

Animals – Staying Alive

- Background Matching: allows animals to vanish into background WITHOUT MOVEMENT
 - Example: American Bittern (also Sparrow)
 - Blends into marsh with vertical lines – puts bill in the air & relies on instinct
 - Example: Ruffed Grouse
 - Ground dwelling – pattern resembles sunlight hitting forest floor (light/dark)
 - Example: Fawn
 - White spots – coyotes find difficult to spot
 - Example: Female White-Tailed Ptarmigan
 - Matches rock
 - Example: Brown Creepers
 - Pattern matches tree trunks
 - Mimicry
 - Example: Gray Tree Frog
 - Bark mimic – changes colour to match lichen on trees
 - Example: Eastern Screech Owl
 - Bark mimic
 - Does not work well 24-7/365 – unless appearance can be changed
 - Example: Snowshoe Hare
 - White in winter, brown in summer
- Disruptive Patterns: patterns disrupt shape of animal – breaks body into blocks
 - Example: Songbirds
 - Facial markings/head markings or eyelines/eyestripes
 - Example: Killdeers
 - Breast bands – useful in nest
 - Example: Canada Geese
 - Chin straps
 - Example: Loons
 - Necklace
 - Example: Leopard Frog
 - Coincident disruptive colouration/group coincident disruptive colouration
- Masquerade: look like a part of the environment – use shape as a camouflage – unedible
 - Example: Angle-Winged Butterflies
 - Dead Leaf Mimics
 - Example: Inchworm, Walking Stick
 - Twig Mimicry
 - Example: Tree Hopper
 - Thorn Mimic
 - Example: Pearly Wood-Nymph
 - Bird Dropping Mimic
 - Example: Caterpillar of Giant Swallowtail
 - Bird Dropping Mimic – shiny and have colour of bird droppings
 - Example: Camouflaged Looper

- Pinecone Mimic
 - Example: Spittlebug
 - Hides as it creates bubbles
- Bicolouration: two different appearances from different directions
 - Backswimmers: aquatic insects with dark underside and white upper surface, so swim upside down
- Countershading: animals make a shadow – self shadow concealment
 - Example: White Tailed Deer
- Startle Patterns: plan B, hidden away until frightened
 - Example: Sphinx Moth
 - Big eyes startles birds
 - Eyespots – fake eyes that make the animal larger NOT STARTLE PATTERNS
 - Example: Abbott’s Sphinx, Eyed Elater, Tiger Swallowtail Caterpillar
 - Example: Underwing Moth
 - Bottom wings hidden until it is frightened
 - Example: Gray Tree Frogs
 - Jumps when frightened – yellow colouring on legs
 - Example: Ring Necked Snake
 - Yellow underside
- Startle Structures
 - Example: Giant Swallowtail Caterpillar has red horns that look like a snake’s tongue – osmetarium
- Startle Sound
 - Example: Beaver tail slap
 - Example: Ruffed Grouse startle sound
- Distraction Patterns: vibrant patterns that deflect the attack of a predator to a non-vital body part
 - Example: Common Wood Nymph & Common Buckeye
 - Example: Butterflies (Hairstreak & Swallowtail)
 - Tails designed as distraction pattern
 - Fake antennae/heads as distraction patterns
 - Example: Five lined skink
 - Autotomy – can grow back bright blue tail
- Body Armour
 - Example: Snails
 - Have a trapdoor made from a harder substance – shell made from calcium
 - Example: Turtles
 - Pull inside shell, which is a continuation of skeleton
 - Blanding’s Turtle: shell slightly closed on the bottom (can close its shell)
 - Snapping Turtles: don’t pull inside since no bottom shell – therefore they bite
- Soft Structures
 - Example: Eastern Tent Caterpillars
 - Build silk tents for hiding during the day – built together
 - Example: Fall Webworm Silk Tent

