Section 1.2 Genes: Answers and Questions

(Student textbook pages 16 to 28)

In this section, students will explore the nucleus and genetic material. They will learn that DNA is a molecule carrying genes that store the full set of information unique to an organism, and that this is the site at which mutations occur. They will also learn that genes control the production of proteins responsible for the structure and function of cells. Students will explore many ethical debates that have developed from our capacity to use our knowledge of DNA in many ways including genetic screening, genetic engineering, and transgenic organisms.

Specific Expectations

- **B1.1** analyse, on the basis of research, ethical issues related to a technological development in the field of systems biology, and communicate their findings
- **B1.3** describe public health strategies related to systems biology, and assess their impact on society

Common Misconceptions

- Students may believe that all mutations are bad. Explain that all differences in DNA (or genes) are mutations, or better yet, "varieties." Some varieties benefit the organism and the species, while others are indeed harmful. And some mutations in the current environment pose no obvious or expressed benefit or harm.
- Students may believe all mutations lead to cancer. Let students know that a deeper conversation on cancer and its causes is still to come. Simplify your answer at this point to say that cancers are caused by a group of mutations that all affect the rate of cell division in one way or another.
- Students may believe that all mutations that arise are then expressed (and in a negative way). Explain that some mutations occur in regions of DNA that are not a part of a gene, and therefore have no effect. Explain also that some genes are not turned on (e.g., coding for proteins). A mutation in a non-coding gene will not produce a change in the organism or its cells.
- Students may think that transgenic organisms and genetically modified organisms (and foods) are hazardous to our health simply because we have not performed long-term studies on the affects of these organisms. They may also think that when a spider silk gene is inserted into the genome of a plant (for greater structural integrity) and the plant is then used for food, the person eating the plant is essentially eating a spider. Explain that all molecules are made of the same components (i.e., atoms) and that genes and proteins are simply molecules, too. Also, explain that allergic reactions in these cases are unlikely and have been tested for in trials.

Background Knowledge

Different proteins have different roles, determined by the metabolic and structural needs of a living cell. Some of these roles include: transporting molecules around a cell; catalysing chemical reactions as enzymes; organ to organ communication (as hormones); directing cell processes; growth and division; and controlling cell death. Many of the cell's organelles are directly responsible for translating the DNA code and manufacturing proteins (ribosomes), modifying and packaging proteins (endoplasmic reticulum) and protein transport (Golgi bodies and vesicles) to ensure they are acting how and where they are intended to.

Gene mutations are errors in the DNA sequence, such as insertions, deletions, and substitutions. The variety of characteristics in the individuals or organisms of a species are, in fact, due to mutations. However, in cases like eye colour and hair colour, we refer to these variations as polymorphisms. Thus, the term mutation is used when a genomic change occurs that is not within the normal variations of the species. If the mutation creates a new variety that is not harmful, then we simply call it a polymorphism.

If a mutation occurs in a body cell of an adult organism, it is likely to have little impact on the organism as a whole, for the body cell has minimal chances to propagate that mutation (except in the case of a cancer mutation, which increases the rate of cell division beyond normal cycles, and thus is passed on to a greater number of cells). The cell may only divide a few more times before the organism dies, creating an insignificant ancestral descent line. However, an error in a sperm or egg cell has vastly larger implications for the embryo; all of the embryo's cells carry the mutation.

Literacy Support

Using the Text

- Encourage students to make a concept map or web to help organize their understanding. They can begin with the headings in the section, and develop the content as they progress through the material.

Before Reading

- ELL To help English language learners search for additional context and information, ask them to seek in upcoming pages (next paragraph, another visual, the section summary) other sources of information on the same topic.
- In pairs, have students anticipate which statements in **BLM 1-4 Chapter 1 Anticipation Guide** may be discussed in this section. Then, as a class, outline the issues. Identify myths and existing attitudes students have on these controversial and complex topics (i.e., cloning, DNA screening, transgenic organisms).
- Have students preview the text features, looking for headings and highlighted words. Then, create an organizer of Key Terms to be defined as they complete the section.
- Use **BLM G-48 K-W-L Chart** to create a chart for each of the three biotechnologies investigated (cloning, DNA screening, and transgenic organisms).

During Reading

- ELL Encourage students to create a storyboard or graphic novel of the text section.
- Support reading by showing as many visual representations as possible such as a DNA model, an animation on the structure of DNA, or a simple Applet on the synthesis of proteins from the DNA code. Go to **www.scienceontario.ca** for more information and links.

