UNIVERSITY OF SWAZILAND

FINAL EXAMINATION PAPER: DECEMBER 2009

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 MAY NOT BE OPENED UNTIL PERMISSION HAS BEEN GRANTED BY THE CHIEF INVIGILATOR

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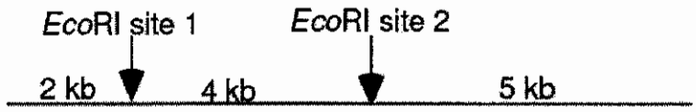
SECTION A (COMPULSORY)

Question 1

(a) Restriction mapping of a linear DNA segment reveals the following *Eco*RI restriction sites.



(i) This piece of DNA is cut with *Eco*RI, the resulting fragments are separated by gel electrophoresis, and the gel is stained with ethidium bromide. Draw an electrophoretogram of the bands that would appear on the gel. (2 marks)

(ii) If a mutation that alters *Eco*RI site 1 occurs in this piece of DNA, show how the new banding pattern on the gel would differ from the one you drew above. (2 marks)

(iii) If mutations that alter *Eco*RI sites 1 and 2 occur in this piece of DNA, show the new banding pattern on the gel. (2 marks)

(iv) If a 1000 bp insertion occurred within the 4 kb region, show how the new banding pattern on the gel would look like. (2 marks)

(v) If a 500 bp deletion occurred within the 4 kb region, show how the new banding pattern on the gel would look like. (2 marks)

(b) A summer squash plant that bred true for white squash was crossed to a plant that bred true for yellow squash, and all the F_1 squash were white. The F_1 was selfed. Among the F_2, three phenotypes were observed in the following numbers: 230 white squash, 58 yellow squash and 19 green squash.
(i) Explain these observations. (3 marks)

(ii) Using defined symbols of your choice, state the parental, F_1 and F_2 genotypes. (7 marks)

(iii) Two F_2 plants were crossed to get F_3 in the following distribution: 50% white squash, 25% yellow squash and 25% green squash. Investigate the genotypes of the two F_2 plants that were crossed. (5 marks)

[Total 25 marks]

SECTION B (ATTEMPT ANY THREE QUESTIONS FROM THIS SECTION)

Question 2

(a) Explain the relationship between allele, locus, gene, and genotype. (4 marks)

(b) Explain the principles of equal segregation and independent assortment, highlighting how they are related. (4 marks)

(c) Explain how the principle of independent assortment is related to meiosis. (2 marks)

(d) State two processes unique to meiosis which are responsible for genetic variation. Indicate the stages or points in meiosis where they take place. (6 marks)

(e) Explain why sister chromatids remain together in meiotic anaphase I but separate in mitotic anaphase and meiotic anaphase II. (3 marks)

(f) State the name given to an event when homologous chromosomes fail to segregate in anaphase I of meiosis. Explain the conditions in humans, giving examples, of the offspring who may result from this abnormal gamete. (6 marks)

[Total 25 marks]

Question 3

(a) In cats, curled ears result from an allele that is dominant over an allele for normal ears. Black colour results from an independently assorting allele that is dominant over an allele for gray colour. A gray cat homozygous for curled ears is mated with a homozygous black cat with normal ears.
(i) Predict the phenotype(s) of F_1 kittens. (1 mark)
(ii) If you self F_1 cats determine the expected phenotypes and their respective proportions the F_2 population. (6 marks)
(iii) Suppose an F_1 cat mates with a neighbour's gray normal-eared cat. State the genetic term given to such a cross and, and hence, predict phenotypic proportions of the progeny expected from this cross. (6 marks)

(b) Suppose you are a forensic criminologist with the Matsapha Royal Swaziland Police (RSP). There has been a burglary report and from the crime scene you have collected a blood sample from which you can extract small amounts of the culprit's DNA. You have three suspects in the holding cells. Explain how you would do DNA fingerprinting to nail down the culprit from the three suspects. (12 marks)

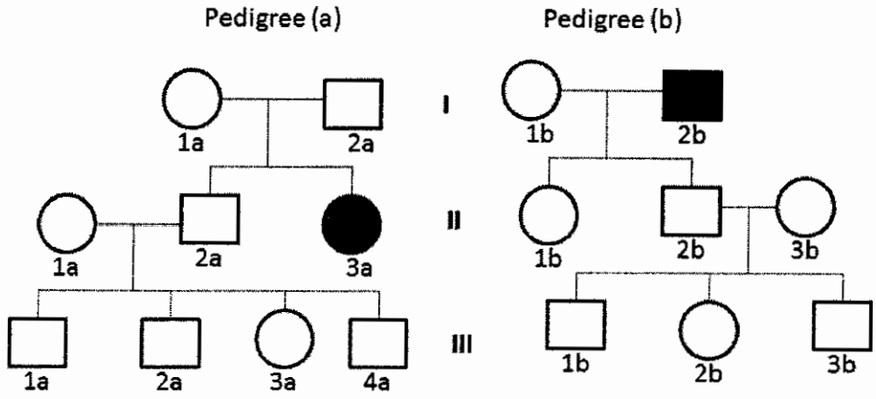
[Total 25 marks]

Question 4

(a) In pea seeds, yellow colour is dominant over green colour and roundness is dominant over wrinkledness. Pure breeding yellow, round plants were crossed with pure breeding green wrinkled plants.Thando Wizzy crossed the resulting F_1 plants with plants that produce green, wrinkled seeds and obtained the following results: 30 yellow, round; 25 green, round; 28 yellow, wrinkled; and 27 green, wrinkled.

