Standards-Based Module
(Lesson/Unit Plan)

Cover Page

Content Area: Life Science

Grade Level: 6, 7, 8

Title of Lesson/Unit: Hummingbirds and Flowers: A Study of Co-Adaptive Relationships

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Time to complete: (2) 50 minute class periods

Title of Lesson/Unit: Hummingbirds and Flowers: A Study of Co-Adaptive Relationships

1. South Carolina State Standards

Standards Addressed:

Grade 6	I.A.1.a-b, I.A.1.d., I.A.2.b,c,h, I.A.4 II.B.2, II.B.3
Grade 7	I.A.1.a-b, I.A.1.d., I.A.2.b,c,h, I.A.4 II.D.2.a,b
Grade 8	I.A.1.a-b, I.A.1.d., I.A.2.b,c,h, I.A.4 II.A.2.a-b, IV.B.1.a-b

2. Lesson/Unit Description:

To present the concept of co-adaptation, students will be introduced to hummingbirds (in general) and the adaptations they have developed over time for acquiring nectar from flowering plants. The students will also be introduced to the adaptations developed over time by flowering plants to attract pollinators in general and hummingbirds in particular. Using the ruby-throated hummingbird (*Archilochus colubris*)/trumpet creeper (*Campsis radicans*) co-adaptation example, students will explain how this flowering plant has adapted to be pollinated by this particular hummingbird and how this hummingbird has adapted to feed on this flower's nectar. Finally, the students will also be able to identify the type of flowers that can be planted in a garden that will attract hummingbirds and why these flowers in particular might be visited by a hummingbird.

3. Focus Questions(s) for Students:

1. What are the natural history, morphology, and behavior of hummingbirds in general?
2. What adaptations have they developed over time to feed on nectar?
3. What physical characteristics have flowers evolved to attract pollinators in general and hummingbirds in particular?
4. How are the ruby-throated hummingbird and the trumpet creeper co-adaptive?
5. What types of flowers would the student plant in a garden to attract hummingbirds and why would hummingbirds be attracted to these plants?

4. Culminating Assessment

1. Introduce the students to the natural history, morphology, and behavior of hummingbirds in general (refer to the PowerPoint presentation).
2. Referring to the presentation, discuss the different mechanisms that flowers have adapted to attract pollinators in general and hummingbirds in particular.
3. Using the presentation, discuss how the ruby-throated hummingbird and the trumpet creeper have adapted together (co-adaptation).
4. Referring to the Student Quiz on the PowerPoint presentation, have the students identify which of the flower types shown will more than likely be pollinated by hummingbirds and why.
5. Have the student complete the student handout to reinforce the vocabulary words and concepts introduced in this lesson.
6. Have the students research 5 plants that: 1) hummingbirds might feed on **and** 2) will grow in a South Carolina garden. Have them include resource citations in their work.

<u>Student Directions:</u>

1. Before the presentation, discuss as a class the students' previous knowledge of hummingbirds, how a flowering plant gets pollinated, and how flowering plants have adapted to attract pollinators.
2. Discuss the physical characteristics of a hummingbird and what a flowering plant would need to develop to have the hummingbird as a pollinator.
3. Discuss the physical characteristics of a flower and what shape a hummingbird would need to be to retrieve the nectar from the flower.
4. Take the Student Quiz, identify which flowers are more than likely pollinated by hummingbirds and explain why.
5. Complete the student handout.
6. Research 5 plants that hummingbirds might feed on and that will grow in a South Carolina garden. Be sure to include information such as: annual/perennial, bloom season, bloom description, light, soil, and water requirements, maximum height and width, and why hummingbirds might feed on these flowers. Do not forget to cite your resources!

