Grade 11 Biology (30S)

A Course for Independent Study

Manitoba

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A Course for Independent Study

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Contents

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Grade 11 Biology (30S)

Introduction

Grade 11 Biology Introduction

Overview

Welcome to Grade 11 Biology: A Course for Independent Study. This course focuses on the structure of the human body and how it works. You will study personal wellness and homeostasis, digestion and nutrition, transportaiton and respiration, excretion and water management, and protection and control.

As a student enrolled in an independent study course, you have taken on a dual role—that of a student and a teacher. As a student, you are responsible for mastering the lessons and completing the learning activities and assignments. As a teacher, you are responsible for checking your work carefully, noting areas in which you need to improve and motivating yourself to succeed.

What Will You Learn in This Course?

This course is designed to assist students in achieving greater understanding of the anatomy and physiology of the systems in the human body. Wellness is a major theme throughout the course and students will be learning about various aspects of wellness, culminating with the development of personal wellness goals at the end of the course.

How Is This Course Organized?

This course is divided into six modules, organized as follows:

- Module 1: Wellness and Homeostasis
- Module 2: Digestion and Nutrition
- Module 3: Transportation and Respiration
- Module 4: Excretion and Waste Management
- Module 5: Protection and Control
- Module 6: Wellness and Homeostatic Changes

The lessons in this course are organized as follows:

- **Lesson Focus:** The Lesson Focus at the beginning of each lesson identifies one or more specific learning outcomes (SLOs) that are addressed in the lesson. The SLOs identify the knowledge and skills you should have achieved by the end of the lesson. For a complete list of the SLOs identified for Grade 11 Biology, refer to the Appendix at the end of this course.
- **Introduction:** Each lesson begins by outlining what you will be learning in that lesson.
- **Lesson:** The main body of the lesson consists of the content and processes that you need to learn. It contains information, explanations, diagrams, and completed examples.
- **Learning Activities:** Each lesson has a learning activity that focuses on the lesson content. Your responses to the questions in the learning activities will help you to practise or review what you have just learned. Once you have completed a learning activity, check your responses with those provided in the Learning Activity Answer Key found at the end of the applicable module. Do not send your learning activities to the Distance Learning Unit for assessment.
- **Assignments:** An assignment is found at the end of each lesson within this course. At the end of each module, you will mail or electronically submit all your completed assignments from that module to the Distance Learning Unit for assessment. All assignments combined will be worth a total of 60 percent of your final mark in this course.

This course also includes the following sections:

- **Glossary:** The glossary defines terms used within this course.
- **Bibliography:** The bibliography lists the main sources for material found in the course.
- **Appendix:** The appendix consists of a list of the specific learning outcomes (SLOs) covered in the course.

What Resources Will You Need for This Course?

You do not need a textbook to complete this course. All of the content is in this package.

Required Resources

To complete this course, you will need the following:

- **A notebook:** Use a notebook for recording your responses to learning activities.
- **Access to a copy of Canada's Food Guide** (especially if you do not have access to the Internet): One has been included with this course. If you cannot find one, contact the Distance Learning Unit at 1-800-465-9915.

Optional Resources

It would be helpful if you had access to the following resources:

- **A photocopier/scanner:** With access to a photocopier/scanner, you could make a copy of your assignments before submitting them so that if your tutor/marker wants to discuss an assignment with you over the phone, each of you will have a copy. It would also allow you to continue studying or to complete further lessons while your original work is with the tutor/marker. Photocopying or scanning your assignments will also ensure that you keep a copy in case the originals are lost.
- **Resource people:** Access to local resource people, such as teachers, school counsellors, and librarians, would help you complete the course.

- **A computer with Internet access:** Some lessons suggest website links as sources of information or for supplementary reference and reading. If you do not have Internet access, you will still be able to complete the course, but you will need to find different ways of accessing information.

Who Can Help You With This Course?

Taking an independent study course is different from taking a course in a classroom. Instead of relying on the teacher to tell you to complete a learning activity or an assignment, you must tell yourself to be responsible for your learning and for meeting deadlines. There are, however, two people who can help you be successful in this course: your tutor/marker and your learning partner.

Your Tutor/Marker

Tutor/markers are experienced educators who tutor Independent Study Option (ISO) students and mark assignments and examinations. When you are having difficulty with something in this course, contact your tutor/marker, who is there to help you. Your tutor/marker's name and contact information were sent to you with this course. You can also obtain this information in the learning management system (LMS).

Your Learning Partner

A learning partner is someone **you choose** who will help you learn. It may be someone who knows something about biology, but it doesn't have to be. A learning partner could be someone else who is taking this course, a teacher, a parent or guardian, a sibling, a friend, or anybody else who can help you. Most importantly, a learning partner should be someone with whom you feel comfortable and who will support you as you work through this course.

Your learning partner can help you keep on schedule with your coursework, read the course with you, check your work, look at and respond to your learning activities, or help you make sense of assignments. You may even study for your examination(s) with your learning partner. If you and your learning partner are taking the same course, however, your assignment work should not be identical.

How Will You Know How Well You Are Learning?

You will know how well you are learning in this course by how well you complete the learning activities, assignments, and examinations.

Learning Activities

The learning activities in this course will help you to review and practise what you have learned in the lessons. You will not submit the completed learning activities to the Distance Learning Unit. Instead, you will complete the learning activities and compare your responses to those provided in the Learning Activity Answer Key found at the end of each module.

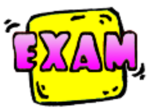
Make sure you complete the learning activities. Doing so will not only help you to practise what you have learned, but will also prepare you to complete your assignments and the examinations successfully. Many of the questions on the examinations will be similar to the questions in the learning activities. **Remember that you will not submit learning activities to the Distance Learning Unit.**

Assignments

At the end of each lesson, you will complete an assignment. Once you have completed all the assignments in a module, you will submit them to the Distance Learning Unit for assessment. The assignments are worth a total of 60 percent of your final course mark. Remember to keep all assignments that have been marked and returned to you, as some will become part of your Wellness Portfolio.

The tutor/marker will mark your assignments and return them to you. Remember to keep all marked assignments until you have finished the course so that you can use them to study for your examinations.

Midterm and Final Examinations



The course contains a midterm examination and a final examination.

- The **midterm examination** is based on Modules 1 to 3 and is worth 20 percent of your final mark in this course. You will write the midterm examination when you have completed Module 3.
- The **final examination** is based on Modules 4 to 6, and is worth 20 percent of your final mark in this course. You will write the final examination when you have completed Module 6.

The two examinations are worth a total of **40 percent** of your final course mark. You will write both examinations under supervision.

In order to do well on the examinations, you should review all of the work that you have completed from Modules 1 to 3 for your midterm examination and Modules 4 to 6 for your final examination, including all learning activities and assignments.

Requesting Your Examinations

You are responsible for making arrangements to have the examinations sent to your proctor from the Distance Learning Unit. Please make arrangements before you finish Module 3 to write the midterm examination. Likewise, you should begin arranging for your final examination before you finish Module 6.

To write your examinations, you need to make the following arrangements:

- **If you are attending school,** your examination will be sent to your school as soon as all the applicable assignments have been submitted. You should make arrangements with your school's ISO school facilitator to determine a date, time, and location to write the examination.
- **If you are not attending school,** check the Examination Request Form for options available to you. Examination Request Forms can be found on the Distance Learning Unit's website, or look for information in the learning management system (LMS). Two weeks before you are ready to write the examination, fill in the Examination Request Form and mail, fax, or email it to

    Distance Learning Unit
    500–555 Main Street
    PO Box 2020
    Winkler MB R6W 4B8
    Fax: 204-325-1719
    Toll-Free Telephone: 1-800-465-9915
    Email: distance.learning@gov.mb.ca

How Much Time Will You Need to Complete This Course?

Learning through independent study has several advantages over learning in the classroom. You are in charge of how you learn and you can choose how quickly you will complete the course. You can read as many lessons as you wish in a single session. You do not have to wait for your teacher or classmates.

From the date of your registration, you have a maximum of **12 months** to complete the course, but the pace at which you proceed is up to you. Read the following suggestions on how to pace yourself.

Chart A: Semester 1

If you want to start this course in September and complete it in January, you can follow the timeline suggested below.

Module	Completion Date
Module 1	Middle of September
Module 2	End of September
Module 3	Middle of October
Midterm Examination	Middle of November
Module 4	Beginning of December
Module 5	Middle of December
Module 6	Beginning of January
Final Examination	End of January

Chart B: Semester 2

If you want to start the course in February and complete it in May, you can follow the timeline suggested below.

