

UNIVERSITY OF SWAZILAND

FINAL EXAMINATION PAPER: MAY 2008

TITLE OF PAPER: GENETICS

COURSE CODE: B303

TIME ALLOWED: THREE HOURS

- INSTRUCTIONS:
1. ANSWER QUESTION 1 (COMPULSORY) IN SECTION A AND ANY THREE OTHER QUESTIONS IN SECTION B.
 2. EACH QUESTION CARRIES TWENTY FIVE (25) MARKS.
 3. ILLUSTRATE YOUR ANSWERS WITH LARGE AND CLEARLY LABELLED DIAGRAMS WHERE APPROPRIATE.
 4. ALL WORKINGS MUST BE CLEARLY SHOWN.

SPECIAL REQUIREMENTS: CANDIDATES MAY BRING CALCULATORS.

THIS PAPER IS NOT TO BE OPENED UNTIL PERMISSION HAS
BEEN GRANTED BY THE INVIGILATORS

SECTION A (COMPULSORY)

Question 1

(a) Explain the chromosome theory of inheritance, highlighting how it is related to Mendel's findings. (2 marks)

(b) Explain why meiosis leads to significant genetic variation while mitosis does not. (1 mark)

(c) In a series of two-point map crosses involving three genes that are linked on chromosome 3 in *Drosophila*, the following distances were calculated: $cd-sr = 13$ m.u.; $cd-ro = 16$ m.u.

(i) Sketch two possible arrangements for these genes. (2 marks)

(ii) Give the mapping data that would explain the correct arrangement. (1 mark)

(d) In a haploid organism, the C and D loci are 8 m.u. apart. From a cross $Cd \times cD$, give the proportion of each of the following progeny classes: (i) CD , (ii) cd , (iii) Cd , (iv) all recombinants. (4 marks)

(e) A population of annual plants was composed exclusively of individuals of genotype a/a . One year, a flood introduced many seeds of genotype A/A and A/a into the population. Immediately after the introduction, there were 55% A/A , 40% A/a and 5% a/a individuals. Because the region had no insects capable of cross pollinating this species of plant, all plants routinely self-pollinated. Calculate the proportions of A/A , A/a and a/a after three generations of selfing. (6 marks)

(f) A snap dragon plant that bred true for white petals was crossed to a plant that bred true for purple petals, and all the F_1 had white petals. The F_1 was selfed. Among the F_2 , three phenotypes were observed in the following numbers:

| | |
|----------------|-----------|
| white | 240 |
| solid purple | 61 |
| spotted purple | <u>19</u> |
| Total | 320 |

(i) Explain these results, showing genotypes of all generations. (5 marks)

(ii) A white F_2 plant was crossed to a solid purple F_2 plant, and the progeny were: white 50%, solid purple 25% and spotted purple 25%. Deduce the genotypes of the F_2 plants crossed. (4 marks)

[TOTAL MARKS = 25]

[PLEASE TURN OVER]

- (i) Explain why these results seem to conflict with classical dominance theory. (2 marks)
- (ii) Deduce the phenotypes of female and male parents and as well as the phenotypes of female and male progeny. (8 marks)

[TOTAL MARKS = 25]

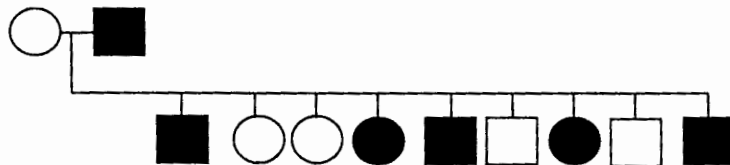
Question 4

(a) Explain how you would use Pulsed Field Gel Electrophoresis (PFGE) to find out on what chromosome a cloned gene is located. (5 marks)

