

Skulls & Evolution

Purpose

- To illustrate trends in the evolution of humans.
- To demonstrate what you can learn from bones & fossils.
- To show the adaptations of various mammals to different habitats and food sources.

Introduction

Much of what we know about evolution comes from the study of comparative anatomy. In many cases, bones (either as fossils or skeletons) have been useful in these studies. Bone and skeletal structures can reveal how an animal moves, eats, reproduces, etc.

In this lab, we will look at the skulls of various mammals.

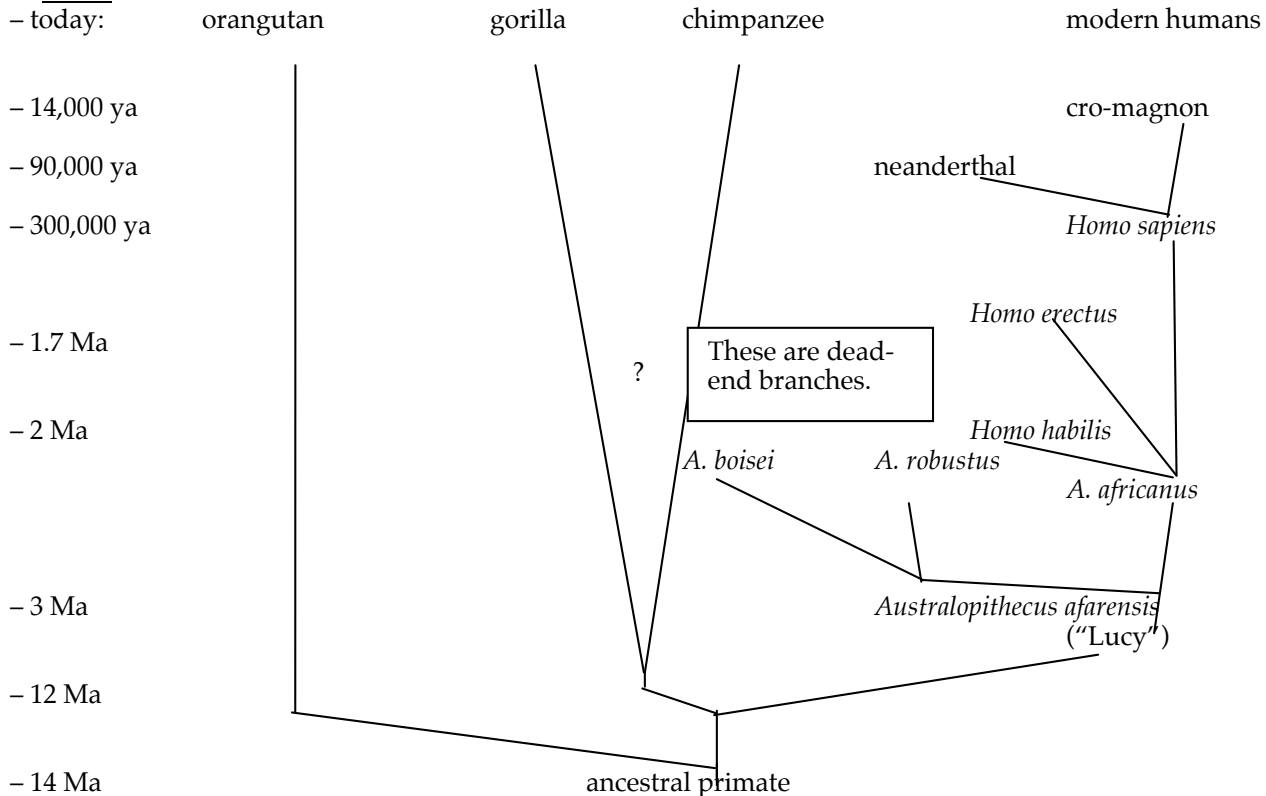
Procedure

In this lab, groups at the same table will work together.

Part I: Human Evolution

Shown below is a *very rough* outline of human evolution. While the general form is agreed on by most scientists, many of the details (exact dates & branching patterns) are still subjects of debate. Although gorilla, chimp, and orangutan are modern primates (and therefore have been evolving as long as humans have) they are thought to resemble ancestral forms.

