufactures
- This is a symbiotic relationship
- Therefore, Heath plants have fungal partners associated with their roots.
- The fungal association with a root is called a Mycorrhizal Association (fungal threads are tied to the root in some way)
- Mycorrhizae (the fungus) inside roots are called Endomycorrhizae
- Orchids also have Endomycorrhizae
- Mycorrhizae also allow trees to grow in bogs
- The most common tree growing in a bog called a Black Spruce
- Spruces have mycorrhizal associations on the outside of their roots. This is called ectomycorrhizae
- Mycorrhizae:
    - increase uptake of nutrients such as Nitrogen and P (In return they get back sugars which they devour)
    - Prevent uptake of toxic compounds

Alders

- Alders have a different solution for N
- Root Nodules: if you cut them up you find symbiotic bacteria inside.
- Inside root nodules are bacteria that FIX nitrogen (they transform from an inorganic state to an organic state)

Some Plants eat Animals: Traps

1. Adhesive Traps

- Sundews are “carnivorous”
- They have modified leaves for capturing and digesting insects
- (Round-Leaved) Sundew leaves are Adhesive Traps (they are sticky)
- Butterwort also have Adhesive Traps

2. Pitfall Traps
- Eg. Pitcher-plants are “carnivorous”
- These modified leaves hold water from rainfall
- They have drops of water on the outside of the pitcher
- As the insects start walking down to get more rewards there are hairs that all point downwards and it can’t get back again
- The inside becomes slippery, and the insect slides and drowns
- So important parts: downward pointing hairs
- Digestive enzymes break the plant down

3. Suction Traps
- Eg. Bladderworts are also “carnivorous”
- Modified leaves that form little sacks that are the traps
- Their underwater leaves are suction traps
- The sacks have a vacuum inside them and a trap door that opens when tiny animals hit them.
- Then they get trapped and there are digestive enzymes inside
- The proper name for the little bladder traps are: Utricles

Another nutrition related problem: Some environments lack sunlight (ie. forests)

The technical term for a lack of sunlight is shade.

Solution 1: some shade plants have leaves with a large surface area (and they are parallel to the ground (horizontal)).
- An example is the Round-Leaved Orchid
- Round-leaved orchids have large leaves
- These leaves are parallel to the ground
- Also, they are typically thin
- Thin, flat leaves offer other advantages
    - 1. Less energy spent in building support tissues
    - 2. Light reaches photosynthetic cells more quickly
    - 3. Suppresses competition (plants can’t grow underneath you)
- There are other plants that grow in shady conditions including shrubs: ie. Hobblebush. It also has really big leaves (about the size of a hand)

Solution 2: Another feature of shade plants: Chlorophyll B

- Chlorophyll B > Chlorophyll A
- This is the total reverse of plants in sunshine
- They need helpers to bring all the energy to spots where photosynthesis occurs
- A is more common in sunny areas
- Hobble bush is known as nature's toilet paper
- This applies to round-leaved orchids as well

Solution 3: have lots of leaves

- Grow as a colony of plants
- Eg. Bunchberry
- They do this by cloning themselves
- Clonal or Colonial Growth
- One plant has a whole bunch of leaves that draw in more sunlight

Solution 4: Another way to beat the shade is to grow away from it (on top of it)

- Positive Phototropism: growing towards the light
- Negative Phototropism: growing away from the light
- Climb atop of the competition
- Eg. Wild Cucumbers grow atop other plants
- They have remarkable little stems called Tendrils which are Thigmotropic (they have the ability to sense another object when they touch it and can grow around it)
- Thigmotropic: growing on top of something else, using tendrils to hoist the plant as it grows
- Thigmo= Greek for touch!

Solution 5: Bloom before the trees open!

- Eg. Trilliums have another solution to the shade problem
- Trilliums usually show up in April/May
- However, there can be penalties for blooming early (ie. cold and snow, it is too cold for the pollinators)
- Flowers that bloom early are called Spring Ephemerals
- Many Spring Ephemerals grow in deciduous forests
- Know that the category is Spring Ephemeral and a great example is the Trillium

We still do find some flowers in the middle of dark forests in the middle of summer in flower, so how do flowers do this?

Mixotrophs:

- Many shade-dwelling orchids photosynthesize (so the leaves still manufacture food through sunlight) AND steal carbon from other plants through Mycorrhizae.

- So this is a two part strategy: one is to have leaves that capture sunlight and make carbon products (sugars), and two, steal carbon products that other plants have already made through mycorrhizae)
- Because they have a mixed strategy, they are called Mixotrophs
    - Great leaves
    - Steal through fungal partners
- Mixotrophs make part of their food

You can also locate plants with no leaves at all in these shaded areas. No green= they are not making food from sunlight. So how do plants grow with no leaves?

Therefore, other plants entirely lose the need for sunlight… No leaves! Eg. Coralroots

Mycoheterotroph: Coralroots:

- Coral Roots are beautiful orchids that live like.. Scavengers? Or maybe even like parasites.
- Because they are THIEVES. They steal their carbon products from other plants through fungus inside their roots.
- They have mycorrhizae inside their roots (endomycorrhizae) and these mycorrhizae steal food from other plants
- Coralroots attain nutrients from mycorrhizae associated with other plants
- These plants are called mycoheterotrophic : they can't make their own food, they get it though their fungal associations

Indian Pipe:

- This wildflower also doesn't need sunlight
- They too have mycorrhizal associations
- Therefore, carbon products come from living plants
- Therefore, this plant is also mycoheteterotrophic.
- It lives like a parasite!
- Holoparasite! - food comes from stealing.

Three Categories
Autotrophic: make all their own food through sunlight and chlorophyll
Mixotrophic: make part of their food, steal part of their food
Mycoheterotrophic: a plant that obtains all of its nutrition from carbon based compounds obtained from fungi

Cancerroot:

- A cancerroot plant has NO leaves and NO mycorrhizae

- Its roots have to attach directly to another plants roots.
- Forgo the partner and do it yourself
- How does it find those plant roots?
- It tracks chemicals (strigolactones) released by host plant to attract mycorrhizae
- Therefore it is a Holoparasite as well as its a parasite plant completely.

Witch's Broom:

- A local plant is parasitic on branches
- Dwarf Mistletoe is a holoparasite
- Its abnormal growth caused by a little parasitic wildflower called dwarf mistletoe and it causes witch's broom

Some plants grow in areas with TOO much sunlight. What are the solutions?