- They enclose leaves when building webs, so no need to leave to eat
- Hairs
 - Soft Hairs
 - Stiff Hairs
 - Example: Porcupine
 - Has quills (modified guard hairs)
 - Have antibiotics on the end (protection for themselves and predator)
- Chemical Defenses
 - Example: Io Moth Caterpillar
 - Hairs + poison = poison spines
 - Aposematic colouration: animals that are armed with a strong defense
 - Example: Milkweed Tussock Caterpillars
 - Example: Striped Skunk
 - Black and white aposematic at nights
 - Example: Ladybugs
 - Manufacture their toxins
 - Sequesters: attain chemicals by eating plants that contain them
 - Example: Monarch Caterpillars – cardiac glycoside (terpenoid) poison from milkweeds
 - Aggressive Mimicry
 - Example: Photuris Fireflies
 - Sequester steroidal toxins by eating male photinus fireflies
 - Released from different parts of the body
 - Example: Sawfly larvae
 - Terpenoids from plants
 - Example: Blister Beetle
 - Plays dead; has a chemical oozing out of leg joint (terpenoid)
 - Example: Yellowjacket
 - Stinger/injector
 - Example: American Toads
 - Toxin Bufotalin in skin glands
- Warning Signals
 - Example: Skunk
 - Sulfur alcohol
 - Shoot with accuracy 2-3 feet away
 - Handstand
 - Example: Bombardier Beetle
 - Hot quinone gas
- Mullerian Mimicry: when a group of UNRELATED animals are all defended and bear similar appearances/colouration
- Batesian Mimicry: poisonous animals copied by edible animals
 - Examples
 - Bumble Bee and Hover Fly
 - Honey Bee and Hover Fly

- Bald-Faced Hornet and Hover Fly
 - Sphecid Wasp and Systropus (Bee fly)
 - Yellowjacket Wasp and Fly, Beetle, Dragonfly, Moth, Raspberry Crown Borer
 - Number of models > # of mimics
 - Models and mimics must be active at the same time of ear
- Behavioural Defense
 - Example: American Toad
 - Inflates with air to appear bigger
 - Example: Hog-Nosed Snakes
 - Swells up to look larger – if that fails it rolls over and plays dead (called Thanatosis)
 - Blister Beetles and Virginia Opossum also play dead
- Behavioural Group Defense: safety in numbers
 - Example: White Tailed Deer
 - Yarding: gather in yards
 - Flocking: visually confuses predators, lowers odds of being caught – passive
 - Snow Geese, Sandpipers
 - Aggressive Group Defenses
 - Example: Yellowjacket wasps
 - Attack pheromones summon the troops
 - Example: Blue Jays vs. Owls
 - Mobbing, alarm calls summon others to join the attack
 - Example: Carpenter Ants
 - They guard Aphids
 - Example: Eastern Cottontail
 - When alarmed, they run away, tail goes up, white tail is prominently displayed
 - White tail shows they are aware of the predator's presence
- Vigilance: being alert and scanning for danger
 - Olfactory = nose adaptations
 - Example: Snakes
 - Pick up molecules of scent on tongue, bring back molecules for analysis in the Jacobson's Organ
 - Example: Moose
 - Enlarged snout houses more sensory cells and a Jacobson's Organ
 - Bull moose use tongue to pick up airborne scents
 - Mammals expose the Jacobson's Organ by flehmen (curl back upper lip)
 - Auditory = ear adaptations
 - Large ears capture sound – called external pinnae
 - Ears pivot to scan all directions
 - Antlers act as disks
 - Animals active at night have large ears
 - Beavers cannot have large ears since it affects their swimming ability
 - Some insects hear and have membranes that act as eardrums and detect sound vibrations

