**Course Code:** SB14U  
**Unit:** Molecular Genetics

<table>
<thead>
<tr>
<th><strong>Course:</strong> Biology, Grade 12 University Preparation</th>
<th><strong>Prerequisite:</strong> Biology, Grade 11, University Preparation</th>
</tr>
</thead>
</table>
| **Course Description:**  
This course provides students with the opportunity for in-depth study of the concepts and processes that occur in biological systems. Students will study theory and conduct investigations in the areas of biochemistry, metabolic processes, molecular genetics, homeostasis, and population dynamics. Emphasis will be placed on the achievement of detailed knowledge and the refinement of skills needed for further study in various branches of the life sciences and related fields. | |

**Unit:** Molecular Genetics

**Big Ideas**  
DNA contains all the genetic information for any living organism.  
Proteins control a wide variety of cellular processes.  
Genetic research and biotechnology have social, legal, and ethical implications.

**Overall Expectations:**  
D1. analyse some of the social, ethical, and legal issues associated with genetic research and biology;  
D2. investigate, through laboratory activities, the structure of cell components and their roles in processes that occur within the cells;  
D3. demonstrate an understanding of concepts related to molecular genetics, and how genetic modification is applied in industry and agriculture.

**Links to Prior Knowledge**  
Students have been learning about the fundamentals of molecular genetics since elementary school. In grade 8 students explored cell structures. In grade 9 they covered meiosis and mitosis. Concepts of deoxyribonucleic acid has also been introduced in both of these grades. Furthermore, students may have also taken grade 11 chemistry which addresses the concepts of covalent bonding. Throughout the grade 11 university preparation biology course students evaluated the importance of recent contributions to our knowledge of genetic processes, and analysed social and ethical implications of genetics and genomic research. Students also explained concepts of DNA, genes, chromosomes and alleles.

**Primary Resources**  
Biology 12 by McGraw-Hill Ryerson 2011
Secondary Resources

**Cracking the Code of Life** (from [http://www.pbs.org/wgbh/nova/genome/program.html](http://www.pbs.org/wgbh/nova/genome/program.html))
Contains 16 different video clips that ranges from the basic knowledge to societal application (DNA codes, Human Genome Project, Variations, Mutations, STSE connections to genetic engineering and business). Each video is less than 10 min long.

**Gizmos** (from [http://www.explorelearning.com/](http://www.explorelearning.com/))
*Activity: Building DNA*
Students construct a DNA molecule, examine its double-helix structure, and then go through the DNA replication process. Learn how each component fits into a DNA molecule, and see how a unique, self-replicating code can be created.

*Activity: RNA and Protein Synthesis*
Students go through the process of synthesizing proteins through RNA transcription and translation. Learn about the many steps involved in protein synthesis including: unzipping of DNA, formation of mRNA, attaching of mRNA to the ribosome, and linking of amino acids to form a protein.

This site from NOVA offers many perspectives on whether GM crops should be grown. Teachers will be able to select from 12 valid arguments that they can put on the board as the starting point for discussion.

Interactive animation of protein synthesis with detailed explanations

**Genetic Learning Center** (from [http://learn.genetics.utah.edu/content/molecules/transcribe/](http://learn.genetics.utah.edu/content/molecules/transcribe/))
*Activity: Transcribe and translate a gene*
Students Transcribe a DNA strand, then use the resulting RNA strand and codon chart to virtually translate RNA to create a polypeptide

**Explore more Genetic Engineering** (from [http://www.iptv.org/exploremore/ge/default.cfm](http://www.iptv.org/exploremore/ge/default.cfm))
[http://www.iptv.org/exploremore/ge/Teacher_Resources/Teacher_Resources.cfm](http://www.iptv.org/exploremore/ge/Teacher_Resources/Teacher_Resources.cfm)
This is a large bank of teacher resources for teaching genetic engineering. Resources include lesson plans, Web links, teaching strategies, worksheets.

**OERB (Ontario Education Resource Bank)** (from [https://resources.elearningontario.ca](https://resources.elearningontario.ca))
This database contains materials/resources for the Molecular Genetics unit of SB4U

This experiment will be used to replace the Banana experiment in the McGraw-Hill textbook.

In this laboratory students use some basic tools of molecular biology to gain an understanding of some of the principles and techniques of genetic engineering
This site provides information on DNA sequencing and how industry used biotechnology

Accomodations
Discuss modifications that must be considered for diverse learners and learners with special needs. For example, vocabulary lists, extra time during tests and quizzes, alternative textbook reference, time-management aids, extra time for assignments, extra time for processing, note-taking assistance, duplicated notes, and alternate work places.

