

# Lab 27. Whale Evolution: How Are Whales Related to Other Mammals?

## Introduction

You have learned about the different categories of large molecules that play an important role in the bodies of organisms. One category of large molecule is called protein. A protein is made up of a chain of amino acids, and a specific gene determines the sequence of amino acids in the chain. Enzymes are examples of proteins that are very important to the function of an organism, and these proteins have very specific structures.

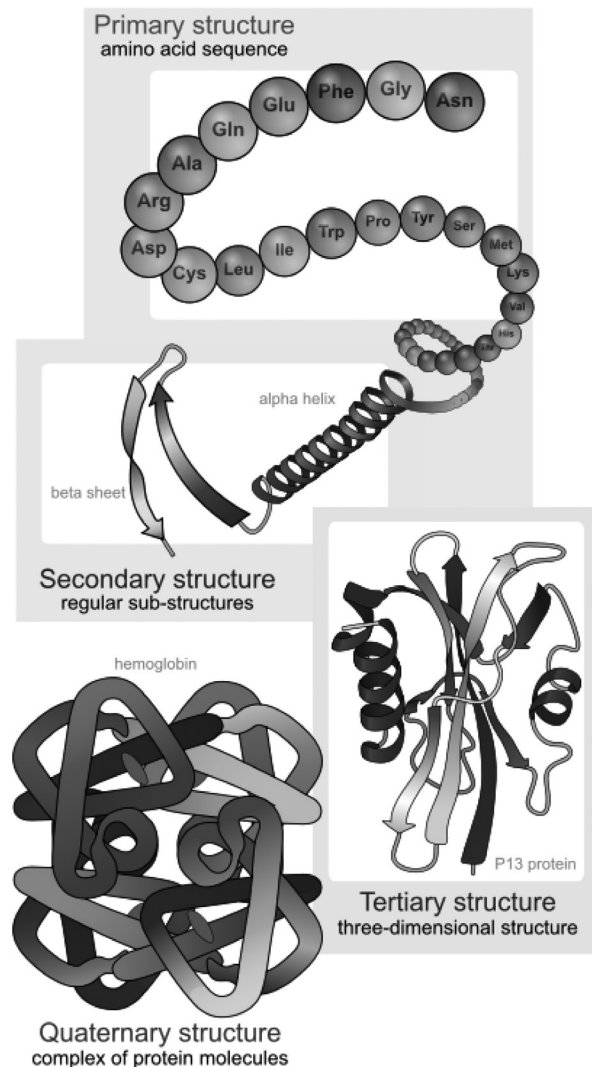
Scientists are often interested in the amino acid sequence of proteins for a number of reasons. Scientists, for example, often want to identify the amino acid sequence of a protein because the sequence determines the structure of a protein (see the figure to the right). Scientists can also use amino acid sequences to examine evolutionary relationships, because all life on Earth shares a common ancestor.

The central idea of biological evolution is that through a process of descent with modification, the common ancestor of all life on Earth gave rise to the biodiversity we see today (see the figure on the bottom right). This idea is important in biology because it enables scientists to study the evolutionary history of life on Earth. The process of descent with modification, for example, suggests that two species that diverged from one another relatively recently in the history of life on Earth will share more genetic similarities than two species that diverged from one another further back in time. Species that share many genetic similarities, as a result, are considered to be more closely related than two species that have many differences. Scientists, therefore, can compare an amino acid sequence for a specific protein to determine the evolutionary history of a group of organisms. In this investigation you will use an online database called UniProt that contains information about amino acid sequences to determine how whales are related to other mammals.