- Example: Tiger Moths
 - Have ears on thorax
 - Example: Lacewings
 - Have ears at the base of wings
 - Example: Mantids
 - Have one ear in front of hind legs on the underside of abdomen
 - Example: Snakes
 - Can't hear but can feel vibrations
 - Visual = eye adaptations
 - Example: Snowshoe Hare
 - Eyes on side of head provide larger view of the surroundings
 - Example: Mallards
 - Eyes on the side give wide view
 - Example: Red Fox, Great Gray Owl
 - Eyes on the front help you hunt
 - Example: Beavers
 - Straight line for being above water
 - Example: UNKNOWN
 - Eyes are at back of head – when feeding stick their head down
 - Example: American Bittern
 - Eyes are placed near bill – for the vertical line background matching
 - Example: Deer
 - Have large eyes that gather more light
 - Example: Flying Squirrel
 - Nocturnal animals display eyeshine
 - More rods than cones – the layer of cells that are reflective are the tapetum lucidum
- Flocking
 - More eyes = better vigilance
 - Single Species Flock
 - When food is plentiful (apple tree with a lot of the same resource)
 - Examples: Sandpipers, Canada Geese, Waxwings
 - Mixed Species Flock
 - When food is scattered (more variety for different species)
 - Examples: Warblers

Plants – Staying Alive

- Physical
- Structural
 - External
 - Woody Armour (bark) – trees
 - Hard Coats – seeds, acorns
 - Spines (hard leaves) – thistles
 - Prickles (epidermal outgrowths) – prickly ash

- New rose buds resemble prickles – automimicry
 - Thorns (modified branches for bigger animals)
 - Trichomes (plant hairs for smaller animals) – ragweed
 - Water Smartweed – no trichomes on leaves in water, trichomes appear when water not present – inducible defense
 - Internal
 - Cell wall components
 - Cell wall with chloroplasts that protect the insides
 - Structural elements (cellulose, hemicellulose, pectin): make tissues hard to digest
 - Lignin gives leaves stiffness, nuts and cherry pits their hardness
 - Silica is found in horsetails and grass
- Non-structural digestibility reducer: tannins, are astringent (extremely dry)
- Chemical Defenses
 - Calcium: deterrent
 - Calcium Oxalate Crystals – arum plants e.g. Skunk Cabbage, Jack In The Pulpit
 - Terpenoids: DON'T contain NITROGEN, taste bitter, serve to repel
 - Examples: Milkweeds (cardiac glycosides), resin on pine cones, resin on poison ivy (urushiol)
 - Alkaloids: DO contain NITROGEN, serve to damage
 - Example: asters
 - Insect Growth Hormones
 - Molting hormones – change outer skeletons (ecdysone)
 - Juvenile hormones
 - Both molting and juvenile are present in insect's growth, then just molting
 - Plants manufacture these hormones
 - Phytoecdysones – have molting hormones – speed up maturation
 - Example: Rock Polypody
 - Phytojuveniles – have juvenile hormones – prevent maturation
 - Example: Bracken Fern
 - Reproductive Hormones: mess up reproductive system (phytoestrogens)
 - Example: Red Clover
 - Phototoxins: allergic reactions
 - St. John's Wort
 - Blueberries – terpenoids replaced with sugar, for animals to eat and spread seeds
 - Phytohormones are chemical messengers that travel through the plant and initiate biochemical responses
 - Examples: Jasmonic acid, ethylene, salicylic acid
 - Like ants – extrafloral nectaries provide food for insects and therefore protection
 - Distress/Wound Hormones: plants release chemicals into air telling insects there are caterpillars to be eaten

Animals – Environmental Stress

- Endothermic (temperature controlled internally) and ectothermic (external)

