UNIT 2:
MECHANISMS OF INHERITANCE

Unit 2: Mechanisms of Inheritance

Specific Learning Outcomes

B12-2-01: Outline significant scientific contributions/discoveries that led to the current understanding of the structure and function of the DNA molecule. (GLOs: A2, A4, A5, B1, B2)

Include: timeline, individual contributions, multidisciplinary collaboration, and competitive environment

B12-2-02: Describe the structure of a DNA nucleotide. (GLOs: D1, D3)

Include: deoxyribose sugar, phosphate group, and nitrogenous bases

B12-2-03: Describe the structure of a DNA molecule. (GLOs: D1, D3)

Include: double helix, nucleotides, base pairing, and gene

B12-2-04: Describe the process of DNA replication. (GLOs: D1, D3)

Include: template, semi-conservative replication, and role of enzymes

B12-2-05: Compare DNA and RNA in terms of their structure, use, and location in the cell. (GLOs: D1, D3)

B12-2-06: Outline the steps involved in protein synthesis. (GLOs: D1, D3)

Include: mRNA, codon, amino acid, transcription, tRNA, anticodon, ribosome, and translation

B12-2-07: Relate the consequences of gene mutation to the final protein product. (GLOs: D1, D3)

Examples: point mutation in sickle-cell anemia, frameshift mutation in β-thalassemia . . .

B12-2-08: Discuss implications of gene mutation for genetic variation. (GLOs: D1, E1, E3)

Include: source of new alleles

B12-2-09: Investigate an issue related to the application of gene technology in bioresources. (GLOs: A3, A5, B1, B2, C4, C5)

Include: understanding the technology/processes involved, economic implications, a variety of perspectives, and personal/societal/global implications

B12-2-10: Investigate an issue related to the application of gene technology in humans. (GLOs: A3, A5, B1, B2, C4, C5)

Include: understanding the technology/processes involved, ethical and legal implications, a variety of perspectives, and personal/societal/global implications

DISCOVERING THE STRUCTURE OF DNA

SPECIFIC LEARNING OUTCOME

B12-2-01: Outline significant scientific contributions/discoveries that led to the current understanding of the structure and function of the DNA molecule. (GLOs: A2, A4, A5, B1, B2)

Include: timeline, individual contributions, multidisciplinary collaboration, and competitive environment

SLO: B12-2-01

SUGGESTIONS FOR INSTRUCTION

TEACHER NOTE

The historical development of our current understanding of the structure and function of DNA is an excellent example of how science operates. The challenge for teachers is to make the excitement of the scientific discoveries come alive to students and to help them gain an understanding of the nature of science.

BACKGROUND INFORMATION

Scientific contributions/discoveries that led to current understanding of the structure and function of the DNA molecule include the following:

- **Friedrich Miescher** isolated nucleic acids from the nuclei of white blood cells.
- **Phoebus Levene** showed that DNA and RNA are distinct nucleic acids, but both are composed of long chains of nucleotides.
- **Walter Sutton** and **Theodor Boveri** suggested that the genetic material of the cell is contained in chromosomes (chromosomal theory of inheritance).
- **Thomas Hunt Morgan et al.** showed that genes are linear arrays on chromosomes.
- **Frederick Griffith** performed experiments indicating that DNA is probably the genetic material of the cell.
- **Oswald Avery et al.** performed experiments indicating that DNA is probably the genetic material of the cell.
- **Alfred Hershey** and **Martha Chase** clearly showed that DNA is the genetic material of the cell.
- **Edwin Chargaff** demonstrated that the number of adenines always equals the number of thymines, and the number of cytosines always equals the number of guanines.
- **Rosalind Franklin** and **Maurice Wilkins** used X-ray crystallography to show the helical structure of DNA.
- **James Watson** and **Francis Crick** proposed the double-helix model of the DNA structure.

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-S2: Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment. (GLOs: B3, B5, C1, C2)

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-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-G1: Collaborate with others to achieve group goals and responsibilities. (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)

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 . . .

ACTIVATE

Class Survey

Pose the following question to students:

- We often see diagrams and models of DNA in electronic and print media. How do you think scientists determined the structure of DNA?

Ask students to share their ideas, and record their responses on the classroom board. Use the responses to lead students in a discussion of the nature of science and the science inquiry process.

ACQUIRE/APPLY

Discovering DNA (U1)

By viewing videos and computer animations that illustrate and describe the historical development of our understanding of the structure and function of DNA, students can enhance their conceptual understanding.

The use of a note-taking strategy such as a Note Frame can help students follow a lecture and organize information (see *SYSTH*, pp. 11.32–11.33).

DISCOVERING THE STRUCTURE OF DNA

SPECIFIC LEARNING OUTCOME

B12-2-01: Outline significant scientific contributions/discoveries that led to the current understanding of the structure and function of the DNA molecule. (GLOs: A2, A4, A5, B1, B2)

Include: timeline, individual contributions, multidisciplinary collaboration, and competitive environment

Resource Links

A wealth of information on DNA can be found in a variety of multimedia formats.

- Cold Spring Harbor Laboratory's DNA Learning Center. *DNA from the Beginning.* <www.dnaftb.org/>.
  An animated primer on the basics of DNA, genes, and heredity is available on this website.

- ———. *DNA Interactive*. <www.dnai.org/>.
  This website has a timeline outlining the history of DNA science. Text biographies of contributors are available, as well as video and audio clips of interviews with researchers, including James Watson, Maurice Wilkins, and Raymond Gosling (Rosalind Franklin's graduate student). Students can follow how the researchers discovered the structure of the DNA molecule.

- The National Science Digital Library (NSDL). Home Page. <http://nsdl.org/>.
  This website has online collections of resources for teachers on DNA-related topics, including lesson plans, videos, interactives, and articles.

- Nature Publishing Group. "Double Helix: 50 Years of DNA." *Nature.* <www.nature.com/nature/dna50>.
  The science journal *Nature* has a special November 22, 2004, feature commemorating the 50th anniversary of the structure of DNA, which can be viewed online. It also contains archives (including Watson and Crick's 1953 paper describing the structure of DNA) and other features.

- Public Broadcasting Services (PBS) Online. *DNA*. <www.pbs.org/wnet/dna/>.
  This website contains a historical timeline and a 3-D DNA explorer, as well as a series on DNA, including "Episode 1: The Secret of Life," which traces the race to determine the structure of DNA.

- ———."Secret of Photo 51." *NOVA beta.* <www.pbs.org/wgbh/nova/photo51>.
  This episode investigates the role played by Rosalind Franklin in the discovery of the structure of DNA. It contains interviews, slide shows, and interactives.

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-S2: Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment. (GLOs: B3, B5, C1, C2)

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-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-G1: Collaborate with others to achieve group goals and responsibilities. (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)

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 . . .

- The University of California Museum of Paleontology. "The Structure of DNA: Cooperation and Competition." 2007. *Understanding Science*. <http://undsci.berkeley.edu/article/dna_01>.

  This interactive case study describes how the work of James Watson, Francis Crick, Maurice Wilkins, and Rosalind Franklin illustrates the nature of science.

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

DISCOVERING THE STRUCTURE OF DNA

SPECIFIC LEARNING OUTCOME

B12-2-01: Outline significant scientific contributions/discoveries that led to the current understanding of the structure and function of the DNA molecule. (GLOs: A2, A4, A5, B1, B2)

Include: timeline, individual contributions, multidisciplinary collaboration, and competitive environment

Discovery of DNA—Chain Concept Map (U2)

Students create a Chain Concept Map (flow chart) summarizing the information about the discovery of DNA. The flow chart should show how the developments in our understanding of DNA relied on and used the ideas and techniques developed in the work of previous scientists. 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. Concept maps can also be peer assessed. For more information on peer assessment, refer to Appendix 4.2A: Peer Assessment (Teacher Background) and Appendix 4.2B: Guidelines for Peer Assessment (BLM).

DNA Extraction—Investigation (P1, S2, G1)

DNA extraction labs are available from many print and online sources and are relatively simple to perform. They use

- inexpensive materials (e.g., dish soap, salt [NaCl], ethanol, plant or animal tissue)
- simple equipment (e.g., beakers, test tubes, mortar and pestle, glass rods, stir sticks)

The DNA extraction technique used today is similar to that developed by Friedrich Miescher in 1869. Students today have the advantage of modern refrigeration to keep ethanol cold. The DNA produced will form long strands that can be spooled onto a glass rod or stir stick. The actual double helix structure cannot be seen with the naked eye.

Resource Links

Some online DNA extraction labs are available on the following websites.

- Agriculture in the Classroom. "DNA Extraction Lab Protocol." Rev. 11 Apr. 2011. Multimedia Educational Resource for Learning and Online Teaching (MERLOT). <www.merlot.org/merlot/viewMaterial.htm?id=423595>.

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-S2: Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment. (GLOs: B3, B5, C1, C2)

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-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-G1: Collaborate with others to achieve group goals and responsibilities. (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)

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 . . .

- Fritz, Stacey. "Strawberry DNA Extraction Using Common Household Ingredients." Rev. 18 Nov. 2009. National Association of Agricultural Educators. <http://naae.ca.uky.edu:8080/clearspace_community/docs/DOC-1584;jsessionid=B6021795EF8220601201DDB13B2B85EA>.
- Genetic Science Learning Center. "DNA Extraction Virtual Lab." *Learn.Genetics.* <http://learn.genetics.utah.edu/content/labs/extraction/>.
- ———. "How to Extract DNA from Anything Living."2008. *Learn.Genetics.* <http://learn.genetics.utah.edu/content/labs/extraction/howto/>.

