

BIOL1902; Natural History Review

Adaptation

features/traits that offer plants and animals advantages to solving problems (**beavers toenails used to groom themselves**) these adaptations can be: physical, physiological or behavioural

Abiotic Stresses

environmental stresses (wind, temp) which arise because of **selective pressures**

Biotic Pressures

pressures that arise from other animals (competition for food and sunlight, pressures from predators and ability to find a mate)

Natural Selection

- identified by Charles Darwin
- never ending, driving force behind evolution
- **ALL pressures combined = natural selection**

Physical Defences

CAMOUFLAGE

a method of cryptic (hiding), which allows an otherwise visible organism or object to remain unnoticed, by blending with its environment. Forms of camouflage...

Background Matching; body has the same form of patterns as the environment around them.

- **Grey Tree Frog:** changes its colour depending on its background. In the winter, they are able to survive while half of its body turns to water and freezes.
- **Snowshoe Hare:** seasonally changes its colours to match their environment. (brown in the summer, white in the winter)

Bio-colouration; background matching from two directions

- **Whirligig Beetles:** have a white stomach and dark backs. This way predators in the water looking up won't notice them, since they'll blend into the bright sky, and predators looking down won't see them since they'll blend into the dark water.
- **Backswimmers:** are the complete opposite of Whirligig Beetles. They have dark stomachs and light backs as they swim backwards onto their backs
- **White Tail Deer/Red Tail Hawk:** are also dark above and light below because the shadow of the sun can camouflage it. This is called **countershading/ self-shadow concealment**.

Disruptive Patterns; animals have search images in their minds while looking for something. By adding in colours it breaks up/ disrupts animal shapes

- **Killdeer;** birds with disruptive patterns to blend in by using breast bands.
- **Canada goose;** have a chin strap to conceal themselves
- **Loons;** have necklaces to hide well
- **Leopard Frog,** brown and green spots and stripes that go across the entire animal to make the patterns work well. When this frog's legs are folded in, there are dark bands that continue and join together, which is called **coincident disruptive patterns**.

Masquerade (mimicry); organism resembles inedible and generally inanimate objects.

- **Angle-Winged Butterfly:** uses its shape to **mimic a dead leaf**. [Morning Cloak, & Easter Comma are other examples of angle-winged butterflies]
- **Walking stick:** is an example of a **twig mimic**.
- **Treehopper:** often have little thorns or spine like parts sticking out of their body, and normally stay very still on a plants while the suck out juices from the plant. This is a **thorn mimic**
- **Luna mouths:** hide up high in trees in daytime, to blend in as **live leaf mimics**.
- **Spittlebug (looks like foam):** sucking insects that suck in the juices of plants, then creates a foam like substance to hide in.
- **Giant Swallowtail Moth;** most caterpillars have a mate finish to the body, however this on has a shiny finish, which makes it a **bird dropping mimic**

In muddy area, butterflies or moths use '**puddling**' to get nutrients. Some mouths are known to hear the sound waves in the air. Behaviours they display is unusual as they are all grouped together. Their patterns of disruption combined **mimics an imagine of a snake**.

BODY ARMOUR

- **Millipede, Snails, Beetles, Turtles:** use their hard outer shells to protect them from predators (painted turtle, paint turtle, blanding's turtle- can partly close its shell)
- **Eastern tent caterpillars:** some animals can use a soft structure as a defence as well; these caterpillars form silk webs and leave their webs at night to feed.
- **Fall Webworm;** make their webs around leaves, and feed inside of them
- **Gypsy Moth Caterpillars & Tussock Mouth Caterpillar:** use their hair as a defence against birds trying to eat them. When they are under attack, they roll into balls
- **Woolly Bear:** has stiffer spines to protect them
- Porcupine: mammal that uses their quills (modified guard hairs) to protect themselves. *They do **NOT** shoot their quills, they must make contact with the receive for their quills to stick in

Chemical Defences

are found and released by a variety of body parts

POISON SPINES: Hair+Poison=Poison Spines

animals who have stiff hairs that are branched and tipped with toxins, creating poison tips.

WARNING COLORATION = posematic coloration

being brightly coloured to warn others of your defences. This allows predators to remember distinctive colours and avoid eating these colours in the future

- **Red Eft:** bright orange skin and spots because its skin is poisonous
- **Milkweed Beetles:** orange and black spots
- **Skunks:** do not use bright coloration because they are nocturnal! Is black and white = aposematic colouration for warning at night, use behavioural warnings first to conserve the chemical defence
- **Aposematic Coloration = Warning Coloration**, allows a predator to learn quickly to avoid that colour pattern

**[black and white, aposematic at night]
[colour in the day, better stay away]**

SEQUESTER

acquired in diet and then stored in the body

- **Monarch Caterpillar:** sequester cardiac glycoside(terpenoid) poisons from Milkweeds
- **Photuris Fireflies:** sequester steroids toxins by flying around in the dark and find an area where **photinus** (male firefighter) are, and eat the male to obtain their toxins, which is called **aggressive mimicry**

RELEASE OF CHEMICALS

Sawfly Larvae: when under attack, bubbles come out of their mouths which are chemical.

Blister Beetles (terpenoid cantharidin): use a chemical defence that oozes out of their leg joints (cantharidin)

Wasp use their stingers to inject their poison

Bombardier Beetle, releases hot quinone (burning gas) which burns predators faces

America Toads: have the toxin bufotalin in skin glands. If this first line of defence fails, the result to their second line of defence which is puffing up their mouth by making themselves seem bigger.

Hognose Snakes: also puff up. If this doesn't work, they literally roll of and play dead. Some blister beetles and possums also play dead.

MULLERIAN MIMICRY

when a group of animals all look alike and all bear similar appearances such as bad taste, a sting, poison spines, etc.

- all look alike share a true defence so their aposematic colouration is an honest advertisement

Mullerian Mimicry= both armed with vemin

BATESIAN MIMICRY

when a harmful model has some unpleasant feature (such as bad taste or a sting) and there is a harmless mimic that looks like it

Eg: Honeybee vs Hover Fly

Bumblebee vs Hover Fly

Bald-faced Hornet vs Hover Fly

- **Monarch:** Poisonous, Model
- **Viceroy:** Edible, Mimic

Because **Monarchs** are poisons, birds will avoid them. By **viceroy's** looking almost identical, it offers them protection by birds thinking it is poisonous when really, it isn't.

Group Defences

social insects (live as a group together, ants ect)

FLOCKING

is considered to be a group defence, as animals travel in groups for safety

they do this because...

- more eyes to watch for danger, better odds of not being eaten
- confuse predators and make it safer for each bird
- **Yellowjacket Wasps:** if one gets excited, called **attack pheromones**, which gets all the other wasps in attack mood.

MOBBING

when a group of birds vocally and physically harasses a predator until it leaves their area

- Bird group behavioural defence can be active and aggressive, by giving out certain alarm calls which reveal their location to get help from other birds. **Ex: Crows**

PISHING

a bird call - elicits a mobbing reaction in small birds

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Plants

For 400 million years, plants have been under attack. Without plants we wouldn't be here. Difference between animals and plants? Plants create their own food

Plant Defences

Physical Defences

also called **mechanical protection**

BODY ARMOUR

- **tough epidermis** (outer skin), bark and woody stems on trees and in shrubs, are used as a form of protection.
- These structures consist of **lignin**; stiff leaf have lignin in its structure, helps keep the structure strong

OTHER ARMOUR

- **structures that pierce:** Physical or mechanical protection is often enhanced with nasty piercing structures such as...

Prickles: are **epidermal outgrowths** with outer surface of the bark/outside epidermal cells, form a prickle (raspberries, blackberries ect...)

- new buds resemble prickles = **automimicry**

Thorns: are **modified branches** Hawthorn Branches & Honey Locust have thorns

Spines: are **modified leaves**, when leaves are modified into sharp structures, they are called spines.

SOMETIMES these three are ALL **aposematic coloured** to allow their prickles, thorns and spines stand out so predators do not eat them

TRICHOMES

small hooked or clubbed plant hairs

- Densely packed together, creates a physical barrier for small animals who try to climb up it.
- **Mullein** have very dense trichomes

- Some trichomes (**glandular trichomes** or **glandular hairs**) have a little ball at the top, which release **sticky glandular secretion**

One type of trichomes: separately stores phenols and enzymes, which break open when animals brushes them. Contents like epoxy mix together and create glue-like ooze that hardens. Some release chemicals that repel; **eg:**

Stinging Nettles: produce painful trichomes. If an animal touches the plant, chemicals are released which creates a burning sensation.

