Exploring Evolution Package

Inside you'll find lesson plans and worksheets to explore evolution in the classroom. The lessons can be introduced in any order depending on your needs and unit plan.

The "Speciation Sleuthing" Project, found on the Beaty Biodiversity Museum website can be a summative assessment of all lessons in this package.

Included Lesson Plans

Supporting Materials

Audio Tour of Beaty Biodiversity Museum:
    http://bit.ly/1FVtKj1
Speciation Sleuthing Summative Project:
    http://www.beatymuseum.ubc.ca/sites/default/files/BBMSpeciationSleuthingProject.pdf

Targeted PLOs

From BC Biology 11/12 Integrated Resource Package, 2006

Grade 11 Biology:

- Taxonomy Lesson
  - B1: Apply the Kingdom system of classification to study the diversity of organisms
    - Explain how the following principles are used in taxonomy to classify organisms:
      - Evolutionary relationships
    - Classify selected organisms using the following taxons:
      - Kingdom, phylum (and sub-phylum), class, order, family, genus, species
    - Apply binomial nomenclature to name selected organisms
- Evolution and Sexual Selection Lessons
  - C1: Describe the process of evolution
    - Describe the five agents of evolutionary change:
      - Mutation, genetic drift, gene flow, non-random mating, and natural selection
- Speciation Lesson
  - C1: Describe the process of evolution
    - Describe the five agents of evolutionary change:
      - Mutation, genetic drift, gene flow, non-random mating, and natural selection
    - Differentiate among and give examples of convergent evolution, divergent evolution, and speciation

Taxonomy: Lesson Plan

Grade Level: Biology 11
Textbook: *Biology* by Miller & Levine 2002. 18.1
Finding Order in Diversity Pages 447 - 450
Time Needed: 30 minutes

Background Knowledge

Students should have some familiarity with the different types of organisms and biodiversity on plant Earth. They may have already started to look at the five (or six) kingdoms of life and what characteristics unite them.

Rationale

Before students can begin to learn how species and populations evolve, they must become comfortable with how organisms are classified.

Assessment

- Students can work on acronyms of KPCOFGS (Kingdom, Phylum, Class, Order, Family, Genus, Species).
- Students can classify common or exotic flora and fauna according to the KPCOFGS system.

Extensions

- Show multiple pictures of different species of sunflower
    - Ask students what they would call this
    - Get at: problem with common names – refer to more than one species

- Acronym for taxonomic hierarchy
    - Kingdom, Phylum, Class, Order, Family, Genus, Species
    - Possible ideas located at - http://www.acronymfinder.com/KPCOFGS.html

- Break down the taxonomic classification for common plants and animals in BC
    - If you have many international students, do this for flora and fauna from their home countries

Additional Resources:

- Shape of Life – Taxonomy Video
  http://shapeoflife.org/video/taxonomy
- Shape of Life – 'Class'ification Lesson Plan
  http://shapeoflife.org/lesson-plan/community/classification
- eScience Labs – classification
  http://www.esciencelabs.com/files/product_pdfs/Life%20Science%20Lab%207%20Classification.pdf
- Marietta College – Biology 106: Animal Diversity Lab
  http://www.marietta.edu/~biol/introlab/animaldiv1.pdf

Taxonomy: Lesson

Taxonomy

- In order to classify and understand the amazing diversity of life, scientists have developed a system to name organisms.
- **Taxonomy** – the science of classifying and naming organisms
- Common names, the names that the public refer to animals, can get very confusing. Even if a group speaks the same language, multiple names may apply to the same animal.
    - Example: the large cat *Felis concolor* is known by the common names puma, cougar, panther, and mountain lion.

Linnaeus' System of Classification

- Who is Linnaeus?
    - Carl Linnaeus was an 18^{th} century Swedish biologist who created the classification system still in use today. He is often called the father of taxonomy.
    - Interesting fact! Carl Linnaeus' body is the type specimen for *Homo sapiens*.
- This classification system uses seven taxonomic ranks or categories which are used in a hierarchy
    - These are in order from largest category to smallest:
        - Kingdom
        - Phylum
        - Class
        - Order
        - Family
        - Genus
        - Species
- **Binomial nomenclature -** the current two-word naming process developed by Carl Linnaeus that is still in use today.
    - Each two part scientific name is made up of a genus and a specific epithet
    - Together the name is used to describe only one organism – a species
        - Example: domestic dog is *Canus domesticus*

Phylogenetic Trees

- A **phylogenetic tree** is a visual representation of the evolutionary history and relationships between different genera (plural of genus) and species of organisms. It is constructed based on shared physical and genetic characteristics that come from sharing a common ancestor.
- A large phylogenetic tree, which encompasses all flora and fauna, is called the tree of life.

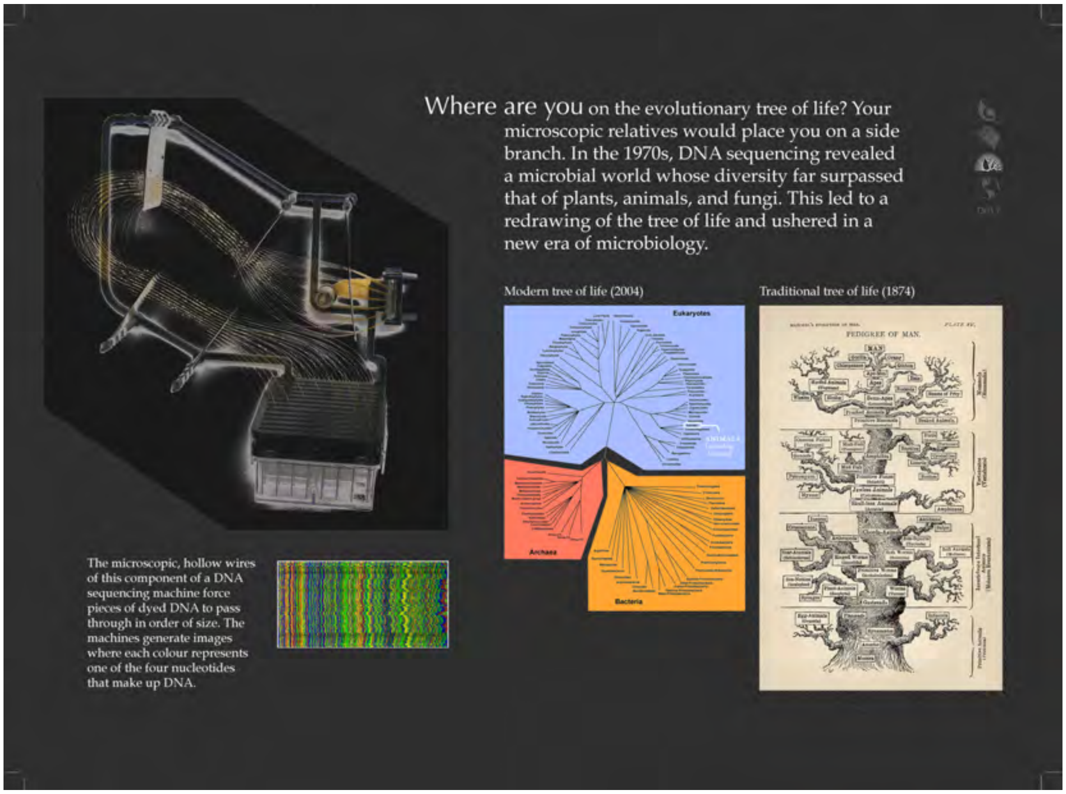


Image 1: Drawer display from "Discovering Biodiversity" display in the Beaty Biodiversity Museum's Tetrapod Collection. Look in the third drawer under the display with the microscope.

