

# PART 1: GENETICS

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## UNIT 1:

## UNDERSTANDING BIOLOGICAL INHERITANCE

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|                            |    |
|----------------------------|----|
| Specific Learning Outcomes | 3  |
| Principles of Inheritance  | 4  |
| Autosomal Inheritance      | 12 |
| Atypical Inheritance       | 18 |
| Sex-Linked Inheritance     | 24 |
| Using Pedigrees            | 28 |
| Genetic Testing            | 32 |
| Genetic Variability        | 40 |
| Chromosome Mutations       | 44 |
| Unit 1 Appendices          | 49 |



## Unit 1: Understanding Biological Inheritance

### Specific Learning Outcomes

- B12-1-01:** Outline Gregor Mendel's principles of inheritance, stating their importance to the understanding of heredity. (GLOs: A1, A2, B1, D1)  
Include: principles of segregation, dominance, and independent assortment
- B12-1-02:** Explain what is meant by the terms *heterozygous* and *homozygous*. (GLO: D1)
- B12-1-03:** Distinguish between *genotype* and *phenotype*, and use these terms appropriately when discussing the outcomes of genetic crosses. (GLO: D1)
- B12-1-04:** Use Punnett squares to solve a variety of autosomal inheritance problems, and justify the results using appropriate terminology. (GLOs: D1, E1)  
Include: monohybrid cross, dihybrid cross, testcross, P generation, F<sub>1</sub> generation, F<sub>2</sub> generation, phenotypic ratio, genotypic ratio, dominant alleles, recessive alleles, purebred, hybrid, and carrier
- B12-1-05:** Describe examples of and solve problems involving the inheritance of phenotypic traits that do not follow a dominant-recessive pattern. (GLO: D1)  
*Examples: co-dominance, incomplete dominance, multiple alleles, lethal genes . . .*
- B12-1-06:** Explain the basis for sex determination in humans. (GLO: D1)  
Include: XX and XY chromosomes
- B12-1-07:** Describe examples of and solve problems involving sex-linked genes. (GLO: D1)  
*Examples: red-green colour-blindness, hemophilia, Duchenne muscular dystrophy . . .*
- B12-1-08:** Use pedigree charts to illustrate the inheritance of genetically determined traits in a family tree and to determine the probability of certain offspring having particular traits. (GLOs: C8, D1)  
Include: symbols and notations used
- B12-1-09:** Discuss ethical issues that may arise as a result of genetic testing for inherited conditions or disorders. (GLOs: A3, B1, B2, C4)
- B12-1-10:** Discuss the role of meiosis and sexual reproduction in producing genetic variability in offspring. (GLOs: D1, E3)  
Include: crossing over and randomness
- B12-1-11:** Explain how chromosome mutations may arise during meiosis. (GLOs: D1, E3)  
Include: nondisjunction
- B12-1-12:** Identify monosomy and trisomy chromosome mutations from karyotypes. (GLO: D1)  
*Examples: Down syndrome, Turner syndrome, Klinefelter syndrome*

## PRINCIPLES OF INHERITANCE

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### SPECIFIC LEARNING OUTCOMES

**B12-1-01:** Outline Gregor Mendel’s principles of inheritance, stating their importance to the understanding of heredity. (GLOs: A1, A2, B1, D1)

Include: principles of segregation, dominance, and independent assortment

**B12-1-02:** Explain what is meant by the terms *heterozygous* and *homozygous*. (GLO: D1)

**B12-1-03:** Distinguish between *genotype* and *phenotype*, and use these terms appropriately when discussing the outcomes of genetic crosses. (GLO: D1)

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SLO: B12-1-01  
SLO: B12-1-02  
SLO: B12-1-03

### SUGGESTIONS FOR INSTRUCTION

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#### TEACHER BACKGROUND

The instructional strategies suggested in this document follow the constructivist model of learning and are organized into two groups: activate and acquire/apply.

By activating students’ prior knowledge of a topic, teachers can

- help students relate new information, skills, and strategies to what they already know and can do
- recognize misconceptions and gaps in student knowledge
- stimulate curiosity and initiate the inquiry process

Acquiring and applying strategies are designed to assist students in processing, integrating, and consolidating their learning.

#### ENTRY-LEVEL KNOWLEDGE

Students were exposed to basic Mendelian genetics in Grade 9 Science. Dominant and recessive genes were discussed, and the terms *genotype* and *phenotype* were introduced.

#### TEACHER NOTE

Students generally find the study of genetics interesting. Once they learn the specialized vocabulary and conventions (e.g., Punnett squares), the concepts can be easy to grasp.

Ensure students understand that Gregor Mendel had no preconceptions about chromosomes, genes, or deoxyribonucleic acid (DNA). He based his principles solely on the numbers of offspring he observed. The scientific process Mendel used could be a theme during instruction for learning outcome B12-1-01.

**SKILLS AND ATTITUDES OUTCOMES**

- B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)  
*Examples: use concept maps, sort-and-predict frames, concept frames . . .*
- B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)  
*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*
- B12-0-S4:** Evaluate the relevance, reliability, and adequacy of data and data-collection methods. (GLOs: C2, C4, C5, C8)  
Include: discrepancies in data and sources of error
- B12-0-S5:** Analyze data and/or observations in order to explain the results of an investigation, and identify implications of these findings. (GLOs: C2, C4, C5, C8)
- B12-0-I4:** Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)
- B12-0-N1:** Describe the role of evidence in developing scientific understanding and explain how this understanding changes when new evidence is introduced. (GLO: A2)
- B12-0-N2:** Understand that development and acceptance of scientific evidence, theories, or technologies are affected by many factors. (GLOs: A2, B2)  
*Examples: cultural and historical context, politics, economics, personalities . . .*
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**ACTIVATE**

**Traffic Lights**

Prepare a Traffic Lights handout containing 10 to 20 terms related to genetics. Some words may be familiar to students from Grade 9 Science (e.g., dominant, recessive, genotype, phenotype, Punnett square, heredity, homozygous, heterozygous), while other terms may not be familiar to students (e.g., independent assortment, Gregor Mendel, purebred, hybrid, allele, carrier). Provide students with red, yellow, and green highlighters or sheets of peel-off dots. Students use green to point out terms/concepts they understand, yellow to indicate those they are somewhat familiar with, and red to show those they are unfamiliar with or don't understand (Keeley).



***Suggestion for Assessment***

Scan the completed Traffic Lights handouts to assess students' understanding of vocabulary and concepts. The information gathered from this formative assessment can be used to plan for instruction. Should the majority of students in the class indicate little or no understanding of or familiarity with genetics terms or concepts, an adjustment in the instructional plan is required to help students develop their conceptual understanding.

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## PRINCIPLES OF INHERITANCE

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### SPECIFIC LEARNING OUTCOMES

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- B12-1-02:** Explain what is meant by the terms *heterozygous* and *homozygous*. (GLO: D1)
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### Rotational Cooperative Graffiti

For this brainstorming activity, organize students into small groups. Give each group a unique topic, as well as poster paper and a marker. (Marker colours are different for each group.) The groups brainstorm as many ideas as they have about the given topic – anything that comes to mind. After the groups have brainstormed ideas for a predetermined period of time, they pass their poster papers to the next group. Once again, the groups record their responses to the topic on the posters. This process continues until each group gets its original poster back. Group members work together to summarize what has been written on their poster. They then share the summary with the class.

Topics may include the following:

- dominant/recessive
- genotype/phenotype
- homozygous/heterozygous
- meiosis/mitosis
- pedigree
- Punnett square

For more information on this strategy, refer to *Senior Years Science Teachers' Handbook: A Teaching Resource* (Manitoba Education and Training, p. 3.15) – hereafter referred to as *SYSTH*.

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### ACQUIRE/APPLY

#### Building Vocabulary (U1)

Introduce new vocabulary to students as required. Students benefit from receiving assistance with vocabulary before they start to read science texts. The use of a variety of strategies (e.g., Word Cycle, Three-Point Approach) can aid students in developing both conceptual and contextual knowledge of the genetics-related vocabulary. For more information on building a scientific vocabulary and think-sheet frames, refer to *SYSTH* (Chapter 10).

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**SKILLS AND ATTITUDES OUTCOMES**

- B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)  
*Examples: use concept maps, sort-and-predict frames, concept frames . . .*
- B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)  
*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*
- B12-0-S4:** Evaluate the relevance, reliability, and adequacy of data and data-collection methods. (GLOs: C2, C4, C5, C8)  
Include: discrepancies in data and sources of error
- B12-0-S5:** Analyze data and/or observations in order to explain the results of an investigation, and identify implications of these findings. (GLOs: C2, C4, C5, C8)
- B12-0-I4:** Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)
- B12-0-N1:** Describe the role of evidence in developing scientific understanding and explain how this understanding changes when new evidence is introduced. (GLO: A2)
- B12-0-N2:** Understand that development and acceptance of scientific evidence, theories, or technologies are affected by many factors. (GLOs: A2, B2)  
*Examples: cultural and historical context, politics, economics, personalities . . .*
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***Suggestion for Assessment***

Completed think-sheet frames can be peer assessed or handed in for teacher feedback. As this learning activity is intended as a formative assessment to check student understanding, a mark is not required. For more information on peer assessment, refer to Appendix 4.2A: Peer Assessment (Teacher Background) and Appendix 4.2B: Guidelines for Peer Assessment (BLM).

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**The Story of Gregor Mendel—Article Analysis (U1, N2)**

The story of Gregor Mendel is a fascinating one. For a brief summary of his life and work, see Appendix 1.1: The Story of Gregor Mendel (BLM). Ask students to read the article and complete a Fact-Based Article Analysis frame (see *SYSTH* pp. 11.30–11.31, 11.41).

Encourage students to use effective reading strategies to acquire new knowledge from text. This includes activating prior knowledge before the reading, taking some form of notes during the reading, and having the opportunity to discuss/reflect on what they read. For more information about strategies for reading scientific information, refer to *SYSTH* (Chapter 12).



***Suggestion for Assessment***

Scan the completed Fact-Based Article Analysis frames to assess students' understanding. The information gathered can be used to plan further instruction.

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## PRINCIPLES OF INHERITANCE

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### SPECIFIC LEARNING OUTCOMES

- B12-1-01:** Outline Gregor Mendel’s principles of inheritance, stating their importance to the understanding of heredity. (GLOs: A1, A2, B1, D1)  
 Include: principles of segregation, dominance, and independent assortment
- B12-1-02:** Explain what is meant by the terms *heterozygous* and *homozygous*. (GLO: D1)
- B12-1-03:** Distinguish between *genotype* and *phenotype*, and use these terms appropriately when discussing the outcomes of genetic crosses. (GLO: D1)
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### Mendel’s Experiments (U1, N1)

Use diagrams and charts to illustrate Mendel’s experiments, observations, and conclusions. The use of visuals will aid students in developing their understanding of the concept of inheritance.

The 10 + 2 Note-Taking strategy can assist students in developing their conceptual understanding. In using this strategy, the teacher presents information for 10 minutes, and then each student summarizes or discusses the material with a partner for two minutes.

### Resource Links

- Cold Spring Harbor Laboratory’s DNA Learning Center. Home Page. <[www.dnalc.org/](http://www.dnalc.org/)>.
- ———. *DNA from the Beginning*. <[www.dnafb.org/](http://www.dnafb.org/)>. This website contains an animated primer on the basics of DNA, genes, and heredity.
- ———. *Lab Center at DNALC*. <<http://labcenter.dnalc.org/dnalc.html>>.
- ———. *Online Education Websites*. <[www.dnalc.org/websites/](http://www.dnalc.org/websites/)>.
- Genetic Science Learning Center. *Learn.Genetics*. <<http://learn.genetics.utah.edu>>. The *Heredity and Traits* section of this website provides tutorials and interactive animations.
- McBrien, Amanda. “Lab: Mendelian Inheritance.” *Dolan DNA Learning Center*. <[http://labcenter.dnalc.org/mendeliangenetics/mendeliangenetics\\_d.html](http://labcenter.dnalc.org/mendeliangenetics/mendeliangenetics_d.html)>. A cob of corn (*Zea mays*) with purple and yellow kernels in a 3:1 phenotype ratio is required in one of the learning activities.
- The National Science Digital Library (NSDL). Home Page. <<http://nsdl.org/>>. The collections of genetics resources for teachers on this website include lesson plans, videos, interactives, and articles.



**SKILLS AND ATTITUDES OUTCOMES**

**B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)

*Examples: use concept maps, sort-and-predict frames, concept frames . . .*

**B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)

*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*

**B12-0-S4:** Evaluate the relevance, reliability, and adequacy of data and data-collection methods. (GLOs: C2, C4, C5, C8)

Include: discrepancies in data and sources of error

**B12-0-S5:** Analyze data and/or observations in order to explain the results of an investigation, and identify implications of these findings. (GLOs: C2, C4, C5, C8)

**B12-0-I4:** Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)

**B12-0-N1:** Describe the role of evidence in developing scientific understanding and explain how this understanding changes when new evidence is introduced. (GLO: A2)

**B12-0-N2:** Understand that development and acceptance of scientific evidence, theories, or technologies are affected by many factors. (GLOs: A2, B2)

*Examples: cultural and historical context, politics, economics, personalities . . .*

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- Nature Education. *Scitable: A Collaborative Learning Space for Science.* <[www.nature.com/scitable](http://www.nature.com/scitable)>.

The science library on this website contains articles, concept overviews, and animations focusing on genetics and evolution. Teachers can build online classrooms to share and discuss articles with students.



***Suggestion for Assessment***

During the last five minutes of the class, have students reflect on their learning by completing an Exit Slip, responding to questions such as the following:

- What do you know now that you didn't know before class today?
- What did you already know?
- What questions do you still have?

Review student responses, looking for areas of confusion, and address the questions during the next class (formative assessment). For information on Exit Slips, see *SYSTH* (p. 13.9).

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**Family Traits (U2)**

Show the class a picture of a family (parents and their children). Pose the following question to students and ask them to respond in their notebooks.

- The children in a family resemble each other and their parents, but they are not identical to each other (except in the case of identical twins) or to their parents. Can you explain why this is so?
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## PRINCIPLES OF INHERITANCE

### SPECIFIC LEARNING OUTCOMES

**B12-1-01:** Outline Gregor Mendel’s principles of inheritance, stating their importance to the understanding of heredity. (GLOs: A1, A2, B1, D1)

Include: principles of segregation, dominance, and independent assortment

**B12-1-02:** Explain what is meant by the terms *heterozygous* and *homozygous*. (GLO: D1)

**B12-1-03:** Distinguish between *genotype* and *phenotype*, and use these terms appropriately when discussing the outcomes of genetic crosses. (GLO: D1)



#### *Suggestion for Assessment*

This question can be used as a formative assessment to observe the level of student understanding of this concept and to help plan future lessons.

### Mendel’s Results—Data Analysis (S4, S5, N1)

Provide students with samples of Mendel’s raw data and ask them to determine which traits are dominant and which traits are recessive. Students should be able to explain the reasons for their choices.

| Parental Traits             | F <sub>1</sub> Progeny | F <sub>2</sub> Progeny    |
|-----------------------------|------------------------|---------------------------|
| wrinkled x round (seeds)    | all round              | 5472 round, 1850 wrinkled |
| yellow x green (seeds)      | all yellow             | 6022 yellow, 2001 green   |
| tall x short (plant height) | all tall               | 787 tall, 277 short       |

#### Resource Link

- Mendel, Gregor. “Experiments in Plant Hybridization.” 1865. Trans. William Bateson. *MendelWeb*. <[www.mendelweb.org/Mendel.html](http://www.mendelweb.org/Mendel.html)>.



#### *Suggestion for Assessment*

Make an accounting of the ratios of some simple Mendelian characteristics among the students in your class (e.g., tongue curling, mid-digit hair, attached/free earlobes). Ask students to determine (if possible) their genotypes for these characteristics by comparing how they express a characteristic with how each of their parents expresses that characteristic.

