Evolution

Educators's Resource Guide

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Evolution is **descent with modification.**[1]

Life has been evolving for a very long time. About 4 billion years ago, simple compounds came together to form entities that could grow and reproduce.[2,3] These entities are the basis of all life on Earth - all the estimated millions or even trillions of species, from microscopic bacteria to fungi, plants, animals and everything in between.[4]

Before the **theory** of evolution was proposed in the 1800s, it was widely accepted that God had created life and that all species were made individually by Him.[5] Because they were divinely created, species were also thought to be unchanging - once they were placed on Earth, they stayed the same forever.[5]

Charles Darwin and Alfred Russel Wallace were the first to put forth the theory of **evolution by natural selection**. They proposed that species were not divine creations but descendants of other species, and that variation and forces within **populations** - like competition and disease - led to the elimination of individuals less well-adapted to their environment.[5] Initially, the concept of evolution by natural selection caused an uproar: it was in direct defiance of special creation and the role of God in making life on Earth. But the theory's reasoning and evidence gained traction over time, and scientists have agreed that all living things evolved from **common ancestors** for the last 150 years.[1]

Pacific Tree Frog, *Pseudacris regilla*
Kevin JF Martin

Evolution by Natural Selection

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Evolution by Natural Selection

Darwin and Wallace observed two important things. One, that there is variation among individuals in populations; and two, that population sizes stay relatively constant, even though many offspring are produced - enough to make population sizes increase.[5] These two observations are the basis of their theory of **natural selection**, the process that Darwin and Wallace showed brings about evolution.

The theory states that having variation within a population means that certain individuals will be better able to survive and reproduce than others - that certain individuals have traits that make them more **fit** in their environment. And consistent population sizes indicate that the environment can't support some of the many offspring produced. So, fit offspring with traits that make them well-suited to their environment will survive and reproduce, while offspring that lack those traits do not live to reproduce, or if they do, produce fewer or weaker offspring.[6] Over time, more and more of the population will have the fit traits, since the fittest individuals reproduce most successfully and pass on their traits to the next generation. The population will have evolved! Natural selection is sometimes explained as the "struggle for existence" or the "survival of the fittest."

But a given trait may not be fit forever. If the environment changes, the traits that make individuals fit can change as well.[6] Over time, the population will shift to adapt to the new environmental conditions: individuals with a different set of traits will be more likely to survive and reproduce, and those traits will become common in the population. Again, the population will have evolved. Eventually this process can lead to organisms that are very different from the original population - so different that they might form a new species.

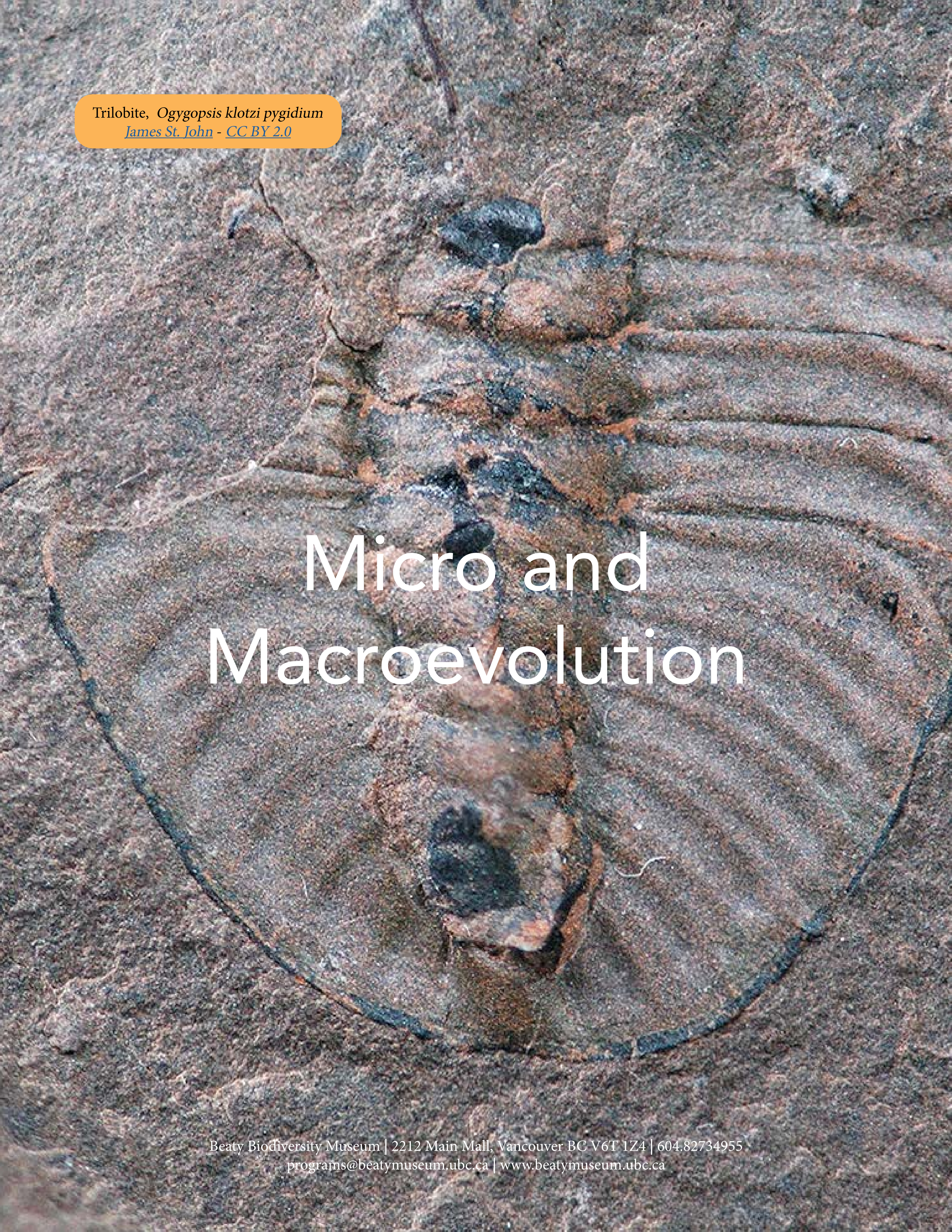
Individuals with traits that make them better suited to their environment are more likely to survive, reproduce and leave offspring, which also have these same traits. Other individuals with traits worse suited to their environment are weeded out before they can reproduce. “Better” and “worse” traits are not constant and change depending on environmental factors.