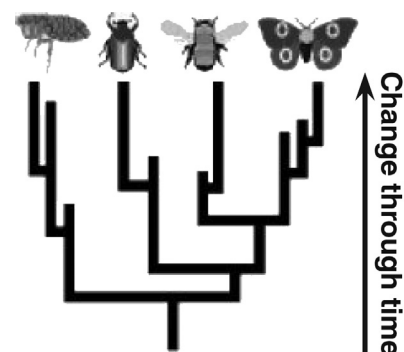
## Your Task

Use the UniProt online database to examine the amino acid sequence for a protein found in all mammals. The protein you will examine is called hemoglobin subunit alpha (HBA); it enables red blood cells to transport oxygen. You will then choose several mammals that you think may be closely related to whales and use the UniProt database to create a phylogenetic tree that illustrates the evolutionary history of this group of mammals based on similarities and differences in the amino acid sequence of the HBA protein. You will then need to explain (1) how whales are related to other mammals and (2) how the phylogenetic tree you created supports your claim.

## Protein structure levels



## Descent with modification



The guiding question of this investigation is, **How are whales related to other mammals?**

## Materials

You will use the following materials during your investigation:

- An online database called UniProt, which can be accessed at *www.uniprot.org*
- Mammal Classification Fact Sheet

## Safety Precautions

1. Use caution when working with electrical equipment. Keep away from water sources in that they can cause shorts, fires, and shock hazards. Use only GFI-protected circuits.
2. Wash hands with soap and water after completing this lab.
3. Follow all normal lab safety rules.

## Getting Started

To answer the guiding question, you will need to use the UniProt database. This database is a collection of amino acid sequences that have been submitted by scientists from all over the world, and it is free for anyone to use. You will use this database to examine the HBA amino acid sequence found in whales and then compare it with the HBA amino acid sequence found in other mammals.

Once you access the UniProt database, follow these directions:

- In the “Query” box at the top of the page type in “HBA Whale” and click “Search.”
  - Click on the first box to select “Sperm Whale.”
  - Your selection should appear in a green toolbar at the bottom of the window.
- Go back up to the “Query” box at the top of the page and type in “HBA” and click “Search.”
- Click on the boxes at the left of the page to make “checks” next to the organisms you want to compare with the sperm whale. Make sure you select animals with the gene HBA listed (not HBA1 or HBA2).
- Once you have made your selections, click on the “Align” button at the bottom of the page. It will take a few seconds to run, so be patient. You are running an application called ALIGN that compares the amino acid sequence of the organisms you selected. The application will provide you with the HBA amino acid sequence for all the organisms you selected, a phylogenetic tree based on differences in the sequence (which are shared derived characteristics), and a key that will tell you which entry belongs to which animal.

Once you know how to use the UniProt database to compare the amino acid sequences of different mammals, you need to think about what data you will need to collect and what you will do with the results of the analysis. To determine what type of data you need to collect, think about the following questions:

- Which mammals will you need to include in the analysis?
- How many mammals will you need to include?
- Will you choose mammals to represent different orders or to represent different families?

To determine what to do with the results of the analysis, think about the following questions:

- How will you keep track of the information you collect and how will you organize it?
- What would you expect to see in the amino acid sequence of a mammal that is closely related to the sperm whale? How about a mammal that is not very closely related to the sperm whale?
- Will you be able to use the results of your analysis as your claim, or are the results of your analysis part of the evidence you will use to support your claim?
- How can you share the results of your analysis with others?

**Investigation Proposal Required?**     Yes         No

### **Connections to Crosscutting Concepts and to the Nature of Science and the Nature of Scientific Inquiry**

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

- the importance of identifying and explaining patterns in science,
- the relationship between structure and function in nature,
- the difference between data and evidence, and
- how science, as a body of knowledge, develops over time.

### **Argumentation Session**

Once your group has finished collecting and analyzing your data, prepare a whiteboard that you can use to share your initial argument. Your whiteboard should include all the information shown in the figure below.

To share your argument with others, we will be using a round-robin format. This means that one member of your group will stay at your lab station to share your group's argument while the other members of your group go to the other lab stations one at a time to listen to and critique the arguments developed by your classmates.

