

# Manitoba

Education, Citizenship and Youth

## SENIOR 3 BIOLOGY 30S A Foundation for Implementation Unit 2 – Digestion and Nutrition

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## Unit 2: Digestion and Nutrition

### Digestion

**S3B-2-01 Identify major structures and functions of the human digestive system from a diagram, model or specimen.**

**Include: tongue, teeth, salivary glands, epiglottis, esophagus, pharynx, sphincters, stomach, small intestine, large intestine, rectum, anus, appendix, liver, gall bladder, pancreas, uvula.**

#### **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.

#### **Suggestions for Instruction**

#### **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, gall bladder, pancreas, uvula.

#### **ACQUIRE/APPLY**

##### ***Surfing for the Stomach***

The internet is an excellent way to have students 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 the students.

For example:

*What is the function of the epiglottis?*

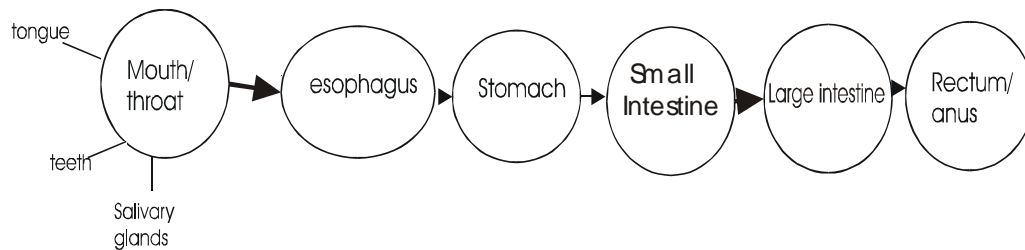
Websites can be identified in advance by the teacher.

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

Suggestion for Assessment: Depending on the approach taken, either the teacher or the 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.

### ***Concept Map – Alimentary Canal***

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 (**Appendix 1**) is provided and contains five main components: mouth/throat, esophagus, stomach, intestines, and rectum/anus. To each of these main areas students should add more details related to specific components (see sample below). Refer to SLO S3B-2-01 for a list.



Additions will be made to this base concept map at several other points in this unit and will serve as an important visual organizer.

Suggestion for Assessment: This concept map will be added to at various stages in the unit. It provides a useful tool for teachers to monitor student understanding of the digestive system (formative assessment) and adjust teaching to address any difficulties. The concept map can also be used as a summative assessment tool at the end of the unit.

### ***What Am I?***

Review the function of each of the parts listed in the learning outcome. Have students create a table including the digestive system structure and explaining its function. Write all the parts of the human digestive system on "post-it" notes. Stick a post-it on the back of each student. Have them ask each other yes/no questions to figure out the structure posted on their back.

Suggestions for Assessment: Exit slips are 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 simply pose a question at the end of the lesson and give students 5 minutes to respond to the slip.

Some suggested questions:

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

### ***Virtual or Real Dissection***

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

The use of live animals and the dissection of animals is a well-established practice in the teaching of life science in particular. Well-constructed learning activities conducted by thoughtful teachers can illustrate important and enduring principles in the life sciences. However, teachers must carefully consider the educational objectives and available alternatives before using animals in the classroom.

Senior 2 Science: A Foundation for Implementation, pg. 27

Biology 30S does not mandate that dissection (either real or virtual) takes place in the classroom. However, it is one suggested approach to familiarize students with the structure of a digestive system. Individual teachers must decide on whether or not to incorporate dissection into their classroom.

There are some Internet sites that provide virtual dissections:

The Virtual Frog Dissection

[http://www-itg.lbl.gov/cgi-bin/vfrog\\_script](http://www-itg.lbl.gov/cgi-bin/vfrog_script)

The Virtual Pig Dissection

<http://www.whitman.edu/biology/vpd/main.html>

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.

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 view of deeper organs

## **Introduction to Mechanical and Chemical Digestion**

**S3B-2-02 Describe the processes of mechanical digestion that take place at various sites along the alimentary canal.**

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

**S3B-2-03 Identify functions of secretions along the digestive tract**

**Include: to lubricate, to protect.**

**S3B-2-04 Identify the sites of chemical digestion along the alimentary canal as well as identify the type of nutrient being digested.**

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

**Suggestions for Instruction**

**ACTIVATE**

***Mechanical Digestion – the First Step***

Begin a discussion with students with the question: 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***

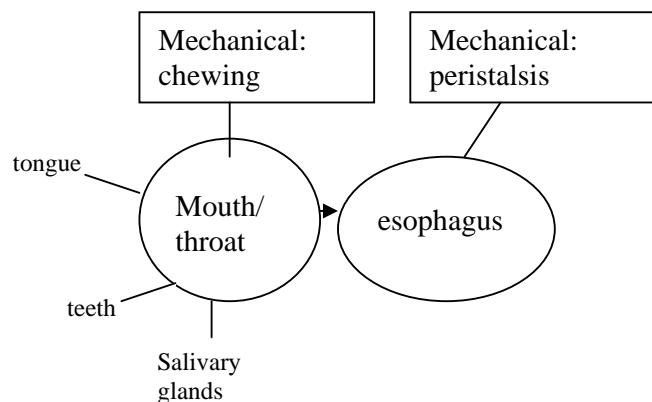
Take a piece of chalk and break it in half. Break one of the halves up into smaller pieces. Have students predict which half of the chalk will dissolve the quickest in a jar of vinegar. Place the pieces chalk into the vinegar and observe during class time. Relate the dissolution and the size of chalk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

**ACQUIRE/APPLY**

***Concept Map – Mechanical Digestion***

Using information gained from direct teaching or text material, have students refer to their concept map 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.

For example:



***Secretion Models-Demonstration***

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 the other bare. Add a drop mild acid 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 notebook, including a description of the model and the link between the model and the digestive system.

Suggestions 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**

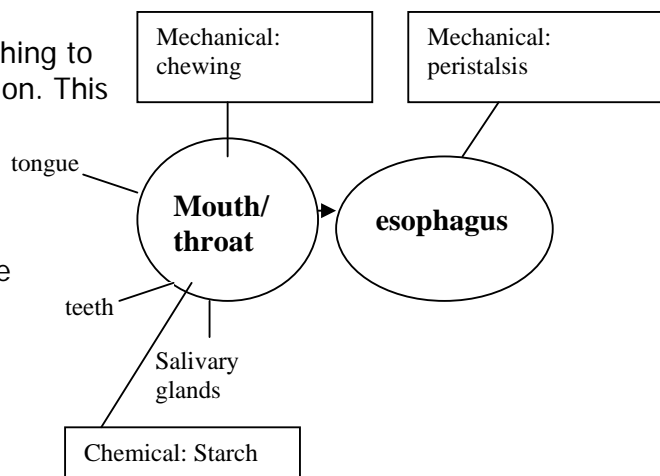
Add a small amount of oil to a test tube of water and have students record what happens. Shake it and have students record what happens. Repeat the demonstration but add liquid detergent to simulate bile. Have students discuss the role of the detergent.

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.

### **Concept Map - Chemical Digestion**

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 (starch, carbohydrates, lipids, proteins). This information should be added to the concept map created earlier.

For example:



Cumulative Assessment: Have students create, from memory, the concept map that they have developed during the previous activities. This would include creating the initial diagram of the 5 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, review and/or re-teaching may be carried out. This activity can also be used as a summative assessment to make a judgement about student achievement to this point.

## Enzymes and Chemical Digestion

**S3B-2-05 Explain the role of enzymes in chemical digestion of nutrients and identify factors that influence their action.**

*Examples: pH, temperature, coenzymes, inhibitors, surface area...*

### Suggestions for Instruction

#### **ACTIVATE**

##### ***Enzyme Reaction-Demonstration***

Prepare fresh pineapple juice by cutting up a pineapple and putting it in a blender until it is puree. Obtain the juice by straining the puree through cheesecloth. Make some gelatin (any type will do, it is helpful if it is darkly coloured). Cut the gelatin into cubes and place 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.

Teacher Notes: 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 bromelin. Canned pineapple will not work in this demonstration, the canning process denatures the bromelin, rendering it incapable of catalyzing the break down of gelatin.

##### ***What's the Key?***

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

## **ACQUIRE/APPLY**

### ***Enzymatic Factors in the Digestion of Lipids - Lab***

Have students perform a lab to demonstrate the action of an enzyme on food particles (See **Appendix 2**). This lab will also allow students to see the effect of factors such as temperature and co-enzymes on enzymatic action.

Suggestions for Assessment: Refer to **Appendix 10** in Unit 1 for Teacher Background Information on assessing and evaluating student lab skills.

## **Absorption**

**S3B-2-06 Describe the processes of absorption that take place at various sites along the alimentary canal**

**Include: uptake of nutrients by villi in the small intestine, uptake of water in the large intestine.**

### **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 and insert them into the tube to try and increase the surface area of the tube as much as possible. Record the new surface area.
4. Have each group share their maximum surface area.

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 intestines would be important.

## **ACQUIRE/APPLY**

### ***Reconstructing Text***

Provide students with an article or use notes from a textbook that explain the process of absorption and the movement of food particles through the alimentary canal. Cut the reading up into paragraphs and have the 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).

### ***Concept Map - Absorption***

Students identify the sites along the alimentary canal where absorption occurs in the concept map created earlier - mark the sites in a different colour.

### ***Comparing Conditions***

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

Suggestions for Assessment: Have students answer the following questions: "In a condition known as microvilli inclusion disease the microvilli fold inwards and therefore have no contact with the intestinal lining. How do you think this condition affects their health? 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

NOTE: students don't need to get the "correct" answer (see Teacher Note). However, their response must be clear and justified using knowledge gained during the unit.

**Teacher Notes:** *Children with microvilli 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**

**S3B-2-07 Describe the homeostatic role of the liver with respect to the regulation of nutrient levels in the blood and nutrient storage. Include: carbohydrate metabolism.**

### **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?"

**Teacher Notes:** Excess tomatoes need to be modified and stored to preserve their nutrients and 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***

As an introduction to hormones as one of the body's key regulatory systems, have students read **Appendix 3** and complete the questions that are included.

### ***Liver Functions***

Have students read **Appendix 4a: The Role of the Liver in Homeostasis** and develop 1-2 questions about the reading (this can be done individually or in small groups). These questions can be compiled and then given back to the students as a short quiz or written assignment.

Suggestion for Assessment: Have students complete an exit slip where they describe the homeostatic adjustment that would occur for a person who has consumed a significant amount of carbohydrates in the past hour. The result should look similar to the "answer" provided by **Appendix 4b: The Liver and Negative Feedback**.

### ***Liver Job Application***

Have the students write a resume for the liver. Include important qualities and abilities. E.g. decision making skills (homeostasis), storage capabilities, regulation of nutrient level.

Suggestions for Assessment: Develop a set of criteria with the students and have them peer evaluate each other's resumes. (Does the liver get the job?)

Suggested Inclusions:

- Address-location in the human body
- Previous Experience-some past challenges to the liver
- Includes abilities-decision making and storage capabilities.