We now know that natural selection is just one of the forces that drive evolution. Other forces - like mutation and genetic drift - are described below.

What is a scientific theory?[6]

A scientific theory is an explanation about how something in nature works that undergoes testing - through observations and experiments - to support or refute it.

- In science: the word “theory” denotes a high level of certainty
- Another example of a scientific theory: the theory of gravity



Trilobite, *Ogygopsis klotzi pygidium*
James St. John - CC BY 2.0

Micro and Macroevolution

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Micro and Macroevolution

Evolution on a smaller scale is known as **microevolution**. Microevolution describes change in a population over time. More specifically, it is the change in frequency of an **allele** (form of a **gene**) at a particular genetic **locus** (place on a **chromosome**) from one generation to the next.[7] Whenever genetic equilibrium - in which the ratio of allele frequencies stays the same - is set off-balance, microevolution is occurring.

Microevolution is always happening in real populations because the frequencies of different alleles are always changing. Allele frequencies change because of:

- **Selection**: some heritable allele combinations (traits) make individuals more or less likely to survive and reproduce[7,8]
    - Traits that confer **fitness** benefits become more common in populations over time
- **Mutation**: changes to the DNA in eggs, sperm or other sex cells creates new genotypic variation - new alleles - that can be passed down to offspring[9]
- **Gene flow**: individuals, propagules like spores or seeds, or gametes are sometimes moved between populations[7,8]
    - Gene flow can introduce new alleles, change the frequency of existing alleles or remove alleles from a population, depending whether genetic variation is added (immigration) or removed (emigration)
- **Chance**: allele frequencies can change randomly over time[7,8]
    - Certain alleles might become more or less common by "luck"
    - This is also called **genetic drift**
- **Non-random mating**: sometimes there is a higher-than-expected probability that individuals with certain allele combinations (traits) will mate[7,8]
    - Females' choice of mate and male-male competition lead to allele ratios skewed in the direction of individuals that get to mate

In a nutshell - Microevolution is always happening in real populations, because the frequency of different alleles is always changing, because selection, mutation, gene flow, genetic drift and non-random mating are always changing allele frequencies.

Evolution on a larger scale is known as **macroevolution**. Macroevolution describes major changes over long periods of time - like the emergence of big groups of organisms, such as amphibians or flowering plants, or **speciation**, the process by which one species divides to form multiple different descendant species.[5] We can find evidence of macroevolution in the geographic distribution of living species, similarities between organisms in early development and the fossil record. The processes of microevolution can lead to macroevolution through geological time.

Evolutionary research at UBC

The theory of evolution was proposed 150 years ago, but many questions about its processes and patterns remain. Researchers study evolution by looking back in time - at the fossil record, at trends in body structure and early development, at similarities and differences in DNA - and by looking in the present - at populations in the throes of evolution.

Red Huckleberry,
Vaccinium parvifolium
Jamie Clarke

Evolution of Leaf Shape, Size and Energy Uptake

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------- Watch -------

Watch Barbara Neto-Bradley's video on leaf shape evolution

explore.beatymuseum.ubc.ca/researchers-revealed/b_neto-bradley

------- Talk with you neighbour -------

What are some examples of leaf shape adaptations?
What advantages might those adaptations lend?

Leaf Shapes

Adaptations are traits that allow individuals in a population to do better in their environment than those that lack those traits.[10] Adaptations are inherited and evolve by natural selection.

Evidence from the fossil record suggests that plants began colonizing land about 470 million years ago.[11] Early land plants were leafless and rootless, and lacked a vascular system - the network of tubes that transport water and nutrients in present-day ferns, horsetails, trees, and flowering plants. Without these structures and systems, they couldn't grow far from wet environments or grow to be very tall. Early land plants are believed to have resembled the mosses and liverworts that blanket and dot the terrestrial realm today.[11]

Plants evolved leaves about 430 million years ago.[11] Leaves actually arose several times, independently, in different plant lineages![12] The evolution and subsequent adaptation of leaves (and shoots/stems) to different environments spurred an evolutionary radiation in land plants - a rapid increase in the diversity of a group of organisms, brought on by high rates of speciation.[11,13] In other words, the innovation of leaves contributed to an explosion of different forms of plants. This rapid radiation led to significant changes in the Earth's soils and atmosphere, and to a significant increase in the number of plant species.[11]

Leaves' main function is to photosynthesize - to take up light and produce sugars for food.[14] But they can also be adapted for other purposes. Sometimes, they take on particular shapes to be better suited to their environments. The broad, flat leaves of many plants are great at absorbing sunlight;[15] the narrow leaves of some riverside plants help to withstand the force of water during flooding;[16] the needles of coniferous trees are hardy and well-suited for harsh environments;[15] the pitchers of some carnivorous plants photosynthesize, but also trap insects to absorb their nutrients;[15,16] the spines of cacti are highly modified leaves used in defense and water loss prevention;[14] the leaves of desert-dwelling aloe plants are filled with a gooey substance that stores water.[14] Leaves are adapted for a host of different uses and environments.

Barbara studies how the shape and size of plant leaves, and therefore their ability to take up energy from the sun, varies across plant groups. She is looking for large-scale patterns in form and function across **clades** - taxonomic groups of organisms that include an ancestor and all of its descendants.

The images below are examples of present-day liverworts and mosses, which early land plants are thought to have resembled. Image credits - Jamie Clarke