The goal of the argumentation session is not to convince others that your argument is the best one; rather, the goal is to identify errors or instances of faulty reasoning in the arguments so these mistakes can be fixed. You will therefore need to evaluate the content of the claim, the quality of the evidence used to support the claim, and the strength of the justification of the evidence included in each argument that you see. In order to critique an argument, you will need more information than what is included on the whiteboard. You might, therefore, need to ask the presenter one or more follow-up questions, such as:

- How did you use the database to collect your data? Why did you decide to focus on those mammals?
- What did you do to analyze your data? Why did you decide to do it that way? Did you check your calculations?
- Is that the only way to interpret the results of your analysis? How do you know that your interpretation of your analysis is appropriate?
- Why did your group decide to present your evidence in that manner?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those alternative ideas?
- How confident are you that your claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your original argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most valid or acceptable answer to the research question!

### **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?

### **Argument presentation on a whiteboard**

|                       |                                    |
|-----------------------|------------------------------------|
| The Guiding Question: |                                    |
| Our Claim:            |                                    |
| Our Evidence:         | Our Justification of the Evidence: |

Your report should answer these questions in two pages or less. This 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!

## Mammal Classification Fact Sheet

| Phylum   | Class      | Order*          | Families†       | Example          |                |
|----------|------------|-----------------|-----------------|------------------|----------------|
| Chordata | Mammalia   | Didelphimorphia | Didelphidae     | Opossum          |                |
|          |            | Diprotodontia   | Phascolarctidae | Koala            |                |
|          |            |                 | Vombatidae      | Wombat           |                |
|          |            |                 | Macropodidae    | Kangaroo         |                |
|          |            |                 | Chiroptera      | Pteropodidae     | Fruit bat      |
|          |            |                 |                 | Emballonuridae   | Sac-winged bat |
|          |            |                 |                 | Vespertilionidae | Evening bat    |
|          |            | Primates        | Lemuridae       | Lemur            |                |
|          |            |                 | Hominidae       | Great ape        |                |
|          |            |                 | Hylobatidae     | Gibbon           |                |
|          |            | Carnivora       | Felidae         | Cat              |                |
|          |            |                 | Canidae         | Dog              |                |
|          |            |                 | Ursidae         | Bear             |                |
|          |            |                 | Phocidae        | Seal             |                |
|          |            |                 | Odobenidae      | Walrus           |                |
|          |            |                 | Mustelidae      | Weasel           |                |
|          |            |                 | Cetacea         | Balaenopteridae  | Humpback whale |
|          |            |                 |                 | Eschrichtiidae   | Grey whale     |
|          |            |                 |                 | Physeteridae     | Sperm whale    |
|          |            |                 |                 | Delphinidae      | Dolphin        |
|          |            | Monodontidae    |                 | Beluga whale     |                |
|          |            | Sirenia         | Phocoenidae     | Porpoise         |                |
|          |            |                 | Dugongidae      | Dugong           |                |
|          |            |                 | Trichechidae    | Manatee          |                |
|          |            | Proboscidea     | Elephantidae    | Elephant         |                |
|          |            | Perissodactyla  | Equidae         | Horse            |                |
|          |            |                 |                 | Tapiridae        | Tapir          |
|          |            |                 |                 | Rhinocerotidae   | Rhinoceros     |
|          |            |                 | Artiodactyla    | Hippopotamidae   | Hippopotamus   |
|          |            |                 |                 | Camelidae        | Camel          |
|          |            |                 |                 | Giraffidae       | Giraffe        |
|          |            |                 |                 | Cervidae         | Deer           |
|          | Bovidae    | Cow             |                 |                  |                |
| Rodentia | Castoridae | Beaver          |                 |                  |                |
|          |            | Caviidae        | Guinea pig      |                  |                |
|          |            | Cricetidae      | Rat             |                  |                |
|          |            | Sciuridae       | Squirrel        |                  |                |
|          | Lagomorpha | Leporidae       | Rabbit          |                  |                |

\* Some orders have been omitted.

† Many of the families within each order have been omitted.