



## *Galapagos Finches: Evolution in a Nutshell*

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Thank you for participating in the Virtual Outreach Program at Michigan State University Museum. Please perform the pre-fieldtrip tasks described below, prior to the virtual fieldtrip. Enclosed with this teacher package are a student handout and the seeds students will use during the program. In the pages that follow, we have assembled resources that we thought would be useful for you in getting ready for this virtual fieldtrip. You will find detailed instructions about the tasks that must be performed before the virtual field trip begins, useful information about the program, curriculum benchmarks addressed by the fieldtrip, a jeopardy game designed by our team to assess students following the fieldtrip, and suggestions of follow-up activities to reinforce the concepts discussed in the fieldtrip.

Our IP address is **35.8.122.60**. If you have any questions, please feel free to get in touch with us at [virtualoutreach@museum.msu.edu](mailto:virtualoutreach@museum.msu.edu) or call us at (517) 353-3882. We are looking forward to the fieldtrip with you and your class!

This program is a LADDERS program: LADDERS is a platform that exercises inquiry-based science teaching. This is done using virtual fieldtrips where students are exposed to museum resources that connect them to real science and real scientists. Using videoconferencing technology, you and your students have the opportunity to visit Michigan State University Museum, a Smithsonian Affiliate and Michigan's largest natural history/cultural museum. Learn more about LADDERS on our website! (<http://laddersprogram.org>).

### Materials you need for the virtual field trip:

The following supplies will help make the virtual trip a successful experience for your students:

- Pliers of various sizes (1 per student): we find it easiest to ask students to each bring 2 pairs of pliers from home. Although students only need 1 pair of pliers per student, the extras will help for students that forget to bring any. This also allows students to have a variety of pliers of all sizes and shapes (the more variation, the better for the success of the program). It is crucial that each student has a pair of pliers for the activity.
- 1 tablespoon, 1 teaspoon, 1 ½ teaspoon, and 1 ¼ teaspoon for the educator to prepare the seed plates before the activity
- Copies of the student handout (1 per student)
- Paper plates (1 per pair of students)
- Paper cups (1 per student)

### Preparations for the virtual field trip:

The program is most successful if you can prepare the seed plates that the students will use in this program before we start. This should take you less than 10 minutes. Students will carry out 2 activities during the program. For each activity, students will work in pairs, with each pair sharing 1 paper plate that contains seeds. We provided enough seeds in your package to make 15 plates for each activity (thus, 30 students can participate). We have included in this package 5 Ziplocs, each containing a different variety of seeds.

- For the 1<sup>st</sup> activity, prepare 15 plates following these proportions: on each plate, place 1 tablespoon of sunflower seeds, 1 teaspoon of thistle seeds, 1 teaspoon of millet seeds, ½ teaspoon of amaranth seeds, and ¼ teaspoon of poppy seeds
- For the 2<sup>nd</sup> activity, prepare 15 plates following these proportions: on each plate, place a few sunflower seeds (less than 5), no thistle seeds, a few millet seeds (less than 5), ¼ teaspoon amaranth seeds, and ¼ teaspoon poppy seeds.

Before the program starts, you can group the students in pairs, and make sure that each student has one handout, a pair of pliers and a paper cup, and that each pair has one plate for the 1<sup>st</sup> activity.

### Brief summary of the activity:

In this program, students will learn about evolution and natural selection by completing an inquiry-based activity. This activity mimics the findings of the research on the Darwin finches in the Galapagos, using pliers to replicate bird beaks, and various seeds as their food source. Students will act as birds with their pliers, and will compete with their classmates for access to food. Students will witness evolution in action, and see how changes in the environment can lead to changes on the population beak size.

