UNIVERSITY OF BRITISH COLUMBIA
Biology 121 Section 121, Instructor: Lynn Norman
Midterm 2, November 3rd, 2022

Name : ______________________________ ______________________________
LAST NAME FIRST NAME

Student Number: ___________________________

Instructions:

1. Read through the entire question first. Answer all questions in the space provided. Answers on the page for rough work (bottom of page 9 and top of page 10) will **NOT** be marked unless directed to do so. Only one answer will be evaluated (please make it clear).

2. Writing can be in pencil or ink, but pencil, erasable ink or answers with white-out cannot be regraded.

3. Answers may be in sentences or point form. Illustrations are acceptable but must be annotated.

4. No other memory devices are permitted excepting a **ONE-PAGE** (double-sided) study sheet in your handwriting. Study sheets that exceed the size limit may be confiscated and may be considered as cheating.

5. Students suspected of any of dishonest practices will be immediately dismissed from the examination and will be subject to disciplinary action.

6. Students may not speak or in any other way communicate with other students while in the examination room.

7. Students may not expose their written paper to other students. The excuse of accidental exposure, forgetfulness, or ignorance will not be accepted and will be subject to disciplinary action.

8. Ensure you have 10 pages (5 pieces of paper) including this cover page.

Mark will be on back page.

Question	Topic	Marks Possible
1	Evidence for evolution	8
2	Mechanisms - Elephants	4
3	Phylogenetic Tree	9
4	Mechanisms & HWE - Frogs	14
Bonus		+1
Total		35

QUESTION1 (8 marks)

1A (2 marks) List two characteristics of living organisms that are interpreted as evidence that all living organisms share a common ancestor? **(2 mark)**

1B (2 marks). Kiwis are a species of bird that have stumpy wings and are unable to fly.

The Kiwi's wings are an example of a (circle your choice). **(1 mark)**

a) Structural homology
b) Developmental homology
c) Molecular homology
d) Analogous trait
e) Vestigial trait
f) None of these options are correct

Their wings support the conclusion that (circle your choice): **(1 mark)**

a) All living organisms share a common ancestor
b) Organisms are related
c) Organisms have changed through time
d) None of the above.

The figures below show the bones that make up the limbs of various vertebrates (Fig. 1) and the evolutionary relationships between these taxa (Fig. 2).

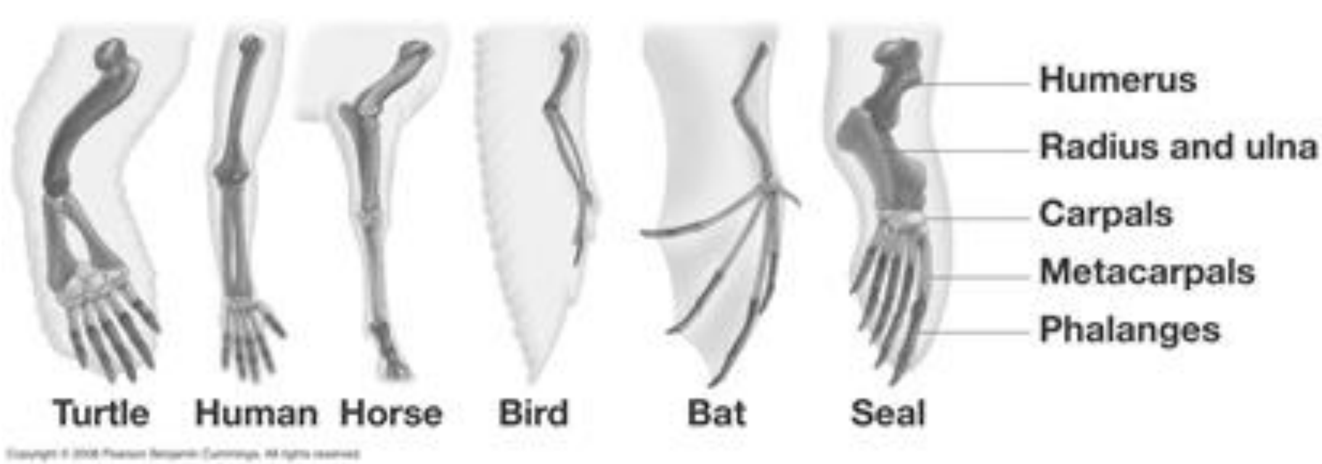


Figure 1.

