UNIVERSITY OF SWAZILAND
FACULTY OF AGRICULTURE AND ENGINEERING
DEPARTMENT OF BIOLOGICAL SCIENCES

MAIN EXAMINATION PAPER 2016/2017

PROGRAMMES:	BSc. II B. Ed Secondary II
COURSE CODE:	BIO211
TITLE OF PAPER:	GENETICS
TIME ALLOWED:	TWO (3) HOURS
INSTRUCTIONS:	1. ANSWER QUESTION ONE IN SECTION A AND ANY OTHER TWO QUESTIONS IN SECTION B. 2. CANDIDATES MAY USE SCIENTIFIC CALCULATORS.

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Section A
Answer ALL questions in this section

Question 1 (Compulsory)

(a) Explain the chromosome theory of inheritance (5 marks)

(b) How is the principle of independent assortment related to meiosis? (4 marks)

(c) State and explain two processes unique to meiosis which are responsible for genetic variation. (6 marks)

(d) 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)
iii) a test-crossed dihybrid. (1 mark)

(e) A heterozygous dominant black female mouse was crossed to a recessive brown male. What proportion of the baby mice were brown? (2 marks)

(f) A pure breeding black-eyed mouse and a pure breeding red-eyed mouse were crossed and all the F_1 progeny had black eyes. After selfing the F_1 progeny, you get 38 black-eyed mice and 13 red-eyed mice in the F_2 generation.
i). Using letters of your own choosing, state the most likely genotypes of the two parents, hence, state the dominant and recessive phenotypes. (3 marks)
ii). Based on your answer above, state the expected genotypes of the F_1. (2 marks)
iii) One phenotypic F_2 class has two genotypes. Explain in proper genetic terms how you would distinguish these two genotypes. (2 marks)

(h) Tay-Sachs disease ("infantile amaurotic idiocy") is a rare human disease in which toxic substances accumulate in nerve cells. The recessive allele responsible for the disease is inherited in a simple Mendelian manner. For unknown reasons, the allele is more common in populations of Ashkenazi Jews of Eastern Europe. A woman is planning to marry her first cousin, but the couple discovers that their shared grandfather's sister died in infancy of Tay-Sachs disease.
i) Draw the relevant parts of the pedigree, and show all the genotypes as completely as possible. (4 marks)
ii) Calculate the probability that their first child will have the disease, assuming that all people who marry into the family are homozygous normal? (2 marks)

(i) John and Martha are contemplating having children, but John's brother has galactosemia (an autosomal recessive disease) and Martha's great-grandmother also had galactosemia. Martha has a sister who has three children, none of whom have galactosemia. Calculate the probability that John and Martha's first child will have galactosemia. (5 marks)

(j) A *Neurospora* cross was made between a strain that carried the mating-type allele ***A*** and the wild-type ***arg***$^{+}$ and another strain that carried the mating type allele ***a*** and the mutant allele for ***arg.*** Four hundred linear octads were isolated, and they fell into the seven classes given in the table below. (For simplicity, they are shown as tetrads and wild type allele is denoted by a "**+**".)

Octad class

	1	2	3	4	5	6	7
	+ . +	+ . *arg*	+ . +	+ . +	+ . +	+ . *arg*	+ . *arg*
	+ . +	+ . *arg*	+ . *arg*	*a* . +	*a* . *arg*	*a* . +	*a* . +
	a . *arg*	*a*. +	*a* . +	+ . *arg*	+ . +	+ . *arg*	+ . +
	a . *arg*	*a* . +	*a* . *arg*	*a* . *arg*	*a* . *arg*	*a* . +	*a* . *arg*
Σ	129	125	95	34	3	7	7

Determine the linkage relationship between the ***a*** and ***arg*** loci and. Hence, calculate the two centromere-locus distances and possibly the ***a-arg*** distance. (12 marks)

[Total Marks = 50]

Section B
Answer ANYTWO questions in this section

Question 2

(a) In rabbits, coat colour is a genetically determined characteristic. Some black females always produce black progeny, whereas other black females produce black progeny and white progeny. Explain these observations. (6 marks)

(b) In sheep, lustrous fleece results from an allele that is dominant over an allele for normal fleece. A ewe (adult female) with lustrous fleece is mated with a ram (adult male) with normal fleece. The ewe then gave birth to a single lamb with normal fleece. From this single offspring, is it possible to determine the genotypes of the two parents? If so, what are their genotypes? If not, why not? (6 marks)

(c) A normal man (A) whose grandfather had galactosemia and a normal woman (B) whose mother was galactosemic want to produce a child. What is the probability that their first child will be galactosemic? (6 marks)

(d) Ptosis (droopy eyelids) may be inherited as a dominant human trait. Among 40 people who are heterozygous for the ptosis allele, 13 have ptosis and 27 have normal eyelids.
(i) Calculate penetrance for ptosis. (2 marks)
(ii) If ptosis had variable expressivity in this population, what would that mean? (2 marks)

(e) Explain what is meant by dosage compensation, highlighting how this is achieved in mammals and Drosophila. Hence, describe one piece of evidence that suggests that the process that causes dosage compensation in female mammals occurs at random. (8 marks)

[Total marks = 30]

Question 3

(a) Explain the following terms:
(ii) Aneuploidy, (1 mark)
(iii) Pericentric inversion, (1 mark)
(iv) Robertsonian translocation, (1 mark)
(vi) Non-disjunction. (1 mark)

(b) Briefly explain why the relation between genotype and phenotype is frequently complex for quantitative characteristics. (3 marks)

(c) Explain how broad-sense and narrow-sense heritabilities differ. (4 marks)

(c) About 70% of all Caucasians can taste the chemical phenylthiocarbamide, and the remainder cannot. The ability to test this chemical is determined by the dominant allele ***T***, and the inability to taste is determined by the recessive allele ***t***. If the population is in Hardy-Weinberg equilibrium, determine the genotypic and allelic frequencies in this population. (4 marks)

(d) In an experimental population of *Tribolium confusum* (flour beetles), body length shows a continuous distribution with a mean of 6 mm. A group of males and females with a mean body length of 9 mm are artificially selected and interbred. The body lengths of their offspring averaged 7.2 mm. Determine the narrow sense heritability in this population. (2 marks)

(e) In a large herd of cattle, three different characters showing continuous distribution are measured, and the variances in the following table are calculated:

	Quantitative traits		
Variance	Shank length	Neck length	Fat content
Environmental	248.1	292.2	53.0
Additive genetic	46.5	73.0	42.4
Dominance genetic	15.6	365.2	10.6

(i) Calculate the broad- and narrow-sense heritabilities for each trait. (6 marks)

(ii) In the population of animals studied, which character would respond best to artificial selection? Justify your answer. (2 marks)

(iii) A project is undertaken to decrease mean fat content in the herd. The mean fat content is currently 10.5 %. Animals with a mean of 6.5% fat content are interbred as parents of the next generation. What mean fat content can be expected in the descendants of these animals? (5 marks)

[Total marks = 30]

Question 4

(a) Describe the following, explaining how they might arise:
(i) trisomy, (2 marks)
(ii) frameshift mutation, (2 marks)
(iii) 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 F1 females were test-crossed with curly, black and cinnabar males. The following 2000 F_2 progeny and their frequencies were produced from the test-cross:

$k\ b^+\ c$	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

(i) Determine the order of genes on the chromosome (2 marks)
(ii) Compute coefficient of coincidence and interference (12 marks)

(c) You have identified a mutant *E. coli* strain that cannot synthesize histidine (his$^-$). To determine the location of the *his*$^-$ mutation on the *E. coli* chromosome, you perform interrupted conjugation experiments with 5 different *Hfr* strains. The following chart shows the time of entry (in minutes shown in brackets) of the wild-type alleles of the first 5 markers (mutant genes) into the his$^-$ strain.

Hfr 1 ------- *his* (1)→ *man* (9) →*gal* (28) →*lac* (37) →*thr* (45)
Hfr 2 ------- *man* (15) →*his* (23) →*cys* (38) → *ser* (42) → *arg* (49)
Hfr 3 ------- *thr* (3) → *lac* (11) → *gal* (20) →*man* (39) →*his* (47)
Hfr 4 ------- *cys* (3) →*his* (18) → *man* (26) → *gal* (45) → *lac* (54)
Hfr 5 ------- *thr* (6) →*rha* (18) → *arg* (36) →*ser* (43) → *cys* (47)

Determine the consensus sequence by noting the overlaps and hence indicate start location and polarity of Hfr's integration into the F$^-$ and the relative position of each gene with respect to any reference locus of your choice. (Assume it takes 100 min to transfer all the genes on the Hfr to F$^-$) (10 marks)

[TOTAL MARKS = 30]

END OF EXAM PAPER