

### Background

Much evidence has been found to indicate that living things have evolved or changed gradually during their natural history. The study of fossils as well as work in embryology, biochemistry and comparative anatomy provides evidence for evolution

### Objective

In this lab you will learn about homologous, analogous and vestigial structures and their significance in evolution theory. You will also compare amino acids sequencing of humans to other vertebrates.

### Materials

Colored pencils

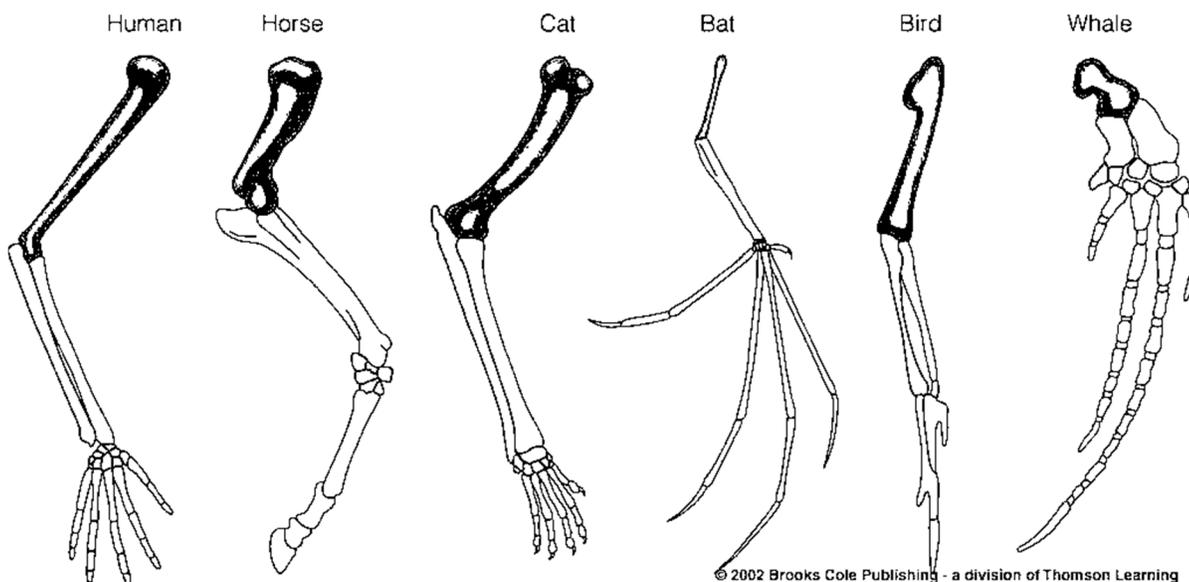
### Procedures and Observations

#### Part I. HOMOLOGOUS STRUCTURES

These structures are **formed in similar ways** during embryonic development and share like arrangements; **however**, they have **somewhat different forms and functions**. They are called **homologous structures**.

1. Carefully examine the drawings of the bones shown in Figures 1 below. Look for similarities among the various animals.

a. Color each part of the human arm a different color. (All bones of the wrist should be a single color, the bone groups of the hand should be a different single color.) Then color the corresponding bone in each of the other animals the same color as the human bone.



b. Describe the function of each set of bones below:

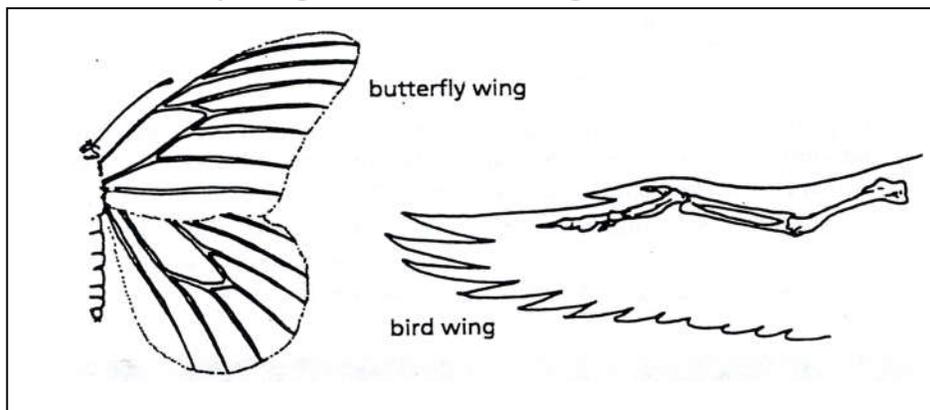
Animal	Function
human	
Whale	
cat	
bat	
bird	
Horse	

c. Are the bones arranged in a similar way in each animal? Why?

## Part II. ANALOGOUS STRUCTURES

Some apparently **unrelated animals** have organs with **similar functions**, yet are **very different in structure and form**. These structures are called ***analogous structures***.

1. Examine the butterfly wing and the bird wing shown.



a. What function do these structures share?