**SKILLS AND ATTITUDES OUTCOMES**

- B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)  
*Examples: use concept maps, sort-and-predict frames, concept frames . . .*
- B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)  
*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*
- B12-0-S4:** Evaluate the relevance, reliability, and adequacy of data and data-collection methods. (GLOs: C2, C4, C5, C8)  
Include: discrepancies in data and sources of error
- B12-0-S5:** Analyze data and/or observations in order to explain the results of an investigation, and identify implications of these findings. (GLOs: C2, C4, C5, C8)
- B12-0-I4:** Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)
- B12-0-N1:** Describe the role of evidence in developing scientific understanding and explain how this understanding changes when new evidence is introduced. (GLO: A2)
- B12-0-N2:** Understand that development and acceptance of scientific evidence, theories, or technologies are affected by many factors. (GLOs: A2, B2)  
*Examples: cultural and historical context, politics, economics, personalities . . .*
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**Mendel’s Publication—Creative Writing Assignment (U2, I4)**

RAFTs (Role–Audience–Format–Topic–Strong Verbs) are creative writing assignments in which students are encouraged to adopt new perspectives on a science concept or issue (for more information, refer to *SYSTH*, pp. 13.22–13.25). In this learning activity, students assume the persona of Gregor Mendel and write an article for publication in a scientific journal detailing his findings. Refer to Appendix 1.2: Mendel’s Publication—Creative Writing Assignment (BLM) for assignment details.



***Suggestions for Assessment***

Create an assessment rubric for the assignment by developing the assessment criteria and performance levels in collaboration with students. Assessment criteria could include biology content, information sources, organization, and so on. Refer to Appendix 5.7: Co-constructing Assessment Criteria with Students (Teacher Background) for more information on the collaborative process. Alternatively, provide students with exemplars of strong and weak assignments, and have them work in groups to identify possible assessment criteria and levels of performance. The exemplars can be teacher-generated or anonymous samples of student work done in previous years.

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## AUTOSOMAL INHERITANCE

### SPECIFIC LEARNING OUTCOME

**B12-1-04:** Use Punnett squares to solve a variety of autosomal inheritance problems, and justify the results using appropriate terminology. (GLOs: D1, E1)

Include: monohybrid cross, dihybrid cross, testcross, P generation, F<sub>1</sub> generation, F<sub>2</sub> generation, phenotypic ratio, genotypic ratio, dominant alleles, recessive alleles, purebred, hybrid, and carrier

SLO: B12-1-04

### SUGGESTIONS FOR INSTRUCTION

#### ENTRY-LEVEL KNOWLEDGE

Students observed, collected, and analyzed data of single-trait inheritance in Grade 9 Science. At that time, students were introduced to Punnett squares and solved single-trait inheritance problems.

#### TEACHER NOTE

Students often ask where the F in F<sub>1</sub> and F<sub>2</sub> come from, and why they are not called the C (child) and G (grandchild) generations. Explain that the F comes from the Latin word *filial*, which refers to offspring or children.

#### ACTIVATE

##### Turn to Your Neighbour

Pose the following genetics problem to students:

- Short hair is dominant over long hair in dogs. Two dogs heterozygous for short hair produce a litter of eight pups. Predict the appearance of the pups and explain how you arrived at your prediction.

Students turn to their neighbours to discuss their predictions and explanations.

#### ACQUIRE/APPLY

##### Problem-Solving Approaches—Class Discussion (S1, G2)

Discuss with students their approaches/steps to solving the problem posed in Turn to Your Neighbour. As the discussion progresses, review with students the conventions used in solving genetics problems. For example, the dominant gene is written first in the heterozygous condition (i.e., Ss, not sS).



##### Suggestion for Assessment

Use the Thumbs strategy – thumbs up (I get it), thumbs down (I don't get it), thumbs sideways (I'm not sure I get it) – to check students' understanding. This strategy can be used as a quick formative assessment to adjust the pace of instruction.

#### SKILLS AND ATTITUDES OUTCOMES

- B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)  
*Examples: use concept maps, sort-and-predict frames, concept frames . . .*
- B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)  
*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*
- B12-0-P1:** Demonstrate confidence in ability to carry out investigations. (GLOs: C2, C5)
- B12-0-S1:** Use appropriate scientific problem-solving or inquiry strategies when answering a question or solving a problem. (GLOs: C2, C3)
- B12-0-S2:** Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment. (GLOs: B3, B5, C1, C2)
- B12-0-S3:** Record, organize, and display data and observations using an appropriate format. (GLOs: C2, C5)
- B12-0-S4:** Evaluate the relevance, reliability, and adequacy of data and data-collection methods. (GLOs: C2, C4, C5, C8)  
*Include: discrepancies in data and sources of error*
- B12-0-S5:** Analyze data and/or observations in order to explain the results of an investigation, and identify implications of these findings. (GLOs: C2, C4, C5, C8)
- B12-0-I4:** Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)
- B12-0-G1:** Collaborate with others to achieve group goals and responsibilities. (GLOs: C2, C4, C7)
- B12-0-G2:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)
- B12-0-G3:** Evaluate individual and group processes used. (GLOs: C2, C4, C7)
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#### Building Vocabulary (U1)

Introduce new vocabulary to students as required. The use of a variety of strategies (e.g., Three-Point Approach, Sort and Predict, Word Clusters) can aid students in developing both conceptual and contextual knowledge of the vocabulary of genetics. For more information on building a scientific vocabulary and for think-sheet frames, refer to *SYSTH* (Chapter 10).

#### Resource Link

- The National Science Digital Library. Home Page. <<http://nsdl.org/>>. The collections of genetics resources for teachers on this website include lesson plans, videos, interactives, and articles.



#### Suggestion for Assessment

Review students' think-sheet frames to ensure accuracy. As this learning activity is intended as a formative assessment to check students' understanding, no mark is required.

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## AUTOSOMAL INHERITANCE

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### SPECIFIC LEARNING OUTCOME

**B12-1-04:** Use Punnett squares to solve a variety of autosomal inheritance problems, and justify the results using appropriate terminology. (GLOs: D1, E1)

Include: monohybrid cross, dihybrid cross, testcross, P generation, F<sub>1</sub> generation, F<sub>2</sub> generation, phenotypic ratio, genotypic ratio, dominant alleles, recessive alleles, purebred, hybrid, and carrier

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### Probability Investigation (P1, S2, S3, S4)

Probability investigations are relatively simple to perform, involving marking and tossing coins to illustrate how probability can be used to predict the outcomes of genetic crosses. Refer to Appendix 1.3: Student Lab Skills (Teacher Background) for information on assessing and evaluating student lab skills.



#### *Suggestion for Assessment*

Assessment of this investigation can be summative (written responses to the questions posed) or formative. The RERUN strategy (Keeley 172–73) can be used for formative assessment of student learning in place of a formal summative lab report.

After students have completed the investigation and answered questions about it, ask them to reflect on their lab experience (individually or in groups) by writing a sentence or two for each letter of the acronym, **RERUN**: **R**ecall (what you did), **E**xplain (why you did it), **R**esults (what you found out), **U**ncertainties (what remains unclear), and **N**ew (what you learned).

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### Genetics Problems—Each One Teach One (U2, G2)

Provide pairs of students with a variety of genetics problems. Students work collaboratively to solve the problems and explain their metacognitive processes to each other (they explain how they were able to determine the answers to the problems). See Appendix 1.7A: Genetics Problems 1 and Appendix 1.7B: Genetics Problems 1 (Answer Key). The sample problems and answers provide examples of typical problems and expected solutions.

**SKILLS AND ATTITUDES OUTCOMES**

- B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)  
*Examples: use concept maps, sort-and-predict frames, concept frames . . .*
- B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)  
*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*
- B12-0-P1:** Demonstrate confidence in ability to carry out investigations. (GLOs: C2, C5)
- B12-0-S1:** Use appropriate scientific problem-solving or inquiry strategies when answering a question or solving a problem. (GLOs: C2, C3)
- B12-0-S2:** Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment. (GLOs: B3, B5, C1, C2)
- B12-0-S3:** Record, organize, and display data and observations using an appropriate format. (GLOs: C2, C5)
- B12-0-S4:** Evaluate the relevance, reliability, and adequacy of data and data-collection methods. (GLOs: C2, C4, C5, C8)  
*Include: discrepancies in data and sources of error*
- B12-0-S5:** Analyze data and/or observations in order to explain the results of an investigation, and identify implications of these findings. (GLOs: C2, C4, C5, C8)
- B12-0-I4:** Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)
- B12-0-G1:** Collaborate with others to achieve group goals and responsibilities. (GLOs: C2, C4, C7)
- B12-0-G2:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)
- B12-0-G3:** Evaluate individual and group processes used. (GLOs: C2, C4, C7)
- 



***Suggestion for Assessment***

Completed work can be handed in for teacher feedback. Provide feedback that is specific and descriptive, describing the performance rather than making a judgment or giving an opinion. This will help students repeat success and know what they need to improve. General comments (e.g., “Try harder next time” or “Good work”) are less effective than specific and descriptive comments (e.g., “You have correctly determined the genotypes of the parents and possible offspring; however, you did not include the probability that the next child will be a carrier of the disease”).

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## AUTOSOMAL INHERITANCE

### SPECIFIC LEARNING OUTCOME

**B12-1-04:** Use Punnett squares to solve a variety of autosomal inheritance problems, and justify the results using appropriate terminology. (GLOs: D1, E1)

Include: monohybrid cross, dihybrid cross, testcross, P generation, F<sub>1</sub> generation, F<sub>2</sub> generation, phenotypic ratio, genotypic ratio, dominant alleles, recessive alleles, purebred, hybrid, and carrier



### Determining the Inheritance Pattern of a Trait—Investigation/Culminating Task (S1, S2, S3, S4, S5, I4, G1, G3)

Students investigate to determine the inheritance pattern of a trait in an organism, documenting and reflecting on the inquiry process. An investigation of this sort can be used as a culminating task for the unit, bringing together a number of knowledge and skills outcomes. Students can work on this investigation throughout the unit. Refer to Appendix 1.5: Scientific Inquiry (BLM) and Appendix 1.6A: Feedback Form for Designing an Experiment (Plan) (BLM).

#### Resource Links

- Lauffer, D., and P. Williams. Wisconsin Fast Plants. Home Page. <[www.fastplants.org/](http://www.fastplants.org/)>.

The fruit fly (*Drosophila melanogaster*) and Wisconsin Fast Plants (*Brassica rapa*) are easy to work with and have short breeding cycles. The results of breeding several generations can easily be observed to determine the inheritance patterns of a variety of traits. Purebred fruit flies and Wisconsin Fast Plants can be obtained from biological supply companies.

- University of Massachusetts Boston. *Virtual Genetics Lab*. <<http://intro.bio.umb.edu/vgl/>>.

In this simulation of the transmission of traits in a hypothetical organism, students determine the mechanism of inheritance of a particular trait based on the logic of genetic analysis.



#### Suggestions for Assessment

The results of the investigation can be expressed in a written report or a multimedia presentation. Laboratory and group work skills can be assessed using checklists. Refer to Appendix 1.3: Student Lab Skills (Teacher Background), Appendix 1.4A: Lab Skills Checklist—General Skills (BLM), Appendix 1.4B: Lab Skills Checklist—Thinking Skills (BLM), and Appendix 1.6B: Rating Scale for Experimental Design and Report (BLM). See *SYSTH* (pp. 11.26–11.29 and 14.11–14.12) for different ways of writing a lab report.



**SKILLS AND ATTITUDES OUTCOMES**

- B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)  
*Examples: use concept maps, sort-and-predict frames, concept frames . . .*
- B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)  
*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*
- B12-0-P1:** Demonstrate confidence in ability to carry out investigations. (GLOs: C2, C5)
- B12-0-S1:** Use appropriate scientific problem-solving or inquiry strategies when answering a question or solving a problem. (GLOs: C2, C3)
- B12-0-S2:** Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment. (GLOs: B3, B5, C1, C2)
- B12-0-S3:** Record, organize, and display data and observations using an appropriate format. (GLOs: C2, C5)
- B12-0-S4:** Evaluate the relevance, reliability, and adequacy of data and data-collection methods. (GLOs: C2, C4, C5, C8)  
*Include: discrepancies in data and sources of error*
- B12-0-S5:** Analyze data and/or observations in order to explain the results of an investigation, and identify implications of these findings. (GLOs: C2, C4, C5, C8)
- B12-0-I4:** Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)
- B12-0-G1:** Collaborate with others to achieve group goals and responsibilities. (GLOs: C2, C4, C7)
- B12-0-G2:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)
- B12-0-G3:** Evaluate individual and group processes used. (GLOs: C2, C4, C7)
- 

Create an assessment rubric for the report/presentation by developing the assessment criteria and performance levels in collaboration with students. Refer to Appendix 5.7: Co-constructing Assessment Criteria with Students (Teacher Background) for more information on the collaborative process. Alternatively, provide students with exemplars of strong and weak lab reports, and have them work in groups to identify possible assessment criteria and levels of performance. The exemplars can be anonymous samples of student work done in previous years.

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ATYPICAL  
INHERITANCE

SPECIFIC LEARNING OUTCOME

**B12-1-05:** Describe examples of and solve problems involving the inheritance of phenotypic traits that do not follow a dominant-recessive pattern. (GLO: D1)

*Examples: co-dominance, incomplete dominance, multiple alleles, lethal genes . . .*

SLO: B12-1-05

SUGGESTIONS FOR INSTRUCTION

TEACHER NOTE

Specialized conventions that indicate co-dominant, incomplete dominant, and multiple allele genotypes can be confusing to students. Introduce the specialized conventions that indicate co-dominant, incomplete dominant, and multiple allele genotypes. With the use of examples, show how the expression of these traits varies from the typical Mendelian ratios.

BACKGROUND INFORMATION

When two alleles of a gene are clearly expressed in the phenotype, the alleles are said to be co-dominant. For example, the roan (pinkish) colour in cattle is the result of the coat being a mix of both red and white hair. The AB blood type in humans is the result of an individual carrying both the  $I^A$  and  $I^B$  alleles.

When two alleles of a gene appear to be blended in the phenotype, the alleles are said to show incomplete dominance. For example, when red-flowered snapdragons are crossed with white-flowered snapdragons, all the offspring ( $F_1$  generation) have pink flowers. If the pink-flowered snapdragons are allowed to self-pollinate, the  $F_2$  generation ratio is 1 red: 2 pink: 1 white.

Some genes may have three or more alleles; however, each individual can have a maximum of two alleles per gene. Human ABO blood types are examples of multiple alleles. Four possible phenotypes (A, B, AB, O) are produced from three different alleles ( $I^A$  – dominant,  $I^B$  – dominant,  $i$  – recessive).

Some genes are lethal when present in the homozygous condition. In chickens, when a developing embryo contains two copies of a recessive gene known as creeper, the embryo dies inside the eggshell. Chicks heterozygous for the condition survive.

**SKILLS AND ATTITUDES OUTCOMES**

- B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)  
*Examples: use concept maps, sort-and-predict frames, concept frames . . .*
- B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)  
*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*
- B12-0-S1:** Use appropriate scientific problem-solving or inquiry strategies when answering a question or solving a problem. (GLOs: C2, C3)
- B12-0-I1:** Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)  
Include: print and electronic sources, resource people, and different types of writing
- B12-0-I3:** Quote from or refer to sources as required, and reference sources according to accepted practice. (GLOs: C2, C6)
- B12-0-I4:** Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)
- B12-0-G2:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)
- 

**ACTIVATE**

**Think-Pair-Share**

Provide students with the following information:

When Gregor Mendel crossed a purple-flowered pea plant with a white-flowered pea plant, the flowers in the next generation were all purple. However, the cross between a red-flowered snapdragon and a white-flowered snapdragon produces pink-flowered snapdragons.

Pose the following questions to students:

- What is the dominant flower colour in pea plants?
- How does the snapdragon cross differ from the pea plant cross?
- Based on your knowledge of alleles and phenotypes, can you provide an explanation for the results of the snapdragon cross?

Give students time to think about the questions and formulate responses individually. Students then pair up with a partner to discuss their ideas.

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**ACQUIRE/APPLY**

**Genetics Problems—Each One Teach One (U2, G2)**

Provide pairs of students with a variety of genetics problems. Students work collaboratively to solve the problems and explain their metacognitive processes to their partners. See Appendix 1.8A: Genetics Problems 2 (BLM) and Appendix 1.8B: Genetics Problems 2 (Answer Key). The sample problems and answers provide examples of typical problems and expected solutions.

## ATYPICAL INHERITANCE

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### SPECIFIC LEARNING OUTCOME

**B12-1-05:** Describe examples of and solve problems involving the inheritance of phenotypic traits that do not follow a dominant-recessive pattern. (GLO: D1)

*Examples: co-dominance, incomplete dominance, multiple alleles, lethal genes . . .*

---



#### *Suggestion for Assessment*

Completed work can be handed in for teacher feedback. Provide feedback that is specific and descriptive, describing the performance rather than making a judgment or giving an opinion. This will help students repeat success and know what they need to improve. General comments (e.g., “Try harder next time” or “Good work”) are less effective than specific and descriptive comments (e.g., “You have correctly determined the genotypes of the parents and possible offspring; however, you did not include the probability that the next child will have the AB blood type”).

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### **Atypical Inheritance Patterns—Demonstrating Understanding (U1)**

At the end of the lesson, pose the following questions to students:

- How do co-dominance and incomplete dominance patterns differ from one another? Explain.
- How do multiple alleles and polygenic traits differ from one another? Explain.

Give students five minutes to respond in their notebooks.



#### *Suggestion for Assessment*

This learning activity provides a quick formative assessment of what students learned in a particular lesson. Students’ responses should include the following:

- The co-dominance pattern shows the expression of two traits, while the incomplete dominance pattern shows a blending of two traits.
  - Multiple allele inheritance shows many forms of a trait, but each individual has only two alleles for the trait. Polygenic inheritance shows a continuum of the forms of the trait, with each individual having many genes involved in the expression of the trait.
-

**SKILLS AND ATTITUDES OUTCOMES**

- B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)  
*Examples: use concept maps, sort-and-predict frames, concept frames . . .*
- B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)  
*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*
- B12-0-S1:** Use appropriate scientific problem-solving or inquiry strategies when answering a question or solving a problem. (GLOs: C2, C3)
- B12-0-I1:** Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)  
Include: print and electronic sources, resource people, and different types of writing
- B12-0-I3:** Quote from or refer to sources as required, and reference sources according to accepted practice. (GLOs: C2, C6)
- B12-0-I4:** Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)
- B12-0-G2:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)
- 

**Atypical Inheritance Patterns—Research and Presentation  
(U2, S1, I1, I3, I4)**

Students research and prepare reports explaining the inheritance of phenotypic traits that do not follow a dominant-recessive pattern. Examples include

- human AB blood type, sickle-cell anemia in humans (co-dominance)
- familial hypercholesterolemia in humans, straight/wavy/curly hair in Caucasians, flower colour in four o'clocks, feather colour in Andalusian chickens (incomplete dominance)
- coat colour in rabbits, kernel colour in corn, chicken feather colour (multiple alleles)
- achondroplasia in humans, flower colour in golden snapdragons, coat colour in yellow mice (lethal genes)

**Resource Links**

- Manitoba Education. *Information and Communication Technology (ICT): Kindergarten to Grade 12*. <[www.edu.gov.mb.ca/k12/tech/index.html](http://www.edu.gov.mb.ca/k12/tech/index.html)>. Refer to this website for ideas about integrating information and communication technologies across the curriculum.
- ———. "Professional Learning for Teachers." *Literacy with ICT across the Curriculum: A Developmental Continuum*. <[www.edu.gov.mb.ca/k12/tech/lict/let\\_me\\_try/le\\_teachers.html](http://www.edu.gov.mb.ca/k12/tech/lict/let_me_try/le_teachers.html)>. Refer to this website for additional information on topics such as plagiarism, evaluating web content, copyright, and making a bibliography.

**ATYPICAL  
INHERITANCE**

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**SPECIFIC LEARNING OUTCOME**

**B12-1-05:** Describe examples of and solve problems involving the inheritance of phenotypic traits that do not follow a dominant-recessive pattern. (GLO: D1)

*Examples: co-dominance, incomplete dominance, multiple alleles, lethal genes . . .*

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***Suggestions for Assessment***

Students present their research on the inheritance of phenotypic traits that do not follow a dominant-recessive pattern. Research findings can be presented as

- written reports
- visual displays (e.g., poster, brochure, bulletin board, comic strip)
- oral presentations
- multimedia presentations (e.g., podcast, wiki, PowerPoint, video)

Presentation components may vary, depending on the type of presentation selected. Refer to Appendix 5.8: Checklist for Creating Visuals (BLM) for use with visuals (e.g., posters, collages, graphic organizers) and Appendix 5.9: Oral Presentation – Observation Checklist (BLM).

Develop assessment criteria for the presentation in collaboration with students. Refer to Appendix 5.7: Co-constructing Assessment Criteria with Students (Teacher Background) for more information on this collaborative process. The criteria should include both content and presentation components. The content criteria should include use of key terms and understandings from the unit.

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**SKILLS AND ATTITUDES OUTCOMES**

- B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)  
*Examples: use concept maps, sort-and-predict frames, concept frames . . .*
- B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)  
*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*
- B12-0-S1:** Use appropriate scientific problem-solving or inquiry strategies when answering a question or solving a problem. (GLOs: C2, C3)
- B12-0-I1:** Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)  
Include: print and electronic sources, resource people, and different types of writing
- B12-0-I3:** Quote from or refer to sources as required, and reference sources according to accepted practice. (GLOs: C2, C6)
- B12-0-I4:** Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)
- B12-0-G2:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)
- 

**NOTES**

**SEX-LINKED  
INHERITANCE**

**SPECIFIC LEARNING OUTCOMES**

**B12-1-06:** Explain the basis for sex determination in humans.  
(GLO: D1)

Include: XX and XY chromosomes

**B12-1-07:** Describe examples of and solve problems involving sex-linked genes. (GLO: D1)

*Examples: red-green colour-blindness, hemophilia, Duchenne muscular dystrophy . . .*

SLO: B12-1-06  
SLO: B12-1-07

**SUGGESTIONS FOR INSTRUCTION**

**ENTRY-LEVEL KNOWLEDGE**

In Grade 9 Science, students were introduced to the role played by human X and Y chromosomes in sex determination. The inheritance of sex-linked traits was also discussed.

**TEACHER NOTE**

The specialized conventions that indicate sex chromosomes and sex-linked genes can be confusing to students. Introduce the specialized conventions that indicate sex chromosomes and sex-linked traits. With the use of examples, show how the expression of sex-linked traits varies from the typical Mendelian ratios.

Be sensitive to the fact that students in your class may have a sex-linked condition (e.g., approximately 1 in 10 males and 1 in 100 females have red-green colour-blindness), or it may run in their families. Hemophilia strikes an estimated 1 in 7500 boys; Duchenne muscular dystrophy affects 1 in 3500 boys in Canada.

**BACKGROUND INFORMATION**

The sex of an individual is determined at the time of fertilization by the type of sex chromosome (X or Y) present in the sperm.

- If the sperm contains an X chromosome, the zygote will be female (XX).
- If the sperm contains a Y chromosome, the zygote will be male (XY).

Through the first six weeks of pregnancy, the embryo develops as a female. Sex differentiation occurs in the seventh week of embryonic development. Genes on the Y chromosome trigger the release of androgens that stimulate the development of male reproductive organs. Should androgens not be released, the embryo continues to develop as a female in response to the release of estrogens. Male and female reproductive organs are produced from the same embryonic tissues.

Sex-linked traits are recessive and carried on the X chromosome. Consequently, because males carry one copy of the gene and females carry two copies of the gene, sex-linked genes are expressed more often in males than in females.



**SKILLS AND ATTITUDES OUTCOMES**

**B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)

*Examples: use concept maps, sort-and-predict frames, concept frames . . .*

**B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)

*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*

**B12-0-S1:** Use appropriate scientific problem-solving or inquiry strategies when answering a question or solving a problem. (GLOs: C2, C3)

**B12-0-G2:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)

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**ACTIVATE**

**Table Conference**

Organize students into groups and pose the following question:

- Henry VIII of England married six times in an attempt to have a legitimate male heir to the English throne. Recalling your knowledge of Grade 9 Science, do you think Henry was correct in blaming his wives for their inability to produce a son? (Henry did eventually have one son, who inherited the throne after his father's death.)

Remind the groups that each student must have an opportunity to speak and that all ideas should be discussed. Students should talk about a variety of possible answers, and discuss their strengths and weaknesses (Keeley).

---

**ACQUIRE/APPLY**

**Table Conference—Class Discussion (U2, S1)**

Engage students in a discussion of their responses to the Table Conference, reminding them to recall their knowledge from Grade 9 Science. As the discussion progresses, review with students the conventions used to denote human sex chromosomes, and introduce the specialized conventions used in sex-linked traits (e.g.,  $X^HY$ ,  $X^HX^h$ ).

Using the Three-Minute Pause strategy, provide students with three-minute breaks after “chunks” of instruction. Students can use the breaks to summarize, clarify, and reflect on their understanding of the information with a partner or a small group in order to process information and develop their conceptual understanding. Three-minute timers or digital stopwatches can be used by students to keep track of time.

**SEX-LINKED  
INHERITANCE**

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**SPECIFIC LEARNING OUTCOMES**

**B12-1-06:** Explain the basis for sex determination in humans.  
(GLO: D1)

Include: XX and XY chromosomes

**B12-1-07:** Describe examples of and solve problems involving sex-linked genes. (GLO: D1)

*Examples: red-green colour-blindness, hemophilia, Duchenne muscular dystrophy . . .*

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***Suggestion for Assessment***

At the end of the lesson, distribute index cards or half sheets of paper. Ask students to describe the “muddiest point” of the lesson – that is, the ideas or parts of the lesson that were confusing or difficult to understand. Let students know you will be using the information to plan the next lesson to benefit them best. At the start of the next lesson, share with students examples of responses that informed your instructional decisions. This will help them realize that you are taking their responses seriously, and they will respond thoughtfully and with more detail in the future.

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**Genetics Problems—Each One Teach One (U2, G2)**

Provide pairs of students with a variety of genetics problems. Students work collaboratively to solve the problems and explain their metacognitive processes to each other (they explain how they were able to determine the answers to the problems). See Appendix 1.9A: Genetics Problems 3 (BLM) and Appendix 1.9B: Genetics Problems 3 (Answer Key). The sample problems and answers provide examples of typical problems and expected solutions.



***Suggestion for Assessment***

Completed work can be handed in for teacher feedback. Provide feedback that is specific and descriptive, describing the performance rather than making a judgment or giving an opinion. This will help students repeat success and know what they need to improve. General comments (e.g., “Try harder next time” or “Good work”) are less effective than specific and descriptive comments (e.g., “You have correctly determined the genotypes of the parents and possible offspring; however, you did not include the probability that the son will be colour-blind”).

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**SKILLS AND ATTITUDES OUTCOMES**

**B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)

*Examples: use concept maps, sort-and-predict frames, concept frames . . .*

**B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)

*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*

**B12-0-S1:** Use appropriate scientific problem-solving or inquiry strategies when answering a question or solving a problem. (GLOs: C2, C3)

**B12-0-G2:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)

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**Sex-Linked Inheritance—Demonstrating Understanding (U1)**

At the end of the lesson, pose the following question to students:

- Why are sex-linked recessive traits such as red-green colour-blindness and hemophilia more commonly found in males than in females? Explain your answer in terms of the X chromosome.

Give students five minutes to respond in their notebooks.



***Suggestion for Assessment***

The use of this quick formative assessment provides information about what students learned in a particular lesson. Students' responses should indicate that males inherit only one X chromosome. Therefore, if the chromosome carries an allele for a recessive disorder, the male will show the trait. Because females inherit two X chromosomes, the allele for the disorder will be masked by the dominant normal gene.

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**USING  
PEDIGREES**

**SPECIFIC LEARNING OUTCOME**

**B12-1-08:** Use pedigree charts to illustrate the inheritance of genetically determined traits in a family tree and to determine the probability of certain offspring having particular traits. (GLOs: C8, D1)

Include: symbols and notations used

**SLO: B12-1-08**

**SUGGESTIONS FOR INSTRUCTION**

**ENTRY-LEVEL KNOWLEDGE**

The use of pedigrees to track the inheritance of a sex-linked trait was introduced in Grade 9 Science.

**TEACHER NOTE**

The inheritance patterns of traits can be determined by pedigree analysis. Students should be able to construct a pedigree, given family information, as well as determine the inheritance pattern of a trait from a pedigree. The inheritance patterns examined should include

- autosomal dominant conditions (e.g., Huntington disease, polydactyly)
- autosomal recessive conditions (e.g., cystic fibrosis, Tay-Sachs disease, attached earlobes)
- sex-linked recessive conditions (e.g., colour-blindness, Duchenne muscular dystrophy, hemophilia)

One commonly available pedigree is that of hemophilia in the descendents of Queen Victoria in the royal families of Europe. Point out the symbolic conventions in a pedigree chart. (i.e., male = □, female = ○, marriage line □-○).

**ACTIVATE**

**Knowledge Chart**

Provide students with a blank Knowledge Chart and have them individually record all they know in the Know Now column. Students then work with a partner to complete the Need to Know column. For more information and a sample Knowledge Chart frame, refer to *SYSTH* (pp. 9.8–9.14, 9.25).

#### SKILLS AND ATTITUDES OUTCOMES

**B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)

*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*

**B12-0-P2:** Demonstrate a continuing, increasingly informed interest in biology and biology-related careers and issues. (GLO: B4)

**B12-0-S1:** Use appropriate scientific problem-solving or inquiry strategies when answering a question or solving a problem. (GLOs: C2, C3)

**B12-0-G2:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)

**B12-0-N1:** Describe the role of evidence in developing scientific understanding and explain how this understanding changes when new evidence is introduced. (GLO: A2)

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#### ACQUIRE/APPLY

##### **Pedigree Analysis (U2, S1)**

A pedigree chart is a graphic representation of genetic inheritance. Review with students the symbols used in pedigrees. Remind students that pedigree charts show only phenotype and gender. Genotypes are then determined logically.

Provide students with sample pedigrees for a variety of inheritance patterns.



##### *Suggestion for Assessment*

Students use a pedigree to determine the inheritance pattern of a trait (e.g., autosomal dominant, sex-linked recessive, autosomal recessive). In addition, when given family information, students create a pedigree illustrating the inheritance of a trait.

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##### **Using Pedigree Analysis to Solve a Genetic Mystery—Case Study (U2, P2, S1, G2, N1)**

Have students work on a case study that traces the discovery of the inheritance pattern of tyrosinemia, a recessive autosomal disorder, in Quebec. See Appendix 1.10A: Using Pedigree Analysis to Solve a Genetic Mystery (BLM) and Appendix 1:10B: Using Pedigree Analysis to Solve a Genetic Mystery (Answer Key).

Regardless of whether students work on the case study individually or in small groups, encourage them to use effective reading strategies to acquire new knowledge and information from the text. This includes activating their prior knowledge before reading the case study, taking some form of notes while reading, and having an opportunity to discuss and/or reflect on what they read in the case study.

**USING  
PEDIGREES**

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**SPECIFIC LEARNING OUTCOME**

**B12-1-08:** Use pedigree charts to illustrate the inheritance of genetically determined traits in a family tree and to determine the probability of certain offspring having particular traits. (GLOs: C8, D1)

Include: symbols and notations used

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**Resource Link**

- National Center for Case Study Teaching in Science, University at Buffalo. Home Page. <<http://sciencecases.lib.buffalo.edu/cs/>>.

This website provides access to a variety of case studies, which teachers can modify or adapt for classroom use, subject to the specified usage guidelines. Teaching notes and answer keys for the case studies are available free of charge. To access the answer keys, users are required to register for a password.



***Suggestion for Assessment***

Responses to the case study can be used as a formative assessment to determine students' levels of understanding and to guide further teaching and learning activity selection (if needed). Group work skills can be peer assessed with a checklist. Refer to Appendix 1.13: Collaborative Process – Assessment (BLM).

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**Hypothesizing (U2)**

Ask students to hypothesize how Queen Victoria became a carrier of hemophilia when neither of her parents had hemophilia, nor was there a previous history of hemophilia in their families.