### Objectives: Student will

- Develop a sense of inquiry
- Understand the process of natural selection
- Understand the value of variation in nature
- Use an inquiry approach to understand evolution
- Be connected to real science, real scientists, and real specimens
- Learn about and construct histogram graphs

### Michigan Science Curriculum benchmarks addressed by this fieldtrip:

Discipline 1: Science Processes (S)

Standard: Inquiry Process (IP)

Standard: Inquiry Analysis and Communication (IA)

Standard: Reflection and Social Implications (S.RS)

Discipline 3: Life Science (L)

Standard: Heredity (HE)

Standard: Evolution (EV)

Standard: Ecosystems (EC)

(see next page for a detailed outline of the benchmarks addressed for each grade level)

## **Michigan Science Curriculum Benchmarks addressed by this field trip**

### **GRADE 5 – MICHIGAN SCIENCE CURRICULUM BENCHMARKS**

#### **Discipline 1: Science Processes (S)**

##### **Standard: Inquiry Process (IP)**

- S.IP.05.11: Generate scientific questions based on observations, investigations, and research
- S.IP.05.12: Design and conduct scientific investigations
- S.IP.05.13: Use tools and equipment appropriate to scientific investigations
- S.IP.05.14: Use metric measurements devices in an investigation
- S.IP.05.15: Construct charts and graphs from data and observations
- S.IP.05.16: Identify patterns in data

##### **Standard: Inquiry Analysis and Communication (IA)**

- S.IA.05.11: Analyze information from data tables and graphs to answer scientific questions
- S.IA.05.12: Evaluate data, claims, and personal knowledge through collaborative science discourse
- S.IA.05.13: Communicate and defend findings of observations and investigations using evidence
- S.IA.05.14: Draw conclusions from sets of data from multiple trials of a scientific investigation

##### **Standard: Reflection and Social Implications (S.RS)**

- S.RS.05.11: Evaluate the strengths and weaknesses of claims, arguments, and data
- S.RS.05.12: Describe the limitations in personal and scientific knowledge
- S.RS.05.13: Identify the need for evidence in making scientific decisions
- S.RS.05.17: Describe the effect humans and other organisms have on the balance in the natural world

#### **Discipline 3: Life Science (L)**

##### **Standard: Heredity (HE):**

- L.HE.05.11: Explain that the traits of an individual are influenced by both environment and genetics

##### **Standard: Evolution (EV)**

- L.EV.05.11: Explain how behavioral characteristics of animals help them to survive in their environment
- L.EV.05.12: Describe the physical characteristics of organisms that help them survive in their environment.

### **GRADES 6 AND 7 – MICHIGAN SCIENCE CURRICULUM BENCHMARKS**

#### **Discipline 1: Science Processes (S)**

##### **Standard: Inquiry Process (IP)**

- S.IP.06/7.11: Generate scientific questions based on observations, investigations, and research
- S.IP.06/7.12: Design and conduct scientific investigations
- S.IP.06/7.13: Use tools and equipment appropriate to scientific investigations
- S.IP.06/7.14: Use metric measurement devices in an investigation
- S.IP.06/7.15: Construct charts and graphs from data and observations
- S.IP.06/7.16: Identify patterns in data

##### **Standard: Inquiry Analysis and Communication (IA)**

- S.IA.06/7.11: Analyze information from data tables and graphs to answer scientific questions
- S.IA.06/7.12: Evaluate data, claims, and personal knowledge through collaborative science discourse
- S.IA.06/7.13: Communicate and defend findings of observations and investigations using evidence
- S.IA.06/7.14: Draw conclusions from sets of data from multiple trials of a scientific investigation

##### **Standard: Reflection and Social Implications (S.RS)**

- S.RS.06/7.11: Evaluate the strengths and weaknesses of claims, arguments, and data
- S.RS.06/7.12: Describe the limitations in personal and scientific knowledge
- S.RS.06/7.13: Identify the need for evidence in making scientific decisions
- S.RS.06/7.17: Describe the effect humans and other organisms have on the balance of the natural world

#### **Discipline 3: Life Science (L)**

##### **Standard: Ecosystems (EC)**

- L.EC.06.23: Predict how changes in one population might affect other populations based upon their relationships in the food web

Although specific benchmarks for grades 8-10 are not specified here, we highly recommend this program for high-school level biology students.