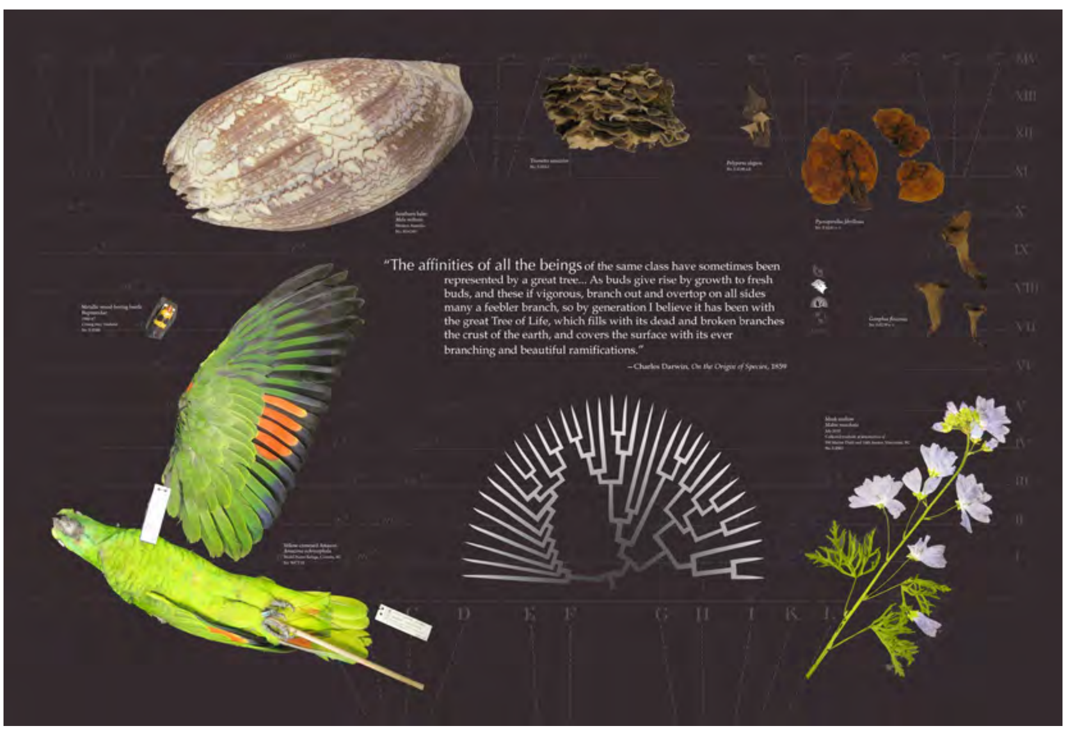


Image 2: Drawer display from "Exploring Evolution" display in the Herbarium at the Beaty Biodiversity Museum.

Evolution: Lesson Plan

Grade Level: Biology 11
Textbook: *Biology* by Miller & Levine 2002.
15.1 The Puzzle of Life's Diversity Pages 369 - 372
15.3 Darwin Presents His Case Pages 378 - 386
16.1 Genes and Variation Pages 393 - 396
Time Needed: 60 minutes

Background Knowledge

In order to discuss how mutations can result in new phenotypes it would be helpful for students to be familiar with the basic structure of DNA and its role in evolution.

Rationale

This overview of evolution covers the history of Darwin and his voyage to the Galapagos on the H.M.S. Beagle. It also discusses the evidence of evolution and what conditions (the 5 agents of evolutionary change) can lead to evolution.

Assessment

- Worksheet based on the HHMI Biointeractive Video
- Online laboratory activities illustrate how phylogenetic trees are formed from NOVA Labs

Extensions

- Discussion – what is a "fact", "truth", "theory" and a "scientific law." This discussion may be beneficial as evolution can be a sensitive subject with some students and their families.
- Expand on the "Evidence of Evolution" section of the lesson.
    - Homologous body structures can be a lesson in itself. Compare the forelimb adaptations in mammals (bats, whales, humans, etc.)

Additional Resources:

- University of California Berkley – Understanding Evolution
  http://evolution.berkeley.edu/evolibrary/home.php
- Howard Hughes Medical Institution Biointeractive Video: Origin of Species: The Making of a Theory
  https://www.hhmi.org/biointeractive/origin-species-making-theory
- NOVA Labs – Evolution Lab
  http://www.pbs.org/wgbh/nova/labs/lab/evolution/
- Biology in Motion – Evolution Lab
  http://biologyinmotion.com/evol/

Evolution: Lesson

Definitions of Evolution

- Biology Textbook: change in a kind of organism over time
- Biology Textbook: process by which modern organisms have descended from ancient organisms
- Understanding Evolution by Berkley: decent with modification
- Collaborative definition – change in the variation of genotypes in a population over time

In general, all definitions involve a group of organisms, a passage of time and a change in the group of organisms. Ask students to write their own definitions.

The History of the Theory of Evolution

- Charles Darwin and his voyages on the Beagle
  - In 1831, at 22 years old, British scientist Charles Darwin joined an exhibition on a military vessel, the H.M.S. Beagle. The Beagle set sail from England and traversed the globe over five years. On this voyage Darwin made many observations about life's biodiversity that would lead to his theory of evolution.
- Darwin's Observations
  - Patterns of Diversity
    - Plants and animals around the globe seemed very well suited to their environments
    - Types of plants and animals lived only in certain areas
      - Example: Darwin did not find familiar European animals in Argentina.
  - Living Organisms and Fossils
    - Darwin found fossils of organisms that resembled animals that were currently alive. He wondered if there was a relationship between these organisms.
  - The Galapagos Islands
    - This small group of islands 1000 km west of South America fascinated Darwin. Though the islands were close together they possessed unique climates and biodiversity.
    - It was here he encountered a small group of brown birds called finches. These finches would become a famous example of his theory of evolution.
      - **Activity – HHMI Biointeractive: Origin of Species: Beak of the Finch
- Darwin's Theory
  - Darwin came to believe that species were not a divine creation that corresponded to each island/climate but that species descended from other species in the same way families were related. In short he came to believe in descent with modification.
  - During his correspondence with Alfred Russell Wallace he came up with his theory of evolution and natural selection. Scientists are still studying evolution, including the Biodiversity Research Centre at UBC.

Natural Selection

- In nature, high birth rates and shortage of basic needs will eventually force organisms into competition for resources. Within a group of organisms, even of the same species, there is variation in traits.
- This variation, if they are in traits related to gathering or competing for resources, could lead to a difference in survival, what Darwin called survival of the fittest. It was an organism that displayed the traits most adapted for life in a specific environment that would pass on the most amount of genetic material to the next generation, and the fit adaptations (if they are heritable) to the next generation. Over time, the entire population or species would evolve to become more fit in its environment.
- **Fitness –** a measure of an organism's ability to produce viable offspring
    - By measuring an organism's ability to reproduce you are also measuring its ability to survive
    - **Viable –** able to survive and reproduce
- For natural selection to occur there needs to be:
    - Variation in traits
    - Differential reproduction (can come from differential survival)
    - Heredity of traits

Image 3: Variation within a species, found in drawer exhibit "Exploring Evolution." Photo by Caelin Rose McCarron.

Image 4: Variability within a species, found in "Exploring Evolution" in first drawer under Image 3.

Evidence of Evolution

- Geographic Distribution of Living Species
- Similarities in Early Development
- The Fossil Record

Image 5: Exhibit on fossils from the Beaty Biodiversity Museum, located in "Exploring Evolution."

Homologous vs. Analogous Body Structures

- A **homologous** body structure is one that has the same position but not necessarily the same function across different organisms. They are similar because the common ancestor of the two organisms had this structure. **Divergent** evolution is when two organisms are related, but the body structure differs in function and/or form due to different selection pressures, this usually results in speciation from a common ancestor.
- Homologous structures often looks similar to each other due to their shared evolution. This is contrasted with convergent evolution.
- **Convergent** evolution is when two organisms have a body structure that is similar in form and/or function to each other. This is due to living in a similar environment (niche) and not due to a common ancestor presenting this structure. These similar structures are called **analogous** structures.