## **Nutrition**

**S3B-2-08 Describe the functions of the six basic types of nutrients: carbohydrate, lipids, proteins, vitamins, minerals, and water.**

**Include: ATP production, construction/repair, regulating.**

**S3B-2-09 Identify dietary sources for each of the six basic types of nutrients.**

**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.

Students will have analyzed and monitored their food intake over a period of time in Senior 2 Health.

### **Suggestions for Instruction**

#### **ACTIVATE**

##### ***Graffiti Brainstorm***

Have students do a rotational cooperative graffiti where each group is presented with poster paper with a heading on it. Each poster has a different heading and each group has a different colour of marker. Each group brainstorms as many ideas they have about the topic – anything that comes to mind. This is done for a predetermined period of time and then the sheets are rotated. This continues until each group gets its original sheet back and works together to summarize what has been written. This summary is then shared with the class. Possible headings:

- carbohydrates
- lipids
- proteins
- vitamins and minerals
- water

*Refer to SYSTH for details on this strategy. (pg. 3.15)*

#### **ACQUIRE/APPLY**

##### ***Reading for Information - Nutrients***

- A) Have students read recent information on nutrients that identify the types of nutrients, their function and related dietary sources (ie. Pamphlets, posters, information from the internet). Groups of students should be given different information sources. Students should record key information in their notebooks, using the strategy of their choice (e.g. mapping, outlining). For more information on strategies available for reading scientific information and notetaking, refer to SYSTH, Chapter 12 – Reading Scientific Information).
- B) Have each group of students share their information with another group and then continue the process until every group has heard the other groups. After the sharing, students analyze whether or not they obtained the same information and if not, why not. 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.

Suggestion for Assessment: Have students complete an Exit Slip. They should be asked 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, a student may indicate they like information from a poster as it has many headings, short sections, pictures, and simple vocabulary.

### ***Testing for Nutrients - Labs***

Have students conduct lab activities to identify the nutrients present in different food samples.

- Testing for Carbohydrates (**Appendix 5a – Student Handout and 5b –Teacher Background**)
- Testing for Proteins (**Appendix 6a – Student Handout and 6b – Teacher Background**)

Teacher Note: Refer to **Appendix 10 in Unit 1** for Teacher Background Information on assessing and evaluating student lab skills.

Suggestion for Assessment: Refer to **Appendix 14, Unit 1** for templates on assessing General Lab Skills and Thinking Skills.

### ***What's in It?***

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 notebook. The following questions may be used to stimulate thinking about this learning activity:

- *What surprised you?*
- *What questions did come to your mind?*

### ***Nutrient Lunches***

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

**S3B-2-10 Evaluate personal food intake and related food decisions.**

*Examples: % daily value of nutrients, portion size, nutrient labels, balance between lifestyle and consumption...*

**S3B-0-P2 Demonstrate a willingness to reflect on their own wellness.**

**S3B-0-P3 Appreciate the impact of personal lifestyle choices on general health and make decisions that support a healthy lifestyle.**

**Entry Level Knowledge:** In Senior 2 Physical Education and Health students examine the nutritional value of a variety of foods.

K.5.S2.C.1a Determine the nutritional value of a variety of foods (e.g., fast food, fad diets, snack foods...) using Canada's Food Guide to Healthy Eating (CFGHE) and other resources.

### **Suggestions for Instruction**

#### **ACTIVATE**

##### ***KWL***

Have students fill out the first column of a KWL chart or similar chart indicating what they already know about what information is provided on food label, and what they would like to know.

##### ***You Are What You Eat***

Watch video about nutrition: e.g. Supersize Me! (2004) Or Nutrition in a Box (1991). The latter is available from the Instructional Resources Library. Following the viewing, have students reflect on the movie from a health and nutrition perspective.

#### **ACQUIRE/APPLY**

##### **Nutrition Labelling – Information and Learning Activities**



Health Canada's website contains the following extensive information on nutrition labelling:

##### Consumer Resources

Posters and an information sheet on nutrition labelling

[Nutrition Labelling Toolkit for Educators](#)

The Toolkit for Educators contains a variety of multi-media products to assist in educating Canadians on the nutrition information found on food labels, to enable them to make informed food choices.

[First Nations and Inuit Focus](#)

Most First Nations and Inuit now eat a mix of traditional and store food. The Nutrition

Labelling - First Nations and Inuit Focus provides information on reading, understanding and using food labels.

[Nutrition Labelling Education Background](#)  
[Ready-to-use articles - Sharing the Nutrition Facts](#)

[http://www.hc-sc.gc.ca/hpfb-dgpsa/onpp-bppn/labelling-etiquetage/education\\_e.html](http://www.hc-sc.gc.ca/hpfb-dgpsa/onpp-bppn/labelling-etiquetage/education_e.html)

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 the food labels and how to use this information to make healthy food choices.

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

Teacher Note: Nutrition Facts and the ingredient list are the foundation of label reading since together 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 which may be of interest to consumers. (Background Fact Sheet 2)

Suggestion for Assessment: Depending on the particular components of the appendix 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.

### ***What Am I Eating?/What is My Lifestyle?***



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 Canada's Food Guide to Healthy Eating. Students can use "FoodFocus" software to evaluate their food intake (available from the Instructional Resources Library).

For this same time period students could also keep track of their activity level, for example, did they walk to school?

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

Suggestions for Assessment: Have students select another student to share their report with. Have the selected student carry out a peer assessment of the suggestions made. This could include:

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

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



### ***Creating a Meal***

Have students complete the Let's Make a Meal activity from the Dietician of Canada Website (<http://www.dietitians.ca>) or an alternate site to assess their ability to plan a healthy diet. This activity could be included in the Wellness Portfolio.

