Lab 20. Descent With Modification and Embryonic Development: Does Animal Embryonic Development Support or Refute the Theory of Descent With Modification?

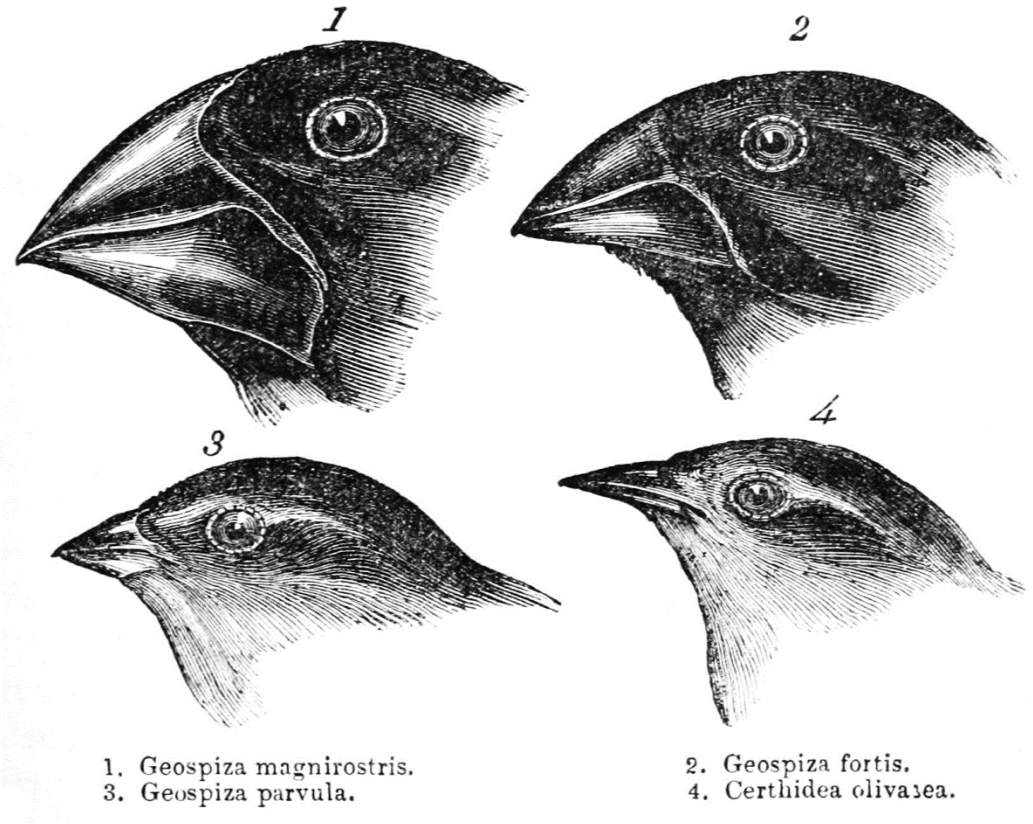
Introduction

One of Charles Darwin's most revolutionary ideas was that all living things are related. According to Darwin, all organisms found on Earth are related to each other because they all share a common ancestor. He argued that this common ancestor lived on Earth sometime in the distant past but is now extinct. All living things, as a result, share many of the same features, and the differences we see in organisms are simply the result of gradual modifications to these features over long periods of time.

Darwin first came to this conclusion by examining similarities and differences in the traits of closely related animals, such as the beaks of the Galápagos finches in Figure L20.1. To explain the similarities in the beaks of these birds, Darwin suggested that the birds were all the descendants of the same ancestor that originally colonized the Galápagos Islands, and the differences in their beaks were simply the result of gradual modifications in beak shape over many generations. The modifications in beak shape made the birds better adapted to survive in a particular environment. He called this theory *descent with modification*. He argued that natural selection, over time, could slowly select for or against slight variations in the basic shape of the beaks of the birds. This selection process would gradually result in some birds with thick beaks that are able to crack nuts and some birds with narrow beaks that are able to pick insects out of the bark of trees.

FIGURE L20.1

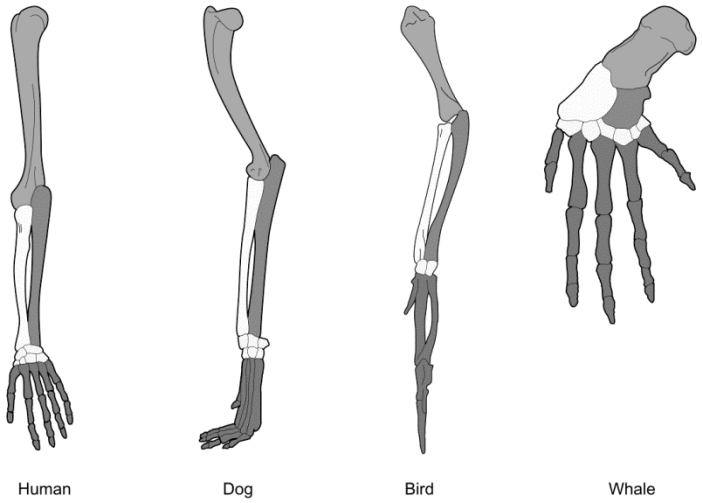
Differences in the beaks of finches found in the Galápagos Islands (Darwin 1845)



The theory of descent with modification can also be used to explain the existence of *homologous structures*, such as the limbs of the four animals in Figure L20.2. Homologous structures are parts of organisms that have similar components even though they may have very different functions. To explain the similar bone structure in these animals, Darwin once again argued that these animals share a common ancestor that had a limb that consisted of a humerus, an ulna, a radius, and carpals and that the observed differences in structure are simply the result of the process of natural selection. Over time, the process of natural selection gradually changed the shape of individual bones but did not completely change the basic layout of the limb. This selection process eventually resulted in whale fins and bird wings that had fingers similar to the fingers of a human or dog. These variations in structure would give their owners an advantage in a particular environment, such as the air in the case of the bird or the ocean in the case of the whale.