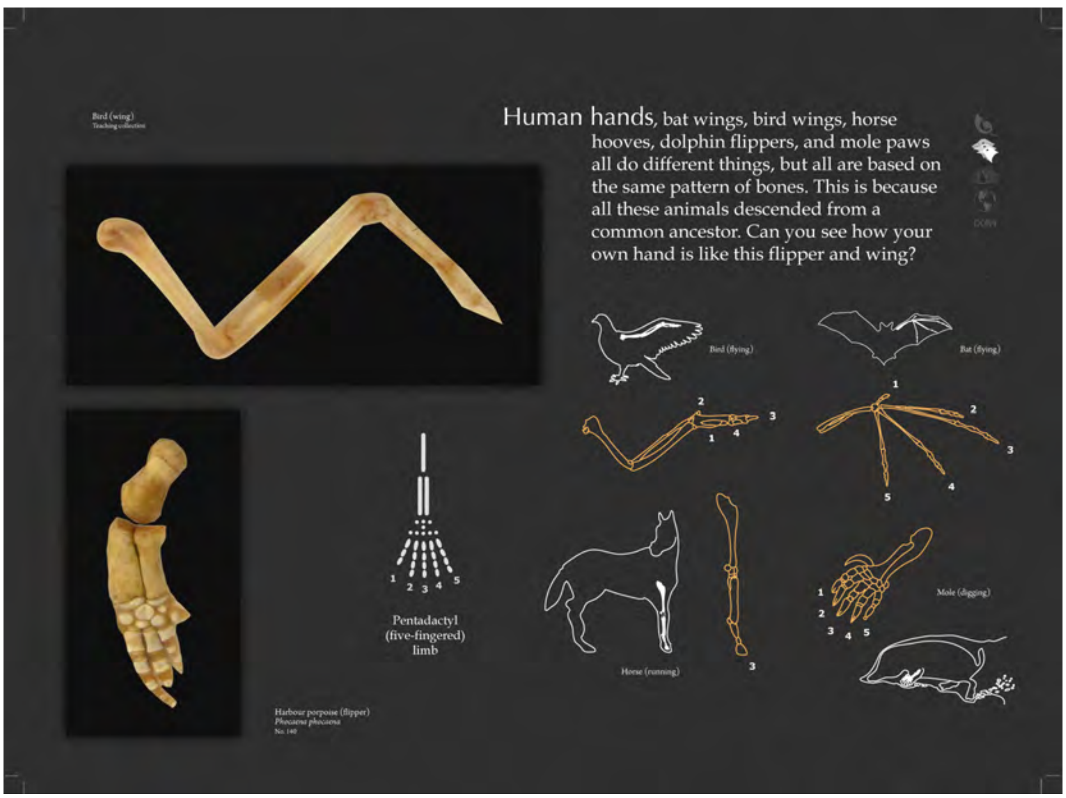


Image 6: Homologous mammal limbs from a display drawer at the Beaty Biodiversity museum, located in "Exploring Evolution," drawer three under Image 2.

BEATY BIODIVERSITY MUSEUM

Image 7: Convergent evolution exhibit, located in drawer 1 under Image 2 in the "Exploring Evolution" display at the Beaty Biodiversity museum.

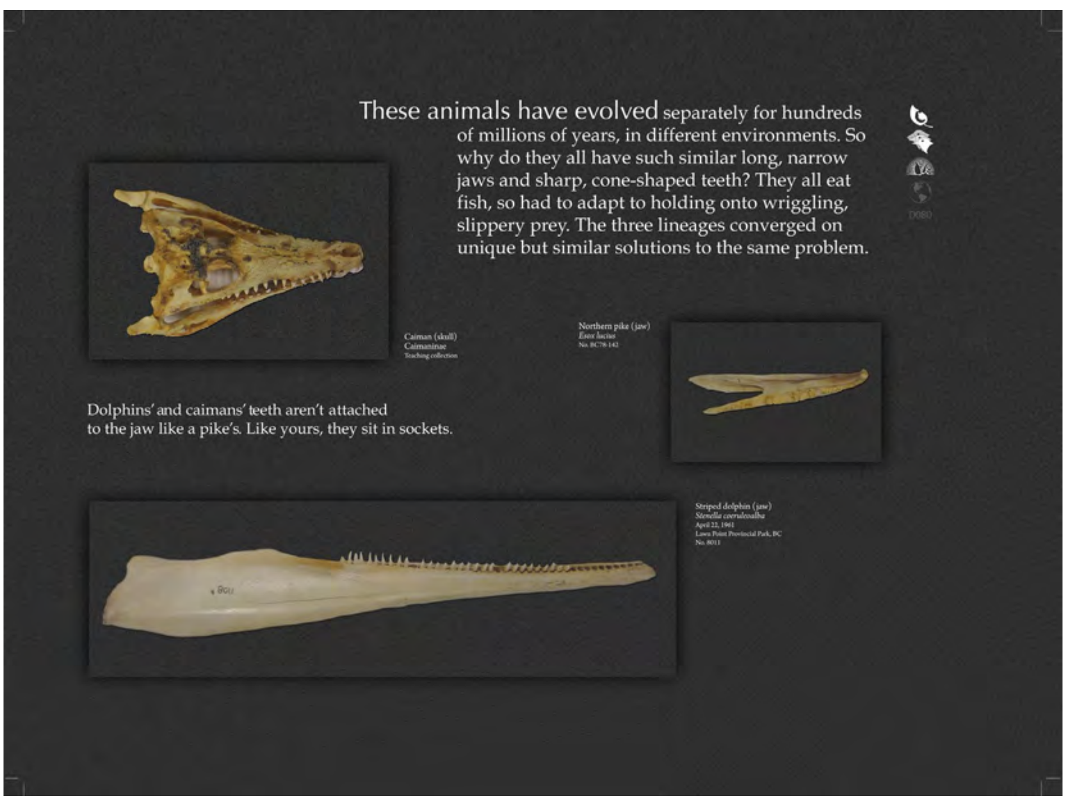


Image 8: Analogous traits exhibition found in "Exploring Evolution," second drawer under Image 2.

What Conditions Can Lead to Evolution?

- Any condition that involves a change in genetic equilibrium (a condition where the ratio of allele frequencies remain constant) can lead to evolution. What can cause this?
    - Mutations
        - New alleles are added to the population by mutation.
    - Immigration and/or Emigration
        - Alleles may change in frequency, be added or removed from a population when organisms enter or leave the population.
    - Genetic Drift
        - Allele frequency can randomly change over time.
        - A large population can minimize this effect.
    - Natural Selection
        - When a there is variation in a trait, which is heritable, and the environment can act on it, differential fitness may occur.
    - Non-random Mating
        - If not all members of a population have an equal opportunity the allele ratios will be skewed towards the allele of the organisms that get to mate.
        - Intersexual selection – female choice
        - Intrasexual selection – male-male competition

Sexual Selection: Lesson Plan

Grade Level: Biology 11
Resource: *http://evolution.berkeley.edu/evolibrary/article/evo_28*
Time Needed: 75 minutes

Background Knowledge

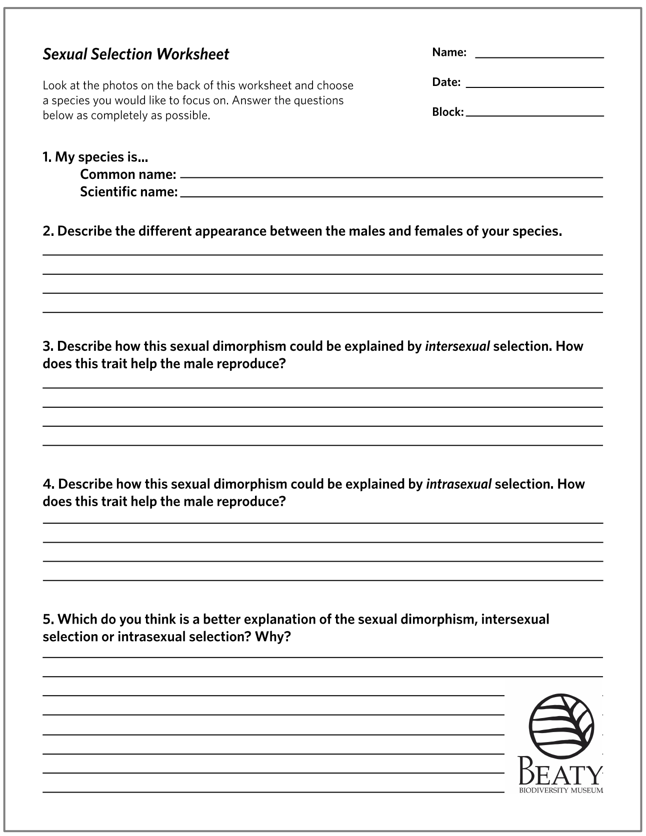
Students should have talked about evolution and the five agents of evolutionary change, which includes non-random mating.

Rationale

This lesson is an in-depth extension of what non-random mating can entail. It explains how sexual dimorphism can develop in animals due to intersexual or intrasexual selection.

Assessment

- There is an accompanying worksheet to this lesson at the end of this package. Representatives of all species on the worksheet can be found at the Beaty Biodiversity Museum.



Sexual Selection Worksheet

Name: ______________
Date: ______________
Block: ______________

Look at the photos on the back of this worksheet and choose a species you would like to focus on. Answer the questions below as completely as possible.