Trichomes can be **inducible (produced on demand):** **Water Smartweed** grows in the water and has floating leaves that lack trichomes. If the habitat dries out, trichomes will appear on the leaves.

Digestibility Reducers

when eaten, these make it hard for animals to digest the plants; most have **dual purposes= structural and defensive**

DIGESTIBILITY REDUCERS; STRUCTURAL ELEMENTS

plant tissues have cells with stiff walls that can be thought of reinforced concrete (second line of defence is to make it hard to digest)

structural elements such as cellulose, hemicellulose and pectin make plant tissues hard to digest

- **Benefit: hard to digest even for insects;** omnivores and carnivores digest very little of the material, if at all.

Lignin: another **structural agent**, stiffens cell walls; often stored in cells called **sclereids**. Gives leaves stiffness, nuts and cherry pits their hardness.

Silica= cell walls strengthened by silica, derived from **silicon** - one of the most common elements in the earth's crust; silica is found in grasses, horsetails; stored in special cells called **phytoliths**

DIGESTIBILITY REDUCERS; NOT STRUCTURE ELEMENTS

these have no other function but defence so these are called **secondary metabolites**

Calcium Oxalate Crystals(secondary metabolites): very powerful defence found in leaves of **Arum** plants: Skunk Cabbage and Jack-in-the-Pulpit **are Arums**; Calcium Oxalate is caustic, has a corrosive taste (burns lips and tongues)

Tannins: common are tannins, which are especially abundant in oak leaves and woody plants. Tannins are not bound inside the cell walls as lignin is, so they play no role in structural support. They deter animals from eating plant tissues because they are astringent (cause proteins to shrink).

CHEMICAL DEFENCES

- Plants usually contain a cocktail blend of chemicals, making it more difficult for herbivores to counterattack.
- Toxins are found in most parts of a plant, especially vulnerable tissues not fortified with lignin or silica, such as buds, young leaves, and unripe fruit
- If a chemical defence is always present, even when a plant is not under attack, it is called a **constitutive defence**. There are several major groups of constitutive toxins that are defined in

part by the presence or absence of the element nitrogen (N). One large group that lacks nitrogen is the terpenoids, whose name reflects their initial discovery in turpentine.

- Chemicals often play **dual roles** in the plant, **primary function: metabolic**
- Other chemicals are produced solely for non-metabolic functions such as for pollination or defence; those are **secondary metabolites**.

Do NOT contain Nitrogen

Terpenoids: often very bitter compounds, major group of chemical toxins. Found in milkweed, which can be sequestered by animals.

Phenolic Glycosides; these are commonly found in many parts of plants, such as in the twigs, leaves, and buds of many plants including poplars and willows. Serve **both** as **deterrents** and as **toxins** to many insects and mammals.

Poison Ivy: all parts of the plant except pollen contain the resin and its active ingredient **urushiol**.

Chemicals that DO contain Nitrogen

Alkaloids, a formidable group made famous by the early Greeks when they killed the philosopher Socrates with a toxic brew made from the leaves of an alkaloid-rich hemlock, not the tree but a member of the parsnip family (Water Hemlocks are possibly the most toxic plants in North America).

- produce very bad effects in those that ingest them
- Alkaloids are a large conglomerate that contains a number of chemically unrelated groups, which makes it very difficult to generalize about their effects.
- Different groups of alkaloids affect herbivores in different ways. The bitter-tasting **quinolizidines** (commonly called “lupine alkaloids” because of their prevalence in that group) have been found to have strong repellent and/or toxic effects on molluscs and insects, and even more potent effects on mammals. The effects on mammals include intoxication, convulsions, and apnoea resulting in death.

Polyhydroxy alkaloids mess up an insect’s digestive system by **binding to digestive proteins**. These alkaloids can occur in the form of **sugar-mimics** that bind up the proteins that break down sucrose and other sugars for absorption in the insect’s midgut. Because the digestive proteins are rendered inoperative, the leaf sugars pass through undigested and the insect (often a caterpillar or beetle) fails to attain nutrition.

- The strong effects of alkaloids have been exploited by our species for very different purposes. Some of the alkaloid toxins we use include caffeine, cocaine, morphine, nicotine, and strychnine!

