Final Exam Notes

Natural History (Carleton University)

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How plants survive hot temperatures

- Excessive heat causes *dessication*: drying out of a plant
- Plants reduce leaf surface area by curling up
- Can also enter dormancy using ABA (acid)

How animals survive hot temperatures

- On hot days animals seek shady sites with water
- Some animals can reduce the surface area in contact with the sun
    - Ex. Dragonflies assume a position called *obelisk*: put their backs in the air, which shades the rest of their body
- Other animals move their body further away from the hottest part of their environment
    - Ex. Tiger beetles *stilt*: elevate their bodies upward off the sand
- *Shunting*: moving blood to body parts with a greater surface area as a way to lose heat
    - Ex. Ducks/beavers bypass the rete mirable and lose massive amounts of heat through their feet/tails when its hot out
- Other social animals work together to make their entire colony cooler
    - Ex. Honey bees work together to cool their hive with their wings
- *Evaporative cooling*: allowing cooler air to pass over a warmer surface, thus cooling the animal
    - Ex. Birds use *panting* to allow air to pass over their respiratory surfaces
    - Ex. Bees cover their bodies in nectar and come in contact with cooler air
    - Ex. Vultures pees on their legs
    - Ex. Mourning doves use *hyperthermia* to raise their body temperature to dangerously high levels; their body temperature is hotter than the environment and causes them to lose heat

How plants and animals get nutrition

Plants can create their own food (*autotrophs*), but animals cannot

Some animals eat plants for nutrition

- *Herbivore*: act of eating plants such as nectar, sap, leaves, fruits, seeds, bark, etc.
- Some animals eat the plants from the inside
    - Ex. Maple spindle gall mites
- *Detritivores*: animals that eat dead plant material
    - Ex. Earthworms
- *Filter feed*: filter particular organic matter from water that is delivered to them
    - Ex. Clams have an internal tube that points upstream and collects food before allowing the water to flow out through the external tube
    - Ex. Black fly larvae filter feed with labral brushes
    - Ex. Puddle ducks filter feed with lamellae (part of their bill)
    - Ex. Swam filter feed with strainers in their bills
- Adaptations to acquire plants as food differ between species

    - *Proboscis*: long tongue used to acquire nectar
        - *Hyoid apparatus*: set of bones and muscles that allows birds to shove their tongue in an out
        - Ex. Hummingbirds and woodpeckers have long beak and extensible tongues to capture their prey
    - *Stylets*: bugs have probing mouthparts to collect sap
        - Ex. Aphids are sucking bugs
- Plant tissues are another major source of food (i.e. leaves, stems), but are hard to eat due to tough structural components such as cellulose
    - *Ingestion*: dealing with plant outside the body
        - Ex. Slugs and snails break off plant tissues using *radulas*: basically a chainsaw that extends out of the mouth
        - Ex. Caterpillars have modified *mandibles*: slices, tears and crushes food
        - Ex. Leaf blotch miner eats the leaf from the inside
    - Mammals use modified teeth to ingest their food
        - Ex. Beavers' *incisors*: sharp teeth never stop growing and self sharpen
            - They are yellow/orange in colour due to iron
        - Ex. Rabbits and mooses' *molars*: cheek teeth grind the food and are powered by large *masseters* (muscles)
    - *Analogous structures*: perform the same function, but from different origins (i.e. mandibles, radula and cheek teeth all do the same thing – ingestion)
    - Birds don't have teeth; instead they have a *ziaard*: part of the stomach with tough muscular walls that contract and ingest food
        - *Grit*: small stones are added to the guzzard to help grind the food
        - Ex. Grouse
    - *Digestion*: chemical breakdown of food that allows it be useful to the animal
        - Ex. Snails and slugs produce their own digestive *enzymes*
        - Ex. Caterpillars eat a lot of food, but end up wasting a lot of food too
        - Ex. Moose don't have digestive enzymes, but use *rumination*: digestion by bacteria in the rumen, cough it back up, break it down more physically and then digest again
            - *Cud*: the food that has been brought back up after the first round of digestion
        - Ex. Hares, rabbits and beavers have *caeca*: intestinal pouches filled with bacteria that help break down food
            - *Coprophagy (coPOOPhagy)*: eating their own droppings to get the nutrients missed the first time around
        - Ex. Ruffed grouse have caeca, but don't eat their droppings
        - Ex. Porcupines do not eat their own droppings; their digestive tract is approximately 25% of their weight
- Fruit is another major source of food for birds and mammals
    - *Seed disperser*: eat the pulp or flesh, but pass out the seeds
        - Ex. Waxwings and bears
    - Almost no birds are *obligate fruit eaters*: rely 100% on eating fruits
        - Ex. Waxwings are as close as they come; they have large *gapes*: mouth openings and short intestines to achieve this