Module	Completion Date
Module 1	Middle of February
Module 2	Beginning of March
Module 3	Middle of March
Midterm Examination	End of March
Module 4	Middle of April
Module 5	End of April
Module 6	Beginning of May
Final Examination	Middle of May

Chart C: Full School Year (Not Semestered)

If you want to start the course in September and complete it in May, you can follow the timeline suggested below.

Module	Completion Date
Module 1	End of September
Module 2	End of October
Module 3	End of November
Midterm Examination	Beginning of January
Module 4	End of February
Module 5	End of March
Module 6	End of April
Final Examination	Middle of May

Timelines

Do not wait until the last minute to complete your work, since your tutor/marker may not be available to mark it immediately. It may take a few weeks for your tutor/marker to assess your work and return it to you or your school.

If you need this course to graduate this school year, all coursework must be received by the Distance Learning Unit on or before the first Friday in May, and all examinations must be received by the Distance Learning Unit on or before the last Friday in May. Any coursework or examinations received after these deadlines may not be processed in time for a June graduation. Assignments or examinations submitted after these recommended deadlines will be processed and marked as they are received.

When and How Will You Submit Completed Assignments?

When to Submit Assignments

While working on this course, you will submit completed assignments to the Distance Learning Unit six times. The following chart shows you exactly what assignment you will be submitting at the end of each module.

Submission of Assignments	
Submission	Assignments You Will Submit
1	**Module 1: Wellness and Homeostatis** Module 1 Cover Sheet Assignment 1.1: Personal Wellness Goal Assignment 1.2: A Walk in the Cold Assignment 1.3: Wellness and Homeostasis
2	**Module 2: Digestion and Nutrition** Module 2 Cover Sheet Assignment 2.1: Introduction to Digestion Assignment 2.2: Nutritional Considerations Assignment 2.3: Digestive Disorders and Diseases Assignment 2.4: Decision Making
3	**Module 3: Transportation and Respiration** Module 3 Cover Sheet Assignment 3.1: Experiment: Effect of Exercise on Heart Rate Assignment 3.2: Respiratory Homeostasis Assignment 3.3: Circulatory and Respiratory Wellness
4	**Module 4: Excretion and Waste Management** Module 4 Cover Sheet Assignment 4.1: Osmoregulation Assignment 4.2: Urinalysis and Kidney Transplantation

Submission of Assignments (continued)	
Submission	Assignments You Will Submit
5	**Module 5: Protection and Control** Module 5 Cover Sheet Assignment 5.1: Option A: Vaccination Policies in Canada, or Assignment 5.2: Option B: Disease Investigation Assignment 5.2: The Nervous System Assignment 5.3: Investigation: Nervous or Endocrine Disorder
6	**Module 6: Wellness and Homeostatic Changes** Module 6 Cover Sheet Assignment 6.1: Understanding Alzheimer's Disease Assignment 6.2: Advances in Medical Technology Assignment 6.3: Wellness Summary

How to Submit Assignments

In this course, you have the choice of submitting your assignments either by mail or electronically.

- **Mail:** Each time you **mail** something, you must include the print version of the applicable Cover Sheet (found at the end of this Introduction). Complete the information at the top of each Cover Sheet before submitting it along with your assignments.
- **Electronic submission:** You do not need to include a cover sheet when submitting assignments electronically.

Submitting Your Assignments by Mail

If you choose to mail your completed assignments, please photocopy/scan all the materials first so that you will have a copy of your work in case your package goes missing. You will need to place the applicable module Cover Sheet and assignment(s) in an envelope, and address it to

Distance Learning Unit
500–555 Main Street
PO Box 2020
Winkler MB R6W 4B8

Your tutor/marker will mark your work and return it to you by mail.

Submitting Your Assignments Electronically

Assignment submission options vary by course. Sometimes assignments can be submitted electronically and sometimes they must be submitted by mail. Specific instructions on how to submit assignments were sent to you with this course. In addition, this information is available in the learning management system (LMS).

If you are submitting assignments electronically, make sure you have saved copies of them before you send them. That way, you can refer to your assignments when you discuss them with your tutor/marker. Also, if the original hand-in assignments are lost, you are able to resubmit them.

Your tutor/marker will mark your work and return it to you electronically.

The Distance Learning Unit does not provide technical support for hardware-related issues. If troubleshooting is required, consult a professional computer technician.

What are the Guide Graphics For?

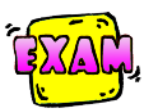
Graphics have been placed inside the margins of the course to identify and guide you in specific tasks. Each graphic has a specific purpose, as described below:

Assignment: Complete an assignment. You will submit your completed assignments to the Distance Learning Unit for assessment at the end of each module.

Internet: Use the Internet, if you have access to it, to obtain more information. Internet access is optional for this course.

Learning Activity: Complete a learning activity. This will help you to review or practise what you have learned and to prepare for an assignment or an examination. You will not submit learning activities to the Distance Learning Unit. Instead, you will compare your responses to those provided in the Learning Activity Answer Key found at the end of the applicable module.

Mail or Electronic Submission: Mail or electronically submit your completed assignments to the Distance Learning Unit for assessment at this time.



Examination: Write your midterm or final examination at this time.

Learning Partner: Ask your learning partner to help you with this task.

Phone of Email: Telephone or email your tutor/marker.

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Module 1 Cover Sheet

Please complete this sheet and place it on top of your assignments to assist in proper recording of your work. Submit the package to:

Drop-off/Courier Address

Distance Learning Unit
555 Main Street
Winkler MB R6W 1C4

Mailing Address

Distance Learning Unit
500–555 Main Street
PO Box 2020
Winkler MB R6W 4B8

Contact Information

Legal Name: ____________________ Preferred Name: ____________________

Phone: ____________________ Email: ____________________

Mailing Address: ____

City/Town: ____________________ Postal Code: __________

Attending School: ❑ No ❑ Yes

School Name: ____

Has your contact information changed since you registered for this course? ❑ No ❑ Yes

Note: Please keep a copy of your assignments so that you can refer to them when you discuss them with your tutor/marker.

For Student Use	For Office Use Only	
Module 1 Assignments	**Attempt 1**	**Attempt 2**
Which of the following are completed and enclosed? Please check (✓) all applicable boxes below.	________ Date Received	________ Date Received
❑ Assignment 1.1: Personal Wellness Goals	______ /15	______ /15
❑ Assignment 1.2: A Walk in the Cold	______ /15	______ /15
❑ Assignment 1.3: Wellness and Homeostasis	______ /16	______ /16
	Total: ____ /46	**Total: ____ /46**

For Tutor/Marker Use
Remarks:

Grade 11 Biology (30S)

Module 2 Cover Sheet

Please complete this sheet and place it on top of your assignments to assist in proper recording of your work. Submit the package to:

Drop-off/Courier Address

Distance Learning Unit
555 Main Street
Winkler MB R6W 1C4

Mailing Address

Distance Learning Unit
500–555 Main Street
PO Box 2020
Winkler MB R6W 4B8

Contact Information

Legal Name: ____________________________ Preferred Name: ____________________________

Phone: ________________________________ Email: ________________________________

Mailing Address: ____

City/Town: ____ Postal Code: ______________

Attending School: ❑ No ❑ Yes

School Name: ____

Has your contact information changed since you registered for this course? ❑ No ❑ Yes

Note: Please keep a copy of your assignments so that you can refer to them when you discuss them with your tutor/marker.

For Student Use	For Office Use Only	
Module 2 Assignments Which of the following are completed and enclosed? Please check (✓) all applicable boxes below.	**Attempt 1** __________ Date Received	**Attempt 2** __________ Date Received
❑ Assignment 2.1: Introduction to Digestion	______ /38	______ /38
❑ Assignment 2.2: Nutritional Considerations	______ /18	______ /18
❑ Assignment 2.3: Digestive Disorders and Diseases	______ /15	______ /15
❑ Assignment 2.4: Decision Making	______ /15	______ /15
	Total: _____ **/86**	**Total:** _____ **/86**

For Tutor/Marker Use
Remarks:

Assessment Rubric for Assignment 2.3 Digestive Disorders and Diseases (15 Marks)				
Assessment Category	**Assessment Criteria**			
In general terms, you need to demonstrate the following to receive the specified marks.				
	3 Marks	**2 Marks**	**1 Mark**	**0 Mark**
Part 1—Disorder or Disease Investigation Presentation ______ /12				
Accuracy	Information presented about the chosen topic is accurate	Information presented about the chosen topic is somewhat accurate	Information presented about the chosen topic has limited accuracy	Information is incorrect or demonstrates that the student did not understand the task
Relevance	Information selected to be presented about the chosen topic is relevant and enhances the reader's understanding of the topic	Information selected to be presented about the chosen topic is somewhat relevant and enhances the reader's understanding of the topic	Information selected to be presented about the chosen topic has limited relevance and may not contribute to the reader's understanding of the topic	Information selected to be presented about the chosen topic is not relevant and does not contribute to the reader's understanding of the topic
Completeness	3 pieces of relevant information are reported on all of symptoms, causes, treatment options, and prevention strategies	2–3 pieces of relevant information are reported on 3–4 of symptoms, causes, treatment options, and prevention strategies	Less than 3 pieces of relevant information are reported on less than 3 of symptoms, causes, treatment options, and prevention strategies	Assignment has not been attempted
Clarity	Information is presented in a clear and logical manner	Information is presented in a somewhat clear and/or somewhat logical manner	Information is presented with limited clarity and/or in an illogical manner	Information presented is unclear and/or illogical and/or demonstrates that the student did not understand the assignment
Part 2—References ______ /3				
	3 different reference sources are included with notes and/or print material for each to document sources	2 different reference sources are included with notes and/or print material for each to document sources	1 reference source is included with notes and/or print material to document source	No references are included or references are included with no notes and/or print material to document them

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Module 3 Cover Sheet

Please complete this sheet and place it on top of your assignments to assist in proper recording of your work. Submit the package to:

Drop-off/Courier Address

Distance Learning Unit
555 Main Street
Winkler MB R6W 1C4

Mailing Address

Distance Learning Unit
500–555 Main Street
PO Box 2020
Winkler MB R6W 4B8

Contact Information

Legal Name: ____________________________ Preferred Name: __________________________

Phone: _________________________________ Email: __________________________________

Mailing Address: ____

City/Town: ____ Postal Code: ______________

Attending School: ❑ No ❑ Yes

School Name: ____

Has your contact information changed since you registered for this course? ❑ No ❑ Yes

Note: Please keep a copy of your assignments so that you can refer to them when you discuss them with your tutor/marker.

For Student Use	For Office Use Only	
Module 3 Assignments Which of the following are completed and enclosed? Please check (✓) all applicable boxes below.	**Attempt 1** ______________ Date Received	**Attempt 2** ______________ Date Received
❑ Assignment 3.1: Experiment: Effect of Exercise on Heart Rate	_______ /15	_______ /15
❑ Assignment 3.2: Respiratory Homeostasis	_______ /20	_______ /20
❑ Assignment 3.3: Circulatory and Respiratory Wellness	_______ /20	_______ /20
	Total: _____ **/55**	**Total:** _____ **/55**

For Tutor/Marker Use
Remarks:

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Module 4 Cover Sheet

Please complete this sheet and place it on top of your assignments to assist in proper recording of your work. Submit the package to:

Drop-off/Courier Address

Distance Learning Unit
555 Main Street
Winkler MB R6W 1C4

Mailing Address

Distance Learning Unit
500–555 Main Street
PO Box 2020
Winkler MB R6W 4B8

Contact Information

Legal Name: ____________________ Preferred Name: ____________________

Phone: ____________________ Email: ____________________

Mailing Address: ____

City/Town: ____________________ Postal Code: ____________

Attending School: ❑ No ❑ Yes

School Name: ____

Has your contact information changed since you registered for this course? ❑ No ❑ Yes

Note: Please keep a copy of your assignments so that you can refer to them when you discuss them with your tutor/marker.

For Student Use	For Office Use Only	
Module 4 Assignments	**Attempt 1**	**Attempt 2**
Which of the following are completed and enclosed? Please check (✓) all applicable boxes below.	________ Date Received	________ Date Received
❑ Assignment 4.1: Osmoregulation	______ /16	______ /16
❑ Assignment 4.2: Urinalysis and Kidney Transplantation	______ /15	______ /15
	Total: _____ **/31**	**Total:** _____ **/31**

For Tutor/Marker Use
Remarks:

Grade 11 Biology (30S)

Module 5 Cover Sheet

Please complete this sheet and place it on top of your assignments to assist in proper recording of your work. Submit the package to:

Drop-off/Courier Address

Distance Learning Unit
555 Main Street
Winkler MB R6W 1C4

Mailing Address

Distance Learning Unit
500–555 Main Street
PO Box 2020
Winkler MB R6W 4B8

Contact Information

Legal Name: ___________________________ Preferred Name: _________________________

Phone: _________________________________ Email: ___________________________________

Mailing Address: ____

City/Town: ____ Postal Code: _______________

Attending School: ❑ No ❑ Yes

School Name: ____

Has your contact information changed since you registered for this course? ❑ No ❑ Yes

Note: Please keep a copy of your assignments so that you can refer to them when you discuss them with your tutor/marker.

For Student Use	For Office Use Only	
Module 5 Assignments	**Attempt 1**	**Attempt 2**
Which of the following are completed and enclosed? Please check (✓) all applicable boxes below.	_____________ Date Received	_____________ Date Received
❑ Assignment 5.1: Option A: Vaccination Policies in Canada Option B: Disease Investigation	_______ /20	_______ /20
❑ Assignment 5.2: The Nervous System	_______ /30	_______ /30
❑ Assignment 5.3: Investigation: Nervous or Endocrine Disorder	_______ /20	_______ /20
	Total: _____ **/70**	**Total:** _____ **/70**

For Tutor/Marker Use
Remarks:

Grade 11 Biology (30S)

Module 6 Cover Sheet

Please complete this sheet and place it on top of your assignments to assist in proper recording of your work. Submit the package to:

Drop-off/Courier Address

Distance Learning Unit
555 Main Street
Winkler MB R6W 1C4

Mailing Address

Distance Learning Unit
500–555 Main Street
PO Box 2020
Winkler MB R6W 4B8

Contact Information

Legal Name: ____________________ Preferred Name: ____________________

Phone: ____________________ Email: ____________________

Mailing Address: ____

City/Town: ______________________________ Postal Code: ____________

Attending School: ❑ No ❑ Yes

School Name: ____

Has your contact information changed since you registered for this course? ❑ No ❑ Yes

Note: Please keep a copy of your assignments so that you can refer to them when you discuss them with your tutor/marker.

For Student Use	For Office Use Only	
Module 6 Assignments Which of the following are completed and enclosed? Please check (✓) all applicable boxes below.	**Attempt 1** __________ Date Received	**Attempt 2** __________ Date Received
❑ Assignment 6.1: Option A: Understanding Alzheimer's Disease Option B: Investigation into Aging	________ /14	________ /14
❑ Assignment 6.2: Advances in Medical Technology	________ /25	________ /25
❑ Assignment 6.3: Wellness Summary	________ /20	________ /20
	Total: ______ **/59**	**Total:** ______ **/59**

For Tutor/Marker Use
Remarks:

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Imprimé au Canada

Grade 11 Biology (30S)

Module 1

Wellness and Homeostasis

This module contains the following:

- Introduction
- Lesson 1: Personal Wellness
- Lesson 2: Introduction to Homeostasis
- Lesson 3: Cells and Homeostasis
- Lesson 4: Energy
- Module Summary

Module 1: Wellness and Homeostasis

Introduction

Welcome to the first module of Grade 11 Biology. This may be the most important course that you will ever take, because you will learn about your own body and how to stay healthy. You will study body systems, and complete your own wellness portfolio in which you will explore and reflect on your lifestyle and wellness.

This module is made up of 5 lessons. In Lesson 1, you will learn how to successfully complete this course. In Lessons 2–5, you will learn about wellness and homeostasis—the main themes of the entire course. Don't worry if you don't know what they mean. You will learn about them later in the course.

In order to complete this first module, you need to study Lessons 1 to 5, and complete the following assignments.

Assignments in Module 1

When you complete Module 1, you will submit your Module 1 assignments to the Distance Learning Unit either by mail or electronically through the learning management system (LMS). The staff will forward your work to your tutor/marker.

Lesson	Assignment Number	Assignment Title
1	Assignment 1.1	Personal Wellness Goal
2	Assignment 1.2	A Walk in the Cold
4	Assignment 1.3	Wellness and Homeostasis

Notes

Lesson 1: Personal Wellness

Lesson Focus

In this lesson, you will

- ❑ become more aware of your personal wellness
- ❑ increase your understanding of your family's health history
- ❑ learn the differences between health and wellness
- ❑ begin working on your Personal Wellness Portfolio by completing a Personal Wellness and Family Health History questionnaire
- ❑ increase your awareness of how one person's health and wellness affects other people

Introduction

It's now time for you to start learning about personal wellness. You will also start working on your Personal Wellness Portfolio. It will give you a great chance to learn more about yourself and your own wellness, and to discover ways to improve your personal health and wellness.

What Is Biology?

Since this is a biology course, you need to know what biology is. **Biology** is the study of living things. It is a very broad discipline and includes many specific areas of study. That is because "living things" vary in form from very simple, one-celled organisms to very complex, multi-cellular organisms. The **diversity** of living things on our planet is incredible.