After Reading

- ELL Encourage students to use images and models to understand the biotechnologies in this chapter. Provide students with **BLM 1-8 Issues in Biotechnology,** which scaffolds this process.
- Have students complete a summary using a graphic organizer to deepen understanding of relationships. The main topic could be either *DNA* or *biotechnologies*.
- Students will benefit from seeing a portion of DNA constructed. Use **BLM 1-10 Modelling DNA.**
- Revisit **BLM 1-4 Chapter 1 Anticipation Guide** and **BLM G-48 K–W–L Chart** to ensure enduring understanding has been developed.

Using the Images

- DI To engage linguistic learners, explain that sickle means "C" or crescent shaped. The explanation for the true shape of red blood cells is a bit simplified for students; typically we talk about red blood cells looking like a jelly-filled donut, until someone squeezed and flattened the middle.
- Figure 1.9 demonstrates the location, size and relationship between generegions and non-gene regions of a piece of DNA. Ensure students understand that there can be thousands of genes on a single DNA strand.

- It is important to note to students that people who have an extra chromosome disorder, such as the girl in Figure 1.11, can be very capable of life skills, as the photo illustrates. Focus on the word "developmental" (development may be slower).
- Figure 1.16 provides a good opportunity to reinforce the central dogma (simplified) that genes code for proteins. Here students learn that proteins can also be pigment molecules and if the gene for a pigment protein is missing or defective, albinism results (although there are multiple genes controlling skin colouration).

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Learning Check questions, pages 18, 22, 26	Students describe the relationship among DNA, genes, and proteins. They explain the structure and nature of DNA as a code, and understand karotypes and DNA screening.	Use the alphabet as an analogy: creating 1 billion words from just 26 letters. Genes (like words) vary in length. Have students construct a given gene using **BLM 1-10 Modelling DNA.**
Activity 1-2 To Test or Not to Test? page 21	Students provide sufficient background to support the perspective of the stakeholder They think critically about the questions	Provide additional time and suggestions of resources (websites, magazines, etc.) for students to use. Allow students to express their answers and thoughts orally, with one student recording the consensus. Allow students to express themselves in another form such as a script or graphic novel.
Section 1.2 Review questions, page 28	Students explain the importance of the nucleus. They list both positive and negative implications of DNA screening. Students explain potential positive and negative impacts of mutations	Select additional questions for practice and reinforcement from **BLM 1-9 Section 1.1 Review,** or **BLM 1-15 Chapter 1 Review.** Consider scaffolding questions to provide clues to students about length of answers and key words that should be used. Allow students to answer with diagrams or graphic organizers. Have students use one of **BLM G-46 T-chart** or **BLM G-47 Venn Diagram** to demonstrate understanding of two sides of an issue. Suggest students use colour in their notes to denote a positive or negative implication of an issue.

Instructional Strategies

- DI There are three controversial biotechnologies introduced in this section (cloning, transgenic organisms, DNA screening) that provide great opportunities for issue analysis that will appeal to linguistic learners and other students who wish to develop, communicate, and debate an informed opinion. You may wish to supply **BLM 1-8 Issues in Biotechnology,** which scaffolds this process, and refer students to Science Skills Toolkit 1 (on pages 529 to 531 of the student textbook).
- Hang a large DNA model in the classroom (using coloured paper clips or sticky notes, for example) and challenge students to identify which gene it could represent. Ask them to research the shape and function of the protein this gene codes for. Or conversely, have students use **BLM 1-8 Modelling DNA** to model a given gene.
- Have students use **BLM G-46 T-chart** to brainstorm a list of diseases and disorders they have heard about (or read about in the textbook) in the left column, then note additional information on the right side as they read. Have students share their lists so other students can contribute more information.

- Have students create a stand-up organizer of information by folding a paper in three to create a triangular table talker on which all three sides are visible (i.e., standing upright). On each side, have students list a question related to cloning, DNA screening, and transgenic organisms. As they read, students should add notes or figures that help answer the question.
- Before reading the narrative on cloning, ask students to draw or write out a feasible procedure for cloning a farm animal. What tools, cells, and procedures would they need?
- Assign a specific disorder from the textbook, and have students fill in what they know and learn using a graphic organizer such as **BLM G-48 K–W–L Chart** or **BLM G-44 Main Idea Web.**
- Display in the room, a karyotype, a DNA model, and a chart showing the mutations found on the 22 (plus 2 sex) human chromosomes. Point out on the DNA model, the anti-parallel construction of the molecule, the connections between building blocks across the middle, and the backbone of the model.
- Enrichment—Have students present information about one important drug's development and marketing. Students could include information about the pharmaceutical company manufacturing the drug, the company's profit, what the drug treats, any controversy surrounding the drug, and any competing drugs.
- Enrichment—Students may wish to do research to gain a deeper understanding of these issues. Students could create a website that explores the issue. Websites could be assessed using a rubric created as a class.
- To assess students on issues in science, use **BLM A-5 Investigating an Issue Checklist.**