- Winter active animals “dress for the occasion”
 - Mammals: layers, hair, guard hairs longer/thicker, dense underfur to trap body heat
 - Birds: bulkier feathers, contour feathers on outside, down feathers underneath
 - Example: Black Capped Chickadee
- Extra layers of fat on inside
 - Subcutaneous: for insulation
 - Internal Brown Fat: for burning
 - Mammals add both, whereas birds only subcutaneous
- Shivering: important means of thermogenesis (to generate heat)
- PALE COLOURS retain body heat better
 - Example: Snowy Owl, Arctic Fox, Snowshoe Hare
 - Gloger’s Rule: paler further north
- Allen’s Rule: short extremities are better
- Bergmann’s Rule: low surface area to volume ratio
 - Plump = low ratio, long = high ratio; plump is better
- Countercurrent Heat Exchanger: veins contact rete mirabile (wonderful net)
 - Arteries bring warm blood to veins, blood coming from veins in feet is warmed up by blood coming through veins from heart
 - Occurs in feet of birds or in snouts
- Mammals breath only through nose in the winter
- Roost Site
 - Coniferous trees offer more warmth and shelter
 - Woodpeckers spend nights inside a tree cavity, same with owls and chickadees
- Flying squirrels huddle
- Shelter building
 - Muskrats build lodges with chunks of cattails, softer plant materials
 - Beavers also build lodges with sticks and mud (which insulates)
- Subnivean space
 - Space underneath the snow for small animals
 - Ruffed grouse burrow in the sno
- Torpor
 - When animals enter deep sleep
- Black capped chickadees raise body temperature by shivering
- Ectotherms
 - Example: Snakes, Adult Turtles, American Toads
 - Go below the frost line and become dormant, place is called hibernaculum
- Insects
 - Go dormant and use glycerol as a cryoprotectant
 - Overwinter in sheltered sites
 - Example: Praying Mantids, Walking Sticks
 - Lay eggs in oothecal
 - Antifreeze can be added
 - Supercooling: when no ice forms inside body
 - Survive winter as adults

- Female Mosquitoes, Wasps, Bees, Angle Winged Butterflies, Silk Moths Coon
 - Example: Goldenrod Gall Fly Grub
 - Frozen, cryoprotectants, ice nucleating sites between them, freeze tolerance
- Not all herps avoid
 - Example: Gray Tree Frogs, Wood Frogs, Spring Peepers, Chorus Frog
 - Stay near soil surface and freeze – freeze tolerant
 - Snapping Turtles overwinter on the bottom where a stream enters a lake – dormancy
 - Lay eggs in spring, hatch in fall, hatchlings head for water
 - Hatchling Painted Turtles stay in the ground all winter – freeze tolerant only as hatchlings
- Endotherms cannot freeze but some go dormant
 - Raccoons: lethargy in sheltered den
 - So do porcupines
 - Chipmunks: torpor “hibernation”
 - Low heartbeat and temperature but awaken every few days
 - Bats: light hibernation
 - High heartrate and body temperature, easily aroused
 - Black bears: light hibernation
 - Low heartrate, high temperature, easily aroused
 - Unelaborate dens, fatten up before winter with beechnuts, don’t urinate or defecate during the winter
 - Tappen: rectal plug that stops fouling
- True Hibernators
 - Groundhogs
 - Largest true hibernator
 - Curl up in a ball and temperature drops
 - Jumping Mice
 - Woodland and Meadow
- Other than temperature – winter also affects mobility
 - Moose: long legs for going through deep snow
 - Snowshoe hares: big feet – large surface area, hind feet bigger
 - Fisher: big feet
 - Also Martins
 - Ruffed Grouse: snowshoes
 - Scales on feet, only in the winter, provides larger surface area
 - Behavioural Adaptations
 - Subnivean space
 - White tailed deer go to yard
 - Browse line identifies where white tailed deer feed
 - Otters have short legs, run/slide – tobogganing
 - Also Minks
- Other solution – escape MIGRATION
 - Tons of examples: Songbirds, Canadian Geese, Monarch Butterflies, Dragonflies (Common Green Darner), Bats (Red Bats)