***Suggestion for Assessment***

A few hypotheses are possible:

- Either Victoria's mother or father developed a mutation in his or her X chromosome, which was then passed on to Victoria.
- Victoria's biological father was someone other than the man married to her mother. The mutation could have developed in his X chromosome, or in fact he had hemophilia.
- A mutation occurred in an X chromosome during the production of Victoria's egg cells.

Student responses can be used as a formative assessment to determine the level of student understanding and to guide further teaching/activity selection (if needed).

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**SKILLS AND ATTITUDES OUTCOMES**

**B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)

*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*

**B12-0-P2:** Demonstrate a continuing, increasingly informed interest in biology and biology-related careers and issues. (GLO: B4)

**B12-0-S1:** Use appropriate scientific problem-solving or inquiry strategies when answering a question or solving a problem. (GLOs: C2, C3)

**B12-0-G2:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)

**B12-0-N1:** Describe the role of evidence in developing scientific understanding and explain how this understanding changes when new evidence is introduced. (GLO: A2)

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**NOTES**

**GENETIC  
TESTING**

**SPECIFIC LEARNING OUTCOME**

**B12-1-09:** Discuss ethical issues that may arise as a result of genetic testing for inherited conditions or disorders.  
(GLOs: A3, B1, B2, C4)

**SLO: B12-1-09**

**SUGGESTIONS FOR INSTRUCTION**

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**BACKGROUND INFORMATION**

Recent advances in genetics have raised ethical questions regarding the screening of individuals for inherited conditions and disorders. DNA screening, biochemical tests, amniocentesis, and family pedigree analysis are all tools that genetic counsellors use. Some tests may be performed on individuals, and others on fetuses.

These tools are used by genetic counsellors to analyze the risk to individuals for developing a disorder, or the risk of passing on a known inherited disorder or condition to offspring. Genetic counsellors can present options to parents so that potential risks can be avoided or reduced.

There are many issues to be considered in genetic testing. Are tests equally available to all Manitobans, or only to those with the money to pay for the tests, or to those who live in larger urban centres? Should genetic testing for a disorder be performed on individuals for whom there is no available treatment (e.g., Huntington disease)? Do third parties (e.g., insurance companies, employers) have the right to genetic test results?

**ACTIVATE**

**Partner Speaks**

Pose the following question to students:

- You know that an inherited genetic condition runs in your family. Given the opportunity, would you be tested to determine whether you carry the gene?

Students take turns discussing the question with a partner, taking careful note of their partner's thoughts on the topic. Pairs then team up, and each student shares his or her partner's thoughts with the small group. After reflecting on the small-group discussions, students record their responses to the question in their notebooks (Keeley).

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#### SKILLS AND ATTITUDES OUTCOMES

- B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)  
*Examples: use concept maps, sort-and-predict frames, concept frames . . .*
- B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)  
*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*
- B12-0-P2:** Demonstrate a continuing, increasingly informed interest in biology and biology-related careers and issues. (GLO: B4)
- B12-0-P5:** Appreciate that developments in and use of technology can create ethical dilemmas that challenge personal and societal decision making. (GLOs: B1, B2)
- B12-0-D1:** Identify and explore a current issue. (GLOs: C4, C8)  
*Examples: clarify the issue, identify different viewpoints and/or stakeholders, research existing data/information . . .*
- B12-0-D2:** Evaluate implications of possible alternatives or positions related to an issue. (GLOs: B1, C4, C5, C6, C7)  
*Examples: positive and negative consequences of a decision, strengths and weaknesses of a position, ethical dilemmas . . .*
- B12-0-D3:** Recognize that decisions reflect values, and consider own and others' values when making a decision. (GLOs: C4, C5)
- B12-0-D4:** Recommend an alternative or identify a position, and provide justification for it. (GLO: C4)
- B12-0-D5:** Propose a course of action related to an issue. (GLOs: C4, C5, C8)
- B12-0-D6:** Evaluate the process used by self or others to arrive at a decision. (GLOs: C4, C5)
- B12-0-I1:** Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)  
Include: print and electronic sources, resource people, and different types of writing
- B12-0-I2:** Evaluate information to determine its usefulness for specific purposes. (GLOs: C2, C4, C5, C8)  
*Examples: scientific accuracy, reliability, currency, relevance, balance of perspectives, bias . . .*
- B12-0-I4:** Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)
- B12-0-G2:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)
- B12-0-G3:** Evaluate individual and group processes used. (GLOs: C2, C4, C7)
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#### ACQUIRE/APPLY

##### **Ethical Issues—Class Discussion (U1, P2, P5, G2)**

Engage the class in a discussion of the ethical issues that may arise as a result of genetic testing for inherited genetic conditions or disorders.

##### **Resource Links**

The following websites contain information about genetic testing and inherited conditions and disorders:

- Canadian Association of Genetic Counsellors. Home Page. <[www.cagc-accg.ca/](http://www.cagc-accg.ca/)>.
- Canadian Hemophilia Society. Home Page. <[www.hemophilia.ca/](http://www.hemophilia.ca/)>.

**GENETIC  
TESTING**

**SPECIFIC LEARNING OUTCOME**

**B12-1-09:** Discuss ethical issues that may arise as a result of genetic testing for inherited conditions or disorders.  
(GLOs: A3, B1, B2, C4)

- The Canadian Society for Mucopolysaccharide and Related Diseases. Home Page. <[www.mpssociety.ca/](http://www.mpssociety.ca/)>. This website includes information on Tay-Sachs disease.
- Cold Spring Harbor Laboratory's DNA Learning Center. *Your Genes, Your Health*. <[www.ygyh.org/](http://www.ygyh.org/)>. Refer to this website for a multimedia guide to genetic disorders.
- Cystic Fibrosis Canada. Home Page. <[www.cysticfibrosis.ca/](http://www.cysticfibrosis.ca/)>.
- Genetic Science Learning Center. *Learn.Genetics*. <<http://learn.genetics.utah.edu/>>.
- ———. "What Are Genetic Disorders?" *Learn.Genetics*. <<http://learn.genetics.utah.edu/content/disorders/whataregd/>>. This website contains tutorials and interactive animations that provide information on genetic disorders, their causes, genetic screening, and the role of genetics.
- Howard Hughes Medical Institute. *Blazing a Genetic Trail*. 1991. <[www.hhmi.org/genetictrail/](http://www.hhmi.org/genetictrail/)>. This website presents information on genetic diseases and screening, and includes a discussion on the ethics of genetic research.
- Huntington Society of Canada. Home Page. <[www.huntingtonsociety.ca/](http://www.huntingtonsociety.ca/)>.
- The Sickle Cell Association of Ontario. Home Page. <[www.sicklecellontario.com/](http://www.sicklecellontario.com/)>



**Suggestion for Assessment**

Students respond to the discussion in their notebooks and reflect on how and why their response to the Partner Speaks question changed (or did not change).

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**Genetic Counselling—Guest Speaker (I1, D1)**

Invite a genetic counsellor or representative from an organization such as Cystic Fibrosis Canada or the Canadian Hemophilia Society to speak to the class about his or her role and the services the organization provides. Questions for the speakers should be prepared by students in advance of the visit.

**SKILLS AND ATTITUDES OUTCOMES**

- B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)  
*Examples: use concept maps, sort-and-predict frames, concept frames . . .*
- B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)  
*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*
- B12-0-P2:** Demonstrate a continuing, increasingly informed interest in biology and biology-related careers and issues. (GLO: B4)
- B12-0-P5:** Appreciate that developments in and use of technology can create ethical dilemmas that challenge personal and societal decision making. (GLOs: B1, B2)
- B12-0-D1:** Identify and explore a current issue. (GLOs: C4, C8)  
*Examples: clarify the issue, identify different viewpoints and/or stakeholders, research existing data/information . . .*
- B12-0-D2:** Evaluate implications of possible alternatives or positions related to an issue. (GLOs: B1, C4, C5, C6, C7)  
*Examples: positive and negative consequences of a decision, strengths and weaknesses of a position, ethical dilemmas . . .*
- B12-0-D3:** Recognize that decisions reflect values, and consider own and others' values when making a decision. (GLOs: C4, C5)
- B12-0-D4:** Recommend an alternative or identify a position, and provide justification for it. (GLO: C4)
- B12-0-D5:** Propose a course of action related to an issue. (GLOs: C4, C5, C8)
- B12-0-D6:** Evaluate the process used by self or others to arrive at a decision. (GLOs: C4, C5)
- B12-0-I1:** Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)  
Include: print and electronic sources, resource people, and different types of writing
- B12-0-I2:** Evaluate information to determine its usefulness for specific purposes. (GLOs: C2, C4, C5, C8)  
*Examples: scientific accuracy, reliability, currency, relevance, balance of perspectives, bias . . .*
- B12-0-I4:** Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)
- B12-0-G2:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)
- B12-0-G3:** Evaluate individual and group processes used. (GLOs: C2, C4, C7)
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***Suggestion for Assessment***

Students summarize the highlights of the guest speaker's presentation in their notebooks. Summaries can be shared with classmates and peer assessed for content. For more information on peer assessment, refer to Appendix 4.2A: Peer Assessment (Teacher Background) and Appendix 4.2B: Guidelines for Peer Assessment (BLM).

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**GENETIC  
TESTING**

**SPECIFIC LEARNING OUTCOME**

**B12-1-09:** Discuss ethical issues that may arise as a result of genetic testing for inherited conditions or disorders.  
(GLOs: A3, B1, B2, C4)

**Bioethical Dilemma—Role Play (D2, D3, D4, D5, D6, G3)**

Organize students into groups of three and assign a role for each student to play (e.g., genetic counsellor, individual, partner/family member) in a scenario. Provide each group with a different scenario from the list of bioethical dilemmas presented in Appendix 1.11: Bioethical Dilemmas—Scenarios (BLM). Review with students that role-playing fosters critical thinking skills while promoting tolerance of alternative views. For more information about role-playing scenarios, refer to *SYSTH* (p. 4.18).

Students play out the scene, discuss the bioethical issue, and make a decision as to the individual's next steps in the given situation. Rotate the roles within the groups. Then provide each group with a new scenario. Repeat so that each student in the group has played a different role at least once. Have each group meet with another group to compare their decisions and share any problem areas they encountered. For more information about decision making, refer to Appendix 1.12: Decision Making (Teacher Background).



***Suggestions for Assessment***

See Appendix 1.13: Collaborative Process—Assessment (BLM) for a peer assessment of the group process.

Observe students using a checklist such as the following:

- Presents evidence to support arguments.
- Uses appropriate language.
- Clarifies and summarizes his or her ideas.
- Gives reasons for not agreeing with opposing points of view.
- Listens actively.

Students complete a self-assessment of their listening skills. Refer to Appendix 1.14: Self-Assessment of Listening Skills (BLM).

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**SKILLS AND ATTITUDES OUTCOMES**

- B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)  
*Examples: use concept maps, sort-and-predict frames, concept frames . . .*
- B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)  
*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*
- B12-0-P2:** Demonstrate a continuing, increasingly informed interest in biology and biology-related careers and issues. (GLO: B4)
- B12-0-P5:** Appreciate that developments in and use of technology can create ethical dilemmas that challenge personal and societal decision making. (GLOs: B1, B2)
- B12-0-D1:** Identify and explore a current issue. (GLOs: C4, C8)  
*Examples: clarify the issue, identify different viewpoints and/or stakeholders, research existing data/information . . .*
- B12-0-D2:** Evaluate implications of possible alternatives or positions related to an issue. (GLOs: B1, C4, C5, C6, C7)  
*Examples: positive and negative consequences of a decision, strengths and weaknesses of a position, ethical dilemmas . . .*
- B12-0-D3:** Recognize that decisions reflect values, and consider own and others' values when making a decision. (GLOs: C4, C5)
- B12-0-D4:** Recommend an alternative or identify a position, and provide justification for it. (GLO: C4)
- B12-0-D5:** Propose a course of action related to an issue. (GLOs: C4, C5, C8)
- B12-0-D6:** Evaluate the process used by self or others to arrive at a decision. (GLOs: C4, C5)
- B12-0-I1:** Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)  
Include: print and electronic sources, resource people, and different types of writing
- B12-0-I2:** Evaluate information to determine its usefulness for specific purposes. (GLOs: C2, C4, C5, C8)  
*Examples: scientific accuracy, reliability, currency, relevance, balance of perspectives, bias . . .*
- B12-0-I4:** Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)
- B12-0-G2:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)
- B12-0-G3:** Evaluate individual and group processes used. (GLOs: C2, C4, C7)
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**Genetic Testing—Case Study (U2, D2, D3, I2)**

Use case studies to have students examine issues related to genetic testing.

**Resource Link**

- National Center for Case Study Teaching in Science, University at Buffalo. Home Page. <<http://sciencecases.lib.buffalo.edu/cs/>>.

This website provides access to a variety of case studies, which teachers can modify or adapt for classroom use, subject to the specified usage guidelines. Teaching notes and answer keys for the case studies are available free of charge. To access the answer keys, users are required to register for a password.

**GENETIC  
TESTING**

**SPECIFIC LEARNING OUTCOME**

**B12-1-09:** Discuss ethical issues that may arise as a result of genetic testing for inherited conditions or disorders.  
(GLOs: A3, B1, B2, C4)



*Suggestion for Assessment*

Assessment will depend on the type of learning activity undertaken. Whatever the form of assessment used, students should be made aware of the criteria beforehand.

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**Letter to the Editor (P2, D1, I1, I2, I4)**

Students find and read two current articles on the topic of genetic testing. When they have completed the readings, ask them to express their own point of view in a letter to the editor. For assignment details, refer to Appendix 1.15: Letter to the Editor – Writing Assignment (BLM).



*Suggestion for Assessment*

Determine assessment criteria in collaboration with students. For more information on the collaborative process, refer to Appendix 5.7: Co-constructing Assessment Criteria with Students (Teacher Background). Assessment criteria could include

- accuracy of content
- effectiveness of communication
- use of research and references

Assess student performance in relation to the pre-established criteria and provide descriptive feedback on the quality of student work without assigning a grade. Indicate two or three next steps that students could take to improve their work, such as extending ideas, revising specific aspects of the work, or practising new skills (Gregory, Cameron, and Davies).

*Examples*

- Next step: Citation and documentation are a new skill we are practising. Check the MLA or APA format of your references.
- Next step: A strong ending to your letter is important. Leave your readers with the most important thought.

Give students the opportunity to revise and resubmit their work prior to assigning a grade for the assignment.

**SKILLS AND ATTITUDES OUTCOMES**

- B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)  
*Examples: use concept maps, sort-and-predict frames, concept frames . . .*
- B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)  
*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*
- B12-0-P2:** Demonstrate a continuing, increasingly informed interest in biology and biology-related careers and issues. (GLO: B4)
- B12-0-P5:** Appreciate that developments in and use of technology can create ethical dilemmas that challenge personal and societal decision making. (GLOs: B1, B2)
- B12-0-D1:** Identify and explore a current issue. (GLOs: C4, C8)  
*Examples: clarify the issue, identify different viewpoints and/or stakeholders, research existing data/information . . .*
- B12-0-D2:** Evaluate implications of possible alternatives or positions related to an issue. (GLOs: B1, C4, C5, C6, C7)  
*Examples: positive and negative consequences of a decision, strengths and weaknesses of a position, ethical dilemmas . . .*
- B12-0-D3:** Recognize that decisions reflect values, and consider own and others' values when making a decision. (GLOs: C4, C5)
- B12-0-D4:** Recommend an alternative or identify a position, and provide justification for it. (GLO: C4)
- B12-0-D5:** Propose a course of action related to an issue. (GLOs: C4, C5, C8)
- B12-0-D6:** Evaluate the process used by self or others to arrive at a decision. (GLOs: C4, C5)
- B12-0-I1:** Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)  
Include: print and electronic sources, resource people, and different types of writing
- B12-0-I2:** Evaluate information to determine its usefulness for specific purposes. (GLOs: C2, C4, C5, C8)  
*Examples: scientific accuracy, reliability, currency, relevance, balance of perspectives, bias . . .*
- B12-0-I4:** Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)
- B12-0-G2:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)
- B12-0-G3:** Evaluate individual and group processes used. (GLOs: C2, C4, C7)
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**NOTES**

**GENETIC  
VARIABILITY**

**SPECIFIC LEARNING OUTCOME**

**B12-1-10:** Discuss the role of meiosis and sexual reproduction in producing genetic variability in offspring. (GLOs: D1, E3)  
Include: crossing over and randomness

**SLO: B12-1-10**

**SUGGESTIONS FOR INSTRUCTION**

**ENTRY-LEVEL KNOWLEDGE**

In Grade 9 Science, students were introduced to meiosis and sexual reproduction and became familiar with the terms *gamete*, *zygote*, *haploid*, and *diploid*. The emphasis in Grade 9 was placed on the importance of meiosis to maintaining chromosome number in sexual reproduction.

