ANSWER GUIDE

University of British Columbia
BIOL 121- 221 & 224. Instructor: Lynn Norman
Midterm 2, March 14, 2023

Name : _____ _____
LAST NAME FIRST NAME

Student Number: _____

Instructions:

1. You have approximately one minute per mark. Please watch time carefully.

2. Please answer all questions in the space provided. The bottom of page 4 can be used for rough work.

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

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

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

6. No other memory devices are permitted except a ONE-PAGE (double-sided), handwritten (by you) study sheet. Study sheets that exceed the size limit may be confiscated and may be considered as cheating.

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

8. 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.

9. Please ensure that you have 10 written pages (5 pieces of paper) including this cover page.

Good luck!!

Question 1 – Evidence for Evolution (6 marks)

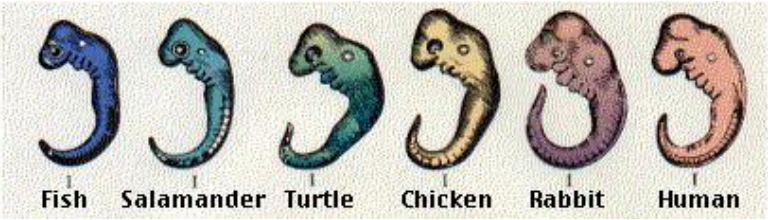
Q1.1 (2.5 marks) What pieces of evidence support the conclusion that all living organisms share a universal common ancestor (LUCA)? Choose all that apply.

a) Animals with four limbs (tetrapods) have common bones in their limbs.
b) Information flows from DNA to RNA to amino acids.
c) DNA is a universal genetic code.
d) Living organisms are made of one or more cells.
e) Fossil animals intermediate in morphology between a fox-like animal and whales.

Q1.2 (2.5 marks) What pieces of evidence support the conclusion that species change over time? Choose all that apply.

a) Trilobites are known from the fossil record from 540 million years ago and disappeared from the fossil record 245 million years ago. No living trilobite species are known.
b) The oldest rocks on earth, found in Canada, have been dated to 4.03 billion years old.
c) It is possible to take a gene from a bacterium and insert it into the genome of a plant and it will produce a functional protein.
d) Animals with four limbs (tetrapods) have common bones in their limbs.
e) Relatives of whales have hip bones and rear limbs. Whales lack rear limbs and have highly reduced hip bones.

Q1.3 (1 mark) The figure below shows the embryos of six vertebrates. At some time during development, all vertebrate embryos have tails.



The presence of an embryonic tail in vertebrates is an example of (circle correct answer).

a) A molecular homology
b) A developmental homology
c) An analogous trait
d) A vestigial trait
e) A structural homology
f) A transitional form

Question 2 - Evolutionary Mechanisms (9 marks)

Lactose is a type of sugar present in mammalian milk (e.g. humans, cows). Young mammals produce a digestive enzyme called lactase, which breaks down the lactose. This process makes it easier for the body to absorb the sugars so that it can be used as a source of calories/energy by young mammals.
Most adult humans do not produce lactase and are unable to digest the milk sugars; therefore, the consumption of milk results in unpleasant side effects so as farting and diarrhea.

However, some human adults continue to produce lactase, which allows them to eat dairy products with no negative consequences. This trait is called lactase persistence (LP). In pre-historic human populations that raised cattle, LP is thought to have resulted in a selective advantage because it allowed adult humans to use fresh cows' milk as a food source. This would potentially have increased the lifetime reproductive success of individuals with LP due to improved nutrition and survival.

In modern European populations, LP is widespread and a single allele is responsible for LP. With the exception of a few groups in other regions, LP is rare or absent.

Q2.1 (2.5 marks) Lactase persistence (LP) in humans originated because (circle the correct answer).

a) The LP allele was needed so people could take advantage of cow's milk as food.
b) Human populations required an adaptive mutation to improve their fitness.
c) Cattle herding caused the LP mutation to occur.
d) A mutation occurred by chance resulting in a change in the DNA sequence of the LP gene.
e) It was inherited from the common ancestor of humans and other mammals.