- *Seed predators*: eat the entire fruit, including the seed
  - Bill size and shape reflect the bird's diet
    - Ex. Grosbeaks have massive conical bills for crushing and slicing
    - Ex. American goldfinches have small, thin beaks for accessing thistle seeds
    - Ex. Red crossbills have odd bills for getting seeds from inside pinecones or spruces
    - Ex. Blue jays hold acorns in their toes and hammer at it with their bills
  - *Niche partitioning*: different species of the same bird feed on different seeds in the same environment so they don't have to compete with one another
    - Ex. Finches

How animals overcome chemical defences of plants

- Avoid the defence until they are gone
- Some herbivores sequester the toxins
- Various insects employ the *vein drain* strategy: cutting the supply of chemicals to the plant before eating it
- Other mammals use enzymes (MFO) to counter toxins

Animal diets

- *Specialists*: eating only one or two different kinds of food
  - Ex. Monarchs eat only milkweed
  - Ex. Red-headed pine sawflies only eat pine needles
- *Generalists*: eating a variety of different foods
  - Ex. Beavers
- Some animals switch foods for a balanced diet
  - Ex. Moose eat fresh leaves, twigs, balsam fir and road salt in the winter to get carbs, protein and small amount of sodium; they eat aquatic plants in the summer to get sodium, which is stored in the rumen
    - *Water-shield*: 500 times more sodium than land plants

Some animals eat other animals for nutrition

- Advantages: proteins are already packaged (i.e. they were packaged by the animal that they ate), animal tissues are easier to digest and they get a better return on their effort
- Disadvantages: harder to find, harder to catch and prey can fight back
- Before enjoying a meal, predators must locate, capture and immobilize their prey

Adaptations for locating prey

- Visual adaptations
  - Keen eyesight is provided by having a large number of cones (colour), large eyes to collect more light and having eyes placed on the front of the head
    - Ex. Hawks can magnify images using *foveae*, which allows tracking of their prey

        - Ex. Tiger beetles have large *compound eyes*: many eye units in one eye
        - Ex. Dragonflies' eyes can have 28,000 *ommatidia* each with 6 or 7 sensory cells
        - Ex. Whirligigs can see above and below the water at the same time
        - Ex. Spiders have eight eyes, but they are all simple
            - The exception is hunting spiders (ex. jumping spider or crab spider), which have exceptional eye sight (anterior, posterior → main, median and lateral)
    - *Diurnal* birds of prey hunt during the day
    - *Nocturnal* birds of prey have special adaptations to hunt at night
        - Large eyes allow more light to come into the eye
        - *Glycogen rich rods* require only a small amount of light to activate the visual neurons
        - Frontal eye placement = depth perception
            - Ex. Owls have a large blind spot and can turn their head 270 degrees to make up for this
- Hearing adaptations
    - Large exterior pinnae (ears) capture and magnify sounds
    - Other animals do not have large exterior pinnae
        - Ex. For owls, modified feathers use *facial disks* to collect sound; they also use *asymmetrical ear opening* and *wide heads* allow pin pointing of sound
        - Ex. Bats use *echolocation*: sounds bouncing off objects
            - Start with low frequency and get higher frequency as they get closer to their prey so they can pinpoint its location and shape
        - Ex. Shrews use ultrasound, which humans cannot hear
- Olfactory adaptations
    - Ex. Moose have an amazing sense of smell due to their enlarged snout that contains a *Jacobson's organ* (or *vomeronasal organ*) and allows them to distinguish between smells more effectively
        - The *flemen* response draws air into the vomeronasal organ
    - Ex. Snakes use the Jacobson's organ for finer odour discrimination (tongue)
    - Ex. Foxes have elongated snouts to improve smell
    - Easier to hunt at dusk because scents are trapped between the hot ground and the cool air
- Tactile (touch) adaptations
    - Ex. Raccoons have touch sensitive (tactile) paws packed with sensory cells
    - Ex. Otters, cats and dogs have tactile sensors near the mouth
        - *Vibrissae*: sensory hairs (i.e. whiskers)
    - Ex. Star-nosed moles have *Eimer's organs* in their nose protuberances, which greatly enhance their ability to smell
    - Birds have *analogous structures* called *rictal bristles*
        - Ex. American woodcock, Wilson's snipes and ducks have pressure sensitive cells called *Herbst corpuscles* in the tip of their bills
        - Ex. Woodpeckers have *Herbst corpuscles* in their tongues
    - Ex. Rattlesnakes have infrared heat sensors (*heat pit*) between their eyes and nostrils that can detect changes as small as 0.001 degrees Celsius

How predators find their prey

- Active searching
  - Ex. Wolves, wolf spiders, tiger beetles, etc.
- *Cryptic waiting*: waiting and ambushing their prey
  - Ex. Praying mantis, owls, etc.
  - Ex. Goldenrod crab spiders change colour to match the background
- Traps
  - Spider webs are *flight intercept traps*
    - Ex. Orb weaver spiders build spectacular silk webs
    - Ex. Funnel weavers usually build webs on the ground
    - *Sheet spider webs*: have knockdown strands that know the insect out of the air and land on the capture sheet
    - Spider webs are *hygroscopic*: absorbs moisture to stay flexible; allows them to be seen best at dawn
    - Other spider web facts
      - Webs contain six or more types of silk
      - Spiders recycle silk from broken webs
      - A complex orb web only takes 20 minutes to build
    - *Stabilimentum*: zig-zag pattern in webs of argiope spiders; they lure insects in with UV light
  - *Pitfall traps*: pits in the ground that other animals fall into
    - Ex. Ant lion larvae make pits and wait until ants fall in before attacking them with their poisonous bite
    - Ex. Mole tunnels also serve as pitfall traps
- Aggressive mimicry
  - Ex. Some fireflies deceive and eat the other species of fireflies
  - Ex. Turtle's tongues look worms to other fish

How predators capture their prey

- Specialized hands/feet
  - Ex. Raccoons use hands to catch frogs
  - Ex. Owls and hawks use talons (owls also have papillae)
  - Ex. Ospreys have special feet for catching fish; rough skin pads (scales), a reversible toe (*papillae*) and opposable claws
  - Ex. Praying mantids and crab spiders have *raptorial legs*, which have spines that help hold their prey in place
- Modified mouth parts
  - Ex. Carnivores such as foxes use their canines and strong *temporalis* muscles
  - Ex. Tiger beetles capture with mandibles
  - Ex. Merganser bills are modified to catch fish (i.e. they sharp projections that make it easier to hold onto slippery fish)
  - Ex. Frogs and toads use the *tongue flick*: folds back and is sticky
  - Ex. Hummingbirds and woodpeckers use the *hyoid apparatus*

How predators immobilize or kill their prey

- Mammals use their teeth (canines)
    - Ex. Foxes and coyotes use the "shake and break" technique
    - Ex. Wolves kill larger prey using the "slashing and shock" technique and hunt in packs
    - Ex. Weasels bite into the cranium (back of skull)
    - Ex. Cats bite into the neck vertebrae
- Birds use talons and bills
    - Ex. Shrikes pummel their prey with their bills
    - Ex. Hawks use their talons to squeeze internal orgrans
    - Ex. Hawks/eagles also have *meet hook bills*
- Snakes and spiders use a variety of methods
    - Ex. Most snakes swallow their prey while it is alive; their jaws detach for large prey and "walk" them into their mouth
    - Ex. Black rat snakes and milk snakes are constrictors; they squeeze tighter when their prey exhales
    - Ex. Mississauga rattlesnakes and short-tailed shrews have poisonous bites
    - Ex. Crab spiders and assassin bugs use poison digestive enzymes included in their *venom*: poisons/toxins that are injected into prey
    - Ex. Robber flies use venom and digestive enzymes and then suck out the inside of their prey

Problems faced by predators

- How to deal with indigestible parts of your prey
    - Selective feeding
        - Ex. Hawks leave bones and feathers
        - Ex. Fishers skin porcupines
        - Ex. Spiders and insects suck out the insides of their prey and leave the empty shell
    - *Scat*: allowing the indigestible parts to past through their bodies
    - Ex. Owls swallow their prey whole, separate the meat from the feathers and bones, then cough out a *pellet* of bones and hair
- Injury during the chase (i.e. mammals will fight back)
- Bioaccumulation of toxins
    - Ex. Peregrine falcons
- *Botulism*: bacteria that get into fish causing birds to get sick after they eat them
- Human persecution
- Starvation is the <u>#1</u> problem faced by predators; they only catch the prey 1/10 attempts

Parasitoids and parasites

- *Parasitoids*: kill their hosts
    - Three ways to get into the host: lay eggs on the host, lay eggs in the host or lay eggs on a leaf, which is then eaten and then they are inside
    - Parasitoids are almost solely larvae
        - Ex. Braconid wasp larvae
        - Ex. Flesh flies lay their eggs on the host