In this course, you will learn more about the human organism. You will study the structure of the human body (**anatomy**) and also how the human body works (**physiology**). These two areas—structure and function—are closely related. You will see this relationship reinforced many times throughout this course.

All living things, including human beings, age and eventually die. Like a car needs consistent and careful attention, a living organism must be adequately maintained. Life requires maintenance because it is a delicate state, a **balance** between "too much" and "too little" of a wide variety of factors.

As humans, we are concerned not only with staying alive, but with the quality of our lives. We want to be both **fit** and **well**. This lesson explores personal health and wellness, and also considers the successful maintenance of health and wellness that is **homeostasis**.

Personal Health and Wellness

What are the differences between personal **health** and personal **wellness**?

Health usually refers to the physical and mental well-being of an individual.

Wellness is a broader term and refers to the relationship between the five factors of well-being, which are physical, emotional, spiritual, intellectual, and social.

- **Physical wellness** includes caring for your body in terms of sleep, exercise, proper nutrition and hydration; exposure to various drugs and medications; and regular medical check-ups. Physical well-being is to some extent an individual and unique state of balance.
- **Emotional wellness** involves the existence of healthy emotions as we experience the events in our lives and the relationships that we have with other people. It is natural to have negative emotions but they must be balanced by positive emotions.
- **Spiritual wellness** is harder to define and is different for each individual. It refers to the human need to understand the deeper meanings of life, the forces that control our present and shape our future. For some people, spirituality involves formal religion while for others it does not.
- **Intellectual wellness** is being willing and able to learn new things while stimulating and challenging your mind. Because life is always changing, it is important that everybody learns new things in order to adapt to those changes and to prevent intellectual stagnation.
- **Social wellness** refers to the degree to which a person interacts successfully with others. This is important because human beings are interdependent on one another.

Your health and wellness depend on a number of factors, such as accidents, illness, environmental conditions, and your family's health history. Environmental factors, like smog and pollution, affect everyone's health and wellness. Certain conditions, illnesses, and predispositions are partly genetic and therefore can run in families. Examples of these include some types of cancer and diabetes.

Learning Activity 1.1

It is now time for you to complete **Learning Activity 1.1**. Remember, Learning Activities are **not** sent in for assessment. However, this Learning Activity will help you complete **Assignment 1.1** (which you **will** send in for assessment).

Learning Activity 1.1

Wellness and Family Health History

This questionnaire will help you to become more aware of your own health, as well as your family's health history, and may be useful in developing your personal wellness goals. You will be referring to these answers when completing Assignment 1.2 in lesson 3. Answer each question honestly and do not be concerned with what you think your answers "should" be.

Please note that, because of the nature of the questions, this learning activity does not have an answer key, though most learning activities do.

Part I: Checklist

Put a "check mark"_✓_ next to the items that apply to you **most** of the time.

1. _____ I am aware of diseases that tend to run in my family.
2. _____ I know what illnesses I have had in my life so far.
3. _____ I know what type of medications that I have had in the past.
4. _____ I have supportive family members and friends.
5. _____ I am involved in community activities.
6. _____ I am a lifelong learner.
7. _____ I can cope with stress safely and consistently.
8. _____ I laugh easily and often.
9. _____ I know how to relax when I need to.
10. _____ I sleep well and generally feel rested.
11. _____ I like myself.
12. _____ I consider how my actions affect others.
13. _____ I eat a variety of foods.

continued

Learning Activity 1.1 (continued)

14. _____ I limit my intake of fast foods.
15. _____ I choose low fat items in my daily diet (low fat dressings, low fat milk, etc.).
16. _____ I include high fibre foods in my diet (whole wheat breads, fruit, etc.).
17. _____ I eat fruit and vegetables every day.
18. _____ I eat dairy products every day (milk, cheese, yogurt, etc.).
19. _____ I eat whole grain products every day (bread, cereal, pasta, etc.).
20. _____ I eat meat or meat alternatives every day (eggs, meat, peanut butter, etc.).
21. _____ I limit my junk food intake.
22. _____ I taste my food before I add salt.
23. _____ I limit my sugar intake.
24. _____ I don’t drink alcohol.
25. _____ I maintain a healthy body weight by balancing exercise and healthy eating.
26. _____ I do activities to make myself more flexible, such as stretching.
27. _____ I do activities to make myself stronger, like weight-lifting.
28. _____ I do activities to improve my cardiovascular fitness, like swimming.
29. _____ I get 30 minutes of non-stop, moderately intense activity at least 3 times a week.
30. _____ I know if my blood pressure is in a normal range.
31. _____ When I exercise, I don’t get out of breath too quickly or feel too uncomfortable.

continued

Learning Activity 1.1 (continued)

32. _____ I do not smoke cigarettes.
33. _____ I do not use illegal drugs.
34. _____ I drink 6 to 8 glasses of non-caffeinated drinks every day.
35. _____ I wear a seat belt in the car.
36. _____ I wear a helmet when riding a bicycle or motorcycle.
37. _____ I wear safety gear when participating in sports.
38. _____ I wear sunscreen when I am outdoors.
39. _____ I follow directions for any medications that I take regularly.
40. _____ I go for regular physical examinations with a doctor.

Part II: Personal Wellness

Choose 5 of the following questions and respond with a few sentences for each question. Do not be concerned with writing what you think you "should" write, just be as honest as you can.

1. Do you have a physical sickness or disease at the present time? What is it, and how are you treating it?
2. Have you had a physical sickness or disease in the past which you believe may reoccur in the future? Are there any steps you can take to prevent a reoccurrence?
3. Do you have a healthy diet? If not, why not? If so, why is it important to you?
4. How often do you get physical check-ups with your doctor? Is that often enough?
5. What types of exercise do you engage in regularly? Do you think it is often enough? Do you think it is too much?
6. Do you get an adequate amount of sleep every night? If not, why not?

continued

Learning Activity 1.1 (continued)

7. Are you a happy person? Why or why not?
8. Do you usually have a positive outlook on your future? Why or why not?
9. What do you like most about yourself? Name three things.
10. Do you forgive yourself for past mistakes? Why or why not?
11. Do you forgive others for past mistakes? Why or why not?
12. Do you feel that you communicate openly with those you are closest to? Why or why not?
13. Do you have problems controlling your anger? Why or why not?
14. Do you keep a personal journal? Why or why not?
15. How often do you pray or meditate? Do you think that is often enough?
16. How often do you read? What types of literature do you most enjoy?
17. Do you enjoy listening to speakers at special interest workshops or presentations? Why or why not?
18. Do you enjoy discussions with others on challenging topics? Why or why not? Who do you enjoy conversations with most?
19. Do you watch educational television? If not, why not? If so, what do you watch?
20. Do you see yourself as a flexible, open-minded person? Why or why not?
21. What activities in your community are you involved in?
22. Do you volunteer your time with any community organizations? If so, which ones? If not, why not?
23. Do you enjoy meeting new people and trying new things? Why or why not?

continued

Learning Activity 1.1 (continued)

Part III: Wellness and Homeostasis

The creation of a *personal* Family Medical History in the Wellness Portfolio is not mandatory. Teachers need to be sensitive with regard to students who may not be able to contact family members, or for families who wish to keep medical histories private. The goal of this activity is to develop an understanding of how some health and wellness issues may be hereditary. A family history may also be an excellent gateway to inquiry into diseases, heredity, and so forth.

You're the Doctor!

A Patient's Family History

Doctors often ask patients if any medical conditions persist in their family. In this activity, you will conduct a family history on a "patient". This may be a general family history that tracks ages, illnesses, and so on or you may track a particular medical condition through a family tree.

Doctor-patient confidentiality requires that you use fictitious names.

Here is a list of questions you should ask your patient:

- Do you have any medical conditions?
- Have you had any hospital visits? What for?
- Do you have any allergies? What kind of allergy? Do other members of your family have allergies?
- How long did your longest surviving relative live?
- Do multiple births (twins, triplets, etc.) occur in your family?
- Were people in the family smokers or non-smokers?
- When were your parents and grandparents born?
- Did any family members experience any medical conditions during their lifetime (e.g., heart attack, diabetes, cancer, arthritis, asthma, allergies, seizures, multiple sclerosis, strokes, ulcers, colon cancer, ovarian cancer, breast cancer, prostate cancer, melanoma)? [NOTE: A doctor works through the different organ systems in this question.]
- If a family member has died, when did it occur? How old were they when they passed away? Did any known conditions cause their death?

continued

Learning Activity 1.1 (continued)

TASK:

1. Ask these questions of someone who will be your "patient" and go back as far into their family tree as you can. You may want to ask these questions of another family member of theirs to fill in gaps.
2. Make notes of these interviews and include them in your Wellness Portfolio.
3. Summarize your work as a medical family tree. Note each person, how the individuals are related, and relevant information about them.

For purposes of a genetic history, what you are creating is a medical tool called a pedigree. You are doing a basic pedigree with added notes. All information is considered private.

Wellness Choices

You are not able to control your genetic makeup. However, you do have control over the choices you make and your own behaviour. The five aspects of wellness discussed earlier in this lesson are all very strongly affected by your lifestyle choices and behaviour. For example, you determine how much sleep you get every night. You make daily dietary decisions. You decide whether or not to read for relaxation. You decide whether or not to smoke.

These decisions affect other people. The lifestyle choices made by a pregnant woman affect her unborn child. The choices made by a father affect his children. The choices made by an individual affect his or her co-workers. The choices made by an individual family affect their community. The province of Manitoba has a "Healthy Living" website that is informative and may help you reflect on your own health and wellness. At the time this course was written, the website was found at:

http://www.gov.mb.ca/healthyliving/index.html

Assignment 1.1

It is now time to complete **Assignment 1.1: Personal Wellness Goals**.

Assignment 1.1

Personal Wellness Goals *(15 marks)*

Review the answers that you wrote for Learning Activity 1.1. Then reflect on your own personal wellness and name **at least three aspects of your personal life that you would like to actively change to improve your personal health and wellness**. Try to name changes that are actually possible and reasonable for you to make. For each goal, explain why you value it and why you want to achieve it.

Look at the raw score next to each question before answering it. Make sure that you write at least that number of points in your answer. For example, if a question is worth 4 marks, make sure that you write at least 4 clear, distinct, correct points, so that your tutor/marker can give you 1 mark for each.

Ask your learning partner to help you.

Personal Wellness Goal #1: *(1 mark)*

Why do you value it and want to achieve it? *(4 marks)*

continued

Assignment 1.1 (continued)

Personal Wellness Goal #2: *(1 mark)*

Why do you value it and want to achieve it? *(4 marks)*

Personal Wellness Goal #3: *(1 mark)*

Why do you value it and want to achieve it? *(4 marks)*

Lesson 2: Introduction to Homeostasis

Lesson Focus

In this lesson, you will

- ❑ identify the 6 characteristics that identify organisms as living things
- ❑ define and give examples of homeostasis
- ❑ explain some of the factors that threaten the maintenance of homeostasis
- ❑ define and give examples of negative feedback
- ❑ explain how the body uses negative feedback in order to maintain homeostasis

Introduction

In the last lesson, you learned about wellness. In this lesson, you will learn about homeostasis. Homeostasis is the fascinating way that all living things, including you, maintain control over their internal environment in order to survive. Understanding homeostasis will help you stay well.

Before exploring homeostasis, you will need to review the characteristics of life.

Characteristics of Life

There are six "characteristics of life" that can be identified as being characteristic of living things. Living things are also called **organisms**. These six characteristics are as follows:

1. Living things show various levels of **internal organization**. The cell is generally considered to be the smallest unit of life. Organisms may be unicellular (made up of one cell) or multicellular (made up of many cells). In an organism, cells may be organized into tissues, organs, and organ systems.

2. Living things must get energy and materials from the environment. These energy and materials are used in **metabolism**, which is the sum of all the chemical reactions that occur in an organism. Some organisms can capture energy that is in the form of sunlight and convert it into energy while other organisms must eat food to acquire energy for life.
3. All living things exert **control** over their body activities in an attempt to maintain a fairly constant internal environment (homeostasis). This control includes the regulation of both internal processes, (like metabolism) and external processes (like hibernation).
4. Living things must **reproduce**. Although each individual of a species need not reproduce, each species must reproduce and pass genetic material from one generation to the next. Organisms can reproduce either asexually or sexually.
5. Living things must **grow and develop**. Organisms grow during their lifespans; the number of cells increases, thus increasing the size of the organism. Organisms also develop during their lifespans; cells move and reorganize themselves, specializing in certain functions. Repair of damaged cells is also a form of development.
6. Living things must exhibit **responsiveness**, which means that they respond to changes in their environments. A condition in the environment that requires an organism to adjust is called a stimulus and a reaction to the stimulus is called a response. Hormones, nerve cells, and other chemical substances in the body can cause the human body to respond in a short period of time. Over long periods of time, organisms can adapt to physical changes in their environment.

Homeostasis

Homeostasis is defined as the maintenance of a fairly constant internal environment in response to changes that occur in the external environment. It is the regulation of an organism’s internal environment to sustain conditions that are both suitable and necessary for survival. Homeostasis is a characteristic of life because it is a process that occurs in all living things. Homeostasis preserves a “fairly” constant internal environment because there are ranges of tolerance for various life processes. For example, the typical human body temperature is usually 37.1°C. However, human body temperature can vary within a certain range of tolerance, either above or below this optimum temperature, before the life of the individual is threatened.

There are three basic strategies that organisms use to maintain homeostasis of their body systems.

1. **Structural:** The organism has particular body structures or physical features to help it adjust to its environment. For example, birds possess down which helps to insulate their bodies against temperature change.
2. **Functional:** The organism's body processes adjust to changes in the environment. For example, the metabolism of a bear decreases dramatically during months of hibernation when food is scarce and temperatures are cold.
3. **Behavioural:** The organism's actions help it to maintain homeostasis. For example, snakes "sun" themselves to elevate their body temperature since they are cold-blooded animals and are unable to internally control it.

It is important to emphasize that the failure of any structural, functional, or behavioural strategy to maintain homeostasis may result in the death of the organism. The maintenance of life requires the maintenance of homeostasis.

Regulating the Human Body

Some examples of life processes that must be adequately regulated in the human body are temperature maintenance, water balance, and waste management.

Only a specific range of body temperatures can be tolerated by any organism. The maintenance of body temperature within specified limits is called **thermoregulation**. An organism's life is threatened if the external temperature is too high or too low; if structural, functional, and behavioural responses cannot result in an acceptable internal body temperature, the organism will die. A good example of a structural adaptation used by many mammals for thermoregulation is the production of sweat; the evaporation of sweat from the skin surface effectively cools that skin tissue.

Osmoregulation is the maintenance of water balance in the organism's internal environment. Each cell is primarily composed of water; life depends on enough but not too much water in the internal environment. An example of a structural and functional adaptation for osmoregulation is the production of urine by many mammals. The kidney is an intricately designed organ that filters blood, removing wastes and excess water to create urine, which is excreted. The kidney removes some but not too much water from the blood, maintaining balance.

Waste management is the maintenance of adequate nutrients in the blood and the removal of harmful wastes from the body. Part of the material consumed as food is of little or no nutritive value. The stomach and small intestine in mammals are the organs in the digestive system in which nutrients are absorbed into the bloodstream. Unused materials pass through these organs and enter the large intestine where these waste products of digestion are eliminated from the body. One harmful by-product of protein digestion is ammonia which is very toxic. The liver converts ammonia to urea, a much less toxic substance. Urea is filtered out of the blood by the kidneys.

Negative Feedback

Negative feedback is a general term used to describe how homeostasis is carefully maintained in living things. Think back to the last time you grabbed the handle of a pot or pan that was still very hot. The receptors in your skin sent the message to your brain that you were holding something that was burning your hand. Your brain reacted and sent the message back to the motor nerve cells in your hand to release the handle immediately, thus restoring homeostasis. This event illustrates how a **reflex** protects the body from harm.

A typical negative feedback system has three components: the sensor, the coordinating centre, and the effector. In the above example, the sensors are the receptors in your skin cells, the coordinating centre is the brain, and the effectors are the motor neurons in your hand.

In order for the human body to maintain homeostasis of its organ systems, numerous negative feedback systems are functioning at the same time. The primary organ systems that are controlled in this way are the **nervous system** (the brain and spinal cord) and the **endocrine system** (glands and the chemical hormones they secrete). These two organ systems in turn control the functioning of all of the other organ systems.

What are the threats to homeostasis? Usually, a stimulus in the environment is recognized by the "sensor" or receptor, usually one of the sense organs. The sensor sends a message through neural pathways to the "coordinating centre" which may be part of the central nervous system or an endocrine gland. The reaction is a response by the **effector**, usually either the contraction of muscle tissue or the production of a hormone. In general, effectors are either muscles or glands.

Other Examples of Negative Feedback

An example of negative feedback in the human body is **thermoregulation**. Since cells in the skin recognize (or are sensitive to) temperature, if the external temperature gets too cold, a message is sent to the hypothalamus which commands the muscles in the skin to shiver. This activity of the muscle tissue warms it and ensures that body temperature does not drop. The body continues to warm up until it is no longer cold. If it gets too warm, the body cools off until it is no longer warm. This continuous adjustment process maintains homeostasis which is a **dynamic** state of balance.

Have you ever noticed that your thirst and need to urinate vary depending on what you are doing and your environment? This is also due to negative feedback, which works to achieves homeostasis by **osmoregulation**. The hypothalamus in your brain is sensitive to how much water is in the blood relative to other materials. A drop in fluid intake by as little as 1% of your body mass results in thirst, which is designed to change behaviour so that you drink fluids. A drop of 5% can cause pain and collapse and a drop of 10% can cause death. If the blood has too much water in it relative to other materials, the kidneys are commanded to remove the water and excrete it as urine.

In summary, homeostasis depends on the coordinated interaction of a number of organ systems. Negative feedback ensures that your body does not ignore external changes that could be dangerous to your health. Once homeostasis has been regained, the signal from the negative feedback system stops. This interaction results in the maintenance of balance which allows life to continue and thrive. The external environment of all organisms is constantly changing. Homeostatic mechanisms repeatedly react by making sure that, despite external change, the internal environment remains stable within acceptable limits.

Learning Activity 1.2

It is now time for you to complete **Learning Activity 1.2**. Remember, Learning Activities are **not** sent in for assessment.

Learning Activity 1.2

Introduction to Homeostasis

This learning activity is different from the previous one in that it has an answer key, which is found at the end of this module. First, answer the following questions to the best of your ability, without looking at the answer key. Then, check your answers in the answer key at the end of this module. You will need a notebook to write your answers in.

Remember, these questions are similar to the ones that will be on your midterm and final examinations. So, if you were able to answer them correctly, you are likely to do well on your examinations. If you did not answer them correctly, you need to go back to the lesson and learn them.

1. Match the terms on the left with the statements on the right; each statement is used once and only once. Print the letter of the correct choice in the space provided.

________ Osmoregulation	a. The maintenance of a relatively stable internal environment.
________ Homeostasis	b. A living thing.
________ Thermoregulation	c. The process that maintains homeostasis.
________ Negative feedback	d. The control of body temperature within specific limits.
________ Organism	e. The maintenance of water balance in the body.

2. Name the five factors of wellness and briefly explain each one.
3. Name the six characteristics that identify living things and briefly explain each one.

After you have answered the questions, check your answers in the Learning Activity Answer Key found at the end of this module. How did you do? If you answered most of them correctly, go on to the next lesson. If you didn't, then you have to go back to the lesson and learn it.

Assignment 1.2

It's now time for you to complete **Assignment 1.2.** This is a fun assignment that will help you think about how various body systems react to external changes in order to maintain homeostasis. Complete it with your learning partner.

A Walk in the Cold ***(15 marks)***

You will read about what happens when you go for a walk in the cold in the winter. Next, you will think about how the body reacts to this event in an effort to maintain homeostasis.

"A Walk in the Cold"

Before leaving the house, you put on your winter outerwear—boots, mitts, hat, scarf, and parka. The increased amount of clothing traps body heat and indoors you begin to sweat as your body tries to cool down. As you leave the house and enter the cold winter air, your exposed cheeks feel cold. Near the end of the walk you notice your toes and fingers beginning to feel numb. You decide to run the rest of the way home again. When you arrive you're glad to find the run has warmed up your fingers and toes; however, as you take off your boots, you begin to sweat again in your parka. You remove your outerwear and step into your warm kitchen. A few minutes later you find yourself becoming cold and you begin to shiver as your body tries to warm up. You decide to make some hot tea.

This example shows how your body works to maintain one specific aspect of its internal environment—a body temperature of approximately 37 degrees Celsius. In fact, if your body fluctuates too much from this temperature, it could lead to death. In addition to a body temperature of about 37 degrees Celsius, you may be familiar with some other body constants. These include a blood pressure of about 120/80 mmHg, a blood pH near 7.4, and blood glucose concentrations at about 100 mg/mL. There are also limits in terms of heart rate, although they vary greatly based on age, gender, and physical fitness.

continued

Assignment 1.2 (continued)

The following three pages are diagrams that you will complete using the reading, "A Walk in the Cold" as your reference. There are three events that you will analyze:

1. You are still inside the house, you have your winter outerwear on, and you have not left for your walk yet; you are beginning to feel warm.
2. You have been walking outside for a few minutes and are beginning to feel cold.
3. You have been back at home for a few minutes and are becoming cold again.

For each of the three events, you will decide the following:

1. What primary change in your body occurred and why?
2. Which receptor recognized that change in your body?
3. Which effector produced a change in your body? Remember that effectors are either muscles or glands.
4. What secondary change was produced by your body?
5. What signalled that homeostasis was restored (return to normal conditions)?

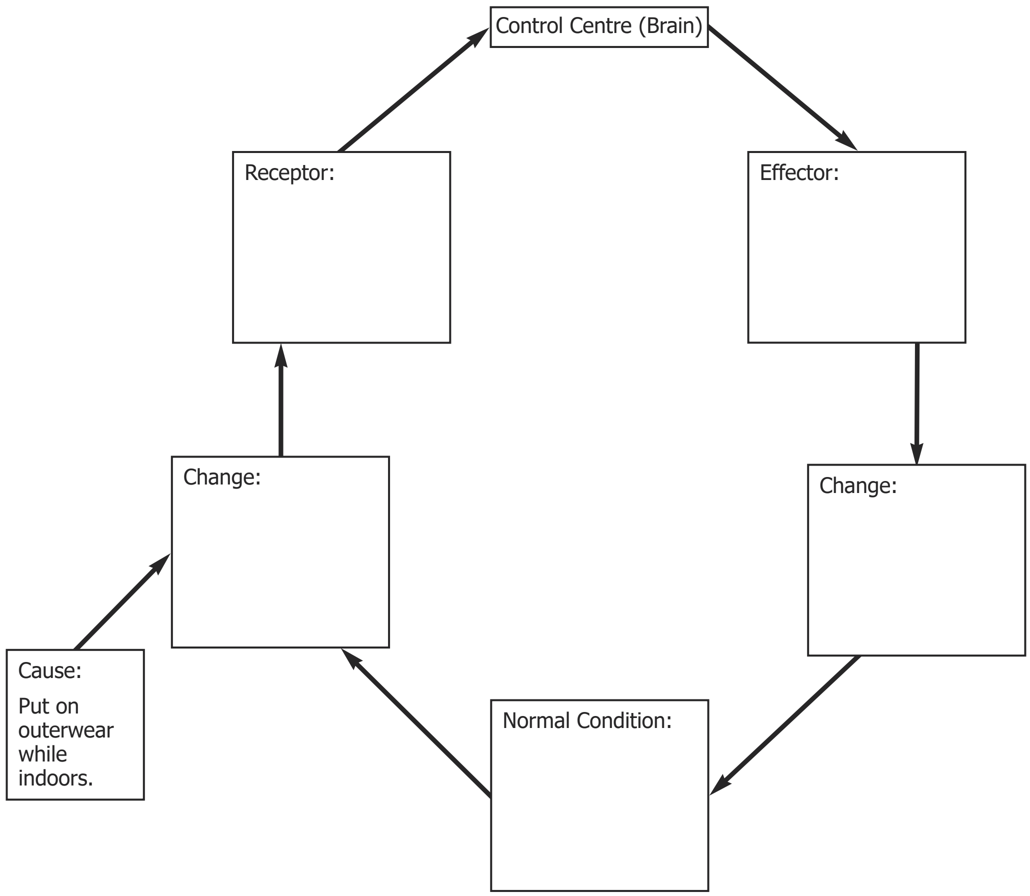
There are three events with five questions each, for a total of 15 answers. Each answer is worth 1 mark, for a total of 15 marks.

continued

Assignment 1.2 (continued)

Event 1: (5 marks)

You are still inside the house, you have your winter outerwear on, and you have not left for your walk yet; you are beginning to feel warm.

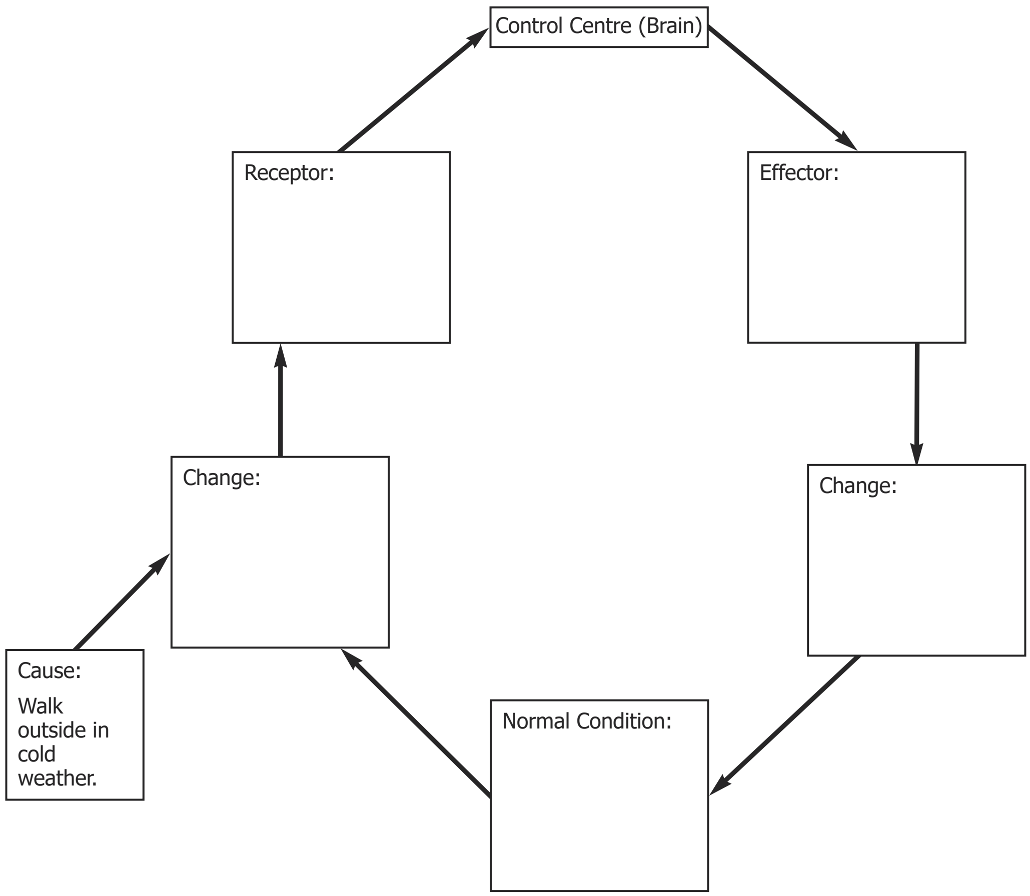


continued

Assignment 1.2 (continued)

Event 2: (5 marks)

You have been walking outside for a few minutes and are beginning to feel cold.

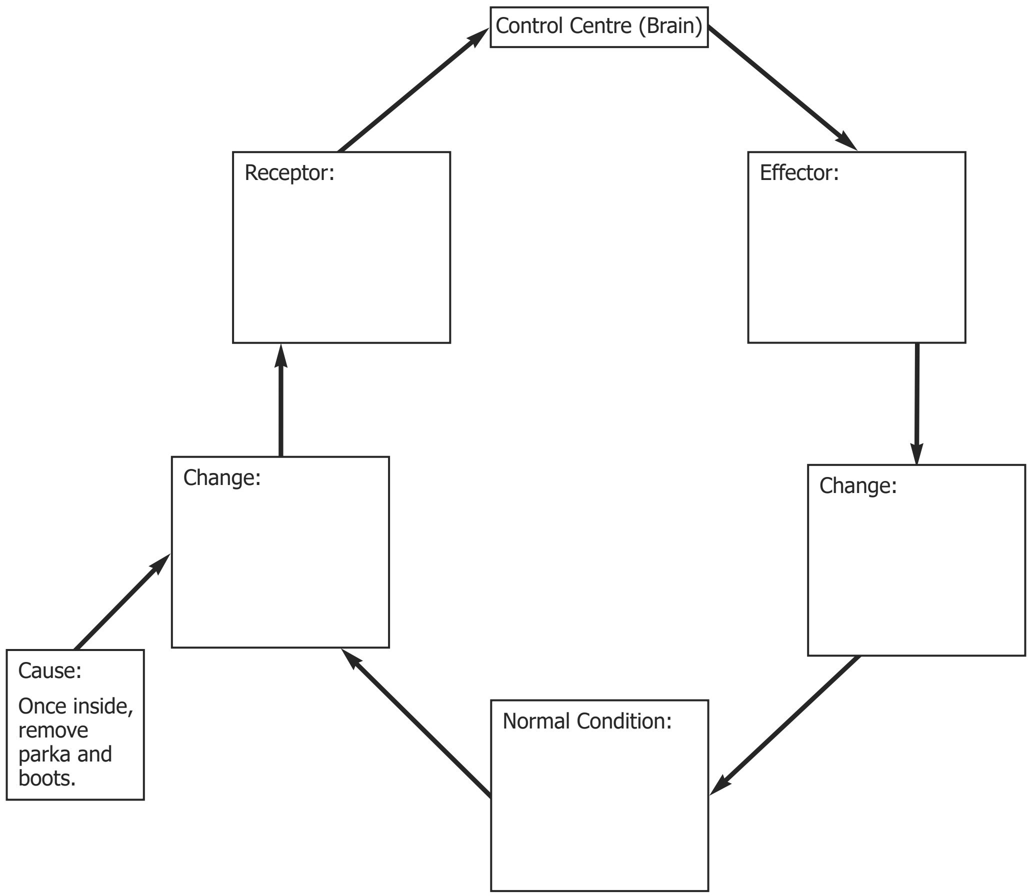


continued

Assignment 1.2 (continued)

Event 3: (5 marks)

You have been back at home for a few minutes and are becoming cold again.



Notes

Lesson 3: Cells and Homeostasis

Introduction

In the previous lesson, you learned about the "Six Characteristics of Life". These were used to help you to understand that life relies on the maintenance of homeostasis. The living condition is a "balancing act" that increases in complexity as the organism increases in complexity.

However, even an individual cell, the simplest form of life, is, in fact, alive. In this lesson, you will learn about the "essential life processes" that all living things, regardless of their level of complexity, must accomplish and manage. More specifically, you will

- identify the vital life processes and explain how an individual cell achieves balance of these essential life processes to maintain homeostasis
- understand the role that the cell membrane plays in the cell as it manages the essential life processes
- explain how the structure of the cell membrane allows it to effectively control what materials pass into and out of the cell
- identify the factors that affect the movement of different substances across the cell membrane

What are the Essential Life Processes?

There are six essential life processes that help to distinguish between living and non-living things. All of these processes occur in all living things, but not in non-living things. Once again you will see how important the maintenance of homeostasis is, as these specific processes must be kept in balance to achieve homeostasis. They are as follows:

1. **Obtaining food:** Some organisms build their own food using the energy from the Sun in a process called photosynthesis. They then use the energy stored in that food to carry out their life processes. These organisms are called producers and include most green plants as well as some algae and bacteria. Many organisms eat other living things and use the energy in that food to stay alive. These organisms are called consumers and include herbivores, carnivores, and omnivores. There are even organisms that eat dead organisms, like some bacteria.
2. **Converting energy:** The food you eat does not instantly give you energy. Every morsel of food is broken down during digestion and converted to forms of energy that are more readily used and stored by the human body.

Photosynthetic organisms that capture the energy from the Sun convert that radiant energy into a usable chemical form called glucose. Glucose, a simple carbohydrate, is then converted and modified in numerous ways to accomplish other life tasks such as growth, movement, reproduction, and repair. Consumers that eat other living things also convert the chemical energy in food into other energy sources that are used to accomplish the same life tasks.

3. **Eliminating wastes:** As a result of the chemical reactions that are involved in the life processes of all organisms, waste materials are produced. Since many of these materials are toxic to the organism, it is essential that it be able to rid itself of those waste products. Examples of waste products include carbon dioxide (a result of breaking down food molecules using oxygen), ammonia (a product of protein digestion), and indigestible food materials.

4. **Reproducing:** In order for a species to survive through time, it must be capable of reproducing offspring. The strategies used to reproduce vary greatly across the biological world. Some organisms are unicellular and simply divide by halving themselves; this form of reproduction is called asexual reproduction because it only involves one parent. Other organisms reproduce using sexual reproduction which involves the joining of genetic material from two parents.

5. **Growing and repairing:** During the lifespan of each organism, its body grows in size which may involve an increase in the number of cells that make up that body. Each organism also develops or changes during its lifespan. Cells die and are replaced by new cells. Cells organize themselves into tissues specialized to perform specific functions in the organism.

6. **Transporting substances:** In every cell, substances must be moved within the cell and also must be moved into and out of the cell. There are many ways in which organisms accomplish the task of transporting materials within their cells, between their cells, and between their cells and their environment. You will learn about some of these methods later in this lesson.

Each of the six essential life processes is carefully controlled by each living cell, whether it is a unicellular organism or a small part of a multicellular organism. Every cell must be capable of reacting to changes in the external environment that threaten that cell's stable internal environment.

