UNIT 2: DIGESTION AND NUTRITION

Unit 2: Digestion and Nutrition

Specific Learning Outcomes

B11-2-01: Identify major structures and functions of the human digestive system from a diagram, model, or specimen. (GLO: D1)

Include: tongue, teeth, salivary glands, epiglottis, esophagus, pharynx, sphincters, stomach, small intestine, large intestine, rectum, anus, appendix, liver, gallbladder, pancreas, and uvula

B11-2-02: Describe the processes of mechanical digestion that take place at various sites along the alimentary canal. (GLO: D1)

Include: chewing in the mouth, peristalsis along the tract, muscle contractions in the stomach, and emulsification by bile in the small intestine

B11-2-03: Identify functions of secretions along the digestive tract. (GLO: D1)

Include: to lubricate and to protect

B11-2-04: Identify sites of chemical digestion along the alimentary canal, as well as the type of nutrient being digested. (GLO: D1)

Include: starch in the mouth; proteins in the stomach; and carbohydrates, lipids, and proteins in the small intestine

B11-2-05: Explain the role of enzymes in the chemical digestion of nutrients and identify factors that influence their action. (GLOs: D1, E2)

Examples: pH, temperature, coenzymes, inhibitors, surface area…

B11-2-06: Describe the processes of absorption that take place at various sites along the alimentary canal. (GLO: D1)

Include: uptake of nutrients by villi in the small intestine and uptake of water in the large intestine

B11-2-07: Describe the homeostatic role of the liver with respect to the regulation of nutrient levels in the blood and nutrient storage. (GLOs: D1, E2, E3)

Include: carbohydrate metabolism

B11-2-08: Describe the functions of each of the six basic types of nutrients—carbohydrates, lipids, proteins, vitamins, minerals, and water. (GLOs: B3, D1)

Include: ATP production, construction/repair, and regulating

B11-2-09: Identify dietary sources for each of the six basic types of nutrients—carbohydrates, lipids, proteins, vitamins, minerals, and water. (GLOs: B3, D1)

B11-2-10: Evaluate personal food intake and related food decisions. (GLOs: B3, C4, C8)

Examples: percentage of daily values of nutrients, portion size, nutrient labels, balance between lifestyle and consumption...

B11-2-11: Investigate and describe conditions/disorders that affect the digestive process. (GLOs: B3, C6, D1)

B11-2-12: Use the decision-making process to investigate an issue related to digestion and nutrition. (GLOs: B3, C4, C5, C8)

DIGESTION

SPECIFIC LEARNING OUTCOMES

B11-2-01: Identify major structures and functions of the human digestive system from a diagram, model, or specimen. (GLO: D1)

Include: tongue, teeth, salivary glands, epiglottis, esophagus, pharynx, sphincters, stomach, small intestine, large intestine, rectum, anus, appendix, liver, gallbladder, pancreas, and uvula

SLO: B11-2-01

SUGGESTIONS FOR INSTRUCTION

ENTRY-LEVEL KNOWLEDGE

In Grade 5, students identified the following structures of the digestive system: teeth, mouth, esophagus, stomach, and intestines. In Grade 8, students compared the structure of digestive organs in a variety of organisms.

ACTIVATE

Do You Remember?

Have students draw from memory an outline of the digestive system that includes the following: tongue, teeth, salivary glands, epiglottis, esophagus, stomach, small intestine, large intestine, rectum, anus, appendix, liver, gallbladder, pancreas, and uvula.

ACQUIRE/APPLY

Surfing for the Stomach (I1)

The Internet is an excellent way for students to explore the digestive system in an interactive manner. Have students complete an Internet Scavenger Hunt to answer questions provided by the teacher or developed by students.

Example:

What is the function of the epiglottis?

Websites can be identified in advance by the teacher.

An alternative would be for students to use specific websites to develop their own questions for other students to answer.

Suggestion for Assessment

Depending on the approach taken, either the teacher or students would identify the “correct” answers. Teachers may also choose to have some of the questions/answers form part of student notes on the digestive system, which can be incorporated into an assessment at a later point in the unit.

SKILLS AND ATTITUDES OUTCOMES

B11-0-U1: Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)

Examples: using concept maps, sort-and-predict frames, concept frames…

B11-0-S3: Demonstrate work habits that ensure personal safety, the safety of others, and concern for the environment. (GLOs: B3, B5, C1, C2)

Examples: application of Workplace Hazardous Materials Information Systems (WHMIS), proper disposal of chemical or biological specimens…

B11-0-S4: Select and use scientific equipment appropriately and safely. (GLOs: C1, C2)

Examples: microscopes, dissection equipment, prepared slides…

B11-0-S5: Demonstrate sensitivity toward, and respect for, living and non-living tissues, specimens, and organisms utilized for biological research. (GLOs: C2, C5)

B11-0-S6: Make detailed observations and/or collect data; organize and display this information using an appropriate format. (GLOs: C2, C5)

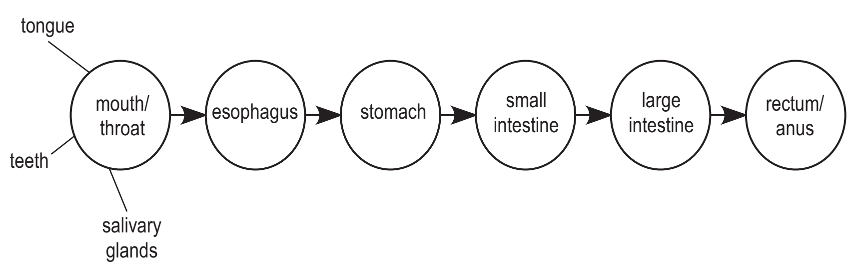
Include: biological drawings

B11-0-I1: Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)

Include: print and electronic sources, resource people, and personal observations

Alimentary Canal—Concept Map (U1)

Have students use a Chain Concept Map (flow chart) to illustrate the main components of the alimentary canal and the process of digestion. The base structure in Appendix 2.1: Concept Map of the Digestive System (BLM) is provided and contains six main components: mouth/throat, esophagus, stomach, small intestine, large intestine, and rectum/anus. To each of these main areas students should add more details related to specific components (see sample below). Refer to SLO B11-2-01 for a list.



Suggestion for Assessment

Additions will be made to this base Concept Map at various stages throughout the unit. It will serve as an important visual organizer and will be a useful tool for teachers to monitor student understanding of the digestive system (formative assessment) and to adjust teaching to address any difficulties. The Concept Map can also be used as a summative assessment tool at the end of the unit.

DIGESTION

SPECIFIC LEARNING OUTCOMES

B11-2-01: Identify major structures and functions of the human digestive system from a diagram, model, or specimen. (GLO: D1)

Include: tongue, teeth, salivary glands, epiglottis, esophagus, pharynx, sphincters, stomach, small intestine, large intestine, rectum, anus, appendix, liver, gallbladder, pancreas, and uvula

What Am I? (U1)

Review the function of each of the parts listed in the SLO B11-2-01. Have students create a table including the digestive system structure and explaining its function. Write all the parts of the human digestive system on self-stick notes. Stick a self-stick note on the back of each student. Have them ask each other yes/no questions to figure out the structure posted on their back.

Suggestion for Assessment

An Exit Slip is a quick assessment tool that helps gain information about what students viewed as important during a particular lesson. The process for an Exit Slip is to pose a question at the end of the lesson and give students five minutes to respond. Suggested questions include the following:

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

Virtual or Real Dissection (S3, S4, S5, S6, I1 OR S5, I1)

Provide students with the opportunity to identify components of a “real” digestive system through either a dissection specimen or a virtual specimen.

As indicated in Section 2 of this document, Grade 11 Biology does not mandate that dissection (either real or virtual) take place in the classroom. Dissection is one of many instructional strategies that may be used to familiarize students with the structure and function of organs and organ systems. Interactive multimedia materials such as computer simulations, tutorials, and video clips can substitute for the use of animals in the classroom. However, these alternatives must satisfy the objectives of teaching scientific methodology and fundamental biological concepts. If, in the judgment of the teacher, available alternatives do not meet these objectives, dissection may be used, provided that no student is forced to participate in a dissection over his or her objections. In the event that a student chooses not to participate in a dissection, he or she should be provided with an alternate activity of comparable complexity and rigour.

SKILLS AND ATTITUDES OUTCOMES

B11-0-U1: Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)

Examples: using concept maps, sort-and-predict frames, concept frames…

B11-0-S3: Demonstrate work habits that ensure personal safety, the safety of others, and concern for the environment. (GLOs: B3, B5, C1, C2)

Examples: application of Workplace Hazardous Materials Information Systems (WHMIS), proper disposal of chemical or biological specimens…

B11-0-S4: Select and use scientific equipment appropriately and safely. (GLOs: C1, C2)

Examples: microscopes, dissection equipment, prepared slides…

B11-0-S5: Demonstrate sensitivity toward, and respect for, living and non-living tissues, specimens, and organisms utilized for biological research. (GLOs: C2, C5)

B11-0-S6: Make detailed observations and/or collect data; organize and display this information using an appropriate format. (GLOs: C2, C5)

Include: biological drawings

B11-0-I1: Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)

Include: print and electronic sources, resource people, and personal observations

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Resource Links

The following websites provide virtual dissections:

- Berkeley Lab. "The Virtual Frog Dissection Kit." *Computer-Enhanced Science Education: The Whole Frog Project*. <http://froggy.lbl.gov/>.
- Fleck, Earl W. "Virtual Pig Dissection." Whitman College Biology Department. <www.whitman.edu/biology/vpd/>.
- U.S. National Library of Medicine. *The Visible Human Project*. 11 Sept. 2003. <www.nlm.nih.gov/research/visible/visible_human.html>.

  This project is the creation of three-dimensional representations of the normal male and female bodies. A sample of images and animations is available online.

For more ideas about integrating information and communication technologies across the curriculum, see

- Manitoba Education. *Information Communication Technology (ICT): Kindergarten to Grade 12*. <www.edu.gov.mb.ca/k12/tech/index.html>.

For additional information on topics such as plagiarism, evaluating web content, and making a bibliography, see

- Manitoba Education. "Professional Learning for Teachers." *Literacy with ICT Across the Curriculum: A Developmental Continuum.* <www.edu.gov.mb.ca/k12/tech/lict/let_me_try/le_teachers.html>.

DIGESTION

SPECIFIC LEARNING OUTCOMES

B11-2-01: Identify major structures and functions of the human digestive system from a diagram, model, or specimen. (GLO: D1)

Include: tongue, teeth, salivary glands, epiglottis, esophagus, pharynx, sphincters, stomach, small intestine, large intestine, rectum, anus, appendix, liver, gallbladder, pancreas, and uvula

Suggestion for Assessment

Establish with students a list of expectations for good dissection skills. Conduct a performance-based assessment by circulating throughout the classroom and assessing dissection skills using a checklist or rating scale.

The following are suggestions to include in the list of dissection skills criteria:

- Secures specimen to the dissection pan.
- Uses care while using scalpel.
- Cuts tissue without damaging organs.
- Moves or removes organs that obstruct a view of deeper organs.

Skills and Attitudes Outcomes

B11-0-U1: Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)

Examples: using concept maps, sort-and-predict frames, concept frames…

B11-0-S3: Demonstrate work habits that ensure personal safety, the safety of others, and concern for the environment. (GLOs: B3, B5, C1, C2)

Examples: application of Workplace Hazardous Materials Information Systems (WHMIS), proper disposal of chemical or biological specimens…

B11-0-S4: Select and use scientific equipment appropriately and safely. (GLOs: C1, C2)

Examples: microscopes, dissection equipment, prepared slides…

B11-0-S5: Demonstrate sensitivity toward, and respect for, living and non-living tissues, specimens, and organisms utilized for biological research. (GLOs: C2, C5)

B11-0-S6: Make detailed observations and/or collect data; organize and display this information using an appropriate format. (GLOs: C2, C5)

Include: biological drawings

B11-0-I1: Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)

Include: print and electronic sources, resource people, and personal observations

Notes

Introduction to Mechanical and Chemical Digestion

SPECIFIC LEARNING OUTCOMES

B11-2-02: Describe the processes of mechanical digestion that take place at various sites along the alimentary canal. (GLO: D1)

Include: chewing in the mouth, peristalsis along the tract, muscle contractions in the stomach, and emulsification by bile in the small intestine

B11-2-03: Identify functions of secretions along the digestive tract. (GLO: D1)

Include: to lubricate and to protect

B11-2-04: Identify sites of chemical digestion along the alimentary canal, as well as the type of nutrient being digested. (GLO: D1)

Include: starch in the mouth; proteins in the stomach; and carbohydrates, lipids, and proteins in the small intestine

SLO: B11-2-02
SLO: B11-2-03
SLO: B11-2-04

SUGGESTIONS FOR INSTRUCTION

ACTIVATE

Mechanical Digestion—The First Step

Begin a discussion with students by asking:

What could you do to help your digestive system if you had a broken jaw?

Have students brainstorm some solutions and justify their explanations. This discussion will help activate students' thinking about the first step in the breakdown of food.

Increasing the Surface Area

Take a piece of chalk and break it in half. Break one of the halves up into smaller pieces. Have students predict which half of the chalk will dissolve more quickly in a jar of vinegar. Place the pieces of chalk into the vinegar and observe during class time. Relate the dissolution and the size of chalk particles to the need for mechanical digestion.

ACQUIRE/APPLY

Mechanical Digestion—Concept Map (U1)

Using information gained from direct teaching or text material, have students refer to their Concept Map of the Digestive System (Appendix 2.1) and label the locations where mechanical digestion takes place with the process that takes place there. This labelling could be done in a particular colour, with future labelling of details related to chemical digestion done in a different colour.

SKILLS AND ATTITUDES OUTCOMES

B11-0-U1: Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)

Examples: using concept maps, sort-and-predict frames, concept frames …

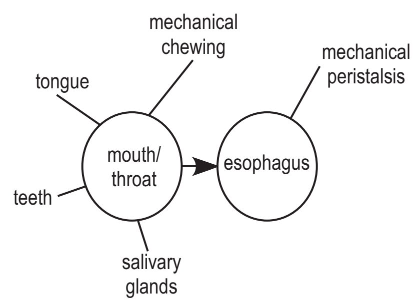
B11-0-S6: Make detailed observations and/or collect data; organize and display this information using an appropriate format. (GLOs: C2, C5)

Include: biological drawings

B11-0-I1: Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)

Include: print and electronic sources, resource people, and personal observations

Example:



Secretion Models—Demonstration (I1, S6)

Use models to demonstrate to students the functions of secretions along the digestive tract.