1. My species is...
Common name: ______________
Scientific name: ______________

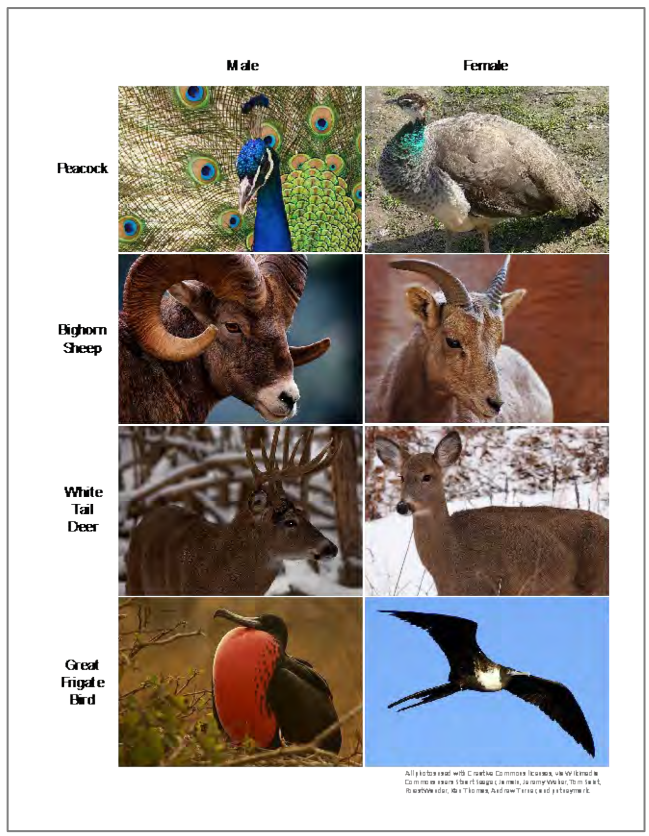
2. Describe the different appearance between the males and females of your species.

3. Describe how this sexual dimorphism could be explained by *intersexual* selection. How does this trait help the male reproduce?

4. Describe how this sexual dimorphism could be explained by *intrasexual* selection. How does this trait help the male reproduce?

5. Which do you think is a better explanation of the sexual dimorphism, intersexual selection or intrasexual selection? Why?

BEATY
BIODIVERSITY MUSEUM



Extensions

- The following videos are good explanations of why sex is important and its benefits and drawbacks compared to asexual selection.
  - Sci Show – Why Sex? (4:52 minutes) https://www.youtube.com/watch?v=gRpEt61XM4M
  - PBS Documentary – Evolution: Why Sex? (56:39 minutes) https://www.youtube.com/watch?v=Wns5OQR74OQ
- Great video examples of intersexual and intrasexual selection. Many of these videos are also used in the Self-Led Evolution and Speciation Tour (marked with a *).
  - Intersexual Examples:
    - *Frigatebird: https://www.youtube.com/watch?v=rHJcX0Z_Wro&index=1&list=PL0ks6yib6Jf5nIMJtakiQs_SI-B5uKlIA
    - Birds of Paradise: https://www.youtube.com/watch?v=W7QZnwKqopo&index=4&list=PL0ks6yib6Jf5nIMJtakiQs_SI-B5uKlIA
    - National Geographic – Birds of Paradise Exhibit: https://www.youtube.com/watch?v=4Ezc3aO4RSk&index=5&list=PL0ks6yib6Jf5nIMJtakiQs_SI-B5uKlIA
  - Intrasexual Examples:
    - *Giraffe: https://www.youtube.com/watch?v=VDhNutbXpFE&index=2&list=PL0ks6yib6Jf5nIMJtakiQs_SI-B5uKlIA
    - *Elephant Seal: https://www.youtube.com/watch?v=RVJduMnXAns&index=3&list=PL0ks6yib6Jf5nIMJtakiQs_SI-B5uKlIA
  - *Bighorn Sheep: https://www.youtube.com/watch?v=Ez7RUSCUhzk&index=6&list=PL0ks6yib6Jf5nIMJtakiQs_SI-B5uKlIA

Additional Resources:

- The American Biology Teacher Article – The Mating Game: A Classroom Activity for Undergraduates That Explores the Evolutionary Basis of Sex Roles http://www.jstor.org/stable/10.1525/abt.2012.74.9.9
- National Geographic Lesson: Sexual Selection http://education.nationalgeographic.com/education/media/sexual-selection/?ar_a=1
- The Cornell Lab – Natural and Sexual Selection: All Illustrated Introduction http://biology.allaboutbirds.org/natural-selection-sexual-selection-an-illustrated-introduction/

Why does sex exist?

- 99% of plants, animals, fungi and protists have sexual reproduction at some point in their life cycle.
- Some species can reproduce both asexually and sexually, for example, sea stars.
- **Asexual reproduction** – type of reproduction where offspring come from one parent and are genetically identical (clones)
  - Types of asexual reproduction: budding, vegetative, binary fission, parthenogenesis, and fragmentation
- **Sexual reproduction** – type of reproduction where two organisms (typically male and female) combine their DNA to create a genetically unique individual
  - Cons of sexual reproduction:
    - Have to find a mate
    - Only half of the population can give birth
    - Takes a longer time than asexual reproduction
  - Pros of sexual reproduction:
    - Genetic variation of offspring. Genetic variation helps species survive in new conditions, for example: in new habitats, predators, disease, etc.
    - Unfit "bad" traits do not have a chance to "pile up" and wipe out a population

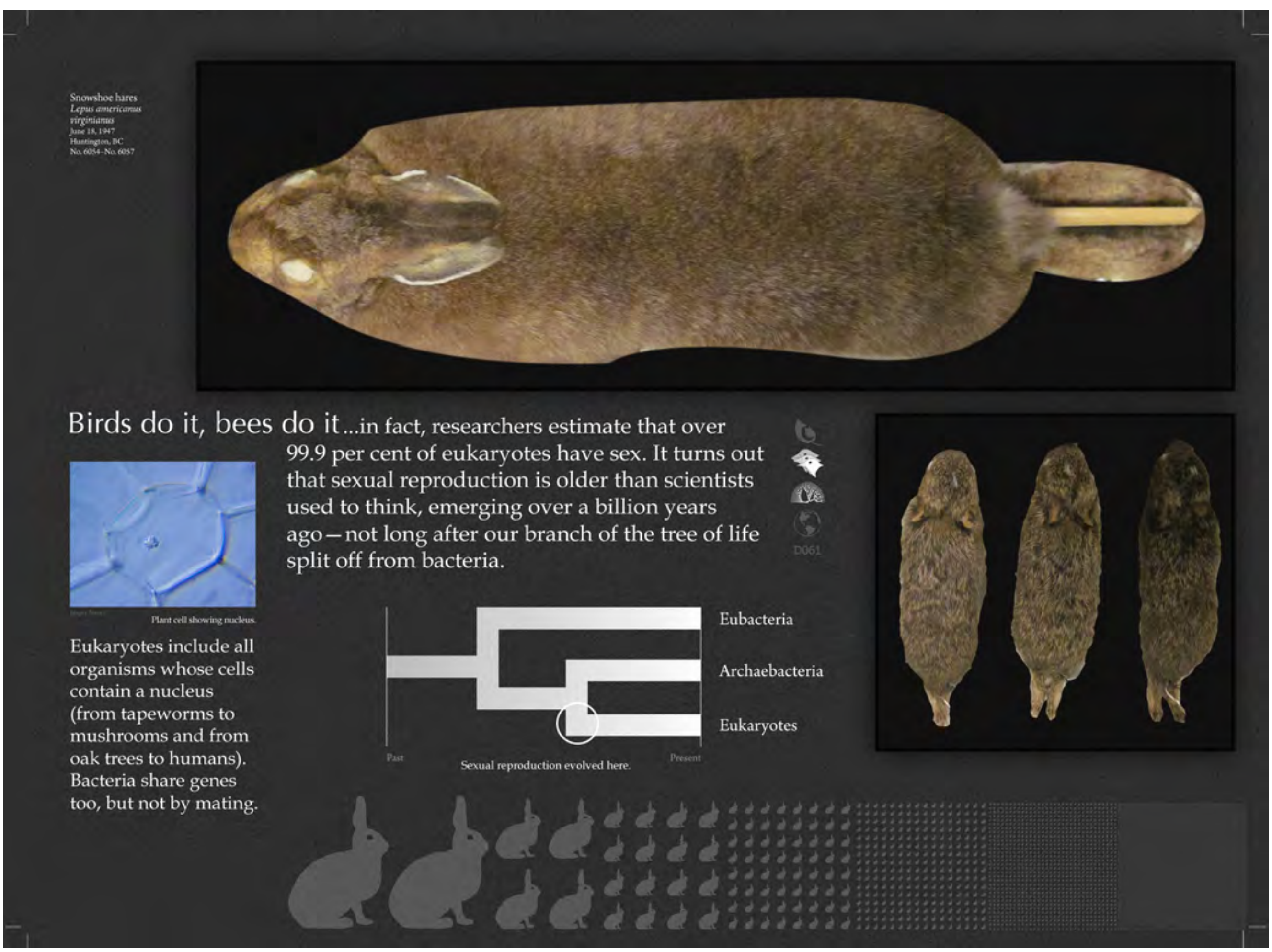


Image 9: Sexual reproduction explained in a Beaty Museum exhibit, located in "Exploring Evolution" in drawer 1 under Image 5.