Date



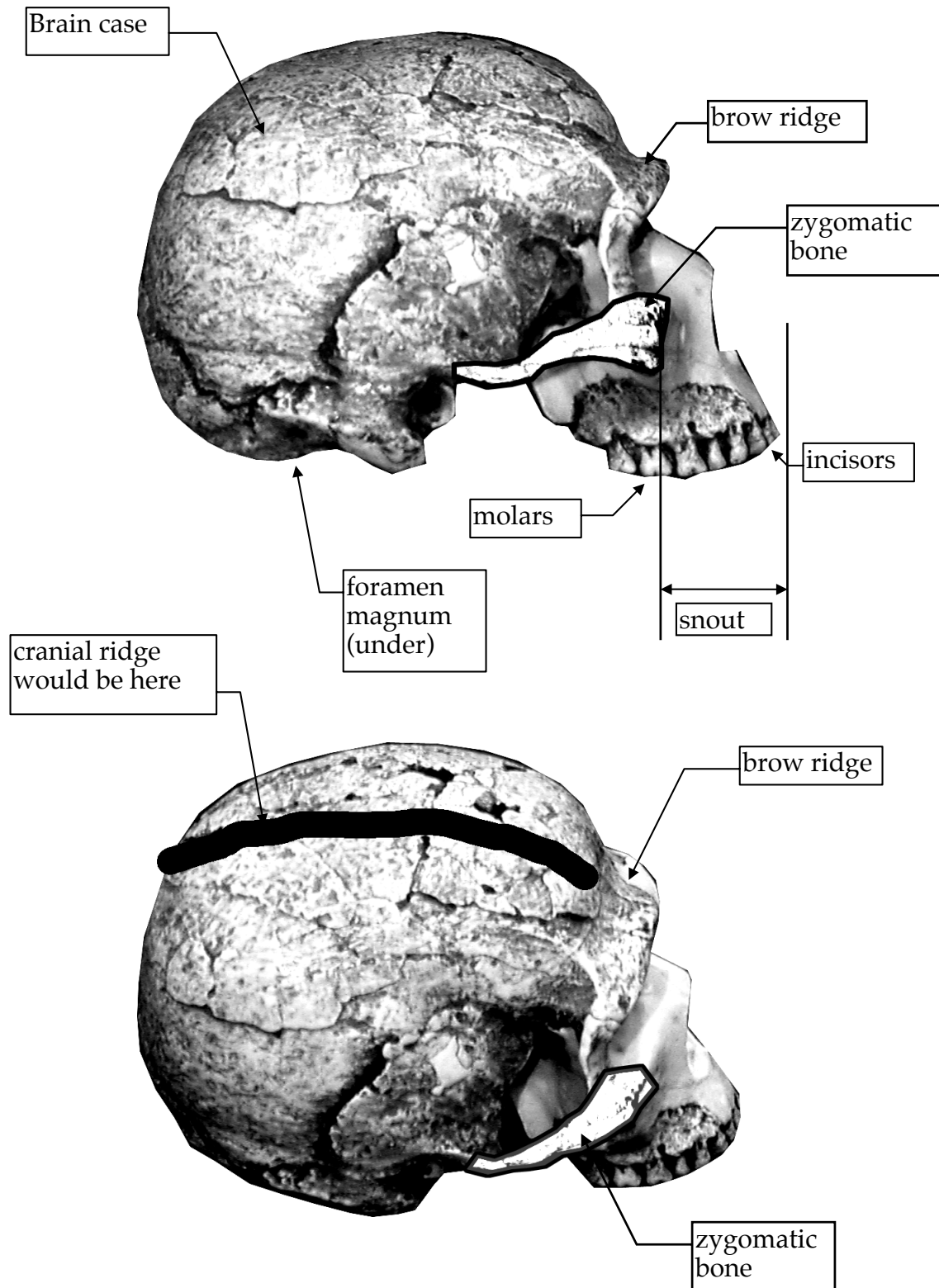
From the comparison of skulls from different primates, seven (somewhat overlapping) trends in the evolution of humans have been found. Note that not all traits in a given skull will be equally 'human' – that is, you will likely find skulls where one feature is ancestral and others are modern.