1C (1 mark) Based on Figure 1 (previous page) and Figure 2 (below), the presence of a humerus in the forelimbs of turtles, seals and humans is an example of a (circle your choice).

a. Structural homology
b. Development homology
c. Transitional form
d. Analogous trait
e. A, B, C & D (all of these are correct)
f. None of these are correct

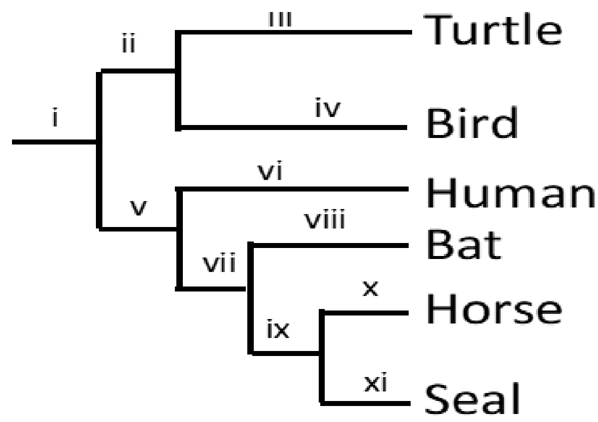


Figure 2.

Answer the next 3 questions (1D-1F) using Figure 2 (above) and the principle of parsimony. Note, <u>branches are labelled with roman numerals in Figure 2</u>.

1D (1 mark) In the space below write the branch number(s) where the humerus most likely evolved.

1E (1 mark) Bats and birds both have wings that are used for flight. The common ancestor of bats and birds most likely (circle your choice)

a) Had wings
b) Lacked wings
c) Had vestigial wings
d) Not possible to determine

1F (1 mark) In the space below, write the branch number(s) where wing(s) likely evolved.

QUESTION 2 (4 marks)

Obtaining elephant tusks for ivory requires killing the elephant. The illegal hunting of African elephants for ivory has reduced their populations. In areas where illegal hunting is common, the frequency of tusklessness (= lacking tusks) in female African elephants has increased, from 19% to 51% over a period of 15 years. The genetic basis for tusklessness is found on the X chromosome. Note – tuskless males do not occur because this mutation is lethal in males.

2A (1 mark) The mutation resulting in tusklessness occurred because of:

a. Illegal hunting, so female elephants could avoid being killed for their ivory
b. A chance change in the DNA on the X-chromosome
c. Female elephants required an adaptive mutation to improve their fitness
d. Impossible to choose between the provided answers.

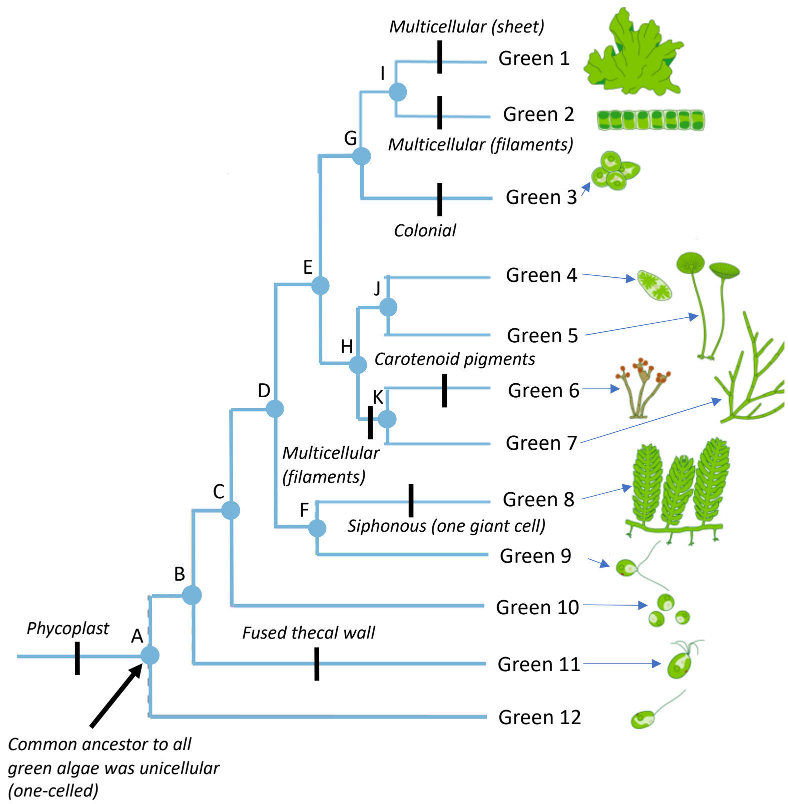
2B (1 mark) Elephants normally use their tusks for a variety of tasks such as defense, stripping bark from trees to eat, and digging for water during dry periods. The loss of tusks in female elephants in areas with illegal hunting is <u>most likely</u> due to:

a. Tusks being lost because they are no longer useful in the current environment.
b. Tuskless females outcompeting tusked females for food and water, therefore passing on the tuskless allele to more offspring.
c. Consistent increase in the frequency of the tuskless mutation due to genetic drift.
d. Females without tusks having an increased chance of survival and therefore passing on the tuskless mutation to more offspring
e. A high mutation rate generating new individuals with the tusklessness allele in the population.