Solution 1: Leaves with small surface area

- Eg. Buttercup plant
- It has tiny leaves
- These leaves grow roughly on a 45 degree angle

Solution 2: Highly Dissected Leaves

- Some plants growing in really sunny, really hot (maybe sandy?) areas have highly dissected leaves
- All this does is reduces surface areas
- Highly dissected leaves have a reduced surface area

Therefore, plants and animals must overcome the same life challenges. So far we have covered the nutritional component BUT there is another component.

Plants and animals must overcome the same life challenges including… THE DRIVE TO ACHIEVE GENETIC IMMORTALITY

- This is why they defend themselves against animals, and focus on nutrition
- They want to reproduce and pass on the genes
- They want to become immoral in the process

REPRODUCTION:

Sexual Reproduction: Involves two sexes
Asexual: only one sex is involved

Asexual vs. Sexual

Benefits to Sexual:

- Diversifying the gene pool
- Two different donors give a sperm and egg together
- Better for evolution and adaption

Asexual:

- Carbon copy
- Lack of diversity and adaptation
- Generally confined to very tiny thing

Two Types of Sexual Reproduction:

- Internal: sperm is put inside the receiving partner
- External: both sperm and egg meet outside the body

External Reproduction/Fertilization

- Fish like this bass use external fertilization
- Frogs and toads use external fertilization
    - The special hold the male frog uses on the female is called Amplexus
- The problem with external fertilization:
    - The sperm could miss the eggs. There is no guarantee it will be fertilized

Internal Fertilization

- Most animals use internal fertilization to better guarantee their efforts
- Some sperm donors never meet even when internal fertilization occurs
    - Eg. Freshwater sponge is an animal that grows as a colony (male and female)
        - They release sperm in the water
        - another sponge downstream can take in the sperm and get the internal eggs fertilized.
        - Hermaphrodite: an animal with both sexes
        - Therefore, sponges are HERMAPHRODITES
    - Eg. Clams also send their sperm into the water
        - They are also hermaphroditic and never meet
    - Eg. Slugs and snails are hermaphroditic
        - BUT they meet their mates and use personal delivery for sperm
        - Sperm meets eggs inside their body= internal fertilization
        - They have “Love Darts” that they pierce each other with
        - Therefore, they receive and deliver hence hermaphrodite
        - Gastropods use an intromittent organ to get sperm to eggs
    - THEREFORE, clams, freshwater sponges, slugs, snails and earthworms are HERMAPHRODITES
        - They are also slow or sedentary

        - Animals that are very slow moving and sedentary double their chances by being hermaphroditic
    - What is the advantage of being hermaphroditic?
        - They are improving the odds of reproducing by having both sexes
        - They are doubling the chances
        - Therefore, hermaphroditism doubles an animals chances of reproducing
    - Eg. Snow Flea's: little animals called Springtails are not hermaphrodites
        - They use internal fertilization yet many never meet their mates
        - Many male Springtails leave Spermatophores on the ground for the female to pick up
        - This is still internal fertilization without meeting a partner
        - Internal fertilization without the two sexes meeting

Lecture 16: Reproduction Continued

- Anything that inserts sperm into another body is called an intermittent organ
- Once again, a general trend is that sedentary or slow moving animals double their chances of reproducing by being both sexes.
- Chemicals in the love dart help stimulate them

Spiders:

- Male spiders use Palps or Pedipalps
- These unusual intermittent organs are actually part of the mouth structure of a male structure
- the male spider reaches down to where the sperm is created and sucks it into this palp
- Then this intermittent organ goes into the female genitalia.
- Therefore, Pedipalps= intromittent organs (primary purpose is to inject sperm into eggs)

Snakes:

- Male snakes have two intromittent organs called Hemipenes
- They can only use one at a time

Penis:

- Penis is an intromittent organ
- A penis deliver sperm close to the egg
- It is also used for stimulation

Intermittent organs are not always on display. When not needed, a penis is usually stored away

- This is for good reason, it can be damaged. If its a moose it might catch on bushes or if its a beaver it might cause drag in the water

- If a bird had a penis hanging it would cause drag in the air

Birds
- Most birds do not have a penis or any other intermittent organ
- Instead, they press their Cloaca's together
- Cloacas are where waste comes out, sperms comes out etc.
- This is called a "Cloacal Kiss"

Some animals have a second type of support:
- A penis bone = Baculum

How do Animals Meet a Potential Mate?
Meet by chance
- Eg. Barnacles are Hermaphrodites
- Barnacles have a "wandering penis"
- This can be up to 40x their body length

Many animals find a mate not by chance but by finding one by… ADVERTISING:
1. Auditory Advertisements
    - Sounds use for advertising for reproduction are called courtship sounds
    - **Some animals use different parts of the body to manufacture sound**
    - Eg. woodpeckers use their bill to DRUM
    - Ruffed Grouse also drum
        - Use their wings and a drumming log
        - The sound comes from air rushing into a vacuum
    - Wilson Snipes make non vocal sounds with their tails
        - Snipes WINNOW.
        - The feathers in the tail vibrate
    - Crickets and grasshoppers make courtship sounds by rubbing wings and/or legs together
        - Stridulation: rubbing body parts together to make sound
        - Many insects produce courtship sounds through stridulation (p. 139)
        - Tree crickets use leaves as amplifiers
    - Band-winged Grasshoppers
        - The sound they make is like electrical zaps
        - Crepitate/Crepitation is the action
    - Cicadas
        - Cicadas produce sound another way
        - Cicadas use Tymbals
        - The hotter it is the faster their muscles move.
        - They are also known as heat bugs
    - **Sound can also be produced vocally**

- American Toads (and frogs)
  - use vocal advertisements
  - Male toads and frogs have Expandible Throat Sacs
  - Their expandible throat sac acts as a resonating chamber
  - Toads have one vocal sac
  - Leopard frogs have two vocal sacs
  - Amplexus stimulates
  - Male Bullfrogs have a large Tympanum
- Birds have a unique way of making sounds
  - No other animal makes sound the way they do
  - They have a Syrinx which no other animal has
    1. The Syrinx allows birds to sing two songs at one time
    2. They can control both sides separately
    3. Birds use 100% of air
  - Song has two main functions:
    1. Declaration of territory (male)
    2. Songs can serve to attract mates
  - Warblers sing two different songs
    1. One for territory announcement
    2. A second function of song is mate attraction
- Female Selection is a major part of sexual selection and a driving force in evolution (subset of natural selection)
- Some Mammals use vocalizations to attract mates.
  - Moose
    - During the RUT, cow moose call to attract bulls
    - Bulls also vocalize and thrash with their antlers (vegetation on antlers)
- Advertising with sound has its advantages:
  - Sound carries a long way
- Advertising with sound has disadvantages:
  - Predators and parasites can hear you
  - Cheaters called satellite males can exploit your efforts

2. Advertisements Can Be Visual

- Typically only one sex is brightly coloured (males)
- Female choice is a powerful component of sexual selection
- Therefore, colours get refined through time
- Female choice is why many male songbirds are beautiful
- In Wilson's Phalarope, the females are more brightly coloured
  - Females have more testosterone in their ovaries than males do in their testes
  - When you have two animals of the same sex that have very different appearance that is called dimorphism. If it involves reproduction, it is called sexual dimorphism.