Activity 1-2 To Test or Not to Test? (Student textbook page 21)

Pedagogical Purpose

Testing for genetic diseases raises many ethical issues. This activity has students examine those issues on a deeper level by considering the perspectives of various stakeholders and understanding that there are always two (or more) sides to an issue. Students practice their critical thinking skills by considering both the benefits and the harm genetic information may pose to a person, a family, a community, and a society.

Planning	
Materials	Chart paper (optional)
Time	10 min to prepare 2 periods to complete

Background

Scientists are working on a cure for Huntington's disease and ways to manage the symptoms. In 2008, the U.S. Food and Drug Adminstration approved tetrabenazine, the first drug that treats the involuntary movements symptomatic of Huntington's chorea.

Nancy Wexler was awarded the Benjamin Franklin Medal in Life Science in 2007 for her role in the discovery of the gene responsible for Huntington's disease. Wexler established a model that is now used to investigate the genetic basis of inherited diseases. She became involved in the hunt for a cure when her mother died of Huntington's disease in 1978. It was already known that Huntington's disease was hereditary, but in the 1970s, the idea of mapping genes was in its infancy. She learned of a Venezuelan town near Lake Maracaibo where numerous members of an extended family suffered from Huntington's disease. In 1981, at a time when she was on staff at the National

Institute of Neurological Disorders and Stroke, Wexler made a trip to this community. She earned the community's trust when she explained that she too was at risk for the disease that the locals termed "El Mal." Within months she had enough DNA samples to take back to the U.S. where biologists found a consistent marker on chromosome 4 of those people with Huntington's disease. Knowing where the gene lay and what a bit of it looked like meant that a test for the disease could be investigated, which could lead to developments in the diagnosis and treatment of Huntington's disease and thus allow researchers to move forward from diagnosis, to treatment, to cure.

Wexler continues to regularly visit the community in Venezuela where she has now collected a family tree of over 18 000 people and some 4000 blood samples. Using this and other data sources, biologists have found the genes for numerous diseases including familial Alzheimer's, kidney cancer, two kinds of neurofibromatosis, and Amyotrophic Lateral Sclerosis (ALS). Go to **www.scienceontario.ca** for more information and links.

Activity Notes and Troubleshooting

- This is a think-pair-share activity.
- Decide on and communicate how students will be assessed. You may wish to develop criteria as a class, using **BLM A-39 Co-operative Group Work Rubric** and **BLM A-47 Communication Rubric** as a starting point.
- Allow students to select a stakeholder role, then combine groups for balance. Alternatively, carry out this activity with a "jigsaw" strategy, having groups gain expertise in a single area before dispersing and regrouping to form groups with a variety of experts who teach each other.
- To conclude, have groups contribute to a class graffiti for each stakeholder, using the questions as a guide to content. Then, as a class, highlight the most compelling arguments in each instance.

Additional Support

- DI ELL Allow linguistic and English language learners to show their understanding with a verbal presentation.
- DI Allow intrapersonal learners to choose the role they are most comfortable with.
- DI Intrapersonal learners may benefit from exploring the role of each stakeholder in turn, then analyzing which viewpoint they most identify with.
- Enrichment—Students can research any federal or provincial Act or legal cases where insurance companies have encountered the need, desire, or ability to access genetic testing information on a policy holder.
- Enrichment—Students can research why it is a certainty that a person who has the Huntington's disease gene will develop the disease. This explores the concept that some alleles are dominant (always expressed, i.e., Huntington's disease) while others are recessive (only expressed if not masked by a dominant allele).

Answers

1. - 6. Accept any opinion supported by accurate points with a full explanation.

Learning Check Answers (Student textbook page 18)

1. All of the cell's proteins are coded for by different genes found embedded on the long strands of DNA.
2. Genes control cell activities and structure by controlling what proteins are made and when.

3. Genes vary in their genetic code, the arrangement of four different building blocks.
4. It is possible because the four components can be assembled in thousands of numbers and combinations.