- **Lubricant—Rubber Tubing and Marble**

  Demonstrate the ease with which the marble passes along a rubber tube if oil is added. Relate this to the role of lubricants in moving the bolus along the digestive tract.

- **Protection—Leaf and Petroleum Jelly**

  Cover the surface of one leaf with petroleum jelly and leave another leaf bare. Add a drop of mild acid to each leaf and have students observe what happens (the leaf with the petroleum jelly is protected from the acid). Relate this to the function of the mucus lining the stomach.

Students should record information from the demonstrations in their science notebooks, including a description of the model and the link between the model and the digestive system.

INTRODUCTION TO MECHANICAL AND CHEMICAL DIGESTION

SPECIFIC LEARNING OUTCOMES

B11-2-02: Describe the processes of mechanical digestion that take place at various sites along the alimentary canal. (GLO: D1)

Include: chewing in the mouth, peristalsis along the tract, muscle contractions in the stomach, and emulsification by bile in the small intestine

B11-2-03: Identify functions of secretions along the digestive tract. (GLO: D1)

Include: to lubricate and to protect

B11-2-04: Identify sites of chemical digestion along the alimentary canal, as well as the type of nutrient being digested. (GLO: D1)

Include: starch in the mouth; proteins in the stomach; and carbohydrates, lipids, and proteins in the small intestine

Suggestion for Assessment

Have students respond to the following questions:

- What would happen to the process of digestion if your salivary gland stopped producing saliva?
- What would happen to the process of digestion if your stomach could not produce any more mucus?

Mixing It Up—Demonstration (U1)

Add a small amount of oil to a test tube of water and have students record what happens. Shake it and have students record what happens. Repeat the demonstration but add liquid detergent to simulate bile. Have students discuss the role of the detergent.

When detergent is added, the oil separates into small droplets and can stay suspended in the water. Relate this to the action of bile in the digestive system. Bile will separate fats into small particles, which can then be chemically digested.

Chemical Digestion—Concept Map (U1)

Use a text resource and/or explicit teaching to address the concept of chemical digestion. This should include the sites of chemical digestion and the type of nutrient being digested (e.g., starch, carbohydrates, lipids, proteins). This information should be added to the Concept Map created earlier.

SKILLS AND ATTITUDES OUTCOMES

B11-0-U1: Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)

Examples: using concept maps, sort-and-predict frames, concept frames …

B11-0-S6: Make detailed observations and/or collect data; organize and display this information using an appropriate format. (GLOs: C2, C5)

Include: biological drawings

B11-0-I1: Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)

Include: print and electronic sources, resource people, and personal observations

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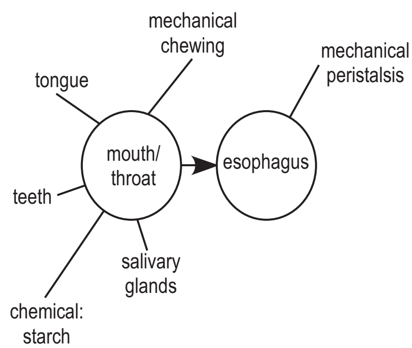
Example:



Cumulative Assessment

Have students create, from memory, the Concept Map that they developed during the previous learning activities. This would include creating the initial diagram of the six main components of the alimentary canal, some details related to each component, and the sites of mechanical and chemical digestion. This can be used as a formative assessment to determine the level of students' understanding of the digestive system to this point. If needed, reviewing and/or re-teaching may be carried out. This activity can also be used as a summative assessment to make a judgment about student achievement to this point.

ENZYMES AND CHEMICAL DIGESTION

SPECIFIC LEARNING OUTCOMES

B11-2-05: Explain the role of enzymes in the chemical digestion of nutrients and identify factors that influence their action. (GLOs: D1, E2)

Examples: pH, temperature, coenzymes, inhibitors, surface area…

SLO: B11-2-05

SUGGESTIONS FOR INSTRUCTION

ACTIVATE

Enzyme Reaction—Demonstration

Prepare fresh pineapple juice by cutting up a pineapple and putting it into a blender until it is puréed. Obtain the juice by straining the purée through cheesecloth. Make some gelatin (any type will do, but it is helpful if it is of a dark colour). Cut the gelatin into cubes and place the cubes in petri dishes. Have students observe what happens when the pineapple juice is poured over the gelatin. Have students relate their observations to the role of enzymes in digestion.

Note: Pineapple belongs to a group of plants called *bromeliads*. Kiwi, papaya, and figs are other types of bromeliads. The enzyme in pineapple juice that is responsible for the breakdown of collagen is *bromelain*. Canned pineapple will not work in this demonstration; the canning process denatures the bromelain, rendering it incapable of catalyzing the breakdown of gelatin.

What's the Key?

Bring a series of locks and keys into the classroom. Have students determine which key fits into which lock. Explain to students that enzymes work in a similar fashion.

ACQUIRE/APPLY

Enzymatic Factors in the Digestion of Lipids—Lab (P1, S3, S4, S6, S8)

Have students perform a lab to demonstrate the action of an enzyme on food particles. Refer to Appendix 2.2A: Enzymatic Factors in the Digestion of Lipids—Student Handout (BLM) and Appendix 2.2B: Enzymatic Factors in the Digestion of Lipids (Teacher Background). This lab will also allow students to see the effect of factors such as temperatures and coenzymes on enzymatic action.

Suggestion for Assessment

Refer to Appendix 1.8: Student Lab Skills (Teacher Background) in Unit 1 for information on assessing and evaluating student lab skills.

SKILLS AND ATTITUDES OUTCOMES

B11-0-P1: Demonstrate confidence in their ability to carry out investigations. (GLOs: C2, C5)

B11-0-S3: Demonstrate work habits that ensure personal safety, the safety of others, and concern for the environment. (GLOs: B3, B5, C1, C2)

Examples: application of Workplace Hazardous Materials Information Systems (WHMIS), proper disposal of chemical or biological specimens…

B11-0-S4: Select and use scientific equipment appropriately and safely. (GLOs: C1, C2)

Examples: microscopes, dissection equipment, prepared slides…

B11-0-S6: Make detailed observations and/or collect data; organize and display this information using an appropriate format. (GLOs: C2, C5)

Include: biological drawings

B11-0-S8: Analyze data and/or observations in order to identify patterns or draw conclusions. (GLOs: C2, C5, C8)

NOTES

ABSORPTION

SPECIFIC LEARNING OUTCOMES

B11-2-06: Describe the processes of absorption that take place at various sites along the alimentary canal. (GLO: D1)

Include: uptake of nutrients by villi in the small intestine and uptake of water in the large intestine

SLO: B11-2-06

SUGGESTIONS FOR INSTRUCTION

ACTIVATE

It's All in the Folds

Provide each group of students with a piece of paper and have them

1. calculate the surface area of a sheet of paper (one side only)
2. roll the paper into a tube and secure it
3. fold additional pieces of paper; insert them into the tube to try to increase the surface area of the tube (as much as possible); and record the new surface area
4. share their maximum surface area with the class

Tell students that their tube is a model of the villi in the small intestine, and have them discuss why an increased surface area in the small intestine would be important.

ACQUIRE/APPLY

Reconstructing Text (U1)

Provide students with an article or notes from a textbook explaining the process of absorption and the movement of food particles through the alimentary canal. Cut up the reading into paragraphs and have students reconstruct it. Students identify the sites where absorption occurs and describe to their neighbour how absorption occurs at different sites.

Suggestion for Assessment

Have students complete a Cloze exercise (insert missing words to text related to the process of absorption).

SKILLS AND ATTITUDES OUTCOMES

B11-0-U1: Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)

Examples: using concept maps, sort-and-predict frames, concept frames…

B11-0-U2: Demonstrate an in-depth understanding of biological concepts. (GLO: D1)

Examples: use accurate scientific vocabulary, explain concepts to someone else, make generalizations, apply knowledge to new situations/contexts, draw inferences, create analogies, develop models…

Absorption—Concept Map (U1)

Students identify the sites along the alimentary canal where absorption occurs, using the Concept Map they created earlier—marking the sites in a different colour.

Comparing Conditions (U2)

Have students use their understanding of absorption to explain what happens in two common conditions: diarrhea and constipation (explanations should refer to water uptake).

Suggestion for Assessment

Have students answer the following questions:

In a condition known as microvillus inclusion disease the microvilli fold inwards and, therefore, have no contact with the intestinal lining.

- How do you think this condition affects the health of an individual?
- What might need to be done to treat this condition? Justify your response.

Written responses could be assessed using the following criteria:

- clarity of response
- completeness of response
- presentation of logical response
- use of unit knowledge to justify response

Student responses do not need to be "correct"; however, they must be clear and justified and include knowledge gained in this unit.

Note: Children with microvillus inclusion disease cannot absorb any nutrients and must be fed intravenously. In order to survive, the children must receive an intestinal transplant, which is quite rare.

THE LIVER

SPECIFIC LEARNING OUTCOMES

B11-2-07: Describe the homeostatic role of the liver with respect to the regulation of nutrient levels in the blood and nutrient storage. (GLOs: D1, E2, E3)

Include: carbohydrate metabolism

SLO: B11-2-07

SUGGESTIONS FOR INSTRUCTION

ACTIVATE

Relating to the Real World

Ask students:

What do we do to our ripe garden tomatoes in order to eat them throughout the year?

Note: Excess tomatoes need to be modified and stored to preserve their nutrients and to be able to access them throughout the year. Relate this concept to the transformation and storage of carbohydrates by the liver.

ACQUIRE/APPLY

Regulatory Systems (U1)

As an introduction to hormones as one of the body's key regulatory systems, have students read Appendix 2.3: Regulatory Systems (BLM) and answer the questions provided.

Liver Functions (U2)

Have students read Appendix 2.4A: The Role of the Liver in Homeostasis (BLM) and develop one or two questions about the reading (this can be done individually or in small groups). These questions can then be compiled and given back to the students as a short quiz or written assignment.

Suggestion for Assessment

Have students complete an Exit Slip on which they describe the homeostatic adjustment that would occur for a person who has consumed a significant quantity of carbohydrates in the past hour. The result should look similar to the "answer" provided in Appendix 2.4B: The Liver and Negative Feedback (BLM).

SKILLS AND ATTITUDES OUTCOMES

B11-0-U1: Use appropriate strategies and skills to develop an understanding of biological concepts. (GLO: D1)

Examples: using concept maps, sort-and-predict frames, concept frames…

B11-0-U2: Demonstrate an in-depth understanding of biological concepts. (GLO: D1)

Examples: use accurate scientific vocabulary, explain concepts to someone else, make generalizations, apply knowledge to new situations/contexts, draw inferences, create analogies, develop models…

B11-0-I4: Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)

Liver Job Application (I4)

Have students write a resumé for the liver. The resumé should include important qualities and abilities, such as decision-making skills (homeostasis), storage capabilities, and regulation of nutrient levels.

Resource

See Liver Transplant Lesson Plan in *Life Is a Gift* (Manitoba Education and Transplant Manitoba) for activities related to Unit 2: Digestion and Nutrition.

Suggestion for Assessment

Develop criteria with the students and have them peer-evaluate each other's resumés. (Does the liver get the job?)

Examples:

- Address—location in the human body
- Previous Experience—some past challenges to the liver
- Abilities—storage and decision-making capabilities

NUTRITION

SPECIFIC LEARNING OUTCOMES

B11-2-08: Describe the functions of each of the six basic types of nutrients—carbohydrates, lipids, proteins, vitamins, minerals, and water. (GLOs: B3, D1)

Include: ATP production, construction/repair, and regulating

B11-2-09: Identify dietary sources for each of the six basic types of nutrients—carbohydrates, lipids, proteins, vitamins, minerals, and water. (GLOs: B3, D1)

SLO: B11-1-08
SLO: B11-1-09

SUGGESTIONS FOR INSTRUCTION

ENTRY-LEVEL KNOWLEDGE

In Grade 5, students examined the nutritional content of a variety of food sources and read food labels for nutrient content. They focused on carbohydrates, proteins, fats, vitamins, and minerals. In Grade 10 Physical Education/Health Education, students analyzed and monitored their food intake over a period of time.

ACTIVATE

Graffiti Brainstorm

Have students participate in a Rotational Cooperative Graffiti (Kagan) learning experience. Provide each group with a sheet of poster paper and a heading. Examples of possible headings are carbohydrates, lipids, proteins, vitamins and minerals, and water.

Each group must have a different heading and a different colour of marker. Predetermine a period of time in which students will brainstorm as many ideas as they have about each topic—anything that comes to mind. Have students circulate the posters until each group has placed their response on each sheet. Once individual groups have received their original posters, they work together to summarize what has been written and share their summary with the class.

For more details on this strategy, refer to *SYSTH* (p. 3.15).

ACQUIRE/APPLY

Nutrients—Reading for Information (I1, I2)

Part 1

Have groups of students read current information on nutrients that identifies the types of nutrients, their functions, and related dietary sources. Give each group different information sources (e.g., pamphlets, posters, information from the Internet). Students record key information in their notebooks, using the strategy of their choice (e.g., mapping, outlining), and comment on the quality of the information (e.g., accuracy, reliability, currency).

SKILLS AND ATTITUDES OUTCOMES

B11-0-P1: Demonstrate confidence in their ability to carry out investigations. (GLOs: C2, C5)

B11-0-S3: Demonstrate work habits that ensure personal safety, the safety of others, and concern for the environment. (GLOs: B3, B5, C1, C2)

Examples: application of Workplace Hazardous Materials Information Systems (WHMIS), proper disposal of chemical or biological specimens …

B11-0-S4: Select and use scientific equipment appropriately and safely. (GLOs: C1, C2)

Examples: microscopes, dissection equipment, prepared slides…

B11-0-S6: Make detailed observations and/or collect data; organize and display this information using an appropriate format. (GLOs: C2, C5)

Include: biological drawings

B11-0-S7: Evaluate the relevance, reliability, and adequacy of data and data collection methods. (GLOs: C2, C4, C5, C8)

Include: discrepancies in data or observations and sources of error

B11-0-S8: Analyze data and/or observations in order to identify patterns or draw conclusions. (GLOs: C2, C5, C8)

B11-0-I1: Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)

Include: print and electronic sources, resource people, and personal observations

B11-0-I2: Evaluate the quality of sources of information, as well as the information itself. (GLOs: C2, C4, C5, C8)

Examples: scientific accuracy, reliability, currency, balance of perspectives, bias, fact versus opinion…

B11-0-G1: Collaborate with others to achieve group goals and responsibilities. GLOs: C2, C4, C7)

B11-0-G2: Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)

For more information on strategies available for reading scientific information and note-taking, refer to *SYSTH* (Chapter 12).