Glucosinolates: Mustards (Brassicaceae) are particularly rich in these secondary metabolites, which are also known as mustard oil glycosides; they are lethal to insects, and in mammals cause toxic symptoms including mouth irritation, diarrhoea, and severe gastro-enteritis. Mustards advertise their ownership of this potent defence through their characteristic smell.

HCN:

Antibiotics:

Latex:

Phytoproteins:

Protein Inhibitors:

Plant-Produced Non-Protein Amino Acids:

Phytohormones:

Reproductive Hormone Mimics:

Phototoxins: eg: **St. John's-Wort**, produces phototoxins in the glands of the leaves, flowers, and stems. When eaten, the chemical spreads in the blood through the animal to the outer surface of its body - it reacts with sunlight, making the skin super sensitive to sunburn; creates sores, infection and even death

Endotherms and Ectotherms

two different ways animals generate their internal temperatures

ENDOTHERMS

generate heat internally, by remaining active and stay warm by...

- increasing body insulation to trap air and body heat

Birds do this by **increasing feather mass in two layers- contour feathers** outside and **down feathers** underneath contour. Some increase feather mass by 50% eg: **Goldfinches**

- putting on an extra layer inside the body

Subcutaneous Fat Reserve (in mammals), white fat is important for insulation. Brown fat is a high efficiency fuel - generates more heat when metabolized than does white fat = heating pad (Examples: Voles and other small mammals) which is why they store brown fat near the heart and other vital organs

Subcutaneous Fat Reserve (in birds), much of the fat is burned as fuel, heat is generated as

byproduct

- being a warmer colour

White is warmer due to lack of pigmentation, hollow pockets that trap air. Eg: **Polar Bears, Arctic Fox**

Gloger's Rule: as you go further north, animals tend to be paler

- having a better body shape for retaining heat

Smaller extremities in north- **Allen's Rule:** short extremities are better

- reducing the surface area of the body losing heat

Lower or smaller surface area to volume ratio (nearer to 1:1). **Bergmann's Rule:** tend to find larger or rounder animals farther north

- reducing the amount of heat being lost through extremities

eg: birds and mammals- Duck and Gull feet and Beaver tails

ECTOTHERMS

organisms that control body temperature through external means

eg: Frogs, Snakes, Turtles, Salamanders, Insects and Spiders

Two main solutions to the cold problem:

- Stay active and deal with subzero temperatures
- escape the cold either by leaving (migration) or by going dormant

how do they avoid freezing?

- Most reptiles & amphibians become inactive
- They escape freezing temperatures by avoiding them by: Behavioural Freeze Avoidance, go Dormant, and Supercooling
- Seek a site where temperatures are not below zero (Ectotherms go dormant below frost line)

Hibernaculum: below the frost line where snakes are dormant

- **Toads and Salamanders** - Dig down **below the frost line**, and, Turtles and most Frogs (Bullfrogs) - go to the bottom of ponds where it does not freeze - here their metabolism slows down, they breathe through skin
- Most insects and other invertebrates also go dormant in areas where it is below zero - they produce **antifreeze**

Supercooling: where ice forms in an animal's body and all body water stays liquid well below zero

Behaviours to Cold

Thermoregulate

Back in warm site, out of the wind, to absorb solar energy.

- **Eg:** many birds, foxes, and other mammals

Warm Extremities

By tucking them under feathers; extremity touches skin, feathers keep warm

- **Eg:** ducks and swans

When sleeping

Deduce surface area

- **Eg:** fox and wolves curl into a ball and put tail over nose , birds tuck head under wing
- Choose warm sites for sleeping or roosting
- Conifer branches covered in snow - less wind, traps body heat
- **Eg:** Moose, and Hares - Lay under conifer branches that are snow covered - less wind under conifers, branches trap heat
- use the snow like **Ruffed Grouse** do
- Use a den - Beavers build lodges and so do Muskrats
- Turn up the heat by shivering: some birds generate more heat by increasing the muscle activity, this happens at night or during cold stretches

Not all animals stay active when the temperature drops; **Ectotherms** cannot because their body temperature drops with environment - they go dormant as body core temperature drops

Dormancy at any life stage

EGGS

Underwing Moths, Praying Mantids (eggs cases are called ootheca)

PUPAL STAGE

Many moths and butterflies including Silk Moths and Sphinx Moths

ADULTS

Angle-Winged Butterflies (that is why we see them very early in the spring), Lady Beetles (That is why we see them in houses in the fall)

LARVA

Wolly Bears Caterpillars

How do animals allow ice to form inside the body?