**TEACHER NOTE**

This learning outcome focuses on how genetic variability results in offspring due to meiosis and sexual reproduction. It is important that students gain a clear understanding of the consequences of meiosis. Students are not expected to memorize the names and events of the stages of meiosis.

**BACKGROUND INFORMATION**

Based only on the random separation of homologous chromosomes during meiosis, a person with 23 pairs of homologous chromosomes can theoretically produce about 8 million ( $2^{23}$ ) different haploid gametes. Add in crossing over, and the chance of any two gametes being the same is highly unlikely. When two haploid gametes unite, the newly formed zygote contains a full set of chromosomes (i.e., the diploid number of chromosomes). Thus, meiosis allows sexual reproduction to take place.

**ACTIVATE**

**Think-Pair-Share**

Pose the following to students:

Humans have speculated about reproduction and inheritance for thousands of years. However, they were not completely ignorant about reproduction. People have observed that in order for animals to reproduce, both a male and a female parent are required, and that the offspring usually resemble, but are not identical to, either parent.

Scientists and philosophers have proposed many explanations (some fanciful) over time. Imagine that you are an observer of nature living 500 years ago. Propose a hypothesis to explain how organisms pass their traits on to their offspring. Your hypothesis should explain the observations noted above.



**SKILLS AND ATTITUDES OUTCOMES**

**B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)

*Examples: use concept maps, sort-and-predict frames, concept frames . . .*

**B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)

*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*

**B12-0-G2:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)

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Give students time to think of a hypothesis individually. Students then pair up with a partner to discuss their ideas and record their hypotheses in their notebooks.

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**ACQUIRE/APPLY**

**Why Is Meiosis Necessary?—Class Discussion (U1, G2)**

Engage the class in determining chromosome number for several generations of the human life cycle if sex cells were produced by mitosis (e.g.,  $46 \rightarrow 92 \rightarrow 184 . . .$ ). Introduce the concept of the need for a reduction division to halve the chromosome set in each gamete (without going into the details of segregation of homologous chromosomes) in order to maintain a constant number of chromosomes from one generation to the next. This will lead to a discussion of the process of meiosis.

**Visualizing Meiosis (U1)**

Use diagrams, videos, models, or computer animations to illustrate and describe the process of meiosis. Emphasize the role meiosis plays in producing genetic variability through the random shuffling of homologous chromosomes and crossing over, rather than focusing on the details of the phases of meiosis. The use of a note-taking strategy such as a Note Frame can help students follow a lecture and organize information. For more information, see *SYSTH* (p. 11.32).



***Suggestion for Assessment***

An Exit Slip provides a quick formative assessment of what students viewed as important during a particular lesson. The process for using an Exit Slip is to pose a question at the end of the lesson and give students five minutes to respond. For more information on Exit Slips, see *SYSTH* (p. 13.9).

**GENETIC  
VARIABILITY**

**SPECIFIC LEARNING OUTCOME**

**B12-1-10:** Discuss the role of meiosis and sexual reproduction in producing genetic variability in offspring. (GLOs: D1, E3)  
Include: crossing over and randomness

---

Questions could include the following:

- Describe what you felt was the most important point made during this lesson.
- What did you learn during this lesson?
- What questions do you still have about this lesson?

For information on Exit Slips, refer to *SYSTH* (p. 13.9).

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**Understanding Meiosis—Chain Concept Map (U2)**

Students create a Chain Concept Map (flow chart) of meiosis by linking the following terms:

- crossing over
- diploid
- haploid
- homologous chromosomes
- random shuffling of chromosomes
- reduction division
- tetrad

The concept map should include a brief description of what is happening at each step in the map. Sketches can be used to accompany the descriptions. For more information on Chain Concept Maps, refer to *SYSTH* (pp. 11.14–11.15).



***Suggestion for Assessment***

Assess students' Chain Concept Maps for conceptual understanding, and provide descriptive feedback on how the concept maps could be improved.

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**SKILLS AND ATTITUDES OUTCOMES**

**B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)

*Examples: use concept maps, sort-and-predict frames, concept frames . . .*

**B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)

*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*

**B12-0-G2:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)

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**Meiosis and Variation—Demonstrating Understanding (U1)**

Pose the following question to students at the end of the lesson:

- How does meiosis lead to variation in a species?

Give students five minutes to respond in their notebooks.



***Suggestion for Assessment***

This learning activity provides a quick formative assessment of what students learned in a particular lesson. In their responses, students should explain that the reassortment of the chromosomes and random crossing over contribute to the large number of possible gametes formed in meiosis. This leads to differences among individual organisms, which results in variation within a species.

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## CHROMOSOME MUTATIONS

### SPECIFIC LEARNING OUTCOMES

**B12-1-11:** Explain how chromosome mutations may arise during meiosis. (GLOs: D1, E3)

Include: nondisjunction

**B12-1-12:** Identify monosomy and trisomy chromosome mutations from karyotypes. (GLO: D1)

Examples: Down syndrome, Turner syndrome, Klinefelter syndrome . . .

SLO: B12-1-11  
SLO: B12-1-12

### SUGGESTIONS FOR INSTRUCTION

#### ENTRY-LEVEL KNOWLEDGE

Students have not studied chromosome mutation in previous science courses; however, students may know individuals with Down syndrome.

#### TEACHER NOTE

Be sensitive to the fact that students in your class may have a chromosome mutation, or may have a family member, neighbour, or friend with a condition.

#### BACKGROUND INFORMATION

*Nondisjunction* is the failure of chromosomes to separate correctly during meiosis. Several common syndromes are caused by nondisjunction, including the following:

- **Down syndrome:** present in about 1 in 800 children born in Canada. All persons with Down syndrome have extra genetic material associated with the 21st chromosome (trisomy 21).
- **Turner syndrome:** present in about 1 in every 2500 girls born in Canada. All girls with Turner syndrome are missing or have a damaged X chromosome (XO).
- **Klinefelter syndrome:** present in about 1 in every 1000 boys born in Canada. All boys with Klinefelter syndrome carry an extra X chromosome (XXY).

#### ACTIVATE

##### Opening Questions

Pose the following questions to students:

- The development of a complex multicellular organism from a single fertilized egg cell is one of the current areas of biological research. Genes carefully regulate the development of each individual organism. What do you think might happen if an organism had an extra regulatory gene or was missing one? What do you think might happen if an organism had an extra chromosome or was missing a chromosome?

Have students respond in their notebooks.

**SKILLS AND ATTITUDES OUTCOMES**

- B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)  
*Examples: use concept maps, sort-and-predict frames, concept frames . . .*
- B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)  
*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*
- B12-0-P2:** Demonstrate a continuing, increasingly informed interest in biology and biology-related careers and issues. (GLO: B4)
- B12-0-S3:** Record, organize, and display data and observations using an appropriate format. (GLOs: C2, C5)
- B12-0-S5:** Analyze data and/or observations in order to explain the results of an investigation, and identify implications of these findings. (GLOs: C2, C4, C5, C8)
- B12-0-I1:** Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)  
Include: print and electronic sources, resource people, and different types of writing
- B12-0-I4:** Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)
- B12-0-G3:** Evaluate individual and group processes used. (GLOs: C2, C4, C7)
- 

**ACQUIRE/APPLY**

**Visualizing Nondisjunction (U1)**

Use models or diagrams to illustrate nondisjunction during meiosis. Flow charts can be used to show how nondisjunction affects the gametes produced by meiosis, and the chromosome monosomies or trisomies that arise after gametes fuse.



***Suggestion for Assessment***

Students respond to the opening questions again in their notebooks and reflect on how and why their answers to the questions changed. The responses can be used as a formative assessment to determine students' levels of understanding of nondisjunction and to guide further teaching and selection of learning activities (if needed).

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**CHROMOSOME  
MUTATIONS**

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**SPECIFIC LEARNING OUTCOMES**

**B12-1-11:** Explain how chromosome mutations may arise during meiosis. (GLOs: D1, E3)

Include: nondisjunction

**B12-1-12:** Identify monosomy and trisomy chromosome mutations from karyotypes. (GLO: D1)

*Examples: Down syndrome, Turner syndrome, Klinefelter syndrome . . .*

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**Concept Frame (U2)**

Graphic organizers assist students in clarifying their thinking, and thereby enhance student learning. Have students complete a Concept Frame for nondisjunction. See Appendix 1.16: Concept Frame (BLM). For more information about using concept organizer frames, refer to *SYSTH* (pp. 11.22-11.25).



***Suggestion for Assessment***

Assess students' completed Concept Frames for conceptual understanding, and provide descriptive feedback on how they could be improved.

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**Chromosome-Related Syndrome—Guest Speaker (P2, I1)**

Invite a local representative from a society or an organization to speak to the class about a chromosome-related syndrome and the role of the organization. Questions for the speakers should be prepared by students in advance.



***Suggestion for Assessment***

Following the presentation, students reflect on questions such as the following:

- What surprised you?
  - What did you find interesting?
  - What do you question?
-

**SKILLS AND ATTITUDES OUTCOMES**

- B12-0-U1:** Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)  
*Examples: use concept maps, sort-and-predict frames, concept frames . . .*
- B12-0-U2:** Demonstrate an in-depth understanding of biological concepts. (GLO: D1)  
*Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, develop creative presentations . . .*
- B12-0-P2:** Demonstrate a continuing, increasingly informed interest in biology and biology-related careers and issues. (GLO: B4)
- B12-0-S3:** Record, organize, and display data and observations using an appropriate format. (GLOs: C2, C5)
- B12-0-S5:** Analyze data and/or observations in order to explain the results of an investigation, and identify implications of these findings. (GLOs: C2, C4, C5, C8)
- B12-0-I1:** Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)  
 Include: print and electronic sources, resource people, and different types of writing
- B12-0-I4:** Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)
- B12-0-G3:** Evaluate individual and group processes used. (GLOs: C2, C4, C7)
- 

**Karyotyping—Investigation (S3, S5, I4, G3)**

Human karyotyping activities are relatively simple to perform. They involve the identification of the sex of an individual and a syndrome (if any) based on a photograph of a chromosome smear.

**Resource Link**

- Genetic Science Learning Center. *Learn.Genetics*.  
 <<http://learn.genetics.utah.edu/>>.

Students can create a karyotype and use a karyotype to predict genetic disorders using interactive animations in the *Heredity and Traits* section of this website.



***Suggestions for Assessment***

Specify in advance the criteria for assessment of the karyotyping investigation. Refer to Appendix 5.7: Co-constructing Assessment Criteria with Students (Teacher Background) for more information on the collaborative process. Lab skills and group work skills can be assessed using a checklist. Refer to Appendix 1.3: Student Lab Skills (Teacher Background), Appendix 1.4A: Lab Skills Checklist—General Skills (BLM), Appendix 1.4B: Lab Skills Checklist—Thinking Skills (BLM), and Appendix 1.13: Collaborative Process—Assessment (BLM).

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NOTES



**UNIT 1:**

**UNDERSTANDING BIOLOGICAL INHERITANCE**

**APPENDICES**

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# Appendix 1.1:

## The Story of Gregor Mendel (BLM)

(1 of 1)

The story of Gregor Mendel and his work provides a fascinating glimpse into the nature of science. Mendel was born in 1822 and, as a young man, attended the University of Vienna. There he studied chemistry, biology, and physics, but left before graduating, probably for health reasons. He entered the Augustinian monastery in Brno, and with the support of the abbot, began his investigation of the inheritance of certain traits in pea plants (*Pisum sativum*). His choice of pea plants as the experimental subject was excellent, as peas grow and reproduce quickly, their mating can be controlled, and the plants have a number of distinct traits that are readily observed.

Over the course of eight years, Mendel conducted experiments and maintained detailed records of his results. His university training led him to design simple experiments that permitted him to observe the inheritance of one trait at a time. His use of mathematics allowed him to formulate conclusions based on his results. These conclusions are known as Mendel's laws or principles of inheritance.

### Mendel's Laws or Principles of Inheritance

- **The Principle of Genes in Pairs:** Genetic characters are controlled by unit factors (genes) that exist in pairs in individual organisms and are passed from parents to their offspring. When two organisms produce offspring, each parent gives the offspring one of the factors from each pair.
- **The Principle of Dominance and Recessiveness:** When two unlike factors responsible for a single character are present in a single individual, one factor can mask the expression of another factor; that is, one factor is dominant to the other, which is said to be recessive.
- **The Principle of Segregation:** During the formation of gametes, the paired factors separate (segregate) randomly so that each gamete receives one factor or the other.
- **The Principle of Independent Assortment:** During gamete formation, segregating pairs of factors assort independently of each other.

In 1865, Mendel presented his findings in a paper entitled "Experiments in Plant Hybridization" at a meeting of the Association for Natural Research in Brno. The paper was published in the *Proceedings of the Brno Society of Natural Science* in 1866. Mendel's work was groundbreaking, not only for his discoveries in genetics, but also for his use of mathematical and statistical analysis as a means of interpreting his results.

The scientific community of the time did not seem to grasp the significance of Mendel's work. As a result, it was largely ignored. Mendel abandoned his research upon his election as abbot in 1868, due in part to his heavy workload, as well as to the lack of recognition for his research. Gregor Mendel died in 1884, never knowing whether the world would acknowledge the importance of his work. In 1900, three scientists working independently rediscovered and confirmed Mendel's laws or principles of inheritance. Hugo de Vries, Carl Correns, and Erich von Tschermak-Seysenegg gave credit to Gregor Mendel in the publications of their papers, thereby giving him the recognition he had long deserved.

# Appendix 1.2: Mendel's Publication—Creative Writing Assignment (BLM)

(1 of 1)

You are to assume the role of Gregor Mendel, having just formulated your conclusions about the inheritance of traits. You are very excited about your findings and want to inform others of your findings. You will write a 500-word article for publication in a science journal, describing your experimental results and conclusions. Keep in mind that it is the year 1866, and your audience consists of scientists who subscribe to the *Proceedings of the Brno Society of Natural Science*.

Here are some tips to help you get started:

- Remember that Mendel knew nothing of genes and chromosomes, and that we use different words today in our discussions of genetics.

| <b>Mendel's Terminology (1866)</b>  | <b>Current Terminology</b> |
|-------------------------------------|----------------------------|
| unit factor                         | gene                       |
| purebred/true breeding              | homozygous                 |
| hybrid                              | heterozygous               |
| two factors that control each trait | allele                     |

- Start your article by introducing the problem. Then describe your experimental design and the results you obtained. Finish by outlining your conclusions.
- Make your points clearly and concisely.
- Include a reference page citing the sources you used.

## Appendix 1.3: Student Lab Skills (Teacher Background)

(1 of 3)

Student lab skills consist of two parts: their actions in the lab and the report that they produce. All too often, teachers have put more energy into evaluating the latter than assessing student thinking and actions during the lab. Do students understand why they are conducting the lab? Are they getting the results they expected? Do they trust their lab technique when they see others getting different results?

Consider the following suggestions when designing your assessment approach for student lab work.

### **Pre-lab**

During the pre-lab talk, teachers traditionally outline the purpose of the lab, the procedure to be followed, methods of data collection, and safety considerations. They also pose questions to the group to check comprehension. Do students know what they are to do and why that approach is being used? Addressing the whole group continues to be the most appropriate approach for an introduction.

### **During the Lab**

At this point, you may have an opportunity to do individual student assessment. General lab skills, such as recording observations or using equipment properly, could be marked on a checklist. You could also interview students between procedures to check the depth of their understanding. This could be done by posing a series of questions to the individual:

- How does this lab relate to what you have studied in class?
- What was the rationale behind your hypothesis?
- Are you getting the results you expected?
- Have you had any difficulties with the procedure?