Part 2

Have each group share their information with another group and continue the process until everyone has had the opportunity to hear all the groups. After the sharing, have students analyze whether or not they obtained the same information and, if not, discuss reasons for the differences. They should also talk about the format of their information source and what traits of the information piece make it easier or more difficult to obtain information from it, as well as the quality of various information sources.

Suggestion for Assessment

Have students complete an Exit Slip. Ask them to comment specifically on what type of information source they found easiest to get information from, and what characteristics of the source they liked. For example, students may indicate they like information from a poster, as it has many headings, short sections, pictures, and simple vocabulary. They should also comment on the quality of information sources.

NUTRITION

SPECIFIC LEARNING OUTCOMES

B11-2-08: Describe the functions of each of the six basic types of nutrients—carbohydrates, lipids, proteins, vitamins, minerals, and water. (GLOs: B3, D1)

Include: ATP production, construction/repair, and regulating

B11-2-09: Identify dietary sources for each of the six basic types of nutrients—carbohydrates, lipids, proteins, vitamins, minerals, and water. (GLOs: B3, D1)

Testing for Nutrients—Labs (P1, S3, S4, S6, S7, S8)

Have students conduct lab activities to identify the nutrients present in different food samples. Refer to Appendix 2.5A: Testing for Carbohydrates—Student Handout (BLM), Appendix 2.5B: Testing for Carbohydrates (Teacher Background), Appendix 2.6A: Testing for Proteins—Student Handout (BLM), and Appendix 2.6B: Testing for Proteins (Teacher Background).

Suggestions for Assessment

Refer to Appendix 1.8: Student Lab Skills (Teacher Background) in Unit 1 for information on assessing and evaluating student lab skills.

Refer to Appendix 1.13A: Lab Skills Checklist—General Skills (BLM) and Appendix 1.13B: Lab Skills Checklist—Thinking Skills (BLM) in Unit 1 for templates on assessing general lab skills and thinking skills.

What's in It? (I1)

Students examine various convenience foods or meal replacements to determine what types of basic nutrients they contain (e.g., drinks, bars, powders and shakes, frozen dinners, fast food) and in what amounts.

Suggestion for Assessment

Have students do a reflection in their science notebooks. The following questions may be used to stimulate thinking about this learning activity:

- What surprised you?
- What questions came to your mind?

SKILLS AND ATTITUDES OUTCOMES

B11-0-P1: Demonstrate confidence in their ability to carry out investigations. (GLOs: C2, C5)

B11-0-S3: Demonstrate work habits that ensure personal safety, the safety of others, and concern for the environment. (GLOs: B3, B5, C1, C2)

Examples: application of Workplace Hazardous Materials Information Systems (WHMIS), proper disposal of chemical or biological specimens …

B11-0-S4: Select and use scientific equipment appropriately and safely. (GLOs: C1, C2)

Examples: microscopes, dissection equipment, prepared slides…

B11-0-S6: Make detailed observations and/or collect data; organize and display this information using an appropriate format. (GLOs: C2, C5)

Include: biological drawings

B11-0-S7: Evaluate the relevance, reliability, and adequacy of data and data collection methods. (GLOs: C2, C4, C5, C8)

Include: discrepancies in data or observations and sources of error

B11-0-S8: Analyze data and/or observations in order to identify patterns or draw conclusions. (GLOs: C2, C5, C8)

B110-I1: Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)

Include: print and electronic sources, resource people, and personal observations

B11-0-I2: Evaluate the quality of sources of information, as well as the information itself. (GLOs: C2, C4, C5, C8)

Examples: scientific accuracy, reliability, currency, balance of perspectives, bias, fact versus opinion…

B11-0-G1: Collaborate with others to achieve group goals and responsibilities. GLOs: C2, C4, C7)

B11-0-G2: Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)

Nutrient Lunches (I1, G1, G2)

Conduct a series of Nutrient Lunches for which groups of students bring snacks of a certain type to class (e.g., for Monday, the assigned group will bring a lipid snack). Before consuming the snack, students work in small groups to identify which snack has the highest amount of the day's nutrient.

Examples:

- lipid lunch = french fries
- protein lunch = cheese, tuna, egg
- carbohydrate lunch = chocolate bar

Suggestion for Assessment

Use an observational checklist to monitor student participation and knowledge.

WELLNESS

SPECIFIC LEARNING OUTCOMES

B11-2-10: Evaluate personal food intake and related food decisions. (GLOs: B3, C4, C8)

Examples: percentage of daily values of nutrients, portion size, nutrient labels, balance between lifestyle and consumption...

SLO: B11-2-10

SUGGESTIONS FOR INSTRUCTION

ENTRY-LEVEL KNOWLEDGE

In Grade 10 Physical Education/Health Education, students examined the nutritional value of a variety of foods, using *Eating Well with Canada's Food Guide* and other resources (SLO K.5.S2.C.1a).

ACTIVATE

KWL

Have students fill out the first column of a KWL (Know, Want to Know, Learned) chart or another similar chart indicating what they already know about information provided on food labels and what they would like to know.

You Are What You Eat

Have the class watch a video or film about nutrition, such as those listed below. After the viewing, have students reflect on the video or film from a health and nutrition perspective.

Resources

- *Nutrition in a Box: The Video Food Quiz*. Learning Seed Company, 1991. Videocassette. (Available from the Instructional Resources Unit library.)
- *Super Size Me: A Film of Epic Portions.* Dir. and Prod. Morgan Spurlock. Samuel Goldwyn Films, 2004. Film.

ACQUIRE/APPLY

Nutrition Labelling—Information and Learning Activities (P2, P3)

WP

Nutrition facts and ingredient lists are the foundation of food labels since they provide an overview of what is in the food. They are present on most prepackaged foods. Nutrition claims are not always provided. When they are, they are highly visible and can highlight a specific aspect of the food that may be of interest to consumers.

SKILLS AND ATTITUDES OUTCOMES

B11-0-P2: Demonstrate a willingness to reflect on personal wellness. (GLO: B3)

B11-0-P3: Appreciate the impact of personal lifestyle choices on general health and make decisions that support a healthy lifestyle. (GLOs: B3, C4)

B11-0-S6: Make detailed observations and/or collect data; organize and display this information using an appropriate format. (GLOs: C2, C5)
Include: biological drawings

B11-0-S8: Analyze data and/or observations in order to identify patterns or draw conclusions. (GLOs: C2, C5, C8)

B11-0-I1: Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)
Include: print and electronic sources, resource people, and personal observations

B11-0-I4: Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)

Health Canada's *Food and Nutrition* website (see <www.hc-sc.gc.ca/fn-an/index-eng.php>) contains information for various groups:

- **Consumers:** The Interactive Nutrition Label and Quiz can be used to help students understand and learn how to use nutrition information on food labels.
- **Educators:** A variety of multimedia resources can be used for introducing students to the nutrition information on food labels and teaching them about how it can support healthy eating choices. Included are a ready-to-use presentation on nutrition labelling and a collection of ready-to-use articles and fact sheets.
- **First Nations, Inuit, and Métis:** *Eating Well with Canada's Food Guide: First Nations, Inuit and Métis* is a new food guide that includes both traditional foods and store-bought foods. A ready-to-use presentation about this new *Food Guide* is available on the website.

Teachers can select which components of this material to share with students and which learning activities to carry out. The goal is to have students understand what information is provided on food labels and how to use this information to make healthy food choices.

As a culminating activity, have students write a piece for inclusion in their Wellness Portfolio. This piece could take the form of a letter to themselves identifying what (one or more things) they would like to do to improve their food choices, based on what they have learned.

Suggestion for Assessment

Depending on the particular components of the Health Canada website that are used with students, a variety of assessments can be used. One suggestion is to use real food labels and have students determine which food choice would be best for someone in a particular situation.

WELLNESS

SPECIFIC LEARNING OUTCOMES

B11-2-10: Evaluate personal food intake and related food decisions. (GLOs: B3, C4, C8)

Examples: percentage of daily values of nutrients, portion size, nutrient labels, balance between lifestyle and consumption ...

What Am I Eating? What Is My Lifestyle? (P2, P3, S6, S8, I1, I4)

Have students monitor and record their own eating habits for a three-day period. Students collect the food labels or food information for all the food items they consume and evaluate their eating habits using *Eating Well with Canada's Food Guide* (Health Canada). Students can use *FoodFocus* (Prowse) software to evaluate their food intake (available from the Instructional Resources Unit library).

For this same time period, students could also keep track of their physical activity (e.g., walk to school).

Students write a summary report in which they draw conclusions about their diet and suggest changes they could make. They also reflect on their activity level and what this lifestyle might mean to their overall health. They could suggest how they could improve their lifestyle as well. Students' reports can be included in their Wellness Portfolios.

Suggestion for Assessment

Have students select another student with whom to share their report. Have the selected student carry out a peer assessment of the suggestions made.

- Were the suggested improvements to diet practical? Would they be effective? If not, why not? Other suggestions?
- Were the suggested improvements to activity level practical? Would they be effective? If not, why not? Other suggestions?

Creating a Meal (P2, P3)

Have students assess their ability to plan a healthy meal by completing a learning activity from a website such as the following. Students could include their work from this learning activity in their Wellness Portfolios.

Resource Link

- Dietitians of Canada. "Let's Make a Meal!" *Eat Well, Live Well*. <www.dietitians.ca/public/content/eat_well_live_well/english/menuplanner/overview.asp>.

Skills and Attitudes Outcomes

B11-0-P2: Demonstrate a willingness to reflect on personal wellness. (GLO: B3)

B11-0-P3: Appreciate the impact of personal lifestyle choices on general health and make decisions that support a healthy lifestyle. (GLOs: B3, C4)

B11-0-S6: Make detailed observations and/or collect data; organize and display this information using an appropriate format. (GLOs: C2, C5)

Include: biological drawings

B11-0-S8: Analyze data and/or observations in order to identify patterns or draw conclusions. (GLOs: C2, C5, C8)

B11-0-I1: Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)

Include: print and electronic sources, resource people, and personal observations

B11-0-I4: Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)

Notes

DISORDERS

SPECIFIC LEARNING OUTCOMES

B11-2-11: Investigate and describe conditions/disorders that affect the digestive process. (GLOs: B3, C6, D1)

SLO: B11-2-11

SUGGESTIONS FOR INSTRUCTION

ACTIVATE

What Do You Think?

Begin a discussion with the class by asking:

> What would happen to you if you could not absorb nutrients efficiently or if you could not absorb them at all?

ACQUIRE/APPLY

Coping with a Disorder (W1, P4)

Invite a guest speaker to speak to students about a disorder, either from a medical perspective (e.g., a doctor) or a personal perspective (e.g., someone suffering from the disorder). Have students prepare questions in advance to address both the medical aspects and the treatment aspects of the disorder. Several guest speakers can be brought in throughout the course. Ensure that the speakers represent a diversity of cultural perspectives and approaches to treating illness (e.g., traditional medicines, homeopathy). Encourage students to develop an understanding of and a respect for this diversity.

Suggestion for Assessment

Have students reflect on questions such as the following:

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

Unravelling the Enigma of Vitamin D (I1, W2)

The article in Appendix 2.7A: Unravelling the Enigma of Vitamin D (BLM) contains a historical look at the development of our understanding about vitamins, and Vitamin D in particular, as scientists first attempted to understand rickets and other diseases. There are a variety of possible approaches to this assignment. Whether students read the article individually or in small groups, they should be encouraged to use effective reading strategies to acquire new knowledge from the lengthy text. This includes activating prior knowledge before the reading, taking some form of notes

Skills and Attitudes Outcomes

B11-0-U2: Demonstrate an in-depth understanding of biological concepts. (GLO: D1)

Examples: use accurate scientific vocabulary, explain concepts to someone else, make generalizations, apply knowledge to new situations/contexts, draw inferences, create analogies, develop models …

B110-P4: Demonstrate an understanding of, and respect for, a diversity of cultural perspectives and approaches to maintaining health and treating illness. (GLOs: A4, B3)

Examples: Asian approaches to health and wellness based on concepts of balance; Indigenous people's traditional medicines, concepts of healing; homeopathy…

B11-0-I1: Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)

Include: print and electronic sources, resource people, and personal observations

B11-0-I2: Evaluate the quality of sources of information, as well as the information itself. (GLOs: C2, C4, C5, C8)

Examples: scientific accuracy, reliability, currency, balance of perspectives, bias, fact versus opinion…

B11-0-I3: Quote from or refer to sources as required, and reference sources according to accepted practice. (GLOs: C2, C6)

B11-0-I4: Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)

B11-0-G1: Collaborate with others to achieve group goals and responsibilities. (GLOs: C2, C4, C7)

B11-0-G2: Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)

B11-0-G3: Evaluate individual and group processes used. (GLOs: C2, C4, C7)

B11-0-W1: Demonstrate a continuing, increasingly informed interest in biology and biology-related careers and issues. (GLO: B4)

B11-0-W2: Appreciate the contributions of scientists, including Canadians, to the field of human biology. (GLOs: A4, B4)

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during the reading, and having an opportunity to discuss/reflect on what they read following the reading. The questions provided in Appendix 2.7B: Unravelling the Enigma of Vitamin D—Student Questionnaire can help with this last step. They can be answered individually or in small groups.

Suggestion for Assessment

Whatever the form of assessment used, students should be made aware of the criteria beforehand. "Answers" to the questions provided in Appendix 2.7C: Unravelling the Enigma of Vitamin D (Teacher Background) can be assessed by the teacher, or shared and debated with other groups, to create an agreed-upon class answer. One or more of the questions could be used in a formal written assessment with established criteria (e.g., uses full sentences, includes examples).