(i) Explain the term pure breeding. (1 mark)
(ii) State the genetic term given to Tando Wizzy's cross. (1 mark)
(iii) Propose a plausible hypothesis on skin colour and texture of pea seed. Hence, use a suitable statistical test to check the consistence of Thando Wizzy's results with your hypothesis. (10 marks)

(b) The following pedigrees, (a) and (b), depict the inheritance of a rare hereditary disorder in two Swazi families.



(i) State the mode of inheritance of this disorder. (1 mark)
(ii) If individuals **II-2a** and **II-1b** have a child, determine the likelihood that that child will have the disorder. (4 marks)
(iii) If individuals **III-3a** and **III-3b** have a child, determine the risk that the child will have the disorder. (4 marks)
(iv) If the first child of **III-3a** and **III-3b** is normal, determine the probability that their second child will have the disease. (2 marks)
(v) If the first child of **III-3a** and **III-3b** has the disease, determine the probability that their second child will have the disease (2 marks)

[Total 25 marks]

Question 5

(a) Explain the difference between genes in coupling configuration and genes in repulsion configuration. (3 marks)

(b) Explain the difference between a genetic map and a physical map. (3 marks)

(c) Explain how one can determine which of three linked loci is the middle locus from the progeny of a three-point testcross. (3 marks)

(d) Waxy endosperm (*a*), shrunken endosperm (*h*), and yellow seedling (*e*) are encoded by three recessive genes in corn that are linked on chromosome 5. A corn plant homozygous for all three recessive alleles is crossed with a plant homozygous for all the dominant alleles. The resulting F_1 are then crossed with a plant homozygous for the recessive genes in a three-point testcross. The alleles in this case are named after the recessive phenotypes. The progeny of the testcross are given below:

Genotype		Number		Description of progeny
a	*h*	*E*	87	
A	*H*	*e*	94	
A	*H*	*E*	3479	
a	*h*	*e*	3478	
A	*h*	*E*	1515	
a	*H*	*e*	1531	
a	*H*	*E*	292	
A	*h*	*e*	280	
Total			**10 756**	

(i) Determine order of these genes on the chromosome, rearrange the genes according to their order, and complete the table above. (7 marks)
(ii) Calculate the map distances between the genes and draw the genetic map. (5 marks)
(iii) Determine the coefficient of coincidence and the interference among these genes. (4 marks)
[Total 25 marks]

Question 6

(a) A man has a rare abnormality caused by a dominant allele ***A***. His mother had this disorder, but his father was normal.
(i) State, with justifications, the genotypes of the man, his mother, his father. (4 marks)
(ii) Determine the likely proportion of the man's children that will have the disorder if he marries a normal woman. (1 mark)

(b) In a plant's genome, there are thre three loci that control plant height. Each locus has two alleles (*A* and *a*, *B* and *b*, *C* and *c*). One strain of genotype *aabbcc* and height 10 cm was crossed with another strain of genotype *AABBCC* and height 22 cm. The resulting F_1 plants were all 16 cm in height. Selfing the F_1 plants produced F_2 progeny. You are hinted that the recessive alleles do not have any incremental effect to the baseline-line height of the plants and the dominant alleles have equal and additive contribution to the plant's height.
(i) Determine the difference in height between two homozygous strains of this plant. (1 mark)

(ii) Explain why all F_1 plants were 16 cm tall. (2 marks)

(iii) Determine the expected number of phenotypic (height) categories in F_2 progeny. (2 marks)

(iv) Give the expected genotypes and phenotypes (heights) in the F_2 progeny. (5 marks)

(c) A total of 6129 UNISWA students were blood typed for the MN locus, which is determined by two codominant alleles, L^M and L^N.

The following data were obtained:

Blood type	Number
M	1787
MN	3039
N	1303

Carry out a chi-square test to determine whether this population is in Hardy-Weinberg equilibrium at the MN locus. (10 marks)

[Total 25 marks]

END OF EXAM PAPER

Chi square Distribution Table

	Probability Values								
df	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
11	2.60	3.05	3.82	4.57	10.34	19.68	21.92	24.72	26.76
12	3.07	3.57	4.40	5.23	11.34	21.03	23.34	26.22	28.30
13	3.57	4.11	5.01	5.89	12.34	22.36	24.74	27.69	29.82
14	4.07	4.66	5.68	6.57	13.34	23.68	26.12	29.14	31.32
15	4.60	5.23	6.27	7.26	14.34	25.00	27.49	30.58	32.80
16	5.14	5.81	6.91	7.96	15.34	26.30	28.85	32.00	34.27
17	5.70	6.41	7.56	8.67	16.34	27.59	30.19	33.41	35.72
18	6.26	7.01	8.23	9.39	17.34	28.87	31.53	34.81	37.16
19	6.84	7.63	8.91	10.12	18.34	30.14	32.85	36.19	38.58
20	7.43	8.26	9.59	10.85	19.34	31.41	34.17	37.57	40.00
25	10.52	11.52	13.12	14.61	24.34	37.65	40.65	44.31	46.93
30	13.79	14.95	16.79	18.49	29.34	43.77	46.98	50.89	53.67
40	20.71	22.16	24.43	26.51	39.34	55.76	59.34	63.69	66.77
50	27.99	29.71	32.36	34.76	49.33	67.50	71.42	76.15	79.49
60	35.53	37.48	40.48	43.19	59.33	79.08	83.30	88.38	91.95
70	43.28	45.44	48.76	51.74	69.33	90.53	95.02	100.42	104.22
80	51.17	53.54	57.15	60.39	79.33	101.88	106.63	112.33	116.32
90	59.20	61.75	65.65	69.13	89.33	113.14	118.14	124.12	128.30
100	67.33	70.06	74.22	77.93	99.33	124.34	129.56	135.81	140.17