This type of assessment may seem very time-consuming, but can be facilitated by using checklists and choosing to meet with a limited number of students during each lab. By using the same checklist for each student throughout the course, you could make ongoing improvements.

## Appendix 1.3: Student Lab Skills (Teacher Background) *(continued)*

(2 of 3)

### Post-lab

You would conduct your traditional post-lab activity. Most of the analysis would be discussed by the larger group before students did their individual write-ups. You would lead the group to an understanding of the big picture and support this with details from the group experience. After this, you might consider posing questions to certain students to check their comprehension:

- What can you conclude from your results? Give me a specific piece of evidence to support this.
- What sources of error occurred in your case?
- What would you do differently next time?

Although these questions may be written in the lab report, taking the time to discuss them with individuals allows you to probe and draw out more understanding. Again, perhaps only certain students would be questioned on a rotational basis.

### Redoing the Lab

Students are often asked to identify possible sources of error. Rarely are they given the opportunity to tighten up their control variables and repeat the lab. Perhaps they want to change their approach to solving the initial problem completely and re-test. Consider the possibility of having students do one less new lab during the course and redo a lab that they have already tried. Students need to test their analytical skills by doing more than one trial. Don't we always tell them that a bigger sample size is more accurate?

### A Variety of Products

Students can summarize their experiences in a lab report. You might also consider using lab frames or lab notebooks. Lab frames allow the teacher to draw out very specific responses. Lab notebooks allow students to record their work as they conduct the lab, which reflects more of the process than the product. Analyzing, answering questions, and drawing conclusions can be done after the post-lab.

**Appendix 1.3:**  
**Student Lab Skills (Teacher Background) (continued)**

(3 of 3)

The following table provides a general suggestion for a lab report. Numerous alternative formats could also be used. Refer to *Senior Years Science Teachers' Handbook (SYSTH)* (pp. 11.26–11.29 and 14.11–14.12) or other resources for more ideas.

| <b>Lab Report Format (Sample)</b> |   |
|-----------------------------------|---|
| <b>Introduction</b>               | <ul style="list-style-type: none"><li>• purpose or question</li><li>• hypothesis or prediction – may be supported by a rationale (What do students think will be found, and why?)</li></ul>   |
| <b>Methodology</b>                | <ul style="list-style-type: none"><li>• materials</li><li>• methods/procedures</li></ul> <p>Note: In many labs, this information will be provided. In student-designed labs, the methodology increases in importance and is developed by the student.</p>   |
| <b>Results</b>                    | <ul style="list-style-type: none"><li>• general observations – may include<ul style="list-style-type: none"><li>– data tables</li><li>– graphs and calculations</li></ul></li></ul>   |
| <b>Analysis</b>                   | <p>Include any of the following items that are appropriate to the lab:</p> <ul style="list-style-type: none"><li>• interpretation/discussion of results</li><li>• indication of whether hypothesis was supported</li><li>• implications of results</li><li>• linking of results to prior knowledge</li><li>• answers to questions</li><li>• error analysis/sources of error</li><li>• summary</li></ul> |

# Appendix 1.4A: Lab Skills Checklist—General Skills (BLM)

(1 of 1)

Name \_\_\_\_\_

| General Skills  | Expectations  | Meeting Expectations | Not Yet Meeting Expectations |
|---|---|----------------------|------------------------------|
| The student   |   |                      |                              |
| is prepared to conduct the lab  | reads lab outline before doing the lab, creates tables, and asks questions that clarify the task instead of asking, "What do I do next?"                                      |                      |                              |
| sets up and uses equipment properly                                       | chooses the correct equipment, sets up properly (e.g., ring height on ring stand), and uses equipment properly (e.g., lighting a Bunsen burner or anaesthetizing fruit flies) |                      |                              |
| follows safety procedures   | demonstrates general safety procedures as well as specifics outlined in pre-lab   |                      |                              |
| records observations  | records own observations as the action is occurring, uses quantitative and qualitative approaches as directed, records in an organized fashion (e.g., uses a table or key)    |                      |                              |
| works independently (individual labs) or works cooperatively (group labs) | knows task and gets right to work or shares tasks and observations, is a good listener, and is receptive to the other students' points of view                                |                      |                              |
| manages time efficiently  | divides and orders tasks to meet deadlines  |                      |                              |
| cleans up adequately  | leaves table and sink clean, puts away all equipment, washes tabletop, and washes hands   |                      |                              |



# Appendix 1.4B: Lab Skills Checklist—Thinking Skills (BLM)

(1 of 1)

Name \_\_\_\_\_

| Thinking Skills                     | Questions  | Understanding of Lab |         |         |
|-------------------------------------|--|----------------------|---------|---------|
|                                     |  | Specific             | General | Limited |
| <b>Knowledge/<br/>Comprehension</b> | <ul style="list-style-type: none"> <li>• What is the purpose of doing this lab?</li> <li>• How does this relate to what you are studying in class?</li> <li>• What is the rationale for your hypothesis?</li> <li>• Why do you need special safety considerations for this lab?</li> <li>• What chemical disposal guidelines have you been given?</li> </ul>   |                      |         |         |
| <b>Application/<br/>Analysis</b>    | <ul style="list-style-type: none"> <li>• How did you decide on this procedure?</li> <li>• Are you having any difficulties with this procedure?</li> <li>• Are you getting the results that you expected?</li> <li>• How would you set up a graph, diagram, or flow chart to depict these results?</li> <li>• Do you see a pattern in your data?</li> <li>• Do any data points not follow the pattern?</li> </ul> |                      |         |         |
| <b>Synthesis/<br/>Evaluation</b>    | <ul style="list-style-type: none"> <li>• What can you conclude from your results?</li> <li>• What evidence do you have to support your conclusion? Specify.</li> <li>• What sources of error occurred in this trial?</li> <li>• What would you do differently in a second trial? What would you do the same?</li> <li>• How do your two trial results compare?</li> </ul>  |                      |         |         |

# Appendix 1.5: Scientific Inquiry (BLM)

(1 of 3)

## Introduction

Science plays an important role in daily life. Whether you investigate how changing the angles of a skateboard ramp affect the height of your jump or which type of skin cream you should buy to clear up acne, science is important to you. Learning more about how science works will enable you to use it more effectively.

People have always tried to understand the world around them. To answer the questions people may have, scientists conduct experiments or investigations that involve imagination, creativity, and perseverance. Scientists do not follow a fixed, step-by-step approach when they are investigating a question. The type of question asked will often determine the approach taken to answer it. Some investigations are mainly observational in nature, while others are more experimental. The following aspects of scientific inquiry can help you construct your own experimental investigation.

## Asking a Question

A good *testable question* will often take the following form: How does \_\_\_ affect \_\_\_? It will focus your testing to only one factor (e.g., How does the amount of sunlight affect the growth of plants? instead of What affects the growth of plants?). It will allow you to make predictions, create a plan, conduct a fair test, and make meaningful observations and conclusions.

Consider another example of a testable question: How does the application of heat affect the viscosity of a fluid? This question includes the cause (the application of heat) and the effect (viscosity of a fluid). These two portions of the testable question are called *variables*. Variables are factors that can affect an event or a process. The *independent variable* is the one variable you choose to change. The *dependant variable* changes as a result of or in response to the change in the independent variable.

## Making a Hypothesis

A *hypothesis* is a suggested answer of how one variable affects the other. The hypothesis should describe the relationship between the independent and dependent variables. Often it follows an *if-then* pattern:

*If the amount of heat added increases, then the viscosity will decrease.*



independent variable



dependent variable

## **Designing the Experiment**

### **Ensuring a Fair Test**

To conduct a fair test, you must ensure that other factors that could affect the outcome of the experiment are controlled or kept the same. The variables that are not changed are called *controlled variables*. For example, in an experiment to see which sponge absorbs the most liquid, the size of the sponge used is a variable you would want to control. Samples of each of the different types of sponges to be tested could be cut to the same size. The amount of liquid each sponge absorbs could be compared fairly, with the results attributed to the type of sponge and not the size of the sponge.

### **Creating a Plan**

The next step is to create a plan to test the hypothesis. First, you must determine what materials are needed to conduct the test. Then you create a plan or method. The method should be recorded. To continue the concept of a fair test, the test should be done several times. This is intended to ensure that results do not happen by chance, but are accurate and dependable.

## **Conducting the Experiment**

During the experiment, it is important to follow your plan, to take accurate measurements, and to make careful observations. Your own safety and that of others should always be on your mind. To increase the accuracy and reliability of the experiment, measurements should be repeated.

## **Observing and Recording Data**

Observations can be recorded in any of the following ways:

- written in sentences
- point-form notes
- graphs
- diagrams
- charts
- lists
- spreadsheets

### Organizing and Analyzing Results

Your conclusion should explain the relationship between the independent variable and the dependent variable. Here is an example of a conclusion on an experiment that involved sunlight and plant growth.

*In our experiment, all variables, other than the amount of sunlight, were kept constant. The geranium plants that received additional sunlight grew more than the plants that were given only limited amounts of sunlight. In the 32 days that we ran the experiment, the plants that received an additional 10 hours of sunlight a day grew an average of 3 cm, while the plants that received only limited sunlight grew an average of 1 cm. Our results support our hypothesis.*

In addition to revisiting the hypothesis, the conclusion should include the sources of error in the experiment. These would be factors that may impede the accuracy of the data. In the reflections on the process component of the conclusion, you may want to suggest ways to improve the experiment.

**Implications and applications for daily use:** Include an additional component to the conclusion that deals with how the experiment or concept applies to everyday living.

# Appendix 1.6A: Feedback Form for Designing an Experiment (Plan) (BLM)

(1 of 1)

Name \_\_\_\_\_

Proposed Experiment Title \_\_\_\_\_

| Criteria  | Yes/No | Comments |
|---|--------|----------|
| The experimental design tests the hypothesis.                                 |        |          |
| The statement of the problem justifies the need for the experiment.           |        |          |
| The procedures are complete, clear, and described sequentially.               |        |          |
| An independent variable is clearly identified.                                |        |          |
| The plan controls and measures the independent variable accurately.           |        |          |
| A dependent variable is clearly identified.                                   |        |          |
| The design ensures the dependent variable is measured accurately.             |        |          |
| A complete list of required materials is provided.                            |        |          |
| The experiment includes proper controls.                                      |        |          |
| An appropriate strategy to use repeated trials and measurements is described. |        |          |
| The experimental design includes appropriate safety concerns.                 |        |          |
| Instructions are provided for proper cleanup and disposal of wastes.          |        |          |

# Appendix 1.6B: Rating Scale for Experimental Design and Report (BLM)

(1 of 1)

Name \_\_\_\_\_

Experiment Title \_\_\_\_\_

|                                   |
|-----------------------------------|
| Level 1: Not Meeting Expectations |
| Level 2: Approaching Expectations |
| Level 3: Meeting Expectations     |
| Level 4: Exceeding Expectations   |

| Criteria  | Level |   |   |   |
|---|-------|---|---|---|
|   | 4     | 3 | 2 | 1 |
| The experimental design tests the hypothesis.   |       |   |   |   |
| The statement of the problem justifies the need for the experiment.                     |       |   |   |   |
| The procedures are complete, clear, and described sequentially.                         |       |   |   |   |
| The plan controls and measures the independent variable accurately.                     |       |   |   |   |
| The design ensures the dependent variable is measured accurately.                       |       |   |   |   |
| A complete list of required materials is provided.                                      |       |   |   |   |
| The experiment includes proper controls.  |       |   |   |   |
| A margin of error is noted, and a thoughtful discussion for reducing error is included. |       |   |   |   |
| An appropriate strategy to use repeated trials and measurements is described.           |       |   |   |   |
| The experimental design includes appropriate safety concerns.                           |       |   |   |   |
| The report is neat, presentable, and well-organized.                                    |       |   |   |   |
| Appropriate vocabulary, mechanics, and complete sentences are used.                     |       |   |   |   |

## Appendix 1.7A: Genetics Problems 1 (BLM)

(1 of 1)

1. In humans, long eyelashes are dominant; short eyelashes are recessive. A woman with long eyelashes and a man with long eyelashes have four children. One child has short eyelashes; the others have long eyelashes.
  - a) List the probable genotypes of the parents.
  - b) List the probable genotypes of the children.
2. Peas may have yellow or green seeds. A cross between a green seed plant and a yellow seed plant (P generation) produced all yellow seeds in the F<sub>1</sub> generation.
  - a) Identify the genotypes of the P generation.
  - b) What would the phenotype ratio of yellow seeds to green seeds be if one plant from the F<sub>1</sub> was crossed with the yellow seed plant from the P generation?
3. In cattle, polled (hornless) is dominant to horned. If a breeder of purebred cattle, all of which are polled, suspects that her recently purchased prize bull is heterozygous for the horned allele, how might she determine whether her suspicion is correct?
4. Cystic fibrosis is a recessive genetic disorder affecting 1 in every 2500 children born in Canada. A child with the disorder is born to a couple who show no symptoms of the disease.
  - a) List the genotypes of the parents and the child.
  - b) What is the chance that the next child the couple has will be a carrier of the disease?
5. In rabbits, black colour is due to a dominant gene (*B*), and brown colour to a recessive gene (*b*). Short hair is due to the dominant gene (*S*), and long hair to its recessive allele (*s*). A homozygous black, long-haired rabbit and a homozygous brown, short-haired rabbit are crossed.
  - a) What would be the genotype of the F<sub>1</sub> generation?
  - b) What would be the phenotype of the F<sub>1</sub> generation?
  - c) If one of the F<sub>1</sub> rabbits was mated with a brown, long-haired rabbit, predict the phenotype and genotype ratios of the offspring.

## Appendix 1.7B: Genetics Problems 1 (Answer Key)

(1 of 3)

1. a) As both parents have long eyelashes, they must both carry the dominant gene ( $L$ ). However, in order to have a child with short eyelashes (genotype  $ll$ ), both parents must also carry the recessive gene and, therefore, both have the genotype  $Ll$ .
- b) The probable genotypes of the children are listed below, using a Punnett square.

$$Ll \times Ll$$

|     |      |      |
|-----|------|------|
|     | $L$  | $l$  |
| $L$ | $LL$ | $Ll$ |
| $l$ | $Ll$ | $ll$ |

Based on probabilities, the genotype of one child is  $LL$  (long eyelashes), two children are  $Ll$  (long eyelashes), and one child is  $ll$  (short eyelashes).

2. a) As the green seed colour seems to disappear in the  $F_1$  generation, it is the recessive trait, while the yellow seed colour is the dominant trait. The genotype of the parent green seed plant will, therefore, be  $yy$ . The parent yellow seed must contain at least one dominant  $Y$  gene. Two possible yellow seed parental genotypes are possible,  $YY$  or  $Yy$ .

$$YY \times yy$$

|     |      |      |
|-----|------|------|
|     | $y$  | $y$  |
| $Y$ | $Yy$ | $Yy$ |
| $Y$ | $Yy$ | $Yy$ |

All  $F_1$  seeds would be yellow.

OR

$$Yy \times yy$$

|     |      |      |
|-----|------|------|
|     | $y$  | $y$  |
| $Y$ | $Yy$ | $Yy$ |
| $y$ | $yy$ | $yy$ |

Half the  $F_1$  seeds would be yellow and half would be green.

Therefore, the genotype of the parent yellow seed plant is  $YY$ .



**Appendix 1.7B:****Genetics Problems 1 (Answer Key) (continued)**

(2 of 3)

- b) Based on the answer in part (a), the genotype of the F<sub>1</sub> generation is  $Yy$ . The parent yellow plant is  $YY$ .

$$YY \times Yy$$

|     |      |      |
|-----|------|------|
|     | $Y$  | $y$  |
| $Y$ | $YY$ | $Yy$ |
| $Y$ | $YY$ | $Yy$ |

A cross between these plants would result in all yellow seeds.

3. Let purebred polled cattle (hornless) be  $PP$ . Horned cattle are, therefore,  $pp$ . The breeder can use a series of test crosses to determine the genotype of the prize bull by mating the bull with horned cows.