Image 10: Asexual reproductive example at the Beaty Museum. Shadowbox located in the herbarium on cabinet 22.10.

Sexual Selection

- **Sexual selection** – an extension of natural selection where certain traits help individuals obtain a mate
  - Example: colouring, size, dance, behaviour, ability to provide shelter, etc.
- There are two types of sexual selection
  - **Intersexual Selection** or Female Choice
    - Females choose which male they want to mate with based on signals
      - Signals can be colouring, size, song, etc.
    - By choosing females gain direct benefits which help themselves or their offspring
      - Benefit for themselves – nuptial gift, food, disease-free mating
      - Benefit for their offspring – better genes resulting in strength, disease-resistance, better at getting food.
    - Male signals can be real indications of a male's vitality or a biased signal
      - Biased signal has nothing to do with a male's vitality but just happens to get attention from the female
        - Example: a male may have a complex song but be weak and inferior to other males
      - Examples at the Beaty Biodiversity Museum:
        - Peacock, Magnificent Frigate Bird, Eastern Flycatcher, California Quail, and others

- **Intrasexual Selection** or Male-Male Competition
  - Males fight with each other for the chance to mate or for territory
  - Males in species that exhibit intrasexual selection often have adapted weapons
    - Example: horns, antlers, tusks, etc.
    - Examples from Beaty Biodiversity Museum:
      - Cowan Tetrapod Collection holds deer, bighorn sheep, giraffes, etc.

Extreme Sexual Dimorphism

- Selection can take traits to the extreme
  - Example: widowbird and its large tail, feathers and courting dances of birds of paradise
- **Sexual dimorphism** – clear differences in the appearance between the different sexes of animals
  - Example: peacocks, deer

Revisit the case of the Birds of Paradise: How did this happen?

- **Runaway selection** – hypothesis of how extreme sexual dimorphism develops
  - How does female choice evolve?
    - A female is born with a preference for a particular trait in her mates
    - She chooses males who exhibit this trait, then they mate
    - Her male offspring exhibit the preferred trait
    - Her female offspring are born with the same preference that their mother had
    - Over many generations more males are born with the preferred trait and more females choose this trait
  - How does male-male competition evolve?
    - Males fight with each other over access to mates
    - Males with a particular traits (large size, bigger antlers, etc.) win more fights
    - The winner mates more often and therefore, passes on more genetic information to the next generation
    - Over many generations, traits which help males win battles get bigger and more exaggerated

Image 11: Animals on display in the Cowan Tetrapod Collection at the Beaty Biodiversity Museum.

Speciation: Lesson Plan

Grade Level: Biology 11
Textbook: *Biology* by Miller & Levine 2002
16.3 The Processes of Speciation Pages 404 - 410
Time Needed: 75 minutes

Background Knowledge
Students should be familiar with the processes and agents of evolution. This will allow students to better understand how reproductive isolation can lead to evolution.

Rationale
This lesson will prepare students to work on the "Speciation Sleuthing" Project. It will also help students appreciate the biodiversity of life.

Assessment

- The "Speciation Sleuthing" Project, found on the Beaty Biodiversity Museum website can be a summative assessment of all lessons in this package.

Extensions

- "Speciation Sleuthing" project will show interesting biological cases of evolution and possible speciation. It gives a number of different options of flora and fauna for students to choose from. An example of an A-level high school project is also included on the Beaty Biodiversity Museum website. The project links current science and the importance of museum specimens with the BC Biology 11 curriculum.

Additional Resources:

- "Speciation Sleuthing" resources:
  - Project Description: http://www.beatymuseum.ubc.ca/sites/default/files/BBMSpeciationSleuthingProject.pdf
  - Student Example: http://www.beatymuseum.ubc.ca/sites/default/files/BBMSpeciationSleuthingProjectStudentExampleUrsus.pdf
  - Marking Criteria: http://www.beatymuseum.ubc.ca/sites/default/files/BBMSpeciationSleuthingProjectMarkingCriteria.pdf
- Howard Hughes Medical Institution Biointeractive Video: Origin of Species: Beak of the Finch https://www.hhmi.org/biointeractive/origin-species-beak-finch

  This HHMI video about finches worked very well in explaining how speciation occurs. It could be shown after the evolution lesson or at the beginning of the speciation lesson to link together the two subjects.

Species Concepts:

- There are many different definitions of species. These different definitions are based on an equal plethora of species concepts. Two of the most popular are highlighted below.
  - **Biological Species Concept –** defines species as members of populations that can interbreed in nature. It is based on reproductive isolation.
  - **Phylogenetic Species Concept –** a "tip" of a branch of a phylogeny which shows that a group of organisms has an independent evolutionary history and has accumulated enough genetic differences to differentiate the group.
- In this lesson we will focus on the Biological Species concept.

What is a Species?

- **Species –** a group of organisms that can interbreed to produce fertile vigorous (viable) offspring
- In order to be considered separate species two sets of animals cannot produce viable offspring.
- Separate species of organisms are **reproductively isolated.**

