Case Study: Is My Baby in Danger?

Teacher Resource

Grade: 11	**Subject:** University Preparation Biology	**Unit:** Genetic Processes

Case Study – Is My Baby in Danger?

Rationale:
Students will explore the processes related to the transmission of hereditary characteristics from parent to child. In particular, the mechanism of how the A,B,O and Rh factor blood groups are obtained by individuals and are passed on is analyzed.

Background Information:
Researchers in the Wakarchuk laboratory at Ryerson University are working with *E. coli* to engineer it to complete human-like glycosylation functions on human therapeutic proteins. Glycosylation is the most prevalent and diverse protein modification that occurs in humans, with 70% of human proteins being glycosylated. Glycosylation is the addition of a carbohydrate unit or chain to a protein. Sialylation is a type of glycosylation that involves the addition of sialic acid, a type of sugar, to proteins. The addition of sugars, and in particular sialic acid, to therapeutic proteins will reduce side effects and increase circulatory half-life of therapeutic proteins in patients.

After obtaining a greater understanding of glycosylation and its abundance in human proteins, the desire to relate it to high school science concepts became a priority. Since glycosylation is so prevalent in human proteins, it is no surprise that it is the driving force behind the ABO blood type system. This relates to the Genetics unit of the Grade 11 University Preparation Biology course. A case study involving a pregnancy includes the concepts of glycosylation, ABO blood types, Rh factor blood groups and Punnet squares.

Curriculum Connections:

- D2. investigate genetic processes, including those that occur during meiosis, and analyse data to solve basic genetics problems involving monohybrid and dihybrid crosses
- D3. demonstrate an understanding of concepts, processes, and technologies related to the transmission of hereditary characteristics
- D2.1 use appropriate terminology related to genetic processes, including, but not limited to: haploid, diploid, spindle, synapsis, gamete, zygote, heterozygous, homozygous, allele, plasmid, trisomy, non-disjunction, and somatic cell
- D2.3 use the Punnett square method to solve basic genetics problems involving monohybrid crosses, incomplete dominance, codominance, dihybrid crosses,

and sex-linked genes
- D3.2 explain the concepts of DNA, genes, chromosomes, alleles, mitosis, and meiosis, and how they account for the transmission of hereditary characteristics according to Mendelian laws of inheritance
- D3.3 explain the concepts of genotype, phenotype, dominance, incomplete dominance, codominance, recessiveness, and sex linkage according to Mendelian laws of inheritance

Lesson Objectives/Concepts:
- Students will gain an understanding of glycosylation and how it relates to the ABO blood typing system
- Students will gain an understanding of the ABO and Rh factor blood typing systems
- Students will gain an understanding of the danger of receiving an incompatible blood type, including the danger that can occur when mother and child are incompatible
- Students will use Punnett squares to determine the probability of having a child with a particular blood type given the parents' blood types

Materials: Access to YouTube, student handout.	**Time:** 1.2 periods A period is 75 minutes.

Introduction (20 minutes):
Questions to ask the class:

1. What do you think glycosylation means, based on your prior knowledge?
   It involves the addition of sugars to proteins and 70% of human proteins undergo this process.
2. Why are we talking about glycosylation?
   It relates to the ABO blood typing system, and small changes on the surface of red blood cells are responsible for the different blood types. Receiving the wrong blood type during a transfusion can be life threatening.
3. Show students the following YouTube videos:
   https://www.youtube.com/watch?v=ttjn1jVACk8
   What are Blood Types? SciShow
   https://www.youtube.com/watch?v=HQWlcSp9Sls
   Blood, Part 1-True Blood: Crash Course A&P #29 CrashCourse
4. Introduce the Case Study. It involves a married couple, Sofia and Miguel, and the potential dangers to their unborn child due to blood type incompatibility between mother and child.
5. By the end of the case study, students will have a better understanding of glycosylation, ABO and Rh factor blood typing systems, and Punnett squares for determining blood type probability.

