SIR ARTHUR LEWIS COMMUNITY COLLEGE

ACADEMIC YEAR (2024/2025) – SEMESTER TWO

END OF SEMESTER EXAMINATION

COURSE CODE	:	**BIO 216**
COURSE TITLE	:	**Genetics and Biotechnology**
LECTURER(S)	:	**Jeannine Monplaisir-Gaillard**
DATE	:	**Tuesday 6th May 2025**
TIME	:	**9:00 – 11:00 a.m.**
DURATION	:	**2 hours**
STUDENT ID #	:	_____

GENERAL INFORMATION AND INSTRUCTIONS

- Students must sign **IN** and **OUT** on the examination class list.
- Write your ID number on the question paper.
- This paper consists of two sections A and B.
- Section A consists of thirty (30) multiple choice questions and Section B consists of three (3) structured questions with parts.
- ALL questions must be answered.
- Circle the correct answer on the question paper for Section A.
- Answer all the structured questions in the space provided for section B.

Question	Student's Mark	Moderated Mark
Section A 1 - 30		
Section B		
1		
2		
3		
Total		

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO

Section A – Multiple Choice Questions

INSTRUCTIONS: Read each question carefully and circle the letter of the answer which best corresponds to the question.

1. A species of fish was found to have 28% of its nucleotides containing adenine in its DNA. What percentage of nucleotides making up the DNA will it contain cytosine?
   (A) 28%
   (B) 22%
   (C) 56%
   (D) 72%

2. In what way are DNA and RNA similar?
   (A) Both are double-stranded structures.
   (B) Equal numbers of adenine and guanine exist in both structures.
   (C) Both are found only in the nucleus.
   (D) The monomers are held together by phosphodiester bonds.

3. Which statement correctly describes the transcription of DNA?
   (A) It produces amino acids.
   (B) It produces messenger RNA.
   (C) It results in increased DNA synthesis.
   (D) It is a semi-conservative process.

4. What is the action of the enzyme DNA ligase?
   (A) DNA is broken up at specific sites.
   (B) DNA fragments are joined together.
   (C) DNA replication occurs.
   (D) DNA transcription occurs.

5. In a genetic engineering experiment, a piece of DNA containing 3000 nucleotides was transcribed and translated into protein. How many amino acids would be required?
   (A) 500
   (B) 1000
   (C) 2000
   (D) 3000

6. In many cells, ribosomes occur in groups along messenger RNA molecules. What is the advantage of this compared with single ribosomes?
   (A) A greater variety of polypeptides can be produced.
   (B) Fewer transfer RNA molecules are used in protein synthesis.
   (C) Larger polypeptide chains can be produced.
   (D) Polypeptides can be produced more rapidly.

7. In man, the A, B, AB, O blood groupings are controlled by a system of multiple alleles. A man of blood group B marries a woman of blood group A and they have one child. Which one of the following statements about the child's blood is correct?
   (A) It could not be group O.
   (B) It could only be group A or group B.
   (C) It could only be group AB.
   (D) It could be any of the groups A. B. AB, O.

8. In domestic cats, the genes for orange fur and black fur are an allelic pair which are sex-linked and codominant. When black females are mated with orange males, which one of the following is the expected proportion of heterozygotes in the offspring?
   (A) 0%
   (B) 25%
   (C) 50%
   (D) 100%

9. Which one of the following phenotypic features of Man can be affected only by the genotype?
   (A) Hair colour
   (B) Intelligence
   (C) Number of fingers
   (D) Number of different blood group antigens

10. A woman who is a carrier of haemophilia had phenotypically normal parents and is married to a man without the recessive haemophilia gene. Which one of the following statements is true?
   (A) Her father must have been a carrier of haemophilia.
   (B) Her mother also possesses the gene.
   (C) All her sons will be haemophiliacs.
   (D) All her daughters will carry the recessive gene.

11. A linkage group is composed of genes which
   (A) affect the same characteristics.
   (B) associate during prophase I.
   (C) segregate at mitosis.
   (D) are situated on the same chromosome.