Suggestion for Assessment

Assess students' lab skills during the investigation using a lab skills checklist. Lab reports can be assessed as well. See Appendix 1.4A: Lab Skills Checklist—General Skills (BLM) and Appendix 1.4B: Lab Skills Checklist—Thinking Skills (BLM). Refer to *SYSTH* (pp. 11.26–11.29 and 14.11–14.12) for different ways of writing a lab report.

DISCOVERING THE STRUCTURE OF DNA

SPECIFIC LEARNING OUTCOME

B12-2-01: Outline significant scientific contributions/discoveries that led to the current understanding of the structure and function of the DNA molecule. (GLOs: A2, A4, A5, B1, B2)

Include: timeline, individual contributions, multidisciplinary collaboration, and competitive environment

DNA Discovery Timeline—Research and Presentation (I1, I2, I3, I4, N1, N2)

Students (individually or in small groups) research a scientist or a team of scientists who contributed to our understanding of the structure and function of the DNA molecule. They research the following on their assigned scientist(s):

- timeline of work
- key contributions/discoveries
- contextual information (e.g., where the science research took place, biographical information on the researcher)

After they have done their research, they prepare a report of their findings and present it to the class.

Suggestions for Assessment

Students prepare and present their research outlining the significant scientific contributions/discoveries that led to our understanding of the structure and function of the DNA molecule.

Research findings can be presented in a variety of formats:

- dramatic presentation (e.g., TV interview, debate between scientists, TV news report, dramatization of the event)
- multimedia presentation (e.g., PowerPoint, video, wiki, podcast)
- oral presentation
- written report (The Jigsaw strategy could be used to share information in small groups. For more information, refer to *SYSTH*, p. 3.20.)
- visual display (e.g., poster, bulletin board, cartoon, timeline)

Presentation components may vary, depending on the type of presentation. Refer to Appendix 5.8: Checklist for Creating Visuals (BLM) for use with visuals (e.g., posters, collages, graphic organizers) and to 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 the 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. See Appendix 11 in General Appendices for samples of assessment rubrics.

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 . . .

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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-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-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-G1: Collaborate with others to achieve group goals and responsibilities. (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)

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 . . .

The Nature of Science—Demonstrating Understanding (U2, N1, N2)

Have students carry out a Focused Free Writing activity by writing about their understanding of the nature of science. The following question can be used to stimulate their thinking:

> Historians debate the extent to which key individuals actually changed the course of history. Do you think the individual scientists or teams of scientists discussed in class influenced the progress of knowledge? Explain your answer.

For more information on Focused Free Writing activities, refer to *SYSTH* (pp. 13.8–13.13).

Suggestion for Assessment

Assess students' responses for conceptual understanding of the nature of science, and provide students with written feedback.

DNA STRUCTURE

SPECIFIC LEARNING OUTCOMES

B12-2-02: Describe the structure of a DNA nucleotide. (GLOs: D1, D3)
Include: deoxyribose sugar, phosphate group, and nitrogenous bases

B12-2-03: Describe the structure of a DNA molecule. (GLOs: D1, D3)
Include: double helix, nucleotides, base pairing, and gene

SLO: B12-2-02
SLO: B12-2-03

SUGGESTIONS FOR INSTRUCTION

ENTRY-LEVEL KNOWLEDGE

Students are familiar with the terms *DNA*, *chromosomes*, and *genes* from Grade 9 Science. They have not previously studied the structure of DNA, but they may have prior knowledge gained from the media.

TEACHER NOTE

Review with students that *DNA* is the nucleic acid that stores and transmits the genetic information of a cell from one generation to the next.

BACKGROUND INFORMATION

A DNA molecule is made of building blocks known as *nucleotides*. Each DNA nucleotide consists of a five-carbon sugar (deoxyribose), a phosphate group, and one of four possible nitrogenous bases (adenine, thymine, guanine, or cytosine). The nucleotides are linked together to form chains that can vary in length and in the sequence of the nitrogenous bases. It is the sequence of nitrogenous bases that provides the genetic code of the DNA.

ACTIVATE

Brainstorming

Write the letters *DNA* on the classroom board or on an overhead projector. Ask students what comes to mind when they see these letters. Invite students to call out their responses. Accept all responses, and write them all down on the board/overhead, clustering them into categories.

Examples

- nucleotide, ATGC (adenine, thymine, guanine, cytosine), double helix = structure
- DNA fingerprinting, crime investigation TV shows = forensic uses
- Frankenfoods, genetically modified organisms (GMO), recombinant DNA = gene technology

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-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-G1: Collaborate with others to achieve group goals and responsibilities. (GLOs: C2, C4, C7)

ACQUIRE/APPLY

Visualizing the Structure of DNA (U1)

The use of diagrams, videos, models, or computer animations that illustrate and describe the structure of nucleotides and DNA will enhance students' conceptual understanding. Discuss with students that a nucleotide is composed of a five-carbon sugar (deoxyribose), a phosphate group, and a nitrogenous base. As there are four different nitrogenous bases (adenine, thymine, guanine, and cytosine), there are four possible nucleotides.

The use of 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

- Boyer, Rodney. "Interactive Animations." *Interactive Concepts in Biochemistry*. 2002. Wiley. <www.wiley.com/legacy/college/boyer/0470003790/animations/animations.htm>.

  This website provides interactive animations, tutorials, and articles on a variety of DNA-related topics.

- Cold Spring Harbor Laboratory's DNA Learning Center. *DNA from the Beginning*. <www.dnaftb.org/>.

  This website contains an animated primer on the basics of DNA, genes, and heredity.

- ———. *DNA Interactive*. <www.dnai.org/>.

  This website contains 3-D animations of the structure of the DNA molecule. Students can play an interactive game and build a fragment of DNA.

DNA STRUCTURE

SPECIFIC LEARNING OUTCOMES

B12-2-02: Describe the structure of a DNA nucleotide. (GLOs: D1, D3)
Include: deoxyribose sugar, phosphate group, and nitrogenous bases

B12-2-03: Describe the structure of a DNA molecule. (GLOs: D1, D3)
Include: double helix, nucleotides, base pairing, and gene

- Genetic Science Learning Center. *Learn.Genetics.* <http://learn.genetics.utah.edu/>.
  The *Tour the Basics* section of this website provides information, tutorials, and interactive animations on the structure of DNA, as well as DNA replication, transcription, and translation.

Suggestion for Assessment

Students complete a Concept Overview frame (see *SYSTH*, p. 11.37). Review the completed frames to assess students' comprehension, and re-teach material if necessary.

DNA Structure—Model Building (U2, G1)

DNA model building activities are readily available and are relatively simple to perform. Students work in groups and build DNA models from paper "nucleotides," clay and paper clips, beads and pipe cleaners, or other materials. If the models are constructed so that the base pairs are able to separate, the models can be used to simulate DNA replication and messenger RNA (mRNA) transcription in future lessons.

Suggestions for Assessment

Students use their DNA models to demonstrate and describe the structure of the DNA molecule to their peers, and receive feedback from peers as to their understanding of DNA structure. For more information on peer assessment, refer to Appendix 4.2A: Peer Assessment (Teacher Background) and Appendix 4.2B: Guidelines for Peer Assessment (BLM).

Alternatively, conduct interviews with individual students or small groups of students. The students use their models to describe and demonstrate their understanding of the structure of DNA.

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-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-G1: Collaborate with others to achieve group goals and responsibilities. (GLOs: C2, C4, C7)

DNA as a Ladder—Analogy (U2, I4)

When examining the structure of the DNA molecule, use the analogy of a twisted ladder. The rails of the ladder correspond to the sugar-phosphate backbones of the DNA molecule, while the rungs of the ladder equate to the paired nitrogenous bases. The rails of a ladder are strong, as they lend stability to the ladder. The "rails" of DNA are held strongly together by covalent bonds, while each half of the "rung" is joined to the other by weaker hydrogen bonds. Both a ladder and DNA have complementary halves.

In order for a ladder to support the weight of the climber, all the rungs of the ladder must be of the same width. Therefore, in a DNA molecule, thymine can only bond with adenine, and cytosine only with guanine. If cytosine and thymine bonded, the rung would be too short. A bond between guanine and adenine would make the rung too long. The double-helix shape of the DNA molecule is the result of the twisting of the ladder into a corkscrew shape.

Suggestion for Assessment

While analogies can be useful when learning new concepts, they are not perfect representations. Ask students to discuss the strengths and weaknesses of the ladder analogy for describing the structure of DNA.

Examples

Strengths of Ladder Analogy	Weaknesses of Ladder Analogy
• double-helix shape is well represented • location of sugar-phosphate backbone is accurate • location of nucleotides is accurate	• individual nucleotides (A, T, C, G) are not represented • individual sugars and phosphates are not shown • base pairing (A-T, C-G) is not represented

DNA STRUCTURE

SPECIFIC LEARNING OUTCOMES

B12-2-02: Describe the structure of a DNA nucleotide. (GLOs: D1, D3)
Include: deoxyribose sugar, phosphate group, and nitrogenous bases

B12-2-03: Describe the structure of a DNA molecule. (GLOs: D1, D3)
Include: double helix, nucleotides, base pairing, and gene

Students' responses can be used as a formative assessment to determine their levels of understanding and to guide further teaching and learning activity selection (if needed).

DNA Replication—Representation Analysis (U2, I2)

Scientific representations are used to convey scientific ideas and come in a variety of forms (e.g., pictures, analogies, models, graphs, diagrams, charts). Because the representations are not exactly like the real thing, they have limitations that can lead to flawed conceptual understanding in students.

Provide students with a representation of DNA replication. Have them work in groups to analyze the representation to identify possible flaws or limitations. Students record their ideas and justify their reasons. For example, a picture of a DNA model is much larger than a DNA molecule is in reality; the picture may colour-code the nitrogenous bases; it may represent a thymine molecule with a T; and it may show the deoxyribose sugar with a D or an S.

