UNIVERSITY OF SWAZILAND

FINAL EXAMINATION PAPER: DECEMBER 2012

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

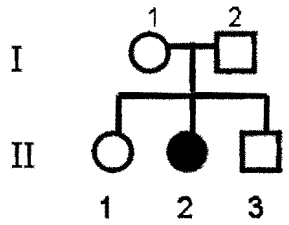
SPECIAL REQUIREMENTS: CANDIDATES MAY BRING CALCULATORS

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

SECTION A (COMPULSORY)

Question 1

(a) Study the following pedigree. Assume the disorder shown is has an autosomal recessive pattern (with full penetrance). Let **A** represent the dominant allele and **a** the recessive allele.



(i). Explain the term full penetrance (1 mark)
(ii). State the genotype of I-1. (1 mark)
(iii). State the genotype(s) of II-1. (1 mark)
(iv). If parents I-1 and I-2 had another (fourth) child, determine the probability that he/she would not have the disease. (2 marks)
(v). What is the probability that II-3 is heterozygous for the dominant and recessive alleles? (2 marks)

(b) You mate pure-breeding white mice with another pure-breeding strain of brown mice, and all the F_1 are black. When the black F_1 are selfed, you obtain 89 black, 31 brown, and 42 white offspring (F_2). Suggest a likely genetic model for the inheritance of coat color in this cross. Use letters of your own choosing, define the phenotypes of each allele, using capital letters for dominant alleles. State the genotypes of the 2 pure breeding parental strains, the genotypes of the F_1, and the genotypes of the F_2. (9 marks)

(c) Suppose you perform a cross between a black-eyed mouse and a red-eyed mouse of unknown genotypes, and all the progeny have black eyes (F_1). You cross the F_1 progeny with one another and you get 38 black-eyed mice and 14 red-eyed mice in the F_2 generation.

(i). Using letters of your own choosing, state the most likely genotypes of the two parents (P) in cross 1, stating which phenotypes are dominant and using a capital letter for the dominant alleles. (1 mark)
(ii). Based on your answer to part (i), state the expected genotypes of the F_1, and in what ratio they should occur (1 mark)
(iii). Based on your answers to parts (i) and (ii), state the expected genotypes of the F_2 (progeny in cross 2), and in what ratio they should occur. (1 mark)
(iv). State the phenotype of each genotype in the F_2 and use this to predict the phenotypic ratios in the F_2 generation. (1 mark)

(v). State a hypothesis and use a Chi Square test to determine whether the observed data are consistent with your hypothesis with $\alpha = 0.05$. (5 marks)

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

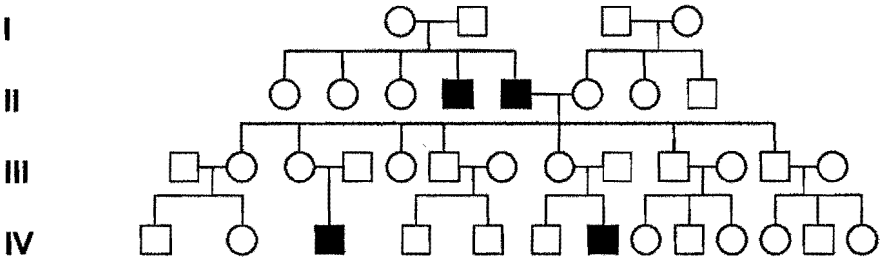
[Total marks= 25 marks]

SECTION B (ANSWER ANY THREE QUESTIONS FROM THIS SECTION)

Question 2

(a) In human beings, the gene for β-globin is located on chromosome 11, and the gene for α-globin, which is another component of the hemoglobin protein, is located on chromosome 16. Would these two chromosomes be expected to pair with each other during meiosis? Explain. (3 marks)

(b) A family with a rare disorder presents the following pedigree.



(i) What is the most likely mode of inheritance? (1 mark)
(ii) Cite the three facts to support for your conclusion. (3 marks)
(iii) Identify all individuals that must be heterozygous. (6 marks)

(c) 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. (4 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 regards to fur colour. (6 marks)

[Total marks= 25 marks]

Question 3

(a) Explain the following:
(i) incomplete dominance, (1 mark)
(ii) expressivity, (1 mark)
(iii) recessive epistasis, (2 marks)
(iv) pleiotropy, (2 marks)
(v) frameshift mutation, (2 marks)
(vi) point mutation. (2 marks)

(b) In Drosophila, curly wings (*k*), black body (*b*), and cinnabar eyes (*c*) result from recessive alleles that are all located on chromosome 2. A homozygous wild-type fly was mated with a curly, black, and cinnabar fly, and the resulting F_1 females were test-crossed with curly, black and cinnabar males. The following F_2 progeny were produced from the test-cross:

Progeny	Number
$k\ b^+\ c$	117
$k^+\ b^+\ c^+$	825
$k^+\ b\ c$	50
$k^+\ b^+\ c$	6
$k\ b\ c$	828
$k\ b^+\ c^+$	51
$k^+\ b\ c^+$	115
$k\ b\ c^+$	8
Total	2000

Determine the interference for occurrence of double cross overs in the three point cross above. (15 marks)

[Total marks= 25 marks]

Question 4

(a) 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. (8 marks)

(iii). Calculate the map distance between *nic* and *ad* loci and draw the most probable genetic map that includes the centromere. (4 marks)

(b). Assume that three loci, each with two alleles (*A* and *a*, *B* and *b*, *C* and *c*), determine the differences in height between two homozygous strains of a plant. These genes are additive and equal in their effects on plant height. One strain (*aabbcc*) is 10 cm in height. The other strain (*AABBCC*) is 22 cm in height. The two strains are crossed, and the resulting F_1 are interbred to produce F_2 progeny. Give the phenotypes and the expected proportions of the F_2 progeny. (10 marks)

[Total marks= 25 marks]

Question 5

(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 below*)

2nd base in codon

1st base in codon	U	C	A	G	3rd base in codon
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	STOP	STOP	A
	Leu	Ser	STOP	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

[Total marks= 25 marks]

Question 6

(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 ***D***, the recessive disease allele is ***d***). In a large population study, Candice and Gcinile determined that 3 in 7000 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 ***DD***, ***Dd***, and ***dd*** genotypes in the adult population. (5 marks)

(iii) The mutation rate at which ***D*** alleles mutate into ***d*** alleles. (5 marks)

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

[Total 25 marks]

END OF QUESTION PAPER