## **Disorders**

**S3B-2-08 Investigate and describe conditions/disorders that affect the digestive process.**

### **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 at all?

##### ***Coping with a Disorder***

Invite a guest speaker to speak 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 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, for example, traditional medicines, homeopathy. Encourage students to develop an understanding of and a respect for this diversity.

#### **ACQUIRE/ APPLY**

##### ***Unravelling the Enigman of Vitamin D***

**Appendix 6** contains a historical look at the development of our understanding about vitamins, and Vitamin D in particular as scientists first attempted to understand Ricketts and other diseases. Have students read the case study and answer the questions that follow.

### ***Share the Information***

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

- ✓ Causes
- ✓ Symptoms
- ✓ Treatment (include a range of treatments, including non-Western, if possible)
- ✓ Prevention
- ✓ Indication of whether it 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. Throughout the course these projects become due as each of the body systems is addressed. Refer to **Appendix 8 – Human Disorders Assignment** for more details.

Suggestion for Assessment: Develop criteria with the students. The list above can form the basis of a “content” section of the evaluation. Additional criteria can relate to the effectiveness of the presentation.

### ***What’s My Diagnosis***

Set up a series of stations for student teams to diagnose and develop treatment plans. See “What’s My Diagnosis” activity (**see Appendix 9**)

Suggestion for Assessment: In What’s My Diagnosis once student teams 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. Assess teams 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.

### ***Microtheme – Pizza Anyone?***

Have students respond to the following microtheme:

A fast food restaurant has asked your advertising firm to develop a campaign that highlights the advantages of eating their pizza. Design a flyer (including diagrams and text\_ that outlines the nutrients in the pizza and where each is digested and absorbed in the system.

Suggestion for Assessment: See **Appendix 3 in Unit 1** for information on assessing microthemes.

## Decision Making

**S3B-2-12** Use the decision-making process to investigate an issue related to digestion and nutrition.

**S3B-0-D1** Identify and explore a current health issue.

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

**S3B-0-D2** Evaluate implications of possible alternatives or positions related to an issue.

*Examples: positive and negative consequences of a decision, strengths and weaknesses of a position...*

**S3B-0-D3** Recognize that decisions reflect values and consider their own values and those of others when making a decision.

**S3B-0-D4** Recommend an alternative or identify a position and provide justification.

**S3B-0-D5** Propose a course of action related to an issue.

**S3B-0-D6** Evaluate the process used by themselves or others to arrive at a decision.

### *Suggestions for Instruction*

#### **ACTIVATE**

##### ***Brainstorming***

Have students carry out a brainstorming session to identify current issues that relate to nutrition and health. The suggestions from the entire class can be compiled and then students given the direction to group the suggestions according to a given criteria, for example, who the issue affects, level of importance, etc.

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

#### **ACQUIRE/APPLY**

##### ***Decision-Making***

Students should be given the opportunity to investigate real-life issue related to nutrition and wellness. This investigation should include in some type of

decision-making process. The type of decision can vary greatly, for example it could be:

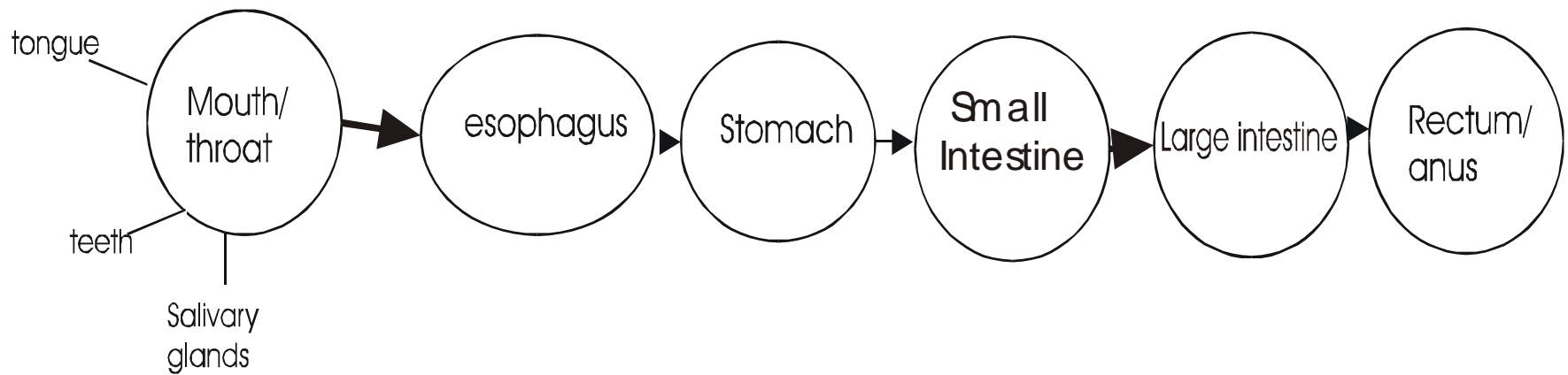
- A very personal/individual decision on a particular topic for inclusion in the wellness portfolio (e.g. how should I go about losing weight? What should I do about a friend who I think is anorexic?)
- A school or community type of decision. (e.g. should pop/chip machines be removed from schools? )
- A far-reaching decision (e.g. should milk cost the same no matter where you are in the province?).

There are a number of approaches that can be used to simulate a real-life context or simply promote interaction between students. For example, a town-hall meeting, a formal debate. Refer to **Appendix 10 Decision-Making** for more details.

