Jan 11-15

Introduction to Zebra Mussels and Freshwater mussels

IQ-1 (unit 1)

- **Zebra** mussels invaded the Great Lakes region in Southern Ontario. They spread rapidly
- There was cause for concern in environmental and economic sectors. Economic impact is already in billions of dollars
- Initial signs were in Lake Simcoe, where the water was a lot clearer. The zebra mussels reduced a lot of particulate matter in the water. The docks were usually where the zebra mussels were found. At sauble beach, a lot of dead zebra mussel shells washed up ashore
- Zebra mussels can attach to any solid substrate.
- Zebra Mussel (***Dreissena Polymorpha***) came from Eastern Eurasia specifically Black and Caspian Sea.
- Most likely method of transport was in ballast water boat. They could've also attached to the ships
- First reported in NA in **1988** in Lake St. Clair.
- The great lakes were also invaded by the **Quagga** mussel
- There are **850** species of Freshwater mussels known. **300** are in NA alone and **41** found in Ontario. In Ontario, all native mussels are from ***Unionidae*** family.
- Zebra mussels endanger the native mussels of region. Native mussels are also endangered by agricultural practices and habitat destruction

Life cycle of Unionids is complex.

- They have a parasitic component, where they use a host cell (fish) to complete reproductive cycle.
- They're **dioecious**, meaning separate males and females.
- Males release sperm in water through exhalant siphon. Females take in sperm downstream through inhalant siphon.
- Fertilization happens internally of female.
- Embryos develop inside a **marsupium**, modified pouches of female gills.
- Embryos develop into larvae called **glochidia**. They're the parasitic part of life cycle. They attach to fish gills to resume development.
- Adult unionid has adaptations to attract fish. One method is called a 'lure', where the mantle tissue of unionid is modified to look like a small prey fish.

Jan 13. Lecture

Unionid larvae, glochidia cannot swim/crawl. Must attach to host fish-

1. Conglutinate: glochidia enclosed in membrane capsule that mimics host prey. The fish swallows and then immediately spits this out but by this time, the glochidia already entered the fish
2. Host capture: Mussels can also hold the fish and pump glochidia into gills
3. Modification of mantle tissue (lure): looks like prey fish. There are both simple and complex lures

IQ-1 (unit 2)

Domain → kingdom → phylum → class → order → family → genus → species

* Humans and zebra mussels have same domain, kingdom but differentiate starting at phylum

Diversity: # of species in taxonomic group or geographical area

- Lake St. Clair had large areas of no mussels but just outside those areas, 5 species were found. This is an example of diversity

Most mussels can be differentiated by phenotype. *Some* males and females can be distinguished by sexual dimorphism.

Ontogeny: physical differences between individuals of different ages. True for both humans and mussels. Finding gravid females and juveniles is a good sign of the succession of next generation

Polymorpha: means many forms. Zebra mussels differ in size, color, stripe pattern, etc.

Intraspecific variation: morphological variation within species

Cryptic variation:

- to be evolutionarily relevant, variation among individuals must be relevant
- *Sometimes*, morphological variability is *not* primarily due to genetic differences, but due to the environment. WHAAA?!? This is known as 'phenotypic plasticity' e.g. in mussels in slow vs. fast running water
- 'Microsatellites' are used to find variations in genomes invisible to the eye

Abundance vs. variation vs. diversity vs. disparity:

- Mollusca phylum is 2nd largest phylum after anthropods, and also the largest primarily aquatic phylum
- Insecta class has over a million described species.

Disparity: differences between species

Phylogenetics: study of living things being related because of common ancestry. Phylogenetic trees are family trees for species

**Random fact: whales are mammals, not fishes

Topology: branching trees that show ancestor, descendant relationships

Cladistics:

- classification simply based on evolutionary relationships
- A clade is any group of species that includes last ancestor and its descendants.
- Clades are monophyletic because they show *one* lineage.
- Reptiles are paraphyletic because the classification leaves out one of the descendants (birds) of the same ancestor
- Convergent evolution: causes features to evolve in more than one independent lineage as a similar adaptation under similar environmental pressure. These are traits are "homoplasy", where the traits are similar but they evolved independently.
- Sharing ancestral traits is called "homology".