Suggestion for Assessment

Ask students to suggest what could be done to improve the representation. The responses can be used as a formative assessment to determine whether students have misconceptions that are reinforced by the representation, or whether they are unable to recognize flaws or limitations in the representation.

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-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-G1: Collaborate with others to achieve group goals and responsibilities. (GLOs: C2, C4, C7)

NOTES

DNA REPLICATION

SPECIFIC LEARNING OUTCOME

B12-2-04: Describe the process of DNA replication. (GLOs: D1, D3)
Include: template, semi-conservative replication, and role of enzymes

SLO: B12-2-04

SUGGESTIONS FOR INSTRUCTION

TEACHER NOTE

Discuss the accuracy of the DNA replication process by emphasizing how one side of the molecule acts as a template for the formation of the other. The process is semi-conservative, as each new DNA molecule formed contains one-half of the original molecule.

Describe the role enzymes play in the DNA replication process. One enzyme causes the strands of DNA to separate, exposing the bases. A second enzyme recognizes the exposed bases and matches them up with free, complementary nucleotides. The enzyme then bonds the sugars and phosphates together to form the backbone of the new strand. Other enzymes "proofread" the new strands to ensure accuracy, and make corrections if required.

Emphasize that the two new DNA molecules formed in replication should be identical to the original molecule. The accuracy of the replication process maintains the integrity of genetic code from one generation of cells to the next, and from parent to offspring.

DNA replication occurs fairly quickly; as many as 4000 nucleotides per second are replicated. This helps explain why bacterial cells, under ideal conditions, can reproduce in 20 minutes.

ACTIVATE

Mechanism of DNA Replication—Thought Experiment

Pose the following question to students and ask them work in groups to develop and refine their ideas.

- When James Watson and Francis Crick developed their model of DNA structure, they immediately recognized that the complementary nature of the two sides of the helix could provide a mechanism for accurate DNA replication. Given your knowledge of DNA structure, can you propose a mechanism for accurate DNA replication?

Students record their proposed mechanism 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-G1: Collaborate with others to achieve group goals and responsibilities. (GLOs: C2, C4, C7)

ACQUIRE/APPLY

Visualizing DNA Replication (U1)

The use of diagrams, videos, models, or computer animations that illustrate and describe the semi-conservative replication of DNA can assist in developing students' conceptual understanding.

Using the Three-Minute Pause strategy, provide students with three-minute breaks after periods of instruction. Students 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. Students can use three-minute egg timers or digital stopwatches to keep track of time.

Resource Links

- Cold Spring Harbor Laboratory's DNA Learning Center. *DNA Interactive*. <www.dnai.org/>.
  This website contains 3-D animations illustrating the processes of replication, transcription, and translation.
- Genetic Science Learning Center. *Learn.Genetics*. <http://learn.genetics.utah.edu/>.
  The *Tour the Basics* section provides information on DNA replication, transcription, and translation in the form of tutorials and interactive animations.
- Howard Hughes Medical Institute. *BioInteractive*. <www.hhmi.org/biointeractive/>.
  Refer to this website for short video and animated clips on a variety of DNA-related topics.

Suggestion for Assessment

For the last five minutes of class, have students complete an Exit Slip, reflecting on how and why their ideas about the mechanism of DNA replication changed. Review students' 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).

DNA REPLICATION

SPECIFIC LEARNING OUTCOME

B12-2-04: Describe the process of DNA replication. (GLOs: D1, D3)
Include: template, semi-conservative replication, and role of enzymes

DNA Replication—Demonstrating Understanding (U1)

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

- How does the structure of DNA lend itself to replication?
- Why is accuracy so important in DNA replication?

Give students five minutes to respond in their notebooks.

Suggestion for Assessment

This quick formative assessment provides information about what students learned in a particular lesson.

DNA Replication—Model Building (U2, G1)

Using their DNA models (see specific learning outcomes B12-2-02 and B12-2-03), students simulate the process of DNA replication. Two new DNA models should result, each model having one original DNA strand and one new strand.

Suggestions for Assessment

Students use their DNA models to demonstrate and describe to their peers the process of DNA replication, and receive feedback from peers as to their understanding of the process. For more information on peer assessment, refer to Appendix 4.2A: Peer Assessment (Teacher Background) and Appendix 4.2B: Guidelines for Peer Assessment (BLM).

Alternatively, conduct interviews with individual students or small groups of students. The students use their DNA models to describe and demonstrate their understanding of DNA replication.

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-G1: Collaborate with others to achieve group goals and responsibilities. (GLOs: C2, C4, C7)

NOTES

PROTEIN SYNTHESIS

SPECIFIC LEARNING OUTCOMES

B12-2-05: Compare DNA and RNA in terms of their structure, use, and location in the cell. (GLOs: D1, D3)

B12-2-06: Outline the steps involved in protein synthesis. (GLOs: D1, D3)

Include: mRNA, codon, amino acid, transcription, tRNA, anticodon, ribosome, and translation

SLO: B12-2-05
SLO: B12-2-06

SUGGESTIONS FOR INSTRUCTION

ENTRY-LEVEL KNOWLEDGE

In Grade 8 Science, students learned about the major structures in plant and animal cells and their functions. The role of proteins in the body is discussed in Grade 11 Biology.

TEACHER NOTE

While students can generally understand the processes of DNA replication and transcription, they may have difficulty grasping the concept of translation. The use of a variety of instructional strategies can help students gain a better understanding of protein synthesis.

BACKGROUND INFORMATION

Ribonucleic acid (RNA) differs from DNA in the following ways:

- RNA contains the nitrogenous base uracil instead of thymine.
- RNA contains ribose instead of deoxyribose.
- RNA is single-stranded.
- RNA carries the genetic information found in DNA in the nucleus to the ribosomes in the cytoplasm.
- RNA comes in three forms (messenger, transfer, ribosomal), all of which are involved in translating the genetic information into the amino acid sequence of proteins.

ACTIVATE

Table Conference

Organize students into table groups. Ask the groups to recall the location and function of the following cell parts: nucleus, nuclear membrane, cytoplasm, and ribosome.

Then, pose the following question to groups:

- If the genetic code for proteins is contained in the DNA in the nucleus of the cell, and the ribosomes that construct the proteins are located in the cytoplasm of the cell, how is it possible that proteins get built?

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-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)

Remind the groups to give each student an opportunity to speak and encourage them to discuss all ideas (Keeley). Students should talk about a variety of possible ideas, and discuss their strengths and weaknesses.

ACQUIRE/APPLY

Visualizing Protein Synthesis (U1)

The use of diagrams, videos, models, or computer animations to illustrate and describe the processes of transcription and translation can assist in the development of students' conceptual understanding.

Suggestion for Assessment

Using information gathered from instruction, students create a Chain Concept Map (flow chart) to illustrate the process of protein synthesis. Teachers can use this tool to monitor students' understanding of protein synthesis and to address any difficulties. For more information on Chain Concept Maps, see *SYSTH* (pp. 11.14–11.15).

PROTEIN SYNTHESIS

SPECIFIC LEARNING OUTCOMES

B12-2-05: Compare DNA and RNA in terms of their structure, use, and location in the cell. (GLOs: D1, D3)

B12-2-06: Outline the steps involved in protein synthesis. (GLOs: D1, D3)

Include: mRNA, codon, amino acid, transcription, tRNA, anticodon, ribosome, and translation

RNA Transcription—Model Building (U2, G1)

Using the DNA model, students simulate the process of mRNA transcription. One strand of mRNA should result.

Suggestions for Assessment

Students use their models to demonstrate and describe to their peers the process of RNA transcription, and receive feedback from peers as to their understanding of the process. For more information on peer assessment, refer to Appendix 4.2A: Peer Assessment (Teacher Background) and Appendix 4.2B: Guidelines for Peer Assessment (BLM).

Alternatively, conduct interviews with individual students or small groups of students. The students use their models to describe and demonstrate their understanding of RNA transcription.

DNA and RNA—Compare and Contrast (U2)

Students complete a Compare and Contrast frame to differentiate between DNA and RNA, or transcription and translation. For a Compare and Contrast template, refer to *SYSTH* (p. 10.24).

Suggestion for Assessment

Review the completed frames to verify students' comprehension, and re-teach material if necessary.

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-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)

Protein Synthesis Assembly Line—Analogy (U2, I4)

With the assistance of a few students, simulate the assembly line manufacture of "widgets," and relate this analogy to the processes of transcription and translation.

- Big Boss (DNA) has the plans for widgets.
- Supervisor (mRNA) makes a copy of the plan and carries the copy to the shop floor assembly line.
- Runners (tRNA) bring the required components (amino acids) to the assembly line from stock shelves.
- Assembler (ribosome) links the components together to form widgets (proteins).

Suggestion for Assessment

While analogies can be useful when learning new concepts, they are not perfect representations. Ask students to discuss the strengths and weaknesses of the assembly line analogy for describing protein synthesis. The responses can be used as a formative assessment to determine students' levels of understanding and to guide further teaching and/or learning activity selection (if needed).

PROTEIN SYNTHESIS

SPECIFIC LEARNING OUTCOMES

B12-2-05: Compare DNA and RNA in terms of their structure, use, and location in the cell. (GLOs: D1, D3)

B12-2-06: Outline the steps involved in protein synthesis. (GLOs: D1, D3)

Include: mRNA, codon, amino acid, transcription, tRNA, anticodon, ribosome, and translation

Translating the Genetic Code (U2)

Ask students to complete the following chart using the mRNA genetic code.