**Resources for teachers**  
**Galapagos Finches: Evolution in a Nutshell**

**Activities designed by LADDERS that can help reinforce the concepts of the program:**

- **Watch the video “Meet the scientists”** to meet a researcher, Dr. McAdam, who works on evolution at Michigan State University. Dr. McAdam is interviewed by a middle-school student who asks the scientist some questions.  
Watch this video directly from the TeacherTube website, at this link:  
[http://www.teachertube.com/view\\_video.php?viewkey=bb0dc014f73da6bb04dc](http://www.teachertube.com/view_video.php?viewkey=bb0dc014f73da6bb04dc)
- **Let students ask questions directly to scientists on our discussion blog!** This internet bulletin board allows students to post their own questions, participate in ongoing discussions, see questions and comments from other middle school students that also participated in this activity. We also encourage any educators to use this to connect with other teachers and provide us with feedback. Scientists studying evolution will answer the students questions so that the students are directly in contact with real science!  
Log in at: <http://laddersprogram.blogspot.com/>
- **Play the Termite Jeopardy Game!** (located on pages 10-12 of this teacher package)  
This game was developed by our LADDERS team to evaluate how well the students understood the concepts presented specifically in this program. The game follows the general rule of a jeopardy game, and includes questions of varying difficulties about designing experiments, termite behavior, and insect communication. You can post your class’s results on the blog discussion group and compete with other schools! We also have an interactive Powerpoint version of this jeopardy game available on our website (<http://laddersprogram.org>) that you can download!

**Ideas for other activities that are linked to this program:**

- Examine variations in nature: talk about variation in birds; go bird watching with the students in the school’s yard (variation can be of beak, but also coloration, size, etc)
- Learn about inheritance/heritability in genetics
- Let the students read some of the articles provided, which present evolution for children
- Geography lesson on where the Galapagos are located using Google Earth
- Install several bird feeders next to the classroom’s windows, and place different types of seeds in each feeder. Let the students observe what kinds of birds feed on each type of seeds, what types of beak is necessary to feed on different seeds, etc.
- Learn about other research happening on the Galapagos (see websites provided below)
- Link this lesson with 4 other lesson plans that have been developed about the Galapagos Islands specifically (which content involve social studies, conservation biology, sciences and art); those lesson plans are aimed specifically at middle-school students:  
[http://www.pbs.org/safarchive/5\\_cool/galapagos/g55\\_contest.html](http://www.pbs.org/safarchive/5_cool/galapagos/g55_contest.html)
- Check out the Galapagos Education website (<http://pubs.nsta.org/galapagos>), which has additional activities designed for middle-school students

## Additional Resources on Evolution for students

**Book:** “Darwin and Evolution for Kids: His Life and Ideas”  
Written By: Kristan Lawson (\$11.55 on Amazon.com)

**Video:** Bill Nye Episode 46: Evolution  
Info: [billnye.com/episode-pdfs/episodeguide46.pdf](http://billnye.com/episode-pdfs/episodeguide46.pdf)

### **Webpages**

<http://science.howstuffworks.com/evolution.htm>

Overview of evolution geared towards middle-school students; includes lots of pictures, diagrams, animations,

[www.brainpop.com/science/populationsandecosystems/naturalselection/](http://www.brainpop.com/science/populationsandecosystems/naturalselection/)

Has a science cartoon about natural selection aimed for middle-school students  
The website requires you to sign in (click on Free Registration trial at the bottom of the page; this is a free 5-day promotion that only requires your name and email to work)

Once logged in, you only need to click on the main screen “Click here to play the movie”.

<http://www.yesmag.ca/PDFs/Climate.pdf>

This is a magazine article from YesMag (issue June/July 2003) aimed at middle school students that illustrate the importance of natural selection, and talks about evolution in the context of global warming. The article has many pictures and depicts real science done by Dr. McAdam’s research team.