SPECIFIC LEARNING OUTCOMES

B11-2-11: Investigate and describe conditions/disorders that affect the digestive process. (GLOs: B3, C6, D1)

DISORDERS

Share the Information (I1, I2, I3, U2)

Students research a specific problem or condition associated with the digestive system. Students may be given the option of sharing this information in the format of their choice (e.g., oral presentation, informational brochure, essay). Regardless of the format selected, student work must contain the following information:

- causes of the problem or condition
- symptoms
- treatments (include a range of treatments, including non-Western, if possible)
- prevention
- indication of whether the condition constitutes a problem with mechanical digestion, chemical digestion, or absorption

Alternative: Similar assignments appear throughout the course related to different body systems. At this point in the course, students may be asked to select one body system for a research project. These projects become due as each of the body systems is addressed throughout the course. For more details, refer to Appendix 2.8: Human Disorders Assignment (BLM).

Suggestion for Assessment

Develop assessment criteria with the students. The list above can form the basis of the "content" section of the assessment. Additional criteria can relate to the effectiveness of the presentation.

SKILLS AND ATTITUDES OUTCOMES

B11-0-U2: Demonstrate an in-depth understanding of biological concepts. (GLO: D1)

Examples: use accurate scientific vocabulary, explain concepts to someone else, make generalizations, apply knowledge to new situations/contexts, draw inferences, create analogies, develop models …

B110-P4: Demonstrate an understanding of, and respect for, a diversity of cultural perspectives and approaches to maintaining health and treating illness. (GLOs: A4, B3)

Examples: Asian approaches to health and wellness based on concepts of balance; Indigenous people's traditional medicines, concepts of healing; homeopathy…

B11-0-I1: Synthesize information obtained from a variety of sources. (GLOs: C2, C4, C6)

Include: print and electronic sources, resource people, and personal observations

B11-0-I2: Evaluate the quality of sources of information, as well as the information itself. (GLOs: C2, C4, C5, C8)

Examples: scientific accuracy, reliability, currency, balance of perspectives, bias, fact versus opinion…

B11-0-I3: Quote from or refer to sources as required, and reference sources according to accepted practice. (GLOs: C2, C6)

B11-0-I4: Communicate information in a variety of forms appropriate to the audience, purpose, and context. (GLOs: C5, C6)

B11-0-G1: Collaborate with others to achieve group goals and responsibilities. (GLOs: C2, C4, C7)

B11-0-G2: Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions. (GLOs: C2, C4, C7)

B11-0-G3: Evaluate individual and group processes used. (GLOs: C2, C4, C7)

B11-0-W1: Demonstrate a continuing, increasingly informed interest in biology and biology-related careers and issues. (GLO: B4)

B11-0-W2: Appreciate the contributions of scientists, including Canadians, to the field of human biology. (GLOs: A4, B4)

What's My Diagnosis? (G1, G2, G3, U2)

Set up a series of stations for groups of students to diagnose problems that affect the digestive process and develop treatment plans. Refer to Appendix 2.9: What's My Diagnosis? (Teacher Background).

Suggestion for Assessment

Once groups of students have diagnosed and treated all patients in the What's My Diagnosis? learning activity, they bring their sheet to the teacher to be checked. If students have misdiagnosed any patients, they are sent back to re-examine them. Assess groups on suggested treatments. A variation of this learning activity can be used as an end-of-unit assessment component where students are given a similar task and asked to provide the diagnosis.

DECISION MAKING

SPECIFIC LEARNING OUTCOMES

B11-2-12: Use the decision-making process to investigate an issue related to digestion and nutrition. (GLOs: B3, C4, C5, C8)

SLO: B11-2-12

SUGGESTIONS FOR INSTRUCTION

ACTIVATE

Brainstorming

Have the class carry out a brainstorming session to identify current issues that relate to nutrition and health. The suggestions from the class can be compiled and then grouped according to given criteria (e.g., whom the issue affects, level of importance).

Note: Students may use this brainstormed list to decide what issue they (or the class) want to investigate in the decision-making learning activity to follow.

ACQUIRE/APPLY

Decision Making (D1, D2, D3, D4, D5, D6)

Give students the opportunity to investigate real-life issues related to nutrition and wellness. This investigation should include some type of decision-making process. The type of decision can vary greatly. For example, it could be

- a very personal/individual decision on a particular topic for inclusion in the Wellness Portfolio (e.g., How should I go about losing weight? What should I do about a friend who I think is anorexic?)
- a school or community decision (e.g., Should pop/chip machines be removed from schools?)
- a far-reaching decision (e.g., Should milk cost the same throughout the province?)

A number of approaches can be used to simulate a real-life context or to promote interaction between students (e.g., a town-hall meeting, a formal debate). For more details, refer to Appendix 2.10: Decision Making (Teacher Background).

Note: Unit 3 provides information on a debating strategy called Creative Controversy (Baloche, et al.). For more details, see *Senior 2 English Language Arts: A Foundation for Implementation* (Manitoba Education and Training, Senior 2, p. 34).

SKILLS AND ATTITUDES OUTCOMES

B11-0-D1: Identify and explore a current health issue. (GLOs: C4, C8)

Examples: clarify what the issue is, identify different viewpoints and/or stakeholders, research existing data/information...

B11-0-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...

B11-0-D3: Recognize that decisions reflect values and consider personal values and those of others when making a decision. (GLOs: C4, C5)

B11-0-D4: Recommend an alternative or identify a position, and provide justification. (GLO: C4)

B11-0-D5: Propose a course of action related to an issue. (GLOs: C4, C5, C8)

B11-0-D6: Evaluate the process used by self or others to arrive at a decision. (GLOs: C4, C5)

Suggestions for Assessment

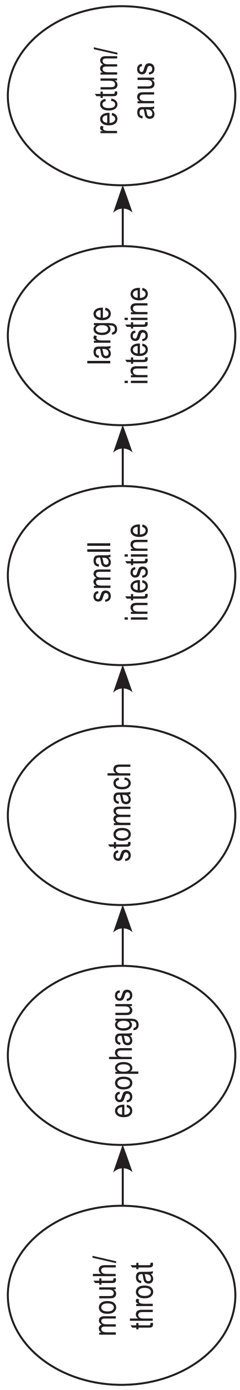
The type of assessment used will vary, depending on the approach taken, but it should focus on the student's ability to demonstrate the skills outlined in Cluster 0.

NOTES

Unit 2: Digestion and Nutrition

Appendices

Appendix 2.1:
Concept Map of the Digestive System (BLM)



Appendix 2.2A: Enzymatic Factors in the Digestion of Lipids—Student Handout (BLM)

Purpose

To investigate the role of enzymes in lipid digestion.

Material and Procedure

1. Obtain five test tubes and mark them #1 to #5.
2. For each test tube, measure and add the materials specified in the table below according to the test tube number. Place test tubes requiring a water bath in the one provided.
3. Once all the solutions have been created, wait 15 minutes.
4. Record observations and note the colour of each solution at the bottom of the table below.

Note: Phenol red is an indicator for pH. The colour red indicates a solution is a base. Yellow indicates the solution is an acid. pH 6.5 (yellow); pH 7.0 (orange); pH 8.2 (red)

	Test Tube #1	**Test Tube #2**	**Test Tube #3**	**Test Tube #4**	**Test Tube #5**
Water (mL)	5	5	5	5	5
Fresh cream (mL)	5	5	5	5	5
Phenol red (drops)	4	4	4	4	4
Bile salts		Pinch	Pinch		Pinch
Pancreatin (mL)			5	5	5
Water bath (37°C)	X	X	X	X	
Results					
Observations					
Colour					

Analysis

1. What is the role of the substances in each of the test tubes: fresh cream, bile salts, and pancreatin?
2. What is the function of Test Tube #1? Explain your response.
3. Compare the contents of Test Tubes #1 and #2. What do the results obtained indicate?
4. Compare the results of Test Tubes #1 and #2 with Test Tubes #3, #4, and #5. What do the results obtained indicate?
5. Both Test Tubes #3 and #5 changed colour. Did you notice any difference in how quickly the colour change took place? What is a possible explanation for this difference?
6. Both Test Tubes #3 and #4 changed colour. Did you notice any difference in how quickly the colour change took place? What is a possible explanation for this difference?
7. Create a summary list of the factors that increased the rate of digestion.

Conclusion

Under the heading "Conclusion," write an interpretation of your results, identify sources of error, and so on.

Appendix 2.2B: Enzymatic Factors in the Digestion of Lipids (Teacher Background)

Objective

To investigate the role of enzymes in lipid digestion.

Background Information

Lipids include fats, such as butterfat and oils. Lipids are digested by pancreatic lipase in the small intestine, a process described by the following two reactions:

1. fat $\longrightarrow$ fat droplets (bile emulsifier)
2. fat droplets + water $\longrightarrow$ glycerol + fatty acids (lipase enzyme)

The first reaction is not enzymatic. It is an emulsification reaction in which fat is physically dispersed by the emulsifier (bile) into small droplets. The small droplets provide a greater surface area for enzyme attack. Lipids are hydrophobic and therefore insoluble, so they are hydrolyzed slowly unless an emulsifier is used. As a result, when the fat droplets are exposed to an enzyme and broken down into glycerol and fatty acids, the pH of the solution will go down.

Material and Procedure

You can purchase pancreatin as a salt from a science supply company and then create your own solution by mixing 5 g of pancreatin with 100 mL of distilled water. Bile salts and phenol red can also be purchased from a science supply company.

Results

Students should find results similar to the ones included in the following table. This is an imprecise type of lab, and observations will vary. However, Test Tubes #1 and #2 should show no change and Test Tubes #3, #4, and #5 should have a change. Students should also observe that the change took place most quickly in Test Tube #3, which contained bile salts and was placed in a water bath. The impact of bile salts (increasing surface area) and temperature as factors affecting enzymatic action is discussed in the Analysis questions.

	Test Tube #1	Test Tube #2	Test Tube #3	Test Tube #4	Test Tube #5
Water (mL)	5	5	5	5	5
Fresh cream (mL)	5	5	5	5	5
Phenol red (drops)	4	4	4	4	4
Bile salts		Pinch	Pinch		Pinch
Pancreatin (mL)			5	5	5
Water bath (37°C)	X	X	X	X	
Results					
Observations	*No change*	*No change*	*Change took place quickly*		
Colour	*Red/ Orange*	*Red/ Orange*	*Yellow*	*Yellow*	*Yellow*

Analysis

1. What is the role of the substances in each of the test tubes: fresh cream, bile salts, and pancreatin?

   The fresh cream is the source of a lipid, the bile salts are the emulsifier necessary to break down the lipids in the cream, and the pancreatin is the enzyme necessary to break the fat droplets into fatty acids.

2. What is the function of Test Tube #1? Explain your response.

   Test tube #1 is the control for the experiment to demonstrate what happens when no emulsifiers or enzymes are added to the solution.

3. Compare the contents of Test Tubes #1 and #2. What do the results obtained indicate?

   Both test tubes contain water, fresh cream, and phenol red, and are placed in a water bath. Neither contains pancreatin. Only Test Tube #2 contains bile salts. There is no change of colour in either test tube, indicating that without pancreatin digestion does not take place. Also, the presence of bile salts was not a factor.

4. Compare the results of Test Tubes #1 and #2 with Test Tubes #3, #4, and #5. What do the results obtained indicate?

   Test Tubes #1 and #2 had no change. A colour change took place in Test Tubes #3, #4, and #5. This indicates that digestion took place in #3, #4, and #5 and can be linked to the presence of pancreatin.

5. Both Test Tubes #3 and #5 changed colour. Did you notice any difference in how quickly the colour change took place? What is a possible explanation for this difference?

   Test Tube #3 changed colour more quickly. The only difference between the two test tubes is that Test Tube #3 was placed in a water bath. This would seem to indicate that temperature accelerates enzymatic activity.

6. Both Test Tubes #3 and #4 changed colour. Did you notice any difference in how quickly the colour change took place? What is a possible explanation for this difference?

   Test Tube #3 changed colour more quickly. The only difference between the two test tubes is that Test Tube #3 contained bile salts. This would seem to indicate that the presence of bile salts accelerates enzymatic activity by increasing surface area.

7. Create a summary list of the factors that increased the rate of digestion.

   Increased temperature, increased surface area (caused by emulsification)

Conclusion

Students should state clearly that enzymes are necessary for digestion of lipids to take place. They may also discuss factors that increase the rate of digestion (presence of bile salts—increasing surface area, increase in temperature). However, this evidence was subjective or qualitative and students should recognize this weakness.

Appendix 2.3: Regulatory Systems (BLM)

The human body has two major systems that help the body detect and respond to environmental change and maintain homeostasis: the nervous and endocrine systems. These systems may work either independently or in a coordinated manner.

Nervous Regulatory System

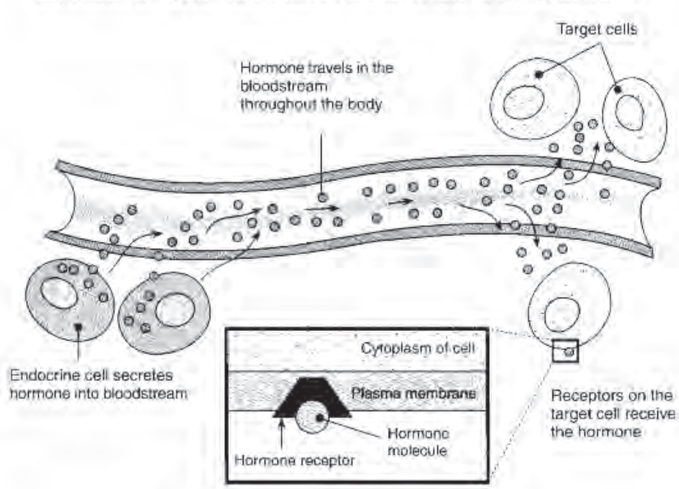
The nervous system contains specialized nerve cells that transmit information in the form of electrochemical impulses along branches that can carry information directly to and from specific target tissues. These impulses can be transmitted over considerable distances and the response is very precise and rapid. More will be learned about the nervous system in a later unit of study.