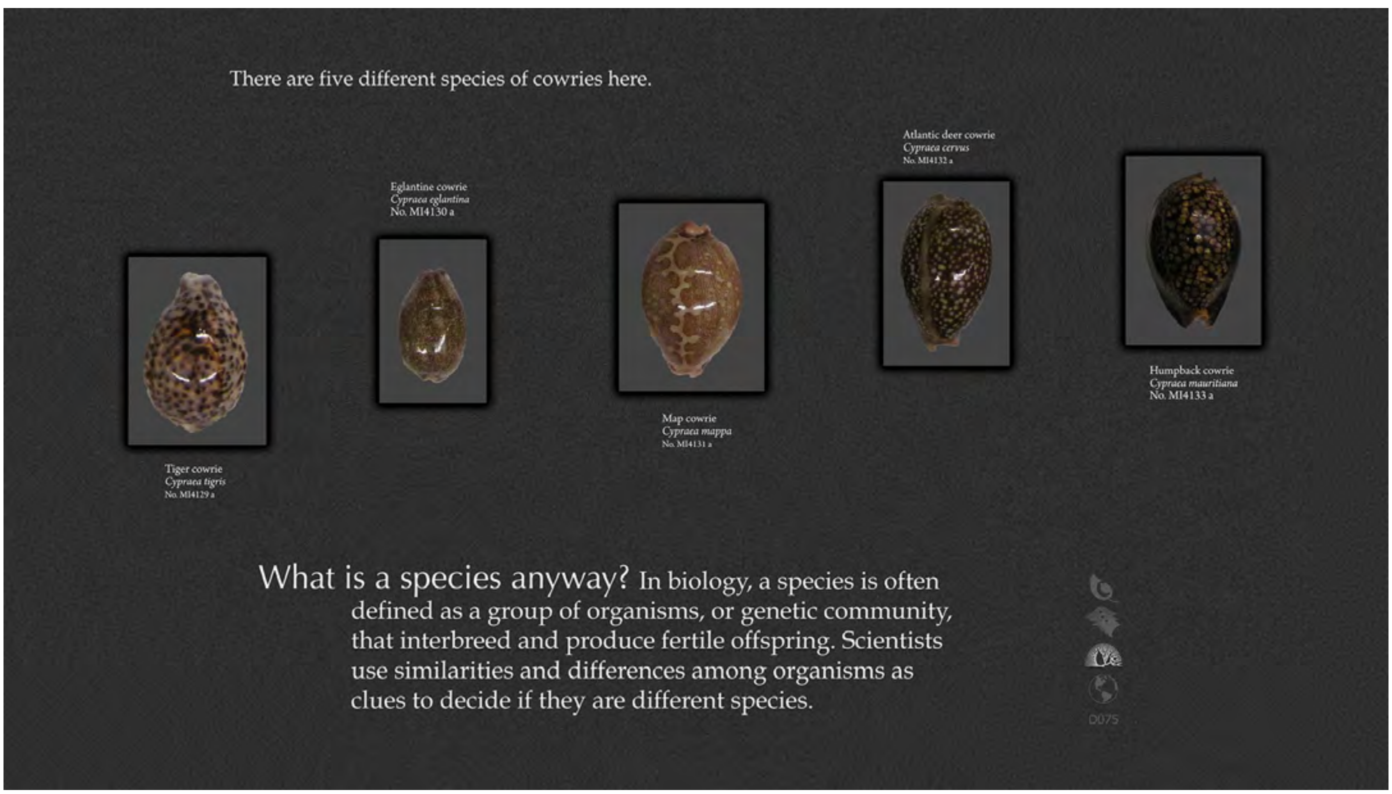


Image 12: Defining a species in a Beaty Biodiversity Museum exhibit, located in the first drawer under the cowrie shell display in "Exploring Evolution."

What is Reproductive Isolation?

- **Reproductive isolation –** the inability of two groups of animals to breed successfully to produce viable offspring. This can be due to geographic, behavioural, physiological or genetic differences
  - **Geographic isolation** – a naturally occurring geological formation that isolates two separate species of animals
    - Example: mountain, river
  - **Behavioural isolation** – different species have different mating behaviour, they are so unique to individual species that two different species will not mate
    - Example: song, mating dance, mating time
  - **Physiological isolation** – incompatibility of genitals, he size or shape do not match (like a lock and key)
  - **Genetic differences/isolation** – even if mating occurs, fertilization may not occur or if offspring are born they are not viable
    - Example: mule – the offspring of a horse and a donkey that is sterile
- These barriers can be classified into two groups:
  - **Pre-zygotic isolation –** type of reproductive isolation that occurs before fertilization would occur.
    - Geographic isolation, behaviour isolation, physiological isolation
  - **Post-zygotic isolation –** type of reproductive isolation that occurs after fertilization has occurred. They hybrid offspring that are produced are not viable.
    - Genetic differences/isolation

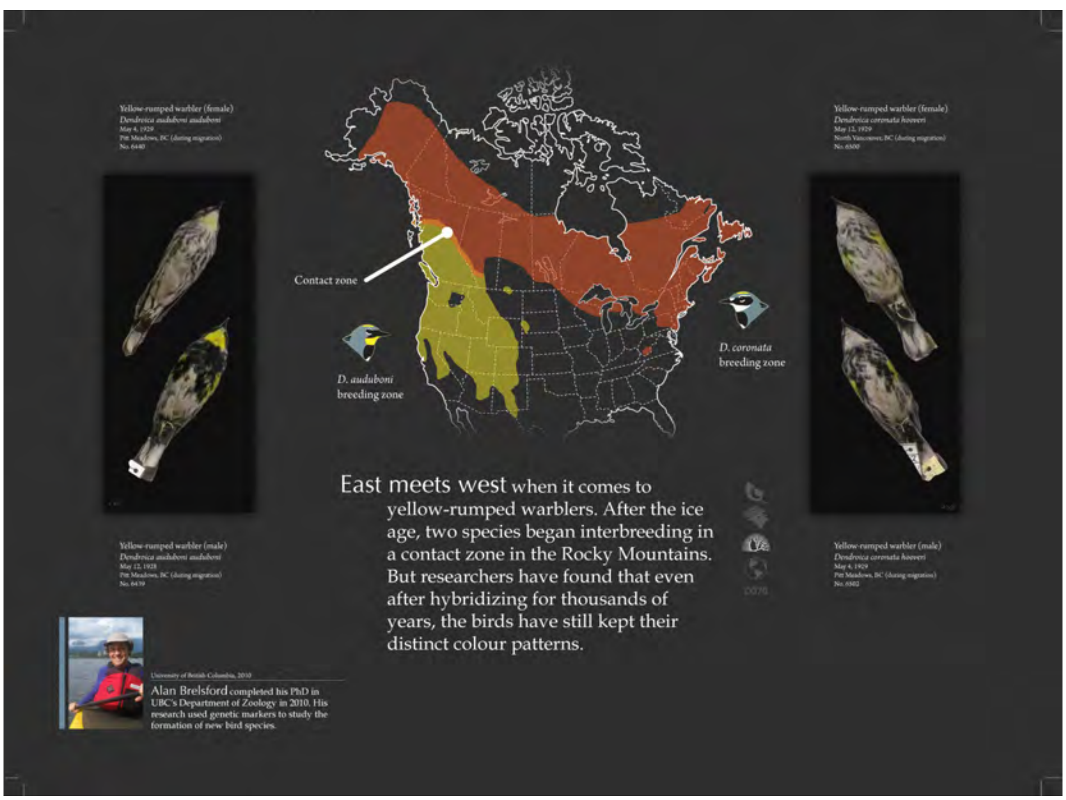


Image 13: Geographic isolation example from the last ice age, on display at the Beaty Museum in the second drawer under the cowrie display in "Exploring Evolution."

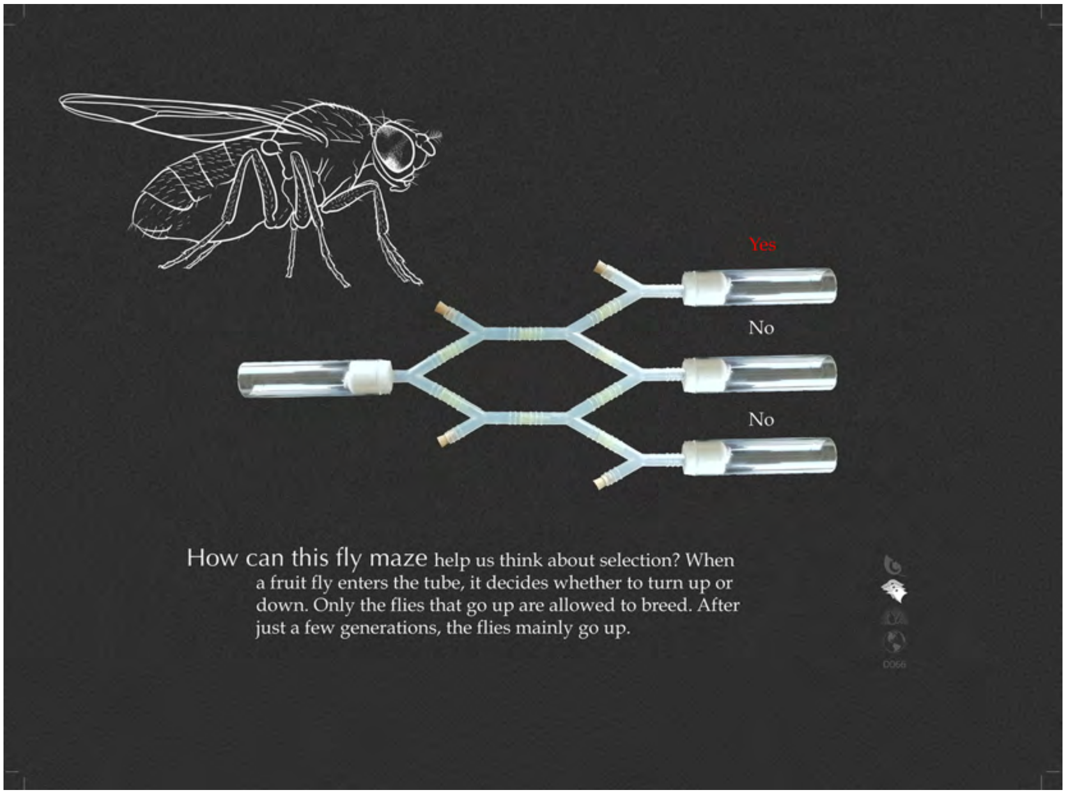


Image 14: Behavioural isolation example on display at the Beaty Museum, located in "Exploring Evolution" in the second drawer under the display on antibiotics.

Image 15: Behavioural isolation example on orca whales, on display at the Beaty Biodiversity Museum in "Discovering Biodiversity," third drawer under the microscope on display.