You will need Adobe Acrobat (free program on the internet) to open this article

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Note: The following 4 pages include additional background information for educators interested in learning more about evolution and natural selection.

**Background on Evolution (Written for Educators):**

(This was written by Irene Salter: <http://www.mysciencebox.org>)

Perhaps the most important idea in all of biology, or perhaps all of science, is the idea of evolution through natural selection. This idea by Charles Darwin provides the foundation of all of current scientific thinking in life science. What is evolution? Quite simply, evolution is descent with modification. This includes both the idea that the frequency of a gene will change in a population over time as environmental conditions change and also the idea that new species descend from common ancestors over many generations. Ultimately, evolution can explain the vast diversity of life on this planet and the idea that all life on Earth shares a common ancestor.

Although there are many mechanisms for organisms to change over time, the most important of these is natural selection. It works in this way:

- There is **variation** in a population. Different individuals have different traits.
- There is **heredity**. Traits can be passed on from parent to offspring through our genes.
- There is **competition** so that some individuals survive and reproduce more than others.
- The end result is **natural selection** – the individuals with the traits that best fit the environment are most likely to survive, reproduce, and pass on their traits to the next generation. In this way, future generations, when viewed at the level of an entire population, will have more advantageous traits and fewer disadvantageous traits compared to their parents.

There are many other mechanisms for evolutionary change besides natural selection:

- *Artificial selection* is a common practice for humans to breed together plants or animals with the most advantageous traits (the sweetest tomato, the most loyal dog, the fastest horse, etc.). Thus, future generations will have more of these traits.
- *Mutation* can affect the distribution of traits by introducing a new trait to a population.
- *Migration* can rapidly change the overall distribution of traits in a population when a group of organisms with different traits enters a new area.
- *Genetic drift* can affect a population through a random chance event – like a hurricane or human activity – randomly destroying organisms with one trait but not another. For instance, when a new house is constructed in a neighborhood with both red and brown ground squirrels, it accidentally bulldozes the nest of the largest red ground squirrel family. Suddenly, brown ground squirrels predominate.

A final important term that is often misused by students is **adaptation**. An adaptation is a trait that is very well suited to a given environment that has, through natural selection, increased in the population over many generations. Students often talk and think about adaptation as if an organism can try to adapt or is able to get what it needs. In neither case are they correct. An organism can't get the genes it needs to survive by "trying"; it either has the genes or not. Similarly, natural selection doesn't have a goal in mind and cannot give a creature what it "needs"; either the genes are there in the population or not.

### Summary of the Grants' research:

(written by: <http://www.pbs.org/wgbh/evolution>)

Few people have the tenacity of ecologists Peter and Rosemary Grant, willing to spend part of each year since 1973 in a tent on a tiny, barren volcanic island in the Galapagos. Even fewer would have the patience to catch, weigh, measure, and identify hundreds of small birds and record their diets of seeds.

But for the Grants, the rewards have been great: They have done nothing less than witness Darwin's theory of evolution unfold before their eyes. That would have stunned Darwin, who thought natural selection operated over vast periods of time and couldn't be observed.

L In their natural laboratory, the 100-acre island called Daphne Major, the Grants and their assistants watched the struggle for survival among individuals in two species of small birds called Darwin's finches. The struggle is mainly about food -- different types of seeds -- and the availability of that food is dramatically influenced by year-to-year weather changes.

A The Grants wanted to find out whether they could see the force of natural selection at work, judging by which birds survived the changing environment. For the finches, body size and the size and shape of their beaks are traits that vary in adapting to environmental niches or changes in those niches. Body and beak variation occurs randomly. The birds with the best-suited bodies and beaks for the particular environment survive and pass along the successful adaptation from one generation to another through natural selection.

