Creating twenty-first century critical thinking classrooms in North Carolina starts with the establishment of core concepts and essential standards that are focused, prioritized and enduring. The 2009 Science Essential Standards are anchored in the premise that one of the best ways for students to learn these core concepts is to learn successively more sophisticated ways of thinking about these ideas over multiple years. If mastery of the core concepts is the ultimate destination, efforts of reform must be to redirect the focus from the “content” to the “learning”. Dr. Lorin W. Anderson, Carolina Distinguished Professor of Education, says content exists outside the student. When content gets inside the student, it becomes knowledge. This transformation of content to knowledge takes place through the cognitive processes used by the student. In other words, he says, “you must tinker with their thinking”. The following learning progressions demonstrate how students’ thinking about natural selection becomes more sophisticated over time.

**Natural Selection Major Implications:**

1. Different plants and animals have different features that help them to survive in different environments.
2. Organisms of the same kind differ in their characteristics, and sometimes the differences provide an advantage in survival and reproduction.
3. Changes in environmental systems can impact the survival of individual organisms as well as species.
4. Natural selection leads to organisms that are well suited for survival in particular environments. Individuals best adapted to their environments are more likely to survive and reproduce. As long as there is some variation between them, there will be inevitable and ongoing selection of individuals with the most advantageous variations. If the variations are inherited, then differential reproductive success will lead to a progressive evolution of particular populations of a species, and populations that evolve to be sufficiently different eventually will become different species.
### Natural Selection

**AP Bio. Enduring Understanding 1.A. Change in the genetic makeup of a population over time is evolution.**

---

#### 2001 AP® Biology Free-Response Questions:

Charles Darwin proposed that evolution by natural selection was the basis for the differences that he saw in similar organisms as he traveled and collected specimens in South America and on the Galapagos Islands.

(a) **Explain** the theory of evolution by natural selection as presented by Darwin.

(b) Each of the following relates to an aspect of evolution by natural selection. **Explain** three of the following.

(i) Convergent evolution and the similarities among species (ecological equivalents) in a particular biome (e.g., tundra, taiga, etc.)

(ii) Natural selection and the formation of insecticide-resistant insects or antibiotic-resistant bacteria.

(iii) Speciation and isolation

(iv) Natural selection and behavior such as kinesis, fixed-action-pattern, dominance hierarchy, etc.

(v) Natural selection and heterozygote advantage.

#### 2009 College Board Sample Multiple Choice Questions: 1.A.2

Which of the following statements best summarized organic evolution as it is viewed by modern evolutionists?

(A) It is goal directed.

(B) It represents the results of selection for acquired characteristics.

(C) It is synonymous with the process of gene flow.

(D) It is the descent of humans from the present-day great apes.

(E) It is the differential survival and reproduction of certain phenotypes.

---

#### Bio.3.4 Explain the theory of evolution by natural selection as a mechanism for how species change over time.

Bio.3.4.2 During the Industrial Revolution, there were two variations of English Peppered Moths, those with light color and those with dark color. The soot from the factories covered the trees. Data was collected to measure the percentage of each type of moth in the area. It was noted that the percentage of dark-colored moths increased over time, while the percentage of light-colored moths decreased. What is the likely explanation for this change?

- The presence of a mutation changed the color of the English Peppered Moths.
- The presence of the dark-colored variation increased the likelihood for survival of the English Peppered Moths.
- The presence of the light-colored variation increased the likelihood for survival of the English Peppered Moths.
- The presence of an acquired trait changed the color of the English Peppered Moths.

Bio.3.4.1 Species A and B share similarities in DNA sequences. What would this suggest about their evolutionary relationship?

- Species A developed before species B.
- Species A and B share a recent common ancestor.
- Species A and B are unrelated.
- Species B developed before Species A.

---

#### Bio.3.5 Analyze how classification systems are developed based upon speciation.

Bio.3.5.2 See Attachment 1

**Constructed Response:** Based upon the dichotomous key in attachment 1, which two organisms are more closely related? Explain your reasoning.

---

#### Bio. 2.1 Analyze the interdependent relationships of living organisms within their environments.

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### Bio. 2.1.2

The different species of Hawaiian honeycreepers shown all descended from a single species of North American bird. They now have different beaks, eat different foods, sing different songs, and live in different environments on the islands. Which factor probably contributed most to the development of these different species?