        - Ex. Thread-waisted, spider and digger wasps (cerceris) all paralyze their prey and then burrow them in the ground with their eggs
        - Ex. Pelecinid wasps lay their eggs on June beetle grubs in the ground
    - Parasitoids can conduct *visual searching*
        - Ex. Flesh flies investigate potential hosts and use an *ovipositor* to lay the actual eggs
            - *Inchneumon wasps* have very long ovipositors that dissolve cellulose to "drill" deep into trees where grubs are; when the eggs hatch, they will eat the grub
- *Ectoparasite*: does not kill the host and eats from outside the host's body
    - Ex. Leeches
    - Ex. Ticks have *hypostomes:* mouthparts with barbs to hold onto and feed off of mooses; they irritate the moose so much that they pull their fur out, often causing them to die from hypothermia
    - Ex. Mites are ectoparasites that use dragonflies to feed
    - Ex. Flat flies use sharp claws to hold onto and feed off of many migratory birds
    - Ex. *Glochidium*: larval clams are ectoparasites that feed on fish; pocketbook clams imitate fake fish to attract their hosts
    - Problems faced by ectoparasites
        - They find the wrong host
        - Their host dies
        - The host fights back (i.e. *grooming and preening*)
            - Ex. Herons have a special grooming claw called a *pectinate toe*
            - Ex. Beavers have a special grooming tool called a *split toe nail*
- *Endoparasite*: does not kill the host and eats from inside the host's body
    - Ex. Cuterebra bot flies are only parasitic in the larval stage
    - Ex. Deer have a parasitic *brainworm*
        - The parasitic larvae leave in deer's droppings, which are then eaten by slugs or snails
        - The brainworm starts living inside the slug or snail (*intermediate host*)
        - The deer consumes the slug or snail (*definitive host*)
        - The brainworm reproduces itself inside the deer
        - If a moose eats an infected slug or snail, the brainworm eats up the spinal cord and kills the moose
            - *Blind stagger*: moose acts drunk before it dies
    - Ex. Robins harbour a parasitic *fluke*
        - The parasitic fluke leave in the bird's droppings, which are then eaten by aquatic snails
        - The fluke starts living inside the snail (*intermediate host)* and causes the snail's antennas to change colours and start pulsing
        - The robbins is attracted to the coloration and pulsing so it eats the snail (*definitive host*)\
    - Problems faced by endoparasites
        - They cannot find an intermediate host
        - Their host dies

- Endoparasites use *parasitic castration* (decreasing an animal's sex drive so that it remains cryptic) to increase their chance of survival

Scavengers: consume animals that have already been killed

- *Necrophagous*: the act of eating dead animals
- Almost all scavengers also eat live animals too
  - Ex. Eagles, red foxes and blue jays
  - Ex. Gulls and ravens are more full-time scavengers
- Ex. Turkey vultures are *obligate scavengers* (100% reliance) and have various adaptations to deal with their situation
  - Naked head, large wings to soar, strong sense of smell, raptorial bill and the ability to digest bad meat
- Some small animals also scavenge
  - Ex. Blow flies and carrion beetles (which bury mice)

How animals deal with food shortages

- Predictable food shortages
  - Dormancy
  - Migration
- Some foods are present all year in fluctuating numbers
  - Seeds, nuts, fruits, berries and small mammals
- When necessary, animals move to food-rich regions
  - *Irruption*: large increase in the number of animals in a certain region because there is less food in the original region
    - Ex. Great gray owls, waxwings and crossbills
- Some animals store food
  - Ex. Shrikes (kill with their bills and) store *larder* (small collection of dead animals used for food) by impaling them on thorns or owls
  - Ex. Owls cache extra food
  - Ex. Beavers create a *food pile* with less wanted food on top (helps to keep the good food from freezing)
  - Ex. Gray squirrels create hundreds of solitary caches (*scatter hoarding*)
  - Ex. Gray jays *scatter hoard* thousands of items and have the following adaptations to help them
    - Enlarged salivary glands, sticky saliva, unbelievable memory (hippocampus deals with spatial memory) and nesting early
  - Ex. Chickadees hippocampus actually grows larger
  - Ex. Red squirrels create larger stashes called *midden*; they would only have a few of these around
  - Ex. Chipmunks employ a mixed strategy and use their *expandable cheek pouches* to gather food and store it underground; they eat a few times a winter when they wake up from dormancy

Plants and how they get nutrients

- *Photosynthesis*: the process by which plants turn water, nutrients (nitrogen, phosphorus, calcium, etc.) and sunlight into food

- *Autotrophic*: ability to make their own food
- What happens to plants in nutrient poor habitats like bogs
    - *Micorrhizae*: relationship with fungus that allows an increased uptake of nutrients and prevents uptake of toxic compounds
        - *Endomycorrhizae*: fungal threads inside the roots that spread all over the bog and collect nutrients for the plants
            - Ex. Heath plants and orchids
        - *Ectomycorrhizae*: fungal sheets formed around the roots
            - Ex. Black spruce
    - *Root nodules*: swellings of root tissue that actually fix nitrogen
        - Ex. Alders
- Some plants eat animals to get the needed nutrients – "carnivorous" – *modified leaf traps*
    - Ex. Sundews are have modified hairs that release a sticky substance (*adhesive trap)*
    - Ex. Pitcher plants are *pitfall traps*: downward pointing hairs direct the insect to pools of rain water where they drown
        - Brood site odours attracts the bugs to the plant
    - Ex. Bladderworts have a trip wire that opens a vacuum and drowns the insect (*suction traps*)
- How plants deal with *shade*: lack of sunlight
    - Have leaves with a large surface so that more sunlight hits them
        - Ex. Round-leaved orchids and hobblebush
    - Leaves are parallel to the ground, thus getting the most sunlight and saving energy
    - Contains more chlorophyll B (more light sensitive) than chlorophyll A (less light sensitive)
    - Have an larger number of leaves attached to a common rhizome
        - Ex. Bunchberries
    - *Phototropism*: grow away from shade (i.e. toward the light)
    - *Negatively phototropism*: grow away from the sun so that they can climb up other plants that are causing the shade
        - Ex. Wild cucumbers grow on top of other plants using *tendrils*: special branches that are drawn to shade and wrap around other plants using *thigmotropic*: touch sensitive cells
        - Ex. Many types of vines
    - Bloom before the tree leaves open up and cause shade
        - Ex. Many *ephemerals* (short lived plants) that grow on forest floors, including trilliums; cold temperatures can affect these plants
    - Lose the need for sunlight (i.e. don't make food)
        - Ex. Coralroot grows in pure shade and has no leaves
            - Has mycorrhizae on its roots that actually attach to mycorrhizae on other plants and get nutrients from there (i.e. it's a thief); therefore they are *mycoheterotrophs*: use fungus to get their food
        - Ex. Indian pipe uses mycorrhizal associations to steal nutrients directly from other plants (acts just like a parasite)
        - Ex. Many orchids photosynthesize and steal carbon from other plants through mycorrhizae; they are *mixotrophs*