If the bull truly is purebred polled ( $PP$ ), all the offspring should be polled.

$$PP \times pp$$

|     |      |      |
|-----|------|------|
|     | $p$  | $p$  |
| $P$ | $Pp$ | $Pp$ |
| $P$ | $Pp$ | $Pp$ |

All calves are polled.

If the bull is heterozygous ( $Pp$ ), some of the offspring should have horns.

$$Pp \times pp$$

|     |      |      |
|-----|------|------|
|     | $p$  | $p$  |
| $P$ | $Pp$ | $Pp$ |
| $p$ | $pp$ | $pp$ |

Half the offspring have horns ( $Pp$ ), and half are polled or hornless ( $pp$ ).

## Appendix 1.7B:

### Genetics Problems 1 (Answer Key) (continued)

(3 of 3)

4. a) Both normal parents must carry the recessive gene (*c*) for cystic fibrosis. Their genotype is, therefore, *Cc*. The child with the disease will have the genotype *cc*.

$$Cc \times Cc$$

|          |           |           |
|----------|-----------|-----------|
|          | <i>C</i>  | <i>c</i>  |
| <i>C</i> | <i>CC</i> | <i>Cc</i> |
| <i>c</i> | <i>Cc</i> | <i>cc</i> |

- b) A carrier of a disease shows no symptoms, but carries the recessive allele. Based on the above Punnett square, there is a 1 in 2 (50%) chance that the next child will be a carrier of cystic fibrosis.
5. a) Homozygous black long-haired rabbit = *BBss*.  
Homozygous brown short-haired rabbit = *bbSS*.

$$BBss \times bbSS$$

|           |             |             |
|-----------|-------------|-------------|
|           | <i>bS</i>   | <i>bS</i>   |
| <i>Bs</i> | <i>BbSs</i> | <i>BbSs</i> |
| <i>Bs</i> | <i>BbSs</i> | <i>BbSs</i> |

The genotype of the  $F_1$  generation is all *BbSs*.

- b) The phenotype of the  $F_1$  generation is all black short-haired.
- c)  $F_1 = BbSs$  (black short-haired)  $\times$  *bbss* (brown long-haired)

$$BbSs \times bbss$$

|           |             |
|-----------|-------------|
|           | <i>bs</i>   |
| <i>BS</i> | <i>BbSs</i> |
| <i>Bs</i> | <i>Bbss</i> |
| <i>bS</i> | <i>bbSs</i> |
| <i>bs</i> | <i>bbss</i> |

Genotype ratio: 1 *BbSs*: 1 *Bbss*: 1 *bbSs*: 1 *bbss*

Phenotype ratio: 1 black short-haired: 1 black long-haired: 1 brown short-haired:  
1 brown long-haired

## Appendix 1.8A: Genetics Problems 2 (BLM)

(1 of 1)

1. A man whose blood group is A and a woman whose blood group is B have a child whose blood group is O.
  - a) What are the genotypes of the three individuals?
  - b) What is the probability of the couple's next child having blood group AB?
2. In radish plants, the shape of the radish produced may be long, round, or oval. Crosses among plants that produced oval radishes yielded 121 plants that produced long radishes, 243 plants that produced oval radishes, and 119 plants that produced round radishes.
  - a) What type of inheritance appears to be involved? Explain your logic.
  - b) What results would you expect from a cross between two long radishes?
  - c) What results would you expect from a cross between two round radishes?
3. In crosses between two crested ducks, only about three-quarters of the eggs hatch. The embryos in the remaining one-quarter of the eggs develop nearly to hatching, and then die. Of the ducks that do hatch, about two-thirds are crested and one-third have no crest.
  - a) What type of inheritance pattern appears to be involved? Explain.
  - b) If a crested and non-crested duck are crossed, what phenotypic ratio would you expect in the ducklings? What genotypic ratio would you expect?
4. In certain cattle, the hair colour can be red (homozygous RR), white (homozygous WW), or roan, a mix of red and white hair (heterozygous RW).
  - a) When a red bull is mated with a white cow, what genotypes and phenotypes of offspring could result?
  - b) If one of these offspring is mated to a white cow, what genotypes and phenotypes of offspring could be produced? In what proportion?
5. How do we account for the variations of skin colour in humans?

## Appendix 1.8B: Genetics Problems 2 (Answer Key)

(1 of 2)

1. a) Because the child's phenotype is type O, the genotype must be  $ii$  (recessive). Therefore, the father (type A) and mother (type B) must both carry the recessive allele. The father's genotype is  $I^A i$  and the mother's genotype is  $I^B i$ .
- b) The probability of the couple's next child having blood group AB is show below, using a Punnett square:

$$I^A i \times I^B i$$

|       |           |         |
|-------|-----------|---------|
|       | $I^B$     | $i$     |
| $I^A$ | $I^A I^B$ | $I^A i$ |
| $i$   | $I^B i$   | $ii$    |

The chance of the couple having an AB ( $I^A I^B$ ) child is 25% or 1 in 4.

2. a) The offspring occur in three types, classified as long, round, and oval (intermediate). This suggests incomplete dominance, with the allele for long ( $L$ ) combining with round ( $l$ ) to produce oval heterozygotes ( $Ll$ ). This hypothesis can be tested by examining the offspring ratio. A cross of  $LL^l \times LL^l$  will result in a ratio of 1 long to 2 oval to 1 round radishes.
- b) When two long radishes are crossed ( $LL \times LL$ ), all the offspring will be long.
- c) When two round radishes are crossed ( $ll \times ll$ ), all the offspring will be round.
3. a) As one-quarter of the eggs do not hatch, this suggests the presence of a lethal gene. Crested is the dominant gene ( $C$ ) and non-crested is recessive ( $c$ ), both the parent ducks would have the  $Cc$  genotype.

The type of inheritance pattern that appears to be involved is shown below.

$$Cc \times Cc$$

|     |      |      |
|-----|------|------|
|     | $C$  | $c$  |
| $C$ | $CC$ | $Cc$ |
| $c$ | $Cc$ | $cc$ |

Not all the eggs carrying embryos with the  $CC$  genotype would hatch. Viable offspring would hatch in a ratio of 2 crested ducks ( $Cc$ ) to 1 non-crested duck ( $cc$ ).

## Appendix 1.8B:

### Genetics Problems 2 (Answer Key) (continued)

(2 of 2)

- b) If a crested duck ( $Cc$ ) and a non-crested duck ( $cc$ ) are bred, half the resulting ducklings would be crested ( $Cc$ ) and the other half would be non-crested ( $cc$ ). The genotype ratio would be 1  $Cc$ : 1  $cc$ . The phenotype ratio would be 1 crested duckling to 1 non-crested duckling.
4. a) The red bull's genotype is  $RR$ . The white cow's genotype is  $WW$ .  
When a red bull is mated with a white cow, the following genotypes and phenotypes of offspring could be obtained:

$$RR \times WW$$

|     |      |
|-----|------|
|     | $W$  |
| $R$ | $RW$ |

All the offspring have the  $RW$  genotype and will be roan in colour.

- b) When the roan offspring ( $RW$ ) is mated with a white cow ( $WW$ ), the following offspring would be expected:

$$RW \times WW$$

|     |      |      |
|-----|------|------|
|     | $W$  | $W$  |
| $R$ | $RW$ | $RW$ |
| $W$ | $WW$ | $WW$ |

A ratio of 1 roan ( $RW$ ) calf to 1 white calf ( $WW$ ) would be expected.

5. Human skin colour is an example of a polygenic trait. It is controlled by at least four genes.

# Appendix 1.9A: Genetics Problems 3 (BLM)

(1 of 1)

1. A couple has four children, all of whom are boys. What is the chance that their next child will be a girl?
2. Duchenne muscular dystrophy (DMD) is a recessive sex-linked disorder. A man and a woman who are both free of the disorder have two children. Their elder son develops DMD, while their younger son is free of the disorder.
  - a) Determine the genotypes of the parents.
  - b) Determine the genotypes of the children.
3. A woman (whose father was red-green colour-blind) and a man with no history of colour-blindness in his family plan to start a family. What is the chance that they will have children who are colour-blind?
4. Given the following data, determine the inheritance pattern of black, orange, and calico coat colour in cats.

Hints: Male cats are XY and female cats are XX. Calico is a mix of orange and black fur.

| <b>Cross Parents</b> |                             | <b>Offspring</b>   |
|----------------------|-----------------------------|--|
| #1                   | black male x orange female  | 1 orange male: 1 calico female                                   |
| #2                   | orange male x black female  | 1 black male: 1 calico female                                    |
| #3                   | orange male x calico female | 1 black male: 1 orange male:<br>1 orange female: 1 calico female |

## Appendix 1.9B: Genetics Problems 3 (Answer Key)

(1 of 2)

1. The probability of their next child being a girl is 50%. The chance of any one child being a certain sex is unaffected by the birth of previous children.

$$XY \times XX$$

|   |    |    |
|---|----|----|
|   | X  | X  |
| X | XX | XX |
| Y | XY | XY |

There is a 50–50 chance of either a boy or a girl.

2. a) The father is not affected. His genotype is  $X^MY$ . To have a son with the disorder, the mother must be a carrier. Her genotype is  $X^MX^m$ .

$$X^MY \times X^MX^m$$

|       |          |          |
|-------|----------|----------|
|       | $X^M$    | $X^m$    |
| $X^M$ | $X^MX^M$ | $X^MX^m$ |
| Y     | $X^MY$   | $X^mY$   |

- b) The elder son is affected by DMD. His genotype is  $X^mY$ . The younger son is free of the disorder. His genotype is  $X^MY$ .
3. The man is not colour-blind. His genotype is  $X^CY$ . The woman is not colour-blind, but inherited the gene for colour-blindness from her father. She is a carrier with genotype  $X^CX^c$ .

$$X^CY \times X^CX^c$$

|       |          |          |
|-------|----------|----------|
|       | $X^C$    | $X^c$    |
| $X^C$ | $X^CX^C$ | $X^CX^c$ |
| Y     | $X^CY$   | $X^cY$   |

There is a 50% chance that their sons will be colour-blind. None of their daughters will be colour-blind.

## Appendix 1.9B:

### Genetics Problems 3 (Answer Key) (continued)

(2 of 2)

4. As calico is a mix of orange and black, the genes for orange and black coat colour are co-dominant. Let  $B$  = black,  $O$  = orange, and  $BO$  = calico. However, there are no male calico cats. Therefore, coat colour must be sex-linked.

Cross #1: black male ( $X^B Y$ )  $\times$  orange female ( $X^O X^O$ )

|       |           |           |
|-------|-----------|-----------|
|       | $X^O$     | $X^O$     |
| $X^B$ | $X^B X^O$ | $X^B X^O$ |
| $Y$   | $X^O Y$   | $X^O Y$   |

1 orange male: 1 calico female

Cross #2: orange male ( $X^O Y$ )  $\times$  black female ( $X^B X^B$ )

|       |           |           |
|-------|-----------|-----------|
|       | $X^B$     | $X^B$     |
| $X^O$ | $X^B X^O$ | $X^B X^O$ |
| $Y$   | $X^B Y$   | $X^B Y$   |

1 black male: 1 calico female

Cross #3: orange male ( $X^O Y$ )  $\times$  calico female ( $X^B X^O$ )

|       |           |           |
|-------|-----------|-----------|
|       | $X^B$     | $X^O$     |
| $X^O$ | $X^B X^O$ | $X^O X^O$ |
| $Y$   | $X^B Y$   | $X^O Y$   |

1 black male: 1 orange male: 1 orange female: 1 calico female



# Appendix 1.10A: Using Pedigree Analysis to Solve a Genetic Mystery (BLM)

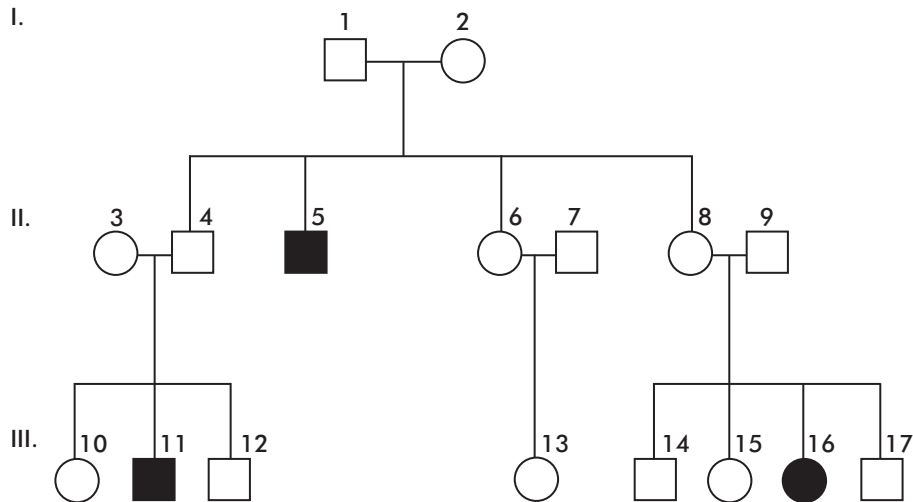
(1 of 4)

## Part A

In the early 1960s, some pediatricians in the Saguenay–Lac-Saint-Jean region of Quebec noticed that some infants in the area were dying from an unknown disease. The babies seemed to be healthy when they were born, but they did not eat well or gain weight as they should. Even when the babies were admitted to hospital and fed through a tube, they did not thrive, and most died within a few months of birth. Autopsies showed that the children all died of liver failure.

Curious, doctors began to investigate what might have caused the infants' livers to fail. They found that people in the area remembered similar baby deaths in the past. The pedigree charts of two families from the Saguenay–Lac-Saint-Jean region are shown below. Individuals with the shaded symbols died of the unknown disease.

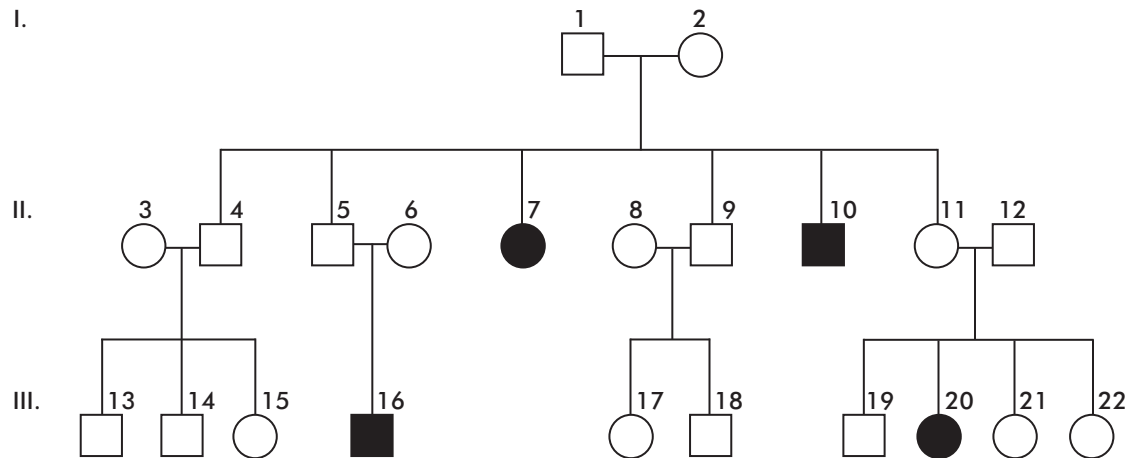
## Family A



**Appendix 1.10A:**  
**Using Pedigree Analysis to Solve a Genetic**  
**Mystery (BLM) (continued)**

(2 of 4)

**Family B**



- Examine the pedigree charts of Family A and Family B and predict how the disease is carried from one generation to the next. Explain your reasoning.
- Predict the genotypes for the following individuals in Family A. You may be unable to determine the full genotype for all individuals.
  - I-2
  - II-5
  - II-9
  - III-12
  - III-16
- Predict the genotypes for the following individuals in Family B. You may be unable to determine the full genotype for all individuals.
  - I-1
  - II-9
  - II-11
  - III-14
  - III-20
- Individual III-10 from Family A and Individual III-19 from Family B plan to start a family together. What is the chance they could have a baby with the disease? Explain.
- What possible reasons might there be for doctors not to have noticed the baby deaths before the 1960s, even though people in the region knew about them?