    - In the case of Wilson's Phalarope, the sexual dimorphism is reversed. Therfore, it is called Reversed Sexual Dimorphism
    - Females mate with many males, and the males do the raising of the young
    - Phalaropes are Poylandrous (female with multiple males)
    - So females have multiple males
- Females select males on the basis of appearance
    - Female mallards choose males with the greenest heads
        - Yellow bills are important too
        - Bright colours reveals age and health
    - Female House Finches choose brightly coloured males
        - Brightly coloured males are better at finding food!
        - Good foragers will be good at feeding young
        - 90% of birds, both male and female take care of young
    - Some birds have ornaments
        - Eg. Atlantic Puffin
            - Ornament- one part of the body is modified for sexual selection
            - For the Atlantic puffin it is their beak
            - Badges of status or maturity
            - Two years per groove
            - Males with two or more grooves are chosen
            - A specific characteristic can give a female information on a males foraging ability
            - Older means he is a survivor that is a good fisherman and so will be good at feeding babies
        - Antlers are ornaments
            - Eg. deer, caribou, moose, elk,
            - They are only there for reproductive purpose
            - Bull (male) moose have antlers
            - Antlers change size and shape with age
            - The Tines: the points on an antler
            - The Palm: the flat part
            - Antlers are shed every winter and grow back the next year
            - When they are growing they are covered in a thick skin called Velvet
            - Moose Antler Bone is the fastest growing bone in the world!
            - Not all antlers are equal
            - Females can tell a bulls age largely by their antlers
            - Therefore, Antlers are indicators of age=maturity
            - Also an indicator of health, because a sick bull cannot put all his resources into his antlers
            - Deformed antlers are not good for impressing females
            - Antlers are visual indicators of age, health and status and are seen by both sexes

- Antler displays can defuse aggression
- Bull moose learn in a process called Sparring
- “Playful” sparring occurs after the rut is over
- Through Sparring Bulls learn that antler size reflects stature (strength and dominance)
- Like song, antlers are a part of sexual selection
- Bull moose are aggressive during the rut and injuries can happen

Lecture 17:

Recall: Antlers are ornaments and products of sexual selection.

Dobsonfly:

- Also has an ornament on its head
- Male dobsonflies have “tusks” which are ornaments

Visual Advertising can include elaborate RITUALIZED DISPLAYS

- This is often called Courtship
- Head Displays: Ducks
    - Many ducks use Head Displays
    - Mallard ducks have green heads and they bob their heads up and down
    - Hooded Mergansers: the males puff up their heads
    - Male Ruffed Grouse use Neck Ruff and Tail Displays
- Aerial Displays
    - Midges you courtship swarms or mating swarms
    - Ebony Jewelwing (a noteworthy damselfly)
        - Males do a courtship flight and female would clap her wings if she wants to mate
    - Male Fireflies Aerial Light Displays
        - Species specific designs
- Synchronized Displays
    - Swans have choreographed synchronized displays
        - A pair of animals both take part in courtship
- Ritualized Dances
    - Sandhill Cranes perform Ritualized Dances
- Communal Display Grounds
    - Wild Turkey
        - Major caruncle is the big red thing
        - They have a beard that hangs down
        - Caruncles are on the back
        - Snood hangs over its beak

        - Male turkeys strut and show off their tails
        - Wild turkeys have Communal Display Grounds
        - The grounds where they dance are called Leks
        - A leks: a group of males doing communal displays in the same area
        - Leks can have 20 males or more in some cases
        - Females watch displays and only the very best displayers get to mate (usually with more than one female)
    - Male Sharp-Tailed Grouse also Dance at Communal Display Grounds
        - They have Leks as well

Olfactory Advertisements (Chemical Advertisements)

- Pheremones used for attracting mates are called sex pheremones
- Moose
    - Both males and females use sex pheremones
    - Females urinate to send sex pheremones and males sense this using their jacobsons organ or vameronasal organ
    - Bulls also have sex pheremones
    - They create Rut Pits and pee in it.
    - They roll in the Rut Pit, picking up pheromones
    - They are called Rut Pits and Wallow Pits

- Snakes
    - Female snakes leave Pheromone Trails
    - Males will follow these trails exactly
    - There is no courtship though
    - Males compete for access to her

- Insects
    - Pheromones are commonly used by insects
    - No courtship here either, just male competition
    - Usually females produce them
    - Males use their antennae to track down females
    - Many Female Moths advertise with pheromones
        - Especially Silk Moths
        - Females release pheromones in PLUMES
        - Males have big antennas - 4 million sensory pores per antena
        - Can sense them a few km away
        - Does a special flight to locate them from the plume
- Hares
    - Pheromones can have a second role
    - Male hares leap over the females and pee on them
    - This releases hormones for the purpose of stimulation

- Porcupines
    - Male porcupines pee on potential partners

Gift Giving (Edible Courtship Gifts)

- Cedar Waxwings
    - A male cedar waxwing will grab food and present it to the female
    - The female and male keep exchanging this food (ie. a berry)
    - Waxwings have courtship displays involving food giving

- Terns
    - During mating season, the male terns will bring the females small fish

- Spiders, Scorpionflies and Dance Flies
    - Edible courtship gifts are also given by some male spiders, scorpionflies and dance flies
    - These are all predatory insects (the females may eat the meals)
    - So why would the male bring her food? To avoid being eaten!

Dummy Nests

- Male Marsh Wrens also offer gifts
- They make dummy nests before the females return
- The more dummy nests a male has, the more females he has
- Why would females gravitate towards males with better/more dummy nests?
- Perhaps indicates more food in the area/territory

Nests

- Male Bass and Bluegill Sunfish offer nests too
- Three forms of males
- Two forms of satellite males
- (one that are big and colourful, create/guard nests, males that are young but can still squirt sperm, males that look female)
- Penalty for satellite males - real penalty if you are caught, you may get bitten
- Therefore, there are 3 appearances for males

Paternity - how to make sure you are the father.