        - Ex. Cancerroot has no leaves and no mycorrhizae
            - They are true parasites (*holoparasite*)
            - Its roots form *haustoria* in the cells of other plants, which it find by tracking their *strigolactones*: chemicals used to attract fungus
                - Its roots actually do the stealing, not a fungus
        - Ex. Witch's broom are caused by dwarf mistletoe (another holoparasite)
- How plants deal with too much sun (ex. Sand dunes)
    - Have leaves with a small surface area
    - Leaves are at a 45 degree angle with the ground, thus getting less sunlight

How plants and animals reproduce

Asexual: only needs one organism vs. sexual: needs a male and a female

External fertilization: when the egg meets the sperm outside the body

- Ex. Fish and toads (*amplexus* is the position toads take when reproducing; stimulates the female)

Most animals use internal fertilization to better guarantee their efforts

- *Hermaphrodites*: have both male and female sexual organs; usually non-moving or very slow animals
    - Ex. Clams and sponges release a sperm into the water and another one will get fertilized downstream
- Some reproduction does not require the male the enter the female
    - Ex. Snow fleas can leave *spermatophores* on the ground for the female to pick up
- However, most animals use an *intromittent organ* to transfer sperm
    - When not needed, *intromittent organs* are store internally to reduce resistance, drag and damage
    - When needed, most *intromittent organs* are inflated with liquid (blood)
    - However, some have the support of a *baculum* or penis bone
    - Ex. *Love darts* on snails and slugs
    - Ex. Spiders have special mouthparts called *pedipalps*
    - Ex. Snakes have two penises called *hemipenes*
    - Ex. Dragonflies enter the *wheel position* and grab the female with their *claspers*
    - Ex. Birds have *cloacah* (*cloacal kiss*)

How animals find the right mate

- Some animals meet their mates by chance
    - Ex. Barnacles
- Auditory advertisements
    - Making auditory advertisements has risks
        - Predators and parasitoids can hear you
        - *Satellite males* (cheaters) can exploit your efforts
    - Ex. Toads and frogs use *extensible throat sacs* that act as *resonating chambers*
        - Male bullfrogs have a larger *tympanum* (eardrum) than females
    - Ex. Woodpeckers drum with their bills on dead branches (reverberation)

    - Ex. Ruffed grouse drum with their wings on "drumming logs"
    - Ex. Snipes use *winnowing*: a sound made by their tail feathers
    - Ex. Crickets and grasshoppers use *stridulation*: rubbing body parts together to make sound
    - Ex. Cicadas use *tymbals* (abdominal muscles) to make noise, but only on hot days because they are ectothermic
    - Ex. Birds advertise with vocalizations using the *syrinx*
        - Song has two purposes: mate attraction and territorial declaration
            - Ex. Warblers have two songs for each function
    - Ex. During the *rut*, cow moose make low frequency calls to attract bulls
        - Bulls thrash their antlers and are aggressive during the rut
- Visual advertisements
    - *Sexual dimorphism*: males and females look differently for sexual purposes
    - The reason behind this is that the females choose the males (sexual selection)
        - Ex. Male song birds are brighter than their female counterparts
        - Ex. Female phalaropes are brighter than their male counterparts because in this species the male chooses the right mate
        - Ex. Female mallards choose the males with the greenest heads because this reveals age and health
        - Ex. Female house finches choose the most brightly coloured male because this shows they are better at hunting (their diet changes their colour)
    - Some animals display ornaments to attract their mates
        - Ex. Puffin bills have a groove for every two years that the animal has been alive; females choose males with two or more grooves because this shows he is a survivor and is good at catching fish
        - Ex. Moose and deer display antlers
            - Antlers shed every winter and grow back the next year
            - They change size and shape with age, maturity and health
            - Two parts: *tines* (points) and *palms* (flat areas)
            - Symmetrical antlers display healthiness
            - Antler displays can help to defuse aggression by other males
                - *Sparring*: touch antlers to see whose is bigger
        - Ex. Dragonflies have tusks
    - Visual advertisements can also include elaborate *ritualistic displays*
        - Ex. Ducks and mergansers use head displays
        - Ex. Ruffed grouse use *neck ruff* and *tail displays*
        - Ex. Midges and ebony jewelwings use aerials displays (do a dance for the female)
        - Ex. Fireflies use light displays
        - Ex. Swans and cranes have choreographed displays done by both partners
        - Ex. Sharp-tailed grouse have communal dancing grounds called *leks*
- Olfactory adverstisements
    - Chemical advertisements called *pheromones*
        - Ex. Moose have pheromones in their urine
            - *Wallow pits*: moose pee in holes and then roll in it
            - Bulls use their tongues to help detect pheromones