FIGURE L20.2

Examples of homologous structures: the limbs of a human, dog, bird, and whale



An important principle of descent with modification is that two closely related species will have more features in common than two species that are not as closely related. For example, two species of bird will have more features in common than a bird and an amphibian. Closely related species have more features in common because they shared a common ancestor in the more recent past. More time gives natural selection more opportunities to modify features or to produce new features in each independent lineage.

The theory of descent with modification can explain many different observations, such as adaptations and homologous structures, which is one of the main criterion scientists use to evaluate the merits of a scientific theory. However, like all theories in science, the principles of descent with modification must be tested in many different ways before it can be considered valid or acceptable by the scientific community. In this investigation, you will therefore test this theory by examining the process of embryo development in animals to determine if it is consistent with the major principles of descent with modification.

Reference

Darwin, C. 1845. *Journal of researches into the natural history and geology of the countries visited during the voyage of H.M.S. Beagle round the world, under the Command of Capt. Fitz Roy, R.N.* 2nd ed. London: John Murray.

Your Task

Collect data about the embryonic development of eight different animals. Then use the data you collect to test the theory of descent with modification.

The guiding question of this investigation is, **Does animal embryonic development support or refute the theory of descent with modification?**

Materials

Your teacher will provide you with a set of the following images that can be used during your investigation:

- Images of amphibian (frog) embryo development
- Images of bird (fieldfare) embryo development
- Images of bird (quail) embryo development
- Images of fish (zebrafish) embryo development
- Images of mammal (bat) embryo development
- Images of mammal (mouse) embryo development
- Images of reptile (snake) embryo development
- Images of reptile (turtle) embryo development

Safety Precautions

Follow all normal lab safety rules.

Investigation Proposal Required? ☐ Yes ☐ No

Getting Started

All animals begin life as a single cell. This single cell then starts to divide and becomes an embryo. As the cells continue to divide, specific structures such as organs and limbs begin to take shape. The embryo eventually starts to look more and more like the animal it will become as it changes and grows in size. Biologists have been studying the process of embryo development in animals since the 19th century. We therefore know a lot about what animal embryos look like as they develop and grow over time.

To answer the guiding question, you will need to compare and contrast the process of embryo development for eight different animals. You will be supplied with 10 embryo images for each animal. The images represent specific embryonic development milestones. You must determine what type of data you need to collect from these images, how you will collect it, and how you will analyze it. To determine *what type of data you need to collect*, think about the following questions:

- What would you expect the process of embryo development to look like in these eight different animals if they shared a common ancestor? What would it look like if they did not share a common ancestor?
- Which animals are more closely related to each other?
- Which characteristics of the embryo will you examine?
- How many different characteristics of the embryos will you need to examine?

To determine *how you will collect the data*, think about the following questions:

- How will you quantify differences and similarities in embryos?
- How will you make sure that your data are of high quality?
- What will you do with the data you collect?

To determine *how you will analyze your data*, think about the following questions:

- How will you compare and contrast the various embryos?
- What type of graph or table could you create to help make sense of your data?

Connections to Crosscutting Concepts, the Nature of Science, and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

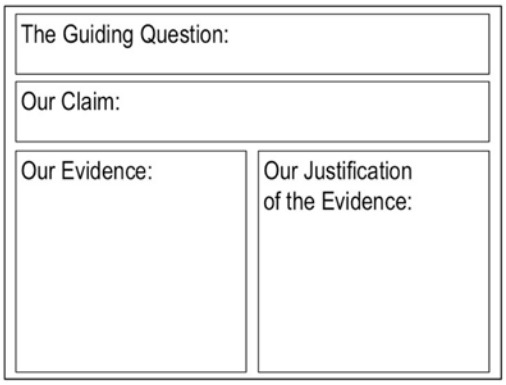
- the importance of looking for patterns in nature,
- the relationship between structure and function in nature,
- how science as a body of knowledge develops over time, and
- the different types of methods that scientists use to answer questions.

Initial Argument

Once your group has finished collecting and analyzing your data, you will need to develop an initial argument. Your argument must include a claim, evidence to support your claim, and a justification of the evidence. The claim is your group's answer to the guiding question. The evidence is an analysis and interpretation of your data. Finally, the justification of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L20.3.

FIGURE L20.1

Argument presentation on a whiteboard



Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations one at a time to listen to and critique the arguments developed by their classmates. This is similar to how scientists present their arguments to other scientists at conferences. If you are responsible for critiquing your classmates' arguments, your goal is to look for mistakes so these mistakes can be fixed and they can make their argument better. The argumentation session is also a good time to think about ways you can make your initial argument better. Scientists must share and critique arguments like this to develop new ideas.

To critique an argument, you might need more information than what is included on the whiteboard. You will therefore need to ask the presenter lots of questions. Here are some good questions to ask:

- What did your group do to analyze the data? Why did your group decide to analyze it that way?
- What other ways of analyzing and interpreting the data did your group talk about?
- Why did your group decide to present your evidence in that way?
- Why did your group abandon the other explanations?
- How sure are you that your group's claim is accurate? What could you do to be more certain?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your initial argument. Your group might need to gather more data as part of this process. Remember, your goal at this stage of the investigation is to develop the best argument possible.

Report

Once you have completed your research, you will need to prepare an investigation report that consists of three sections that provide answers to the following questions:

1. What question were you trying to answer and why?
2. What did you do during your investigation and why did you conduct your investigation in this way?
3. What is your argument?

Your report should answer these questions in two pages or less. The report must be typed, and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid!