Index No:

RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

Bachelor of Science in Applied Sciences
Second Year – Semester II Examination – January/ February 2023

BIO 2203 – GENETICS & EVOLUTION

Time: Two (02) hours

Answer <u>four (04)</u> questions including question number 1.

1. Multiple choice questions. Answer all sections in this question by **underlining** the most **appropriate option** with a **pen**.

   a) Which of the following is responsible for producing combinations of characteristics in individuals that were not present in either parent?
      i.   Segregation of alleles during the formation of gametes.
      ii. Segregation of alleles of different genes independently from each other.
      iii. Mutations
      iv. All of the above

   b) Which of the following is a reason to suggest that sex linkage is a deviation from Mendel's laws?
      i.   Prevents segregation of alleles in a gene during gamete formation.
      ii. Prevents segregation of homologous chromosomes during gamete formation.
      iii. Prevents segregation of alleles of different genes independently from each other during gamete formation.
      iv. Prevents segregation of non homologous chromosomes during gamete formation.

   c) Termination region of a gene
      i.   signals the end of the gene.
      ii. controls the transcription of the gene.
      iii. does not code for a functional gene product.
      iv. codes for a functional gene product.

   d) How are eukaryotes capable of producing more proteins than the number of protein coding genes available in their genome?
      i.   By having a high mutation rate in protein coding genes.
      ii. By having a high recombination rate in protein coding genes.
      iii. Through the action of mobile genetic elements.
      iv. Through alternative splicing strategies.

e) An operon is a
   i. cluster of genes that are transcribed together to produce a single mRNA.
   ii. cluster of genes that are transcribed together to produce multiple mRNA.
   iii. single gene that upon transcription produces multiple mRNA.
   iv. single gene that upon transcription produces a single mRNA.

f) In fruit flies, eye colour is X-linked and red eye colour is dominant to white eye colour. Which of the following is **not** possible in a cross between a red-eyed male and a heterozygous female?
   i. Red-eyed male
   ii. White-eyed male
   iii. Carrier female
   iv. White-eyed female

g) Which of the following is **not** a phenotypic ratio caused by an epistatic interaction?
   i. 9:7
   ii. 12:3:1
   iii. 9:3:3:1
   iv. 15:1

h) Cystic fibrosis is a disease caused by the recessive allele of the CFTR gene located in an autosomal chromosome. The disease mainly affects the lungs but also affects digestion, growth and fertility. What type of a genetic phenomenon does CFTR gene have?
   i. Gene and Environment interaction
   ii. Polygenic interaction
   iii. Epistatic interaction
   iv. Pleiotropic interaction

i) Who formulated the first explicit evolutionary theory?
   i. Charles Lyell
   ii. Jean Baptiste Lamarck
   iii. Charles Darwin
   iv. Thomas Malthus

j) What are the five main components of Darwin's theory of evolution?
   i. Modification, blending inheritance, gradualism, populational change, natural selection
   ii. Modification, blending inheritance, gradualism, populational change, dispersal
   iii. Modification, common descent, gradualism, populational change, natural selection
   iv. Modification, common descent, gradualism, populational change, genetic drift

k) Which of the following statements are **not** true of Hox genes?
  i. They have a similar role in development across all animal phyla
  ii. They are part of a gene regulatory network
  iii. They transform a structure into another structure
  iv. They occur in most animal phyla, where they play broadly similar developmental roles

l) The rate of evolution is represented by the equation: $\Delta p \approx s\, p\, (1-p)$, where p is the frequency of the A_2 allele, $1-p$ is the frequency of the A_1 allele, and s is the selection coefficient. Which of the following statements correctly summarizes this equation?
  i. The rate of evolution is the strength of selection divided by the amount of genetic variation.
  ii. The rate at which the frequency of allele A_2 evolves is proportional to the strength of selection and the amount of genetic variation.
  iii. The rate of evolution is the strength of selection minus the amount of genetic variation.
  iv. The rate at which the frequency of allele A_1 evolves is proportional to the strength of selection and the amount of genetic variation.

m) How are biological species usually identified?
  i. By testing for evidence of interbreeding.
  ii. By using morphological characters for diagnosing species.
  iii. By testing if hybrid offspring are fertile.
  iv. By investigating if the relevant species overlap in distribution.

n) Recent research based on DNA sequence analyses has shown evidence for multiple episodes of hybridization between *Homo sapiens* and two other hominins. The two other hominins are:
  i. Denisovans and Neanderthals
  ii. Neanderthals and *Homo habilis*
  iii. Denisovans and *Australopithecus afarensis*
  iv. San and Uzbek

o) Gene flow and selection are opposing forces. Which of the following statements agrees with this?

     i. Gene flow erodes the genetic differences between populations and local selection enhances the genetic differences between populations.

     ii. Local selection erodes the genetic differences between populations and gene flow enhances the genetic differences between populations.

     iii. Local selection reduces the genetic differences between populations and gene flow increases the genetic differences between populations.

     iv. Gene flow equalizes the genetic differences between populations and local selection reduces the genetic differences between populations.