DNA Complement	DNA Template	mRNA Codon	tRNA Anticodon	Amino Acid
			GCG	
GTA				
		AAC		
				tryptophan
	AGC			

Suggestion for Assessment

Whatever the form of assessment used, students should be made aware of the assessment criteria beforehand.

Answers

DNA Complement	DNA Template	mRNA Codon	tRNA Anticodon	Amino Acid
CGC	GCG	CGC	GCG	arginine
GTA	CAT	GUA	CAU	valine
AAC	TTG	AAC	UUG	asparagine
TGG	ACC	UGG	ACC	tryptophan
TCG	AGC	UCG	AGC	serine

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-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)

NOTES

GENE MUTATION

SPECIFIC LEARNING OUTCOMES

B12-2-07: Relate the consequences of gene mutation to the final protein product. (GLOs: D1, D3)

Examples: point mutation in sickle-cell anemia, frameshift mutation in β-thalassemia . . .

B12-2-08: Discuss implications of gene mutation for genetic variation. (GLOs: D1, E1, E3)

Include: source of new alleles

SLO: B12-2-07
SLO: B12-2-08

SUGGESTIONS FOR INSTRUCTION

ENTRY-LEVEL KNOWLEDGE

In Grade 9 Science, students investigated and described environmental factors and personal choices that may lead to genetic mutation.

TEACHER NOTE

Be sensitive to the possibility that there may be students in your class who have a condition such as sickle-cell anemia or β-thalassemia, or who have a family member, neighbour, or friend with the condition.

Review with students the fact that only mutations that arise in sex cells can be passed on to the next generation. Somatic cell mutations cannot be passed on to offspring.

BACKGROUND INFORMATION

Refer to Appendix 2.1: Mutation (Teacher Background) for more information.

ACTIVATE

Opening Questions

Pose the following questions to students:

- What comes to mind when you hear the word *mutation*?
- Do think that a mutation could ever be a good thing? Why or why not?

Ask students to respond in their notebooks. Accept all student contributions. Note that most, if not all, student contributions will have negative connotations.

ACQUIRE/APPLY

Viewing Blood Cells—Microscope Activity (S3, I4)

Students examine slides of normal red blood cells and sickle-shaped red blood cells under a microscope and create biological drawings of the red blood cells found on the two slides.

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-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-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)

Suggestions for Assessment

Appendix 2.3B: Microscope Skills Checklist (BLM) can be used to assess students' microscope skills. For more information, refer to Appendix 2.3A: Microscope Skills Checklist (Teacher Background). See Appendix 2.2A: Biological Drawing (BLM) for information on creating biological drawings, and assess drawings using Appendix 2.2B: Rating Scale for Biological Drawing (BLM).

Gene Mutation and Variation (U1)

The use of diagrams, videos, models, or computer animations that illustrate and describe gene mutation and variation will enhance students' conceptual understanding.

The use of the Three-Minute Pause note-taking strategy can assist students in developing their conceptual understanding. After presenting information for a period of time, pause for three minutes to allow students to process the information.

Resource Link

- Canadian Museum of Nature. *The GEEE! in Genome*. <www.nature.ca/genome/index_e.cfm>.

  This website contains tutorials, polls, illustrations, learning activities, videos, and online games on a variety of topics such as protein synthesis, mutation, and variation.

GENE MUTATION

SPECIFIC LEARNING OUTCOMES

B12-2-07: Relate the consequences of gene mutation to the final protein product. (GLOs: D1, D3)

Examples: point mutation in sickle-cell anemia, frameshift mutation in β-thalassemia . . .

B12-2-08: Discuss implications of gene mutation for genetic variation. (GLOs: D1, E1, E3)

Include: source of new alleles

Point and Frameshift Mutations—Demonstrating Understanding (U1)

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

- What is the difference between a point mutation and a frameshift mutation?
- Which is likely to have the greatest impact on an organism? Explain.

Give students five minutes to respond in their notebooks.

Refer to Appendix 2.4: Point and Frameshift Mutations (BLM).

Suggestion for Assessment

This quick formative assessment provides information about what students learned in a particular lesson. The responses can be used to determine students' levels of understanding and to guide further teaching and/or learning activity selection (if needed).

Simulating Mutations (U1, S5)

Provide students with the following 15-nucleotide sequence of a DNA template:

TAC GCA TGG AAT TAT

- Ask students to
  - determine the mRNA codons for the DNA
    (Answer: AUG CGU ACC UUA AUA)
  - determine the amino acid sequence
    (Answer: MET-ARG-THR-LEU-ISO)
- Next, have students, individually,
  - change one DNA nucleotide at random (i.e., simulate a point mutation)
  - determine the effect of the DNA change on the amino acid sequence

  Compare all resulting amino acid sequences in the class. Note that not all point mutations lead to changes in the amino acid sequence. This is due to the redundancies in the code; that is, a single amino acid may be specified by several codons. For example, four different codons all code for glycine.

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-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-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)

- Using the original DNA sequence, have students, individually,
  - add or remove one DNA nucleotide at random (i.e., simulate a frameshift mutation)
  - determine the effect of the DNA change on the amino acid sequence

  Compare all resulting amino acid sequences in the class. Note the significant change in the amino acid sequence caused by the insertion or deletion of a nucleotide. This may lead to a devastating impact on protein function and serious consequences for the organism affected.

  Refer to Appendix 2.4: Point and Frameshift Mutations.

Mutations: Good or Bad?—Class Discussion (U2, G2)

Use the examples of sickle-cell anemia and β-thalassemia to demonstrate how random changes in DNA nucleotides often result in altered proteins that do not function as well as the normal protein. Refer to Appendix 2.4: Point and Frameshift Mutations. In the discussion, note how individuals heterozygous for either condition have an advantage over homozygous dominant and recessive individuals in their resistance to malaria (heterozygous advantage).

Suggestion for Assessment

Students respond to the Opening Questions again in their notebooks and reflect on how and why their ideas about mutations have changed. Assess students' responses for conceptual understanding (formative assessment).

INVESTIGATING APPLICATIONS OF GENE TECHNOLOGY IN BIORESOURCES

SPECIFIC LEARNING OUTCOME

B12-2-09: Investigate an issue related to the application of gene technology in bioresources. (GLOs: A3, A5, B1, B2, C4, C5)

Include: understanding the technology/processes involved, economic implications, a variety of perspectives, and personal/societal/global implications

SLO: B12-2-09

SUGGESTIONS FOR INSTRUCTION

ENTRY-LEVEL KNOWLEDGE

In Grade 9 Science, students investigated Canadian and international contributions to research and technological developments in the field of genetics. Students also discussed current and potential applications and implications of biotechnologies, including their effects upon personal and public decision making, and used the decision-making process to address a current biotechnology issue. Topics of discussion included genetic engineering, cloning, the Human Genome Project, and DNA fingerprinting.

TEACHER NOTE

Ongoing research in the field of gene technology provides both great promise and possible threat for the future. The knowledge base and its technological applications are rapidly advancing/changing. However, many ethical and practical issues surrounding the use of gene technology are hotly debated today.

Possible topics for discussion include the following:

- xenotransplantation (the transplantation of cells, tissues, or organs from one species to another)
- use of genetically modified organisms (GMOs) for food production
- patenting of transgenic organisms (e.g., seeds)
- production of drugs/vaccines using GMOs
- cloning animals, including pets
- species conservation, storing DNA
- "recreating" extinct species (e.g., woolly mammoths)

ACTIVATE

Focused Listing

Ask students to write the word *biotechnology* at the top of a piece of paper, and then list as many related terms, facts, ideas, definitions, concepts, or experiences as they can recall from previous grades (Keeley). This learning activity can also be done in small groups.

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-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-S2: Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment. (GLOs: B3, B5, C1, C2)

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-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-I3: Quote from or refer to sources as required, and reference sources according to acceptable practices. (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-G1: Collaborate with others to achieve group goals and responsibilities. (GLOs: C2, C4, C7)

B12-0-G3: Evaluate individual and group processes used. (GLOs: C2, C4, C7)

Suggestion for Assessment

Scan the lists generated by students during the Focused Listing activity to assess students' understanding of vocabulary and concepts. The information gathered can be used to plan for further instruction. Should the majority of students in the class indicate little or no understanding of or familiarity with the biotechnology terms or concepts, an adjustment in the instructional plan is required to help students develop their understanding.

INVESTIGATING APPLICATIONS OF GENE TECHNOLOGY IN BIORESOURCES

SPECIFIC LEARNING OUTCOME

B12-2-09: Investigate an issue related to the application of gene technology in bioresources. (GLOs: A3, A5, B1, B2, C4, C5)

Include: understanding the technology/processes involved, economic implications, a variety of perspectives, and personal/societal/global implications

ACQUIRE/APPLY

Gene Technology—Headlines (U1, D1, I1)

Present the class with a headline and an article related to the application of gene technology in bioresources. Brainstorm other possible gene technology applications with students, and have each student find a headline and a related newspaper or magazine article.

Examples

Bioresource	Issue
food production	use of GMOs for food
agriculture/horticulture	patenting of transgenic organisms (e.g., seeds)
microbiology	production of drugs/vaccines using GMOs (e.g., insulin for diabetes)
animals	cloning animals, including pets
animals/plants	species conservation, storing DNA (e.g., global seed bank in Norway)
animals/plants	"recreating" extinct species (e.g., woolly mammoths)

Post the headlines on the class bulletin board. The headlines and articles will be the introduction to the student presentations later in the unit.

Suggestions for Assessment

Ask students to read the gene technology article that accompanied their headline and respond to the following questions:

- What technology or processes are outlined in the article?
- What issue is discussed in the article?
- What perspectives are presented in the article?
- What implications (societal, global, and personal) related to the issue are noted in the article?
- If the article includes visuals, what story do they tell?