D Natural selection at its most powerful winnowed certain finches harshly during a severe drought in 1977. That year, the vegetation withered. Seeds of all kinds were scarce. The small, soft ones were quickly exhausted by the birds, leaving mainly large, tough seeds that the finches normally ignore. Under these drastically changing conditions, the struggle to survive favored the larger birds with deep, strong beaks for opening the hard seeds. Smaller finches with less-powerful beaks perished. So the birds that were the winners in the game of natural selection lived to reproduce. The big-beaked finches just happened to be the ones favored by the particular set of conditions Nature imposed that year.

R Now the next step: evolution. The Grants found that the offspring of the birds that survived the 1977 drought tended to be larger, with bigger beaks. So the adaptation to a changed environment led to a larger-beaked finch population in the following generation.

S Adaptation can go either way, of course. As the Grants later found, unusually rainy weather in 1984-85 resulted in more small, soft seeds on the menu and fewer of the large, tough ones. Sure enough, the birds best adapted to eat those seeds because of their smaller beaks were the ones that survived and produced the most offspring.

Evolution had cycled back the other direction.

### **Want to know more about evolution? Good resources on Evolution for Educators**

Check out these two outstanding sites that explains evolution for teachers and educators! Both sites contain lots of additional resources, including video clips for students and hands-on activities:

<http://evolution.berkeley.edu/>

<http://www.pbs.org/wgbh/evolution>

Or read a full account of the story and research of the Grants in the Galapagos written by **Jonathan Weiner** for a general public: “**The beak of the finch**”

Or check out this neat magazine article online:

<http://www.nwf.org/nationalwildlife/article.cfm?issueID=75&articleID=1075>

This is a magazine article from the National Wildlife Federation aimed for adults that illustrate the research done by Dr. McAdam’s team. The article addresses the importance of natural selection in the light of global warming. We recommend this article for teachers.

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## Useful definitions for Educators

All definitions were obtained on the Berkeley evolution website (<http://evolution.berkeley.edu/>) or from biology-online.org website.

**Adapt:** To undergo natural selection so that members of a population are, on average, better able to survive and reproduce.

**Adaptation:** A feature produced by natural selection for its current function.

**Common Ancestor:** Ancestral organism shared by two or more descendent lineages; in other words, an ancestor that they have in common. For example, the common ancestors of two biological siblings include their parents and grandparents; the common ancestors of a coyote and a wolf include the first canine and the first mammal.

**Competition:** The use of the same limited resources by two or more species. The relationship occurs when commodities (like food, mate, shelters, etc) are scarce and there are not enough to go around for all members that need them.

**Conspecifics:** Of the same species; for instance, three individuals of the same species are conspecifics.

**Fitness:** A genotype's success at reproducing (the more offspring the genotype leaves, the higher its fitness). Fitness describes how good a particular genotype is at leaving offspring in the next generation relative to other genotypes.

**Genetic Variation:** Genetic diversity in a population; natural differences between living things caused by genetic and environmental factors.

**Genotype:** The set of genes an organism has.

**Heritability:** The proportion of phenotypic variation in a population that is attributable to genetic variation among individuals. Variation among individuals may be due to genetic and/or environmental factors

**Natural Selection:** Differential survival or reproduction of different genotypes in a population leading to changes in the gene frequencies of a population.

**Niche:** The part of the environment occupied by a particular species along with the resources it uses and produces. A species' niche includes such factors as energy consumed, time of consumption, space occupied, temperature required, mode of reproduction, and behavior.

**Phenotype:** The physical features of an organism. Phenotype may refer to any aspect of an organism's morphology, behavior, or physiology. An organism's phenotype is affected by its genotype and by its environment.

**Selection:** Placing organisms under conditions where the growth of those with a particular phenotype will be favored.

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**JEOPARDY GAME!**  
**Galapagos Finches: Evolution in a Nutshell**

Instructions to set up the game:

- Draw a jeopardy board on the chalkboard by making a 5-column X 6-row grid. There are 5 categories with 5 questions each, plus category headers. Write “100, 200, 300” and so on down the grid.