- Loss of habitat
- Geographic isolation
- Egg size
- Predation

*Source: Virginia Standards of Learning, Biology Exam 2008*
### Assessment Items Based on Learning Progressions for Natural Selection

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>8.L.4</strong> Understand the evolution of organisms and landforms based on evidence, theories and processes that impact the earth over time.</td>
<td></td>
</tr>
<tr>
<td><strong>8.L.3</strong> Understand how organisms interact with and respond to the biotic and abiotic components of their environment.</td>
<td></td>
</tr>
<tr>
<td><strong>7.L.2</strong> Understand the relationship of the mechanisms of cellular reproduction, patterns of inheritance and external factors to potential variation among offspring.</td>
<td></td>
</tr>
<tr>
<td><strong>6.L.2</strong> Understand the flow of energy through ecosystems and the responses of populations to the biotic and abiotic factors in their environment.</td>
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</tbody>
</table>

**8.L.4.2 Explain the relationship between genetic variation and an organism’s ability to adapt to its environment. 5F/M2.4**

The different species of Hawaiian honeycreepers now have different beaks, eat different foods, sing different songs, and live in different environments on the islands.

Two researchers wanted to see if they could observe natural selection at work. They decided to bring the birds to a new home. The new home they designed would have some of the characteristics of each of the birds’ old environment; however, some changes would be harsh and very different.

Which statement best predicts what will happen to the birds?

a. none of the birds will try to adapt to the change and all of the birds will die
b. some of the birds will be able to adapt to the change but some of the birds will die
c. all of the birds will be able to adapt to the change because they have a common ancestor
d. all of the birds will try to adapt to the change because they have a common ancestor

**8.L.3.1 Habitat Change Vol. 2 pg. 143**

Explain how factors such as food, water, shelter, and space affect populations in an ecosystem. 5D/M1a

A small, short furred, gray animal called a divo lives on an island. This island is the only place on Earth where divos live. The island habitat is warm and provides plenty of the divos’ only food—tree ants. The divos live high in the treetops, hidden from predators.

One year the habitat experienced a drastic change that lasted for most of the year. It became very cold and even snowed. All of the ants died. The trees lost their leaves, but plenty of seeds and dried leaves were on the ground.

Circle any of the things you think happened to most of the divos living on the island after their habitat changed.

a. The divos’ fur grew longer and thicker.
b. The divos switched to eating seeds.
c. The divos dug holes to live under the leaves or beneath the rocks.
d. The divos hibernated through the cold period until the habitat was warm again.
e. The divos died.

Explain your thinking. How did you decide what effect the change in the habitat would have on most of the divos?

**7.L.2.3 Which of the following prenatal activities could lead to low birth weights and higher frequencies of developing asthma?**

- eating fast food 3 times a week
- smoking
- walking 2 miles a day
- not taking prenatal vitamins

**6.L.2.3 Why do large trees have a difficult time living in a Tundra?**

- A Tundra is too hot for trees to grow large.
- Animals that live in a Tundra destroy most vegetation.
- Flooding occurs too often in a Tundra for large trees to grow.
- The soil in a Tundra is too nutrient-poor for large trees to grow.*
### Assessment Items Based on Learning Progressions for Natural Selection

| 5.L.3 Understand why organisms differ from or are similar to their parents based on the characteristics of the organism. | 4.L.1 Explain the effects of environmental changes, adaptations and behaviors that enable animals (including humans) to survive in changing habitats. | 3.L.2 Understand how plants survive in their environments. | 4.L.1.4 Three students were trying to help their friend predict what would happen to his pet rabbits when he moved them from their warm, sunny home in Florida, to their new cold home in Alaska. This is what they each thought:

**Friend 1:** “I think all of the rabbits will try to adapt to the change.”

**Friend 2:** “I think most of the rabbits will try to adapt to the change.”

**Friend 3:** “I think few or none of the rabbits will try to adapt to the change.”

Which friend do you most agree with and why? Explain your ideas about adaptation.

---

**Sam’s pet dog had puppies. Three of the puppies were black and two were white. The father dog was black. The mother dog was white. Why are the dogs different colors?**

- a. Puppies inherit more traits (genes) from their fathers than their mothers.
- b. The puppies got half their traits (genes) from their father and half from their mother.
- c. Male traits (genes) are stronger than female genes.
- d. Black puppies have more traits (genes) than white puppies.