**Appendix 1.10A:**  
**Using Pedigree Analysis to Solve a Genetic**  
**Mystery (BLM) (continued)**

(3 of 4)

**Part B**

Doctors determined that the liver failure in the affected babies was caused by hereditary *tyrosinemia*, an autosomal recessive disease. These children had a biochemical defect that made them unable to produce an enzyme needed to break down tyrosine, an amino acid. As a result, tyrosine accumulated in their livers, eventually leading to liver failure and death.

The prevalence of hereditary tyrosinemia is generally quite low, affecting only about 1 in 100,000 newborns worldwide. However, in the Saguenay–Lac-Saint-Jean region in the period from 1967 to 1971, tyrosinemia affected 1 baby in 1042, and it was estimated that 1 person in 16 was a carrier for the disease (De Braekeleer and Larochelle). By 1986, the prevalence of tyrosinemia declined, affecting approximately 1 baby in 1850, with an estimated 1 person in 21 being a carrier of the disease (De Braekeleer and Larochelle).

6. What are some possible reasons for the significantly higher number of babies born with tyrosinemia in Saguenay–Lac-Saint-Jean compared with the situation worldwide?
7. What are some possible reasons for the decline in the number of babies born with tyrosinemia today in Saguenay–Lac-Saint-Jean?

**Part C**

By tracing family histories and constructing pedigrees, the Quebec geneticist Dr. Claude Laberge determined the Saguenay–Lac-Saint-Jean region was settled by 50 families from Charlevoix in the 1840s. Until recently, the Saguenay–Lac-Saint-Jean region was quite isolated and most people living in the region were descended from the original settlers.

All the tyrosinemia victims were traced back to one ancestral couple, Louis and Marie Gagne, who immigrated to Quebec from France in 1644 (Laberge). Either Louis or Marie must have carried the gene for tyrosinemia and passed it to some of their nine children, and many grandchildren, two of whom settled in Charlevoix. Some of their offspring later moved to the Saguenay–Lac-Saint-Jean region.

Marriages between cousins and second cousins were common in the Saguenay–Lac-Saint-Jean region, due to the small number of original settlers and lack of immigration into the area. As a result, a significant proportion of people in the region carry the tyrosinemia gene. This is an example of the *founder effect*, in which a gene mutation is observed in high frequency in a specific population, even though the mutation was originally found in a single ancestor or a small number of ancestors.

**Appendix 1.10A:**  
**Using Pedigree Analysis to Solve a Genetic**  
**Mystery (BLM) (continued)**

(4 of 4)

Today, genetic screening and genetic counselling are available to couples with tyrosinemia in their family histories. The gene has been located on chromosome 15. Prenatal diagnosis, newborn screening, and carrier testing are available.

8. What were some possible sources of information that Dr. Laberge might have used to construct the pedigrees?
9. Why would marriages between cousins or second cousins result in an increase in the number of babies born with tyrosinemia?
10. If you planned to have children with a partner whose family came from the Saguenay–Lac-Saint-Jean region, should you be concerned that your children may be born with tyrosinemia?

**References**

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## Appendix 1.10B: Using Pedigree Analysis to Solve a Genetic Mystery (Answer Key)

(1 of 3)

### Part A

1. The fact that one-quarter of the children are afflicted when the parents are not suggests a two-allele system involving a defective recessive allele. Since females and males were equally afflicted, it is an autosomal trait and not a sex-linked trait.
2. Let  $T$  = normal gene and  $t$  = tyrosinemia gene.
  - a)  $Tt$
  - b)  $tt$
  - c)  $Tt$
  - d)  $T?$
  - e)  $tt$
3. Let  $T$  = normal gene and  $t$  = tyrosinemia gene.
  - a)  $Tt$
  - b)  $T?$
  - c)  $Tt$
  - d)  $T?$
  - e)  $tt$
4. Both individuals have siblings who died of the disease. There is a 50% chance each could be a tyrosinemia carrier ( $Tt$ ) and a 25% chance each could carry two normal copies of the gene ( $TT$ ).
  - If both individuals are carriers ( $Tt \times Tt$ ), there is a 25% chance they will have a child with the disease ( $tt$ ).
  - If one individual is a carrier ( $Tt$ ) and the other does not carry the gene ( $TT$ ), there is no chance they will have a child with the disease.
  - If neither individual is a carrier of the disease ( $TT$ ), there is no chance they will have a child with the disease.
5. Possible reasons for the doctors not to have noticed the baby deaths before the 1960s:
  - This was before Medicare (universal health care) was available, and a poor family could not afford to take a sick baby to a hospital.
  - Many more babies died of a variety of childhood diseases (infant mortality was higher), so these specific deaths were not noticed.
  - There were few medical specialists such as pediatricians in the Saguenay-Lac-Saint-Jean region to treat sick babies.

**Appendix 1.10B:**  
**Using Pedigree Analysis to Solve a Genetic**  
**Mystery (Answer Key) (continued)**

(2 of 3)

**Part B**

6. Possible reasons for the significantly higher number of babies born with tyrosinemia in Saguenay-Lac-Saint-Jean compared with the situation worldwide:
  - People didn't move into or out of the area, so the gene flow was restricted.
  - Relatives (e.g., cousins) marrying each other increased the chance of having a baby with the disease.
  - Large families resulted in more babies with the disease.
  - People didn't know what caused the babies to die, so they kept having children.
7. Possible reasons for the decline in the number of babies born with tyrosinemia today in Saguenay-Lac-Saint-Jean:
  - Genetic testing is now available for neonatal testing and carrier identification.
  - People are having smaller families.
  - Migration into and out of the area has increased (carriers move out, non-carriers move in).
  - People who have one baby with tyrosinemia don't have any more children.
  - People with tyrosinemia in their families choose not to have children.

**Part C**

8. Possible sources of information that Dr. Laberge might have used to construct the pedigrees include
  - hospital records
  - church records (baptisms, marriages, births, deaths)
  - gravestones
  - family interviews
  - family records (family trees)

Appendix 1.10B:  
Using Pedigree Analysis to Solve a Genetic  
Mystery (Answer Key) *(continued)*

(3 of 3)

9. Cousins share one set of grandparents. Therefore, they share some common genes.
- When cousins marry and have children, the probability of having children with tyrosinemia increases, as does the probability of having children who are carriers.  
*Example*  
parents (cousins):  $Tt \times Tt$   
children: 1  $TT$ : 2  $Tt$  (carriers): 1  $tt$  (tyrosinemia)
  - When unrelated individuals have children together, even if one parent is a carrier, the couple is unlikely to have a child with the disease.  
*Example*  
parents:  $TT \times Tt$   
children: 1  $TT$ : 1  $Tt$  (carrier)
10. Unless your family also came from the Saguenay–Lac-Saint-Jean region, it is highly unlikely that both you and your partner would carry the tyrosinemia gene. Your children should not be affected.

# Appendix 1.11:

## Bioethical Dilemmas—Scenarios (BLM)

(1 of 2)

### 1. Huntington Disease

You and your older brother (age 20) have just found out that your father has been diagnosed with Huntington disease. This is an incurable disorder that causes a slow progressive deterioration of the brain, resulting in death. Symptoms show up in the affected individual around age 30 to 50. Huntington disease is an autosomal dominant disorder, for which a genetic screening test has been developed. A DNA test can reveal with 100 percent certainty whether or not one will develop the disease.

### 2. Down Syndrome

You have two healthy children from a previous marriage, but now you and your second husband would like to have a child together. You are 40 years old, and are concerned about the higher chance of having a child with Down syndrome. This condition is caused by the presence of an extra chromosome 21, which leads to intellectual disability and health problems in the affected individual. Amniocentesis is available for prenatal Down syndrome diagnosis.

### 3. Hemophilia

You and your wife are thinking of starting a family. However, you have hemophilia, a sex-linked recessive bleeding disorder. You are being successfully treated with injections of Factor VIII, the blood-clotting enzyme your body lacks. No prenatal screening tests are available for this disorder.

### 4. Cystic Fibrosis

You and your spouse have just found out that your 14-month-old daughter has cystic fibrosis. This is a fatal autosomal recessive disorder affecting the lungs and digestive tract. People with cystic fibrosis live shorter lives, and require daily medication and physical therapy. Your wife is pregnant again. Your doctor has informed you that genetic screening is available for prenatal cystic fibrosis diagnosis.

### 5. Tay-Sachs Disease

When you were a child, you had a sister who died of Tay-Sachs disease. Now you and your partner want to start a family, but you have concerns about the risk of passing this recessive autosomal disorder to your children. Children born with Tay-Sachs disease suffer from progressive brain deterioration and loss of motor function. There is no treatment or cure, and death occurs in early childhood. Carriers of Tay-Sachs can be identified through a blood test, and amniocentesis can be used for prenatal Tay-Sachs diagnosis.



## Appendix 1.11:

### Bioethical Dilemmas—Scenarios (BLM) *(continued)*

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(2 of 2)

#### 6. Turner Syndrome

As a result of the information you have learned in this biology course, you think you may have Turner syndrome. Females with Turner syndrome are usually short in stature, tend to be weak in mathematics, and do not menstruate. They cannot have children. Your parents have never heard of this condition, caused by a missing X chromosome, and diagnosed with a blood test.

#### 7. Sickle-cell Anemia

Sickle-cell anemia is present in both your family and your partner's family. Blood tests have revealed that you are both carriers of the disease. Individuals with the disease tend to live shorter lives and suffer chronic pain, swelling in the joints, increased risk of infection, stroke, and heart attack. There is no cure for the disease, and treatment involves the use of drugs and blood transfusions. Amniocentesis can be used to diagnose sickle-cell anemia in fetuses.

## Appendix 1.12: Decision Making (Teacher Background)

(1 of 2)

The decision-making process is an approach for analyzing issues and making a choice among different courses of action. Issues are often complex, with no one right answer. They can also be controversial, as they deal with individual and group values. To make an informed decision, students must understand scientific concepts involved in an issue and must be aware of the values that guide a decision. The decision-making process involves a series of steps, which may include

- identifying and clarifying the issue
- being aware of the different viewpoints and/or stakeholders involved in the issue
- critically evaluating the available research
- determining possible alternatives or positions related to an issue
- evaluating the implications of possible alternatives or positions related to an issue
- being aware of the values that may guide a decision
- making a thoughtful decision and providing justification
- acting on a decision
- reflecting on the decision-making process

In Grade 9 Science, students were introduced to the decision-making process. The issues in Grade 12 Biology involve personal and societal decisions. If students don't have much experience with the decision-making process, teachers can initiate the process with more guidance, giving students the opportunity to use this approach in a structured environment. This could be done by providing students a specific scenario or issue to study. Students would eventually become active participants in this process by choosing their own issues, doing their own research, making their own decisions, and acting on those decisions.

The decision-making process can be approached in a variety of ways. For instance, students can play the role of different stakeholders involved in an issue, work in small groups to discuss issues, or make a decision based on their own research and personal values. Students can be asked to take a stand and debate issues, or be placed in situations where they have to reach a consensus. Students should not always defend a point of view that they agree with. They should be asked to put themselves in someone else's mindset and speak from that person's point of view.

## Appendix 1.12:

### Decision Making (Teacher Background) *(continued)*

(2 of 2)

Regardless of the approach used, the following questions can guide students in the decision-making process:

- What is the issue?
- What important scientific information is needed to understand this issue?
- Where do I find this information?
- Who has a stake in this issue, and why?
- What are the possible options?
- What are the pros and cons for each of the possible options?
- What is my decision?
- What criteria were used to make this decision?

#### **Assessment**

Because there are so many different ways of approaching an issue, a variety of products or culminating tasks can result from a decision-making process, such as a town hall meeting, a round-table discussion, a conference, a debate, a case study, a position paper, a class presentation, a class discussion, and so on. Regardless of what those products or events are, the assessment should focus on the skills outlined in Cluster 0: Biology Skills and Attitudes.

For role-playing activities such as town hall meetings, round-table discussions, or conferences, assessment criteria should be related to how students are able to put themselves in the position of their stakeholder. The assessment criteria could include the following:

- The position is clearly stated.
- Evidence is presented to support arguments.
- Answers to questions are clear and aligned with the position of the stakeholder.
- The presentation is clear and organized.
- The position of the stakeholder is accurately represented.
- Personal biases are absent.

# Appendix 1.13: Collaborative Process—Assessment (BLM)

(1 of 1)

Name \_\_\_\_\_

| <b>Assessment of Collaborative Group Work</b>   |               |
|---|---------------|
| Assess your collaborative processes, using the following rating scale.                              |               |
| <b>Rating Scale</b>   |               |
| 4 - We were consistently strong in this area.   |               |
| 3 - We were usually effective in this area.   |               |
| 2 - We were sometimes effective in this area.   |               |
| 1 - We were not effective in this area. We experienced problems that we did not attempt to resolve. |               |
| <b>Group Process</b>  | <b>Rating</b> |
| We were respectful of individual group members' approaches and strengths.                           |               |
| We encouraged and supported each person in contributing to group discussions and decision making.   |               |
| We questioned and challenged each other's ideas, but did not make personal attacks.                 |               |
| We tried to explore a wide range of ideas and perspectives prior to making decisions.               |               |
| We shared work and responsibilities equitably.  |               |
| We dealt successfully with the problem of absent or disengaged members.                             |               |
| We made our decision(s) through consensus.  |               |
| We used our time productively.  |               |

# Appendix 1.14: Self-Assessment of Listening Skills (BLM)

(1 of 1)

Name \_\_\_\_\_

| My Listening Performance  | Yes | An Area to Improve |
|---|-----|--------------------|
| I knew the reason for listening to help keep me focused.                        |     |                    |
| I was prepared for the presentation and knew what the speaker would talk about. |     |                    |
| I looked at the speaker and stayed focused.                                     |     |                    |
| I kept my movement to a minimum and did not fidget or shift around.             |     |                    |
| I often looked at the speaker, made eye contact,* nodded, or smiled.            |     |                    |
| I listened carefully to the main points, even if I didn't agree.                |     |                    |
| I made notes and wrote down questions or comments.                              |     |                    |
| I did not judge the speaker's ideas before he or she was finished.              |     |                    |
| I used respectful language to ask questions or make comments.                   |     |                    |
| I listened carefully to detect exaggeration, bias, prejudice, or emotion.       |     |                    |
| I can recall the main ideas and some details of what I heard.                   |     |                    |
| I can make comments and/or give my own opinion on what I heard.                 |     |                    |
| I assessed/evaluated the validity of the evidence the speaker presented.        |     |                    |

\* Consider cultural appropriateness.

## Additional Comments

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## Appendix 1.15:

# Letter to the Editor—Writing Assignment (BLM) (1 of 1)

### Introduction

As you read about various issues in newspapers or magazines, you are presented with different points of view. The more well-read you are, the better you are able to formulate your own opinion on an issue. Your task is to find and read **two current articles**, written in the last two years, on the topic of genetic testing. Try to find articles with a Canadian focus. If you wish, you may read or view more articles on the topic to increase your understanding. Once you have completed your readings, express your point of view on genetic testing in a letter to the editor.

### Before You Begin

1. Consider what you have been learning in class on the topic. What are your responses to some of the issues raised?
2. As you read the articles you have selected, highlight the statements you wish to react to. Address yourself to the arguments outlined in each article. You may want to summarize the arguments briefly before refuting them or reacting to them in the letter.
3. Look at sample letters to the editor from various newspapers. Consider what makes them powerful (or not).

### Drafting the Letter

1. Create a strong opening. You must catch the editor's attention in order to be published. Put your introduction and main claim in the first paragraph.
2. Be persuasive. You are trying to convince someone of your point of view by reacting to the material in the articles you read. Refer to points from those articles in your letter and reference them appropriately.
3. Make your points clearly and concisely. There is little space in most newspapers for letters; the briefer you are, the more likely your letter will be published. Make your letter 200 to 300 words in length.
4. You may use rhetoric to make your point. A rhetorical question is asked for effect with no answer expected.
5. Create a strong ending by leaving your readers with the most important thought.

# Appendix 1.16: Concept Frame (BLM)

(1 of 1)

Name \_\_\_\_\_

**Concept**

**Explanation**

**Examples**

**Like**

**Unlike**