Hormonal Regulatory Systems*

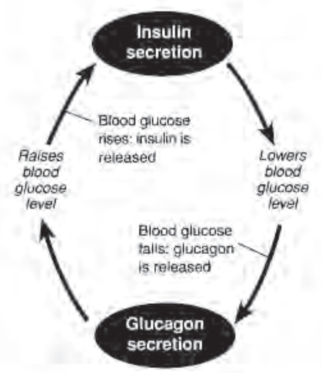
The endocrine system regulates the body's processes by releasing chemical messengers (hormones) into the bloodstream. Hormones are potent chemical regulators: they are produced in minute quantities yet can have a large effect on metabolism. The endocrine system comprises endocrine cells (organized into endocrine glands), and the hormones they produce. Unlike exocrine glands (e.g., sweat and salivary glands), endocrine glands are ductless glands, secreting hormones directly into the bloodstream rather than through a duct or tube. Some organs (e.g., the pancreas) have both endocrine and exocrine regions, but these are structurally and functionally distinct. The basis of hormonal control and the role of negative feedback mechanisms in regulating hormone levels are described below.

The Mechanism of Hormone Action

Endocrine cells produce hormones (chemical messengers) and secrete them into the bloodstream where they are distributed throughout the body. Although hormones are broadcast throughout the body, they affect only specific target cells. These target cells have receptors on the plasma membrane which recognize and bind the hormone (see inset, below right). The binding of hormone and receptor triggers the response in the target cell. Cells are unresponsive to a hormone if they do not have the appropriate receptors.



Antagonistic Hormones



The effects of one hormone are often counteracted by an opposing hormone. Feedback mechanisms adjust the balance of the two hormones to maintain a physiological function. Example: insulin decreases blood glucose and glucagon raises it.

(continued)

*Source: Allan, Richard, and Tracey Greenwood. "Hormonal Regulatory Systems." *Senior Biology 2, 2004. Student Resource and Activity Manual (2003)*: 252. Reproduced by permission of Biozone International.

1. a) Explain what is meant by a **hormone**: ______________________________

   ____

   b) Explain what is meant by **antagonistic hormones** and provide an example of two such hormones:

   ____

   Example: ______________________________

   c) Explain the role of feedback mechanisms in adjusting hormone levels (explain using an example if this is helpful):

   ____

   ____

2. Explain how a hormone can bring about a response in target cells even though all cells may receive the hormone:

   ____

   ____

3. Explain why hormonal control differs from nervous system control with respect to the following:

   a) The speed of hormonal responses is slower: ______________________________

   ____

   b) Hormonal responses are generally longer lasting: ______________________________

   ____

Appendix 2.4A:
The Role of the Liver in Homeostasis (BLM)

The liver has many important functions. Almost all the blood circulating from the intestines to the heart passes through the liver. Therefore, everything you eat that gets into the bloodstream passes through your liver. The liver then either stores nutrients or breaks them down even more. The liver transforms nutrients into proteins, fats, and cholesterol. It also stores vitamins (A, D, K, and B12), minerals, and carbohydrates.

The liver also plays the role of a filtering system. Toxic substances, including alcohol, are transformed into less harmful substances.

As you have seen in Unit 1, glucose is necessary for cells to produce ATP, the molecule that stores energy. The amount of ATP that the body needs at any one time changes; therefore, the body needs to be able to store glucose when it is not needed, but release glucose when it is needed.

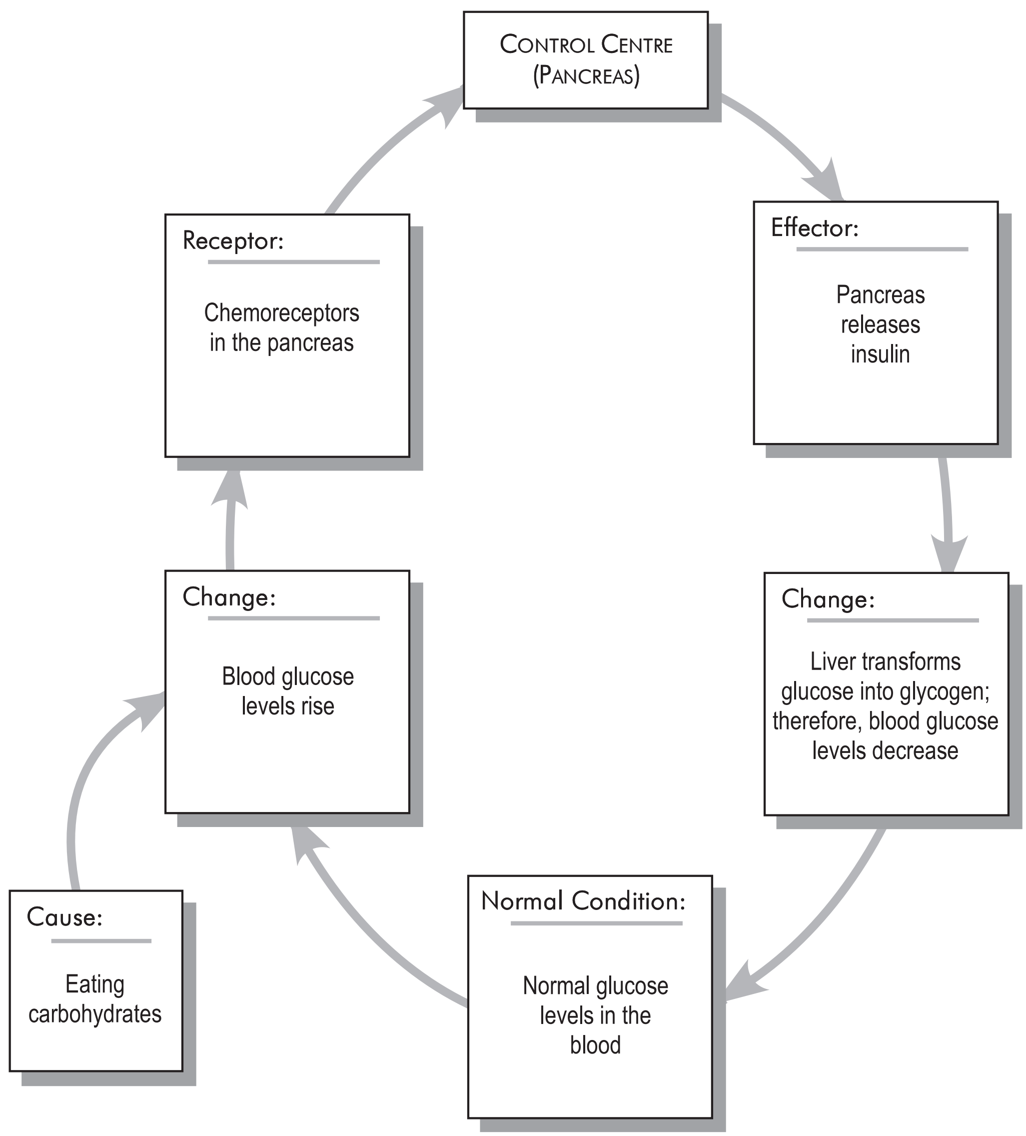
Two hormones responsible for controlling the concentration of glucose in the blood are insulin and glucagon, which are produced in the pancreas. The liver also plays an important role in blood glucose control. It is here that excess glucose is stored in the form of glycogen.

When you eat a meal, blood glucose levels start to rise. When they reach a certain concentration, receptors in the pancreas stimulate the production of insulin. This hormone reaches the liver, which then converts blood glucose into glycogen. Blood glucose levels drop and return to a normal level.

If blood glucose levels drop below a certain level, receptors in the pancreas stimulate the production of glucagon. This hormone reaches the liver, which then converts glycogen into glucose. Glucose is released into the bloodstream and blood glucose levels rise until they return to a normal level.

Appendix 2.4B: The Liver and Negative Feedback (BLM)

Negative Feedback Pathways—Liver and Pancreas



Appendix 2.5A: Testing for Carbohydrates— Student Handout (BLM)

Introduction

One of the major functions of carbohydrates is to provide living cells with a source of energy. Carbohydrates are composed of molecular building blocks known as *monosaccharides*, or *simple sugars*. Glucose is the most well-known simple sugar.

The type of carbohydrate formed is determined by three factors:

- the number of monosaccharide units
- the type of monosaccharide units
- the physical arrangement of these units

Benedict's solution produces a range of colours, depending upon the concentration of monosaccharide (simple sugar) in the sample:

- green—low concentration
- yellow—low to medium concentration
- orange—medium concentration
- reddish/orange—medium to high concentration
- brick red—high concentration

Purpose

To become familiar with a test to indicate the presence of reducing sugars and to classify substances accordingly.

Materials and Samples

Materials	Suggested Samples
two test tubes	milk
hot water bath	potato
eyedropper	apple
goggles	bread
Benedict's solution	apple juice
apron	unsalted cracker
gloves	banana
	plain yogourt
	clear, non-diet pop

Procedure

CAUTION

DO NOT SPILL CHEMICALS ON SKIN OR CLOTHES.

ALL GLASSWARE MUST BE CLEANED BEFORE AND AFTER EACH TEST.

1. Obtain two test tubes. Mark one **T** (for test) and the other **C** (for control).
2. To both test tubes add a single eyedropperful of Benedict's solution.
3. To the **T** test tube add one eyedropperful of sample to be tested, and to the **C** test tube add an eyedropperful of water.
4. Place both test tubes in the community hot water bath for four minutes. Create a table to record the initial and final colours.
5. Repeat for all other samples assigned.

Analysis

1. From your tested samples identify the sample that had the highest concentration of sugar and the sample that had the lowest concentration.
2. Differentiate between the structure of a molecule of glucose and a molecule of sucrose and record differences in the table below.

Sucrose	Parameter	Glucose
	Number of atoms	
	Relative size	

3. List the samples that you tested where sugar was present.
4. When testing a sample with Benedict's solution, the colour changes from blue to violet. Is a sugar present? Explain.
5. Specify the process on the planet that creates carbohydrates.
6. What is the purpose of the control test tube?
7. Why must the glassware be clean in biochemical testing?

Appendix 2.5B: Testing for Carbohydrates (Teacher Background)

Introduction

An important function of carbohydrates is to provide living cells with a source of energy. Carbohydrates are composed of molecular building blocks known as *monosaccharides*, or *simple sugars*. Glucose is the most well-known simple sugar.

The type of carbohydrate formed is determined by three factors:

- the number of monosaccharide units
- the type of monosaccharide units
- the physical arrangement of these units

Benedict's solution produces a range of colours, depending upon the concentration of monosaccharides (simple sugar) in the sample:

- green—low concentration
- yellow—low to medium concentration
- orange—medium concentration
- reddish/orange—medium to high concentration
- brick red—high concentration

Note: Benedict's solution is used to test urine for glucose in diagnosing diabetes. Be sure to test the pop you plan to use in advance as some brands may work better than others.

Purpose

To become familiar with a test to indicate the presence of reducing sugars and to classify substances accordingly.

Materials and Samples

Materials	Suggested Samples
two test tubes	milk
hot water bath	potato
eyedroper	apple
goggles	bread
Benedict's solution	apple juice
apron	unsalted cracker
gloves	banana
	plain yogourt
	clear, non-diet pop

Procedure

CAUTION

Do not spill chemicals on skin or clothes.

All glassware must be cleaned before and after each test.

1. Obtain two test tubes. Mark one **T** (for test) and the other **C** (for control).
2. To both test tubes add a single eyedropperful of Benedict's solution.
3. To the **T** test tube add one eyedropperful of sample to be tested and to the **C** test tube add an eyedropperful of water.
4. Place both test tubes in the community hot water bath for four minutes. Create a table to record the initial and final colours.
5. Repeat for all other samples assigned.

Note: Have students record their findings in a data table similar to the one below.

Samples	Initial Colour	Final Colour

Analysis

1. From your tested samples identify the sample that had the highest concentration of sugar and the sample that had the lowest concentration.

   Results will vary, depending on the particular samples tested. Apples, apple juice, bananas, and non-diet pop are generally higher in concentration of monosaccharides, whereas milk, potatoes, breads, unsalted crackers, and plain yogourt are lower.

2. Differentiate between the structure of a molecule of glucose and a molecule of sucrose and record differences in the table below.

Sucrose	**Parameter**	**Glucose**
46	Number of atoms	*24*
Larger	Relative size	*Small*

3. List the samples that you tested where sugar was present.

   Answers will vary, depending on samples used.

4. When testing a sample with Benedict's solution, the colour changes from blue to violet. Is a sugar present? Explain.

   No. Violet is not in the colour range for a positive Benedict's test.

5. Specify the process on the planet that creates carbohydrates.

   Photosynthesis

6. What is the purpose of the control test tube?

   It is meant as a comparison to eliminate the temperature variable.

7. Why must the glassware be clean in biochemical testing?

   To prevent contamination and invalidation of a test.

Appendix 2.6A: Testing for Proteins—Student Handout (BLM)

Introduction

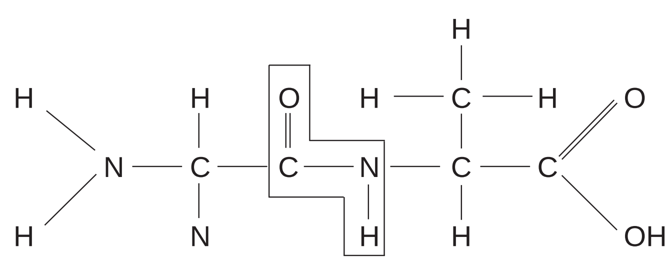
Proteins are massive molecules containing thousands of atoms.

The molecules are composed of subunits called *amino acids.* These amino acids, of which there are 22 different kinds, all contain an amino group (NH_2) and a carboxyl group (–COOH). In a protein molecule the amino acids are joined together by a carbon-nitrogen bond called a *peptide bond.*

The peptide bond links the carboxyl group of one amino acid to the amino group of another (see the figure below).

All proteins contain these elements:

Carbon
Oxygen
Hydrogen
Nitrogen



Purpose

To test samples for the presence of amino acids.

Materials and Samples

Materials	Suggested Samples
goggles	milk
apron	egg white
gloves	gelatin
eyedropper	tofu
two test tubes	apple
test tube rack	unsalted cracker
biuret reagent	potato

Biuret reagent reacts with certain amino acids to produce a striking colour change. The presence of a *violet* or *purple* colour indicates a positive test; any other colour is a negative result.

Procedure

1. Add one eyedropperful of water into one test tube, and to the other test tube add a comparable amount of the sample to be tested.
2. To each test tube add the following: one eyedropperful of biuret reagent.
3. Agitate the system for a couple of minutes and then observe the colours. Record the colours in the table that follows.
4. Clean your test tubes well and repeat the test with the other samples that are provided.