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

## Appendix

**Appendix 1: Concept Map of the Digestive System**



## Appendix 2a: Enzymatic Factors in the Digestion of Lipids-Student Handout (BLM)

### Purpose

To investigate the role of enzymes in lipid digestion.

### Materials and Procedure:

1. Obtain 5 test tubes and mark them 1 to 5.
2. For each test tube measure and add the materials 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 the colour of the solution at the bottom of the table.

Note: Red Phenol 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)

	<b>Test Tubes</b>				
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
Water (mL)	5	5	5	5	5
Fresh Cream (mL)	5	5	5	5	5
Red Phenol (drops)	4	4	4	4	4
Bile Salts		Pinch	Pinch		Pinch
Pancreatin (mL)			5	5	5
Water Bath (37°C)	X	X	X	X	
<b>Results</b>					
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 the Test Tube #1? Explain your response.
3. Compare the contents of Test Tube #1 and #2. What do the results obtained indicate?  
Both test tubes contain water, fresh cream, Red Phenol 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 tubes 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 Tube #1 and #2 with Test Tubes #3, 4, 5. What do the results obtained indicate?  
Test Tubes #1 and 2 had no change, Test Tubes #3, 4 and 5 had a colour change take place. 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

Under the heading Conclusion, write an interpretation of your results, identify sources of error, etc.

## Appendix 2b: Enzymatic Factors in the Digestion of Lipids

### - Teacher Notes

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 → fat droplets (bile emulsifier)
- 2) fat droplets + water → 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. Thus as the fat droplets when exposed to an enzyme are broken down into glycerol and fatty acids the pH of the solution will go down.

Note: 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 Red Phenol can be purchased from a science supply company.

### Results

Students should find results similar to the ones included in the table below.

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 Reflection Questions.

	Test Tubes				
	1	2	3	4	5
Water (mL)	5	5	5	5	5
Fresh Cream (mL)	5	5	5	5	5
Red Phenol (drops)	4	4	4	4	4
Bile Salts		Pinch	Pinch		Pinch
Pancreatin (mL)			5	5	5
Water Bath (37°C)	X	X	X	X	
<b>Results</b>					
Observations	No change	No change	Change took place quickly		
Colour	<b>Red/ Orange</b>	<b>Red/ Orange</b>	<b>Yellow</b>	<b>Yellow</b>	<b>Yellow</b>

## Analysis

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

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

3) What is the function of the 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.*

4) Compare the contents of Test Tube #1 and #2. What do the results obtained indicate?

Both test tubes contain water, fresh cream, Red Phenol 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 tubes indicating that without pancreatin digestion does not take place. Also, the presence of bile salts was not a factor.

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

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

6) 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.

7) 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.

8) Create a summary list of the factors that increased the rate of digestion. Increased temperature, increased surface area (caused by emulsification)

Conclusion

### 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 (bile salts – increasing surface area, increase in temperature). However, this evidence was more subjective or qualitative and students should recognize this weakness.

## Appendix 3: Regulatory Systems

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 that 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 about the nervous system will be learned in a later unit of study.

### Hormonal Regulatory System

Insert pg. 252 from Senior Biology 2 2004

## **Appendix 4a: The Role of the Liver in Homeostasis**

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) and minerals as well as carbohydrates.

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

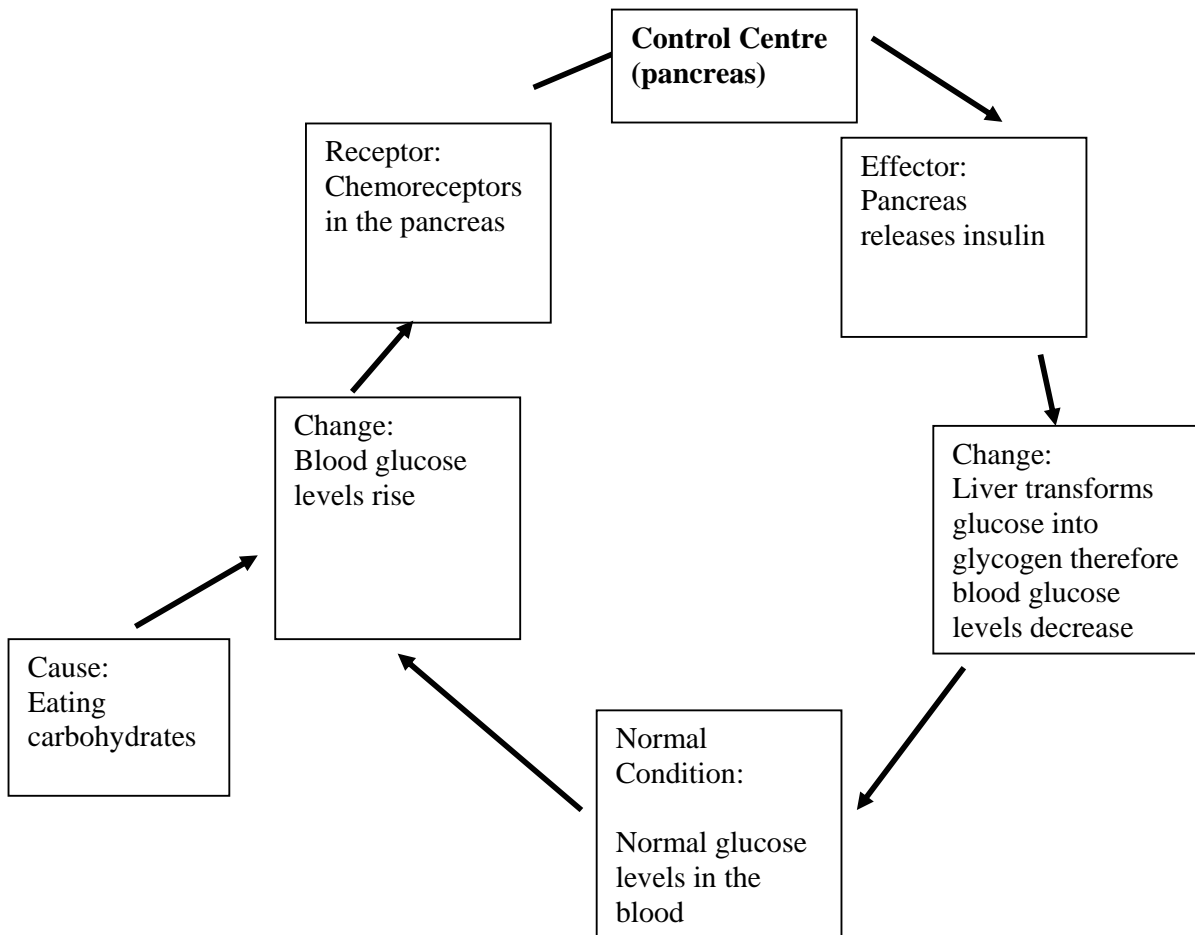
As you have seen in unit 1, glucose is necessary for cells to produce ATP, the molecule that stores energy. The amount of ATP that the body needs at any one time changes therefore the body needs to be able to store glucose when the body doesn't need it, but release glucose when it is needed.