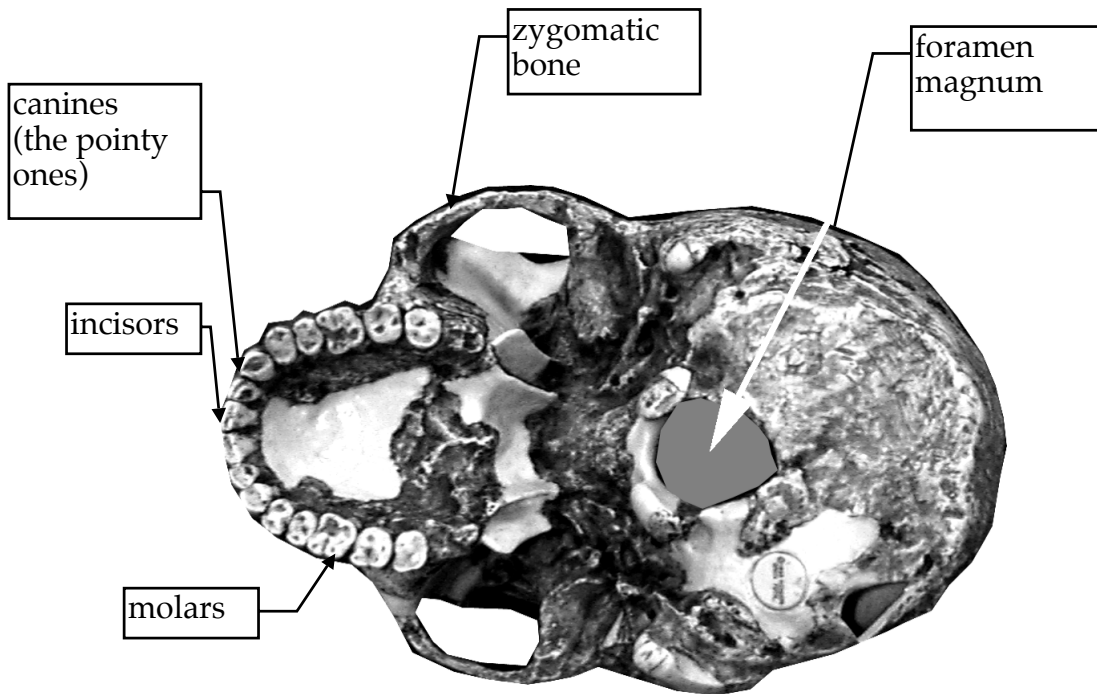
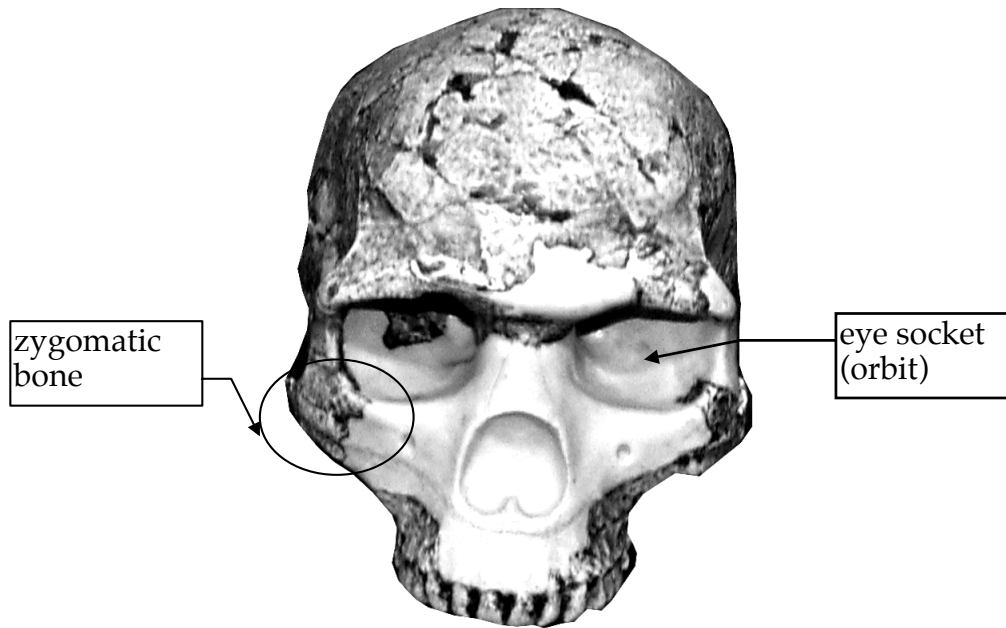
This chart describes these seven trends. The following pages illustrate the skull features described in the table.