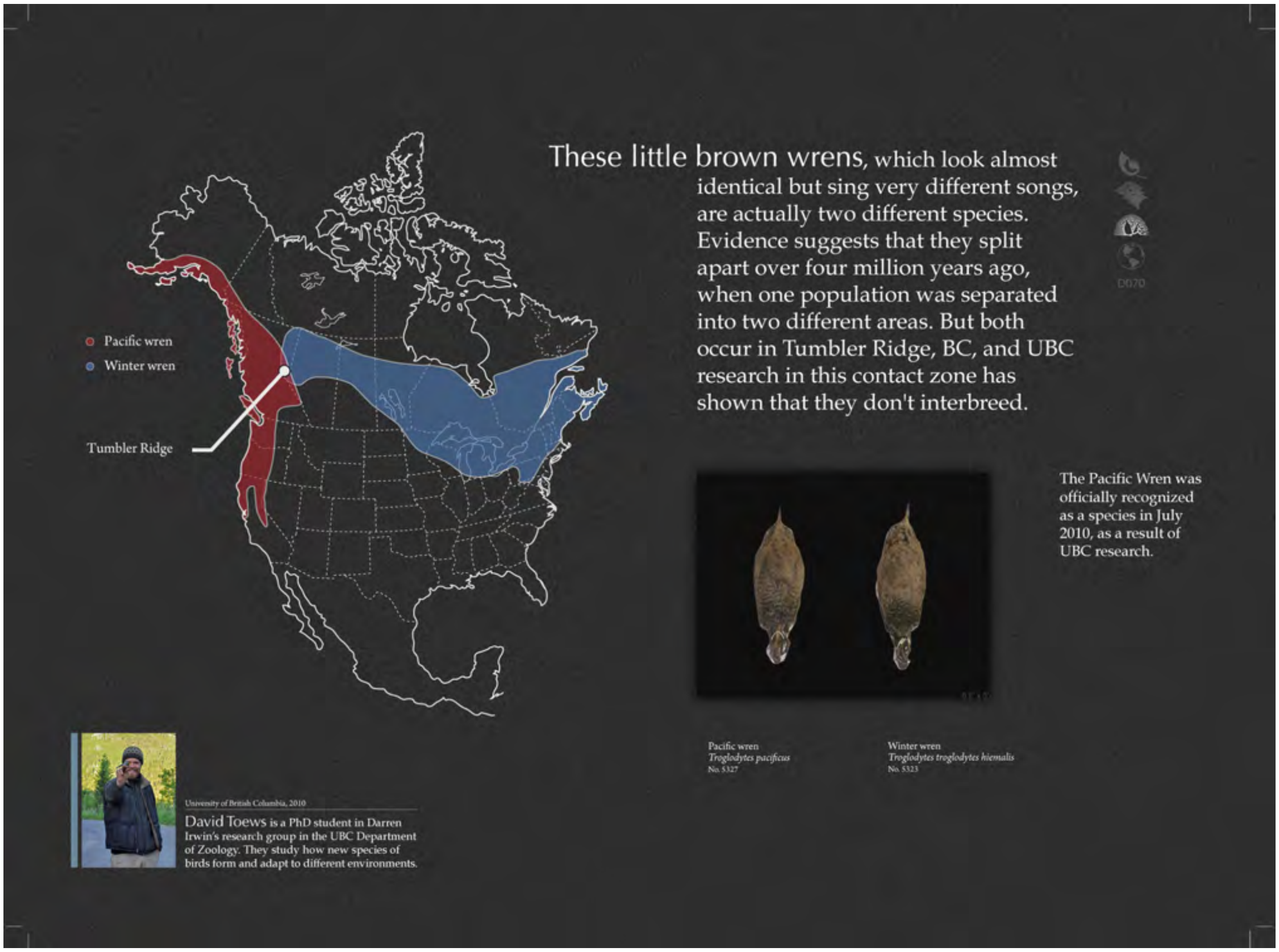


Image 16: Behavioural isolation of bird songs, on display at the Beaty Museum in the third drawer under the speciation display in "Exploring Evolution." For more information on this example, check out Dr. Darren Irwin's talk at https://www.youtube.com/watch?v=rxyB1Qnqr4c.

How do populations become reproductively isolated?

- To become reproductively isolated a group of organisms must evolve at least one of the following so that offspring are no longer fertile and vigorous:
    - o Genetic differences
    - o Different mating behaviour
    - o Morphological differences

Example of Reproductive Isolation and Speciation (Tiger Beetles):

- A population of one species of beetles exist across a mountain range.
- The beetles have 2 traits for colour: reddish-brown and yellowish-green.
- One day a landslide occurs and splits the population into two groups, they are geographically isolated.
- Over a long period of time, the beetles to the left of the mountain range evolve to be reddish-brown and mate at night while the beetles on the left side of the mountain range evolve to be yellowish-green and mate during the day.
- Over many generations the rocks, which split the mountain range, erode and the two groups of beetles are brought back into contact with each other.
- Due to morphological and behavioural (mating time) differences they two groups of beetles no longer interbreed.
- They are now a separate species.

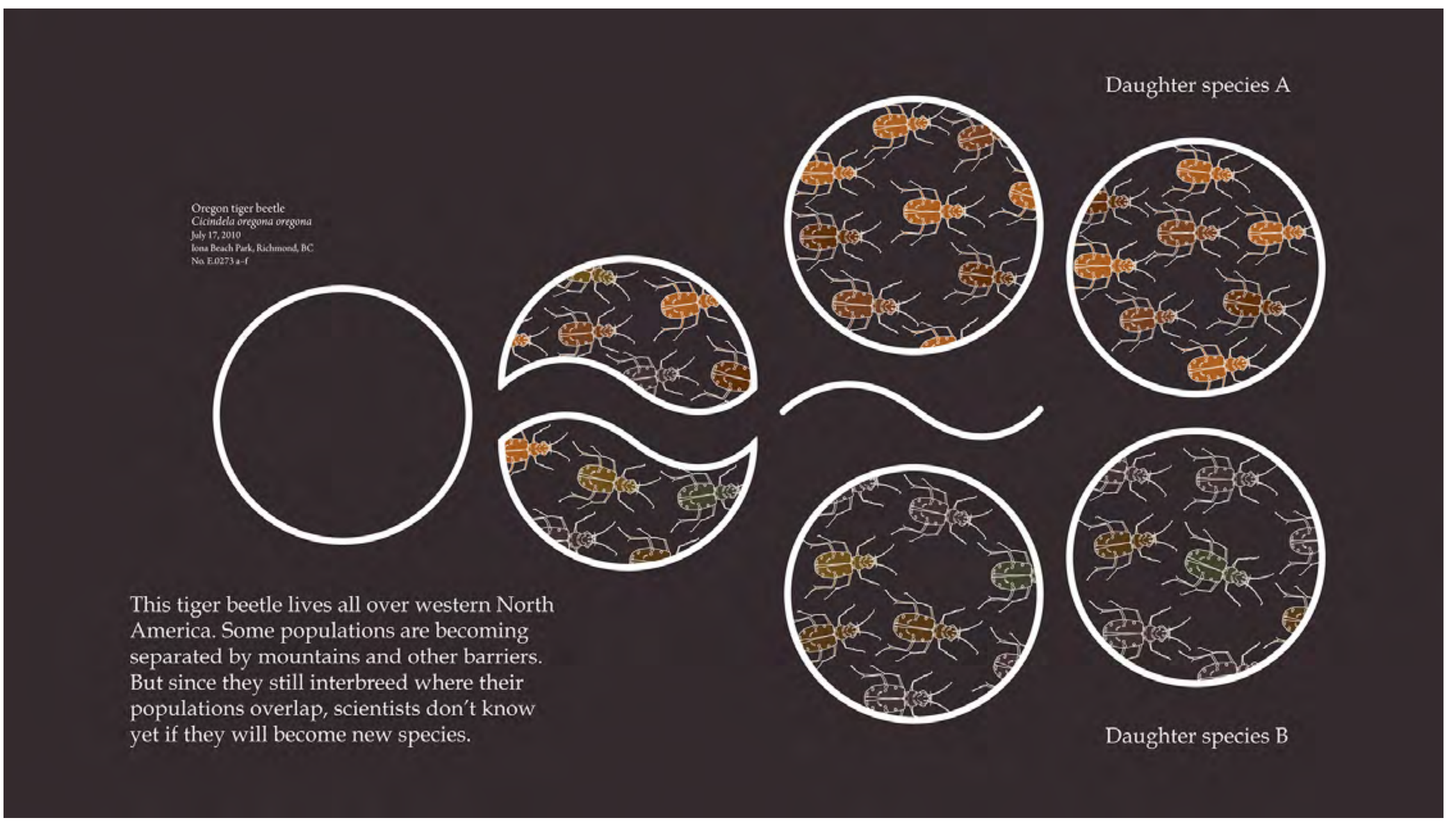


Image 17: Tiger Beetles in reproductive isolation, which results in speciation. Explained in Beaty Museum exhibits, found in "Exploring Evolution."

