UNIVERSITY OF SWAZILAND

MAIN EXAMINATION PAPER: DECEMBER 2010

TITLE OF PAPER: GENETICS

COURSE CODE: B303

TIME ALLOWED: THREE HOURS

INSTRUCTIONS:
1. THIS PAPER IS DIVIDED INTO TWO SECTIONS
2. ANSWER QUESTION 1 (COMPULSORY) IN SECTION A AND ANY THREE OTHER QUESTIONS IN SECTION B
3. EACH QUESTION CARRIES TWENTY FIVE (25) MARKS
4. ILLUSTRATE YOUR ANSWER WITH LARGE AND CLEARLY LABELLED DIAGRAMS WHERE APPROPRIATE

SPECIAL REQUIREMENTS: CANDIDATES MAY BRING CALCULATORS

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

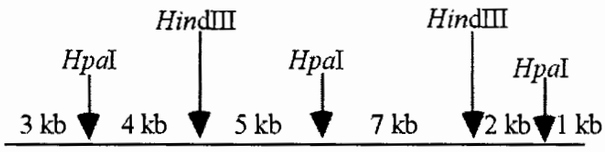
SECTION A (COMPULSORY)

Question 1

(a) Assuming that genes assort independently, state the phenotypic ratios produced by the following crosses:
(i) a selfed monohybrid, (1 mark)
(ii) a selfed dihybrid, (1 mark)

(b) Pure breeding black rabbit was crossed with a pure breeding white rabbit. All F_1 progeny were black. Selfing F_1 produced 11 black and 4 white F_2 rabbits.
(i) Explain the term pure breeding. (1 mark)
(ii) Explain these results. (1 mark)
(ii) Give the proportion of white rabbits (if any) obtainable from test-crossing an F_1 rabbit. (1 mark)

(c) A 22-kb piece of DNA has the following restriction sites:



In three separate digestions, *Hpa*I alone was used to completely digest this DNA, followed by, *Hind*III alone, and finally a third batch of this DNA was completely digested by both restriction enzymes. The fragments resulting from each of the three digestions and undigested DNA sample were subjected to gel electrophoresis, with ethidium bromide staining. Sketch the expected electrophoretogram. (5 marks)

(d) A cross is made between a strain of *Neurospora crassa* with genotype nic^+ ad^+ and another strain with genotype *nic ad*. The following linear octads are observed.

1	2	3	4	5	6	7
nic^+ ad^+	nic^+ ad^+	nic^+ *ad*	nic^+ *ad*	nic^+ *ad*	nic^+ ad^+	nic^+ *ad*
nic^+ ad^+	nic^+ ad^+	nic^+ *ad*	nic^+ *ad*	nic^+ *ad*	nic^+ ad^+	nic^+ *ad*
nic^+ ad^+	*nic ad*	nic^+ ad^+	nic^+ *ad*	*nic* ad^+	*nic* ad^+	*nic* ad^+
nic^+ ad^+	*nic ad*	nic^+ ad^+	nic^+ *ad*	*nic* ad^+	*nic* ad^+	*nic* ad^+
nic ad	*nic ad*	*nic ad*	*nic* ad^+	*nic* ad^+	nic^+ *ad*	nic^+ ad^+
nic ad	*nic ad*	*nic ad*	*nic* ad^+	*nic* ad^+	nic^+ *ad*	nic^+ ad^+
nic ad	nic^+ ad^+	*nic* ad^+	*nic* ad^+	nic^+ *ad*	*nic ad*	*nic ad*
nic ad	nic^+ ad^+	*nic* ad^+	*nic* ad^+	nic^+ *ad*	*nic ad*	*nic ad*
423	105	101	4	4	15	15