Example of a grid to draw on the board:

Science Talk	Evolution in a Nutshell	Cool Facts	Live or Die	Adaptations around us
100	100	100	100	100
200	200	200	200	200
300	300	300	300	300
400	400	400	400	400
500	500	500	500	500

Instructions to play the game:

- Split up class into smaller groups or “teams” (4 students per team is ideal)
- Randomly choose one team to start. This team gets to pick a category and question in that category (100, or 200, etc). The number for each question of a category corresponds to the number of points the team that correctly answers the question would win.
- Read the chosen question aloud. All teams can participate. The first team to raise their hands gets to answer the question first. If the first team answers incorrectly, another team can try to answer (again, the first team to raise their hands). The team that answers the question correctly gets to pick the next question. We suggest you erase the box each time a question is answered.
- Keep track of points for each team on the board. We suggest to only add points for getting the correct answer, not to deduct points for getting an answer wrong.
- After all questions have been answered, students get to answer the final jeopardy question. Write this question on the board, and all groups have 2 minutes to write down the answer on a piece of paper. All groups that answer correctly receive an additional 700 points

**Have fun!**

## Evolution Jeopardy Questions

### **Category: Science Talk**

100. This subject studies how information is passed from parents to kids in genes.  
Q: What is genetics?
200. This scientist is famous for his work on evolution.  
Q: Who is Charles Darwin?
300. The process where good traits become more common in the next generation, and bad traits less common.  
Q: What is natural selection?
400. Variability, heritability and selection are all required in order for this to occur.  
Q: What is evolution (or natural selection)?
500. The number of surviving offspring an animal has in its lifetime.  
Q: What is fitness?

### **Category: Evolution in a Nut Shell**

100. The islands off the coast of South America that are visited by scientists who study evolution.  
Q: What are the Galapagos Islands?
200. This island has a large crater in its middle.  
Q: What is Daphne Major Island?
300. This animal has been studied for evolutionary changes on Daphne Major.  
Q: What is the finch?
400. This part of the bird has a lot of variation and is used in evolution studies.  
Q: What is the beak?
500. Birds with this beak size are better suited for dry conditions because they can crack open the harder seeds.  
Q: What are birds with larger beaks?

### **Category: Cool Facts**

100. Its age is 4.5 billion years!  
Q: What is Earth?
200. Our DNA is 99.4% in common with this animal.  
Q: What is a chimp?
300. What's left behind of animals and plants that can be as old as 3,500,000,000 years.  
Q: What are fossils?
400. The molecule storing your genetic information that reaches from here to the moon if stretched out.  
Q: What is DNA?
500. More than 90% of our bodies are made of this.  
Q: What are bacteria?

**Category: Live or Die**

100. A group of organisms capable of breeding with each other.  
Q: What is a species?
200. When a species is eliminated.  
Q: What is extinction?
300. Differences in animals causing some to look different than others.  
Q: What is variation
400. An animal's ability to change to its surroundings.  
Q: What are adaptations?
500. Resources are limited. As a result, all members do this to survive.  
Q: What is competing for resources?

**Category: Adaptations Around Us**

100. An animal with a well adapted neck for eating leaves off the tall trees.  
Q: What is a giraffe?
- 200: An animal whose stripes help confuse predators.  
Q: What is a zebra?
- 300: This animal's large feather display scares away predators because their feather spots look like eyes.  
Q: What is a peacock?
- 400: This animal is able to change its color to its surroundings to help blend in with the environment.  
Q: What is a chameleon?
- 500: These animals have spines growing from their backs in order to protect them.  
Q: What is a hedgehog (or porcupine!)

**Final Jeopardy: 700 points**

Name two of the three things that are necessary in order for evolution to occur.

Answer: Students get the points if they cite 2 of the following 3 requirements:

1. Variation
2. Heritability
3. Selection

This game was designed by the LADDERS team