Which friend do you most agree with and why? Explain your thinking about heredity.

---

**A student moved his pet rabbits from sunny Florida to cold Alaska when they were all very small. Some of the rabbits have long ears, good for hearing, and some have short ears that help hold in heat. Once the rabbits were moved to Alaska what do you think happened to the rabbits that were born in Alaska.**

- a. All of the new rabbits will have short ears, because Alaska is very cold.
- b. Most of the new rabbits will have long ears, because long ears are most fit for Alaska.
- c. Some of the rabbits will have long ears and some will have short ears, because they will look like their parents.
- d. All of the new rabbits will have short ears because only rabbits with short ears can survive in Alaska.

Which friend do you most agree with and why? Explain your ideas about heredity and adaptation.

---

**Friend 1:** “I think all of the rabbits will try to adapt to the change.”

**Friend 2:** “I think most of the rabbits will try to adapt to the change.”

**Friend 3:** “I think few or none of the rabbits will try to adapt to the change.”

Which friend do you most agree with and why? Explain your ideas about adaptation.

---

**Four friends investigated four types of plants to determine which would be best to plant in their butterfly garden. This is what they each suggested:**

- **Friend 1:** “Sample A, because they produce lots of roots to absorb nutrients.”
- **Friend 2:** “Sample B, because they produce colorful flowers to attract butterflies.”
- **Friend 3:** “Sample C, because they grow very tall.”
- **Friend 4:** “Sample D, because they have very large dark green leaves to make plenty of food.”

Which friend selected a characteristic that will most likely enable the plants to survive in the butterfly garden? Explain your choice.

---

**After class, three students were trying to help their friend understand what their teacher meant when he said “survival of the fittest”. This is what they each said:**

- **Friend 1:** “I think ‘fit’ means bigger and stronger.”
- **Friend 2:** “I think ‘fit’ means more apt to reproduce.”
- **Friend 3:** “I think ‘fit’ means able to grow taller.”
- **Friend 4:** “I think ‘fit’ means able to produce dark green colors.”

Which friend do you most agree with? Explain what you think “survival of the fittest” means?
**Assessment Items Based on Learning Progressions for Natural Selection**

<table>
<thead>
<tr>
<th>2.L.2. Remember that organisms differ from or are similar to their parents based on the characteristics of the organism.</th>
<th>1.L.1 Understand characteristics of various environments and behaviors of humans that enable plants and animals to survive.</th>
<th>K.L.1 Compare characteristics of animals that make them alike and different from other animals and non living things.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have students observe pictures of various butterflies, and identify ways in which two or more are alike and different.</td>
<td>Create a garden habitat that will attract and provide the basic needs for birds, butterflies and plants that are found in North Carolina. Research and plant appropriate flowers.</td>
<td></td>
</tr>
<tr>
<td>Have students research and draw habitats of similar plants and animals that are found in other parts of the world. Discuss differences and similarities (e.g., type of materials used to build each shelter) and explain how each environment enables the different plants and animals to survive.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joey decided to create a garden habitat, exactly like the one from school, in his backyard except he would include plants and animals from other parts of the world as well as those from NC. Which plants and animals do you think will grow and survive best? Explain your selections.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living Owl</td>
<td>Living Butterfly</td>
<td>Statue of Owl</td>
</tr>
</tbody>
</table>
Assessment Items Based on Learning Progressions
for Natural Selection

Attachment 1

3.5.2 Using the key provided, drawing III can be identified as which bird?

I) 90cm II) 69cm III) 50cm

IV) 31cm V) 20cm VI) 7.5cm

Taxonomic Key to North American Birds

1.a. Larger than 40 cm ................................................................. 2
1.b. Not larger than 40 cm .......................................................... 4

2.a. Hooked beak ................................................................. 3
2.b. Beak not hooked ............................................................. Phasianus colchicus

3.a. Feathers over eyes that look like ear ......................... Bubo virginianus
3.b. No Feathers that look like ears ................................. Haliaeetus leucocephalus

4.a. Head one solid color of feathers ................................. 5
4.b. Head not solid color of feathers ................................. Colinus virginianus

5.a. Bill flat ................................................................. Anas platyrhynchos
5.b. Bill pointed .............................................................. Archilochus colubris

a.) Bubo virginianus

b.) Haliaeetus leucocephalus

c.) Colinus virginianus

d.) Anas platyrhynchos