

**NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
FACULTY OF APPLIED SCIENCES
DEPARTMENT OF APPLIED BIOLOGY AND BIOCHEMISTRY
BACHELOR OF SCIENCE HONOURS DEGREE IN APPLIED
BIOLOGY AND BIOCHEMISTRY**

GENETICS SBB 1204

**EXAMINATION PAPER
MAY 2017**

This examination paper consists of 4 pages

Time Allowed: 3 hours
Total Marks: 100
Special Requirements: Statistical tables

INSTRUCTIONS TO CANDIDATES

- 1. Answer Four (4) Questions. Each question carries 25 marks.**
- 2. Where a question contains subdivisions, the mark value for each subdivision is given in brackets.**
- 3. Illustrate your answer where appropriate with large, clearly labeled diagrams.**

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1. (a) State Mendel's laws of inheritance and illustrate how he derived them. (7 marks)
- (b) Describe, with the aid of examples, any **three** genetic phenomena that lead to the modification of the 9:3:3:1 Mendelian dihybrid ratio. (18 marks)
2. (a) Chickens with short wings and legs are called creepers. When creepers are mated to normal birds they produce creepers and normals with equal frequency. When creepers are mated to creepers they produce 2 creepers to 1 normal. Crosses between normal birds produce only normal progeny. Using genetic crosses explain these results. (5 marks)

(b) Coat colour in rabbits is controlled by the *C* gene with four alleles:

c^+ - wild type

c^{ch} - chinchilla (light grey)

c^h - Himalayan (white with black extremities)

c - albino

These alleles are related as shown by the following dominance hierarchy: $c^+ > c^{ch} > c^h > c$.

(i) A wild type coat female rabbit mates with a chinchilla coat male, and over several generations they produce litter with the following coat colour distribution: wildtype – 13; chinchilla – 7; himalayan – 6.

Use genetic crosses to determine the genotypes of the parents. (5 marks)

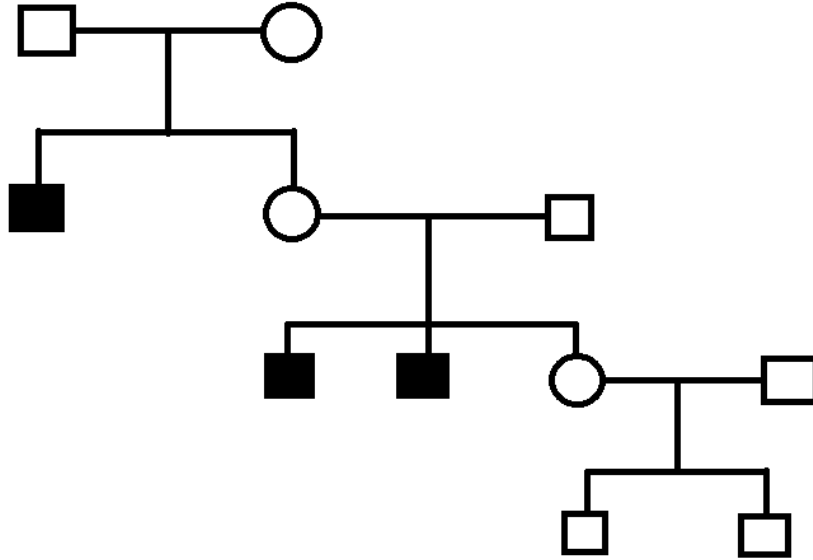
(ii) A farmer wants to sell one of his most popular wild type male rabbits to a rabbit breeder. However the rabbit breeder wants to know if the male rabbit is pure breeding or not before buying it. Using appropriate symbols and genetic crosses, describe in detail, how the farmer would proceed to do so. (5 marks)

(c) Write short notes on the following:

(i) Sex limited and sex influenced traits. (5 marks)

(ii) Penetrance and expressivity. (5 marks)

3. (a) A woman with a family history of haemophilia approaches you as a professional in genetic risk assessment and genetic counselling. Haemophilia is a recessive X-linked disorder characterized by the inability of blood to clot. As shown in the pedigree below, the woman (II-2) has a brother (II-1) and 2 sons (III-1 and III-2) with haemophilia. The woman has a daughter (III-3) whom she wishes to know if she is a carrier of haemophilia or not. The daughter (III-3) already has two sons who are non-haemophiliac.



Calculate the probability that the consultant's daughter (III-3) is a carrier of haemophilia. (15 marks)

(b) Eye colour in humans is controlled by an autosomal locus. The allele for brown eyes (**B**) is dominant over the allele for blue eyes (**b**). Two heterozygous brown-eyed individuals have five children. Calculate the probability that:

- (i) The first, second and last-born children will all be brown eyed and the third and fourth children will be blue eyed. (4 marks)
- (ii) Two of the couple's five children will be blue-eyed. (6 marks)

4. Three recessive genes in the V linkage group of the tomato are: **a** producing absence of anthocyanin pigment (anthocyaninless), **hl** producing hairless plants, and **j** producing jointless fruit stems. Among 3 000 progeny from a trihybrid testcross, the following phenotypes were observed:

259 hairless	268 anthocyaninless, jointless, hairless
40 jointless, hairless	941 anthocyaninless, hairless
931 jointless	32 anthocyaninless
260 normal	269 anthocyaninless, jointless

- (a) State the genotypes of the parents in this cross. (2 marks)
- (b) Determine the order and configuration of the 3 genes on the chromosome. (6 marks)
- (c) Calculate the recombinant frequencies and the interferences between the genes. (15 marks)
- (d) Draw a genetic map of the genes. (2 marks)
5. (a) In Caucasian humans, hair straightness or curliness is governed by a single pair of alleles showing partial dominance. Individuals with straight hair are homozygous for the *Is* allele, while those with curly hair are homozygous for the *Ic* allele. Individuals with wavy hair are heterozygous (*IsIc*). In a population of 1,000 individuals, 245 were found to have straight hair, 393 had curly hair, and 362 had wavy hair.
- (a) Calculate the allelic frequencies of the *Is* and *Ic* alleles. (4 marks)
- (ii) Using an appropriate statistical test determine if this population is in Hardy-Weinberg equilibrium. (10 marks)
- (b) With regards to the inheritance of quantitative traits, define the following terms:
- (i) Additive gene action. (2 marks)
- (ii) Dominant gene action. (2 marks)
- (iii) Heritability. (2 marks)
- (c) For a certain variety of tomatoes it is well known that the mean number of fruits per plant is 80 and the narrow sense heritability (h^2) for this trait is 0.5. If two parental tomato plants with a mean (between them) of 105 fruits per plant are crossed, estimate the average number of fruits per plant expected in the F_1 offspring. (5 marks)
6. (a) With regards to chromosome structure and number, distinguish between the following terms:
- (i) Deletion heterozygote and inversion heterozygote. (2 marks)
- (ii) Chromosome-level break and chromatid-level break. (2 marks)
- (iii) Aneuploidy and euploidy. (2 marks)
- (b) Describe the different mechanisms through which polyploidy arises in plants. (10 marks)
- (c) With the aid of specific examples, discuss the economic significance of euploidy. (9 marks)

END OF EXAMINATION