Students can also make a separate list of key vocabulary used in their article.

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-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-S2: Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment. (GLOs: B3, B5, C1, C2)

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-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-I3: Quote from or refer to sources as required, and reference sources according to acceptable practices. (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-G1: Collaborate with others to achieve group goals and responsibilities. (GLOs: C2, C4, C7)

B12-0-G3: Evaluate individual and group processes used. (GLOs: C2, C4, C7)

Alternatively, students could read their article and complete a Fact-Based Article Analysis or an Issue-Based Article Analysis (see *SYSTH*, pp. 11.30–11.31, 11.40–11.41).

Encourage students to use effective reading strategies to gain new knowledge from text. This includes activating their 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).

INVESTIGATING APPLICATIONS OF GENE TECHNOLOGY IN BIORESOURCES

SPECIFIC LEARNING OUTCOME

B12-2-09: Investigate an issue related to the application of gene technology in bioresources. (GLOs: A3, A5, B1, B2, C4, C5)

Include: understanding the technology/processes involved, economic implications, a variety of perspectives, and personal/societal/global implications

What Is Genetic Engineering? (U1)

The use of diagrams, videos, models, or computer animations that illustrate and describe recombinant DNA techniques will enhance students' conceptual understanding.

The use of a note-taking strategy such as a Note Frame can help students follow a lecture and organize information (see *SYSTH*. p. 11.32).

Resource Links

- BIOTECanada. Home Page. <www.biotech.ca/>.
  This website provides information on the uses and benefits of biotechnology.
- Canadian Museum of Nature. *The GEEE! in Genome.* <www.nature.ca/genome/index_e.cfm>.
  This website contains tutorials, polls, illustrations, learning activities, videos, and online games on a variety of topics such as cloning and stem cells, GMOs, Canadian researchers, and genetic disorders.
- Cold Spring Harbor Laboratory's DNA Learning Center. *DNA Interactive.* <www.dnai.org/>.
  In the *Manipulation* section of this website, students can investigate recombinant DNA technologies, the ethical issues surrounding their use, and how recombinant DNA technology is used to engineer an organism to make a commercially viable product.
- Council for Biotechnology Information. *Canada: English.* <www.whybiotech.ca/>.
  This website provides information about the benefits and safety of agricultural biotechnology and its contributions to sustainable development. See the *Resources and Information* section for articles, reports, key topics, and fact sheets, including "Biotech Basics—A Guide to Plant Biotechnology in Canada."
- CropLife Canada. *Biotechnology*. <www.croplife.ca/web/english/biotechnology/>.
  This website contains the following resource:
  Crop Protection Institute of Canada. *Plant Biotechnology: A Secondary School Teacher's Resource Manual*. Etobicoke, ON: Crop Protection Institute of Canada, n.d.

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-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-S2: Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment. (GLOs: B3, B5, C1, C2)

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-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-I3: Quote from or refer to sources as required, and reference sources according to acceptable practices. (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-G1: Collaborate with others to achieve group goals and responsibilities. (GLOs: C2, C4, C7)

B12-0-G3: Evaluate individual and group processes used. (GLOs: C2, C4, C7)

- Genome Canada. Home Page. <www.genomecanada.ca/en/>.
  The *Information for the Public* section of this website discusses a range of topics in genomics research, including forestry, agriculture, and human health. *GE³LS: Genomics and Society* addresses ethical, environmental, economic, legal, and social aspects of genomic research.

Suggestion for Assessment

The use of Note Frames assists teachers in monitoring students' understanding (formative assessment). The information can be used to adjust teaching to address difficulties. Students can also exchange their Note Frames and provide each other with feedback (peer assessment).

INVESTIGATING APPLICATIONS OF GENE TECHNOLOGY IN BIORESOURCES

SPECIFIC LEARNING OUTCOME

B12-2-09: Investigate an issue related to the application of gene technology in bioresources. (GLOs: A3, A5, B1, B2, C4, C5)

Include: understanding the technology/processes involved, economic implications, a variety of perspectives, and personal/societal/global implications

Designing a Genetically Modified Food Crop—Poster (U2, D6, I4, G1, G3)

Students apply their understanding of the genetic engineering of crops by creating a poster outlining the steps needed to make an imaginary genetically modified food crop (e.g., jalapeanuts—peanuts with the capsaicin gene inserted, making them spicy). See Appendix 2.5: Designing a Genetically Modified Food Crop (BLM) for details.

Suggestions for Assessment

See Appendix 1.13: Collaborative Process—Assessment (BLM) for a peer assessment of the group process. Refer to Appendix 5.8: Checklist for Creating Visuals (BLM) for use with visuals such as posters, collages, graphic organizers, and so on.

Inner-City Science Centre—Field Trip (P1, S2)

The Inner-City Science Centre (ICSC), located in Niji Mahkwa School on Flora Avenue in Winnipeg, Manitoba, provides access to modern science facilities, technology, and instruction, including a fluorescent microscope and Manitoba's first flash gel system for sorting DNA. Students can take part in hands-on science experiments after school or as a field trip using top-of-the-line biotech equipment ranging from a spectrophotometer (to check the purity and concentration of plasmid DNA) to an incubating orbital shaker (to grow bacterial culture) and a centrifuge (to separate cells or bacteria).

Suggestion for Assessment

Have students complete an I Used to Think, But Now I Know reflection after the field trip to ICSC. Ask students to recall their ideas at the start of the topic discussion, and have them explain how their ideas changed or became more detailed compared to what they knew at the beginning of instruction (Keeley). Students can discuss their reflections with a partner.

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-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-S2: Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment. (GLOs: B3, B5, C1, C2)

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-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-I3: Quote from or refer to sources as required, and reference sources according to acceptable practices. (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-G1: Collaborate with others to achieve group goals and responsibilities. (GLOs: C2, C4, C7)

B12-0-G3: Evaluate individual and group processes used. (GLOs: C2, C4, C7)

Gene Technologist—Guest Speaker (U2, P2, I1)

Invite a gene technologist to speak to the class. Students prepare questions in advance of the visit.

Questions may include the following:

- Who are your clients? (if appropriate)
- What background/education/experience is required to work in the field of gene technology?
- What gene technology methods are used where you work?
- What proportion of your work generates revenue? What proportion is pure research?
- Does your work provide a service to the public?

This is also a good opportunity for students to explore related careers.

INVESTIGATING APPLICATIONS OF GENE TECHNOLOGY IN BIORESOURCES

SPECIFIC LEARNING OUTCOME

B12-2-09: Investigate an issue related to the application of gene technology in bioresources. (GLOs: A3, A5, B1, B2, C4, C5)

Include: understanding the technology/processes involved, economic implications, a variety of perspectives, and personal/societal/global implications

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 presentation 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).

Applications of Gene Technology—Research and Presentation/ Culminating Task (P5, D1, D2, I1, I2, I3, I4)

Students investigate an aspect of the application of gene technology in bioresources, including the technology used, issues involved, perspectives, and implications. An investigation of this sort can be used as a culminating task for the unit, bringing together a number of knowledge and skills outcomes.

Suggestion for Assessment

Students prepare oral presentations, accompanied by visuals, that outline the technology, issues, perspectives, and implications related to the use of gene technology in bioresources. See Appendix 2.6A: Gene Technology Presentation (BLM), Appendix 2.6B: Gene Technology Presentation Outline—Graphic Organizer (BLM), Appendix 2.6C: Gene Technology Presentation—Teacher Background, and Appendix 2.6D: Assessment Rubric for Gene Technology Presentation (BLM).

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-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-S2: Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment. (GLOs: B3, B5, C1, C2)

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-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-I3: Quote from or refer to sources as required, and reference sources according to acceptable practices. (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-G1: Collaborate with others to achieve group goals and responsibilities. (GLOs: C2, C4, C7)

B12-0-G3: Evaluate individual and group processes used. (GLOs: C2, C4, C7)

NOTES

INVESTIGATING APPLICATIONS OF GENE TECHNOLOGY IN HUMANS

SPECIFIC LEARNING OUTCOME

B12-2-10: Investigate an issue related to the application of gene technology in humans. (GLOs: A3, A5, B1, B2, C4, C5)

Include: understanding the technology/processes involved, ethical and legal implications, a variety of perspectives, and personal/societal/global implications

SLO: B12-2-10

SUGGESTIONS FOR INSTRUCTION

ENTRY-LEVEL KNOWLEDGE

In Grade 9 Science, students investigated Canadian and international contributions to research and technological developments in the field of genetics. Students also discussed current and potential applications and implications of biotechnologies, including their effects on personal and public decision making, and used the decision-making process to address a current biotechnology issue. Topics of discussion included genetic engineering, cloning, the Human Genome Project, and DNA fingerprinting.

TEACHER NOTE

Ongoing research in the field of gene technology provides both great promise and possible threat for the future. The knowledge base and its technological applications are rapidly advancing/changing. However, many ethical and practical issues surrounding the use of gene technology are hotly debated today.

Possible topics for discussion include the following:

- DNA fingerprinting
- cloning humans
- gene therapy
- stem cell research
- DNA sequencing
- use of DNA in tracing human origins
- "designer" babies
- genetic screening/testing

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-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-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-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 . . .

B12-0-N3: Recognize both the power and limitations of science in answering questions about the world and explaining natural phenomena. (GLO: A1)

ACTIVATE

Role Play

Knowledge of a client's genetic screen could affect the cost of insurance. Insurance companies operate on a risk-assessment basis, with individuals who have a greater potential of developing health complications being charged more for insurance than individuals who are deemed healthy. Actuaries look at statistics to determine how much their clients should be charged. With current advancements in genetic testing, there is the potential to discriminate against those with "bad genes." It is quite possible that individuals classified as high risk may be denied the opportunity to purchase insurance. However, insurance companies must operate as a business, looking out for themselves, their shareholders, and their clients' best interests.