Learning Check Answers (Student textbook page 22)

5. A karyotype is a micrograph that shows chromosomes in a cell, indicating whether the right number are present or whether any are broken.
6. Example: Amniocentesis is a procedure that starts with a needle extracting amniotic fluid through a pregnant woman's abdomen and ends with a karyotype of the fetus. Blood sampling tests for the presence or absence of specific proteins, which indicate whether a particular gene is functioning.
7. Proteins perform a wide range of jobs essential to an organism's health. Having too little protein means the job may not get done (e.g., red blood cells poor in the protein hemoglobin cannot transport oxygen), while having too much of a certain protein (e.g., enzymes that act as a catalyst) could mean overloading cells with a certain substance (e.g., sugar).
8. People with PKU need to adjust treatment levels to handle phenylalanine, which their bodies cannot break down.

Learning Check Answers (Student textbook page 26)

9. The genetic code is considered universal because all types of organisms share the same cellular coding system (language), the same four DNA building blocks.
10. Transgenic organs may save humans from various types of organ failure. They may also make humans vulnerable to viruses that have only affected the donor species up to now.
11. Example: The ability to predict the long-term health of a fetus may be seen as not respecting the rights of that future generation (individual) to determine their own health. Or, these may support the right of future generations to avoid undesirable characteristics or diseases. Technologies that overcome longstanding human limitations may be seen to not value human limitations.
12. Example: Yes, canola oil is a common ingredient and many breads contain wheat genetically modified to increase crops.

Section 1.2 Review Answers (Student textbook page 28)

Please also see **BLM 1-11 Section 1.2 Review (Alternative Format).**

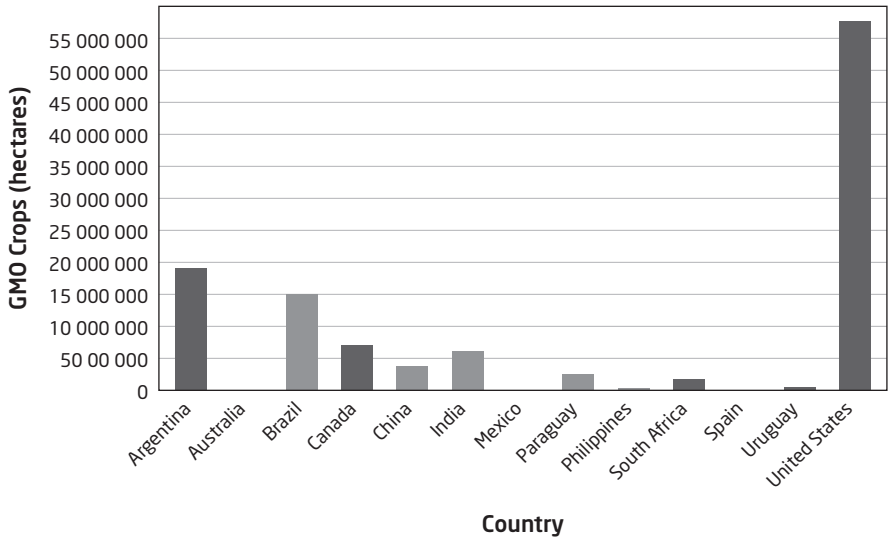
1. The nucleus is so important because it contains and protects DNA, which controls production of proteins that direct the operations, structural components, and function of the living cell.
2. 

3. Example:

Positive Implications	Negative Implications
• help people take preventative measures • Screening in utero means action can be taken at its earliest to prevent disease or harmful symptoms of the genetic disease.	• People are left with no hope as their futures seem predetermined. • Diagnosis in utero may be costly. • may prompt parents to make decisions about the life of the child

4. Example: Have the scientific standards in place before beginning, and abide by standards. Or, have results checked (repeated) by independent researchers.

5. a.



b. Example: Argentina had the most GMO Crops. A comparison to the total amount of agricultural area would enable a ratio analysis, or change the unit of measure to items (e.g., number of bananas) or mass.

c. Many European countries, like France, Italy, and Germany, are not included. Some might not have enough farmland available or might not agree with the idea of using GMO crops.

6. 20 075 minutes or 13.94 days

7. Example: Athletes may try to use genes from faster or stronger animals to improve their performance, regenerative genes to promote recovery from injury, or even genes that improve the efficient use of oxygen.

8. A mutation is any change in a gene or chromosome (an inaccurate copy of the parent gene). An albino deer would be easily spotted by a predator, meaning it would likely not survive in the wild. An albino deer in the zoo, however, would have a much longer life expectancy (though perhaps still shorter than its wild, brown relatives).