QUESTIONS

MENDELIAN GENETICS AND PROBABILITY

1. If two people with sickle cell trait have children, what is the chance that a child will have normal RBCs in both high- and low-oxygen environments? What is the chance that a child will have sickle cell disease? Write the possible genotypes in the Punnett square.

	S	s
S	SS	Ss
s	Ss	ss

Normal RBCs in high- and low-oxygen environments 0.75 ($\frac{1}{4}+\frac{1}{4}+\frac{1}{4}=\frac{3}{4}$)

Sickle cell disease 0.25 ($\frac{1}{4}$)

a. What is the chance that a child will carry the *HbS* gene but not have sickle cell disease? 0.5 ($\frac{1}{4}+\frac{1}{4}=\frac{2}{4}=\frac{1}{2}$) (50%)

b. What are the chances that these parents will have three children who are homozygous for normal RBCs? (Show your work.) $\frac{1}{4}\cdot\frac{1}{4}\cdot\frac{1}{4}=\frac{1}{64}$ (1.56%)

c. What are the chances that these parents will have three children who have both normal and mutant hemoglobin beta chains? (Show your work.) $\frac{1}{2}\cdot\frac{1}{2}\cdot\frac{1}{2}=\frac{1}{8}$ (12.5%)

d. What are the chances that all three of their children will show the disease phenotype? (Show your work.) $\frac{1}{4}\cdot\frac{1}{4}\cdot\frac{1}{4}=\frac{1}{64}$ (1.56%)

e. What are the chances that these parents will have two children with sickle cell trait and one with sickle cell disease? (Show your work.) $\frac{1}{2}\cdot\frac{1}{2}\cdot\frac{1}{4}=\frac{1}{16}$ (6.25%)

f. In the cross above, if you know that the *child does not have sickle cell disease*, what is the chance that the child has sickle cell trait? $\frac{2}{3}$ (66.67%)

2. An individual who has sickle cell trait has children with an individual who does not have the *HbS* allele.

a. What are the genotypes of the parents? Ss, SS

b. In the Punnett square, show all the possible genotypes of their children. State the genotype and phenotype ratios of the offspring.

	S	S
S	SS	SS
s	Ss	Ss

Genotype: 2 SS : 2 Ss (1SS : 1Ss)

Phenotype: 2 Normal : 2 Carriers (1 Normal : 1 Carrier)

c. What are the chances that any one of this couple's children will have sickle cell disease? 0%

d. If this couple lives in the lowlands of East Africa, what are the chances that one of their children would be resistant to malaria if exposed to the malaria parasite? 50%

3. A woman with sickle cell disease has children with a man who has sickle cell trait. Answer the following questions.

   a. What are the genotypes of the parents? Sa x ss

   b. What is the genetic makeup of the gametes the mother can produce? s, s

   c. What is the genetic makeup of the father can produce? S, s

   d. In the Punnett square, show all the possible genotypes of their children. Then summarize the genotype and phenotype ratios of the possible offspring.

	S	s
s	Ss	ss
s	Ss	ss

Genotypes: 1Ss : 1ss
Phenotypes: 1 Carrier : 1 sickle cell

   e. What are the chances that any one of this couple's children will have sickle cell disease? 50%

   f. If this couple moves to the lowlands of East Africa and has children, which of their children would be more likely to survive? Explain your answer.
   The Ss (Carrier) children would be more likely to survive because they are healthy and resistant to malaria.

4. In humans, blood type is a result of multiple alleles: I^A, I^B, and i^O. A few simple rules of blood type genetics are that
   - I^A is dominant over i^O,
   - I^B is dominant over i^O, and
   - I^AI^B are codominant.

   Two parents who are heterozygous for type A blood and have sickle cell trait have children. Answer the following questions.

   a. What is the genotype of the parents? I^AiSs x I^AiSs

   b. What are the genetic makeups of all the possible gametes they can produce? I^AS, I^As, iS, is

   c. Complete the dihybrid Punnett square to determine the frequency of the different phenotypes in the offspring. (Note: Consider blood type and normal versus mutant hemoglobin in the various phenotypes.)

	I^AS	I^As	iS	is
I^AS	I^AI^ASS	I^AI^ASs	I^AiSS	I^AiSs
I^As	I^AI^ASs	I^AI^Ass	I^AiSs	I^Aiss
iS	I^AiSS	I^AiSs	iiSS	iiSs
is	I^AiSs	I^Aiss	iiSs	iiss

9 A + Normal
3 O + Normal
3 A + Sickle cell
1 O + Sickle Cell

5. Now try a different way of solving a dihybrid cross. Because of Mendel's (second) law of independent assortment, you can work with the blood type gene and the hemoglobin gene separately. Set up two monohybrid crosses with the following parents: the mother is heterozygous for type B blood and has sickle cell trait, while the father has type AB blood and also has sickle cell trait.

	I^B	i
I^A	$I^A I^B$	$I^A i$
I^B	$I^B I^B$	$I^B i$

	S	s
S	SS	Ss
s	Ss	ss

a. What are the chances that a child of this couple will have type B blood and sickle cell trait? (Show your work.)
$\frac{1}{2} \cdot \frac{1}{2} = \frac{1}{4}$ (25%)

b. What are the chances that a child will have type AB blood and will not have sickle cell disease? (Show your work.)
$\frac{1}{4} \cdot \frac{3}{4} = \frac{3}{16}$ (18.75%)

c. What are the chances that a child will have type B blood and sickle cell disease? (Show your work.)
$\frac{1}{2} \cdot \frac{1}{4} = \frac{1}{8}$ (12.5%)

d. What are the chances that a child will have type B blood and at least some normal hemoglobin? (Show your work.)
$\frac{1}{2} \cdot \frac{3}{4} = \frac{3}{8}$ (37.5%)