Unit Outline

<table>
<thead>
<tr>
<th>Lesson (Title and Topic)</th>
<th>Expectation Codes</th>
<th>Lesson Summary</th>
<th>Resources/Teaching strategies</th>
<th>Assigned work</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>STSE - Introduction to Molecular Genetics</td>
<td>D 3.7, A 2.1, A 2.2</td>
<td>Review what is the function of DNA (hereditary genetic material from grade 11 biology). Introduce the term “biotechnology” Discuss Human Genome Project Activity: Students create a mind map at the beginning of class outlining what they think genetics is (what it encompasses). On the back of the page, they create a blank mind map to be filled in at the end of class (revised mind map) based on what was reviewed.</td>
<td>PBS video clip #1 and #15 (Human Genome project) Mind-Map Question/Answer/</td>
</tr>
<tr>
<td>2</td>
<td>Extracting DNA Lab</td>
<td>D 2.1 D 2.3 [PR, AI, C]</td>
<td>Students will extract DNA from Onion cells and observe it’s characteristics. They will also understand the steps involved in isolating DNA and why each is needed. Lesson: Teacher begins with short discussion on what DNA extraction is and why it is necessary. Introduce the lab experiment, it’s purpose, materials needed, and procedure. Flowchart: Students fill in a flow chart of the lab procedure, outlining the importance of each step. Lab Activity: In groups of 4 students will complete the lab experiment and record their observations. Lab Questions: Students complete and hand in lab questions.</td>
<td>Lecture Lab activity Demonstration Graphic organizers Procedure handout</td>
</tr>
</tbody>
</table>
| 3 | DNA Structure | D 2.3  
|   |              | D 3.7  
| Students will learn about the chemical composition of DNA and how this composition influences DNA’s structure  
**Lecture:** Introduce the history of DNA structure research (Watson and Crick).  
**Activity:** Have students make paper models of DNA  
Use transparencies/ chalkboard magnets to demonstrate 3’ and 5’ notation  
**Homework:** Assign reading on DNA Replication (pages 219-226 of Mcgraw text) | Discussion/ Lecture  
Group Learning |
| 4 | DNA Replication and Repair | D 3.1  
| Lesson:** Using computer lab or laptops, students will follow along in lecture overviewing DNA replication/repair with this animation and this interactive tool.  
**Activity:** Students will use the building DNA Gizmo on the Explore Learning Website. They will complete the Handout while working on the Gizmo.  
**Pair-Work:** Students will generate flash cards of key terms in the section and take turns quizzing each other.  
**Activity:** Students will complete a flow chart summarizing key steps in DNA replication. They can work independently or in groups of up to 3. They must use the key terms for enzymes and other molecules involved. Students will hand in their flowchart for formative assessment using a co-created rubric (communication) | Computer Lab  
Question/Answer  
Graphic Organizers | DNA replication flowcharts for formative assessment |
5 | Introducing Protein Synthesis | D3.2 D 3.3 D3.7 [IP] | **Hook:** Breakdown lesson from previous day. Take up any questions from homework.  
**Lesson:** Teacher led lesson giving an overview of Protein Synthesis (Major steps, components, purpose). Introduce concept of one-gene/one-polypeptide outlining Beadle and Tatum’s experiment (Page 245). Also introduce the genetic code using table 6.1 - students receive copy missing some entries to fill in.  
**Video:** Watch video on protein synthesis, discuss as class  
**Anchor Charts:** As a class create anchor charts that highlight the major steps leading up to protein synthesis and those directly involved. Post these charts up in class for future reference.  
Teacher will also distribute the success criteria for the Translation/Transcription Oral Test. | Lecture  
Graphic Organizer  
Discussion |

6 | Investigation Transcription & Translation | D 3.2 D 3.3 | **Discussion:** Discussion to compare the structure and function of RNA versus DNA. Create an anchor chart for later reference (Refer to page 251).  
**Activity:** Using set of Transcription/Translation manipulatives, students will depict the process of protein synthesis on their lab bench (Groups of 3-5). Students will be provided with handouts, and may use the textbook and internet resources. The teacher will circulate between groups and take a photo of each group’s final display to be used for formative assessment. | Group Discussion  
Anchor Chart  
Group Work (3-5)  
Depiction of Transcription & Translation (formative) |