Contact Guarding:

- Moose will contact guard and chase off other bulls
- Male dragonflies and damselflies have claspers and they form a wheel and stay coupled during copulation and after

Long Copulations:

- Male walking sticks use BONDAGE
- “Handcuffs” claspers keep walking sticks couples for a day or two

Copulatory Plugs:

- Many beetles use Headless Sperm
- Featherwing Beetles use Giant Sperm
- Mosquito ejaculate hardens making a cement plug
- Some males add anti-aphrodisiacs to the plug
- Male garter snakes also create a plug and secrete anti-aphrodisiacs
- Honey bee: the male body explodes during sex, and the part of their body in the female forms a plug

Plants Get Sexy too!

When it comes to reproduction, are plants different than animals?

Difference #1: Plants cannot move around to find a mate
Similarity #1: similar because they both produce a sperm and egg. Most plants are hermaphroditic!

Flowers are sex machines!

Plant Sex 101:

- Floral Sex Organs
- Stamens (male): the whole structure
    - Anthers: produce sperm
- Pistil (female): the whole structure
    - Stigma: receives sperm
    - Style: holds up the stigma
    - Ovary: produces eggs

Pollen Grains:

- Do plants have a penis or an intermittent organ? YES. Pollen Grains are the plant’s penis. Analogous to an intermittent organ for an animal is a flowers Pollen Grains, because they both bring sperm to the egg.
- Pollen Grains are the floral equivalent of an intromittent organ.
- A Pollen Grain contains two sperm and a tube nucleus

Double Fertilization:

- Unique to plants

Lecture 18:

Problem: How do plants get the sperm in pollen grains to the eggs?

Anemophily: Wind Pollination

- Examples of wind Pollination
    - Grass Pollen is carried by wind
    - Sedges are wind-pollinated
    - Ragweed is wind-pollinated
    - But Goldenrod is NOT wind-pollinated
    - Coniferous tree pollen is also wind-carried
- Wind Dispersed Pollen is:
    - Small
    - Lightweight
- The term for wind pollination is Anemophily
- The Benefits of Wind Pollination:
    - Wind is not a limited resource
    - Powerful can carry it far
- The Disadvantages of Wind Pollination:
    - Delivery is not guaranteed
- Solution:
    - Create a LOT of Pollen

Hydrophily: Pollination by Water

- This is really rare
- river weed is the example
- The plants use the force of water to carry pollen down

Couriers:

- Birds:
    - Hummingbirds are an animal courier
    - pollinators = “surrogate lovers”
- Majority of animal couriers are insects
- Therefore, insects are the most important group of pollinators (entomophily)
    - Wasps
    - Butterflies
    - Moths
    - Flies
    - Beetles
    - Bees * (probably the most important)
- Bees including:

- Bumble bees and honey bees

Pollination By Insects is Called Entomophily

Why do pollinators help flowers have sex? Because they are bribed!

1. Food:
    a. Pollen attracts some insects such as Hover Flies or Bees
        i. Some flowers offer only pollen as food
        ii. These are pollinated by bees
        iii. The whole at the end of it is called the Poricidal Pore
        iv. They also use Anther Cones/Tubes
        v. The bees have to shake their wings at a certain frequency to get the pollen
        vi. Therefore, it is called Buzz Pollination
        vii. Bee's often have a Pollen Basket on their legs
    b. Besides Pollen, what is the second edible enticement? Nectar! (sugar water)
    c. Nectar (Sugar Water)
        i. Nectar is held in Nectaries
        ii. Buttercup nectaries are small sleeves at the base of each petal
        iii. Nectar is held in Shallow Cups in MilkWeeds
            1. Cups attract a variety of insects, very general who can obtain
        iv. Columbine has special nectar leaves with Long Spurs
            1. Much more specific about what pollinators can go here
            2. Long Spurs require Long Tongues
        v. Cardinal-Flowers have really long spurs… but bees ignore them.
            1. Who do they attract?
            2. Hummingbirds

Flowers Advertise!

Flower Advertisement: Colour
- Different combinations of colour and form attract different pollinators
- Shape and Colour are Long Range Visual Attractants
- Different Insects Prefer Specific Colours
    - Bees love Blue
    - Yellow flowers attract flies and a few wasps
    - Most see green as a neutral grey colour
    - They see our yellow as "insect red" or "bee red"
    - Most insects cannot see the colour red, those that do are primarily located in the tropics

- Red is seen by very insects but it is seen by… hummingbirds. This is why cardinal flowers attract hummingbirds.

Flower Advertisement: Scent

- Scents are close range attractants
- Evening Primrose
  - The flower opens up and lets go its perfume in the evening
  - They release scent at dusk when their flowers open
  - Attracts moths
  - Primrose moth hides inside it during the day
  - Flowers time their scent release to when their pollinators are at peak flight time
- Wild Ginger
  - It smells like Rotting Fungus
  - They are pollinated by Fungus Gnats
  - This is Brood Site Deception (deceiving insects into believing they found a place to lay their eggs, they don't actually lay them their, but they pick up pollen)
- Red Trilliums
  - Red Trilliums smell like rotting flesh
  - They attract flesh flies which lay their eggs on carcass
  - Therefore, they are pollinated by flies drawn to carrion (dead animals)
  - This is another example of Brood Site Deception
- Flowers also use Close Range guidance aids
  - Spots, Bulls Eye,
  - These patterns are Nectar Guides
  - Nectar Guides:
    - Guide insects to where the nectar is
    - Nectar guides can be landing targets
    - Insects can see ultraviolet, so they see nectar guides and patterns that we cannot see.
- Why go through all this hassle?
- Cross-Pollination (Outbreeding) is better for Greater Genetic Diversity / Variability

How do plants avoid Self Pollination?

- Self-Sterility= Self-incompatibility (ie. the flowers pollen will not work on its own female parts)
- Another is Spatial Separation of the sexes
  - A) On the same plant (Monoecious)
    - Coniferous trees have wind pollination as their process
    - Male flowers of conifers are usually near the bottom of the tree and the females are near the top (pine cones are at the top)
    - Why are female flowers on top? To avoid self-pollination.
    - This is why pine cones are at the top
  - B) Spatial Seperation with each sex on a seperate plant (Dioecious)

        - White Campion: either only male or female flowers on one plant
    - C) Spatial Placement in the same flower
        - Example:
    - D) Temporal Separation of the Sexes
        - Jewelweed Flowers start off as males
        - The male part falls off the flower and becomes female
        - Temporal sex change: dichogamy
        - Plants with Spiral Floral Arrangements display dichogamy with a “twist”
            - Lower flowers open first and are functionally male with pollen blocking the way inside the flower
            - After the pollen is removed, flowers become functionally female
            - Therefore, the lower flowers are the first to become female, and bees/insects are drawn to the lower ones first
            - After a flower becomes female it offers even stronger attractions
            - Lower and older flowers= female
            - Younger and higher flowers = male
            - Pollinators start at lower flowers, work their way up the spiral
            - Direction of pollen flow prevents self-pollination