2C (2 marks) If a nearby African elephant population initially <u>lacks</u> the tuskless allele, what evolutionary mechanism would be <u>most likely</u> to result in the tuskless trait occurring in this population? Briefly (in one sentence) describe how this could occur?

QUESTION 3 (9 marks)

To the right is a figure of the phylogeny of the Chlorophyta, a group of green algae. Capital letters (A, B, C, etc.) refer to nodes and vertical lines indicate when a trait first evolved.



3A (3 marks) Fill in the blanks below.

___________ represents the most recent common ancestor of **Green 1** and **Green 11**.

____________ represents the most recent common ancestor of **Green 3** and **Green 4**.

_______________ represents the closest living relative(s) of **Green 3**.

3B (3 marks) Based on the phylogeny above, which of the following groups are monophyletic? Fill in the chart below with an X indicating whether the suggested groups are monophyletic or not.

Groups	Monophyletic	Not monophyletic	Can't Tell
Greens 7 and 8, plus node D			
Greens 4, 5, 6, 7, plus nodes J, K, H			
Greens 1, 2, 3, plus nodes I, G, E			

3C (1 mark) You discover a new type of green algae ("Green 13") that DNA sequencing suggests is most closely related to **Green 3**. According to the principle of parsimony, **list the trait(s)** you expect "Green 13" to have in the space below.

3D (2 marks) Which type of algae, **Green 11** or **Green 12**, is more evolved? Briefly explain your answer and make specific reference to the tree above.

QUESTION 4 (14 marks)

The northern leopard frog (*Rana pipiens*) exhibits three genetically-based skin phenotypes (color, spots, and mottling).

In the 1970s, biologists determined the allele frequencies for spots in a small, isolated population (= 120 individuals). Spots is controlled by a single gene with two alleles (T1 = spots, T2=no spots)

In 2000, biologists returned to this population and re-calculated allele frequencies for spots. The population size of the frogs did not change. Their data are shown in the table below.

Skin phenotype (gene)	Allele frequencies (1970)	Allele frequencies (2000)
Spots (*T* gene)	0.4 : 0.6 (*T1* : *T2*)	0.6 : 0.4 (*T1* : *T2*)

4A (2.5 marks) Explain how genetic drift could explain the change in allele frequencies for skin spots (*T* gene) for this specific northern leopard frog population. Provide evidence and reasoning.

In 2000, the researchers also collected observational data on skin colour in the leopard frogs. Skin colour in frogs is controlled by a single gene (R gene) and two alleles (R1 and R2 allele).

Frogs with two copies of the R1 allele have green skin. Frogs with two copies of the R2 allele have brown skin. Frogs that are heterozygotes have patches of brown and green skin.

The table below shows the data collected by the researchers.

Table 1: Data from study of frog skin colour

Phenotype	Genotype	# of observed frogs	Observed genotype frequencies	Expected genotype frequencies
Green Skin	*R1/R1*	18	0.150	
Patches of Green and Brown Skin	*R1/R2*	96	0.800	
Brown Skin	*R2/R2*	6	0.050	0.203

4B (2 marks) What are the frequencies of the R1 and R2 alleles in this population? Please show your work and retain 3 decimal places.

4C (2 marks) Using the Hardy-Weinberg Equation, calculate the **expected frequencies for the R1/R1 and R1/R2 genotypes.** Show your calculations and write the expected frequencies in the blank spaces in the table above. Retain 3 decimal places.

4D (2.5 marks) Is this population in Hardy-Weinberg Equilibrium (HWE) with respect to genotype frequencies for the R gene?

Circle one answer: Yes No We need more information

Explain your answer, referring to specific genotypes. There is no need to refer to assumptions of HWE.

4E (5 marks) Research suggests that visual predators may have more difficulty detecting frogs with more than one skin colour (e.g. green and brown patches) because the patches break up the outline of the frog making it more difficult for the predators to see the frogs.

Given this information, can you conclude with certainty that the difference between observed and expected values for this leopard frog population could be due to natural selection? Circle one answer:

Yes / No

Explain why or why not with specific reference to each of the three criteria required for selection.

Criterion for selection	Explanation