Activities/Procedure (50 minutes):

Pre-teaching, done in advance of this lesson:

- Ensure you have taught students the basics of Mendelian genetics including the concepts of alleles, homozygous, heterozygous, dominant, recessive, incomplete dominance, codominance and the use of Punnett squares to solve basic monohybrid cross problems.

Lesson:

- Students should be divided into small groups. They should work together as they go through the case study handout to understand the concepts within it, and to answer the questions that are found throughout.
- The teacher should circulate around the room guiding students as necessary and answering any questions that come up.
- Ask students to complete the case study questions for homework if incomplete to go over the answers next day as a class.

Summary/Closure (5 + 15 minutes next period):

- Ask students if anything surprised them about the case study contents/information.
- Take up the questions with the class at the start of next period, soliciting answers from students.

Assessment:

- As you are circulating around the classroom, assess the level of understanding amongst the groups of students.
- You may collect student answers to assess them for accuracy and completion as a diagnostic tool.
- Answers to case study questions are provided.

Extensions/Connections:

- With some modifications, this case study can be used for the Genetics unit of Grade 11 College Preparation Biology.

Answers to Questions

1. What is a frameshift mutation?
   Since ribosomes read a sequence in groups of three nucleotides, if a nucleotide is added or deleted from a sequence, it will alter the reading frame. A different sequence of three nucleotides will be read and it will result in different amino acids and a different polypeptide being made. (10)

2. What is an antigen?
   Something that the immune system recognizes as either belonging to the person or as something foreign. For example, our blood cells have antigens on their surface. (10)

3. What is an antibody?
   Our immune system makes antibodies against foreign antigens. This helps our immune system elicit an immune response when our bodies come into contact with the foreign antigen destroying it.

4. What is the name given to a protein that has a carbohydrate attached?
   Glycoprotein

5. Fill in the following chart about blood donors and blood recipients.

Blood Type	Can Donate Blood To	Can Receive Blood From
A	A, AB	A, O
B	B, AB	B, O
AB	AB	A, B, AB, O
O	A, B, AB, O	O

6. There are actually 8 blood types, instead of 4 if you consider the Rh factor. List the 8 blood types.
   A^+, A^-, B^+, B^-, AB^+, AB^-, O^+, O^-

7. What is the <u>universal donor</u> blood type?
   O

8. What is the <u>universal recipient</u> blood type?
   AB

9. What is the difference between co-dominance and incomplete dominance?
   Co-dominance:
   Both alleles are fully expressed and it results in a mixed phenotype that shows characteristics of both alleles. Example: Red + White = Red and White

   Incomplete dominance:
   Neither allele dominates the other and it results in both being expressed as shown in a blended phenotype. Example: Red + White = Pink

10. Complete the following chart for the possible genotypes for each blood type. Although each blood type can come with or without the Rh factor, focus on just the ABO blood typing system.

Blood Type	Possible Genotypes
A	I^AI^A or I^Ai
B	I^BI^B or I^Bi
AB	I^AI^B
O	ii

11. What are the possible genotypes for Sofia's blood type?
    I^AI^A or I^Ai

12. What is the only possible genotype for Miguel's blood type?
    ii

13. If Sofia is homozygous dominant for type A blood, what is the probability that their child will have type A blood or type O blood? Use a Punnett square to help you determine the answer.

    Sophia I^A I^A

I^Ai	I^Ai
I^Ai	I^Ai

    i

    Miguel

    i

    There is a 100% (4/4) probability that their child will have type A blood.

14. If Sofia is heterozygous for type A blood, what is the probability that their child will have type A blood or type O blood? Use a Punnett square to help you determine the answer.

Sophia I^A i

I^Ai	ii
I^Ai	ii

i

Miguel

i

There is a 50% (2/4) probability that their child will have type A blood and a 50% (2/4) probability that their child will have type O blood.