Snakewort, *Conocephalum salebrosum*

Broom moss, *Dicranum scoparium*

Fan moss, *Rhizomnium glabrescens*

Catherine's moss, *Atrichum undulatum*

Bald Eagle,
Haliaeetus leucocephalus
Jamie Clarke

Evolution of Bird Wing Range-of-Motion and Flight Style

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------- Watch -------

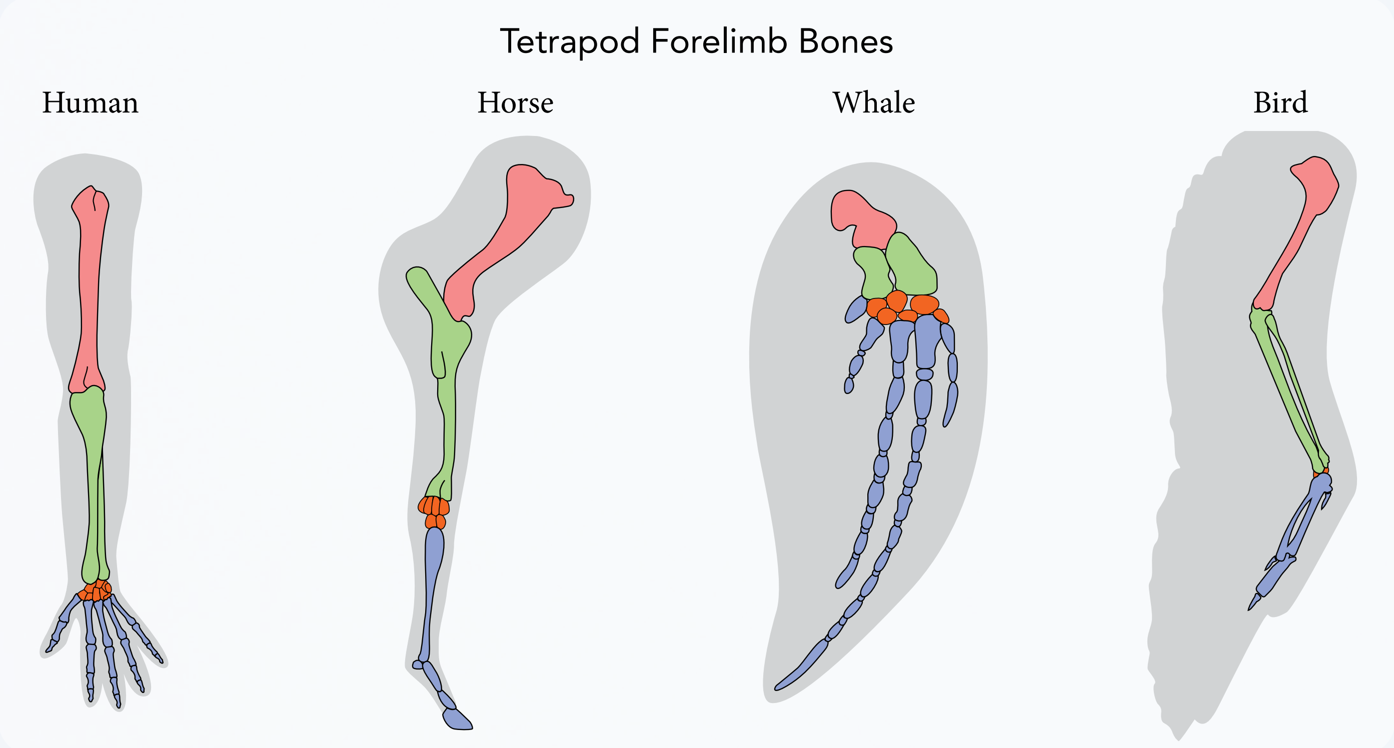
Watch Vikram Baliga's video on the evolution of wing range-of-motion and flight styles in birds - explore.beatymuseum.ubc.ca/researchers-revealed/v_baliga

------- Talk with you neighbour -------

Name some examples of flight/movement styles seen in birds - what are some of the different ways birds move?

Bird Wings

Animals with four limbs - amphibians, reptiles, birds and mammals - are called **tetrapods** (meaning "four feet" in ancient Greek). Some tetrapods have secondarily lost their limbs, like snakes; others have evolved specialized limbs for swimming, flying or manipulating objects, like whales, bats and monkeys. But regardless of their modified or missing limbs, all tetrapods, living and extinct, descended from a **common ancestor**.[17] Because they share an evolutionary history, they share many homologous characters - including the skeleton of the forelimb or arm.



Tetrapod forelimbs are made up of a collection of bones that are highly conserved between groups. Though their form and function vary, their organization stays the same.[18] Starting at the shoulder and moving away from the body, the upper arm has just one bone, called the humerus. Below that, the forearm is made up of two bones: the radius, which is the bigger of the two, and the ulna, which often forms the elbow. The many bones that make up the wrist are called the carpals. Those that make up the hand are called the metacarpals, and the fingers, the phalanges.

Birds have specialized forelimbs for flying - wings! Although birds' wings are made up of the same bones as other tetrapods' forelimbs, they have a few key adaptations for flight:[19]

- Hand bones are fused for extra strength
- Wrist joint is reduced to two bones for lightness
- Bones are hollow for lightness
- Wings are covered in feathers, which provide a light, rigid surface for flying

Flying is an intriguing method of movement. Many aspects of wing and flight biology - evolution, biomechanics, physiology, etc - have been studied… But Vikram came across an enduring mystery of avian flight. Why do bird species with similar flight styles (like gliding, hovering, bounding) and body sizes have differently shaped wings?[20] And if wing shape is only loosely related to mass and flight method - what explains diversity in flight style and body size across species?

Vikram hypothesized that wing mobility might be the missing component. Birds don't keep their wings locked straight out on either side of their bodies when they fly.[21] Instead, they bend, fold, twist and stretch their wings to varying degrees, using their elbow and wrist joints - similar to how people bend, twist and extend their arms when swimming.[20,21] These motions change the shape of the wing in flight, which is also called "wing morphing."

Vikram determined wing morphing in 61 bird species by measuring the range of motion at the elbow and hand joints of wing specimens from the Beaty Biodiversity Museum collections. He and his team found that wing range-of-motion corresponds more strongly to a bird's size and how it flies than either of those variables correspond to wing shape.[21] In other words, the way birds fly has more to do with how they move their wings than the shape of their wings.

Flapping and bounding birds like robins have joints with ample range of motion and are able to move their wings rather freely.[21] Soaring birds like eagles have a much more limited range of motion in their joints, which might help them keep steady as they glide through the air.[21] Some diving birds like common murres have even stiffer wing joints that don't bend or twist much at all - perhaps so they can use their wings as paddles to swim underwater.[21]

So, flight style is dictated by the wing's skeleton - the shapes of the forelimb bones and how those bones interact with each other. Vikram says that the forces of nature have consistently acted on and changed the skeleton of the wing so that range of motion, flight behaviour and body size evolve together.