Know this for exam:

- Pink Lady’s Slippers employ a placement strategy and also use deceit and a trap

Lecture 19:

- Another form of avoiding self pollination occurs
- Purple Loosestrife:
    - Purple loosestrife has 3 forms of flowers
    - Each form is on a seperate plant
    - Two sets of stamens
    - One pistil in each flower
    - Pistils vary in length
        - Short Style Form
        - Medium Style Form
        - Long Style Form
    - These flowers cannot pollinate the same kind of flower
    - This strategy is called Heterostyly (style varies)
    - Because there are three forms of flowers (3 style lengths) it is called TRISTYLY
- Pickerel Weed
    - Also has three forms
- DISTYLY - two forms
- Pink Lady’s-slippers:
    - Pinky Lady’s slippers deceive pollinators with false promises
    - Pink Lady’s slippers employ a placement strategy and also use deceit and a trap

    - This Pouch-Petal has a slit-opening where the bee enters and gets trapped inside
    - Typically bees
    - Staminode with a big ball of pollen
    - Both exits are partially blocked by the staminode and sticky pollen masses
    - Any pollen the bee is carrying is pulled off by the stigmatic surface, and they take the plants pollen with them
    - They bloom early when naive bee workers are still learning
    - This one has a TRAP WITH NO REWARD
- Pseudopollen
- Pseudonectaries
    - Basically they both offer fake food to trick/deceive pollinators
- Common Milkweed
    - Milkweed has clamping SADDLEBAGS of pollen
    - When the insects leg goes down the slit, it gets stuck. If it goes down another, then it will release
    - Small insects may die if they are completely stuck
- White Water-Lily
    - Opens first as female flower (stigma below)
    - A sweet liquid attracts flies and beetles
    - The flower closes overnight, trapping its guest
    - The next day it opens as a male and as insects crawl to freedom they pick up pollen from the now-active stamens
- Grass Pink
    - Grass Pink has a SLAM DUNK trick
    - They have fake stamens and pseudopollen
    - It has a hinged petal
    - winged “coffin” with sex organs
    - If a bee lands on the pseudopollen, the petal collapses, trapping the bee
    - Petal plays an active role, he calls it a slam dunk
- Laurels
    - Laurels have bashing stamens
    - When they step on the arm of the anther, it springs up, bashing them with pollen
- Bunchberry
    - Also known as “pop” flowers
    - Bunchberry flowers explode like land mines
    - The stamens are the fastest moving floral parts in the world
- Twayblades
    - Twayblades also have explosive sex!
    - Twayblades open as males with a “canon” with pollen ready to fire
    - Once the cannon is fired, the flower is functionally female (dichogomy)
    - Note that the older flower is on the bottom and is female (insects go female to male and avoid self pollination that way)

- Helleborine
    - Releases the odours of a plant under attack (wound hormones) without being under attack
    - These attract predatory wasps (they think their might be a caterpillar there)
    - Also provides nectar
    - Some flowers offer insects something else they crave…
- Bee and Fly Orchids
    - Bee and Fly Orchids offer SEX
    - Look and feel like female insects and give off sex pheremones
- Overall, flowers exploit the animals coming in.

Therefore, Cross-Pollination is the General Rule.

Wildflowers go to Plan B!

- Next to the warm ground they have flowers that SELF-POLLINATE and produce seeds
- Cleistogamous Flowers are an insurance policy (they are closed and never open and are used for self pollination)
- Many Spring Ephemerals have these (they bloom early and might not have insects around yet)
- They guarantee seed production even if it is too cold for pollinators to fly

Dandelions

- Dandelions primarily self-pollinate
- But these plants are the exception not the rule
- Allows them to come in and dominate quickly
- The habitats they live in are rather temporary in nature

Challenge #5: Getting Progeny off to a good start in life

- For animals: Parental Care
- For animals: Seed Dispersal

Seed Dispersal

Seeds can be Protected PHYSICALLY:

- Some use hard structures, such as scaly CONES
- Some have ARMOUR in the form of HARD SEED COATS such as those on ACORNS

Seeds can be protected CHEMICALLY:

- Ie. blueberries
    - What chemical makes plants taste bitter? Terpenoids.
    - Unripe berries are protected with bitter TERPENOIDS

    - The unripe colour of a blueberry might be aposematic colouration, it tells seed dispersers it isn't ripe
- Ie. Milkweed Seeds
    - Milkweed seeds are well protected by the pod full of cardiac glycosides (terpenoids)
    - Once mature, the pods open and the seeds are off

How are Seeds Sent Off?

1. Plants in open habitats such as old fields often use the wind (ie. grasses, cattails)
    a. Wind Dispersal of Seeds= ANEMOCHORY
    b. In order to fly seeds have adaptations
        i. Small, lightweight seeds
        ii. Dandelions are carried by silk parachutes
    c. But no solution is perfect. What is a drawback to having seeds dispersed via anemochory?
        i. Missing the target habitat
    d. So the problem is missing the target. What is the solution?
        i. Solution: produce lots of seeds
        ii. Each Firewood Flower produces 70,000-100,000 seeds
        iii. But there is never only one way to solve a problem including seed dispersal
2. Some seeds harness the power of animals
    a. Hooks and barbs catch on hair or feathers (the seeds hitch hike!)
    b. The common name for this plant is Stick Tight
    c. Burdock seeds also hitch hike (velcro was based off this)
    d. Queen Anne's Lace also uses animal power for seed dispersal, but not every day!
        i. The Umbel closes on cloudy days and opens on sunny days
        ii. How does a dead structure do this? Humidity
    e. Dispersal via animals: ZOOCHORY

Lecture 20:

- Other sun loving plants exploit animals in a very different way
- The plants bribe animals with sweet food and the seeds travel inside the animals!
- Dispersal via animals (outside): EPIZOOCHORY
- Dispersal via animals (inside): ENDOZOOCHORY

Endozoochory: (dispersion via inside of animal):

- These animals have been exploited as SEED DISPERSERS (bears, raccoons)
- Recall that waxwings eat fruit and poop out the seeds
- They have also been exploited as seed dispersers

- Recall some animals are SEED PREDATORS
- Seed dispersal also takes place in very different habitats

How do spring ephemerals such as trilliums disperse seeds in the forest in mid-summer?