Results

Sample	Post-Reaction Colour	Protein Present (+ or –)

Analysis

1. Why must the test tubes be cleaned after each test?
2. The test tube with the water acts as a control for the biochemical testing procedure. What is the value of this control?
3. Differentiate between proteins and carbohydrates under the following topics:

Topic	Carbohydrates	Proteins
Elements present		
Relative size		
Chemical test for...		
Building block (subunit)		
Uses	1.	1.
	2.	2.

4. Why are important molecules such as enzymes and antibodies composed of proteins and not of carbohydrates?

Appendix 2.6B: Testing for Proteins (Teacher Background)

Introduction

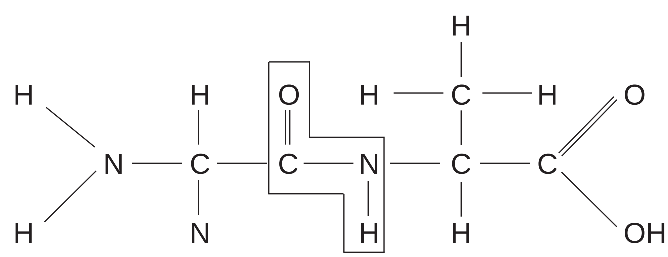
Proteins are massive molecules containing thousands of atoms.

The molecules are composed of subunits called *amino acids.* These amino acids, of which there are 22 different kinds, all contain an amino group (NH_2) and a carboxyl group (–COOH). In a protein molecule the amino acids are joined together by a carbon-nitrogen bond called a *peptide bond.*

The peptide bond links the carboxyl group of one amino acid to the amino group of another (see the figure below).

All proteins contain these elements:

Carbon
Oxygen
Hydrogen
Nitrogen



Purpose

To test samples for the presence of amino acids.

Materials and Samples

Materials	Suggested Samples
goggles	milk
apron	egg white
gloves	gelatin
eyedropper	tofu
two test tubes	apple
test tube rack	unsalted cracker
biuret reagent	potato

Biuret reagent reacts with certain amino acids to produce a striking colour change. The presence of a *violet* or *purple* colour indicates a positive test; any other colour is a negative result.

Procedure

1. Add one eyedropperful of water into one test tube, and to the other test tube add a comparable amount of the sample to be tested.
2. To each test tube add the following: one eyedropperful of biuret reagent.
3. Agitate the system for a couple of minutes and then observe the colours. Record the colours in the table that follows.
4. Clean your test tubes well and repeat the test with the other samples that are provided.

Results

Results will vary, depending on the samples used. The table below provides an example of what student data might look like.

Sample	Post-Reaction Colour	Protein Present (+ or –)
milk	*No change*	–
egg white	*Purple*	+
gelatin	*Purple*	+
tofu	*Purple*	+
apple	*No change*	–
unsalted cracker	*No change*	–
potato	*No change*	–

Analysis

1. Why must the test tubes be cleaned after each test?

   The test tubes must be cleaned because there may be protein residue in the test tubes, which would result in an incorrect conclusion.

2. The test tube with the water acts as a control for the biochemical testing procedure. What is the value of this control?

   This test tube demonstrates what would occur without the presence of a protein and can be used for reference. It checks whether the reagents/solutions are also contaminated and provides a basis for comparison.

3. Differentiate between proteins and carbohydrates under the following topics:

Topic	Carbohydrates	Proteins
Elements present	*C/H/O*	*C/H/O/N*
Relative size	*Smaller*	*Larger*
Chemical test for...	*Benedict's solution*	*Biuret reagent*
Building block (subunit)	*Monosaccharide*	*Amino acid*
Uses	*1. Structural*	*1. Enzymes*
	2. Energy	*2. Hormones*

4. Why are important molecules such as enzymes and antibodies composed of proteins and not of carbohydrates?

   Carbohydrate structure is fixed. In proteins the structure can vary and, therefore, accommodate the needs of the cell.

Appendix 2.7A: Unravelling the Enigma of Vitamin D* (BLM)

by Roberta Conlan and Elizabeth Sherman, with the assistance of David R. Fraser, Mark R. Haussler, Michael F. Holick, Robert Neer, Anthony W. Norman, and Munro Peacock

Summary

Rickets was a common disease afflicting children in the eighteenth century. However, the cause for it was not well understood, and many children died because there was no cure (see Tracing the Cause of Disease). As physicians began investigating other diseases such as beriberi, they realized that there were factors in food other than proteins and salts which were essential to health. Research into these "accessory food factors" led scientists to demonstrate the existence of vitamins (see "A Substance Different from Protein and Salts ..."). As scientists turned their attention to rickets again, they found that exposure to sunlight seemed to be an effective treatment. Physicians also were attempting to isolate nutrients in food that might help and found that an unknown nutrient in cod-liver oil was effective against rickets. Following the designation of vitamins in alphabetic order, they dubbed this new nutrient vitamin D.

Scientists explored the relationship between nutrition and irradiation of foods and found that irradiated foods contained the nutrient that seemed to fight rickets (see Closing in on Rickets). But scientists still knew nothing of what this nutrient was and how it worked to cure rickets. The search continued for the exact substance in food and skin that was activated by ultraviolet radiation. Through extensive research, scientists isolated 3 forms of vitamin D, which made it possible to synthesize the vitamin in large quantities (see Animal, Vegetable, or Mineral?). Research continued to determine how vitamin D worked in the body and scientists were able to determine the process by which vitamin D regulates the amount of calcium in the body (see Vitamin D's Connection to Calcium Control). Further investigations have shown that vitamin D plays many roles beyond maintaining the body's calcium levels (see More Than Just a Way to Regulate Calcium).

Introduction

Most of us know that to maintain good health we need to eat a balanced diet that includes fruits, vegetables, grains, protein, and some fat. In this age of fast food and missed meals, however, many of us also take supplements to ensure that we're getting the minimum daily requirement of essential vitamins and minerals—nutrients necessary only in very small quantities to prevent disease and to keep us optimally healthy.

The first of these so-called micronutrients was discovered a little over a century ago, with investigations into the causes of such diseases as scurvy, beriberi, and rickets. The following article focuses on the twists and turns leading to the discovery and understanding of one such nutrient: vitamin D, a substance that occurs naturally in only a few foods and that is

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*Source: "Unravelling the Enigma of Vitamin D." <www.beyonddiscovery.org/content/view.txt.asp?a=414>. Reproduced by permission of the National Academies of Sciences.

also manufactured in the skin when a precursor interacts with the short ultraviolet rays of the sun. Without adequate levels of 1,25-dihydroxyvitamin D3—the active metabolite of vitamin D—in the blood, the body cannot absorb and use the dietary calcium essential for such vital functions as the electrochemical signalling between brain cells. When dietary calcium and the mineral phosphorus are not properly absorbed through the intestine, the body also cannot build strong bones. In children, vitamin D deficiency results in the once common disease known as rickets, which leaves its lifelong mark of bowed legs and deformed ribs. In adults, the result is the bone disease osteoporosis.

Today, as growing numbers of Baby Boomers celebrate their fiftieth-plus birthdays, concerns about the brittle bones and fractures associated with advanced age are focusing renewed attention on vitamin D. Increasingly, researchers are learning that vitamin D is essential in maintaining health and preventing disease not just during the crucial growing years of childhood but throughout life. Recent studies show that vitamin D insufficiency may even be, in one researcher's words, "an unrecognized epidemic" among both women and men who are middle aged and older. In addition to affecting bone growth, scientists are finding that vitamin D and calcium may affect diseases and disorders as disparate as colon cancer, multiple sclerosis, premenstrual syndrome, psoriasis, high blood pressure, and depression.

A Case of Mistaken Identity

One of the reasons vitamin D was a puzzle to scientists for so many years was that it was initially misidentified as a true vitamin, that is, an essential substance that our bodies cannot manufacture and which, therefore, can only be obtained from our food. But, unlike essential dietary trace elements, such as vitamins A, B, and C, which humans must get directly from food, vitamin D can be produced in the body through a photosynthetic reaction when the skin is exposed to sunlight. The resulting substance is only a precursor, however, which must then undergo two transformations—first in the liver and then in the kidney—to become the biologically active substance the body uses. This active form of vitamin D is a hormone, chemically akin to familiar steroid hormones, such as the sex regulators testosterone and estrogen and the stress regulator cortisol.

Arriving at a clear understanding of the multifaceted nature of vitamin D and its role in the body—especially its relationship to calcium—was the culmination of three different avenues of research. The earliest investigators were interested in the causes and prevention of particular diseases, such as scurvy, beriberi, and rickets. On a separate track, scientists were examining how the known primary constituents of food (proteins, fats, carbohydrates, salts, and water) affected health and growth. Work along these two fronts dovetailed to yield the concept of vitamins—an essential micronutrient in food—and to establish that vitamin deficiencies can lead to disease. This allowed a lack of vitamin D to be identified as the cause of rickets. But many aspects of this "vitamin" remained baffling, since it was actually a hormone whose active form is produced in our bodies in response to regulatory signals. Understanding of the vitamin D hormone and its roles in human physiology would require the knowledge and tools of a third line of research that had been developed by organic chemists studying sterols—the steroid alcohols (such as cholesterol) that occur in both animal and plant fats. Just as a tapestry image emerges from the weaving of many threads, clues from each line of inquiry eventually formed a pattern that solved the enigma of vitamin D.

Tracing the Cause of Disease

The first solid hint that a specific dietary deficiency could lead to disease came in 1754. In that year the Scottish naval surgeon James Lind showed that scurvy—the painful and sometimes fatal bane of mariners on long ocean voyages—could not only be cured but also prevented with the juice of oranges, lemons, and limes. By the late eighteenth century, British sailors (soon nicknamed "Limeys") were reaping the benefit of Lind's discovery.

Meanwhile, the advent of the Industrial Revolution in Britain in the late 1700s brought with it a different scourge: rickets. The disease itself had first been described by physicians in the mid 1600s, but it was then relatively rare. By the nineteenth century, however, as more and more families left the outdoor life of the farm for factory work in the smoggy air of industrial cities, rickets had become a plague all over Europe. Symptoms of the disease were unmistakable. The bones of afflicted infants remained soft, like cartilage, and the babies were slow to sit, crawl, and walk. As the children grew, their soft bones bent under the additional weight, leaving the children with rickets' telltale pigeon breast, bowed legs, or knock-knees. Rachitic children (that is, children with rickets) also suffered from tetany: painful spasms of the hands, feet, and larynx, along with difficulty in breathing, nausea, and convulsions. This condition, later found to be symptomatic of insufficient calcium, was often so severe that children died.

Throughout the nineteenth century, sporadic reports of cures for rickets surfaced, but with little effect. In 1822, for example, a Polish physician observed that children in Warsaw suffered severely from rickets, whereas the disease was virtually unknown in the city's rural outskirts. After experimenting with the two groups, he concluded that sunbathing cured rickets. Five years later, a French researcher reported cures among those given the home remedy cod-liver oil. Neither treatment gained widespread attention, in part because the prevailing medical wisdom was that people needed only to get adequate amounts of the so-called macronutrients—proteins, fats, and carbohydrates—in order to maintain health. However, researchers looking into the causes of such diseases as pellagra and beriberi began to suspect that the macronutrients might not be the whole story—that, in fact, there was more to ordinary food than met the eye.

"A Substance Different from Protein and Salts . . ."

In the late 1880s Dutch physician Christiaan Eijkman was sent to the East Indies (now Indonesia) to investigate why beriberi was so widespread in the region. Eijkman observed that hens in his Jakarta laboratory suffered symptoms of nerve disease (polyneuritis) that were strikingly similar to those for beriberi—including muscle weakness, nerve degeneration, and paralysis. He then began a series of experiments to try to find a culprit organism, which he assumed was the cause. (Like most of his contemporaries, Eijkman was influenced by the work of Louis Pasteur and believed that a bacterium caused beriberi.)

Eijkman failed in this effort, but in 1897 he did succeed in establishing something more significant. He showed that the hens contracted the beriberi-like polyneuritis soon after their feed was changed to polished rice—that is, rice whose outer husk had been removed. He also proved that by adding rice bran (the parts removed in polishing) to the hens' food, the disease could be cured.

Eijkman and his successor, Gerrit Grijns, later used water or ethanol to extract the mysterious antineuritic factor from rice hulls. "There is present in rice polishings a substance different from protein and salts," the two researchers wrote in 1906, "which is indispensable to health and the lack of which causes nutritional polyneuritis."

In 1926 B. C. P. Jansen and W. Donath, two Dutch chemists working in Eijkman's old laboratory in Jakarta, crystallized the water-soluble antineuritic factor—now called vitamin B1, or thiamine—from rice bran.

Another researcher soon after the turn of the century also came to believe in the existence of certain "accessory food factors." English biologist Sir Frederick Gowland Hopkins developed this concept in the course of work that began with his discovery in 1901 of the amino acid tryptophan. Building on techniques developed in this research, Hopkins went on to perform a series of now classic experiments demonstrating that whole foods (as opposed to purified forms of proteins, fats, and carbohydrates) contain certain unknown constituents essential to health and growth.

Biochemist Casimir Funk, whose own work led him to believe these factors were amines (compounds derived from ammonia), suggested they be called "vital amines" or "vitamines" for short. The "e" was later dropped when scientists realized that these various nutrients have different chemical properties and functions and that many contain no amines at all. Hopkins and Christiaan Eijkman—in belated recognition of his seminal work with beriberi—would later share the 1929 Nobel Prize for Physiology or Medicine for the discovery of essential nutrient factors.

At about the same time that Hopkins was demonstrating the existence of vitamins, other researchers were investigating the effects of different diets on the health of experimental animals. Over the next two decades, they would identify a number of vitamins, demonstrating again and again that these essential nutrients are not equally distributed in the foods we eat.

In 1913, for example, Wisconsin researchers Elmer McCollum and Marguerite Davis discovered a fat-soluble accessory substance. By feeding rats diets of different foods and observing the effects on the animals' growth and health, McCollum and Davis found that the new substance is present in egg yolk and butter fat but absent from lard and other fats. They called the nutrient "fat-soluble vitamin A." These scientists were further able to show that vitamin A in the diet prevents night blindness and the eye disease xerophthalmia. The team of L. B. Mendel and T. B. Osborne independently published similar results within weeks.