- Majority of birds migrate and travel tremendous distances
 - Scarlet Tangers → Brazil
 - Arctic Terns – 20k km
 - New Champion: Red Knot – 26838 km
 - Fat powers the flight
 - Semipalmated sandpipers double their body weight, convert food into fats quickly while on route
- Songbirds migrate at night – cooler, hidden from predators, calmer, safer
- Blue Jays, Swallows, Hummingbirds migrate during the day
- Thermal: Hawks and Eagles use to soar upwards
 - Glide down to thermals
 - Then soar up on it
 - Process is called THERMAL HOPPING
 - Thermals provide lift, created by sunshine
 - Slotted wings – extra adaptation for extra lift
- Sandpipers – day and night
- Daytime migrants navigate by the sun and landforms
- Nighttime migrants use moon and constellations as a compass
- Diurnal (day) and nocturnal (night) both use Earth's Magnetic Field
 - Rhodopsin – retinal photopigment – detects magnetism
- Geese: V shape – free lights to save energy
- Banding used to track migration
 - Songbirds caught in mist nets
 - Geolocators provide great migration info
 - Motus – picks up signal from birds flying in radius, signalers are called nanotags
- Half of birds don't come back – habitat loss, cats, fly into buildings

Plants – Environmental Stress

- Plants become cold hardy
 - Excess water withdrawn and evaporated from leaves
 - Water drawn out of cells – increases solute concentration
 - Protective sugars added to cells increasing solute concentration
 - Increase flexibility of cell membrane
 - Ice forms between cells but not inside, freezing point is lowered (but no antifreeze)
 - Become cold hardy through acclimation
- Acclimation
 - Triggered by change in photoperiod
 - Phytochromes: light sensitive photopigments
 - Cells go dormant, plant is responsive to low temperatures
 - Next stage triggered by cold temperatures
- Retaining needles – damage by solar radiation
- Chlorophyll – use sun's energy to create heat, not photosynthesize
- Skunk Cabbage heat generator
- Desiccation

- Conifers retain leaves so size and shape is important
- Leaf surface area is small – close stomata, thick cuticles
- Hairs on the underside of leaves
- Leaf surface area reduced by rolling up
- Deciduous trees have big leaves with large surface area, so they are dropped
- Conifers retain leaves
 - Some shapes shed snow (short branches, small needles)
 - Boreal forest dominated by spindly and spire shaped trees
 - Example: Balsam Fir spire shape, Black Spruce spindly shape
- Freezing rain can mess it all up
- Heat is also a problem – desiccation
 - Plants curl leaves to reduce surface area

Animals – Environmental Stress (heat)

- Animals go to where it is cool
- Heat shunted to body parts with a greater surface area – abdomen
- Dragonflies: reduce surface area facing the sun by assuming obelisk position
 - Also shunt
- Tiger beetles raise bodies by stilting
- Rete Mirabile: bypassed, blood shunted to the extremities, raises temperatures of heat
- Beavers: divert blood through the tail (rete mirabile)
- Honeybees work together to cool hive
- Foxes: pant – evaporative cooling
- Birds: pant (no sweating)
- Bees: evaporative cooling, create drops of liquid, spread on body
- Vultures: poop on their legs
- Mourning Doves: allow internal temperature to rise to 45 degrees
 - Smaller gradient
 - Could die to hyperthermia

Animals – Nutrition

- Herbivory: eating plants, like fruit, grass, seeds, sap, bark, twigs
 - Detritivore: dead plant material
- Filter feeders:
 - Clams
 - Black Fly Larvae: elegant labral brushes used
 - Dabblers/puddle ducks (e.g. Mallards)
 - Lamellae: filter system on side of the beak
 - Large beak: Northern Shoveler
 - Tongues
- Adaptations for plant foods
 - Long Proboscis: for nectar
 - Hyoid Horns: extend the tongue