	<u>Feature</u>	<u>Details</u>	<u>Explanation</u>
1	Brain case	<ul style="list-style-type: none"> – size? – cranial ridge? – brow ridge? 	The bigger brain case allows a bigger brain which, in general, allows greater intelligence.
2	Teeth	<ul style="list-style-type: none"> – size? – canines - large and sharp or more like incisors? 	See under "Snout"
3	Palate	<ul style="list-style-type: none"> – sides parallel "U" or splayed out "V" 	See under "Snout"
4	Forehead (compared to face)	<ul style="list-style-type: none"> – size? – height? 	Related to size of brain case.
5	Location of eye sockets (orbits)	<ul style="list-style-type: none"> – sides / front of skull 	Eyes in front allows binocular vision (seeing most objects with both eyes at once) which allows depth perception and 3-d vision.
6	Snout	<ul style="list-style-type: none"> – present? – length? 	A reduced snout moves the molars under the rest of the skull which allows more flexibility in chewing and grinding food. This allows a more varied diet. The snout also blocks vision below the face.
7	Foramen magnum (where the backbone attaches)	<ul style="list-style-type: none"> – location - rear or bottom of skull? 	Foramen magnum at bottom of skull allows walking erect, as opposed to walking on 4 legs.

You can also determine if an animal is carnivorous, herbivorous, or omnivorous (eats both meat and plants) by looking at its molars. In general (there are, of course, exceptions), blade-like molars are characteristic of carnivores and are used to shear the meat into smaller pieces for digestion. Flat molars are characteristic of herbivores and are used to grind the plant material for digestion. The molars of omnivores (like humans) are intermediate.

Here are the parts of the skull that are important for this lab: (clearer color pictures of a different species can be found on page 271 of the Lab Atlas as a reference point).





The palate is the upper jaw, which is not present in this skull. However, you can infer the shape of the palate by looking at the shape of the upper jaw. In this case, it is rather splayed out (V-shaped).

Note: There are often differences between individual members of a given species. In your analysis, you should *look* at all samples of a given species when *collecting your data*; in your report, you should *pick one example* to describe.

- 1) Each group will be given several skulls of primates. Using the chart on the first page of this lab section, put your skulls in order from ancestral primate to modern human. Note that the orangutan, gorilla, and chimp are considered to be more ancestral than any of the other samples; the orangutan is the most ancestral, followed by the gorilla, then the chimp.
- 2) For each property listed in the table, determine how that property changes as you go from ancestral primates to modern humans. You should discuss this as a class.
- 3) To the best of your ability, try to determine when, on the chart on the first page of this lab section, humans first walked upright.

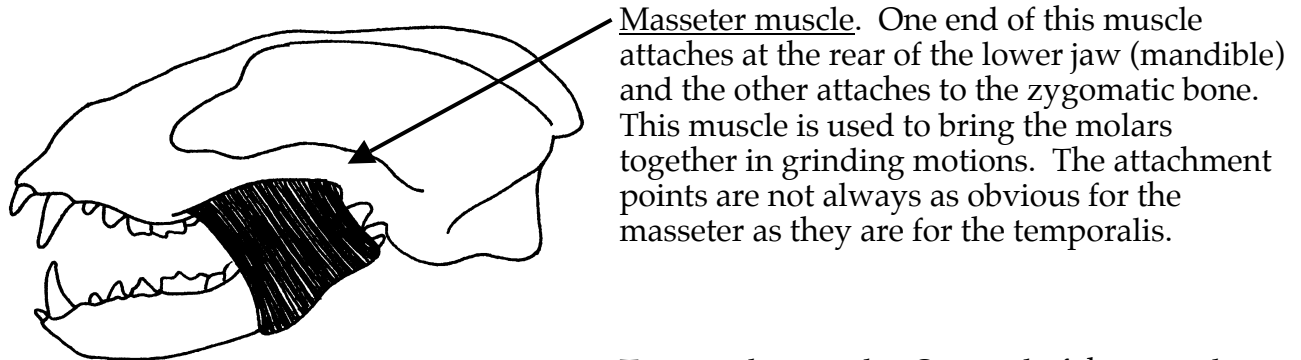
Part II: Comparing skulls of other mammals

- 4) Each group will be given four skulls, two from carnivores (exclusively meat-eating: leopard, cougar), one from an omnivore (eats both plants and meat: raccoon, wolf, great dane), and one from a herbivore (exclusively plant-eating: deer or sheep). The skulls will be marked with the animal they came from.
- 5) Consider the following features and determine the trends in these features as you go from carnivore to omnivore to herbivore.