5. Materials/Equipment/Resources:

Per Class:

Access to a computer and projector
Field guides and books about birds and plants (*see Additional Resources)*

Per Student:

Student handout

6. Teacher Preparation:

1. Read background information and be prepared to explain: hummingbird natural history, morphology, and behavior, the basics of plant pollination and plant reproductive parts, and the co-adaptive features of hummingbirds and the flowers they feed on.
2. Make sure the PowerPoint presentation is ready and make copies of the student handout.
3. Make sure that reference books, nursery catalogs, etc., as well as, online resources will be available to the students for their assignment.

Background Information

1. What is a hummingbird?
   A. Order Apodiformes, Family Trochilidae, contains over 328 species
   B. Found exclusively in the Western hemisphere (the New World): North, Central, and South America and the Caribbean Islands, in all climates and altitudes (forests, gardens, plains, desert, mountains, etc.)
   C. Physical characteristics
      i. Weight ranges: 2-22g
      ii. Body length ranges: 60mm to 216mm
      iii. Bill length ranges: 1-10cm, usually slightly **decurved** (pointing down), rarely **recurved** (pointing up)
      iv. Have long, tubular tongues that can be extended beyond the bill
      v. Colorful hummingbirds are actually not colorful at all
         a. Iridescence of every color of the rainbow is caused by light refracting from specialized feathers, not by pigments (only pigment colors hummingbirds have are blackish to red, white is unpigmented)
         b. Angle of the light refracting from the feather will also alter the color so that the same feather appears to have a different color depending on the light
         c. Commonly, species are **sexually dimorphic** (adult males and females have different coloration so you can tell them apart)
   D. Mostly **nectarivores** (eat nectar) but supplement their diet as **insectivores** (eat insects)
   E. Become **torpid** at night (state of inactivity used to conserve energy - there is a reduction in body temperature and **metabolism** (the storing and releasing of energy in the body's cells))
   F. Huge metabolic rate

i. Use nectar for carbohydrates
ii. Laps at nectar, does not suck it up like a straw
iii. Eat insects for protein and fat
iv. Often consume more than half their total body weight in food and drink
v. Can also consume more than 8 times their weight in water

G. Unusual Flying Abilities
i. Due to the unique method of rotating the entire wing with little or no wrist or elbow flexing (horizontal figure 8 motion), they are able to fly forwards, backwards (the only birds that can do so), and hover for prolonged periods
ii. Rapid wingbeat (200 per second in the smaller species and 80 per second in forward flight)

H. Breeding
i. To attract females, hummingbirds of the southern hemisphere often congregate in large groups, or **leks**. This helps their often inaudible voices be heard by females.
ii. In the northern hemisphere, males often advertise solo.
iii. Males often use aerial stunts to attract females. The pattern of flight varies by species, and even among individuals.
iv. Males and females do not spend time together beyond what it takes to fertilize the eggs.
v. One male may mate with several females in a breeding season.

I. Nesting
i. In general, the nest is small, and cuplike. It is usually constructed of soft plant materials, and covered with lichens for camouflage.
ii. Most hummingbirds secure their nest to a branch using spiderwebs, but some suspend them, and some attach their nests to a large leaf.

J. Migration
i. Hummingbirds in general do not migrate
ii. Three exceptions to this are:
a. The rufous hummingbird: it breeds along the west coast from southern Alaska to inland southern California. It winters in southern Texas to mid Mexico.
b. The calliope hummingbird: breeds in the mountains of western North America from Southern Canada to northern Baja California. It winters in south-central Mexico.
c. The ruby-throated hummingbird (see migration section below)

2. Flower Pollination Overview
A. **Angiosperms** are the flowering plants. Their name means seeds that are enclosed in an ovary, in this case the fruit.
B. Angiosperms have **flowers** which are modified stems with leaves and other structures that are specialized for reproduction.
C. In order for reproduction in flowering plants to occur, there has to be **pollination** (when pollen is transferred from the anther to the stigma of a flower)
D. Plants use two methods of pollination
i. Wind pollination
a. In wind pollination, plants release large amounts of pollen into the air, and the wind carries them to the stigma.

b. Because wind is an imperfect vehicle of pollen transportation, lots of pollen is released so that at least a small percentage will have a better chance to land on the stigmas of other flowers of the same species
c. The pollens that cause people to suffer from allergies (ex. oak and ragweed) are mainly wind-borne pollens.

ii. Animal-aided pollination
a. In animal-aided pollination, and animal is the vector of pollen transfer.
b. Any nectar or pollen eating animal, from birds to kinkajous to bats, can potentially carry pollen from flower to flower.
c. The main kind of pollinator, however, is insects.