Two hormones are responsible for controlling the concentration of glucose in the blood. These 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 returns 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 blood stream and blood glucose levels rise until they return to a normal level.

## Appendix 4b: The Liver and Negative Feedback



## Appendix 5a: Testing for Carbohydrates

### -Student Handout (BLM)

#### **Introduction**

One of the major 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 sugar in the sample:

green- low concentration:

yellow- low to medium concentration

orange- medium concentration

reddish/orange-medium to high

brick red-high concentration

#### **Purpose**

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

#### **Materials:**

Suggested Samples	Two test tubes
milk	Hot water bath
potato	Eye dropper
apple	Goggles
bread	Benedict's solution
apple juice	Apron
saltless cracker	gloves
banana	
plain yoghurt	

non diet 7-Up	
---------------	--

**Procedure**

\*\*\*\*\***CAUTION**\*\*\*\*\*  
**DO NOT SPILL CHEMICALS ON SKIN OR CLOTHES**  
**ALL GLASSWARE MUST BE CLEANED BEFORE AND AFTER EACH TEST**  
 \*\*\*\*\***CAUTION**\*\*\*\*\*

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

**ANALYSIS**

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

Sucrose	Parameter	Glucose
	# atoms	
	Relative Size	

3. List the samples that you tested where sugar was present.
4. When testing a solution with Benedict's reagent, the color 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 spotless in biochemical testing?

## **Appendix 5b: Testing for Carbohydrates – Teacher Notes**

### **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 or reagent 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
- brick red-high concentration

**Teacher notes:** Benedict's reagent is the solution used to test urine for glucose in diagnosing diabetes.

### **PURPOSE:**

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

### **MATERIALS:**

Two test tubes	Suggested Samples
Hot water bath	milk
Eye dropper	potato
Goggles	apple
Benedict's solution	bread
Apron	apple juice
gloves	saltless cracker
	banana
	plain yoghurt
	non diet 7-Up

**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 **C** [ for control].
2. To both test tubes add a single eyedropper full of Benedict's solution.
3. To the **T** test tube add one eyedropper full of sample to be tested and to the **C** test tube add an eyedropper full of water.
4. Place both test tubes in the community hot water bath for 4 minutes. Record the initial and final colors in the table below.
5. Repeat for all other samples assigned.

SUBSTANCE	INITIAL COLOR	FINAL COLOR
<b>milk</b>	<i>Blue</i>	
<b>potato</b>	<i>Blue</i>	
<b>apple</b>	<i>Blue</i>	
<b>bread</b>	<i>Blue</i>	
<b>apple juice</b>	<i>Blue</i>	
<b>saltless cracker</b>	<i>Blue</i>	
<b>banana</b>	<i>Blue</i>	
<b>plain yoghurt</b>	<i>Blue</i>	
<b>non diet 7-Up</b>	<i>Blue</i>	

**Analysis**

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

Sucrose	Parameter	Glucose
<i>46</i>	# atoms	<i>24</i>
<i>larger</i>	Relative Size	<i>small</i>

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

4. When testing a solution with Benedict's reagent, the color 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 spotless in biochemical testing?

*To prevent contamination and invalidate a test.*

## Appendix 6a: Proteins – Student handout (BLM)

### INTRODUCTION:

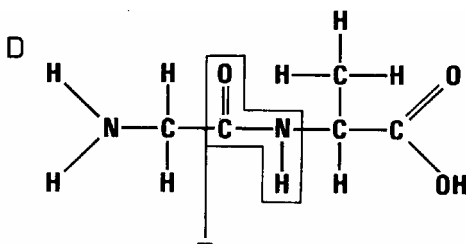
Proteins are massive molecules containing thousands of atoms.

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<sub>2</sub>) 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 the elements:

**CARBON**  
**OXYGEN**  
**HYDROGEN**  
**NITROGEN**



### PURPOSE:

To test samples for the presence of amino acids.