INVESTIGATING APPLICATIONS OF GENE TECHNOLOGY IN HUMANS

SPECIFIC LEARNING OUTCOME

B12-2-10: Investigate an issue related to the application of gene technology in humans. (GLOs: A3, A5, B1, B2, C4, C5)

Include: understanding the technology/processes involved, ethical and legal implications, a variety of perspectives, and personal/societal/global implications

Divide the class into two large groups. Assign each group a different scenario and have the groups prepare their responses.

Scenario 1

You represent an individual who has obtained a genetic screen and would like to purchase life insurance. Results show that you are at extremely high risk for developing cancer and hypertension (high blood pressure). However, you are currently a healthy individual. You do not smoke, you have a healthy diet, and you exercise regularly. Explain why you should be given the opportunity to purchase life insurance at a reasonable price.

Scenario 2

You represent an insurance company. A potential client has approached your company about the possibility of purchasing life insurance. After reviewing the individual's file, including the genetic screen, you realize the individual falls into a high-risk category. Explain to the potential client why you need to charge him or her considerably more for life insurance than a standard rate.

Pair up students from opposite groups. Students role play their scenarios and attempt to negotiate a fair settlement. Emphasize that positive social processes must be used in the negotiations (e.g., bargaining, compromise, sensitivity). For guidelines for role-playing scenarios, refer to *SYSTH* (p. 4.18).

Following the role-playing, students analyze the negotiation process and record their reflections in their notebooks.

ACQUIRE/APPLY

Using Gene Technologies (U1)

The use of diagrams, videos, models, or computer animations that illustrate and describe applications of gene technology in humans will enhance students' conceptual understanding.

Resource Links

- Cold Spring Harbor Laboratory's DNA Learning Center. *DNA Interactive.* <www.dnai.org/>.
  In the *Applications* section of this website, students can investigate techniques of forensic analysis and use them to solve a historical puzzle, and discover how DNA science can be applied to health care and to tracing human origins.

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-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-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-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 . . .

B12-0-N3: Recognize both the power and limitations of science in answering questions about the world and explaining natural phenomena. (GLO: A1)

- Genetic Science Learning Center. *Learn.Genetics.* <http://learn.genetics.utah.edu/>.
  The *Genetic Technology* section of this website includes interactive animations and tutorials on stem cells, cloning, gene therapy, and transgenic mice. The *Virtual Labs* section features interactive labs on DNA extraction, polymerase chain reaction (PCR), gel electrophoresis, and DNA microarray.

- Howard Hughes Medical Institute. *BioInteractive.* <www.hhmi.org/biointeractive/>.
  This website contains short video and animated clips on a variety of DNA-related topics.

INVESTIGATING APPLICATIONS OF GENE TECHNOLOGY IN HUMANS

SPECIFIC LEARNING OUTCOME

B12-2-10: Investigate an issue related to the application of gene technology in humans. (GLOs: A3, A5, B1, B2, C4, C5)

Include: understanding the technology/processes involved, ethical and legal implications, a variety of perspectives, and personal/societal/global implications

Suggestion for Assessment

During the last five minutes of the class, have students complete an Exit Slip, reflecting on 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 students' 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).

Human Cloning—Research and Debate (U2, P2, P5, D2, I1)

Advise students that they will conduct research on and debate the following question:

- Should human cloning be permitted?

To help them record their research findings in preparation for the debate, students create a Fact and Opinion Recording Sheet by folding a sheet of loose-leaf paper in half and labelling one half "Fact" and the other half "Opinion." During the course of their research, students document statements that are either facts or opinions. If no opinions are stated in a given article, students can add their own opinions.

The Creative Controversy strategy can be used for this debate. This debating strategy requires students to gather arguments so that they can switch sides in a debate, and then move to consensus. For information on the Creative Controversy strategy, refer to *Senior 2 English Language Arts: A Foundation for Implementation* (Manitoba Education and Training, pp. 2–34).

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-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-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-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 . . .

B12-0-N3: Recognize both the power and limitations of science in answering questions about the world and explaining natural phenomena. (GLO: A1)

Suggestions for Assessment

Collect students' Fact and Opinion Recording Sheets and assess students on their accuracy of categorizing fact and opinion statements. Establish performance criteria with the class before the debate, and use the classroom-based criteria to create a rubric, such as Appendix 2.7: Debating Skills Rubric (BLM). Students can complete a self-assessment of their listening skills. See Appendix 1.14: Self-Assessment of Listening Skills (BLM).

INVESTIGATING APPLICATIONS OF GENE TECHNOLOGY IN HUMANS

SPECIFIC LEARNING OUTCOME

B12-2-10: Investigate an issue related to the application of gene technology in humans. (GLOs: A3, A5, B1, B2, C4, C5)

Include: understanding the technology/processes involved, ethical and legal implications, a variety of perspectives, and personal/societal/global implications

Selecting the Perfect Baby—Case Study (P5, D1, D2, D3, N3)

The case study "Selecting the Perfect Baby: The Ethics of 'Embryo Design'" by Julia Omarzu (available on the National Center for Case Study Teaching in Science website) considers the ethical issues of genetic manipulation and fertility treatments. Give students the opportunity to work with others to discuss and answer the questions provided. Each student should, however, record his or her individual response to the final question, as responses may vary among group members.

Encourage students to use effective reading strategies to acquire new knowledge and information from text when reading a case study. 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.

Resource Links

- 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.

- Omarzu, Julia. "Selecting the Perfect Baby: The Ethics of 'Embryo Design.'" 18 Aug. 2002. *Case Collection*. National Center for Case Study Teaching in Science. <http://sciencecases.lib.buffalo.edu/cs/collection/detail.asp? case_id=347&id=347>. Case Teaching Notes are available at <http://sciencecases.lib.buffalo.edu/cs/files/genetic_selection_notes.pdf>.

Suggestions for Assessment

Observe students as they discuss the issues raised in the case study. The topic can be emotionally charged. Note the willingness of students to listen to others and be open to others' opinions.

Assessment can be focused on a number of areas, such as group work. It can involve self-assessment and peer assessment, as well as a written response to the questions and a personal reflection.

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-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-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-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 . . .

B12-0-N3: Recognize both the power and limitations of science in answering questions about the world and explaining natural phenomena. (GLO: A1)

The Guy Paul Morin Case—Microtheme (U2, I1, I2, I3, I4, N2)

Microthemes are short writing assignments designed to help students learn the material by looking at it in a different way (Martin, "Writing 'Microthemes' to Learn Human Biology"). They require more than simply reading the text or articles and memorizing notes. Each microtheme addresses a specific problem, allowing the writer to illustrate his or her understanding. For more information on microthemes, refer to Appendix 2.8A: Microthemes (Teacher Background).

Have students complete the assignment outlined in Appendix 2.9: Gene Technology Microtheme Assignment (BLM).

INVESTIGATING APPLICATIONS OF GENE TECHNOLOGY IN HUMANS

SPECIFIC LEARNING OUTCOME

B12-2-10: Investigate an issue related to the application of gene technology in humans. (GLOs: A3, A5, B1, B2, C4, C5)

Include: understanding the technology/processes involved, ethical and legal implications, a variety of perspectives, and personal/societal/global implications

Resource Links

- National Association of Criminal Defense Lawyers (NACDL). <www.nacdl.org/>.
- ———. *The Champion*. <www.nacdl.org/public.nsf/freeform/championmag?OpenDocument>.

  For an overview of the Guy Paul Morin case, see the following article:

  King, Jack. "The Ordeal of Guy Paul Morin: Canada Copes with Systemic Injustice." *The Champion* (Aug. 1998): 8. Available on the NACDL website at <www.nacdl.org/public.nsf/championarticles/19980808?opendocument>.

Suggestion for Assessment

Discuss assessment criteria with the class. Refer to Appendix 2.8B: Microthemes—First Draft Checklist (BLM) and Appendix 2.8C: Microthemes—Final Draft Assessment (BLM).

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-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-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-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 . . .

B12-0-N3: Recognize both the power and limitations of science in answering questions about the world and explaining natural phenomena. (GLO: A1)

NOTES

NOTES

Unit 2:
Mechanisms of Inheritance
Appendices

Appendix 2.1: Mutation (Teacher Background)

Mutation is the only mechanism by which new genetic material enters the gene pool. Often, mutations involving base substitutions are neutral or without effect. For example, redundancies in the genetic code mean that a single amino acid may be specified by several codons. Therefore, a change in one base may not result in a change of amino acid. Also, the substitution of one amino acid for another may not affect the function of an enzyme, as the enzyme's active site is not changed.

In general, random changes in DNA nucleotides result in altered proteins that do not function as well as the normal protein. Hemoglobin molecules in individuals with severe (homozygous) forms of sickle-cell anemia and thalassemia cannot carry oxygen as efficiently. Sickle-cell anemia is an example of a point mutation, the substitution of one DNA nucleotide for another, so that one codon may code for a different amino acid. An example of a frameshift mutation is β-thalassemia, which involves the deletion or addition of nucleotides, so that every codon beyond the point of insertion or deletion is read incorrectly during translation.

Occasionally, however, the altered protein functions more effectively, or works in a way that gives a selective advantage to its possessor. This is how new alleles arise and contribute to evolution. In the case of sickle-cell anemia and thalassemia, individuals heterozygous for the condition are only mildly affected by anemia. However, they have a higher resistance to malaria than do those who have homozygous normal hemoglobin. This is an example of heterozygous advantage in which individuals with two different alleles of a gene have an increased survival rate.