E. Plants have developed many ways to get animals to aid both in their fertilization and in seed dispersal
i. They offer food
a. **Nectar** - sugary liquid made by the plant, and that many animals, especially insects and hummingbirds, feed on heavily
- Flowers will only make so much nectar which insures that a hungry animal must visit several flowers to get all the nectar it wants
- When the animal goes for the nectar, pollen sticks to them, and as the animal goes to another flower, the pollen gets transferred

b. Pollen - some animals eat the pollen itself
- As the animal goes from flower to flower eating the pollen, inevitably, pollen will stick to them and gets transferred to the next plant

c. Fruit - all of us eat fruit
- Since the seeds are encased in the fruit we eat, we aid in seed dispersal
- Some seeds must actually pass through the digestive system of an animal before they will **germinate** (begin growing)

ii. They advertise their presence
a. Color
- Many insects see better in the violet range of the spectrum (ROY G BI**V**). Flowers which are blue, purple, or have high ultraviolet reflectant pigments are specialized to attract these insects.
- Red colors, on the other hand, have low ultraviolet reflectivity. This color is specialized to attract animals such as birds

b. Smell
- Some flowers smell sweet, signaling that they have nectar. These plants attract nectar eating insects such as bees or butterflies.
- Some flowers may smell like rotting flesh; these attract flies, beetles, and other scavengers.

c. Shape
- Flowers have to be a certain shape to accommodate insect pollinators. They have to have a "landing platform" so that the insect can land and rest while eating nectar or exploring the flower.
- If the plant does not use insects or other animals that need a landing platform, they won't have them.

F. Plant reproductive parts
    i. **Stamen**: male reproductive structure, 2 parts
        a. Long, stalk-like structure which is called the **filament** supports the **anther** which bears the pollen (see presentation)
    ii. **Pistil**: female reproductive structure, 3 parts
        a. **Stigma** is the flat surface that receives pollen during pollination; **style** is the tube connecting the stigma to the **ovary** which is the place of fertilization and seed development, and forms the fruit (see presentation)

G. When the pollen makes contact with the stigma, it develops a pollen tube.
    i. The plant sperm nuclei (there are 2) are carried in this tube, as it makes its way down the style into the ovules.
    ii. **Double fertilization** occurs: not only is the egg fertilized, but another set of cells is fertilized
        a. The fertilized egg produces a zygote, which develops into the plant embryo
        b. The second set of cells grows into what becomes the food that the embryonic plant uses while in the seed.

H. Plants usually only accept pollen from their own species.

3. Plant-Animal Coadaptation: a case study of a hummingbird and its flowering plant
    A. **Coadaptation** - the mutual influence of two different species interacting with each other and influencing each other's adaptations over time.
    B. The shape of the flower that a hummingbird visits and the shape of the hummingbird's bill are an example of coadaptation.
        i. Long, tubular flowers have **nectaries** (nectar producing structures) all the way at the bottom of the flower.
        ii. The hummingbird must insert its bill into the flower's tube.
        iii. The stamens of the flower are long, and project out of the flower.
        iv. When the hummingbird goes to lap up the nectar with its tongue, the pollen on the anthers rubs onto the hummingbird's forehead.
        v. The hummingbird goes from plant to plant, transferring pollen and fertilizing the flowers.