Closing in on Rickets

By this time, a number of studies had focused attention again on rickets, which was still a severe problem in Scotland and in parts of northern Europe. A few investigators approaching the question from another direction had picked up the nearly forgotten clue about the effectiveness of sunlight. In 1892, British scientist T. A. Palm found a relationship between the geographic distribution of rickets and the amount of sunlight in the region. In 1913, University of Wisconsin's H. Steenbock and E. B. Hart made a more direct link, showing that lactating goats kept indoors lose a great deal of their skeletal calcium, whereas those kept outdoors do not. Six years later, in 1919, the German researcher K. Huldschinsky carried out a remarkably innovative experiment and cured children of rickets using artificially produced ultraviolet light. Two years after that, researchers Alfred F. Hess and L. F. Unger of Columbia University showed that by simply exposing rachitic children to sunlight, they were able to cure them of the disease.

On the nutritional front, in the meantime, British physician Sir Edward Mellanby, still searching for a dietary deficiency as the cause of rickets, decided in 1918 to test porridge, the staple food of Scotland, by feeding dogs exclusively on oats. Inadvertently, he also kept the animals indoors throughout the experiment, thereby inducing rickets. When he cured the dogs of the disease by feeding them cod-liver oil, Mellanby naturally credited the oil's recently identified vitamin A with the cure.

On learning of Mellanby's experiments, McCollum, who had since moved from Wisconsin to Johns Hopkins University in Baltimore, decided to pursue them further. From his own work on isolating vitamin A, McCollum had found that certain foods may contain more than one accessory food substance. He thus designed a series of ingenious experiments to follow up on Mellanby's findings and discover what else, if anything, cod-liver oil might have to offer. He began by heating and aerating the oil to destroy its vitamin A. As expected, the treated oil no longer cured night blindness. But, to everyone's surprise, it did remain effective against rickets. Clearly, an unknown essential nutrient was responsible. In his 1922 publication of these experiments, McCollum followed the designations of vitamins in alphabetic order; since vitamins B and C had recently been named, he dubbed the new miracle worker "vitamin D."

By the early 1920s, then, it appeared that the world had two cures for rickets: cod-liver oil and irradiation—that is, exposure to sunlight or ultraviolet light. Despite this promise, the disease remained intractable. Although physicians knew that sunlight was essential for young bones, the streets of industrial cities were as smoky and sunless as ever. And changing people's dietary habits to include prescriptive doses of cod-liver oil was no easy matter.

Then came a series of experiments that tied together the nutritional research and the findings concerning irradiation, offering a solution to this critical piece of the vitamin D puzzle and paving the way for a widely available cure for rickets. During the course of extensive nutritional research, Harry Goldblatt and Katherine Soames, working in London, discovered that the livers from irradiated rats, when fed to other rats, were growth promoting, whereas the livers from unirradiated rats were not. In the early 1920s, two teams of researchers—H. Steenbock and A. Black, and Alfred Hess and Mildred Weinstock—followed up on this strand of research, as well as Huldschinsky's lead, by further experimenting with the effect of ultraviolet light on foods fed to rats.

Independently, the two teams of researchers irradiated excised skin as well as such food substances as vegetable oils, egg yolk, milk, lettuce, or rat chow and found that irradiation produced a substance that seemed to work on rickets much as the vitamin D in cod-liver oil did. Rats that were fed irradiated foods or irradiated skin were protected against rickets, whereas those fed unirradiated foods or skin were not. Recognizing that simply irradiating certain foods that were common in most people's diets could spare large numbers of children from the bone disease, Steenbock patented the food irradiation process using ultraviolet light in 1924, donating all future proceeds to support research at the University of Wisconsin.

Animal, Vegetable, or Mineral?

By 1924, the practical side of the battle against rickets had been won. Across the United States, children began consuming irradiated milk and bread and, seemingly overnight, the imminent threat of epidemic disease dwindled to a half-forgotten historical event. But the quest to understand vitamin D was only just beginning, for scientists still knew almost nothing of what it was or how it worked.

The search continued for the exact substance in food and skin that was activated by ultraviolet irradiation. Several teams of researchers—Wisconsin's Steenbock and Black; Columbia University's Hess, Weinstock, and F. Dorothy Helman; and O. Rosenheim and T. A. Webster of the National Institute for Medical Research in London—confirmed that the substance is present in animal and vegetable fats. Moreover, they proved that it is localized in the fraction of fats known to contain sterol molecules. The researchers found that purified cholesterol (a major animal sterol) and phytosterols (vegetable sterols), both of which otherwise have no antirachitic properties, are rendered antirachitic by ultraviolet irradiation.

Up to this point, researchers investigating vitamin D had to be content with characterizing the elusive substance on the basis of its physiological effects. As it happened, however, the work of organic chemist Adolf Windaus, in Göttingen, Germany, would produce chemical tools that would finally help pinpoint the molecular identity of vitamin D. Early in the century, Windaus had embarked on his study of cholesterol and related sterols, about which virtually nothing was known at the time. From the very start, he believed that sterols, which occur in every cell, must be considered as the parent substance of other groups of natural substances, and he was convinced that investigations into the structure of these molecules would yield unexpected results.

By 1925, Windaus was recognized as the leading expert on sterols, and Hess invited him to come to New York to work on antirachitic vitamins. Windaus also was collaborating with Rosenheim and Webster in London at the time, and in 1927 both teams, using a series of clever chemical transformations and comparisons with known compounds, deduced that ergosterol was the likely parent substance of vitamin D in food. Back in his own laboratory in Göttingen the following year, Windaus isolated three forms of the vitamin: two derived from irradiated plant sterols, which he called D1 and D2, and one derived from irradiated skin, which he called D3. F. A. Askew's British team followed up in 1931, successfully defining the chemical makeup of D2—the form of vitamin D found in irradiated foods (now called ergocalciferol)—which was derived from the precursor molecule ergosterol. Five years later, in 1936, Windaus synthesized the molecule 7-dehydrocholesterol and then converted it by irradiation to vitamin D3, now known as cholecalciferol. Although it was assumed that vitamin D was photosynthesized in the skin from 7-dehydrocholesterol, the final proof did not emerge until more than three decades later. A Wisconsin team led by R. P. Esvelt and one led by Michael F. Holick at the Endocrine Unit of Massachusetts General Hospital then independently demonstrated that vitamin D3 is, in fact, what is produced in the skin through irradiation.

Because of these discoveries, it became possible to synthesize the vitamin in large quantities. Synthesizing the vitamin costs a fraction of what it costs to irradiate foods and does not destroy or change food flavours, as irradiation sometimes does. Synthesized vitamin D provided the capstone of the public health campaign to eradicate rickets. For his "research into the constitution of the sterols and their connection with the vitamins," Windaus was awarded the Nobel Prize for Chemistry in 1928.

Vitamin D's Connection to Calcium Control

With rickets under control, scientists now concentrated on finding out how the miracle bone builder worked. Over the next forty years, a number of research teams teased out vitamin D's metabolic pathway in the body. One of the confusing initial findings was that the metabolic by-products of vitamin D all seemed to be biologically inactive. How, then, did vitamin D build bone and cure rickets?

Scientists did not have the tools to follow this complicated process in living subjects until the advent, in the mid 1960s, of new techniques using radioactively labelled substances. Between 1968 and 1971, researchers made great progress in understanding the metabolic processing of vitamin D and its physiological activity. In 1968 a team headed by Hector F. DeLuca at the University of Wisconsin isolated an active substance identified as 25-hydroxyvitamin D3, which the team later proved to be produced in the liver. During the next two years, the Wisconsin team, Anthony W. Norman and colleagues at the University of California-Riverside, and E. Kodicek and co-workers at Cambridge University in England independently reported the existence of a second active metabolite. Kodicek and David R. Fraser showed that this second metabolite is produced in the kidney. Finally, in 1971 all three research groups published papers in which they reported the chemical/molecular structure of this metabolite, which was identified as 1,25-dihydroxyvitamin D3. It was now clear that the liver changes vitamin D3 to 25-hydroxyvitamin D3, the major circulating form of the vitamin. The kidneys then convert 25-hydroxyvitamin D3 to 1,25-dihydroxyvitamin D3, the active form of the vitamin.

But how does all of this affect calcium deposition to build strong bones? Since the 1950s, scientists had been puzzling over the implications of two findings related to this question. In the early part of that decade, the Swedish researcher Arvid Carlsson made the startling discovery that vitamin D can actually remove calcium from bones when it is needed by the body. At about the same time, the Norwegian biochemist R. Nicolaysen, who had been testing different diets on animals for years, concluded that the uptake of calcium from food is guided by some unknown "endogenous factor" that alerts the intestines to the body's calcium needs. Answers began to emerge with the experiments tracing the activation of vitamin D.

An important result of those experiments was that 1,25-dihydroxyvitamin D3, the active form of vitamin D, was reclassified as a hormone that controlled calcium metabolism. A hormone is a chemical substance produced by one organ and then transported in the bloodstream to a target organ, where it causes a specific biological action. Evidence for reclassifying the active form of vitamin D came with the realization that 1,25-dihydroxyvitamin D3 is produced by the kidneys and that its secretion by the kidneys is followed by its buildup in cell nuclei of the intestine, where it regulates calcium metabolism. By 1975, Mark R. Haussler at the University of Arizona confirmed the discovery of a protein receptor that binds the active vitamin D metabolite to the nucleus of cells in the intestine.

With vitamin D now linked to the intestine, scientists were zeroing in on the mechanism of calcium control. Researchers noted that as the level of calcium in the diet rises, the amount of active vitamin D hormone in the body falls and vice versa—a feedback-loop pattern that clearly pointed to the vitamin D hormone as Nicolaysen's calcium-regulating "endogenous factor." Many research teams, including those at the University of Wisconsin and Cambridge University, now focused on tracing the relationship of vitamin D hormone to the rest of the body's endocrine system. They found that a hormone produced by the parathyroid gland is critical to maintaining adequate levels of vitamin D hormone in the blood. When calcium is needed, the parathyroid gland sends the parathyroid hormone to the kidneys to trigger production of vitamin D hormone. That hormone, in turn, prompts the intestines to transfer calcium from food to the blood. When calcium intake is too small to support normal functions, both vitamin D and the parathyroid hormone trigger a process in which stored calcium is mobilized from the bones (confirming the Swedish finding nearly twenty years earlier).

Regulating blood calcium levels is important. When there is too little calcium in the blood, soft-tissue cells—especially nerves and muscle—shut down, sending the body into convulsions; when there is too much calcium in the blood, organs calcify and eventually cease to work. For human patients who had lost their parathyroid glands or their kidneys and could no longer regulate the level of calcium in their blood, the newly synthesized vitamin D hormone, when given with plenty of calcium, had a dramatic effect, curing them of convulsions and chronic bone disease.

More Than Just a Way to Regulate Calcium

Now that its role in calcium uptake had been sketched out, researchers in the 1970s began investigating vitamin D in greater detail—and with surprising results. Several groups managed to find the vitamin D hormone in the nucleus of cells that were not part of the classical calcium maintenance system including the brain, lymphocytes (infection-fighting white blood cells), skin, and malignant tissues. What business would vitamin D have in these places?

In the early 1980s, Japanese researcher Tatsuo Suda made the exciting discovery that adding the hormone to immature malignant leukemia cells caused the cells to differentiate, mature, and stop growing. The amount of vitamin D hormone needed to stop the runaway growth of tumours and cancers has so far proved too toxic for human use, but Suda's discovery suggested that this fascinating hormone had roles beyond the part it played in maintaining the body's calcium levels. This finding spurred on a new era in vitamin D research.

In the mid 1980s, a group of researchers led by S. C. Manolagas found that vitamin D hormone also seemed to play a part in modulating the immune system. In 1993, S. Yang and other researchers in DeLuca's laboratory found that rats given a large dose of vitamin D hormone were protected from the inflammation normally associated with wounds and chemical irritants. This unexpected immunosuppressant function for vitamin D hormone suggested a whole new range of possibilities—including its use in the control of autoimmune diseases.

More developed is vitamin D hormone's effect on psoriasis, a disfiguring skin disorder that affects some 50 million people worldwide. For reasons unknown, psoriasis causes skin cells to multiply uncontrollably. Failing to differentiate and develop normally, the skin cells clump in unsightly rashes, scales, and scars. In the 1980s, a Japanese research team demonstrated that 1,25-dihydroxyvitamin D3 can inhibit skin cell growth. A team of scientists at Boston University School of Medicine, led by Michael F. Holick, investigated this inhibition further and reasoned that it could be used for the treatment of psoriasis.

Initial experiments by Holick and co-workers with vitamin D hormone have shown that topical applications of the hormone are remarkably effective. After two months, the lesions of 96.5 percent of the patients treated with a topical calcitriol (vitamin D hormone) preparation had improved with no noticeable side effects, as compared with 15.5 percent of the controls treated with petroleum alone. In 1994 the U.S. Food and Drug Administration approved a vitamin D-based topical treatment for psoriasis, called calcipotriol.

As we enter the twenty-first century, we recognize that the basic scientific research done in the previous two centuries has not only untangled the workings of the elusive vitamin D hormone, but also has given us ways to protect the health of both adults and children. Researchers are pursuing many new applications for vitamin D, but its role in building and maintaining bone continues to be an important health issue, especially among middle-aged and older adults.

Credits

"Unravelling the Enigma of Vitamin D" was written by science writers Roberta Conlan and Elizabeth Sherman, with the assistance of Drs. David R. Fraser, Mark R. Haussler, Michael F. Holick, Robert Neer, Anthony W. Norman, and Munro Peacock for Beyond Discovery(TM) The Path from Research to Human Benefit, a project of the National Academy of Sciences.