Appendix 2.2A: Biological Drawing (BLM)

Making a Biological Drawing

Use the following criteria for making a biological drawing:

1. What to Use
   a) Use a sharp pencil.
   b) Use a clean sheet of unlined paper.
2. What to Draw
   a) Draw only what you see.
   b) Draw only what is necessary.
3. How to Draw
   a) Centre your diagram.
   b) Draw a large enough diagram to show details clearly (approximately half a page).
   c) Make your proportions accurate.
4. Showing Depth
   a) Do not shade.
   b) Show depth with stippling.
5. Label Your Drawing
   a) In your title, include the name of the slide, the total magnification, the date observed, the field diameter, and the size of the object.
   b) Label specific information. Labels should be printed, written horizontally, and placed to the right of the drawing.
   c) Use a ruler to draw labelling lines and do not cross the lines.

Appendix 2.2B:
Rating Scale for Biological Drawing (BLM)

Name _____

Title of Drawing or Lab _____

	Possible Points	Self-Assessment	Teacher Assessment
1. Tools/Material (What to Use) a) Used sharp pencil. b) Used clean sheet of unlined paper.			
2. Content (What to Draw) a) Drawing includes only what was observed. b) Drawing includes only what is necessary.			
3. Approach (How to Draw) a) Diagram is centred. b) Diagram is large enough to show details clearly. c) Proportions are accurate.			
4. Showing Depth a) Did not shade. b) Used stippling to show depth.			
4. Labelling (Label Your Drawing) a) Title includes the name of the slide, the total magnification, the date observed, the field diameter, and the size of the object. b) Specifics on diagram are labelled. c) Labelling lines are drawn with a ruler and do not cross.			
Totals			
Comments			

Appendix 2.3A:
Microscope Skills Checklist (Teacher Background)

When using the Microscope Skills Checklist, use one page per student and use it throughout the course. Either a check mark or a date reference can be placed in the appropriate column to indicate whether the student is *meeting* or *not yet meeting expectations*. Anecdotal comments can be recorded in the space provided below the table (be sure to include a date with the comment).

While these skills could be assessed through a pencil-and-paper task, that approach would not provide feedback on the student's *skill level* in performing the required tasks. It would only provide information as to a student's *knowledge* of what the steps/procedures are. Performance tasks and observational assessment should be used whenever possible.

Appendix 2.3B: Microscope Skills Checklist (BLM)

Name _____

Skills	Meeting Expectations	Not Yet Meeting Expectations
1. General Microscope Skills a) Handles and cares for microscope properly. b) Selects proper magnification to see the object (i.e., cell or tissue). c) Uses only fine focus on medium and high power. d) Watches from the side when bringing object and lens together. e) Uses diaphragm and/or mirror to adjust light properly.		
2. Proper Technique to Focus Object under Various Magnifications (i.e., parfocal) a) Starts on low power with coarse adjustment. b) Centres object. c) Adjusts fine focus. d) Moves up to medium or high power using only fine focus.		
3. Preparing a Wet Mount Slide a) Places specimen and drop of water on slide. b) Lowers cover slip at a 45° angle.		
4. Staining a Wet Mount Slide a) Prepares the wet mount slide. b) Places a drop of stain on one side of the cover slip. c) Draws through with a paper towel.		
5. Oil Immersion Technique (Optional) a) Properly focuses slide on high power. b) Swings lens to the side. c) Puts drop of oil on slide. d) Positions oil immersion lens and focus.		
6. Technical Skills a) Determines total magnification. b) Determines object size.		
Comments (include date)		

Appendix 2.4:
Point and Frameshift Mutations (BLM)

Point mutation: substitution of one DNA nucleotide for another, so that one codon may code for a different amino acid.

Normal beta hemoglobin chain

```
ATG GTG CAC CTG ACT CCT GAG GAG AAG TCT GCC ACT GCC CTG TGG GGC AAG GTG AAC GTG GAT GAA GTT GGT . . .
   Val  His  Leu  Thr  Pro  Gln  Glu  Lys  Ser  Ala  Thr  Ala  Leu  Trp  Gly  Lys  Val  Asn  Val  Asp  Gln  Val  Gly . . .
```

Sickle-cell beta hemoglobin chain

```
ATG GTG CAC CTG ACT CCT GTG GAG AAG TCT GCC ACT GCC CTG TGG GGC AAG GTG AAC GTG GAT GAA GTT GGT . . .
   Val  His  Leu  Thr  Pro  Val  Glu  Lys  Ser  Ala  Thr  Ala  Leu  Trp  Gly  Lys  Val  Asn  Val  Asp  Gln  Val  Gly . . .
                        ^
```

Substitution of thymine for adenine causes coding for valine instead of glutamine. This causes the beta hemoglobin chain to fold incorrectly, producing defective hemoglobin. The red blood cells are distorted into a sickle or crescent shape and their oxygen-carrying capacity is reduced.

Frameshift mutation: deletion or addition of nucleotides, so that every codon beyond the point of insertion or deletion is read incorrectly during translation.

Normal beta hemoglobin chain

```
ATG GTG CAC CTG ACT CCT GAG GAG AAG TCT GCC ACT GCC CTG TGG GGC AAG GTG AAC GTG GAT GAA GTT GGT . . .
   Val  His  Leu  Thr  Pro  Gln  Glu  Lys  Ser  Ala  Thr  Ala  Leu  Trp  Gly  Lys  Val  Asn  Val  Asp  Gln  Val  Gly . . .
```

β-Thalassemia hemoglobin chain

```
                                  -AA
ATG GTG CAC CTG ACT CCT GAG GAG G    TCT GCC ACT GCC CTG TGG GGC AAG GTG AAC GTG GAT GAA GTT GGT . . .

ATG GTG CAC CTG ACT CCT GAG GAG GTC TGC CGT TAC TGC CCT GTG GGG CAA GGT GAA CGT GGA TGA
   Val  His  Leu  Thr  Pro  Gln  Glu  Val  Cys  Arg  Tyr  Cys  Pro  Val  Gly  Gln  Gly  Glu  Arg  Ala  Stop
                                     ^                                                                  ^
```

Missense (change in the codons) from point of nucleotide deletion creates an early polypeptide chain termination. The beta hemoglobin molecule is short, producing a defective hemoglobin molecule. The red blood cells are smaller than normal and their oxygen-carrying capacity is reduced.

References

Carnegie Institution for Science. "Sickle Cell Anemia." Available at <http://carnegiescience.edu/first_light_case/horn/lessons/sickle.html> (17 Sept. 2010).

Orkin, Stuart H., and Sabra C. Goff. "Nonsense and Frameshift Mutations in β^{o}-Thalassemia Detected in Cloned β-Globin Genes." *The Journal of Biological Chemistry* 256.19 (1981): 9782–84. Available online at <www.jbc.org/content/256/19/9782. full.pdf+html?sid=21c12b48-7a1d-434b-867e-4c219a3d534e> (6 Apr. 2011).

Appendix 2.5: Designing a Genetically Modified Food Crop (BLM)

Introduction

Imagine that you are working for a gene technology company that focuses on developing genetically modified food crops. You and your colleagues (classmates) have been assigned the task of designing potential new food crops. You will be divided into teams of three or four by your manager (teacher) to brainstorm ideas for potential new food crops. One of your team's ideas for a new food crop will be presented to the company in the form of a poster.

Purpose

You will apply your understanding of genetic engineering of crops by creating a poster outlining the steps of the genetic engineering process, as well as the potential benefits and limitations of your new genetically modified food crop.

Materials

- poster paper
- markers
- other items you want to include on your poster (e.g., diagrams, pictures)

Procedure

1. Your manager will divide you into teams of three or four.
2. In your teams, brainstorm ideas for a new genetically modified food crop.
3. Choose one of your team's ideas, and outline the steps necessary to create the new crop.
4. Create a poster that outlines the steps of the process to create the new genetically modified food crop.
   a) Explain, and include drawings of, each step in the genetic engineering process.
   b) List the potential benefits and limitations of the new food crop.
5. Each team will use their poster to present their new genetically modified food crop idea to their colleagues and manager.

Appendix 2.6A: Gene Technology Presentation (BLM)

You will now prepare a five- to seven-minute oral presentation, accompanied by visuals, that outlines the technology, issues, perspectives, and implications related to the use of gene technology in bioresources.

Review the headlines presented throughout the Mechanisms of Inheritance unit and the issues discussed in class. Which gene technology issue interests you the most? On which issue can you find adequate information for your presentation (e.g., current, covers various points of view, catchy visuals)?

Prepare a presentation that outlines the gene technology, and the issues, perspectives, and implications related to its use. Focus on the varied points of view. What are the concerns of each side? You must use two current sources of information (within the last two years). Your presentation will have two parts, visual and oral. The visual may take a variety of forms (e.g., PowerPoint, model, poster, demonstration) and is meant to outline the key ideas of your presentation. You must give the details in your five- to seven-minute oral presentation.

In the oral presentation, introduce your topic, the type of technology involved, and the selected issue, and then discuss two differing perspectives on the issue, as well as the societal, global, and personal implications. Back up your points with facts from your research. For more information, see Appendix 2.6B: Gene Technology Presentation Outline—Graphic Organizer (BLM). Throughout the unit, you have learned how genes work in organisms and how we can manipulate that knowledge to our advantage. Use the facts and vocabulary of the unit in your presentation.

Appendix 2.6B: Gene Technology Presentation Outline—Graphic Organizer (BLM)

Name _____

Your teacher must approve your presentation outline before you proceed. Bring at least two resources to review with your teacher.