Q2.2 (2.5 marks) The relatively high frequency of the LP allele in the European population is most likely an example of (circle the correct answer):

a) Artificial selection that resulted in a change in the frequency of LP in a population.
b) Sexual selection that resulted in an increase in the frequency of the LP allele.
c) Natural selection that resulted in an increase in the frequency of the LP allele.
d) Evolution as the theory that organisms share a common ancestor.
e) Evolution as a result of genetic drift.

Q2.3 (2.5 marks) Research suggests that the LP allele rapidly increased in frequency in European populations. What factor best explains this rapid increase in allele frequency? (circle the correct answer)

a) LP was needed by human populations to improve nutrition in humans with the allele.
b) Individuals with the LP allele had more offspring so genetic drift favors the LP allele.
c) Individuals with the LP allele had more offspring than those lacking the LP allele.
d) A high mutation rate generated multiple identical LP alleles in the population.
e) Individuals with the LP allele were more likely to migrate to other populations.

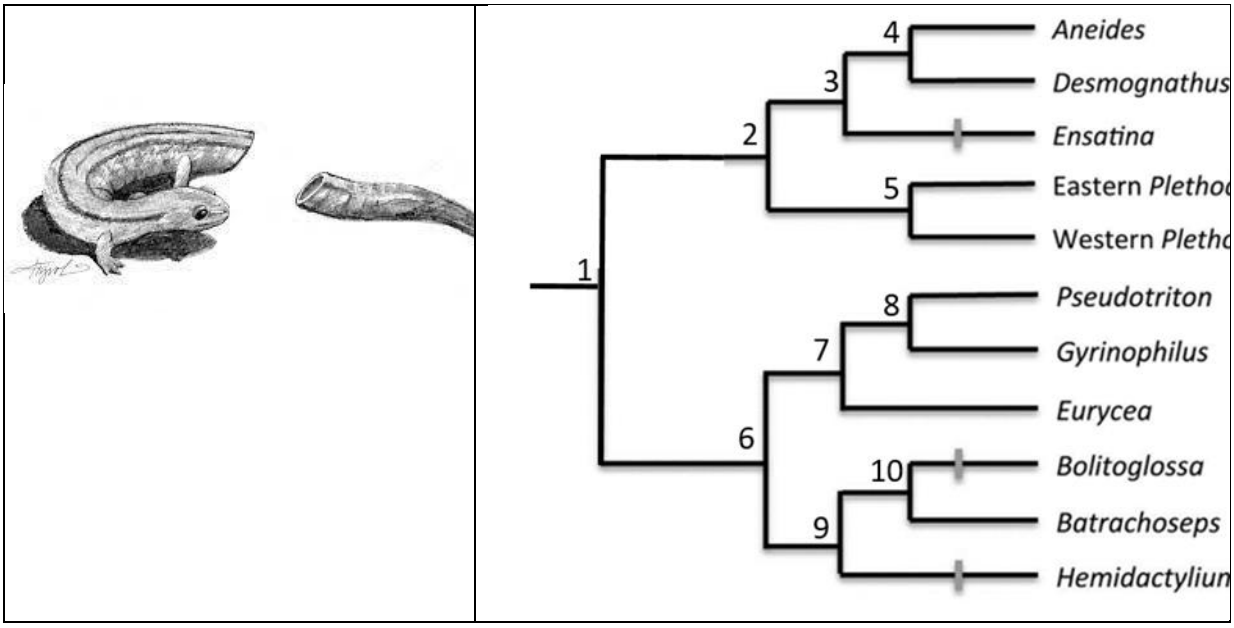
Q2.4 Consider a European population that lacks the LP allele (population #1). It is located close to a population that has the LP allele (population #2). What evolutionary mechanism would most likely result in the LP trait appearing in the population that initially lacked the LP allele (#1)? Briefly explain how this occurs (1.5 marks)

Gene flow
An individual or individuals from population #2 (or population with the LP allele) joined population #1 (or population without the LP allele)
And mated with individuals

This space can be used for rough work. It will not be marked unless you direct the marker to this page.