------- Watch -------

Watch the video of Vikram morphing wings

explore.beatymuseum.ubc.ca/researchers-revealed/v_baliga/#bottom

+ ------- Supplementary Resources -------

Flight Types and Wing Shapes

explore.beatymuseum.ubc.ca/~/flight-types-wing-shapes.pdf

Yellow-Bellied Sapscuker,
Sphyrapicus varius
Jamie Clarke

Reproductive Barriers Between Sapsuckers

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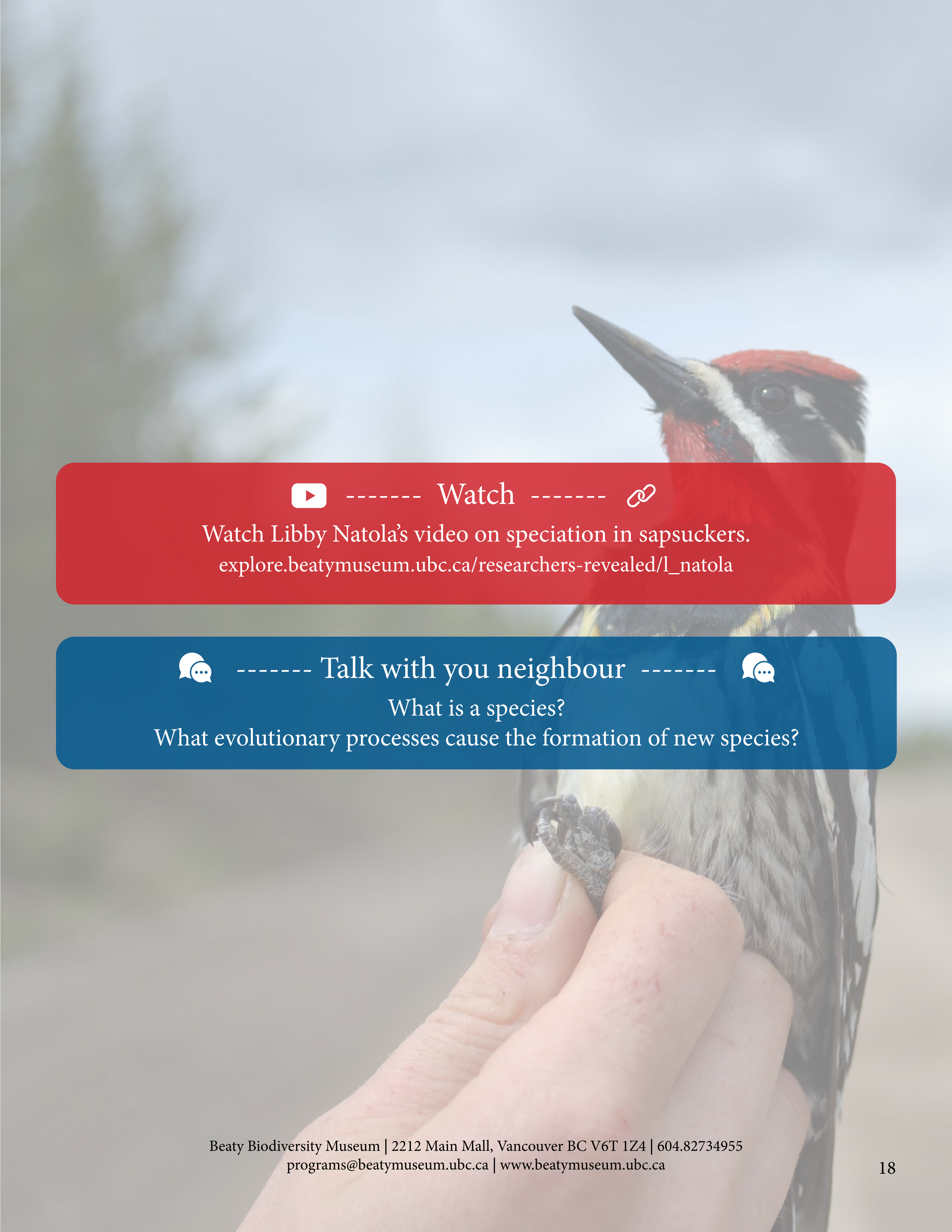


------- Watch -------

Watch Libby Natola's video on speciation in sapsuckers.

explore.beatymuseum.ubc.ca/researchers-revealed/l_natola

------- Talk with you neighbour -------

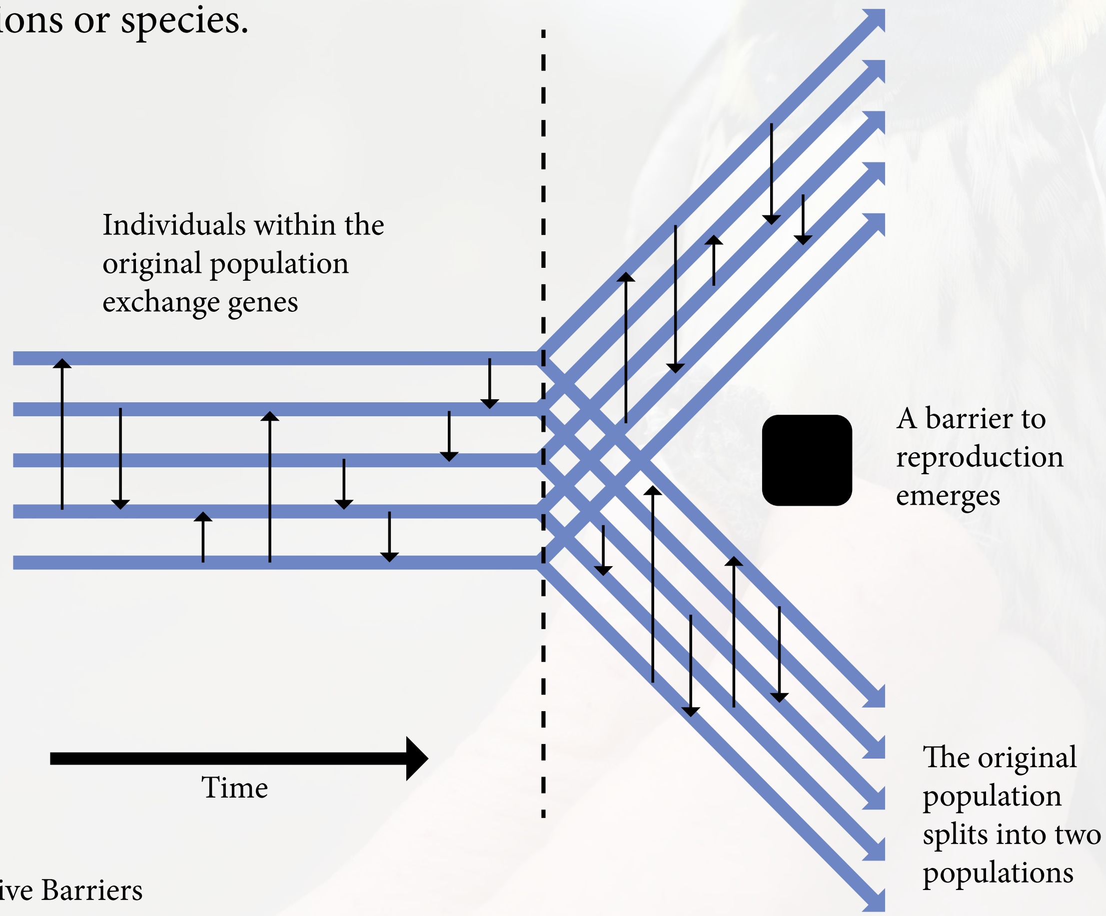
What is a species?