- Example: Hummingbird
 - Stylet: narrow injection tool to get sap
- Aphids suck
- Ingestion can be problem with tough structural components
- Radula: used by slugs and snails to break off plant tissues (chainsaw)
- Modified Mandibles: Caterpillars
- Some caterpillars eat leaves from inside
 - Example: Leaf Blotch Miner
- Incisors: never stop growing, self sharpen
 - Moose only have lower incisors – helps rip off plant material (rather than bite)
 - Large cheek teeth, powered by masseters, grind the food
- Mandibles, radula, and cheek teeth perform the same function but have different origin
 - Function is to bite off smaller plant materials
 - Considered analogous structures
- Gizzard: muscle to break down plant material – analogous to mandibles, etc.
 - Example: Spruce Grouse and Ruffed Grouse
- After ingestion comes digestion
- Snails and slugs produce digestive enzymes
 - Caterpillars don't – instead defecate a lot
- Larger animals: bacteria inside the rumen of the stomach
 - Example: Moose
 - Food digested, produces cud, digests again – food processed twice
 - Rumination: chewing after processed once
 - Symbiotic relationship with bacteria and moose
 - Caecum: sacs of bacteria on the intestines
 - Example: Beavers
 - Have caeca in the back part of intestine
 - Eat their droppings – coprophagy
 - Grouse have caeca
- Porcupines don't eat their droppings – digestive track is 26% of their weight
- Animals that eat fruit have other food sources
- Fruit eating specialists:
 - Bohemian Waxwing
 - Large gape to swallow berries whole
 - Cedar Waxwing
 - Large gape for fast external processing
 - Short intestines for fast internal processing
 - Small gizzard
- Seed Dispersers: eat fruit and pass out the seeds
- American Goldfinches: large beaks, seed predators
- Red Crossbill: goes into cone and puts bill under scales
- Red Squirrels: bite off cone scales with incisors
- Chickadees: hammer off seeds

- Some herbivores sequester toxins
- Milkweed Beetle: cuts off veins of leaf and eats it
 - Vein Drain
- Enzymes can be used to neutralize the toxins
 - MFOs (mixed function oxidases)
- Specialists only eat one food source
 - Examples: Monarch Butterflies and Red Headed Pine Sawflies
- Generalists have a highly diverse diet
 - Example: Beavers
- Dietary switch between seasons
 - Moose: twigs and leaves (low Na) in summer, balsam fir (low Na) in winter
 - Go to water in summer to get sodium and feed on aquatic plants – high Na
 - Water-shield = 500 times more Na than land plants
 - Sodium stored in the rumen with bacteria
 - Gather a whole year of sodium
 - They eat mud and drink water in ditches since it has NaCl from salt used on roads
- Major advantage in eating animals that eat plants: protein
 - Bypasses step of processing plants
 - More return for the effort, easier to digest
 - Disadvantage: can be hard to find, prey well protected and fight back
- Predation: act of killing another animal
- Some eat from inside while the animal is alive
 - Parasitoid – inside
 - Parasite (e.g. Ticks) – outside
- Turkey Vultures are scavengers
- Predators must
 - Locate, Capture, Immobilize
- Hawks – diurnal birds of prey
 - Eyesight – enhanced vision
 - Large eyes collect more light
 - Large number of cones
 - Magnify the image 2-3 times
 - Frontal placement – depth perception
 - Retinal foveae
 - Temporal foveae lock on to the prey
 - Central foveae – search foveae
 - Foveae are depressions in the eye/retina
- Owls
 - Large eyes – more lights
 - Glycogen rich rods – good for low light levels
 - Frontal placement of eyes
 - More depth perception, large blind spot, 270 degree head turning recovers
- Tiger Beetles: large compound eyes
 - Ground beetles are nocturnal counterparts

- Dragonflies
 - Visual hunters – have 28k ommatidia each with 6 or 7 sensory cells
- Whirligigs can see above and below the water
- Spiders have 8 eyes
 - Jumping spiders move their retinas to change their field of view
- Crab spiders are visual hunters
- Large pinnae
- Owls hear with their faces
 - Facial discs capture sound – like satellite dishes
 - Wide heads – large ear opening
 - Horizontal auditory crosshairs
 - Asymmetrical – more exaggerated at ears
 - In general – wide heads and asymmetrical ear openings