Question 3 - Phylogenetic Trees (10.5 marks)

Some species of salamander can intentionally drop part of their tail as a defense mechanism against predators (see figure below). Predators are distracted by the lost part of the tail, which wiggles and the salamander can escape. The lost portion will grow back over several years. The phylogenetic tree below shows the relationships among a group of salamanders. The character marks on the phylogenetic tree indicate where tail-dropping likely arose in salamanders. The numbers refer to nodes.



Q3.1 (2 marks) Fill in the blanks below

Node 6 or #6

_____represents the most recent common ancestor of *Batrachoseps* and *Pseudotriton*.

Bolitoglossa and Batrachoseps – this is all or nothing.

_____represent(s) the closest living relative(s) of *Hemidactylium*

Q3.2 (2 marks) True or false: *Eurycea* is less evolved than *Gyrinophilus*? Circle the correct answer below. Explain your answer and make specific reference to the tree above

True False

False

They are equally evolved (or equivalent)

They have both been evolving

Since they diverged from their common ancestor at node 7 or since common ancestor of 3 taxa – *Eurycea, Gyrinophilus & Pseudotriton*

Q3.3 (3 marks) Based on the phylogeny on the previous page, which of the following groups are monophyletic, paraphyletic or polyphyletic? Use an X to indicate the classification of each group.

Groups	Monophyletic	Paraphyletic	Polyphyletic
Eastern *Plethodon*, Western *Plethodon*, plus node 5	X		
Aneides, Desmognathus, Ensatina and node 2		X	
Pseudotriton, Gyrinophilus, Bolitoglossa, node 8 and node 10.			X

3.4 (3.5 marks) Is the presence of tail-dropping in *Ensatina* and *Hemidactylium* an example of a homologous trait or an analogous trait? Explain your answer. Make specific reference to the phylogenetic tree on the previous page. Your answer should demonstrate your understanding of both homologous and analogous traits.

Analogous trait

Explanation (Analogous):

- tail-dropping evolved independently
- in the unique lineage to *Ensatina* and *Hemidactylium*
- no need to mention specific nodes, but nice touch if they do.
- due to convergent evolution
- in response to a shared environmental demand (reduce risk of predation).

Explanation (Homology):

- the trait was not inherited from their common ancestor
- at node 1

If students incorrectly answered that tail-dropping is a homologous trait shared by these two taxa, students can get a maximum of 1 mark for showing understanding of homology, e.g.

> *inherited from a common ancestor at node 1 or equivalent (e.g. common ancestor of all species in tree)*

Question 4 – Hardy-Weinberg Equilibrium and Evolutionary Mechanisms (18.5 marks)

In Gray Tree-Frogs (*Dryophytes versicolor*), male frogs call to defend territories and attract female frogs during the breeding season. The males have no contact with their offspring other than fertilization; so, their only contribution is genetic. The call length varies amongst males from 0.5 seconds per call to 2 seconds per call. Calling is energetically costly. Experimental evidence has demonstrated that females strongly prefer males with long calls (2 seconds) over males with shorter calls, and that males with long calls fertilize more of a female's eggs than males with short calls.

A researcher, Dr. Brett McFluffypants, collected data on the observed genotypes of a population of 500 Gray Tree-Frogs. The results are shown in the table below.

Call Duration	Genotype	Number of frogs	Observed genotype frequencies	Expected genotype frequencies
0.5 seconds	C1C1	100	0.200	0.063
1 second	C1C2	50	0.100	0.375
2 seconds	C2C2	350	0.700	0.563

Q4.1 (2 marks) What are the allele frequencies for the C1 and C2 alleles in this frog population? Please report to 3 decimal places and show your complete calculations.