- Spring Ephemerals use a most ingenious strategy
    - They pay animals to disperse their seeds
    - They use ants
    - Elaiosomes - a special package of protein (food) on a seed that ants go after and carry back to their homes for dispersal
- Violet seeds also also a spring flower
    - They have Elaisomes too
    - But first they are dispersed from the plant
    - The pods shrink, squeezing out seeds one by one
    - This type of dispersal is called Ballistic Ejection
    - Then the ants take over, grab the seeds and move them somewhere else

Larger animals disperse seeds in forests too

- Squirrels and birds take the seeds with the intention of eating them later but either forget where they are or die and then the seed germinates there

Two Other Spring Ephemerals (bloom early) use another method of dispersal

- Mitrewort
    - Mitrewort doesn't use animals or wind
    - What disperses its seeds?
    - They use rain drops!
    - Therefore, the little cups the seeds are held in are called SPLASH CUPS
- Foamflower
    - Foamflower uses raindrops in another way
    - Foamflower has spring boards

Is wind ever an option for seed dispersal in a forest?

- In autumn leaves fall off the trees and wind is available
- Maple Samaras (keys) are adaptations for wind dispersal
- Some tree seeds have Sails (ie. Basswood)
- Yellow Birch
    - Seeds are wind dispersed in winter
    - They have little wings on the side
- Key thing: a number of trees use wind but not in summer
- Tiny windblown seeds that land on stumps or logs = PERCHED BIRCH
- Some plants at ground level use the wind too
    - Ie. Indian Pipe
    - Indian Pipes bloom in late summer

- In fall the upright seed pods mature and split open, making tiny seeds available to the wind

Every Habitat offers Seed Dispersal Challenges

- Many shoreline or aquatic plants have flotation devices on their seeds (ie. Wild Iris)
- Dispersal by water is called Hydrochory
- Orange Jewelweed grows in wet places
    - When the seeds are mature, the pod straps are under high tension and explode open when touched, the straps acting as catapults
    - Seeds are thrown several metres from the plant
    - This is called Ballistic Ejection
    - Jewelweed is also called “touch me nots”

Advantages of Seed Dispersal:

1. Avoids crowding and competition
2. Prevents spreading of disease or parasites
3. Prevents in-breeding
4. Saves some of the off-spring from being eaten

But seeds are not produced each year in the same number

- Many plants vary seed production based on environmental conditions
    - “Boom or Bust Strategy”
- Some plants abort seeds if conditions become poor

The Animal Equivalent of Seed Dispersal is… PARENTAL CARE.

Parental Care

- The goal: getting progeny off to a good start in life
- American Toad: American toad eggs laying in the right habitat
- Females choose the right habitat (ie. dragon fly)

Choosing the Right Habitat:

- Temporary or EPHEMERAL PONDS are egg-laying habitat for… FREEZE TOLERANT FROGS (eg. Grey Tree Frog) (the benefit- no fish) (many salamanders do this too)
- Rotting Logs can be important egg laying sites (eg. smooth green snakes) (benefit: protection and humidity)
- Monarch butterflies lay their eggs on milkweed

Eggs of most insects, amphibians and reptiles are not guarded

- Turtles (snapping)
    - Parental care in turtles only involves laying their eggs in the ground

        - The soil temperature during egg incubation determines the sex of hatchiling turtles!
- Walking Stick
    - Walking stick eggs end up underground but are not placed there by the female
    - Like seeds of spring flowers, they are carried by eggs underground (they have a protein package for ants to eat as well)
    - They mimic these seeds
    - They are carried by ants for the edible capitulum
- Northern water and Garter Snakes
    - Northern water and garter snakes hold eggs internally until they hatch
    - Ovoviviparity: the eggs are held internally until they hatch
    - Once they are external, they are not guarded, they are on the one.
    - So the only parental care given by these snakes is to hold them internally
    - The eggs are not nourished internally
    - The young that are “born” are not guarded

Other female animals guard their eggs

- Five-Lined Skink
    - They guard the EGG. not once they hatch
- Female Red-Backed Salamanders
    - Female red-backed salamanders guard eggs
    - This is the one salamander that does not go to water, it goes to a rotting log and waits for them to hatch
- Female Wolf Spiders
    - Female wolf spiders carry their eggs around
    - The Egg Sac is held by the SPINNERETTES
    - Babies are carried on the mother’s back
- Female Nursery Web Spiders
    - Female nursery web spiders carry their egg sac in their “jaws”
    - They build a nursery web and guard the sac
    - They also guard their young
- All of the aforementioned animals provide a small investment internally

Do any male animals guard the eggs and young?

- Some male fish (bass and bluegill sunfish) do
- Male Giant Water Bugs also
    - Eggs are stuck to the males back and the female glues his wings shut

Larger Animals often provide a lot of parental investment both internally and externally

- Moose
    - Moose have an 8th month gestation with placental connection
    - Young are born PRECOCIAL
    - Precocial: they can move around/born in a pretty advanced stage

        - Parental care for the female moose involves protecting the young and feeding the young
        - Cow moose protect their young for one year
        - Total parental investment: 20 months
- In 95% of mammals, females provide ALL of the parental care (but there are some exceptions)
    - Wolves and foxes exhibit BIPARENTAL CARE
    - Biparental care: both parents are involved in rearing the young
    - Wolves are SOCIAL ANIMALS
        - The pack cooperatively raises the pups
        - In mid-summer pups are taken to open places called RENDEZ-VOUS SITES
        - Commonly found in beaver meadows
        - Adults go off hunting and bring food back to the young on a regular basis
        - Food is brought to the pups at rendez-vous sites

Lecture 21:

- Wolf howling *
- Wolf howling event began in 63
- Ie. wolves
- Wolves have a gestation period of 9 weeks
- Wolf pups are altricial
- About half of wolves die of natural causes (ie. hunger)
- Biggest danger they face is really starvation

Not All Females Invest a Lot Internally

- Blackbear
    - Black Blackbear cubs are born highly altricial
    - Altricial: born in an underdeveloped or premature stage
    - Females stay with the cubs for 1.5 years
    - The biggest danger: male Black Bear
    - Female black bears do protect them!
- Opossum
    - Even more altricial are the young of Opossums
    - They are born after 13 day gestation
    - Most altricial locally
- Bears
    - Bears mate in June and give birth in january
    - Their gestation is two months
    - Delayed implantation: allows bears to mate and give birth when the timing is right
    - Mid-summer they are spending the time getting food

Many Carnivores display Delayed Implantation (besides bear)

- Fisher
    - Mate at the end of march
    - Implantation doesn't occur until the following february and they give birth at the beginning of march
    - Delayed implantation!
    - Blastocyst - is what implants on the wall (it floats in the uterus until implantation)

Bats

- Bats mate in summer and give birth the next spring
- Gestation- about 40 days
- How?
- Bats do not exhibit delayed implantation!
- Instead, they STORE SPERM
- This is called Delayed Fertilization

Social Insects (Bumblebees and Paper Wasps)

- Social insects such as bumblebees and paper wasps also store sperm
- Delayed fertilization

Paper wasps, ants and other social insects display GROUP CARE for the young

- Ants are social insects and have castes

Birds

- After mating birds show two major types of parental care
- The most common is when both parents take part in raising young (both share in parental investment)
- Over 90% of all birds provide BIPARENTAL CARE

The Other 10%....