(i) Explain why *nic* and *ad* loci should be linked. (3 marks)
(ii) Calculate the centromere to locus distance for the *nic* and *ad* loci. (5 marks)
(iii) Calculate the map distance between *nic* and *ad* loci and draw the most probable genetic map that includes the centromere. (6 marks)
(iv) Relative to the centromere, explain why the nic-ad distance is in discrepancy with and the distances calculated in **Q1 (d)(ii)** above. (1 mark)

[Total 25 marks]

SECTION B (ATTEMPT ANY THREE QUESTIONS FROM THIS SECTION)

Question 2

(a) Mpendulo crossed plants that bred true for flat flower petals with plants that bred true for ruffled flower petals. The F_1 generation plants had ruffled flower petals. He allowed F_1 plants to self-pollinate to form a second generation, and analyzed the seeds of the resulting F_2 generation. Ruffled phenotype was dominant over flat phenotype.

(i) Assign symbols to denote the dominant and recessive alleles for the two phenotypes. (1 mark)

(ii) State the genotype of the F_1 plants. (1 mark)

(iii) Write down the genotypic ratio of the F_2 plants. (1 mark)

(iv) Write down the phenotypic ratio of the F_2 plants. (1 mark)

(v) One phenotypic class above has two genotypes. To which of the pure breeding parental plants should you cross them to tell them apart? What ratio of phenotypes do you expect in the resulting progeny in each case?

(vi) In his experiment, Mpendulo obtained 184 F_2 plants with ruffled petals and 40 plants with flat petals. Investigate whether or not these results are consistent with the phenotypic ratio in **Q2 (a)(iv)** above. (8 marks)

(b) A herd of pure breeding black polled (hornless) bulls was allowed to mate with a herd of pure breeding horned brown cows. All F_1 calves were black and hornless. One F_1 bull and a fellow F_1 cow were crossed to get an F_2 calf.

(i) Explain the genetic relationships between the two fur colour phenotypes as well as polled and horned phenotypes. (2 marks)

(ii) Calculate the probability that the F_2 calf will have either horns or brown fur. (5 marks)

(ii) Suppose the above F_1 pair was allowed to produce another calf, calculate the probability that the two calves will be phenotypically identical with regard to skin colour. (6 marks)

[Total 25 marks]

Question 3

In one experiment, pure breeding black Labrador male dog was crossed with a pure breeding brown Labrador female dog. The resulting F_1 had all black puppies. Selfing F_1 resulted in a *black: brown* dog distribution of 3:1. In another experiment, a man allowed his pure breeding black Labrador female dog to mate with a friend's pure breeding albino male dog resulting in all black puppies in the F_1. The F_1 was allowed to intercross resulting in F_2 progeny with a total of 48 puppies as follows: 26 Black, 10 brown and 12 albino.

(a) Explain these results. (5 marks)

(b) Using defined symbols of your choice, determine the genotypes of Parents, F_1 progeny and albino F_2 progeny in the second experiment. (12 marks)

(c) One F_2 albino female dog was crossed with an F_2 black male. The resulting F_3 progeny had the following distribution: 50% albino: 37.5% Black: 12.5% brown. Investigate the genotypes of the F_2 progeny used in the cross and give the genotypes of all the F_3 progeny. (8 marks)

[Total 25 marks]

Question 4

(a) Explain the following terms:

(i) incomplete dominance, (1 mark)
(ii) expressivity, (1 mark)
(iii) penetrance, (1 mark)
(iv) recessive epistasis, (2 marks)
(v) pleiotropy, (2 marks)

(b) In *Drosophila melanogaster*, cut wings (*ct*) is recessive to normal wings (ct^+), sable body (*s*) is recessive to gray body (s^+), and vermilion eyes (*v*) is recessive to red eyes (v^+). All three recessive mutations are X-linked. A female fly with cut wings, sable body, and vermilion eyes is crossed to a male homozygous for the normal wings, gray body, and red eyes. The F_1 females produced by this cross were mated with cut, sable, vermilion males in a testcross. The progeny resulting from the testcross are listed below.