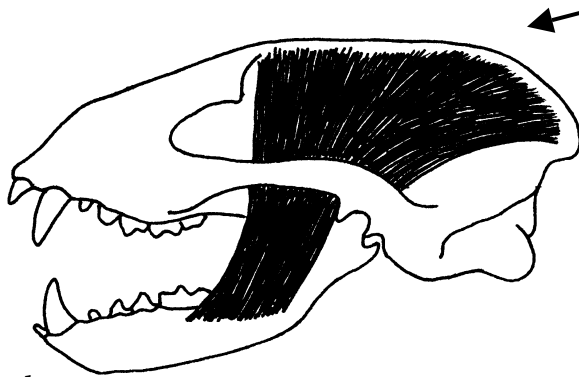
	<u>Feature</u>	<u>Details</u>	<u>Explanation</u>
1	Canine teeth	<ul style="list-style-type: none"> • present? • large or small 	Used for cutting and tearing of food.
2	Molars	<ul style="list-style-type: none"> • flat cross-section • pointed & blade-like 	Used for grinding food.
3	Eye Sockets (orbits)	<ul style="list-style-type: none"> • allow for overlapping fields of vision? • allow for greater visual field coverage 	Overlapping fields of vision allow for better depth perception; more visual field allows better observation.
4	Masseter muscle attachment points (see next page for description)	<ul style="list-style-type: none"> • large • small 	Used for moving jaws when grinding food.
5	Temporalis muscle attachment points (see next page for description)	<ul style="list-style-type: none"> • large • small 	Used for moving jaws when biting and tearing food.
6	Dental Formula (see next page for description)	<ul style="list-style-type: none"> • the particular formula 	Different nutrition.

Masseter & Temporalis Muscles

These muscles are found in all mammals (although they are less clear in primates). They are different sizes and have slightly different attachment points depending on the animal's diet, etc. The figure below shows the difference between the two muscles on the skull of a badger (carnivore). The figure was taken from *Skulls and Bones* by Glenn Searfoss, an excellent and very readable book on this subject.



Masseter muscle. One end of this muscle attaches at the rear of the lower jaw (mandible) and the other attaches to the zygomatic bone. This muscle is used to bring the molars together in grinding motions. The attachment points are not always as obvious for the masseter as they are for the temporalis.



Temporalis muscle. One end of this muscle attaches at the rear of the lower jaw (mandible), the muscle passes between the zygomatic bone and the rest of the skull, and the other end attaches to the temples, the top of the skull, or the cranial ridge (if present). In some cases, there is a 'tab' of bone on the mandible that fits between the zygomatic bone and the rest of the skull; the temporalis muscle attaches here. You can feel your temporalis muscle working if you put your finger on your temple as you chew

something,

Dental Formula

The dental formula is a way of expressing the number and types of teeth that an animal has. There are 5 types of teeth (adapted from

http://animaldiversity.ummz.umich.edu/site/topics/mammal_anatomy/kinds_of_teeth.html):

- **Incisors (I)** These are the most anterior teeth. Incisors are usually simple teeth, though the crown is sometimes lobed. In many species, incisors are used as pincers for grasping or picking, both in feeding and in grooming; they are also used for biting, cutting, and stripping.
- **Canines (C)** All mammals have a single canine in each quadrant, if they have canines at all. These teeth are often absent; when present, the canines are the first tooth in the maxilla. They tend to be moderately to very long, and most commonly they consist of a single cusp with one root (but there are exceptions). Canines are most often used for stabbing and holding prey, and it is in herbivorous species that they are often reduced in size or missing altogether. Canines are used by some species as weapons in social displays or fighting.
- **Premolars (P)** The premolars lie immediately posterior to the canines. In the upper jaw, they are found in the maxillary. Premolars are usually, but not always, slightly smaller and simpler than the molars that follow them. They are distinguished from molars because premolars are deciduous; that is, there is a milk set that is later replaced by an adult set.

- **Molars (M)** The most posterior teeth in the jaws of most mammals are molars. As with premolars, they vary tremendously in size, shape, and function. The completion of their eruption is usually delayed until the individual reaches near adult size.
- **Post Canines (PC)** These are found posterior to canines in seals, dolphins, and whales instead of molars.