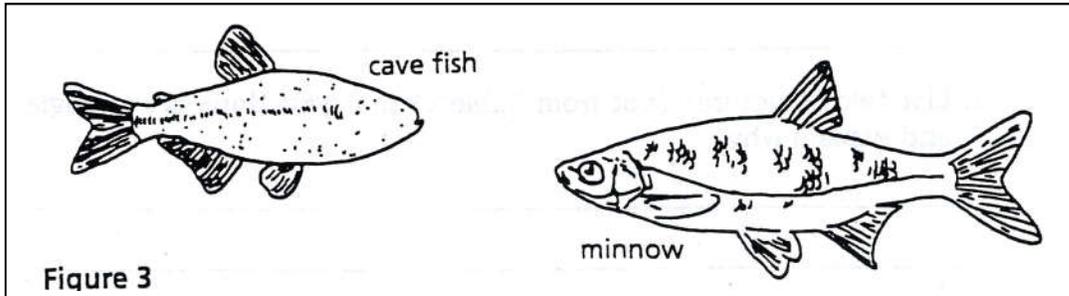
b. How do the structures differ?

c. Do birds and insects share any *structural similarities* that would suggest they are closely related?

### Part III. VESTIGIAL STRUCTURES

Organs or structures that have lost their function in the organism and become reduced in size (because of efficiency) are called **vestigial structures**. Gradual changes have occurred through time that have in some cases reduce or removed the function of some body structures and organs. The penguin's wings and the leg bones of snakes are examples of this phenomenon.

1. The cave fish and minnow show in Figure 3 are related, but the cave fish is blind.



a. Explain why eyesight is not an important adaptation to life in a cave.

b. Does the appearance of the cave fish and a minnow suggest common ancestry? Why?

2. Read the list of human vestigial structures shown. Suggest a possible function for each structure after reading why it became vestigial. Record your answers in the table.

Structure	Probable Function	Why Vestigial?
appendix		Because it could have been used to harbor symbiotic bacteria for digestion of cellulose, which is no longer necessary with the modern diet of humans
coccyx (tail bone)		Not needed for walking upright
muscles that move ears		Rely more on other senses, especially vision
muscles that make hair stand up		Not needed when clothing was adapted
little toe		Not needed once humans adapted a ground-dwelling lifestyle instead of an arboreal one
wisdom teeth		Diet changed, fire used to cook & soften food

## Part IV. COMPARING AMINO ACID SEQUENCES

Because DNA codes for the sequences of amino acids in proteins, evolutionary relationships that might otherwise go undetected can be determined. By comparing the amino acid sequences in homologous proteins of similar organisms and of diverse organisms biologists believe that ***the greater the similarity between the amino acid sequences of two organisms, the closer their relationship***. Conversely, the greater the differences, the more distant the relationship.

1. Examine Figure 4, which compares corresponding portions of hemoglobin molecules in humans and five other vertebrate animals. Hemoglobin, a protein composed of several long chains of amino acids, is the oxygen-carrying molecule in red blood cells. The sequence shown is only a portion of a chain made up of 146 amino acids. The numbers in Figure 1 indicate the position of a particular amino acid in the chain.

	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101
Human	THR	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Chimpanzee	THR	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Gorilla	THR	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Rhesus monkey	GLN	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Horse	ALA	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
Kangaroo	LYS	LEU	SER	GLU	LEU	HIS	CYS	ASP	LYS	LEU	HIS	VAL	ASP	PRO	GLU
	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116
Human	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Chimpanzee	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Gorilla	ASN	PHE	LYS	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Rhesus monkey	ASN	PHE	LYS	LEU	LEU	GLY	ASN	VAL	LEU	VAL	CYS	VAL	LEU	ALA	HIS
Horse	ASN	PHE	ARG	LEU	LEU	GLY	ASN	VAL	LEU	ALA	LEU	VAL	VAL	ALA	ARG
Kangaroo	ASN	PHE	LYS	LEU	LEU	GLY	ASN	ILE	ILE	VAL	ILE	CYS	LEU	ALA	GLU

### Data Table

Use the figure above to fill in the follow table analyzing sequences 87-116

Organisms	Total Number of Amino acids	Number of Amino Acid Differences	% Difference
Human and Chimpanzee	<b>146</b>		
Human and Gorilla	<b>146</b>		
Human and Rhesus Monkey	<b>146</b>		
Human and Horse	<b>146</b>		
Human and kangaroo	<b>146</b>		

- a. Which animal in this comparison has the least amount of amino acids in common? What does that mean?

## Summary Questions

1. Explain why the homologous structures in Part I are evidence of evolutionary relationships.
2. Explain why analogous structures occur in nature and why they are not examples of evolutionary relationship
3. Using your imagination, what parts of the human body might become vestigial in the next million years. Explain your reasoning.
4. How do amino acids comparisons help determine evolutionary relationships?
5. Identify another piece of evidence not illustrated in this lab and describe how it may be used to infer an evolutionary relationship between organisms.

## Evidence for Evolution Video WS

### **Vestigial Structures: Proof of Evolution in your own body!:**

<https://www.youtube.com/watch?v=rFxu7NEoKC8>

What is a vestigial structure? List and **describe at least 2** of the vestigial structures/reflex mentioned in the video. What do vestigial structures tell us about evolutionary relationships?

**Lungfish:** <https://www.youtube.com/watch?v=tqWciuuKn3c>

List and describe the unique adaptations a lungfish possesses. You must identify **at least two** adaptations!

**Mimic Octopus:** <https://www.youtube.com/watch?v=t-LTWFnGmeg>

Describe the **physical and behavioral adaptations** of the Mimic Octopus.

### **Evolution in Action: Heliconius Butterflies:**

[https://www.youtube.com/watch?v=luMO0OH\\_yEs](https://www.youtube.com/watch?v=luMO0OH_yEs)

What is **speciation**?

Is this an example of physical or behavioral evolution? Support your answer.