Teaching the concept of: Mechanism of Evolution

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Background information:

Evolution describes the process of change in organisms over time (i.e., the “what”) while the mechanisms of evolution propose to explain the “how” and “why” of evolution. There are five mechanisms of evolution including natural selection, artificial selection, sexual selection, genetic variation, and genetic drift. This presentation will cover all mechanisms mentioned and offer teaching and assessment ideas to assist student understanding of these concepts.

*Natural selection* is the primary mechanism of evolution. It describes the non-random process where organisms better adapted to their environment tend to survive and produce offspring.

*Artificial selection*, or selective breeding, occurs when humans select for favourable traits in organisms and decides which organisms reproduce.

*Sexual selection* is a specific case of natural selection, where selection occurs based on mating behaviour of organisms. It acts on behaviours that allow organisms to successfully find and reproduce with a mate. This selection sometimes is strong enough to produce traits that may be harmful to an organism’s survival.

All above forms of selection act to produce adaptations in populations. *Adaptations* are behaviours or features that exist in a population because of an improved function.

*Genetic drift* is another mechanism of evolution but unlike selection, is a random process. In each generation, individuals survive and reproduce merely by chance. Unlike selection, genetic drift does not produce adaptations.

*Genetic variation* is the basis of selection and genetic drift. Without genetic variation, the other mechanisms would not occur. There are three primary sources of genetic variation: mutations (changes in DNA), gene flow (or migration, the movement of genes from one population to another), and sex (genetic shuffling and recombination of genes).

Curriculum expectations assessed: (SBI3U - Grade 11 Biology)

C1.1 Evaluate the possible impact of an environmental change on natural selection and on vulnerability of species.

C2.1 Use appropriate terminology related to evolution, including but not limited to extinction, natural selection, phylogeny, speciation, niche, mutation, mimicry, adaptation and survival to the fittest

C3.1 Explain the fundamental theory of evolution, using the evolutionary mechanism of natural selection to illustrate the process of biological change over time

C3.4 describe some evolutionary mechanisms and explain how they    
affect the evolutionary development and extinction of various species

Planning and teaching ideas:

Prior knowledge:

    Students should understand the theory of evolution before delving into the mechanisms of evolution. They should know that genes carry the information that is transferred from parent to the offspring. Students should also have a clear idea of phenotype and genotype. Students should understand that genetic variation is the prerequisite for evolution to take place.

Teachers should spend time on presenting evidence of evolution (e.g., fossil records) and key evolutionary scientists that have made significant contributions to evolutionary science (e.g., Lyell, Malthus, Lamarck, Darwin, etc.), although this could be easily integrated into these lessons.

## Teaching ideas (see lesson sequence for specific ideas):

* Using inquiry approach and ask questions that intrigue students to find out how scientists explain curious occurrences in nature
* Have students hypothesize why adaptations occur before revealing (e.g., in videos, pause and have students Think/Pair/Share)
* Use of multimedia - virtual labs, online simulations, videos
* Use of simulations – hands on and virtual

Lesson sequence:  
  
**1. Diagnostic assessment + genetic variation**

* mutations
* gene flow (role play)
* sex + genetic shuffling

**2. Natural selection**

* How natural selection acts on hummingbirds - watch video and take notes (whole class) (http://www.youtube.com/watch?v=xkwRTIKXaxg&feature=related)
* Clipbirds - a hands-on activity to demonstrate bird beak size evolution (small groups) (http://www.ucmp.berkeley.edu/education/lessons/clipbirds/ )
* Students go to http://hhmi.com/biointeractive/shortfilms/ and choose one of the short films - watch and summarize how natural selection impacted that particular organism (individual)

**3. Sexual selection**

* Hook: cricket comic strip - debunking “Survival of the fittest” (http://evolution.berkeley.edu/evolibrary/article/0\_0\_0/sneakermales\_01)
* Video - Evolution: Constant Change and Common Threads, Lecture 4 – From Butterflies to Humans by Sean B. Carroll, Ph.D. (http://media.hhmi.org/hl/05Lect4.html)Looking at sexual selection in fruit flies Parts 10-14)
* Online simulation: http://www.pbs.org/wgbh/evolution/sex/guppy/index.html What causes guppy colouration?

4. Genetic drift

* vs. natural selection: compare and contrast (use a graphic organizer - Venn diagram)

**5. Applications and societal implications** - see below for more detail  
  
Applications and Societal Implications  
  
Artificial Selection

* + by farmers is the intentional selection of certain desired traits in plants and crops (e.g., organic farming)
  + animal breeding (e.g., dogs, horses)
  + genetic engineering (e.g., antibiotic resistance genes, DNA manipulation)
  + Used to evolve proteins with particular properties, such as modified enzymes or new antibodies.