4. Trumpet Creeper/Ruby-Throated Hummingbird Coadaptation
    A. The only hummingbird native to South Carolina (and the Eastern US) is the Ruby-throated hummingbird (*Archilochus colubris*)
        i. The first hummingbird the English colonists came across was the ruby-throated hummingbird. The name "Hummingbird" came from the loud wing sounds this species makes during flight, although most hummingbirds do not have a loud wing sound.
            a. Click on the speaker icon in the presentation to listen to the wing sounds of the ruby-throated hummingbird
    B. The ruby-throated hummingbird's breeding and nesting range extends from southern Canada to Florida, and from the East Coast to mid Texas and the mid Dakotas. Birds have also been seen as far west as Utah and California. They prefer mixed woodlands; clearings or gardens must be present to provide adequate flowers for nectar.
    C. Physical characteristics
        i. Weight average 3.34g for females; 3.03g for males

ii. Males average 70mm and females average 90mm in total body length
iii. **Culmen** (exposed bill) length: average 19mm
iv. Coloration: Metallic green on its back, white on its belly; the males have a brilliant red throat

D. Diet
i. The ruby-throat's main carbohydrate source is from nectar that it collects from flowering plants.
ii. One of the main nectar sources is the trumpet creeper.
a. Other typical hummingbird flowers are: red buckeye, jewelweed, columbine, red morning-glory, wild bergamot, bee-balm, scarlet painted-cup, trumpet (or coral) honeysuckle, fly-honeysuckle, cardinal flower, royal catchfly, round-leaved catchfly, lilies, and scarlet sage (see teacher supplement for more information)
iii. The ruby-throated hummingbird is also an insectivore; it gets most of its protein from small flying insects or those caught in the flowers it feeds on.
iv. Most of the flowers that the ruby-throated hummingbird visits are red or orange, however, hummingbirds are curious and will visit any color flower until they find one with nectar.

E. Breeding
i. Males arrive to the breeding grounds 7 to 10 days before the females to establish breeding territories (along the eastern sea board in spring)
ii. Males use aerial acrobatics to attract a potential mate
iii. Males fly upwards about 15m, then dive down, pulling up at the last moment, making a giant "U" shape
a. The sound of the males' wings are especially loud and they vocalize (chirping sounds)
b. Click on the weblink in the presentation to hear the male vocalizations during breeding
iv. The females choose their mate, then leave to make their nests
v. Males will try to mate with more than one female, which is good because the ratio of males to females is skewed towards the females

F. Nesting
i. Oaks, maples, beech, birch, hornbeam, hemlock, poplar, hackberry, pine, and spruce are popular nesting trees.
ii. Nests are constructed 5-20 feet from the ground, and usually have some type of shade cover overhead.
iii. The nests are made of soft plant materials and are glued to the tree limb with spiderweb or pine resin.
iv. Nests are often covered with lichens for camouflage away from other nests.
v. Nest in April, laying 2 eggs, occasionally 1, rarely 3
vi. Young are **fledged** (they have developed flight feathers and are ready to leave the nest) in June
a. The best chance to see the birds during the standard school year is in late May or late August to early September

G. Migration
i. Ruby-throated hummingbirds arrive in their nesting locales all along the eastern seaboard in the spring, and usually leave by mid fall.

ii. They winter in warmer, tropical areas such as southern Florida and Mexico.
iii. They must store at least 2 grams of fat to make the 800 kilometer journey to Mexico

I. The ruby-throated hummingbird has many adaptations which allow it to get nectar from the trumpet creeper
   i. The ruby-throated hummingbird has a straight, long bill
      a. This is adapted to fit into the tubular flowers that it gets nectar from
   ii. The ruby-throated hummingbird's migration coincides with the flowering period of the trumpet creeper
   iii. The forehead of the ruby-throated hummingbird is a perfect angle and height to come into contact with the anthers and stigma of the trumpet creeper
   iv. The tongue of the ruby-throated hummingbird is long, and has a **bifurcated** (forked) ending
      a. A long tongue helps the ruby-throated hummingbird reach the nectar, which is in the base of the flower.
      b. A forked tongue has more surface area with which to draw nectar up
   v. The metabolism of the hummingbird is very high, so it prefers flowers that produce large amounts of nectar, which the trumpet creeper provides.