        - Ex. Female snakes leave pheromone trails; males track them and form mating swarms
        - Ex. Female insects, such as silk moths, produce pheromones that are detected using the male's antennas
    - Pheromones can also be used to stimulate the female
        - Ex. Male hares and porcupines pee on the females
- Gift giving
    - Ex. Male cedar waxwings provide food to their potential mates
    - Ex. Male terns help feed the baby so it shows they can provide
    - Ex. Male spiders give food gifts to avoid being eaten
    - Ex. Male wren builds *dummy nests* to show that his territory is rich in food
    - Ex. Male bass and sunfish also provide nests

How animals ensure paternity

- *Contact guarding*: protecting the female and baby after they have been born
    - Ex. Moose
    - Ex. Ordonates (dragonflies and damselflies) use *claspers* to hold the female behind the head
    - Ex. Male walking sticks use *handcuffs* (*bondage*) to ensure paternity for a minimum of a couple days
- *Copulatory plugs*: plugging the females reproductive openings
    - Ex. Beetles produce *headless sperm* that form a plug
    - Ex. Featherwing beetles have one *giant sperm* that is so big it fertilizes the egg and creates a plug
    - Ex. Honey bees leave their genetalia inside the female as a plug
    - Ex. Mosquitoes ejaculation turns into cement
- Some males add *anti-aphrodisiacs* to the plug to turn off other males who try to mate

How plants reproduce

- Reproduction is the only purpose of a flower
- Floral sex organs
    - *Stamen*: male part that produces sperm
    - *Pistil*: female part that produces eggs
    - *Pollen grains*: floral equivalent of an intermittent organ
- <u>*Double fertilization*</u> event is unique to plants
- *Anemophily*: wind pollination
    - Delivery is not guaranteed, therefore these plants LOTS of pollen
    - Ex. Grasses, sedges and conifers have small, lightweight pollen that is easily carried by the wind
- *Hydrophily*: pollination by water
    - Used be very plants
- *Entomophily*: pollination by insects
    - These insects are know as *pollinators*
    - Insects are attracted to these plants because they are bribed by food that is placed right next to the sex organs
        - *Pollen bribes*

        - Ex. Hover flies
        - Ex. Bees must shake the *poricidal pore* to let the pollen out (also known as *buzz pollination*) and hold it in their *pollen basket*
    - *Nectar*: sugar water
        - Ex. Buttercup *nectaries* (holders) are small sleeves at the base of each petal that hold the nectar
        - Ex. Milkweeds hold nectaries in *shallow cups* (can be accessed by many different types of inscts)
        - Ex. Columbine has special nectar leaves with *long spurs* (can only be accessed with insects with long tongues)
            - *Long tongue bees* = bumblebees
        - Ex. Cardinal flowers have long spurs, but bees ignore them; they are eaten by hummingbirds

Flowers advertise so that pollinators know which plants to visit

- *Visually*: different colours and forms of flowers attract different pollinators from *a long distance away*
    - Ex. Bees are drawn to blue
    - Ex. Queen Anne's lace has a little purple flowers that lure in insects
- However, insects see colours differently than we do
    - Green is seen as grey
    - Yellow is seen as grey
    - Very few insects see red
- *Scents* often help to attract and guide insects from *a close distance away*
    - Most scents released by flowers are sweet
        - Ex. Evening primrose release scent at dusk when their flowers are open
    - However, not all scents are sweet
        - Ex. Wild ginger smells like decaying fungus (*brood site deception* for fungus gnats)
        - Ex. Red trilliums smell like rotting flesh (*brood site deception* for carrion beetles)
    - Ex. Helleborine releases *wound hormone mimics* that attract wasps; once the wasp is there it finds nectar and helps pollinate
    - Ex. Bee and fly orchids release *sex pheromones* to lure in insects
- *Close range guidance aids*: patterns that visually guide the insects to nectar
    - Converging lines, spots, bull's eyes or landing targets
        - Ex. Marsh marigold have nectar guides that can only be seen by insects since they see UV light