7 | Transcription & Translation | D 3.2 D 3.3 | **Hook:** Provide students with printed copies of the visuals they created in previous class. Watch protein synthesis animation to review what students learned previously.  
**Lesson:** Review the steps of protein synthesis, using chalkboard manipulatives. Students will take notes in either visual or text format, identifying key terminology  
**Consolidation:** Using their notes from the lecture, students will create cue cards for terminology and processes involved in transcription and translation, to be used for review. | Lecture |
<table>
<thead>
<tr>
<th>8</th>
<th>Computer Exploration Lab - Analysing Cell Components &amp; Protein Synthesis</th>
<th><strong>Investigation:</strong> Explore Protein Synthesis using the <a href="#">interactive guide</a>. Add any necessary cue cards for later review. Transcribe and Translate a Polypeptide. <strong>Activity:</strong> Students will save and submit screenshots of 3 polypeptides they transcribed, to be checked for completion. <strong>Consolidation:</strong> In pairs, students quiz each other using the cue cards created in previous class to prepare for their oral test.</th>
<th>Computer Lab</th>
<th>Virtually transcribed genes (formative)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Determining the Genetic Code</td>
<td><strong>Hook:</strong> Remind students of the <a href="#">Human Genome Project</a>, and the One gene-one polypeptide hypothesis. Have a short class discussion about the importance of the genetic code. <strong>Investigation:</strong> Using the codon chart introduced in lesson 5, students in pairs or small groups will determine the DNA sequence that codes for a given polypeptide (Adapted from Activity 6.2, p261). Each group will investigate a different polypeptide, creating a visual representation of their results.</td>
<td>Group Work (2-3) Investigation</td>
<td>Visual Display of genetic code &amp; polypeptide</td>
</tr>
<tr>
<td>10</td>
<td>Mutations</td>
<td><strong>Hook:</strong> Short discussion of an <a href="#">article</a> regarding tanning beds and skin cancer. Discuss the meaning of the words carcinogen and mutagen. <strong>Lesson:</strong> Present information using Powerpoint, covering how mutagens cause mutations, the effects of mutations, and repair. <strong>Discussion:</strong> Discuss the differences between types of mutations, while creating a mind map anchor chart. <strong>Consolidation:</strong> Allow time for students to explore mutations using manipulatives while answering accompanying questions. Students can also use this time to quiz each other using their cue cards in preparation of tomorrows oral test.</td>
<td>Lecture Discussion Mind Map/Anchor Chart</td>
<td>Mutation question sheet</td>
</tr>
<tr>
<td>11</td>
<td>Oral Test</td>
<td><strong>Hook:</strong> Have students break into their groups for the first 5 minutes of class to work on run through their oral test components. <strong>Investigation:</strong> Work individually on genetic code gizmos while the oral tests are going on. Students will read and answer questions from the textbook regarding gene therapy for homework. <strong>Assessment:</strong> Students will perform oral test and have a marking debrief with the rubric.</td>
<td>Oral Test</td>
<td>Genetic code and cell component Gizmo worksheet</td>
</tr>
</tbody>
</table>
|   | Comparing Gene Expression in Eukaryotes and Prokaryotes | D 1.1 D 3.3 | **Hook:** Inner life of a cell animation (7 mins)  
**Lesson:** Use powerpoint presentation to teach students the differences in gene expression between eukaryotes and prokaryotes. This will include the differences and similarities in operons and mechanisms of gene expression.  
**Activity:** Four stations in the room where students will explore different gene sites (SINEs, LINEs) in the human genome. All the information will be provided, or the technology will be provided for research. | Animation  
Powerpoint with fill in the blank sheet.  
Group work | Exit card for formative assessment |
|---|---|---|---|---|---|
| 13 | Understanding the Applications of Molecular Genetics and Biotechnology | D 3.6 | **Hook:** Collect Exit cards and discuss any questions that have arisen.  
**Lesson:** Introduce various tools in biotechnology and how they work (gel electrophoresis, PCR, vector transformations, cloning). The lesson will also introduce the lab for restriction enzymes the next day - introduce bacteriophage lambda DNA and what restriction endonucleases are. Students will be expected to take notes throughout the lesson. Handouts will be given at the end of the class for students to compare their notes with (for gel electrophoresis and PCR).  
**Additional resources:** Bacterial transformation virtual lab | PowerPoint  
Handout with cell functions  
Mind-map  
Group Work |
| 14 | Lab: Restriction Enzyme Digest of Bacteriophage DNA | D 1.2 [IP, PR, AI, C] | **Investigation:** Students will use prior knowledge to understand how restriction enzymes are used to cut DNA. Activity is entitled DNA Scissors: Introduction to Restriction Enzymes. Students will create a solution of bacteriophage lambda DNA and restriction endonucleases EcoRI, HindIII, and BamHI. Once the DNA has been splice, students will load DNA into the gel electrophoresis equipment so it can run over night  