What evolutionary processes cause the formation of new species?

Sapsucker Speciation

Biologists have been defining and debating what makes a "species" for a long time. There are many species concepts based on different aspects of biology: ecology, genetics, evolution… One of the most enduring is the **biological species concept**. It states that a species is a group of organisms that breed or could breed with one another and that have been isolated from other groups by **reproductive barriers**.[7]

Reproductive barriers are characteristics of organisms.[22] They reduce the likelihood that members of different populations or species will interbreed, either by preventing mating from happening at all (**pre-mating barriers**) or by producing disadvantaged offspring (**post-mating barriers**). Reproductive barriers can cause populations or species to separate and follow different evolutionary paths, leading to and reinforcing **speciation** - the splitting of one species into two or more descendant species.[22] Speciation can also be brought about by geographic barriers, when, for example, a river or mountain separates populations or species.



Reproductive Barriers

Before sperm or pollen can even be transferred, pre-mating barriers hinder the ability of species A to find or recognize a mate of species B. Pre-mating barriers can be:[22]

- **Behavioural**: differences in behaviour make members of different species unattractive to each other
- **Mechanical:** reproductive structures (genitals, pollination parts) don't fit together
- **Ecological**: species breed in different habitats or at different times, or in the case of flowering plants, have different pollinators or pollination strategies

Post-mating barriers act after members of species A and B have already mated, and the sperm or pollen of one species has met the egg or ovule of the other. They affect offspring's development or ability to find food, court a mate and compete with others in their community.[22] Post-mating barriers can be:[22]

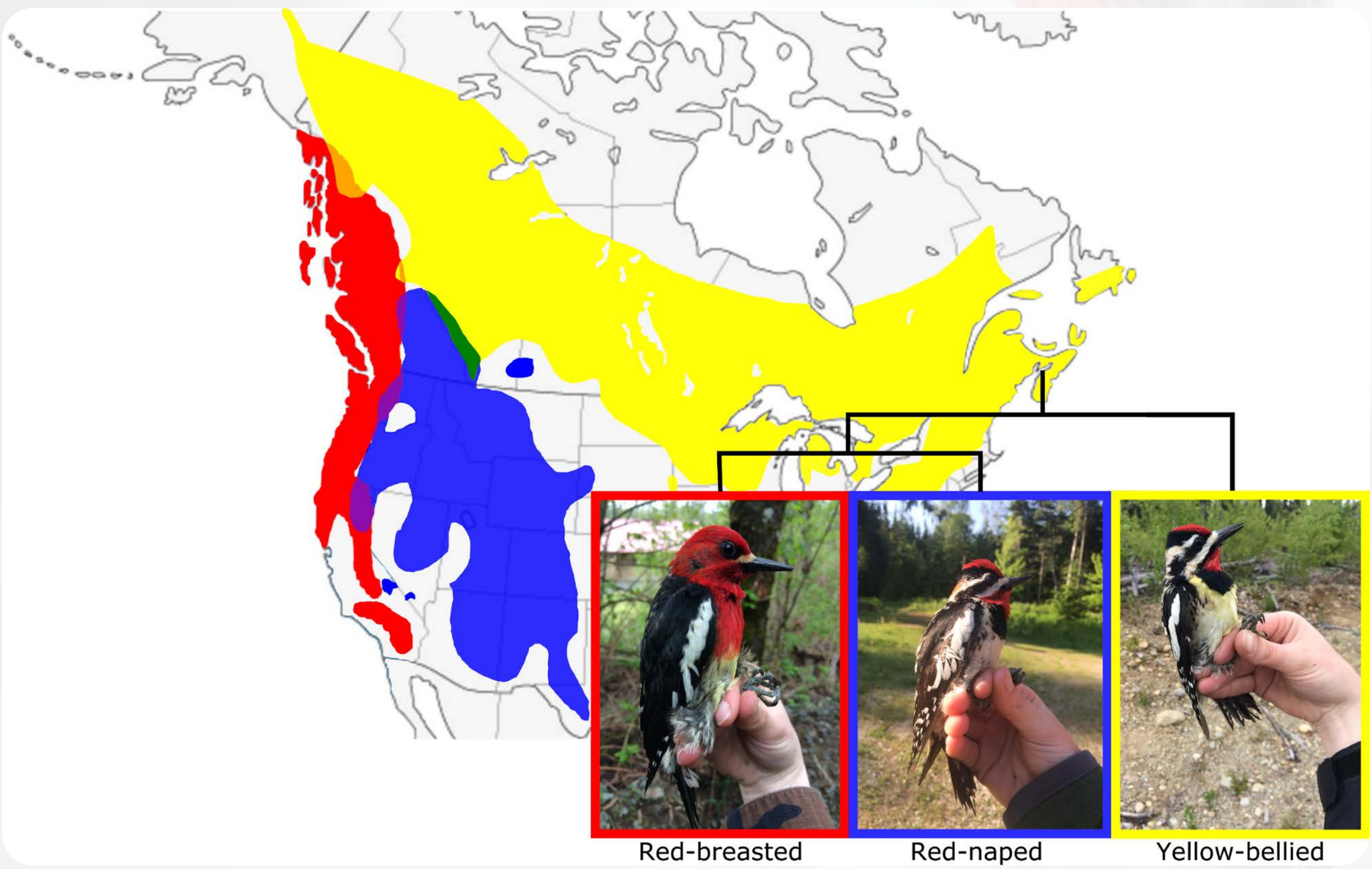
- **Intrinsic**: hybrids have developmental issues unrelated to the environment
    - They die shortly after birth or have issues with their reproductive, neurological or physiological systems that make them sterile
- **Extrinsic**: hybrids are impeded by environmental factors
    - They fare worse because they don't have a suitable niche in their ecosystem or are undesirable to potential mates

Libby studies speciation in a group of woodpeckers called sapsuckers. She looks at places where red-breasted, red-naped and yellow-bellied sapsuckers come into contact and breed with each other, producing **hybrid** offspring (with parents of two different species). These places of contact, called **hybrid zones**, provide researchers with a "snapshot" of the speciation process.[23]

Species don't just suddenly diverge and become distinct from one another. Speciation happens gradually over time, as barriers to reproduction build up. That means that when we study diverging populations or species, we get a quick glimpse of a particular moment in a very long-lasting process.