- After mating, male ducks and grouse desert the females
- Female only parental care
- Female only parental investment after mating
- Shells require lots of CALCIUM and inside = yolk
- Yolk is nutrition for the embryo inside
- Ducks, Grouse and Sandpipers = large eggs, 40% yolk
    - BUT ducks, grouse and sandpipers = little effort in nest building
- Songbirds= small eggs, 25% yolk
    - BUT songbirds= elaborate nests
- Why the difference?
- DUCK AND GROUSE

        - have precocial chicks which leave the nest after hatching
        - Longer development in the egg allows chicks to hatch mobile and largely self-sufficient
- Songbirds
    - After hatching, altricial nestlings remain in the nest
    - Incubation for altricial is about half of precocial
    - Loons are about 29 days and average song bird is about 13 days (but then they have 12-14 days in the nest

What is the difference between parental care and parental investment? Parental care is outside the body. Parental investment includes inside and outside investment.

Nests: (altricial birds)

- Songbirds often > or = 1000 material gathering trips
- Barn swallows build nests out of mud → 1700 trips carrying mud
- Typically they use local materials
    - Conserve energy
    - Background matching
- The outer shell often has camouflage
    - Ie. Wood Thrush uses dead leaves
    - Maybe mosses
- Soft material is often added
- External material- camouflage
- Inside- soft material

Lecture 22:

Martins in general have the same function as Fishers

- Delayed implantation

Terns also have lackluster nests

Cavity Excavators:

- Woodpeckers are cavity excavators
- That can create a cavity in preexisting trees

Cavity Adopters

- Birds that do not make cavities but still nest in them
- Ie. tree swallows
- Ie. owls
- They use a whole that is already made
- It could be one that was made by a woodpecker, or somewhere a branch broke off

- In general, there is a higher success rate for birds that nest in cavities in trees (rather than open cup nests)
- But there is a great demand for cavities, raccoons use them, gray tree frogs use them
- Cavity excavators have an even higher success rate than cavity adopters

Cavity Excavators have a higher nest success than cavity adopters

- They can make them anywhere
- They can custom fit the hole size for the body so larger animals can't get in
- New location, predators might not know where it is
- They have the tools for excavating which means they have the tools for defence

Cavity Adopter

- Great Crested Flycatchers are cavity adopters
    - They ass cast snake skins to their cavity entrance
    - The birds grab them and hang them partly outside the nest
    - Why?
    - Keep away prey
- White breasted Nuthatches
    - White breasted Nuthatches are cavity adopters
    - They add defensive compounds around the cavity entrance
    - The chemicals come from blister beetles
    - Cantharidin (a terpenoid)
- Red Breasted Nuthatches
    - Red breasted nuthatches add conifer resins around perimeter outside and inside nest hole
    - This is all done for Nest Protection
- Hawks
    - Hawks add green conifer sprigs to nests
- Purple Martins
    - Purple martins are cavity adopters
    - Many cavity adopters add green leaves to their nest
    - This is inside the cavity
- European Starlings
    - Choose specific plants
    - They choose Yarrow and Queen Anne's Lace

Why do all these birds add green material?

- A number of theories, not important
- Important: Tannins and other plant defences discourage nest parasites
- In studies of Starling's specifically, they found that plants release chemicals that reduce the number of mites
- This is often called NEST SANITATION

- A better name for it is CHEMICAL HYGIENE
- Nest Protection Hypothesis: keep out pathogens/parasites

What is the process by which birds bring their eggs to the hatching stage?

- INCUBATION
    - Some birds lose their feathers
    - Brood Patch: Skin is wrinkly and flacid to provide warmth, area where feathers are plucked out or fall out
    - Therefore, Brood Patches: featherless heating pads
    - Keeps eggs at 37 degrees Celsius (99 degree fahrenheit)

Who has Brood Patches

- Female Grouse have them
- Female ducks have them
- But males do not. Why? They do not incubate the eggs
- After mating, the males desert them
- Who incubates in hummingbirds?
    - Females only
    - After mating, the males desert

Who incubates in species where pair bond remains in tact?

- Many warblers have female only incubation, male feeds her on nest
- In other species, both sexes incubate
    - In Killdeer, males often do the night shift
    - male woodpeckers incubate at night
    - Both take turns in the day time
    - Therefore, both males and females have brood patches
    - Male northern flickers- all night
        - Females and males - shifts during the day
- How do we know that males incubate eggs?
    - They have a brood patch

Phalaropes

- Females are more colourful than male
- Female phalaropes do not develop brood/incubation patches because they do not incubate, the males do
- Male-only incubation
- Polyandry- a female has many male mates

How can you tell which adult birds are the parents?

- DNA

Cuckoldry:

- Cuckoldry is common in “monogamous” birds
- > 70% of 150 species studied had offspring sired by a male outside the pair

Purple Martin
- Mature males return first and take over the highest nest site (safer)
- Extra pair copulations almost double the number of the male’s offspring
- (add 3.6 fertilized eggs to his own mates 4.5 eggs)
- Extra pair fertilization- just means they were successful

Female Scarlet Tanagers
- Female scarlet tanagers solicit EPC’s but from males wandering in from distant territories
- This is for genetic diversity

When do the eggs hatch?
- Precocial: all at once
    - When eggs all hatch at the same time this is called synchronous hatching
- Altricial: all at once
    - Synchronous hatching

How to ensure synchronous hatching?
- Incubation delayed until all eggs (full clutch) are laid
- Eggs are usually laid singly, early in the morning
    - Why?
        - Don’t fly with the weight of an egg
        - Eggs develop overnight
- On average they are laid one per day
- Ruffed Grouse- up to 12 eggs in clutch
    - Starts incubating after full clutch is laid
- There is also communication between hatching baby birds

Owls and Hawk
- Owls and hawk clutches hatch asynchronously (one at a time)
- Incubation starts after the first egg is laid

Asynchronous Hatching
- May lessen feeding stress on parents
- Reduce odds of losing entire brood
- Ensure survival of some young in times of food stress