A dental formula specifies the teeth, reading from anterior to posterior of one half of the jaw. You start in the middle of the two front teeth and work your way back. The number of teeth in one side of the upper jaw is written over the number in one side of the lower jaw.

For example, consider the human skull shown at the bottom of page Skulls-4. You start with the midpoint between the incisors at the front of the skull and move down one side to the rear of the skull. There are 2 incisors, 1 canine, 2 premolars (much narrower than the molars), and 3 molars. Although it is not shown, the lower jaw has the same pattern. Therefore, the

dental formula would be: $I \frac{2}{2} C \frac{1}{1} P \frac{2}{2} M \frac{3}{3}$. This translates as “on one side of the upper jaw, there are 2 incisors, followed by 1 canine, followed by 2 premolars, followed by 3 molars; the lower jaw is the same.” That gives a total of 16 teeth on one side of the skull; multiply by 2 to get the total number of teeth in that skull = 32 which is typical for an adult human.

It will not be possible to determine the type of some of the teeth you find today (especially molars vs. premolars since we are only looking at skulls of adult animals), so you should try your best and discuss your conclusions with your lab mates. *We will therefore grade this part of your lab report generously.*

6) Each lab room will have at least one bottle-nosed dolphin skull. The dolphin is a marine mammal – that is, it lives in the ocean but has evolved from a land-dwelling mammalian ancestor. Compare the skull of the dolphin with that of the carnivore.

Part III: Marine Mammals III

You answered these two questions in the HMNH lab based on skeletal and morphological data. In this part, you will use the skulls and only the skulls of relevant animals to look at the same questions. **You should be sure to include the dental formula in your analyses, along with whichever other features you find relevant.**

You should use the techniques for looking at skulls and the features you have seen in the other skulls as you answer these questions.

We have provided you with the following skulls that may be useful in answering these questions:

Marine Mammals

Dolphin
Gray Seal
Harp Seal
River Otter
Sea Otter

Terrestrial Mammals

Sheep
Dog/Wolf
Raccoon
Leopard
Human

- a) How many major different groups of marine mammals are there? A full-credit answer to this question consists of three parts:
- The number of groups of marine mammals that you have determined. Note that, since we do not have and manatee/dugong skulls, this number may be less than the number you gave in the two previous labs.
 - An explanation of why you chose the groups that you chose. We are not interested in the “right” answer here; just a well-reasoned argument based on your observations. What are the key differences between groups? What are the key features that make members of each group similar? This part must include a *data table* of the format described on page HMNH-9 and an explanation of how you used the data in the table to draw the conclusions you drew.
 - Which of the marine mammals belong to each group?
- b) Which is the closest living land relative of a seal? Seals evolved from land-dwelling ancestors. Although that ancestor is now extinct, it has modern-day descendants. Based on your observations of the skulls, you must decide which land mammal is most closely-related to seals - *you should use the harp seal for this comparison. You must include the harp seal in your data table.*
- A full-credit answer to this question has two parts:
- The terrestrial mammal that you think is most closely-related to the land ancestor of seals. Choose from the list of terrestrial mammals above.
 - An explanation of why you chose that mammal. This part must include a *data table* of the format described on page HMNH-9 and an explanation of how you used the data in the table to draw the conclusions you drew. Again, we are not interested in the “right” answer; just a well-reasoned argument based on your observations.

In each part, we are not interested in the correct answer; we are interested in the *data* you cite and your *argument* based on that data. The more specific about the data you are and the more clear your argument is, the more credit you will get.

Lab report:

- Must be typed; handwritten reports will not be accepted. Hand-drawn and labeled drawings are fine.
- Due at the start of the lab session you are currently in during the week listed on the syllabus. This is a firm deadline.
- Although you will perform these activities as a group, each member of the group must turn in an individual lab report. Each person's report must be in his or her own words as much as possible.
- Your lab report must contain answers to the following questions.

Part I: Human Evolution

1) Describe how each of the seven properties changes as you go from ancestral primates to modern humans using specific details listed in the table on page Skulls-2. Describe the *trend*, not just the individual observations; you must describe the trend for *each* of the features in the table. **Please format your answer as a table similar to the one below:** (note that the answers are just a humorous example)

Property	Trend
Brain Case	As you go from ancestral primates to modern humans, the brain case gets less pointy.
(etc)	

2) At which stage in human evolution did hominids first walk upright; name the species and explain your reasoning.