C1 = 0.250
C2 = 0.750

- must be reported to 3 decimal places
- work must be shown
- do not deduct marks for rounding error.

Q4.2 (3 marks) What are the expected genotype frequencies for this frog population? Report to 3 decimal places. Please show your complete calculations and complete the table above.
- see table; do not deduct marks for rounding error
- must show calculations
- must be reported to 3 decimal places.

Q4.3 (2 marks) Is this population in Hardy-Weinberg Equilibrium or not? Circle your choice below.

Yes or No (no marks for circling no)

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

Students must compare at least one observed and predicted/expected genotype frequency
Must be quantified
Must state that difference is > 0.100
If a mistake is made in genotype (e.g. wrote C1 instead of C1C1), then mark deduction

Q4.4 (5.5 marks) Could sexual selection explain why this population is or is not in HWE for the C gene? Circle your answer below.

Yes or No (no marks for circling yes)

Explain why or why not with specific reference to the three conditions that must be met for sexual selection to occur. Please be specific.

Condition for sexual selection	Explanation for how that condition is met or not.
There is variation in call length	Call duration ranges from 0.5 sec to 2 sec
Call length if heritable	C gene or genotypes
There are differences in fitness linked to differences in call length	For full marks differences in call duration must be linked to differences in mating opportunities/reproductive success (or fertilization). Explanation should also refer back to HWE. Students can either refer to differences in male fitness or female fitness **e.g. MALES** a) females prefer males with long calls over short calls, so the males with long calls should have more mating opportunities b) males with long calls also fertilize more eggs than the males with short calls Therefore, the males with long calls should have greater reproductive success than males with short calls This would explain why more males with long calls (C2C2) were observed than expected; and why the population is not in HWE . **e.g. FEMALES** females that choose to mate with males with long calls than males with shorter calls a) will have more of their eggs fertilized and therefore more offspring b) and may have healthier offspring (or offspring with better genes), as calling is energetically expensive/indicator of a male's health/quality - Therefore females that choose males with long calls should have greater fitness (reproductive success) than females that choose males with shorter calls. - Connect to HWE and why more C2C2 individuals than expected

Q4.5 (3 marks) Genetic Drift and Gray Tree Frog Population.

Circle the correct answer.

a) Genetic drift cannot be affecting allele frequencies in this Gray Tree Frog population as sexual selection is already acting on the population. T F

b) Genetic drift could introduce a new call length allele into the Gray Tree Frog population. T F

c) Genetic drift could result in decreased genetic variation in this Gray Tree Frog Population over many generations. T F

Q4.6 (3 marks) General Genetic Drift Questions.

Evaluate the following statements about genetic drift. Indicate if genetic drift occurs or does not occur. If genetic drift occurs indicate if it is likely to have a large or small effect on allele frequencies.

	Genetic Drift (Circle One)	If genetic drift occurs, the likely effect of genetic drift on allele frequencies (Circle One)
If the population was very large (1000s of individuals) and there was no change in population size. (must have both answers correct)	○ Occurs ○ Does not Occur	○ Small effect ○ Large effect
If the population was small (10s of individuals) and there was no change in population size. (must have both answers correct)	○ Occurs ○ Does not Occur	○ Small effect ○ Large effect
If the population was initially very large (1000s of individuals) but was reduced in size to 10s of individuals due to a natural catastrophe and then increased back to 1000s of individuals. (must have both answers correct)	○ Occurs ○ Does not Occur	○ Small effect ○ Large effect

Bonus Question (1 mark) Organism of the Day

List one feature/characteristic of an Organism of the Day. Briefly describe how this feature/characteristic could increase the fitness of this organism in its environment.

- accurate feature of an organism of the day
- how this feature increases fitness (i.e. must refer to reproductive success)

Question	Marks Possible	Your Grade
1 – Evidence for Evolution	6	
2 – Evolutionary Mechanisms	9	
3 – Phylogenetic Trees	10.5	
4 – HWE & Mechanisms	18.5	
Bonus	1	
Total	**44**	