12. A woman with normal colour vision, whose father was red-green colour blind, marries a red-green colour blind man. What is the probability of her first-born child being red-green colour blind?
   (A) 1.0
   (B) 0.75
   (C) 0.50
   (D) 0.25

13. In the F_2 generation of a dihybrid cross between yellow, round seeded and green, wrinkled seeded pea plants, 17 out of 254 pea seeds were green and wrinkled. Other seeds were:

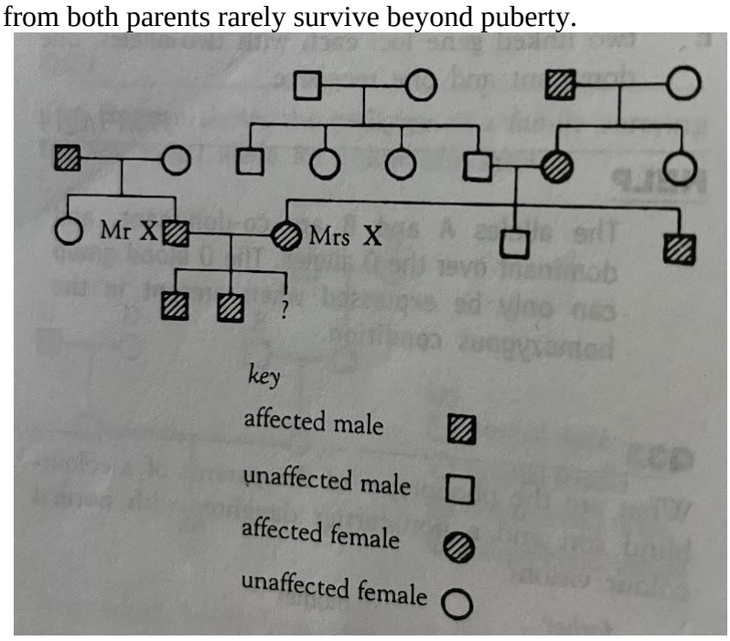
   Yellow and round
   Green and round
   Yellow and wrinkled

   What do these results indicate?
   (A) Crossing over has occurred.
   (B) Green and wrinkled are both recessive characteristics.
   (C) The alleles for green and wrinkled are linked.
   (D) The allele for green is recessive but not the allele for wrinkled.

14. A red-flowered plant crossed with a white-flowered plant of the same species, produced F_1 plants which all had pink flowers. Self-pollination of the F_1 plants produced an F_2 generation in which 39 plants had red flowers, 83 had pink flowers and 40 had white flowers.
   What does this experiment demonstrate?
   (A) Incomplete dominance
   (B) Continuous variation
   (C) A dihybrid cross
   (D) Linkage

15. The genotype of a human zygote will differ from that of both parents. Which of the following **does not** contribute to this variation?
   (A) Crossing over occurring during meiosis.
   (B) Mutation of genes.
   (C) Presence of dominant genes
   (D) Random fusion of gametes

16. The family tree below was assembled by a genetic counsellor for Mr and Mrs X who suffer from heart disease due to hyperchlolesterolaemia. Children who inherit the **dominant** mutant allele from both parents rarely survive beyond puberty.



What is the probability that Mr and Mrs X's third child will be unaffected?

(A) 0.0
(B) 0.25
(C) 0.5
(D) 0.75

17. Which of the following results in an extra chromosome to the chromosome complement of a cell, as in Down's syndrome?

(A) Allopolyploidy
(B) Autopolyploidy
(C) Non-disjunction
(D) Polygenetic inheritance

18. Which of the following increases the number of different alleles in a population?

(A) Crossing over
(B) Gene mutation
(C) Random fusion of gametes
(D) Reassortment of chromosomes in meiosis

19. The diagram shows the results of two types of gene mutations.

Original base sequence - CGATTACCATGCATA

Mutant sequence 1 - CGATTAACCTGCATA
Mutant sequence 2 – CGATTACCAGGCATA

What types of gene mutation produce mutant sequences 1 and 2?

	1	2
(A)	deletion	insertion
(B)	insertion	deletion
(C)	inversion	substitution
(D)	substitution	insertion

20. Sickle cell haemoglobin differs from normal haemoglobin because of a single change in an amino acid; valine replaces glutamic acid.

Coding triplets in DNA for glutamic acid are CTT and CGC.
Coding triplets in DNA for valine are CAA and CAG.
Which mRNA codon will produce sickle cell haemoglobin if substituted for the normal haemoglobin?

(A) GAA
(B) GTC
(C) GTT
(D) GUC

21. A mutation is a change produced by an alteration in the genetic mechanism and

(A) may arise spontaneously.
(B) is always induced by the environment.
(C) is never advantageous.
(D) is not inherited.