### MATERIALS:

Goggles	Suggested samples
apron	milk
Gloves	egg white
eyedropper	gelatin
2 test tubes	tofu
test tube rack	apple
Biuret's Solution	saltless cracker
	potato

Biuret's reagent reacts with certain amino acids to produce a striking color change. The presence of a **MAUVE OR PURPLE** color indicates a positive test; any other color is a negative result.

1. Add one eye-dropper full of water into one test tube and to the other a comparable amount of the sample to be tested.

2. To each test tube add the following:  
1 eye dropper full of Biuret Solution

3. Agitate the system for a couple of minutes and then observe the colors. RECORD THE COLORS IN THE TABLE THAT FOLLOWS.

4. Clean your test tube well and repeat the test with the other samples that are provided.

### Results

Sample	Post Reaction color	Protein Present + or -

### ANALYSIS

1. Why must the test tubes be cleaned between 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 proteins with carbohydrates under the following topics:

Topic	Carbohydrates	Proteins
Elements present		
Relative size		
Chemical test for....		

Molecular shape		
Uses	1. 2.	1. 2.

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

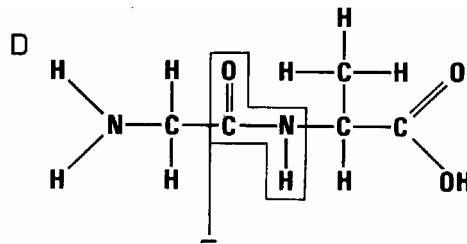
## Appendix 6b: Proteins – Teacher Notes

### 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<sub>2</sub>) 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 protein contain the elements:

**CARBON**  
**OXYGEN**  
**HYDROGEN**  
**NITROGEN**



**PURPOSE:**

To test samples for the presence of amino acids.

**MATERIALS:**

Goggles	Suggested samples
apron	milk
Gloves	egg white
eyedropper	gelatin
2 testubes	tofu
test tube rack	apple
Biuret=s Solution	saltless cracker
	potato

Biuret's reagent reacts with certain amino acids to produce a striking color change. The presence of a **MAUVE OR PURPLE** color indicates a positive test; any other color is a negative result.

1. Add one eye-dropper full of water into one test tube and to the other a comparable amount of the sample to be tested.

2. To each test tube add the following:  
1 eye dropper full of Biuret Solution

3. Agitate the system for a couple of minutes and then observe the colors.  
RECORD THE COLORS IN THE TABLE THAT FOLLOWS.

4. Clean your test tube well and repeat the test with the other samples that are provided.

### Results

Sample	Post Reaction color	Protein Present + or -
milk	<i>No change</i>	-
egg white	<i>purple</i>	+
gelatin	<i>purple</i>	+
tofu	<i>purple</i>	+
apple	<i>No change</i>	-
saltless cracker	<i>No change</i>	-
potato	<i>No change</i>	-

### ANALYSIS QUESTIONS:

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

*The test tube must be cleaned because there may be protein residue in the test tube 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 to see if the reagents are contaminated as well and provides a basis for comparison.*

3. Differentiate proteins with carbohydrates under the following topics:

<b>Topic</b>	<b>Carbohydrates</b>	<b>Proteins</b>
Elements present	C/H/O	C/H/O/N
Chemical test for...	Benedict's	Biuret
Relative size	Smaller	Larger
Molecular shape		
Uses	1. Structural 2. Energy	1. Enzymes 2. Hormones

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

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

## **Appendix 7a: Unravelling the Enigma of Vitamin D**

### **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 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 signaling 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 beriberilike 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 thiamin--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 flavors, 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 labeled 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 D<sub>3</sub>, 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 coworkers 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 D<sub>3</sub>. It was now clear that the liver changes vitamin D<sub>3</sub> to 25-hydroxyvitamin D<sub>3</sub>, the major circulating form of the vitamin. The kidneys then convert 25-hydroxyvitamin D<sub>3</sub> to 1,25-dihydroxyvitamin D<sub>3</sub>, 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 D<sub>3</sub>, 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 D<sub>3</sub> is produced by the kidneys and that its secretion by the kidneys is followed by its build up 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 tumors 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 D<sub>3</sub> 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 coworkers 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 and 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

"Unraveling 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 1968-1970, 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 coworkers.
- 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 D<sub>3</sub>, 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 coworkers 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 7b: Unravelling the Enigma of Vitamin D**

### **Student Questions**

#### **Unraveling the Enigma of Vitamin D**

- 1) Outline the symptoms, cause, and treatment for Ricketts.
- 2) With a better understanding of the operation of vitamin D as a calcium regulator, it's active form, 1,25-dihydroxyvitamin D, 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 shut down 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 7c: Unravelling the Enigma of Vitamin D

### Student Answers

1)

symptoms

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

cause

- lack of UV light
- lack of 1,25-dihydroxyvitamin D

treatment

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

2) when calcium level is low:

- parathyroid gland secretes hormone to kidneys
- kidneys convert 25-hydroxyvitamin D<sub>3</sub> (from the liver) to the active form 1,25-dihydroxyvitamin D (25-hydroxyvitamin D<sub>3</sub> produced by irradiation of skin on 7-dehydrocholesterol)
- 1,25-dihydroxyvitamin D prompts intestines to transfer calcium from food to blood
- if calcium intake in food is too low calcium stored in bone is released to blood

3)

- towns covered in smog and people working inside resulted in lack of uv light exposure
- without uv light, could not produce vitamin D<sub>3</sub>
- without vitamin D<sub>3</sub> could not control uptake of calcium from diet
- resulted in less calcium for bones, and muscle problems like spasms and tetany

4) early 1800's - Hopkins shows whole foods contain specific unknown parts necessary for health and growth