Niches:

- **Niche –** an organism's particular role in an ecological community. It is a combination of an organism's habitat and its place in the food web (what it eats)
- Two different species cannot occupy the exact same niche at the same time
  - There are not enough resources for both species to share
    - Example of resources: food, water, space, sunlight
  - When two species try to occupy the same niche, the following can occur
    - **Coexistence** (remain two different species) **–** bird species occupy different niches and reproductive isolation is complete
    - **Extinction –** both species share the same niches and one species outcompetes the other until it goes extinct on the shared island
    - **Evolution –** birds share the same niche and interbreeding occurs as reproductive isolation isn't 100% complete. The shared gene pool is re-established and over time they become the same species.

BEATY BIODIVERSITY MUSEUM

The Beaty Biodiversity Museum is unique. Other museums keep their research specimens in back, away from the public. Here, over 95 per cent of our collection space is open to exploration. Although our precious specimens have to be kept in sealed cabinets, you can peer through the windows right into the research collections.

The Cowan Tetrapod Collection contains over 40,000 specimens of mammals, birds, amphibians, and reptiles, representing every continent on Earth, with most specimens coming from western Canada.

The Marine Invertebrate Collection contains thousands of specimens representing the major lineages of animals, such as cnidarians, molluscs, annelids, crustaceans, echinoderms, and sponges.

The Herbarium houses the largest collection of plants and fungi in western Canada, with more than 600,000 specimens. It is also world's largest collection of BC plants and Canada's largest collection of bryophytes, with over half a million specimens that are critical to the identification and conservation of plant biodiversity.

The Herbarium also contains the world's largest research collection of BC fungi, including about a dozen type specimens, which scientists have used to describe new species.

The Spencer Entomological Collection holds over 600,000 specimens that highlight the diversity of British Columbia's insects and other arthropods, as well as jumping spiders from around the world.

The Fish Collection boasts over 800,000 specimens, with particularly spectacular and important holdings from Canada, the Aleutians, the Malay Archipelago, Mexico, the Galapagos, Panama, and the Amazon.

The Fossil Collection contains over 20,000 specimens that range from recent shells to 500-million-year old fossils of blue-green algae, as well as specimens from British Columbia's famous Burgess Shale.

As you expore the exhibits, look for these four symbols representing the drama, change, heritage, and conservation of biodiversity. An exhibit that relates to one of these themes will have the symbol highlighted.

Drama

A tide pool is a place of murder, thievery, deception, and conspiracy, but also a place of cooperation and interdependency. Explore the ecological interactions that sustain and define all life.

Change

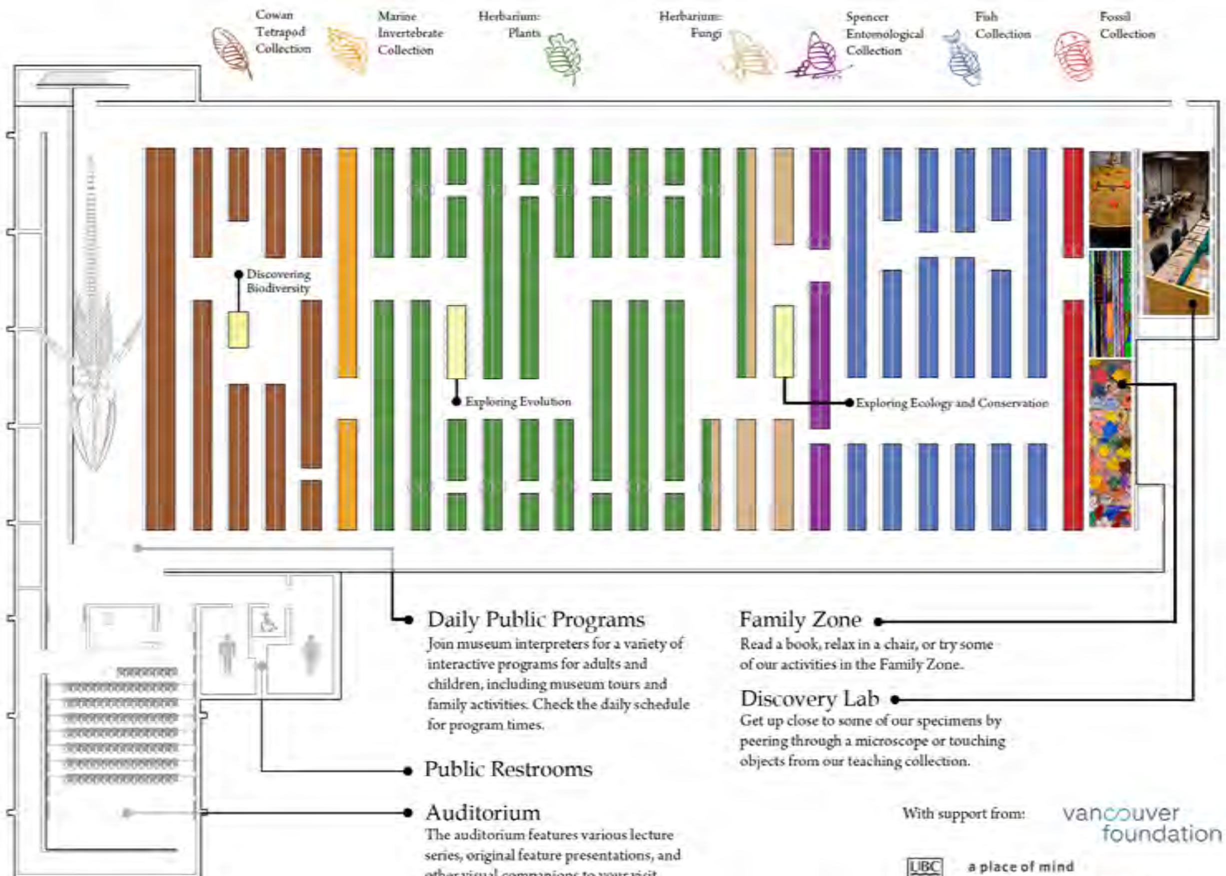
Biodiversity was not always as it is now. Learn about the dynamic mix of chance and circumstance that drives evolution and has produced all the species alive today.

Heritage

Discover how you are related to all life on Earth in a vast evolutionary tree descended from a single ancestral species, and explore the enormous diversity of both the past and the present.

Conservation

Biodiversity is important, but it is fading, and its fate is in your hands. Find out why biodiversity matters, what threatens it, and what you can do to help protect it.



Family Zone

Read a book, relax in a chair, or try some of our activities in the Family Zone.

Discovery Lab

Get up close to some of our specimens by peering through a microscope or touching objects from our teaching collection.

With support from: vancouver foundation

a place of mind THE UNIVERSITY OF BRITISH COLUMBIA FACULTY OF SCIENCE

Sexual Selection Worksheet

Name: ____________________

Date: ____________________

Block: ____________________

Look at the photos on the back of this worksheet and choose a species you would like to focus on. Answer the questions below as completely as possible.

1. My species is...

Common name: ____

Scientific name: ____

2. Describe the different appearance between the males and females of your species.

3. Describe how this sexual dimorphism could be explained by *intersexual* selection. How does this trait help the male reproduce?

4. Describe how this sexual dimorphism could be explained by *intrasexual* selection. How does this trait help the male reproduce?

5. Which do you think is a better explanation of the sexual dimorphism, intersexual selection or intrasexual selection? Why?

BEATY
BIODIVERSITY MUSEUM

Male | Female

Peacock

Bighorn Sheep

White Tail Deer

Great Frigate Bird

All photos used with Creative Commons licenses, via Wikimedia Commons users Stuart Seeger, Jamain, Jeremy Weber, Tom Saint, ForestWander, Ken Thomas, Andrew Turner, and putneymark.