22. In which situation would evolution be slowest for an inbreeding population?

	Migration	Selective Pressure	Variation due to Mutation
(A)	absent	high	high
(B)	absent	low	low
(C)	high	high	low
(D)	high	low	high

23. All the alleles present in the gametes of a sexually reproducing population are known as the population's

(A) gene frequency.
(B) gene pool.
(C) genome.
(D) genotype.

24. Which is the longest phase in the cell cycle of a human cell?

(A) Anaphase
(B) Prophase
(C) Interphase
(D) Telophase

25. A diploid cell contains four pairs of homologous chromosomes. Each pair is heterozygous Aa, Bb. Cc and Dd.

After meiosis, how many different combinations of these alleles could be produced in the haploid daughter cells?

(A) 4
(B) 8
(C) 16
(D) 64

26. Different enzymes are used in the various steps involved in the production of bacteria capable of synthesizing a human protein. Which step is catalysed by restriction enzymes?

(A) Cutting open a plasmid vector.
(B) Cloning DNA.
(C) Producing cDNA from mRNA.
(D) Reforming the DNA double helix.

27. What describes a promoter?

(A) A length of DNA that controls the expression of a gene.
(B) A piece of RNA that binds to DNA to switch off a gene.
(C) A polypeptide that binds to DNA to switch on a gene.
(D) A triplet code of three DNA nucleotides that codes for "stop".

28. Which statement correctly describes the electrophoresis of DNA fragments?
    (A) Larger fragments of DNA move more rapidly to the anode than smaller fragments.
    (B) Positively charged fragments of DNA move to the anode.
    (C) Small negatively charged fragments of DNA move more rapidly to the negative pole.
    (D) Smaller fragments of DNA move more rapidly than larger fragments.

29. The following stages may be used in the process of genetic engineering to obtain a desired gene.
    1. Potential difference applied
    2. Cut by restriction enzymes
    3. DNA extracted from cell
    4. Fragments travel to anode
    5. ^{32}P probe added
    6. Fragments placed in well at end of gel

    Which of the following identifies the correct sequence of the process?
    (A) 2 3 5 4 6 1
    (B) 3 2 6 1 4 5
    (C) 4 3 6 2 1 5
    (D) 5 6 1 3 4 2

30. Why are bacteria generally used in gene cloning?
    (A) They contain enzymes that cut DNA into fragments.
    (B) They can replicate DNA in a short time.
    (C) They reproduce exponentially by binary fission.
    (D) They accept foreign DNA into the nuclei.

Total 30 marks

Section B

INSTRUCTIONS: Answer all the questions in Section B by filling in your responses in the space provided after each question.

1. In a unique variety of a guava plant, the dominant alleles of two unlinked genes, T/t and G/g, are needed to make the guava fruit very tough and so inedible. All other genotypes result in soft fleshy fruit that are therefore edible.
    - Guava plants with genotypes including the dominant **T** produce fruits with an extra thick outer coat present.
    - Guava plants with genotypes in which the recessive allele **t** is homozygous produce fruit with no outer coat.
    - Guava plants with genotypes including the dominant allele **G** have a hard waterproof substance called lignin added to their outer coats, but this is added only if the outer coat is present.
    - Guava plants with genotypes in which the recessive allele **g** is homozygous, do not have added lignin.

(a) State the phenotypes (**edible/inedible**) of guavas of plants with the following genotypes:

TtGG----------

ttGg ----------(2)

(b) Two guava plants of genotypes **TTgg** and **ttGG** were interbred to give an F1 generation and these in turn were interbred to give an F2 generation.

Draw a genetic diagram of the cross, including gametes, showing the genotypes and phenotypes of the F1 and F2 generations. Give the ratio of phenotypes expected in the F2 generation by describing each genotype as edible or inedible.

Parental Phenotypes:

Parental genotypes:

Gametes:

F1 genotypes:

F1 phenotypes:

F1 self-crossed:

Gametes:

FEMALE GAMETES	MALE GAMETES			

F2 phenotype ratio:

(6)

(c) A geneticist is investigating the inheritance of genes for redish brown eye colour **(R)** and tiny hairs **(h)** on the legs of flies. The allele for hairy legs is recessive and causes the flies to have tiny hairs all over their legs. The allele for hairless legs **(H)** is dominant. White eyes are a result of the homozygous recessive allele **(r)**. The geneticist wishes to determine if the genes assort independently. A test cross is done between a fly with reddish brown eyes and hairless legs and a fly homozygous recessive for both traits.