J. The Trumpet Creeper: *Campsis radicans*, Family Bigoniaceae, Order Scrophulariales
   i. Although the ruby-throated hummingbird can feed on many different flowers, the trumpet creeper flower is highly dependent on the ruby-throated hummingbird for pollination.
      a. Some bee pollination occurs, but hummingbirds account for the majority of pollinations.
      b. Unlike many flowers, the trumpet creeper cannot self-pollinate very well.
   ii. The trumpet creeper has many specialized adaptations for hummingbird pollination.
      a. The flowers produce no scent
         c. Scent production in flowers is mainly used to attract insect pollinators.
         d. Because the trumpet creeper does not want to attract insects, it does not produce a scent
      b. There is no landing platform
         e. Insects need a landing platform in order to feed on the nectar, for the most part, they cannot hover
         f. The ruby-throated hummingbird hovers while extracting nectar; it does not need a platform.
      c. The anthers and stigma are positioned so as to contact the forehead of the ruby-throated hummingbird.
         g. They are angled to point upwards.
         h. Although insects may come into contact with the anthers, they rarely touch the stigma. If they do, they usually only deposit the plant's own pollen.
      d. The color of the flower is dark orange
         i. Hummingbirds frequent red and orange flowers more than other colors

j. Red and orange colors are not obvious to bees and other insects; these colors blend with the background foliage. Because insects rely on ultraviolet reflectivity to find flowers, and red has such low ultraviolet reflectivity, insects cannot "see" red.
k. Birds, on the other hand, see red very well, and learn to associate this color with lots of nectar.

e. The flowers produce a high concentration of nectar which the hummingbird needs to survive

7. Procedures:

1. Introduction to the Topic:
   A. Use the PowerPoint presentation to introduce the students to hummingbirds, pollination, and co-adaptation.
2. Teacher Directed Discussion:
   A. Discuss what the students previously knew about hummingbirds and the different mechanisms flowers use to attract pollinators.
   B. Discuss what characteristics a hummingbird would look for in a flower.
   C. Discuss what a flower needs to attract a hummingbird as a pollinator.
   D. Discuss the relationship between the trumpet creeper and the ruby-throated hummingbird described under "Background Information."
   E. After the quiz, discuss why the flowers shown would or would not be pollinated by hummingbirds.
3. Equipment and Skills Demonstration
   A. Show the students how to look up reference books in the library, how to do an online search, which websites are more reputable than others (i.e. .gov, .edu, .org, or a website that has references listed)
   B. Show the students how to cite their resources
4. Student Activity:
   A. Independent Practice
      i. Have each student write down the answers to their quiz.
      ii. Have the students research 5 plants that will 1) attract hummingbirds and 2) will grow in a South Carolina garden.

8. Differentiation of Instruction

1. Gifted and talented students can access Web sources from the recommended list to enrich their learning experience.

9. References

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USDA-Natural Resource Conservation Service, Wildlife Habitat Management Institute, Wildlife Habitat Council. 1999. Ruby-throated Hummingbird (Archilochus colubris) Fish and Wildlife Habitat Management Leaflet no. 14.

10. Additional Resources

Web Sources:

http://www.rubythroat.org
http://www.birds-n-garden.com/hummingbirds_crafts.html Make your own feeder
http://www.botgard.ucla.edu/html/MEMBGNewsletter/Volume3number3/Hummingbirds.html Why do humming birds hum?
http://www.enature.com/guides/select_group.asp online field guide
http://www.fcps.k12.va.us/StratfordLandingES/Ecology/mpages/ruby-throated_hummingbird.htm (listen to hummingbird vocalizations)
http://plants.usda.gov/ Online plant database with public domain pictures
http://www.scwf.org South Carolina Wildlife Federation—gardening resources
http://business.clemson.edu/LFLearn/ Resources for gardening at your school
http://www.math.sunysb.edu/~tony/birds/hummingbird.html (wing sound recordings)