Topic
Type of Technology
Issue
Perspective A
Perspective B
Possible Actions
Societal Implications
Global Implications
Personal Implications
Other Key Points
Type of Visual Presentation

Appendix 2.6C: Gene Technology Presentation (Teacher Background)

Introduction

Present a headline from a magazine or newspaper article about the application of gene technology in bioresources. Brainstorm possible topics with students. Schedule deadlines for finding headlines and presentation dates. You can expect that students may bring a variety of headlines that may not fit the topic, or will be factual and not issue-based. This is a good opportunity to discuss the dynamic nature of biology, even if the article is not suitable for the presentation.

Sample Presentation Outline

Topic: Genetically Modified Food

Type of Technology
Genes do not always work when spliced into foreign surroundings; they need help to function. Biotechnologists do not simply insert genes; instead, they use promoters. A promoter is a gene fused to a DNA section from a pathogenic virus that promotes gene expression. The gene then functions, but not in its natural way. It acts like an invading virus.

Issue
Do the benefits of using genetically modified foods outweigh the detriments?

Perspective A
Traditional breeding methods are slow and labour-intensive. Through genetic modification, organisms can be given a desirable gene in one generation. That gene can be from similar or distantly related species. For example, INGARD®, genetically modified (GM) cotton, contains a gene from a soil bacterium that makes it more resistant to a caterpillar pest. The economic benefit of using the GM cotton is that it requires less herbicide use. The crop may also be healthier. The economic detriment of using the GM cotton is that the seeds are much more expensive to buy.

Perspective B
The major arguments against GM foods are the potential risks to the environment and possible risks to humans. There is a concern that the GM gene will spread into the environment, as evidenced by the case of contamination of local crops by Roundup Ready® Canola in Saskatchewan in the late 1990s. Will we see new allergic reactions, exposure to toxins, and new diseases emerge by using viral and bacterial vectors to transfer genes?

Appendix 2.6C:
Gene Technology Presentation (Teacher Background) *(continued)*

Possible Actions

- Grow GM crops (recognizing limitations on distribution).
- Use some GM crops only for animal feed.
- Do not use GM crops without further testing.

Societal Implications

- A healthier human population from improved food sources (e.g., rice that contains Vitamin A that helps prevent blindness)

Global Implications

- Accessibility of GM crops (e.g., can everyone afford to grow them?)
- Growing GM crops in marginal areas (e.g., developing salt-tolerant crops)
- Growing GM crops over a larger range (e.g., frost/drought-resistant crops such as frost-tolerant strawberries)

Personal Implications

- Healthier food sources (e.g., potatoes that absorb less oil when fried are being developed)
- Choosing whether or not to grow GM crops

Other Key Points

- Monsanto versus Schmeiser court case over the use of Roundup Ready Canola

Type of Visual Presentation

- PowerPoint
- Pictures of GM foods, pictures of canola, focus on how genes are spliced, picture of a label for GM food

Appendix 2.6D: Assessment Rubric for Gene Technology Presentation (BLM)

Name _____

Criteria	Exemplary 4	Accomplished 3	Developing 2	Beginning 1
Content	• shows excellent depth of understanding of topic • clearly identifies issue, two perspectives, and implications	• shows good understanding of topic • identifies issue, two perspectives, and implications	• shows basic understanding of topic • somewhat identifies issue, two perspectives, and implications	• shows minimal understanding of topic • poorly identifies issue, two perspectives, and implications
Organization	• presentation is very well organized, logical, and interesting	• presentation is organized, logical, and interesting	• presentation shows signs of organization, but some parts do not fit the topic	• presentation shows poor organization and lack of preparation
Visuals	• makes excellent use of visuals • visuals support the key ideas well	• makes good use of visuals • visuals support the key ideas	• makes adequate use of visuals • visuals support the key ideas somewhat	• makes poor use of visuals • visuals do not support the key ideas
Delivery	• words are clear, and spoken at correct speed • voice is loud enough to be heard easily	• most words are clear, and often spoken at correct speed • voice is loud enough to be heard	• some words are clear, but at times spoken too quickly • voice sometimes cannot be heard	• many words are unclear, and spoken too quickly or too slowly • voice often cannot be heard
Audience	• audience is very involved and interested	• audience is involved and interested	• audience is somewhat involved and interested	• audience is not involved or interested
Comments				

Appendix 2.7: Debating Skills Rubric (BLM)

Name _____

Criteria	Exemplary 4	Accomplished 3	Developing 2	Beginning 1
Organization of Opening Statement	• always maintains focus on the topic	• maintains focus on the topic, with few exceptions	• does not consistently maintain focus on the topic	• does not maintain focus on the topic
Use of Evidence to Support Claims	• always uses evidence to support claims	• usually uses evidence to support claims	• rarely uses evidence to support claims	• does not use evidence to support claims
Persuasiveness	• arguments are always clear and convincing	• arguments are generally clear and convincing	• arguments are sometimes clear and convincing	• arguments are not clear and/or not convincing
Teamwork	• always uses team members effectively	• usually uses team members effectively	• sometimes uses team members effectively	• does not use team members effectively
Organization of Closing Statement	• always responds with points that are specific to the topic	• usually responds with points that are specific to the topic	• sometimes responds with points that are specific to the topic	• does not respond with points that are specific to the topic

Appendix 2.8A: Microthemes (Teacher Background)

Microthemes are writing assignments designed to help students learn the science material by looking at it in a different way (Martin, "Writing 'Microthemes' to Learn Human Biology"). This involves more than simply reading the textbook or memorizing notes. Students must examine a particular case study and interpret what is going on. Afterwards, they express their ideas in a short, written work. Their writing must be concise, detailed, and accurate.

Each microtheme is based on a case study related to the unit of study and poses a question or gives a particular task. A microtheme may require specific thinking skills (e.g., create an analogy, analyze data, write from a particular point of view, examine more than one point of view).

Assessment of microtheme tasks is usually approached differently than assessment of traditional classroom activities. Microtheme tasks require higher-level thinking. It is preferable to have students complete only a few microthemes but to rework them until they have met the preset standard. This usually requires a minimum of two drafts. The standard relates to science content, task completion, and communication, and may reflect a particular grade (e.g., 70 percent). Editing of the first (and subsequent) draft may be done by the teacher or by other students in the class, with the feedback provided being formative in nature.

Students may be given the opportunity to count microthemes for a greater value, and then devalue other categories (e.g., tests, if students exhibit test anxiety). Microthemes might also be given to students who need to be absent for a period of time (e.g., due to illness, vacations) but still need to work with the material.

Appendix 2.8B: Microthemes—First Draft Checklist (BLM)

(For Teacher or Peer Editing)

Name _____	Microtheme _____
Science Content ❑ Accurate ❑ Complete/sufficient detail provided ❑ Uses appropriate scientific vocabulary ❑ Uses appropriate examples and/or diagrams — *detail should reflect high-school level* — *use of biological terms enhances the writing (correct use of terms, doesn't detract from flow)*	**Feedback**
Task Completion ❑ Task completed effectively (e.g., explanation given, question answered, argument made, point of view represented) — *last paragraph should provide a concise summary of problem and solution, statement of recommendation, etc.* **Provide additional criteria related to specific microtheme:** ❑ ❑ ❑	**Feedback**
Communication ❑ Communicates effectively (spelling, grammar, flow) ❑ Format or voice appropriate to the task or audience — *clear sentence structure* — *writing is clear and unambiguous* — *no spelling or grammatical errors*	**Feedback**

Appendix 2.8C: Microthemes—Final Draft Assessment (BLM)

Name _____	Microtheme _____	
Science Content ❑ Accurate ❑ Complete/sufficient detail provided ❑ Uses appropriate scientific vocabulary ❑ Uses appropriate examples and/or diagrams — *detail should reflect high-school level* — *use of biological terms enhances the writing (correct use of terms, doesn't detract from flow)*	**Possible Points** 5 — met all criteria 3–4 — met most criteria 1–2 — met few criteria Score _____	**Comments**
Task Completion ❑ Task completed effectively (e.g., explanation given, question answered, argument made, point of view represented) — *last paragraph should provide a concise summary of problem and solution, statement of recommendation, etc.* **Provide additional criteria related to specific microtheme:** ❑ ❑ ❑	**Possible Points** 5 — met all criteria 3–4 — met most criteria 1–2 — met few criteria Score _____	**Comments**
Communication ❑ Communicates effectively (spelling, grammar, flow) ❑ Format or voice appropriate to the task or audience — *clear sentence structure* — *writing is clear and unambiguous* — *no spelling or grammatical errors*	**Possible Points** 5 — met all criteria 3–4 — met most criteria 1–2 — met few criteria Score _____	**Comments**
	Overall Score _____	

Appendix 2.9:
Gene Technology Microtheme Assignment (BLM)

The Guy Paul Morin criminal case is a famous Canadian example of how DNA evidence freed an innocent man from life imprisonment for murder. Research the case and the use of DNA fingerprinting or profiling. Include one article on the Morin case and one article on the DNA fingerprinting procedure. Highlight the key points.

When you have done your reading, prepare to write your microtheme assignment. Imagine that the defence attorney in the 1995 trial wants to use DNA fingerprinting evidence to prove Morin's innocence. His problem is that the jury is not very familiar with the DNA fingerprinting procedure. You have been called as an expert witness for the defence, as it is felt that your explanation would be more easily understood by the jury. The defence attorney does not want a technical expert who will talk above the heads of the jury.

Prepare your presentation and write it up as a dialogue between you and the defence attorney. Be sure to outline the DNA fingerprinting procedure. As mishandling of the evidence has been a problem in this case, you must indicate how the materials were properly collected and tested. What are the proper guidelines to follow? Include one diagram that you will use to instruct the jury.

The microtheme should be 300 to 400 words in length and a dialogue format should be used. Spelling and grammar will be checked.