v	*ct*	*s*	510
v^+	*ct*	*s*	1
v^+	ct^+	*s*	14
v^+	ct^+	s^+	500
v^+	*ct*	s^+	73
v	*ct*	s^+	20
v	ct^+	*s*	81
v	ct^+	s^+	1
Total			1200

(i) Determine order of these genes on the chromosome. (2 marks)
(ii) Identify and label the parental, single cross-over and double cross-over progeny (4 marks)
(iii) Calculate the map distances between the genes and draw the genetic map. (7 marks)
(iv) Determine the coefficient of coincidence and the interference among these genes. (5 marks)

[Total 25 marks]

Question 5

(a) Explain the following:

(i) Hardy-Weinberg equilibrium law, (1 mark)
(ii) polygenic inheritance, (1 mark)
(iii) broad-sense heritability, (1 mark)
(iv) narrow sense heritability. (1 mark)

(b) A recessive mutation in rats causes a defect in courtship behavior. The affected individuals are perfectly viable, but never reproduce. (The wild type dominant allele is ***A***, the recessive disease allele is ***a***). In a large population study Nosmilo determined that 1 in 8,000 rats is affected with this disease. Given that this population is in Hardy-Weinberg equilibrium, determine the following:
(i) The frequencies of the dominant and recessive alleles in the gametes of this population. (5 marks)
(ii) The frequencies of the ***AA***, ***Aa***, and ***aa*** genotypes in the adult population. (5 marks)
(iii) The mutation rate at which **A** alleles mutate into **a** alleles. (5 marks)

(c) Nozipho is a rice breeder. She has a farm with a population of genotypically identical rice plants, where variance for grain yield is 4.67. Would it be prudent to advise Nozipho to improve yield in this strain of rice by artificial selection? Explain your answer. (6 marks)

[Total 25 marks]

Question 6

(a) Explain what is meant by semi-conservative DNA replication. (3 marks)

(b) Many of the origins of replication that have been characterized contain core sequences with higher A-T content than G-C. Explain why this is so. (3 marks)

(c) Arrange the following enzymes in the temporal order of their action during DNA replication in *E. coli*: (5 marks)
(i) DNA polymerase I,
(ii) DNA polymerase III,
(iii) DNA primase,
(iv) DNA gyrase,
(v) DNA helicase.

(d) Identify three different types of RNA that are involved in translation and list the characteristics and functions of each. (6 marks)

(e) In what sense and to what extent is the genetic code
(i) degenerate, (4 marks)
(ii) ordered, (2 marks)
(iii) universal? (2 marks)
(*You may refer to* ***The Universal Genetic Code*** *on page 7*)

[Total 25 marks]

Chi square Distribution Table

df	*Probability Values*								
	0.995	0.990	0.975	0.950	0.500	0.050	0.025	0.010	0.005
1	0.00 +	0.00 +	0.00 +	0.00 +	0.45	3.84	5.02	6.63	7.88
2	0.01	0.02	0.05	0.10	1.39	5.99	7.38	9.21	10.60
3	0.07	0.11	0.22	0.35	2.37	7.81	9.35	11.34	12.84
4	0.21	0.30	0.48	0.71	3.36	9.49	11.14	13.28	14.86
5	0.41	0.55	0.83	1.15	4.35	11.07	12.38	15.09	16.75
6	0.68	0.87	1.24	1.64	5.35	12.59	14.45	16.81	18.55
7	0.99	1.24	1.69	2.17	6.35	14.07	16.01	18.48	20.28
8	1.34	1.65	2.18	2.73	7.34	15.51	17.53	20.09	21.96
9	1.73	2.09	2.70	3.33	8.34	16.92	19.02	21.67	23.59
10	2.16	2.56	3.25	3.94	9.34	18.31	20.48	23.21	25.19

The Universal Genetic Code

First base	Second base: U	Second base: C	Second base: A	Second base: G	Third base
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Met	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

END OF QUESTION PAPER