Glimpses into hybrid systems can be very informative. Species that meet and mate in hybrid zones are somewhere along the speciation continuum: they might show signs of minor reproductive isolation - the beginning stages of speciation - or close-to-full-blown separation. They might also be somewhere in-between those two extremes. Species' positions along the speciation continuum depend on how long ago they split and the strength of the barriers between them.

Red-breasted and red-naped sapsuckers are most closely related to each other, but red-naped and yellow-bellied sapsuckers look most alike. Libby is trying to find out whether species are more likely to interbreed if they're more related or more similar in appearance.[23] She also studies how important pre- and post-mating barriers are in the sapsucker system, and whether post-mating barriers reduce the number of hybrid sapsuckers laid, hatched and fledged.[23]



Sapsucker Distributions - Libby Natola

Stickleback,
Gasterosteus aculeatus

Fitness of Hybrid Sticklebacks in New Environments

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Watch Mackenzie's video on hybrid fitness in changing environments.

explore.beatymuseum.ubc.ca/researchers-revealed/m_kinney

Talk with you neighbour

Are there advantages to being a hybrid?

Hybrids

Mackenzie studies a very special set of species: the benthic-limnetic threespine stickleback species pair. Benthic and limnetic stickleback fishes live in the same lakes, but look, act and feed very differently from one another - and so rarely interbreed. These fish pairs are now found in only a few lakes on Texada Island, off of the Sunshine Coast in southwestern BC.[24] UBC researchers are some of the leading experts on this unique fish system.

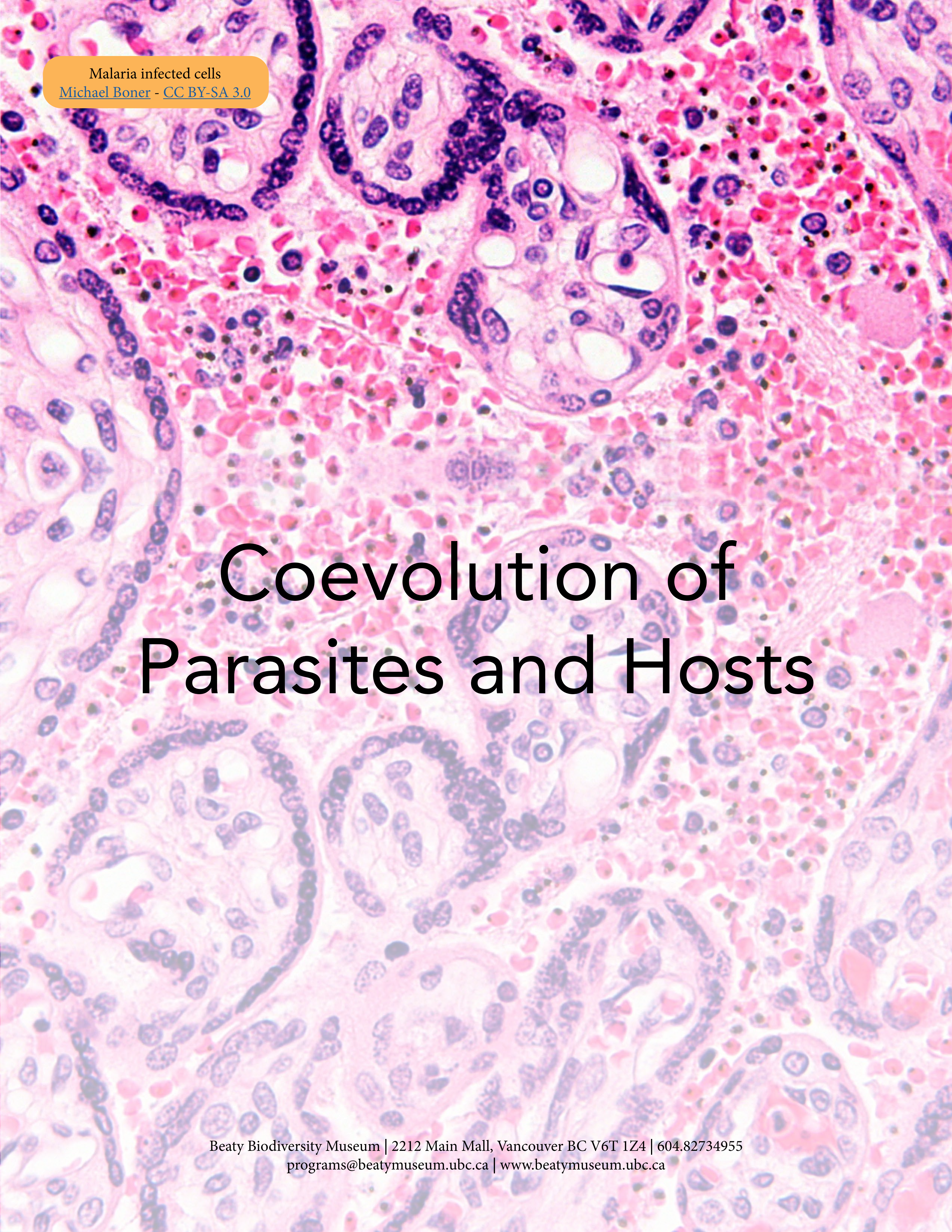
As their name suggests, both benthic and limnetic threespine sticklebacks have three spines that stick up off of their dorsal (back) surface.[25] They also have spines that protrude sideways from their bellies and armoured plates to further protect them from predators.[25] These fishes are small - less than 7 cm long as adults.[25] Within lakes, benthic and limnetic sticklebacks are strongly reproductively isolated, meaning they don't interbreed very frequently.