How plants avoid self-pollination

- *Self-sterility or self-incompatibility*: chemical reaction doesn't take place if it is a sperm and egg from the same flower
- *Monoecious*: spatial separation of the sexes on one plant
    - Ex. Male parts on the conifers are usually near the bottom and females parts are at the top so that they don't get hit by the male pollen

    - Ex. Lady slippers have a slit in the *pouch petal* that bees must go through to get the nectar; when they enter, the pollen is rubbed off and they must push through the *staminode* to get out; the staminode is covered in sticky pollen masses and then when the bee enters the next lady slipper, it pollinates it
- *Dioecious*: spatial separation on different plants
    - Ex. White campions
- *Dichogamy*: temporal (timed) separation of the sexes
    - Ex. Orange jewelweed flowers start off as males, but once they release the pollen, they fall off and become female
    - Ex. Spiraled plants have the bottom flowers open up first as males with lots of pollen; once the pollen is taken, these plants become female and attract the bees much more strongly than the male flowers; this prevents the bees from visiting a male flower first, and then pollinating a female flower
    - Ex. White water lily opens up first as females, then closes up with the flies inside and reopens in the morning as a male; when the insects fly out, they rub against pollen
- *Heterostyly*: the plant organizes its sexual organs in several different forms; once they get the pollen from one plant, it can only pollinate a plant of a different form
    - *Distyly and tristyly*
    - Ex. Pickerel weed and purple loosestrife
- Some plants take a more "active" role in pollination
    - Ex. Milkweeds have *clamping saddle bags* of pollen (i.e. they wrap around the insects leg like a saddle bag on a horse)
    - Ex. Sheep laurel have *bashing stamens*: come loose and hit the insect with pollen
    - Ex. Bunchberries flowers are landmines and when they are stepped on by an insect, they explode and release the stamen (<u>fastest</u> moving plant in the world)
    - Ex. Twayblades can sense the vibrations of an insect and use a *cannon* to shoot pollen at it
- *Pseudostamens* and *pseudopollen*: fake stamens and pollen
    - Ex. Grass pink has a *slam dunk trick*: when the bee lands on the *pseudopollen*, the petal collapses and *slam dunks* the bee into the flowers female sexual organ, then when it crawls out it is recovered in pollen
    - Ex. Grass of Parnassus also use *pseudopollen*

When they are no pollinators because of cold weather

- *Cleistogamous flowers*: flowers that self-pollinate and produce seeds as an insurance policy in case they can't be pollinated in other ways
    - They grow really close to the ground where it is much warmer
    - Many spring ephemerals have these because they bloom so early (too cold)
- Self-pollination is the main strategy for plants that grow in habitats with no pollinators
    - Ex. Dandilions self-pollinate very quickly to dominate new or temporary habitats

Getting their progeny off to a good start in life

Until the seeds are ready for dispersal, plants protect them

- Some use hard, heavily protected structures

    - Ex. Cones
- Others use hard seed coats
    - Ex. Acorns
- The rest are chemically protected
    - Ex. unripe berries are aposematically coloured and have bitter *terpenoids*
    - Ex. Milkweed is well protected by the pod, which is full of cardiac glycocides

Seed dispersal: process of sending our progeny into the world

- Advantages of seed dispersal (i.e. having progeny in different location)
    - Avoid overcrowding and competition
    - Prevents spreading of diseases or parasites
    - Prevents inbreeding
    - Avoids all offspring being eaten
- Once mature, the pods open and the seeds are released
- *Anemochory*: seed dispersal via wind
    - Often used by plants in open habitats (i.e. fields)
    - Same adaptations as pollen – small, lightweight, silk parachutes (dandilions)
    - Produce many seeds because hitting target is not guaranteed
        - Ex. Maple samaras (keys) are adaptations to disperse seeds a short-distance from their parent
        - Ex. Basswood tree seeds have sails to help them fly
        - Ex. Yellow birch seeds are aimed at stumps or logs (*perched birch)*
    - Some ground level plants use wind too
        - Ex. Indian pipe
- *Zoochory*: seed dispersal by animals
    - *Hooks and barbs* catch on hairs or feathers and are carried around by animal
        - Ex. Burdock seeds
    - *Endozoochory*: seed dispersal by the insides of an animal
        - Ex. Berries bribe bears to eat them and then the bear will poop out the seed somewhere else
            - Berry seeds have special adaptations that allow them to survive in stomach acid
    - *Elaiosomes*: fleshy structures around the seeds of spring ephemerals that attract ants to take them to other locations
        - Ex. Violets use *ballistic ejection*: pods shrink, squeezing out seeds and making them more available to ants; ants are attracted because of elaiosomes
- Using rain as a means of seed dispersal
    - Ex. Orange jewelweed grows in wet places and when raindrops hit the mature seeds, the pod straps release tension and catapult the seeds several metres away
    - Ex. Mitreworts use *splash cup dispersal*: rain falls into splash cup and splashes seeds a short distance away
    - Ex. Foamflowers use *springboard dispersal*: raindrop hits one side of the "diving board" and the other side flings away the seed
- *Hydrochory*: seed dispersal by water
    - Many shoreline or aquatic plants have flotation devices on their seeds