(4 x 15 = 60 marks)

2. A scientist was interested in determining the order of three genes (E, F, G) located in a single chromosome in common garden pea plants. A cross between two plants resulted seeds with the following genotypes. Answer the questions below using the following table.

Genotype	Number of seeds
EFG/efg	370
EFg/efg	8
EfG/efg	37
Efg/efg	95
eFG/efg	85
eFg/efg	43
efG/efg	12
efg/efg	350

a) Identify the parental genotypes giving reasons. **(10 marks)**

b) Identify the genotypes that were created through single and double cross overs. Provide your reasons for the selection. **(10 marks)**

c) Determine the order of the E, F and G genes on the chromosome. **(20 marks)**

d) Calculate the distances between adjacent genes in map units. **(40 marks)**

e) Draw a linkage map depicting the order of the genes and the distances between them on a chromosome. **(20 marks)**

3. The Sri Lankan leopard (*Panthera pardus kotiya*) is a leopard subspecies endemic to Sri Lanka. The melanistic colour forms of the leopard are occasionally recorded from Sri Lanka and it has been found that melanism is caused due to a recessive allele in a single gene. Thus, the heterozygotes have the typical wild type coloration. In a recent census in the southwestern wet zone of Sri Lanka, 4 melanistic leopards and 396 leopards with the wild type colouration were found. Answer the following questions assuming that the leopard population is in Hardy-Weinberg equilibrium.

    a) What are the assumptions of the Hardy-Weinberg equilibrium?   **(10 marks)**

    b) What is the frequency of the melanistic genotype?   **(20 marks)**

    c) Calculate the frequency of the dominant allele that is responsible for producing the wild type coloration?   **(20 marks)**

    d) How many of the leopards would be heterozygotes in the population?   **(20 marks)**

    e) If the population decreased to 320 individuals in five years, assuming that the population is still in Hardy-Weinberg equilibrium, how many of them would you expect to have the wild type coloration?   **(30 marks)**

4. Figure 1 shows three different trajectories of allele frequency through time, with each curve having a different value of the selection coefficient, *s* (source: Bergstrom & Dugatkin, 2016).
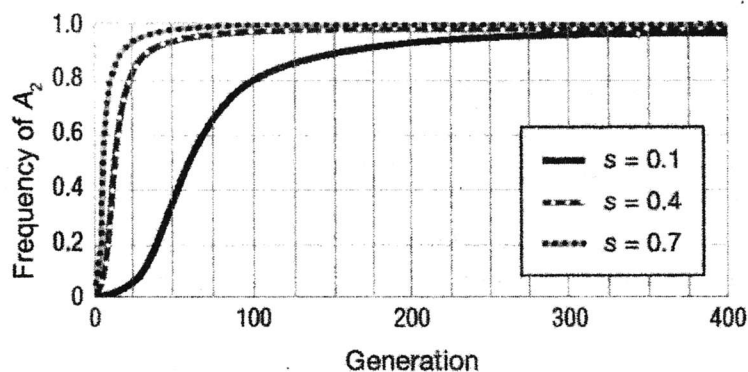

Figure 1. Allele frequencies through time.

    a) Define the term fixation and indicate the approximate generation at which each of the three curves (*s* = 0.1, 0.4 and 0.7) attain fixation.   **(25 marks)**

    b) All three curves show similarity in how genetic variation changes in relation to the frequency of allele A_2. Describe this shared pattern.   **(15 marks)**

c) The three curves differ in how genetic variation changes as a beneficial mutation spreads through the population. Describe this difference.   **(20 marks)**

d) Name and define a mode of selection that might lead to the spread of a beneficial mutation, such as the one described in question 4(c)   **(15 marks)**

e) What is the ultimate impact of the mode of selection specified in 4(d) on genetic variation?   **(10 marks)**

f) Give three examples of rapid selection in response to strong selection.   **(15 marks)**

5. Due to climate change a once widespread species (Figure 2A) is reduced in distribution and is restricted to two isolated populations that are separated by habitat from which the species is absent (Figure 2B).
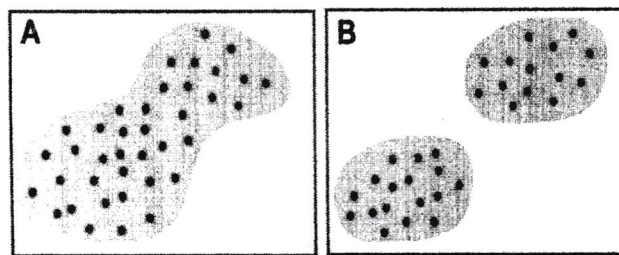

Figure 2. Change in the distribution of a species from a widespread distribution (A) to a restricted one (B).

a) Name and define the process that could have caused the change in distribution shown in the figure.   **(10 marks)**

b) If the two populations shown in part B of the figure evolve into distinct species, would they be described as sister species or sibling species? Explain the difference between sister species and sibling species.   **(25 marks)**

c) What mode of speciation describes the situation, as shown in the figure above, where a widespread species undergoes range fragmentation and subsequent speciation?   **(5 marks)**

d) Compare allopatric, parapatric and sympatric speciation, giving one example for each case.   **(60 marks)**

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