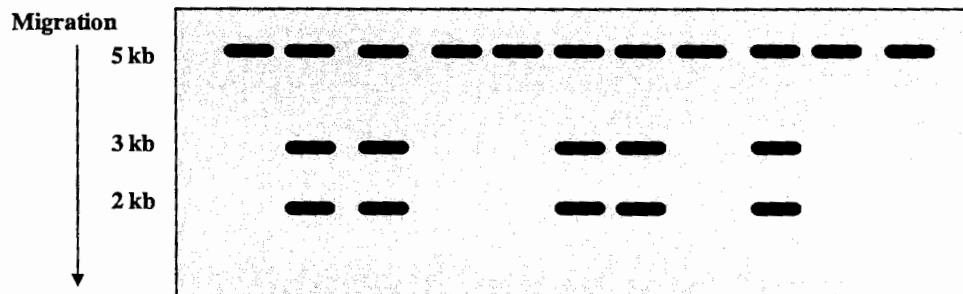
(b) In a bacterial vector, you have cloned a plant gene that encodes a photosynthesis protein. Now you wish to find out if this gene is active in roots and other non-photosynthetic tissue. Explain how you would experimentally achieve this. (5 marks)

(c) DNA studies are performed on a large family that shows a certain autosomal dominant disease of late onset (approximately 40 years of age). A DNA sample from each family member is digested with the restriction enzyme *TaqI* and subjected to gel electrophoresis. A Southern blot is then performed, with the use of a radioactive probe consisting of a part of human DNA cloned in a bacterial plasmid. The autoradiogram, aligned with the family pedigree, is as shown below. Affected members are shown in black.

PEDIGREE



AUTORADIOGRAM



- (i) Analyse fully the relation between the DNA variation, the probe DNA, and the gene for the disease. Hence sketch the relevant regions where the DNA fragments are located on the chromosome for both the father and the mother. (8 marks)
- (ii) Explain the genetic condition of the last son who lacks the 3 kb and 2 kb fragments. (4 marks)
- (iii) Explain how useful these results would be in counselling people in this family who wish to subsequently marry. (3 marks)

[TOTAL MARKS = 25]

[PLEASE TURN OVER]

Question 5

(a) Explain the difference between replicative and conservative modes of transposition and briefly describe an experiment that demonstrates each of these modes in prokaryotes. (12 marks)

(b) Crown gall tumors are found in many dicotyledonous plants infected by the bacterium *Agrobacterium tumefaciens*. The tumors are caused by the insertion of DNA from a large plasmid carried by the bacterium into the plant DNA. Suppose that a tobacco plant of type A is infected, and it produces tumors. You remove the tumor tissue and grow it on a synthetic medium. Some of these tumor cultures produce aerial shoots. You graft these shoots onto a normal tobacco plant of type B, and the graft grows to an apparently normal A-type shoot and flowers. You then remove cells from the graft and place them in a synthetic medium, where they grow like tumor cells.

(i) Explain why the graft appears to be normal. (8 marks)

(ii) When seeds are produced by graft, the resulting progeny are normal A-type plants. No trace of the inserted plasmid DNA remains. Propose a possible explanation for this 'reversal'. (5 marks)

[TOTAL MARKS = 25]

Question 6

(a) XYY humans are fertile males and XXX humans are fertile females. Reconcile these observations with the mechanisms of sex determination and dosage compensation. (5 marks)

(b) Two inbred lines of beans are intercrossed. In the F_1 , the variance in bean weight is measured at 1.5. The F_1 is selfed and in the F_2 , the variance in bean weight is 6.1. Estimate the broad heritability of bean weight in the F_2 population of this experiment. (5 marks)

(c) In the experimental population of *Tribolium* (flour beetles), the body length shows a continuous distribution with a mean of 6 mm. A group of males and females with body lengths of 9 mm are removed and interbred. The body lengths of their offspring average 7.2 mm. From these data, calculate the heritability in the narrow sense for body length in this population. (5 marks)

(d) In a plant, height varies from 6 to 36 cm. When 6-cm and 36-cm plants were crossed, all plants were 21 cm. In the F_2 generation, a continuous range of heights was observed. Most were around 21 cm, and 3 of 200 were short as the 6-cm P_1 parent.

(i) Explain the mode of inheritance illustrated, and give the number of genes involved. (5 marks)

(ii) Calculate by how much each allele contributes to the height. (5 marks)

[TOTAL MARKS = 25]

[END OF QUESTION PAPER]