Benthic sticklebacks live on the bottoms of lakes. They are the larger of the two types, chunky and robust with dark-coloured bodies to blend in with vegetation on the lake floor.[25] Benthics eat big prey like snails, clams, and invertebrate nymphs and larvae, and feed by swimming slowly, sporadically stopping above rocks and plants on the lake floor to look for food. Sometimes, benthics have reduced armouring and may have only one or two of the dorsal spines.[25]

Stickleback, *Gasterosteus aculeatus* - Diana Rennison

Limnetic sticklebacks live in the water column, above the lake bottom. They are smaller and more slender, with light-coloured bellies and silver sides for camouflage.[25] When foraging for small invertebrates like water fleas, copepods and insect larvae, limnetic sticklebacks draw back, arching their bodies into an S-shape, before quickly striking forward and swallowing their small, fast-moving prey.[25]

Like Libby, Mackenzie studies **hybrids**. Sometimes, environmental pressures can cause closely related species (like benthic and limnetic sticklebacks) to hybridize so extensively that they collapse into a single species.[26] Such extensive hybridization can introduce variation into populations - variation which is essential for adaptation to the environment. Mackenzie studies whether hybridization between benthic and limnetic threespine sticklebacks produces fish that are better able to adapt to changing environments. More specifically, she is looking to see if interbreeding between benthics and limnetics produces hybrid offspring with the genetic variation needed to adapt to rapidly changing conditions.[26] For her research, Mackenzie collects fish from the wild, breeds hybrids, and places benthic, limnetic and hybrid individuals in normal and novel experimental environments to see if hybrids have any advantages in new, different circumstances.



Malaria infected cells

Coevolution of Parasites and Hosts

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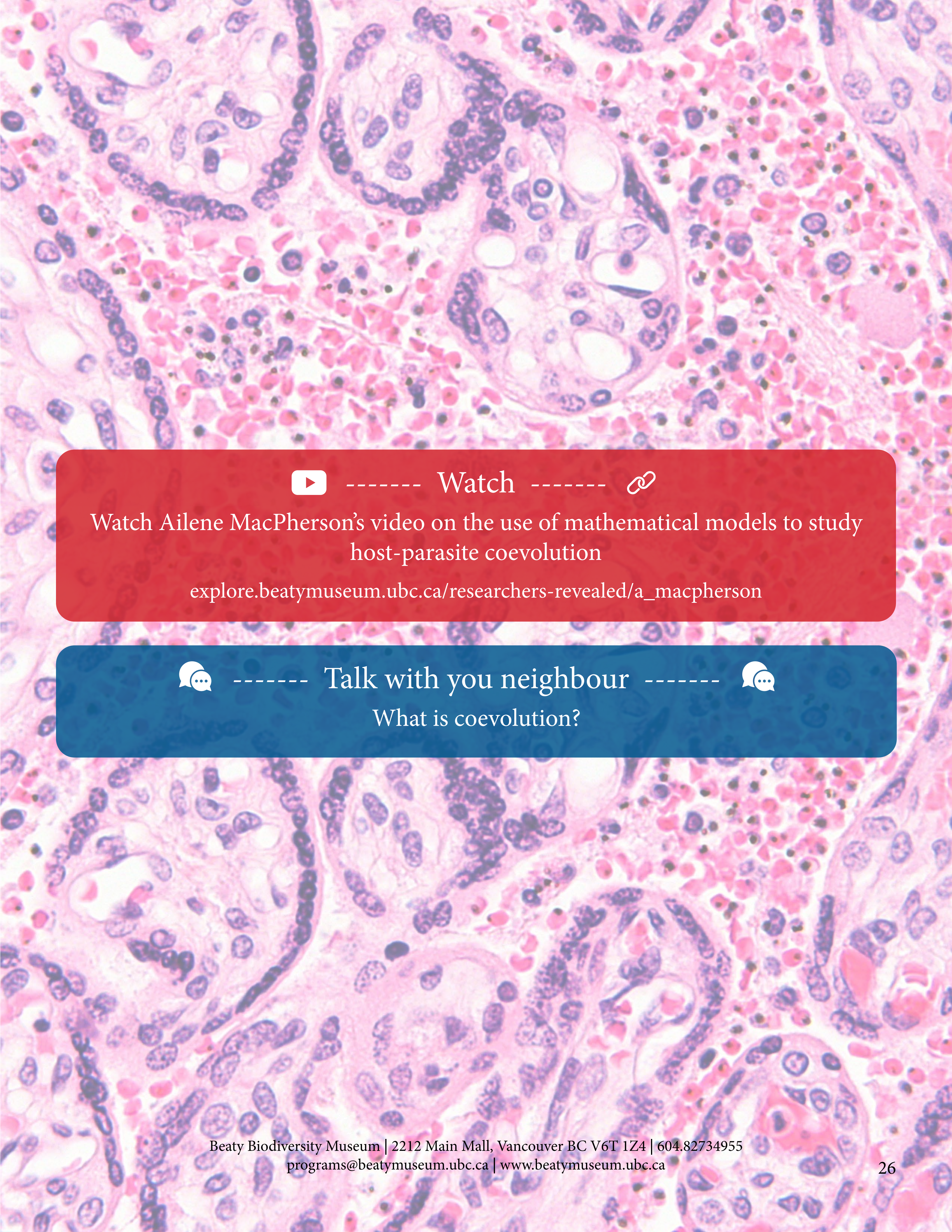

Watch

Watch Ailene MacPherson's video on the use of mathematical models to study host-parasite coevolution

explore.beatymuseum.ubc.ca/researchers-revealed/a_macpherson

Talk with you neighbour

What is coevolution?

Coevolution

Aileen studies a specific type of evolution called **coevolution**. Coevolution is reciprocal (back-and-forth) evolutionary change in interacting species.[27] In other words, it is the process by which two or more species evolve together by imposing selection pressures on each other.[28]

Predators and prey, herbivores and plants, parasites and hosts, flowers and pollinators, competing species - organisms in all types of inter-species relationships coevolve.