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Lecture notes (3-4)

Genetic variation: differences at the DNA level among individuals within a population or species. Can happen in populations through mutation, natural selection, genetic drift and gene flow.

Mutations: Genetic errors in DNA replication. Random with respect to fitness. Can result from recombination. Primary source of genetic variation. DO NOT occur to benefit organism. Could have neutral/good/bad impact on organism

Type of mutation	Description	Cause	Significance
Point	Base pair mutations in DNA question	chance errors during DNA synthesis/repair	Creates new alleles
Chromosome	rearrangement or fusion of chromosome parts	Radiation or other factors break DNA	changes proximity of genes
Gene duplications	Creates an additional copy	unequal crossing over in meiosis	allow duplicate genes to diverge in function
Genome duplication`	addition of complete set of chromosome	Hybridization/other errors in mitosis/meiosis	Duplicate all genes; create new species

Alleles: alternate forms of the same gene.

Natural Selection: Non-random differences in survival and or reproduction among individuals with differences in heritable characteristics. ONLY natural selection can lead to evolution of adaptations. Non-random with respect to fitness, so it occurs to benefit populations with desirable traits. Opposite to mutations, in this aspect.

Genetic drift: evolution by chance due to sampling error.

- Bottleneck: Event (such as natural disaster) reduces population, diversity and allelic variation. End population is poor representation of genetic makeup of original population
- Founder effect: portion of population moves to obscure location far enough way to become separate population; could become new species

Gene Flow: Movement of genes among populations (two or more). Makes the populations more similar to one another. Does not create genetic isolation/speciation unless there are specific barriers involved. Such as:

- Geographical barriers like formation of new mountains, rivers or a new population founded on separate island
- Ecological differences such as having different diets, being nocturnal vs diurnal, etc.

*Note about Studies/graphs: A well sampled study will have a sinusoidal(ish) curve.

IQ-1 Unit 3

Observation of natural world as biologists lets us see two common patterns. 1) There's a lot of diversity. 2) Organisms are well suited to their habitat.

Adaptation: 1) enhances the survival and reproduction of organisms that can bear it. 2) Physical, physiological, behavioral or other characteristic evolved through Natural Selection.

Note: Individuals DO NOT adapt during its lifetime in response to external conditions, species adapt over a period of time through Natural Selection.

Population: for sexual species, it's a group of interbreeding individuals and their offspring

Genotype: set of genes possessed by individuals
Phenotype: physical expression of genes
Frequency: decimal representation of phenotype, genotype, gamete, etc.

Natural Selection-

Darwin had two objectives with his *Origin of Species*. One was to show that species were related through common ancestry. Secondly, to show that Natural selection accounts for the differences between species

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- *Individuals within populations are variable*. Every individual is unique.
- *Variability among individuals is partly heritable*. Offspring look more like their parents than unrelated members of same population. This is due to the transmission of genes that happen during meiosis
- *Not everyone survives and reproduces; some individuals are more successful than others.* Not all offspring produced in each generation survive. #Overproduction. For example not every egg laid will grow up to be egg laying adults.
- *Survival and reproduction is associated with heritable variation*. Key to natural selection. Some traits are more beneficial to survival (and afterwards, reproduction) than others.
- Not every feature in an organism is an adaptation

Resistance genes can appear through Natural Selection or mutations. Certain strains of bacteria will have resistance to whatever antibiotic we throw at it. Then it will pass on the genes to its offspring. This is an example of how evolution works in all living things.

Strains of antibiotic resistant bacteria may be passed around through gene flow to areas where the resistant bacteria did not previously exist. With technology, we can also tamper with bacterial DNA to make it resistant to a certain antibiotic

More Natural selection notes:

- Natural Selection does NOT create new traits. It shows us the desirable traits required to survive
- Two-step interaction between mutations and Natural Selection lead to the evolution of new adaptive features
- Adaptations do not result in optimal characteristics, meaning they are not 'perfect'. There are genetic, historical, and developmental limitations.