**Consolidation:** Class debrief about the function of restriction enzymes, and how they are used in bacteria transformations. | Hands on Group work  
Group work  
Discussion/Debrief |
| 15 | Lab (continued): Gel Electrophoresis | D 1.2 [IP, PR, AI, C] | **Investigation:** The fragments produced will be separated using gel electrophoresis. Fragment sizes will be calculated from ananalysis of the agarose gel.  
**Cooperative learning:** Students will get into groups of 3-4 to analyze the results of DNA electrophoresis and discuss how the patterns of DNA fragments compare when a piece of DNA is digested using different restriction endonucleases? | Gel electrophoresis  
Group work (3 - 4) | Formal Lab Write-up. |
|   | How genetic modification is applied in industry and agriculture | Hook: DNA sequencing: Discuss the implications of the Human Genome Project  
Jig-Saw: Divide class into 4 groups, each explore how biotechnology has applied in food, in medicine, in industry, and in the environment. After 30 min send students to expert groups where each student takes a turn teaching the group what they learned from the home group. Provide a graphic organizer so the students have a place to record the information | Group discussion  
Graphic organizer for student response |
|---|---|---|
| 16 | Crime Scene Investigation Lab  
D 2.1  
D 3.5  
D 3.6  
[PR, AI, C] | Discussion: Where can the biotechnology techniques be used in the real world? What are some benefits and problems associated with the discussed biotechnologies?  
Activity: Explain that a crime has been committed and the criminal is unknown. The teacher will divide the class in two groups of 2-3 and give the students the case. Using the techniques used in previous classes, students will find the criminal. | DNA analysis activity  
Group work (2 - 3)  
DNA analysis questions |
| 17 | Review | Students will be given a review handout and be encouraged to work either independently or collaboratively to complete the handout. The teacher will walk around performing diagnostic assessment. 20 mins will be devoted half way through the period for the QR scanning code review game. The latter half of the period will be devoted to answer questions on the board. | Peer-to-Peer collaboration  
Teacher review lesson  
Review Game |
<p>| 18 | Test | Students will have the whole 75 minute period to write their test. Once done they can pick up the Newspaper article assignment on “How to Build a Better Athlete”. | |</p>
<table>
<thead>
<tr>
<th>Assessment</th>
<th>Description</th>
<th>Achievement Category</th>
<th>Assessment Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA replication flowchart</td>
<td>Students create a flowchart of the steps in DNA replication. All correct key terms must be used. In groups of up to 3.</td>
<td>K I A C X</td>
<td>Formative - using co-created rubric to assess knowledge and communication.</td>
</tr>
<tr>
<td>Transcription/Translation Depiction</td>
<td>Using manipulatives at their lab bench, students create a visual depiction of the process of transcription &amp; translation</td>
<td>X</td>
<td>Formative - Teacher observation and assessment for learning using photo of final product</td>
</tr>
<tr>
<td>Virtually Transcribed Genes</td>
<td>Using computer simulation, students will transcribe genes using the codon chart, submitting screenshots of 3 genes they transcribe</td>
<td>X I X X</td>
<td>Formative - Teacher assesses for general understanding and learning skills</td>
</tr>
<tr>
<td>Determining Genetic Code</td>
<td>Students will analyse a given polypeptide, and determine the genetic code and base pairing of DNA, creating a visual display of their results.</td>
<td>X I X X X</td>
<td>Evaluation - visual (rubric)</td>
</tr>
<tr>
<td>Mutation Questions</td>
<td>Students will use manipulatives to answer a series of questions on mutagens, resulting mutations and repair.</td>
<td>X I X X X</td>
<td>Evaluation - question sheet (rubric) Diagnostic - Teacher observation</td>
</tr>
<tr>
<td>Oral Test</td>
<td>Students will work in groups to complete an oral test on the processes of Translation and Transcription</td>
<td>X</td>
<td>Midway test focusing on Translation and Transcription</td>
</tr>
<tr>
<td>Gizmo Worksheet</td>
<td>Students will complete gizmo worksheet and online quizzes specifically dealing with genetic code and operons.</td>
<td>X</td>
<td>Evaluation - Dry Lab worksheet (marks embedded in questions)</td>
</tr>
<tr>
<td>Exit Card (Lesson 1 and 12)</td>
<td>Students submit a pre-made exit</td>
<td>X</td>
<td>Diagnostic Assessment – Teacher observation</td>
</tr>
<tr>
<td>Activity</td>
<td>Description</td>
<td>K</td>
<td>T</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Restriction enzyme/gel electrophoresis lab</td>
<td>Student will complete the assigned lab questions</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>DNA analysis activity</td>
<td>Students will create gel electrophoresis readouts and complete the associated questions</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Summative Test</td>
<td>Students will complete a written unit test</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

K - Knowledge/understanding  T - Thinking & Investigation  C - Communication  A - Application