Garter snakes and rough-skinned newts are a well-known example of predator-prey coevolution. Rough-skinned newts are highly toxic: they contain a substance called tetrodotoxin, a poison that prevents messages from being passed from the nervous system to the muscles.[29] Eating a rough-skinned newt can lead to paralysis and suffocation as the consumer's muscles stop contracting.[29] Some newts harbour so much poison in their bodies that a single animal could kill 10 to 20 people.[29]

Rough-skinned Newt, *Taricha granulosa*

Why would such a small newt evolve to be so toxic? The answer lies in the coevolutionary back-and-forth between newts and their predators, garter snakes. Garter snakes have evolved resistance to the tetrodotoxin in rough-skinned newts and are one of the only animals (besides other rough-skinned newts) known to prey on them.[29,30] In response to the snakes' adaptation to the toxin, newts have become increasingly poisonous over time. This kind of coevolution is sometimes called an **evolutionary arms race**. Predators adapt to and put selection pressures on their prey, and their prey develop counter-adaptations in response. Each side - predators and prey - build up their defenses in response to the other.

Garter Snake, Thamnophis sirtalis

An example of coevolution between plants and pollinators is the star orchid and the hawk moth. Star orchids have very long tubular structures called nectar spurs that hold the sweet nectar hawk moths like to drink.[31] When hawk moths visit star orchids to drink their nectar, they stick their faces into the orchid's pollen to reach the food all the way at the end of the tube.[31] The moths pollinate the orchids by visiting different flowers, sticking their faces in the pollen as they feed, and passing it to other flowers.[31]

Because the nectar is hard to reach in the nectar spurs, hawk moths have evolved longer and longer tongues over time. But as their tongues got longer, they were able to reach the nectar without getting pollen on their faces. Eventually, only those orchids with the longest nectar spurs were pollinated by the moths - long-spurred plants were the most fit. So nectar spurs got longer as a result, then moth tongues got longer, and so on... In a continual elongation of pollinator tongues and flower spurs.

Convolvulus hawk-moth, *Agrius convolvul* Charles James Sharp - CC BY-SA 4.0

Aileen uses mathematical models to illustrate how parasites and their hosts coevolve. She collects big datasets of parasite and target host **genotypes**, and looks for statistical associations between them.

What does coevolution between hosts and parasites look like? To start off, parasites that are well-adapted to the most common host genotypes in a population have the highest fitness.[22] As these well-adapted parasites proliferate, the fitness of common hosts decreases - they become more likely to be infected, and less likely to survive and produce successful offspring.[22] Rare host genotypes then become less likely to be infected and therefore have higher fitness.[22] Over time, the rare host genotypes become more prevalent in the population. Those parasites that are well-adapted to common hosts are now selected against and parasites adapted to rarer hosts have a fitness advantage, since the rare host genotype is now more prevalent.[22] And parasites and hosts continue to evolve in response to each other in this way… Each "struggling for existence" as the other tries to adapt and exclude it.

Glossary

Adaptation: a heritable trait evolved via natural selection that allows individuals in a population to do better in their environment than those that lack that trait

Allele: one of the different forms of a gene

Arms race: a pattern in which species develop adaptations and counter-adaptations in a continual "one-upping" of defenses and counter-defenses

Biological species concept: the definition of a species as a group of organisms that breed or could breed with one another, and that have been isolated from other groups by reproductive barriers

Chromosome: a single DNA molecule and its associated proteins

Clade: a taxonomic group of organisms which includes an ancestor and all of its descendants

Coevolution: the process by which two or more species evolve together by imposing selection pressures on each other

Common ancestor: a population of individuals from which other populations, species or taxonomic groups have descended with modification

Evolution: descent with modification

Evolution by natural selection: theory proposed by Darwin and Wallace which states that species evolve from other species via the process of natural selection

Evolutionary radiation: a rapid increase in the diversity of a group of organisms, brought on by high rates of speciation

Fitness: a measure of an organism's ability to survive and produce offspring that also survive and reproduce (viable offspring)

Gene: a unit if inheritance; the sequence of DNA nucleotides that does something specific in a cell (like make a protein or an RNA molecule) and that is found at a specific location on a chromosome

Gene flow: movement if individuals, spores, seeds, gametes or other propagules between populations

Genetic drift: the process by which alleles become more or less frequent in a population by chance

Genotype: the combination of an organism's alleles, which together make up its genetic composition

Homologous character: a trait that is shared by a group of species because it has been inherited from a common ancestor, so shares the same evolutionary origin - but does not necessarily share the same function

Hybrid: an individual born of parents of two different species

Hybrid zone: area where species' ranges overlap and where those species interbreed to produce hybrid offspring

Locus: site on a chromosome

Macroevolution: major evolutionary changes over long periods of time

Microevolution: change in a population over time, or change in the frequency of an allele from one generation to the next

Mutation: a random change in a cell's DNA which may be beneficial, harmful or neutral; when mutations occur in sex cells like sperm and eggs, they can can be passed on to offspring and introduce new variation into a population

Natural selection: the process by which organisms with traits that are better suited to their environment go on to survive and reproduce, passing on these traits to the next generation, and those with with traits worse suited to their environment do not

Non-random mating: a higher-than-expected probability that individuals with certain traits will mate

Population: a group of individuals of the same species that occupy a boundaried area

Post-mating barrier: a type of reproductive barrier that acts on the offspring of individuals of different populations or species, and which affect the offspring's fitness

Pre-mating barrier: a type of reproductive barrier that prevents individuals from different populations or species from finding or recognizing each other, so mating does not occur

Reproductive barrier: a characteristic of an organism, which reduces the likelihood that organism will mate with a member of a different population or species - either by preventing mating from happening at all (pre-mating barriers) or by producing disadvantaged offspring (post-mating barriers)

Secondarily lost: a trait that evolved in a lineage but was subsequently lost in certain species or groups

Selection: the process by which forces acting on a population result in differences in mortality across population members and favour the transmission of specific traits to the next generation(s)

Speciation: the process by which one species divides into multiple descendant species

Theory: in science, an explanation about how some part of the natural world works that is backed up by evidence and that can be tested

Additional Activites and Resources

Correcting some common misrepresentations of evolution in textbooks and the media

evolution-outreach.biomedcentral.com/articles/10.1186/1936-6434-6-11

A great resource for teachers on common misunderstandings and misrepresentations of evolution in teaching materials.

Beaty Exploring Evolution Package

beatymuseum.ubc.ca/learn/educator-resources/pre-and-post-visit-activities/explore-evolution-resource-package/

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