## Medicine

* + The pathogens are affected by the antibiotic action, those bacteria which have undergone a genetic change that is a mutation will be able to survive and reproduce. This genetic variation will enable the bacteria to survive and thrive. This trait is eventually passed on to their offsprings, which results in development of a fully resistant colony of pathogens.
  + Research and interpretations of the changes that occur during an organism’s evolution helps to reveal the genes needed to construct parts of the body or genes which may be responsible for any disorder. For example: the Mexican tetra fish

# Potential student difficulties and possible solutions:

* There are often misconceptions about the popular phrase “survival of the fittest” as students commonly think that only the stronger, faster, and better organisms survive. It would help to clarify that the phrase was actually coined by Herbert Spencer, a philosopher who read Darwin’s findings, and then define the term “fittest”. (In science, fitness actually refers to the success of an organism to reproduce. In the beginning of the lesson on Sexual Selection, this is addressed.)
* Students may find it difficult to understand the difference between somatic or genetic variation and why the latter is responsible for evolution.

(Students shall be explained that somatic variations are not inherited from parents to the offspring whereas genetic variations are transferred. Thus, only genetic variations make an impact on offspring and population.)

* Some students may object to the topic of evolution because it is incompatible with their religious faith. Possible solutions to this problem include:
  + sending home a letter before beginning the unit to notify parents about the unit and what it entails. Open up communication with parents and offer a chance for them to ask questions or voice concerns.
  + emphasizing that evolution is a scientific theory that serves to explain observations we see in the natural world
  + may need to consult with head of department or administrator if student refuses to participate in learning

# Differentiated instruction:

* Kinesthetic learners will benefit from the hands-on and virtual labs such as the Clipbirds and guppy colouration.
* Auditory learners will benefit from videos of guest lecturers and mini-lectures given by the teacher
* Visual learners will benefit from visual presentations such as videos, powerpoint presentations to teach genetic variation and cricket comic strip
* Activities mentioned vary from whole class (e.g., discussions) to small groups (e.g., Clipbirds lab), to individual (e.g., online simulation), although groupings can be altered to suit class needs

Accommodations and modifications  
Students with IEP’s:

* accommodate according to IEP strategies and methods
* provide additional time, extra support where needed

Students that are ELL’s:

* provide graphic organizers to take notes
* pair up with another student that speaks first language
* pre-teach vocabulary by providing a glossary of key terms ahead of lesson
* allow use of electronic dictionaries or online translation tools
* use visual representations where possible to explain concepts

Enriched students:

* allow independent study projects in a topic that interests them
* independently find other examples of mechanisms at work and share with class/teacher

# Assessments:

* diagnostic assessment - anticipation guide
* exit slips to assess learning during teacher-led instruction (K/U)
* graphic organizers to summarize learning (K/U, T/I)
* lab reports (e.g., Clipbirds, guppy simulation) (K/U, T/I, C)
* Case study (e.g., natural selection) (K/U, A)
* Discussions (K/U, C)

As a summative task, students are asked to answer the question: how do evolutionary mechanisms affect my life? They will research a topic (an application or societal implication) and present their answer using one of the following methods:

* + electronic poster using Glogster
  + traditional poster to illustrate topic
  + written lab report
  + role-play/drama
  + video
  + Powerpoint or Prezi presentation
  + lyrics and song
* Evaluation of summative task will address the following achievement chart categories (T/I, C, A)

Annotated references and sources:  
  
Farabee, M.J. (2001). Development of Evolutionary Theory. Retrieved July 17, 2012, from http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookEVOLI.html

*An online source for concepts in evolution.*

Howard Hughes Medical Institute. (2012). Biointeractive - Evolution. Retrieved July 17, 2012, from http://www.hhmi.org/biointeractive/evolution/index.html

*A collection of videos (lecturers, animations) and articles about evolution.*

University of California Museum of Paleontology. (2012). How does evolution impact my life? Retrieved July 17, 2012, from http://evolution.berkeley.edu/evolibrary/search/topicbrowse2.php?topic\_id=47  
  
 *A list of resources and topics for applications and societal implications.*

University of California Museum of Paleontology. (2012). Understanding Evolution. Retrieved July 17, 2012, from http://evolution.berkeley.edu/evolibrary/teach/index.php

*A comprehensive website that provides a deep conceptual understanding of evolution, as well as teaching strategies, common misconceptions, and tons of resources (e.g., image library, teaching materials database).*

WGBH Educational Foundation and Clear Blue Sky Productions, Inc. (2011). Evolution library. Retrieved July 17, 2012, from http://www.pbs.org/wgbh/evolution/library/index.html

*A set of resources including books, articles, links and images related to topics in evolution.*