They use **Cryoprotectant** - they add glucose to cells, **AND**, they control the ice formation by creating special proteins for ice to form around = **nucleating sites**

Freeze-tolerant= when an animal freezes and survives. **Eg:** Hatching Painted Turtles

Types of Dormancy

PERIODS OF INACTIVITY

Lethargy OR Short-term dormancy (only when necessary - during severe cold, not true hibernation - little drop in the body temperature) **Eg:** Porcupines, Raccoons, and Skunks (stay in dens)

LONG-TERM DORMANCY (light hibernation)

All hibernators display period arousal, **not deep hibernation** **Eg:** Chipmunks - heartbeat and body temperature - not deep hibernation, for they awaken and eat and crap every few days

BATS

- different low body temperature, high heartbeat - can have bouts of longer dormancy periods greater than 30 days in Hibernaculum
- needs the temperature to remain near freezing: in caves, rock crevices, attics, mine shafts, etc. - some huddling occurs

BEARS

- Also "**hibernate**" - better called **prolonged torpor** or **dormancy**
- **Not true hibernation, low heartbeat** (drops to 8 bpm) but **high body temperature** (does not drop much - low 30s)
- Do not go below frost line, dens very crude - under treefalls and some are lined, aroused easily (in the sense they wake up easily), do not defecate - rectal plug
- Before dormancy they put on a great amount of fat by eating lots of fruits and nuts (especially beech nuts)

True or Deep Hibernation

GROUNDHOGS

- **largest mammal** to undergo this hibernation
- greatly **reduced metabolism, body temperature < 10 degree celsius - heartrate < 10 BPM**
- hibernates below the frost line rolled-up position (lower the SA:VOL ratio), never a complete

winter-long sleep, occasionally awakens, then falls back into sleep, maybe once a month
Meadow Jumping Mice and Woodland Jumping Mice also undergo hibernation

Mobility Problems

For those animals that stay active, cold temperatures bring a second major problem: Snow, builds up and gets deeper. Solutions to this problem are:

- use of **subnivean space** - small mammals, move to areas of less snow (Moose go to hemlock groves and White-tailed deer go to hemlock or cedars - WHY? There is food in low areas, cedars especially, and less snow, not compacted under trees makes it easy to walk, safety in numbers)
- Walk in tracks of others (Wolves), use the body as a toboggan (Otters and Mink)
- Long legs (Moose), Snowshoes (Snowshoe Hard, Fisher, Linx, Marten, Ruffed Grouse (grow their own snowshoes))

Migration

Is mainly a response to food supply but solves the temperature problem as well

Best known in birds: A few ectotherms (monarch butterfly, green darner dragonfly, one local mammal - red bat)

Eg: Flycatchers, Swallows, Warblers, Songbirds - All eat insects, AND, Sandpipers - eat worms

SONGBIRDS

Fly 500km (several hundred miles) each night, put down, feed, rest in stopovers

SANDPIPERS

Much greater distances -Migrate both **DAY and NIGHT**

SEMIPLUMATED SANDPIPER

Flies 4,000-5,000km (several thousand miles) in 3.5 days

RED KNOT

Just found to fly non-stop 5,1000km in 8 days

Birds that migrate by day: Blue Jays, Hawks, Hummingbirds, Blackbirds, Swallows

FAT USED AS FUEL

Fuel instead of carbohydrates for travelling because

Carbohydrates = more weight to carry, Fat = no water needed to metabolize, and Fat is stored easily

1gm of fat power= 8gm of carbohydrates

Types of Flight; used by birds

FLAPPING

Birds that flap continuously are: **Ducks, Geese, Sandpipers, Hummingbirds**

Most energy efficient flight = no flapping at all (Hawks)

THERMAL

Use rising air columns to lift hawks (or other birds) to a great height, then glide down to the next

column of rising warm air

- Hawks use of rising air columns is called **Thermalling or Thermal Hopping**

NAVIGATION

migration compasses are used

Daytime Migrants- use the sun, landforms

Nocturnal Migrants- use the moon and stars (most songbirds)

Most birds: Use the Earth's magnetic field - likely detected by a photopigment in the eye that interacts with the Earth's magnetic field