Part II: Comparisons of other mammals

3) Describe how each of the six properties changes as you go from carnivore to omnivore to herbivore. For each property, briefly explain how this change fits in with the animals' changed diet.

4) On the pictures of the dolphin skulls on the next pages, label the following parts:

- blowhole
 - eye sockets (or where the eyes would be)
 - zygomatic bone
 - foramen magnum
- If a part appears in more than one picture, you need only label the one where it is shown most clearly.
- Attach the labeled pages to your lab report.

5) To which part of a terrestrial mammal skull does the blowhole of a dolphin correspond?

6) Looking at the teeth of the dolphin, which is more likely: (explain your reasoning)

- dolphins grind up their food like a herbivore
- dolphins bite off pieces of food and chew them up like humans
- dolphins grab and kill their prey with their teeth and swallow them whole or in large pieces

Part III: Marine Mammals III

7) The answers to questions (a) and (b) from page Skulls-8.

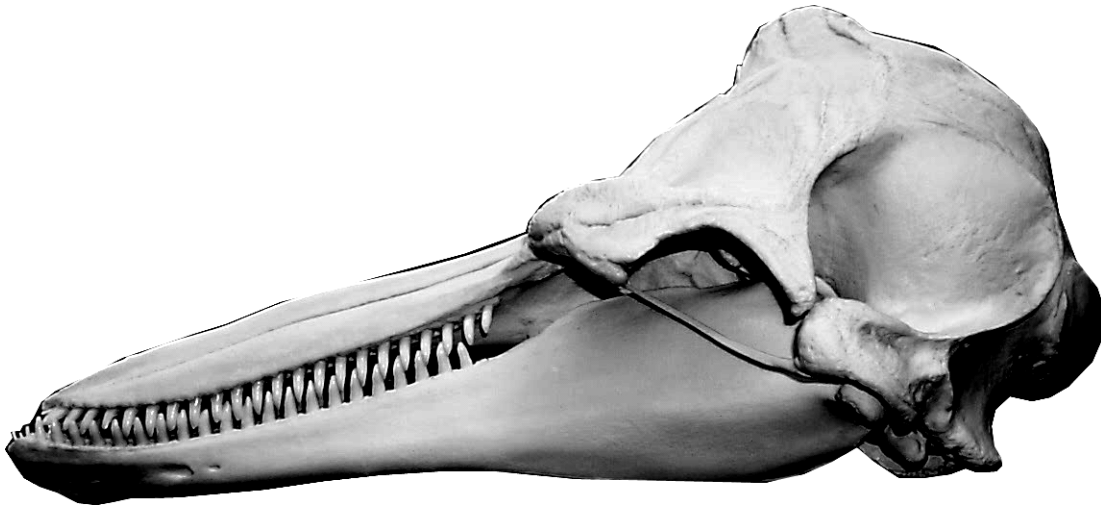
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Dolphin worksheet (attach to your lab report)

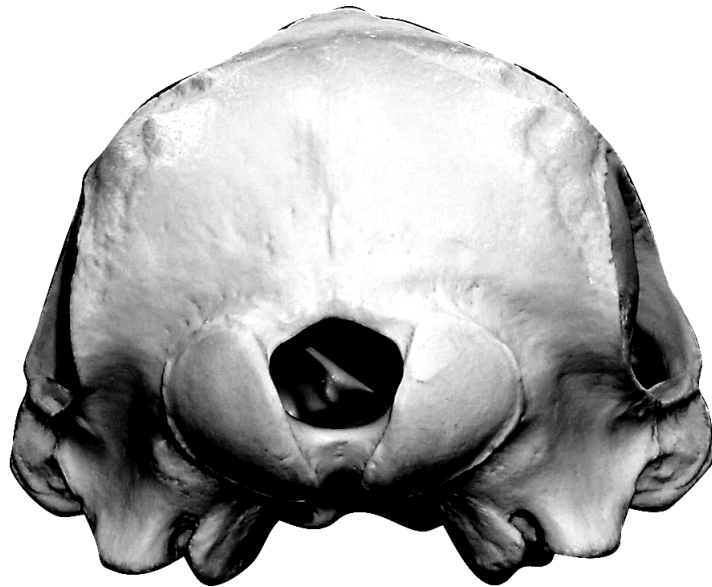
An intact dolphin;
left side view.



- Dolphin skull; left side view:



Rear view:



Top (dorsal) view:

