Genetic Probability

Science Grade-Level Expectations
The exercises in the instructional task address content related to the following science grade-level expectations:

(SI-M-A7) Communicate ideas in a variety of ways (e.g., symbols, illustrations, graphs, charts, spreadsheets, concept maps, oral and written reports, equations) (GLE 19)
(SI-M-B3) Describe why all questions cannot be answered with present technologies (GLE 30)
(LS-M-B3) Use a Punnett square to demonstrate how sex-linked traits are inherited (GLE 21)

	Objectives
Task	- Determine genetic probabilities for offspring - Analyze the inheritance pattern of both X and Y chromosome sex-linked traits
Sample Student Exemplar Response	

Implementation Tips:

- This task is intended to be integrated into a larger unit that contains hands-on science opportunities, student-led investigations, non-fiction reading, and a variety of other instructional strategies.
- Teachers may choose to use or modify the task as part of an instructional lesson or as a formative or summative assessment.
- Strategic instructional decisions will need to be determined prior to implementation such as:
  - Should the provided text be read aloud to students or read independently by students?
  - Will students work collaboratively or individually to complete the task?
  - What content knowledge and skills will students need to have prior to attempting the task?
  - Does the task need to be modified based on the needs of the students at the time of implementation?

- Read *Hemophilia Day: One Family's Story* from the Center for Disease Control (CDC).
- In sexual reproduction one gene (allele) of each pair comes from each parent. A trait genetically determined by an allele located on the sex chromosome is called a sex-linked trait. Examples of sex-linked traits are color blindness, hemophilia, calico cats, Duchenne muscular dystrophy, and Hunter's syndrome. Sex-linked traits may be either dominant or recessive. Hemophilia is a recessive sex-linked trait. Below are all the possible genetic combinations for hemophilia in humans:

$X^H X^H$ = female, normal
$X^H X^h$ = female, carrier
$X^h X^h$ = female, hemophiliac

$X^H Y$ = male, normal
$X^h Y$= male, hemophiliac

Task Part 1: Show the cross between a normal male and a carrier female. Show how you solve the problem showing the genetic cross and possible genetic combination (genotypes) and phenotypes in the offspring. Record the genetic probabilities for children of this couple.

- Below are all the possible genetic combinations for weak tooth enamel disorder caused by the flawed gene on the Y chromosome for producing amelogenin**,** a protein affecting the development of tooth enamel.

Task Part 2: Show a cross between male with the weak tooth enamel gene and a normal female. Record the genetic probabilities for children of this couple.

X X = female, normal

$X Y^A$ = male, with weak tooth enamel
X Y = normal male

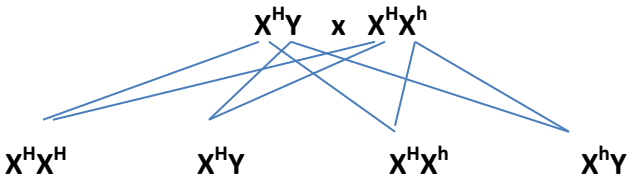
Task Part 3: Compare the inheritance patterns for hemophilia and for weak tooth enamel to determine which disorder is more likely to occur if the couples have an equal number of sons and daughters. State your conclusion citing evidence to support it.

Sample Student Exemplar Response

Part 1

	X^H	X^h
X^H	$X^H X^H$	$X^H X^h$
Y	$X^H Y$	$X^h Y$

or



The mother is a carrier of the hemophilia gene, and the father does not have hemophilia.

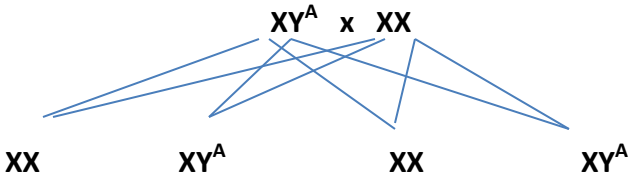
Genetic probabilities for this couple:
Genotype probability: 1 X^HY: 1X^hY: 1X^HX^H: 1 X^hX^H
Phenotype probability: 1 normal son: 1 son with hemophilia: 1 normal daughter: 1 carrier daughter or
25% normal sons: 25% sons with hemophilia: 25% normal daughters: 25% carrier daughters

There is a 50% chance that each son will have hemophilia with the genotype of X^hY.
There is a 50% chance that each daughter will be a carrier of the hemophilia gene with the genotype of X^HX^h .
There is a 0% chance that a daughter will exhibit (phenotype) hemophilia.

Part 2

	X	X
X	X X	X X
Y^A	X Y^A	X Y^A

or



Genotype probability of 1 XX: 1 XY^A
Phenotype probability: all sons will have weak tooth enamel: all females will have normal tooth enamel
There is a 100 % probability that all sons will inherit weak tooth enamel, XY^A.
There is 0% probability that any daughters will inherit weak tooth enamel.

Part 3

Males are more likely to exhibit disorders that are carried on the X chromosome, such as hemophilia. This is because males only have one X chromosome. If the X chromosome they have carries the disorder, they will exhibit the disorder. Females have two X chromosomes, so they won't exhibit the disorder as long as their other X is normal and the disorder is recessive.

Males are more likely than females to exhibit disorders that are carried on the Y chromosome, such as weak tooth enamel, because women don't have a Y chromosome.

Therefore, the disorder that is more likely to occur if an equal number of daughters and sons are born is the tooth enamel disorder. It will occur more often because all sons will inherit the disorder, though none of the daughters will inherit the tooth enamel disorder. Only 50% of the sons will inherit hemophilia and none of the daughters will have the disorder, though 50% of the daughters will be carriers.