TABLE 1: CATEGORIES OF OFFSPRING AND RESPECTIVE NUMBERS RECORDED

PHENOTYPE	**GENOTYPE**	**OBSERVED NUMBER OF OFFSPRING**
Redish brown eyes and hairless legs		**163**
Redish brown eyes and hairy legs		**170**
White eyes and hairless legs		**136**
White eyes and hairy legs		**131**

(i) Determine the genotype of **EACH** phenotypic category in Table 1, using the symbols given. Write your answers in Table 1. (2)

(ii) Write a null hypothesis for the test cross in (c)

---(1)

(iii) A 1:1:1:1 phenotype ratio was expected in the offspring. Carry out a chi-square test by completing Table 2 to determine if the null hypothesis is supported by the actual number of offspring obtained.

TABLE 2: CALCULATED VALUES FOR CHI-SQUARED TEST FOR DATA GIVEN

PHENOTYPE	EXPECTED RATIO	OBSERVED NUMBER	EXPECTED NUMBER	O-E	$(O-E)^2$	$(O-E)^2/E$
Redish brown eyes and hairless legs	1	160				
Redish brown eyes and hairy legs	1	163				
White eyes and hairless legs	1	131				
White eyes and hairy legs	1	126				
Chi-Squared value:						

(5)

(iv) Calculate the degrees of freedom ---------- (1)

(v) Using the table of probabilities provided on the next page, and your calculated Chi-square value from Table 2, state the probability of the deviation occurring by chance and state whether the null hypothesis is supported or not.

---(2)

(vi) If the Chi-square value was calculated to be 17.8 instead, what will be the probability of the deviation occurring and should the null hypothesis be accepted or rejected?

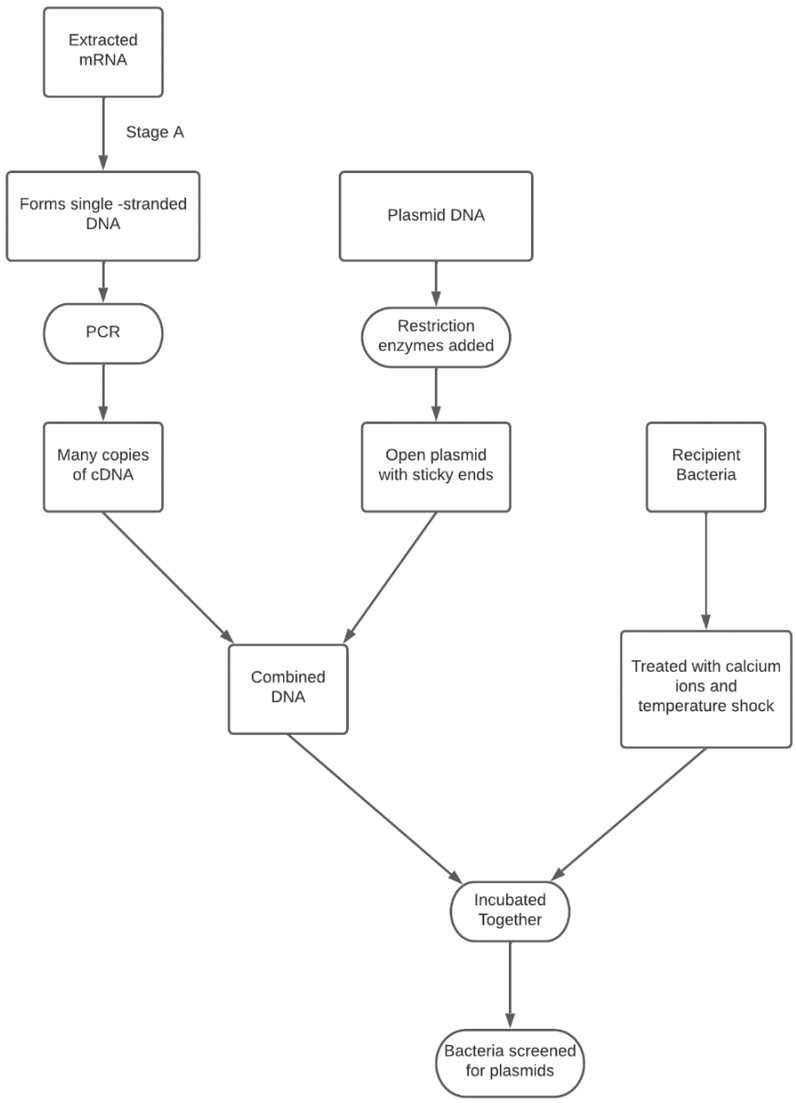
---(2)