- Some of the mussels we studied in class have different phenotypes due to different flow rates of water (fast moving vs. slow moving). The unique bumps and ridges developed by the mussels are due to mutations that allowed a slight change in morphology. If these mutations allow mussels to attach to substrate longer to pass on their offspring, then generations later, all mussels in that area will have the specific trait of the first ancestors. This is adaptation by natural selection

How do we explain complex adaptations like the ones unionids use to attract host fishes?

- We know mussels use lures. These lures are namely the modification of mantle tissue. Males have mantle tissue but they not need to use it. Females modify their mantle tissue to transfer their larvae into a fish host. When mantle tissue is not modified, it acts as shell.
- The process of *'co-option'* is a common mechanism that allows a feature that serves a primary function to take on another function. In the case of the mantle lures, the already shell-making tissue later with slight modifications contributes to attracting fish-hosts. This helps us understand that the disparity among mussels with functioning complex lures resulted from ancestors who had simpler lures.
- The wavy-eyed lampmussels, *Lampsilis Fasciola* is a good example of variation among individuals within the same species. We can figure out which tissue was 'co-opted' to form lures. https://www.youtube.com/watch?v=w04wvaXtTdI

There is an estimated 10 million-100 million species on Earth. 99.9% of all species that existed on Earth are extinct.

Speciation- origin of new species
Extinction- loss of existing species

Species- are MOST COMMONLY (but not exclusively) defined by the 'Biological Species Concept' which states that species are *groups of interbreeding natural populations reproductively isolated from other such groups*.

Two individuals, in theory, who can produce fertile offspring are considered to be part of the same species. Simpler definition would state that species are genetically separate from other groups.

Endangered: abundance of species has dwindled. Action needs to be taken to preserve them
Extirpated: Individuals of species may exist but they are not found where they were once common. Mermaids? lol jk
Extinct: Zero, nada, zilch representation of species available.

Background extinction is the process through which species *slowly* become rarer and rarer under normal circumstances (without human interference) and becomes extinct.

Mass extinction is different than 'background' because 50% or more existing species dies out in a relatively *short* amount of time (tens to hundreds of thousands of years). Mass extinctions can affect entire groups of species even clades. Spike in diversity follows a mass extinction because new niches open up and the survivors diversify. Over the past 600 millions of years, there has been 6 major mass extinctions to report.

- The commonly known one is Cretaceous-Tertiary (K-T), where dinosaurs went extinct roughly 65 million years ago.
- The most deadly mass extinction was “The Great Dying”, roughly 250 million years ago. 95% of Earth’s species vanished. This is also believed to be caused by a meteorite. Occurred over a million years. It’s approximated to take about a 100 million years for biodiversity levels to recover.
- WE are currently in the midst of another mass extinction known as the “Holocene Extinction”, caused almost entirely by humans through pollution, climate change, deforestation, etc. Step yo game up humanity.

Multiple factors lead to extinction. They include but are not limited to:

- depletion of food sources
- Habitat changes or destruction
- disappearance of flower pollinator

For the freshwater mussels we learned about, two of the key factors that caused the decrease in population were invasive species (zebra mussels) and agricultural practices.

Mussels are *bivalve molluscs*. *Bivalve*s are the most common aquatic animals with external two-part shells. Hundreds of millions of years ago, another phylum, *Brachiopada,* used to be dominant. It’s believed that the Great Dying wiped out most of the *Brachiopada*

Lecture 3 homework

Genetic Variation types	Random?	Genetic Variation: increase? decrease? same?	Resulting population	Genetic difference among populations. Increase? Decrease? Same?
GD: Bottleneck	Yes	Decrease	1	N/A
GD: founder effect	Yes	Decrease	2	Increased, because there’s two different populations now
Gene Flow	Yes	Increase	2	Depends on magnitude of flow
Mutation	Yes	Increase	1	N/A
Natural Selection	No	Decrease	1	N/A