Timeline

- 1600—In the mid 1600s, rickets is first described.
- 1900—In the early 1900s, Sir Frederick Gowland Hopkins demonstrates that whole foods (as opposed to purified proteins, fats, and carbohydrates) contain certain unknown constituents essential to health and growth.
- 1906—Christiaan Eijkman and Gerrit Grijns extract the antineuritic factor from rice hulls, later shown to be vitamin B1.
- 1918—Sir Edward Mellanby induces rickets in dogs and then cures the disease by feeding the animals cod-liver oil.
- 1919—K. Huldschinsky cures children of rickets using artificially produced ultraviolet light.
- 1920—In the early 1920s, Harry Goldblatt and Katherine Soames, H. Steenbock and A. Black, and Alfred Hess and Mildred Weinstock independently discover that irradiating certain foodstuffs with ultraviolet light renders those foods antirachitic.
- 1922—Elmer V. McCollum destroys vitamin A in cod-liver oil and shows that the separate antirachitic substance remains. He calls the newly identified substance "vitamin D."
- 1927—Adolf Windaus, O. Rosenheim, and T. A. Webster deduce that ergosterol is the likely parent substance of vitamin D in food.
- 1931—F. A. Askew defines the chemical makeup of the form of vitamin D found in irradiated foods (now called ergocalciferol), derived from the precursor molecule ergosterol.
- 1936—Windaus deduces the chemical structure of vitamin D3 produced in the skin (now known as cholecalciferol) and identifies the structure of its parent molecule, 7-dehydrocholesterol.

- 1968—Hector F. DeLuca and colleagues isolate an active vitamin D metabolite and identify it as 25-hydroxyvitamin D3. They later prove that the substance is produced in the liver.
- 1968— Between 1968 and 1970, the existence of a second active metabolite produced from 25-hydroxyvitamin D3 is reported by Anthony W. Norman, Mark R. Haussler, and J. F. Myrtle; by E. Kodicek, D. E. M. Lawson, and P. W. Wilson; and by DeLuca and co-workers.
- 1970—In the 1970s, researchers discover the relationship of vitamin D to the body's endocrine system and calcium regulation.
- 1971—Three research groups identify the chemical/molecular structure of the final active form of vitamin D as 1,25-dihydroxyvitamin D3, which is soon reclassified as a hormone controlling calcium metabolism.
- 1975—Haussler confirms the discovery of a protein receptor that binds the active vitamin D metabolite to the nucleus of cells in the intestine.
- 1980—In the 1980s, a Japanese research team and, independently, Michael F. Holick and co-workers show that vitamin D hormone inhibits skin cell growth. Holick and colleagues demonstrate that topical applications of the vitamin D hormone are a remarkably effective treatment of psoriasis.
- 1980—In the mid-1980s, researchers find that vitamin D hormone seems to play a part in modulating the immune system.
- 1994—The U.S. Food and Drug Administration approves a vitamin D-based topical treatment for psoriasis, called calcipotriol.

Appendix 2.7B: Unravelling the Enigma of Vitamin D—Student Questionnaire

Questions

After you have read the article, “Unravelling the Enigma of Vitamin D,” answer the following questions:

1. Outline the symptoms of, the causes of, and the treatments for rickets.
2. With a better understanding of the operation of vitamin D as a calcium regulator, its active form, 1,25-dihydroxyvitamin D3, had its classification changed from vitamin to hormone. Explain how vitamin D is involved in the regulation of calcium in our bodies.
3. Low levels of calcium in the blood result in the shutdown of soft tissue cells such as muscle and nerve cells. Use this information to explain why rickets became a common condition at the time of the Industrial Revolution in Europe, and to explain the symptoms of rickets.
4. Scientific discoveries often arise as the result of work done by many different scientists, over a period of time, on unrelated topics. Describe how this is true for the discovery and use of vitamin D.

Appendix 2.7C: Unravelling the Enigma of Vitamin D (Teacher Background)

1. Outline the symptoms of, the causes of, and the treatments for rickets.

   Symptoms of Rickets

   - bones of developing children remain soft, like cartilage
   - babies slow to sit, crawl, and walk
   - as children grow, weight on soft bones results in pigeon breast, bowed legs, and knock-knees
   - tetany: painful spasms in feet, hands, and larynx
   - problems breathing, nausea, and convulsions

   Causes of Rickets

   - lack of ultraviolet (UV) light
   - lack of 1,25-dihydroxyvitamin D3

   Treatments for Rickets

   - sunlight
   - cod-liver oil
   - irradiated food
   - vitamin D supplement

2. With a better understanding of the operation of vitamin D as a calcium regulator, its active form, 1,25-dihydroxyvitamin D3, had its classification changed from vitamin to hormone. Explain how vitamin D is involved in the regulation of calcium in our bodies.

   When calcium level is low

   - the parathyroid gland secretes a hormone to kidneys
   - kidneys convert 25-hydroxyvitamin D3 (from the liver) to the active form 1,25-dihydroxyvitamin D (25-hydroxyvitamin D3 produced by irradiation of skin on 7-dehydrocholesterol)
   - 1,25-dihydroxyvitamin D3 prompts intestines to transfer calcium from food to blood
   - calcium stored in bone is released to blood (if calcium intake in food is too low)

3. Low levels of calcium in the blood result in the shutdown of soft tissue cells such as muscle and nerve cells. Use this information to explain why rickets became a common condition at the time of the Industrial Revolution in Europe, and to explain the symptoms of rickets.

   Reasons rickets became a common condition during the Industrial Revolution in England

   - towns covered in smog and people working in factories resulted in lack of UV light exposure
   - without UV light, people could not produce vitamin D3
   - without vitamin D3, people could not control uptake of calcium from diet
   - less calcium for bones and muscles resulted in problems such as spasms and tetany

4. Scientific discoveries often arise as the result of work done by many different scientists, over a period of time, on unrelated topics. Describe how this is true for the discovery and use of vitamin D.

   Examples of key discoveries by different scientists that students can use to demonstrate how the discovery and use of vitamin D came about:

   early 1800s—Hopkins shows whole foods contain specific unknown parts necessary for health and growth.

   1906—Eijkman and Grijns extract antineuritic chemical from rice hulls.

   1918—Mellanby cures rickets in dogs with cod-liver oil.

   1919—Huldschinsky cures rickets in children using UV light.

   early 1920s—Goldblatt and Soames, Steenbock and Black, and Hess and Weinstock independently show that eating certain foods irradiated with UV light can be used to cure rickets.

   1922—McCollum destroys vitamin A in cod-liver oil and shows oil still contains chemical that can cure rickets (terms it vitamin D).

   1927—Windaus, Rosenheim, and Webster deduce that ergosterol is the likely parent substance of vitamin D in food.

   1931—Askew defines chemical makeup of the type of vitamin D found in irradiated food.

   1936—Windaus deduces the chemical structure of vitamin D3 produced in skin.

   1968—DeLuca et al. identify vitamin D metabolite produced in liver.

   1968–70—Second vitamin D metabolite is discovered by several labs.

   1971—Three separate groups discover the chemical/molecular structure of the active form of vitamin D.

   1970s—Researchers discover the relationship between vitamin D and calcium regulation.

   1980s—Separate researchers show that vitamin D hormone inhibits skin cell growth, and that topical applications treat psoriasis.

   mid 1980s—Vitamin D hormone is discovered to play a part in the immune system.

   1994—The U.S. Food and Drug Administration approves topical vitamin D cream to treat psoriasis.

Appendix 2.8: Human Disorders Assignment (BLM)

The human body is a very efficient machine. Most of the time it works well, adjusting to changes in the environment, resisting infections, and adapting to meet a host of potential dangers. However, the body is not perfect; it cannot always cope with a particular infection or its own systems may fail and result in sickness.

This assignment will give you an understanding of one disorder by researching it in detail. It should make you aware of sources of information about human disorders, or the many support programs that are available for some diseases. It should also give you a greater understanding of the problems faced by someone who is disabled or afflicted by a disorder.

Format

Discuss the final format of this research project with the teacher.

Due Date

The assignment is due the last week of class discussion on a specific body system. During this same week, you will be required to make a short presentation of your topic to the class.

Components

In your project, consider including

- a brief description of the disorder (introduction)
- the cause or causes of the disorder
- the symptoms
- the treatments
- any side effects or associated problems
- an explanation of the problem, if known
- prognosis and possible future treatments
- other relevant factors

A bibliography of at least three sources must be included.

Topic

To add interest to the topic, consider selecting a disorder with which you are familiar, either directly or indirectly. Perhaps you, or members of your family, have suffered from a particular disorder and you could usefully learn more about the disease. Or you might consider visiting a person suffering from arthritis (or another ailment) and conduct an interview discussing how that person copes with difficulties, or how the disorder has affected his or her lifestyle. If you approach such a person, remember to be considerate and sensitive to feelings. The individual may be quite willing to talk about his or her disorder and you may gain some special insights to problems.

Choose a topic from the list below, or another one approved by your teacher.

Digestive System

anorexia nervosa/bulimia
ulcers
appendicitis
dysentery
malabsorption
diabetes
cancer of stomach/bowel
liver cirrhosis

Respiratory System

emphysema
tuberculosis
sudden infant death syndrome (SIDS)
smoking and lung cancer
pneumonia
asthma

Transport System

heart attack
anemia
hypertension
hemophilia
arteriosclerosis
hemorrhoids
angina pectoris
Rh disease

Excretory System

nephritis
kidney dialysis
lupus
kidney stones
kidney transplants

Nervous System

stroke
meningitis
multiple sclerosis
spina bifida
Alzheimer's disease
cataracts
Lyme disease
epilepsy
Parkinson's disease
concussion
psoriasis
mental illness
cerebral palsy
polio

Appendix 2.9: What's My Diagnosis? (Teacher Background)

Setting Up

- This learning activity requires cutting 10 patient profiles (see attached) and pasting them onto cards (e.g., large file cards).
- Larger station cards, numbered 1 through 10, need to be set up around the room, with the patient profile cards placed at the respective stations (laminated large colour sheets with station numbers come in handy for all sorts of labs/activities including this one).
- To set the mood, you may choose to wear a lab coat, a stethoscope, and a surgical cap or mask, and/or play music, such as the theme song for a hospital show.

Getting Started

- Group students into teams (groups of three work well).
- Assign one student on each team as the head doctor, one as the consulting or assisting doctor, and one as the nurse.
- Instruct the nurses to read a patient profile card to the doctors and provide their opinions on the problem.
- The doctors then discuss the problem and decide on a diagnosis—if there is a disagreement, it is understood that the head doctor will make the final decision.
- Treatment is then decided on by all three team members, as they record both the diagnosis and the treatment on a piece of paper by station number.
- Since the state of affairs in Canadian medicine dictates that doctors must work quickly in order to earn high salaries, the teams work as quickly as they can, visiting all 10 patients (in any order). Once they have diagnosed and treated all patients, they bring their sheet to the teacher to be checked. If they've misdiagnosed any patients, they are sent back to re-examine them.

Assessment

- Collect sheets from teams and assign a mark out of 10.
- Prizes for the most successful team include NOT receiving a malpractice lawsuit, along with a "treat."

Diagnosis	Treatment
1. Anorexia nervosa	seek counselling
2. Heartburn	avoid caffeine and eating before bed
3. Appendicitis	obtain prompt medical attention (surgery?)
4. Hemorrhoids	use ointment, and perhaps laxatives until healed
5. Cirrhosis of liver	stop drinking
6. Malnutrition	change diet
7. Perhaps cancer/tumour	obtain prompt medical attention (scope/biopsy/surgery/chemo/radiation?)
8. Lactose intolerance (no milk on weekends)	change diet, use lactase
9. Ulcer	use antibiotics for *H. Pylori*, evaluate aggravating diet
10. Gallbladder/bile problem	change diet, consider surgery

Station #1

Erin is 15 years old. She is a very high achiever who maintains a 90+ average in school. She is involved in the band and a variety of sports. Recently her parents have noticed that she excuses herself from family meals whenever possible. They have also noticed that she has become obsessed with exercising and seems to be losing weight. They are quite concerned, so they visit their family doctor.

Station #2

George is a middle-aged man (45 years old). He has recently been experiencing some pain in the centre of his chest. He is concerned about his heart. He notices that his pain is often worse when he drinks a lot of coffee, and also when he eats right before bed.

Station #3

Ashley is 12 years old, and very active. She has not been feeling well for the past couple of days. She has been staying home from school due to a fever, chills, and dizziness. Her parents think it is the flu, but when she starts to complain of terrible pain in her lower right side they rush her to the doctor's office.

Station #4

Mary has a two-year-old daughter, and has given birth to a beautiful baby boy five days ago. She has terrible pain and itchiness on her bottom, and is experiencing severe pain whenever she has a bowel movement. Although a little embarrassed, she visits her doctor with the problem.

Station #5	Station #6
Bob has been a heavy drinker for the past 20 years. He has been feeling unwell for the past couple of months and has noticed his skin colour is slightly off. He finally decides to visit his doctor when he experiences some pain in his upper abdomen.	Amanda is a busy woman with four children and a career. Although she attempts to take time for herself, and tries to live a healthy lifestyle, she is often too caught up in her busy schedule to eat properly. She starts to notice that she is unusually tired, her hair is falling out (more than normal), and her gums are bleeding quite frequently. She visits her doctor for a check-up.

Station #7	Station #8
Sam is an elderly gentleman who has always been fairly healthy—no problems other than the frequent heartburn he has suffered throughout his life. Over the past couple of months he has lost a bit of weight and has noticed a lump in his throat when he swallows. Since it has been getting worse, he is worried and finally visits his doctor.	Doug is a young boy who frequently experiences cramping, bloating, and diarrhea. His parents are puzzled that the condition seems to be worse during the week than it is on the weekend, since they always drink pop and eat poorly most weekends. Doug eats a perfectly balanced diet on weekdays, yet this is when he feels the worst. They visit the doctor in an attempt to help him.

Station #9	Station #10
Shannon has been experiencing mild pain in her upper abdomen for a couple of weeks. Recently her pain has increased a great deal, and she often finds herself doubled over in pain, unable to find any relief. She decides to see her doctor right away.	Grant has always enjoyed fast food. Over the past few months he has noticed that every time he eats fast food, he experiences pain and discomfort throughout his digestive system. He doesn't experience this problem when he isn't eating greasy food. He makes an appointment with his doctor in an effort to figure out the problem.

Appendix 2.10: Decision Making (Teacher Background)

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

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

In Grade 9 Science, students were introduced to the decision-making process. Most of the issues in Grade 11 Biology are personal decisions related to health and wellness, but there are also issues with a societal focus. If students don't have a lot of experience with the decision-making process, teachers can start the process with more guidance, giving students a chance to use this approach in a structured environment. This could be done by giving them a specific scenario or issue to study. Students would eventually become active participants in this process by choosing their own issues, doing their own research, making their own decisions, and acting on those decisions.

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

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

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

Assessment

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

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

- position is clearly stated
- evidence is presented to support arguments
- answers to questions are clear and aligned with the position of the stakeholder
- presentation is clear and organized
- position of stakeholder is accurately represented
- personal biases are absent