

Name _____
Last (as on TCard) First (as on TCard) Preferred First (optional)

Student # _____ Signature _____

**UNIVERSITY OF TORONTO
Faculty of Arts and Science**

MIDTERM EXAMINATION FALL 2016

HMB265H1F General and Human Genetics

Duration — 70 minutes

Aids: Non-Programmable Calculator Only

This exam is out of 38 marks.

Instructions:

Write your full name and student number on every page of the exam.

Part 1- Multiple Choice (17 questions worth 2 marks each, total 34 marks)

- 1.1 Answer the multiple choice questions on the scantron.
- 1.2 Refer to the "MARKING INSTRUCTIONS" on the scantron for information on filling it out (e.g., use HB pencil; no stray marks anywhere on the scantron).
- 1.3 In the "FORM" box on the scantron, indicate which "FORM" (A, B, C or D) is indicated on the top of your exam page.
- 1.4 Fill in SIGNATURE, SUBJECT and DATE on the scantron.
- 1.5 Correctly bubble in your STUDENT NUMBER, LAST NAME and INITIALS on the scantron.

Part 2- Short Answer (2 questions worth 4 marks total)

- 2.1 Answer all questions using complete, concise sentences and writing legibly using ink only in the lined space provided.

Good luck!

Invigilators are not permitted to interpret questions for individual students. If you think that a question is ambiguous, answer as you understand it, then make a note here. Please be specific.

THIS IS FORM A

FORM A

Name _____

Student # _____

Part 1--MULTIPLE CHOICE. Choose the one answer that best answers the question. 17 questions worth 2 marks each, total 34 marks.

- 1) What aspect of chromosome behaviour most clearly accounts for Mendel's law of segregation?
- A) Movement of homologous chromosomes to opposite poles during anaphase I of meiosis.
 - B) Independent alignment of different homologous chromosome pairs during metaphase I of meiosis.
 - C) Movement of sister chromatids to opposite poles during anaphase II of meiosis.
 - D) Crossing-over between homologous chromosomes during prophase I of meiosis.
- 2) In poppies, the *R* gene controls flower colour and the *H* gene controls height. Plants with a dominant *R* allele are red in colour, while plants that are *r/r* are white. Plants with a dominant *H* allele are tall, while plants that are *h/h* are short. What would be the expected ratios of phenotypes among the offspring of the cross *R/r; H/h* x *r/r; H/h*, assuming independent assortment of each gene?
- A) 3 (red & tall): 1 (red & short): 3 (white & tall): 1 (white & short)
 - B) 9 (red & tall): 3 (red & short): 3 (white & tall): 1 (white & short)
 - C) 1 (red & tall): 1 (red & short): 1 (white & tall): 1 (white & short)
 - D) 3 (red & tall): 3 (red & short): 1 (white & tall): 1 (white & short)
- 3) Wild-type daffodils are yellow in colour. Cersei find's orange-flowered mutant daffodil plants growing in six different locations (numbered 1-6). She establishes pure-breeding lines of each mutant plant and performs crosses between them. The F₁ phenotypes are listed in **Table 2** found at the end of the exam. Based on the data in the table, how many different genes in the pathway for yellow daffodils has Cersei identified?
- A) 4
 - B) 2
 - C) 5
 - D) 3
- 4) Hodor, a *Drosophila* geneticist, finds that when he perform testcrosses with a certain strain of flies, he always sees a 1:1 ratio of parental types to recombinant types for the genes *m* and *n*, and the genes *m* and *o*, yet he sees a 3:1 ratio of parental types to recombinant types for the *n* and *o* genes. What best explains these results?
- A) The *m*, *n*, and *o* genes are all found on different chromosomes.
 - B) The *m* and *o* genes are both on the same chromosome, while the *n* gene is on a different chromosome.
 - C) The *m* and *n* genes are both on the same chromosome, while the *o* gene is on a different chromosome.
 - D) The *n* and *o* genes are both on the same chromosome, while the *m* gene is on a different chromosome.

FORM A

Name _____

Student # _____

- 5) Daenerys is a summer research student working with fruit flies. She crosses a female fruit fly with vermilion eyes and wild-type wings to a male with wild-type red eyes and cut wings. Daenerys observes that the F_1 progeny consist of females with red eyes and wild-type wings, and males with vermilion eyes and wild-type wings. When the F_1 progeny are intercrossed, the F_2 generation consists of two types of females in a 1:1 ratio—(i) vermilion eyes, wild-type wings and (ii) red eyes, wild-type wings; and two types of males in a 1:1 ratio—(i) vermilion eyes, wild-type wings and (ii) red eyes, cut wings. Are the genes for eye colour and wing type X-linked or autosomal?
- A) Both genes are autosomal.
 - B) Both genes are X-linked.**
 - C) The eye-colour gene is X-linked and the wing-type gene is autosomal.
 - D) The eye-colour gene is autosomal and the wing-type gene is X-linked.
- 6) In a particular species of chinchilla on the island of Westeros, the coat colour gene (C) has two alleles, C^G and C^W , which show codominance. Chinchillas of the genotype $C^G C^G$ are grey in colour; chinchillas of the genotype $C^W C^W$ are white in colour; and those of the genotype $C^G C^W$ are both grey and white. The island has 800 chinchilla inhabitants, and the frequency of the C^W allele among this indigenous population is 0.35. A ship gets stranded on the island. On this ship, there are 200 chinchillas of the same Westeros island species. Of the 200 chinchillas, 65 have grey coats, 90 have grey and white coats, and 45 have white coats. Assume that the indigenous population was at Hardy-Weinberg equilibrium, and the new population of 1000 also meets the criteria for Hardy-Weinberg equilibrium. If there were 640 chinchillas born in the next generation, how many would be expected to have a grey coat?
- A) 406
 - B) 298
 - C) 270
 - D) 254**
- 7) Genes C and D are both located on chromosome 3 in mice, and it is known that the recombination frequency between the genes is 28%. If a mouse with genotype $C/C; d/d$ is crossed to a mouse with genotype $c/c; D/D$, and the F_1 generation is intercrossed, what proportion of the F_2 generation will show both recessive phenotypes?
- A) 36%
 - B) 14%
 - C) 4%
 - D) 2%**

FORM A

Name _____

Student # _____

Questions 8 and 9 are based on the Bolton family pedigree shown in **Figure 1** at the end of the exam. This family is affected by autosomal dominant polycystic kidney disease (ADPKD), a common disorder.

- 8) What is the probability that individuals III-5 and III-6 have a child that is a girl and is also affected by ADPKD?
- A) 1/6
 - B) 1/3**
 - C) 1/2
 - D) 1/4
- 9) Individuals III-5 and III-6 have a boy named Roose that is affected by ADPKD. What is the probability that a child of Roose and individual IV-2 is a boy and is NOT affected by ADPKD?
- A) 1/6
 - B) 5/6
 - C) 1/12**
 - D) 5/12
- 10) Seeds of some beans are speckled. Jaime crosses a true-breeding strain with small speckles to a true-breeding strain with large speckles. He observes that all of the F₁ progeny have both large and small speckles. Which of the following statements best explains Jaime's result?
- A) The trait is controlled by one gene and the alleles are incompletely dominant.
 - B) The trait is controlled by one gene and the alleles are codominant.**
 - C) The trait is controlled by two genes and the alleles are codominant.
 - D) The trait is controlled by two genes and the alleles are incompletely dominant.
- 11) Tyrion, for his undergraduate research project, crossed male rabbits (genotype $A/a; B/b; c/c; D/D; E/e; F/F$) with female rabbits (genotype $A/a; b/b; C/c; D/d; E/e; F/F$). What is the probability of producing individuals with the fathers' genotypes?
- A) 1/32**
 - B) 3/32
 - C) 1/16
 - D) 9/64

FORM A

Name _____

Student # _____

- 12) In a certain species of butterfly, wing colour is the result of the action of two genes, *Y* and *G*. Jon, a second year research student, crosses a true-breeding strain of butterfly with yellow wings to a true-breeding strain with green wings, and all of the F_1 generation have yellow wings. Jon then crosses butterflies from the F_1 generation together, and observes a 13:3 ratio of yellow: green in the F_2 generation. What is the most likely explanation for the F_2 ratio that Jon has observed, and what is the genotype of the F_2 green butterflies?
- A) dominant epistasis: $y/y; g/g$
 - B) recessive epistasis: $y/y; G/-$
 - C) dominant epistasis: $y/y; G/-$**
 - D) recessive epistasis: $y/y; g/g$
- 13) The Greyjoy family pedigree is shown in **Figure 2** at the end of the exam. Members of this family are affected by a debilitating condition known as Hostage Syndrome. A graduate student has been studying the inheritance pattern of this trait. Based on the information in the pedigree, what is the least likely mode of inheritance of this condition?
- A) X-linked dominant
 - B) autosomal recessive
 - C) X-linked recessive**
 - D) autosomal dominant
- 14) In humans, red-green colour blindness and Duchenne muscular dystrophy (DMD) are both X-linked recessive traits. The genes for red-green colour blindness and DMD are 30 map units apart. Sansa's father Ned is red-green colour blind. Sansa's brother Robb has DMD. Sansa and her mother Catelyn both have normal vision and do not have DMD. There is also no previous history of red-green colour blindness in Catelyn's family. Sansa and Joffrey decide to have children together. Joffrey has normal vision and does not have DMD, but has a brother Tommen who has DMD. What is the chance that Sansa and Joffrey have a child who has both red-green colour blindness and DMD?
- A) 5.25%
 - B) 3.75%**
 - C) 1.125%
 - D) 2.625%

FORM A

Name _____

Student # _____

- 15) This question is based on **Table 1** shown at the end of the exam booklet. *Drosophila* females heterozygous for three autosomal recessive mutations, *ap*, *pr*, and *sc*, were crossed to tester males yielding 1000 progeny. The numbers of progeny observed in the phenotypic classes are given in the table. What is the value of interference?
- A) 0.52
 - B) 0.66
 - C) 0.34
 - D) 0.48
- 16) Which of the following situations best demonstrates haploinsufficiency?
- A) Lack of spotting in leopards is caused by a dominant wild-type *Usp* allele.
 - B) Crumpled wings in dragonflies are caused by a recessive *Cws* mutant allele.
 - C) Short whiskers in mice are caused by a recessive wild-type *Swk* allele.
 - D) Flightless beetles are caused by mutant FLB proteins that bind and inactivate wild-type FLB proteins.
- 17) The blue and yellow feather pattern of a certain species of parrot is determined by a gene that has two alleles, *B* and *Y*, which show codominance. Some parrots have completely blue feathers (*BB*), some parrots have completely yellow feathers (*YY*), and others have blue and yellow feathers (*BY*). In a population of 630 parrots that is at Hardy-Weinberg equilibrium, 202 parrots have completely yellow feathers. How many parrots in this population would be expected to have either blue or yellow feathers?
- A) 119
 - B) 273
 - C) 309
 - D) 321

Name _____

Student # _____

Part 2- Short Answer (2 questions worth 4 marks total).

18. (a) Samwell is a graduate student studying flower colour in begonias. He isolates pure-breeding lines of begonias that carry 5 different mutations in a particular flower colour gene called *heartsbane* (*h*). Samwell names these mutations *red*, *yellow*, *white*, *purple*, and *orange*. What experiment can Samwell perform to identify dominance relationships between these different mutant alleles, and what will he establish with this experiment (be specific)? (2 marks)

ANSWER:

He can perform reciprocal crosses between the different pure-breeding mutant lines (1 mark) to establish a dominance/allelic series (1 mark).

18. (b) Samwell notices that begonias heterozygous for the *red* and *orange* alleles are red in colour, while begonias heterozygous for the *orange* and *yellow* alleles are orange in colour. Samwell also observes that heterozygotes for the *purple* allele are always purple in colour, and heterozygotes for the *white* allele are never white. Taking your answer from part (a) into account, diagram Samwell's results. (2 marks)

ANSWER:

$h^{purple} > h^{red} > h^{orange} > h^{yellow} > h^{white}$ (2 marks)

Figures and Tables

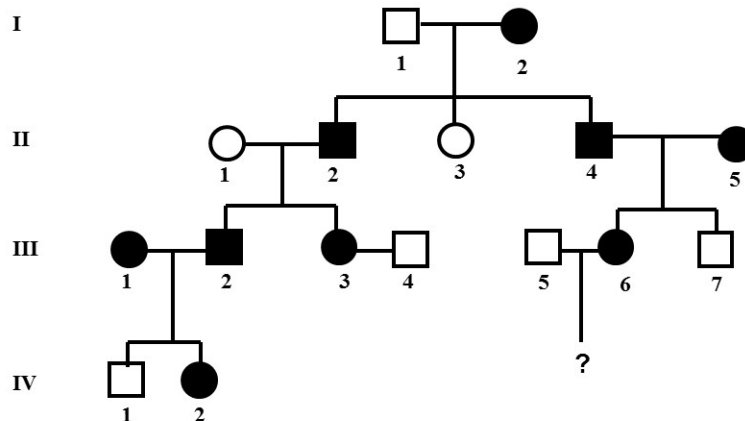


Figure 1: Bolton family pedigree.

Name _____

Student # _____

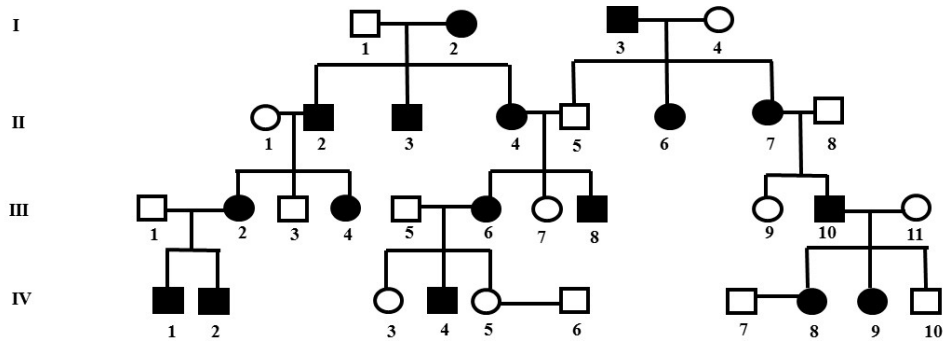


Figure 2: Greyjoy family pedigree.

Table 1:

Phenotype of F ₂	Number in Class
<i>ap</i> ⁺ <i>pr</i> <i>sc</i>	136
<i>ap</i> <i>pr</i> ⁺ <i>sc</i> ⁺	123
<i>ap</i> ⁺ <i>pr</i> ⁺ <i>sc</i>	308
<i>ap</i> <i>pr</i> <i>sc</i> ⁺	289
<i>ap</i> ⁺ <i>pr</i> <i>sc</i> ⁺	68
<i>ap</i> <i>pr</i> ⁺ <i>sc</i>	55
<i>ap</i> <i>pr</i> <i>sc</i>	12
<i>ap</i> ⁺ <i>pr</i> ⁺ <i>sc</i> ⁺	9

Table 2:

	1	2	3	4	5	6
1	orange	yellow	yellow	orange	yellow	yellow
2	yellow	orange	yellow	yellow	yellow	yellow
3	yellow	yellow	orange	yellow	yellow	orange
4	orange	yellow	yellow	orange	yellow	yellow
5	yellow	yellow	yellow	yellow	orange	yellow
6	yellow	yellow	orange	yellow	yellow	orange

END OF EXAM

Total Pages = 7

Total Marks = 38