- If environment is good, plants produce lots of seeds (*boom*); if environment is bad, plants produce less seeds (*bust*)

The animal equivalents of seed dispersal are *parental investment* (i.e. how long their young develop inside the womb) *and parental care* (i.e. how long they protect their young after they are born)

- No care after eggs are left in the right habitat
    - Ex. Toads and dragonflies
        - *Temporary or ephemeral ponds* are good egg-laying habitats for freeze-tolerant frogs because they have very few predators
    - Ex. Eggs of most amphibians, reptiles and insects are not guarded
    - Ex. Parental care in turtles ends after they bury their eggs in the ground
        - The temperature of the soil during incubation determines the sex of the hatching turtle… UHM WHAT
    - Ex. Walking sticks abandon their eggs once they are laid, but the eggs have a *capitulum* that ants find irresistible, and thus bring underground where it is protected
- *Ovoviviparity*: egg is held internally until it hatches
    - Ex. Northern water and garter snakes
- Other animals guard their eggs after they are hatched
    - Ex. Five-lined skink
    - Ex. Red-backed salamander protects egg in rotting logs
    - Ex. Female wolf spiders carry eggs in an *egg sac* (round bag of silk) held by their *spinerettes*; once hatched, they are carried on their mother's back
    - Ex. Female nursery web spiders carry the egg sac in their *chelicerae* (jaws); they build a nursery web and guard their young
- *R-strategy*: very little care vs. *K-strategy*: lots of care
- Animals that provide lots of parental investment and care
    - In 95% of mammals, females provide ALL of the parental care
        - Ex. Moose have eight month gestation and have *precocial* young: advanced (i.e. can walk); then the cow moose protects them for a year
    - However, there are exceptions
        - Wolves, coyotes and foxes exhibit *biparental care*: both male and female take care of young
            - Wolves are social animals that take care of the pups as a *pack*
            - In mid-summer, pups are taken to opens spaces called *rendezvous sites*
    - Ex. > 90% of all birds provide biparental care
        - Eggs are a very large investment that store calcium and yolk
            - Ducks, grouse and sand pipers have large eggs (40% yolk)
                - *Altricial nestlings* remain in nest
            - Song birds have small eggs (25% yolk) and elaborate nests
                - *Precocial chicks* leave the nest after hatching and are more developed since they were in the egg longer
            - *Incubation*: sitting on an egg

        - *Brood patches* are featherless heating pads on the undersides of birds that keep the eggs warm
        - Ex. Male phalaropes do all the incubation
    - *Nest sanitation* is part of parental care
        - Ex. young produce fecal sacs for their droppings
    - *Nest protection* is all important
        - Ex. Gulls throw up or shit on intruders
        - Ex. Mobbing
        - Ex. Hawks add green conifer to their nests, which discourages parasites
        - Ex. *Distraction displays*: song birds act like a rodent on the ground to distract the predator = *rodent dun*
            - Ex. Killdeer and ducks use *feigned injury display = broken wing acts*
    - *Brood amalgamation (aka creching)*: bring several groups together to enhance the chances that the females genes survice
        - Ex. Ducks and geese
    - *Egg dumping*:
    - Ex. Male ducks and grouse desert the females after mating
- *Altricial* young: born very undeveloped
    - Ex. Bears are very undeveloped and the mother stays with her young for 1.5 years
    - Ex. Opossums are born after 13 days and then attach to the mothers nipples and cannot got off them cause they swell (large external investment)
- *Delayed implantation*: egg doesn't plant on wall of uterus
    - Ex. Bears mate in June and give birth in January, but their gestation is only 2 months
    - Ex. Fishers
- *Delayed fertilization*: sperm is stored and introduced to egg at a later date
    - Ex. Bats, bumble bees and wasps
- *Brood reduction*: only some of the young live – survival of the strongest
    - *Siblicide*: killing of the sibling
        - Ex. Two eagles are born, but the older one kills the younger one
    - *Infanticide*: adult kills infants
        - Ex. Female muskrats kill their neighbours young to increase chances of their young surviving
        - Ex. When a tree swallow remates, the new male kills all of her young
        - Ex. Female voles will abort their fetuses if they smell a strange male's urine or scent (*Bruce effect*)
- *Obligate brood parasite*: always laying eggs in another bird's nest
    - Ex. Brown-headed cow birds lay there eggs in other nests and then will kill the other bird if it doesn't take care of its chick (*mafia theory*)
        - Birds defend this by nest desertion or egg rejection
- *Cuckoldry*: females have young from several males
    - Ex. Purple martins