1906 - Eijkman & Grijns extract antineuritic chemical from rice hulls

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

1919 - Huldschinsky cure rickets in children with uv light  
early 1920's - Goldblatt & Soames, Steenbock & Black, Hess & Weinstock  
all independently show 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 which can cure rickets ( terms it vitamin D)  
1927 - Windaus, Roseenheim & Wenster deduce ergosterol parent  
substance of vitamin D in food  
1931 - Askew defines chemical makeup of type of vitamin D found in  
irradiated food  
1936 - Windhaus deduces chemical structure of vitamin D<sub>3</sub> produced in  
skin  
1968 - DeLuca et al. identify vitamin D metabolite produced in liver  
1968-70 - second vitamin D metabolite discovered by several labs  
1971 - three separate groups discover chemical structure of active form  
of vitamin D  
1970's - researchers discover relationship between vitamin D and calcium  
regulation  
1980's - separate researchers show vitamin D hormone inhibits skin cell  
growth, topical applications treat psoriasis  
mid 1980's - vitamin D hormone discovered to play part in immune system  
1994 - U.S.D.A approve topical vitamin D cream to treat psoriasis

## **Appendix 8: Human Disorders Assignment**

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 sickness results. This assignment will give you an understanding of one disorder 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 and give you a greater understanding of the problems that face some disabled or afflicted person.

The final format of this research project should be discussed with the teacher.

Due date: The last week of class discussion on the system. You will be required to make a short presentation of your topic to the class during the same week.

The following points should be considered in your project:

- a) a brief description of the disorder by way of introduction
- b) the cause or causes of the disorder
- c) the symptoms
- d) treatment
- e) any side effects or associated problems
- f) an explanation of the problem if known
- g) prognosis and possible future treatments
- h) other relevant factors
- i) a bibliography of at least three sources must be included

It adds interest to the topic if you can select a disorder with which you are familiar, either directly or indirectly. Perhaps you, or a member 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 conducting an interview which would show how that person copes with difficulties, or how the disorder has affected their life-style. If you approach such a person try to be considerate and sensitive to feelings. Such people are often quite willing to talk about their disorder and you may gain some very special insights to their problems.

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

### **Digestive System**

anorexia nervosa/bulimia  
ulcers  
appendicitis  
dysentery

malabsorption  
diabetes  
cancer of stomach/bowel  
liver cirrhosis

### **Respiratory System**

emphysema  
tuberculosis  
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 9: What's My Diagnosis?**

### *Setting up:*

- This activity requires the cutting and pasting of patient profiles (attached) onto cards (i.e. large file cards).
- Larger "station cards", numbered 1 – 10 need to be set up around the room, with the "patients" distributed (laminated large colour sheets with station numbers come in handy for all sorts of labs/activities including this one).

### *Getting going:*

- Have students assemble into small groups (3 works well).
- Assign one student as the doctor, one as the consulting or assisting doctor, and one to play the nurse.
- Instruct the nurses to read the cards 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 work quickly in order to earn the big bucks, 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.

### *Other/Evaluation:*

- Prizes for the most successful team include NOT receiving a malpractice lawsuit, along with a *treat* or *coupon* for "5% extra on a quiz or assignment" (unless of course your salary allows for more!! 😊)
- I usually wear my lab coat, along with a stethoscope and surgical cap / mask for this. 😊
- Mood music comes from taping the intro to E.R. or another hospital show.
- I usually collect the work from all groups, and assign a mark out of 10.

<p>Station #1</p> <p>Erin is 15 years old. She is a very high achiever, maintaining a 90+ average in school, and 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.</p>	<p>Station #2</p> <p>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.</p>
<p>Station #3</p> <p>Ashley is 12 years old, and very active. She hasn't 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.</p>	<p>Station #4</p> <p>Mary has one 2 year old daughter, and has just given birth to a beautiful baby boy 5 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.</p>
<p>Station #5</p> <p>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 color is slightly off. He decides to finally visit his doctor when he experiences some pain in his upper abdomen.</p>	<p>Station #6</p> <p>Amanda is a busy woman with 4 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.</p>

<p>Station #7</p> <p>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, and it has been getting worse. He is worried and finally visits his doctor.</p>	<p>Station #8</p> <p>Doug is a young boy who frequently experiences cramping, bloating and diarrhea. His parents are puzzled that the condition seems to be worse through the week than on the weekend, since they always drink pop and eat poorly most weekends!! Doug eats a perfectly balanced diet through the week, yet is when he feels the worst. They visit the doctor in an attempt to help Doug.</p>
<p>Station #9</p> <p>Shannon had been experiencing mild pain in her upper abdomen for a couple of weeks. Recently her pain had increased a great deal, and she often found herself doubled over in pain without finding any relief. She got in to see her doctor right away.</p>	<p>Station #10</p> <p>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.</p>

***Diagnosis/Treatment:***

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

## **Appendix 10: Decision-Making**

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. In order to make an informed decision, students must understand scientific concepts involved in an issue and also 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 process

Students have been introduced to the Decision-making process in Senior 1 Science. Most of the issues in Biology 30S 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 their point of view. Regardless of the approach used, the following questions can guide students in the decision-making process:

- What is the issue?
- What is the important scientific information 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, for example a town hall meeting, a round table, a conference, a debate, a case study, a position paper, a class presentation, a class discussion, etc. Regardless of what those products or events are, the assessment should focus on the skills outlined in cluster 0.

For role-playing activities such as town-hall meetings, round tables or conferences, assessment criteria should be related to how the students are able to put themselves in the position of their stakeholder. They 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