Parental Investment includes Parental Care

Parental Care Includes:

- Nest sanitation:
- Removing egg shells once they hatch
    - Why take the egg shells away?
    - Sharp shell edges could injure newly hatched chicks
    - Unhatched eggs could be trapped inside hatched shells
    - Hatched shells could interfere with brooding (this could reduce the survival of the hatched nestlings nest mates)
    - Hatched shells could reduce nest hygiene and increase the risk of bacterial infection
    - Hatched shells could reduce nest camoflouge, thereby increasing the risk of visually oriented predators **
- Parental care involves removing the nestlings droppings
    - The mother bird grabs the fecal sac in her bill
    - Only altricial birds have fecal sacs
- Parental care involves feeding the young
    - Feeding young is a major investment of time and energy
    - Young are fed up to a dozen or more times per hour
    - Easier when two parents feed the young (Biparental Care) in 90% of all bird species
    - Baby birds beg for food and open their mouth wide (gape)
    - Inside of bird mouth is coloured, this tells the parents where to drop the food
    - The young have to compete for food
- Parental Care includes nest defence
    - Defence can involve aggressive responses
    - Gulls and terns attack intruders
    - Mobbing is an aggressive group defence
    - Nest defence can involve leading or carrying the young to safety

- Nest defence includes:
    - leading the young to safety
    - Distraction displays
        - Leading the predatory away
        - Feigning injury, broken wing act. (ducks)
        - Killdeer distraction displays involve a feigned injury distraction display
    - Small ground-nesting birds lead predators away with a Rodent Run
    - Nest defence DIFFERS when it peaks in intensity
        - Birds weigh their risks
        - Precocial birds: the strongest display it puts on is just before the eggs hatch
        - Altricial Birds: the strongest defence they put on is just before fledging (leaving nest)

Lecture 23:

- Both strategies for nest defence: invest the most in defence when they have the most to lose

Brood Amalgamation:

- The number of young with a female does not always equal the number of eggs she laid
- Duck and Goose broods can be extremely large due to: BROOD AMALGAMATION
- Creche
    - This group of young ducklings is called a creche.
    - Eg. a Creche of mergansers
    - Creches might provide safety in numbers for both the donors and the recipients young
- Facultative Brood Parasitism (Egg Dumping)
    - A female drops off one egg in a neighbours nest
    - These ducks are facultative brood parasites
    - Why? It's like an insurance policy!
    - Black-Billed Cuckoos are another example
    - So are Yellow-Billed Cuckoos
    - Cuckoos make their own nest but are known to lay an egg in another Cuckoo's nest
    - When a black-billed cuckoo lays an egg in another black-billed cuckoos nest this is Intraspecific brood parasitism
    - If a black-billed cuckoo lays an egg in a yellow-billed cuckoos nest, this is interspecific brood parasitism (inter = between two species) (intra- within one specie)
- Brown-headed Cowbird
    - Cowbirds: do not display female-only parental care and they do not display male-only parental care and they do not display biparental care
    - Brown-headed cowbirds:
        - Never build nests
        - Never incubate eggs
        - Never feed babies
    - They are brood parasites
    - They are not intraspecific brood parasites (don't make their own nests)
    - They are not facultative brood parasites (they always do it)
    - Therefore, they are obligate brood parasites
    - Baby cowbirds are always raised by "foster parents"
    - >220 species parasitized
    - 144 of them have raised cow birds (were hosts)
- Why do birds accept a cowbirds egg and raise another birds young?
    - Many birds cannot recognize a cowbird egg
- Female Cowbirds find a host nest in three ways
    - Sit on high perch and watch silently for nest building

    - Walk on ground and silently watch for nest building
    - Drive bird off nest by flying into shrubs and leaves and noisily flapping wings
- Adaptations for Female Cowbirds:
    - Fast egg-laying (20-40 seconds)
    - Thick egg shells
    - Fast hatching (~ 10 days) (bird gets most of the food)
    - Removal of host egg prior to laying
- Adaptations for young Cowbirds:
    - Outcompete nest mates
    - Can physically crush them
    - Can knock them out of the nest
- Some do recognize and do NOT accept!
    - Host can abandon the nest
    - Yellow warblers can build a nest on top of the parasitized nest
- Some birds recognize cowbird eggs and respond differently
    - They toss the eggs out! By grabbing it in their bill (bigger birds)
        - American Robins and Grey Catbirds are GRASP EJECTORS
    - Smaller birds are puncture ejectors
        - Cedar wax wings and Baltimore Oriole are two examples
        - But there are drawbacks- might puncture own egg OR
            - There can be retaliation! (Mafia Hypothesis)

Mammals

- Opossums can have as many as 20 (even 50) babies
    - After they are born, the highly altricial babies climb into the marsupium
    - Problem: only 13 nipples
    - Many die before they even reach the marsupium
    - An opossums marsupium can be analogous to a uterus of a larger animal
    - This is called Brood (litter) Reduction
- Eagles
    - Optimum number of eggs for eagles is one but two are often produced
    - The eggs hatch at different times and the older, larger young often kills its sibling
    - This is called Siblicide
- Muskrats
    - Display another type of brood reduction
    - Female muskrats will kill their neighbours young
    - This is called Infanticide (adult killing young)
    - Knocks off competition for their own baby
- Tree Swallow
    - When a female tree swallow loses her mate and finds a replacement
    - The new male then kills her young
    - This is also Infanticide
- Meadowvoles

- Female voles will abort their foetuses when they smell a strange males urine or scent (the male would kill it, so she aborts and mates with him instead)
- BRUCE EFFECT

Lessons:

1. Every living thing is geared to pass on its genes
2. Nature is really complex
3. Every single habitat is filled with living organisms
4. Nature is alive and dynamic
5. Plants are clever
6. Interesting after dark
7. Winter is beautiful
8. Nature is often cryptic

“Because I have known the torment of thirst I would dig a well where others may drink”

Lecture 24: REVIEW

CORE CONCEPTS:

Startle Patterns: bold and often colourful patterns that are exposed suddenly to startle a predator, sometimes serve a deflection or distraction role; see deflection patterns

Deflection Patterns (Distraction Patterns): patterns that direct a predators attack to a non-vital part of an animals body; some deflection patterns first serve as a startle pattern

Mullerian Mimicry: whereby two or more animals (ie. milkweed beetles and milkweed bugs) share similar appearances and each honestly advertises some form of defence

Batesian Mimicry: whereby a harmless animal, the mimic, resembles (behaves, looks or sounds like) another animal, the *model, that is toxic or otherwise well defended

Foveaa - search and pursuit
Temporal - pursuit