TABLE 3: CHI-SQUARED DISTRIBUTION

DEGREES OF FREEDOM	PROBABILITY										
	0.95	**0.90**	**0.80**	**0.75**	**0.50**	**0.30**	**0.20**	**0.10**	**0.05**	**0.01**	**0.001**
1	0.004	0.02	0.06	0.15	0.46	1.07	1.64	2.71	3.84	6.64	10.83
2	0.10	0.21	0.45	0.71	1.39	2.41	3.22	4.60	5.99	9.21	13.82
3	0.35	0.58	1.01	1.42	2.37	3.66	4.64	6.25	7.82	11.34	16.27
4	0.71	1.06	1.65	2.20	3.36	4.88	5.99	7.78	9.49	13.28	18.47

Total 21 marks

2. The flow chart below outlines stages in the process by which foreign DNA may be inserted into a bacterium.



(a) In the case of the insulin producing gene, name the specific cell type which the mRNA can be extracted from.

---(1)

(b) Name the enzyme used to make the single-stranded DNA in stage A

---(1)

(c) If the original mRNA contained the base sequence **AGCCUAGUC,** write down the corresponding sequence of bases in the single-stranded DNA made in stage A.

---(1)

(d) What does the c in cDNA stand for?

---(1)

(e) What does PCR stand for?

---(1)

(f) What is the name of the machine used in the PCR process?

---(1)

(g) What are sticky ends?

---(1)

(h) What is the term used to describe the role of plasmids in this process?

---(1)

(i) What is the name given to combined DNA?

---(1)

(j) Suggest why bacteria were treated with calcium ions?

---(1)

(k) Bacteria are screened for plasmids using gene markers. Give one example of a gene marker.

---(1)

(l) State two benefits of using genetically modified organisms other than making insulin.

---(2)

(m) State two hazards of using genetically modified organisms.

---(2)

Total 15 marks

3. (a) Determine if the following statements about genetic diseases and gene therapy are true or false by writing T next to the statement if it is true or F next to the statement if it is false.

    I. In gene therapy, DNA is changed in the cells of a patient to treat a genetic disease –

    II. The normal gene to replace the faulty gene is usually directly injected into the patients' cells –

    III. Somatic cell gene therapy is presently prohibited –

    IV. Gene therapy is a relatively safe procedure causing no harm to patients –

    V. One of the genetic diseases in which gene therapy holds a promise of a cure is cystic fibrosis –

    VI. Among the epigenetic research conducted by scientist, the most extensively studied disease is cancer –

    VII. HIV is linked to cervical cancer –

    VIII. Activation of tumor-suppressor genes causes cells to become cancerous –

    IX. People with SCID produce a thick sticky mucous –

    X. If a genetic disease is caused by a recessive gene, that gene must be removed before a working copy of the gene is added –

(10 marks)

(b) The following passage is a summary of the main principles of natural selection. Some of the words have been omitted. Write the most appropriate term in each space.

The theory of natural selection was developed by ----------.

In this theory, it was observed that individuals in a natural population have great

---------- potential and yet the numbers of individuals in a

population remain relatively ----------. This is because many die

due to environmental factors and therefore do not reproduce. There is

---------- amongst members of a population and those with

the features best adapted to the environment survive. They reproduce and pass on their

advantageous ---------- to their offspring. This may lead to a

change in the ---------- pool of the population and over time may

lead to evolutionary change.

(**6 marks)**

(c) Match each item below to a type of variation (continuous or discontinuous)

I. Height in humans -

II. ABO blood groupings in humans –

III. Characteristics NOT influenced by the environment –

IV. Polygenic inheritance –

V. Related to quantitative genetics –

VI. Best represented on a bar chart or a pie chart –

(6 marks)

Total 22 marks

END OF EXAMINATION