For example, a cell must be capable of not only obtaining food, but identifying materials in its environment as food. Imagine a cell that is in need of salt. If the cell cannot detect any salt in its environment it needs to be able to move to look elsewhere. If the food that a cell finds is alive, the cell must kill it in order to ingest it. However, if that food is alive and dangerous to the cell (like certain bacteria), the cell must first be able to protect itself in order to ingest it.

Also, the cell must be able to move numerous substances within itself as well as between itself and the environment. A cell that requires sugars, salt, or water must be able to import these particles across the cell membrane. Once the cell has acquired the necessary particles, it will transport them to other structures within the cell, called organelles. Likewise, the cell must be able to move waste materials out of its environment. The transport of all these substances occurs across the cell membrane. You will now learn how the individual cell accomplishes the amazing feat of maintaining a relatively stable internal environment in spite of environmental change.

The Cell Membrane

The **cell membrane** is sometimes referred to as the **plasma membrane**. All living cells possess such a membrane which serves as its boundary with the external environment. The membrane encloses the cell's contents. The cell membrane is composed primarily of proteins, carbohydrates, and the phospholipid bilayer. It is very thin (5–10 nm thick) and can best be observed through an electron microscope.

The cell membrane, because of its structure, is capable of keeping necessary materials inside the cell and of keeping unwanted materials outside the cell. In other words, a cell can determine what it wants and doesn't want, both inside of the cell and outside of the cell. We say, then, that the plasma membrane is **selectively permeable** or **semi-permeable**. This means it lets in some, but not all, materials and also keeps some, but not all, materials out.

Understanding the structure of the cell membrane will help you understand how it accomplishes the vital tasks it performs in the life of the cell. Scientists have been studying the structure of the cell membrane for many years. As a result of their research, cell biologists have elaborated the **fluid-mosaic model** to illustrate the structure and function of the cell membrane.

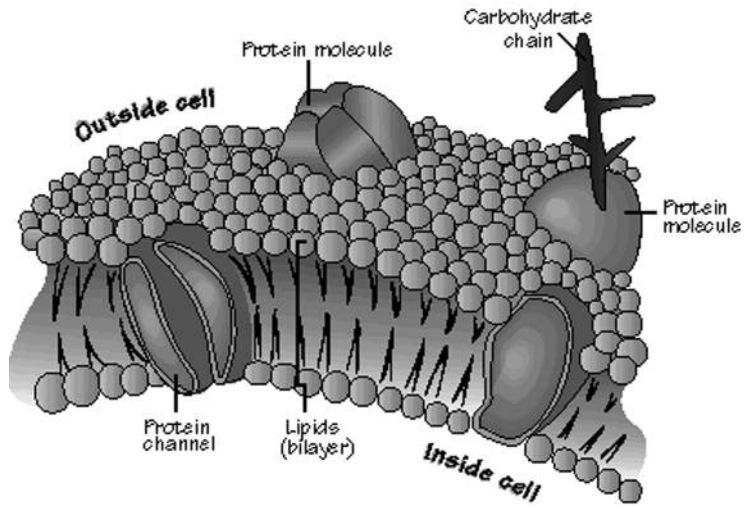
General Structure of the Cell Membrane

The fluid-mosaic model shows that the cell membrane is in fact made of two layers of fatty substances, called phospholipids, sandwiched together. Since there are two layers of phospholipids this is commonly called the **phospholipid bilayer**. If you look closely, you will notice that the bilayer is made up of individual phospholipids. A phospholipid consists of a circular phosphate group, called the head, and two long chains of fatty-acids called the tail. The circular head is a polar molecule and is hydrophilic, meaning it is soluble in water. The tail regions are non-polar and **hydrophobic**, meaning they repel water. Since the head portion of the phospholipid points outward, the inner and outer layers of the cell membrane are soluble in water.

However, the hydrophobic tails point inward and therefore ensure a barrier both inside and outside the cell that repels water.

Embedded into this sandwich are large molecules of protein and cholesterol. Some of the protein molecules extend completely through the membrane. Others are located in either the outer surface or the inner layer of the membrane, as you can see in the diagram below.

The Structure of the Cell Membrane



The Structure of the Cell Membrane: Reproduced, with permission from Thinkquest, from http://library.thinkquest.org/C004535/cell_membranes.html.

The function of the embedded cholesterol molecules is to prevent the phospholipid molecules from sticking together. Therefore, cholesterol helps maintain the fluid condition of the membrane so that molecules can easily pass through it. Small molecules such as oxygen, carbon dioxide, and water are able to pass freely across the cell membrane by **diffusion** but the movement of larger molecules such as amino acids and sugars are carefully regulated. That regulation is accomplished directly by the protein molecules that are embedded in the phospholipid bilayer.

Proteins in the Cell Membrane

Various types of membrane proteins exist and each type carries out a specific cellular function.

- **Channel** proteins span the entire width of the lipid bilayer and protrude on both the inner and outer sides of the membrane. Channel proteins, also called **integral proteins**, allow particular molecules to cross the membrane by providing a channel for them to pass through. Structurally, these proteins create a "hole" that is of a particular shape that will only allow certain molecules to pass through them.

- **Carrier** proteins selectively interact with specific molecules so that they can cross the membrane. Essentially, these proteins "pick up" the particular molecules on one side of the membrane and bring them to the other side of the membrane.
- **Receptor** proteins have shapes that allow only specific molecules to bind to them. The binding of the molecule usually results in a change in the shape of the receptor protein and a resulting change in the cell. This particular type of protein acts like a padlock and the molecule that "fits" into it is the key. When they are put together, the lock changes (opens). When this "key" molecule comes in contact with the portion on the exterior of the cell membrane containing the receptor protein, information about the environment is transferred into the cell, which triggers a response by the cell.
- Some of these plasma membrane proteins have carbohydrates attached to them and are called glycoproteins; these molecules act as "identification tags" that mark each different type of cell.

Passive Transport

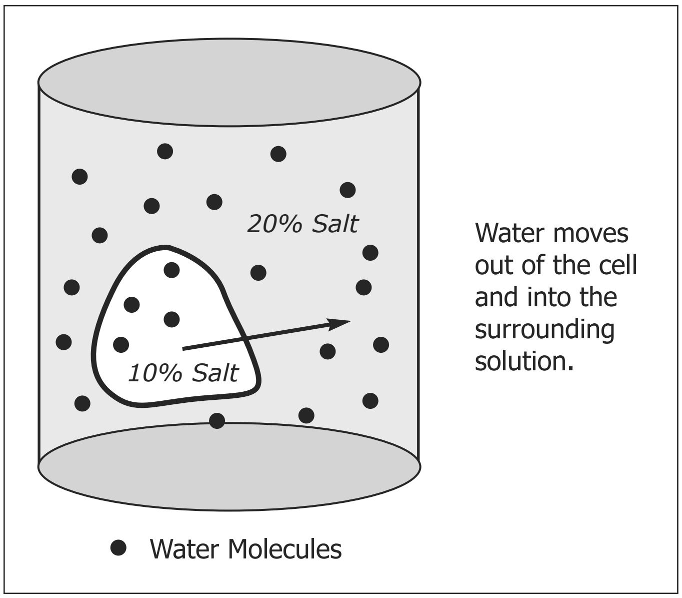
There are two general ways that materials can pass into or out of the cell through the cell membrane: **passive transport** and **active transport**. While active transport does require energy to transport molecules, passive transport does not.

Passive transport is also called **diffusion**. Diffusion involves the movement of molecules from a region in which they are highly concentrated to a region in which they are less concentrated. The molecules move across the membrane through pores, small holes in the cell membrane, rather than using carrier proteins. This process is sometimes said to involve moving along, or with, a **concentration gradient**. Small molecules such as oxygen (O_2), carbon dioxide (CO_2), and water (H_2O) move through the cell membrane by diffusion. If carbon dioxide builds up within the cell, for example, it will be more highly concentrated in the cell than it is outside of the cell and it will diffuse out of the cell into the environment. Diffusion continues until the molecules involved are evenly distributed throughout the system on both sides of the membrane. The system is then said to be in **equilibrium**.

A special type of diffusion is the diffusion of water, called **osmosis**. Osmosis is the diffusion of water through a selectively permeable membrane from an area of high concentration of water to an area of lower concentration of water. If water moves into the cell because of a high concentration of other molecules (which are not able to diffuse) within the cell, the cell swells. If water moves out of the cell because of a high concentration of other molecules (which are not able to diffuse) outside the cell, the cell shrinks. Cells cannot control diffusion since it is a passive process; they do, however, have special mechanisms for preventing too much water from entering or for pumping the water out.

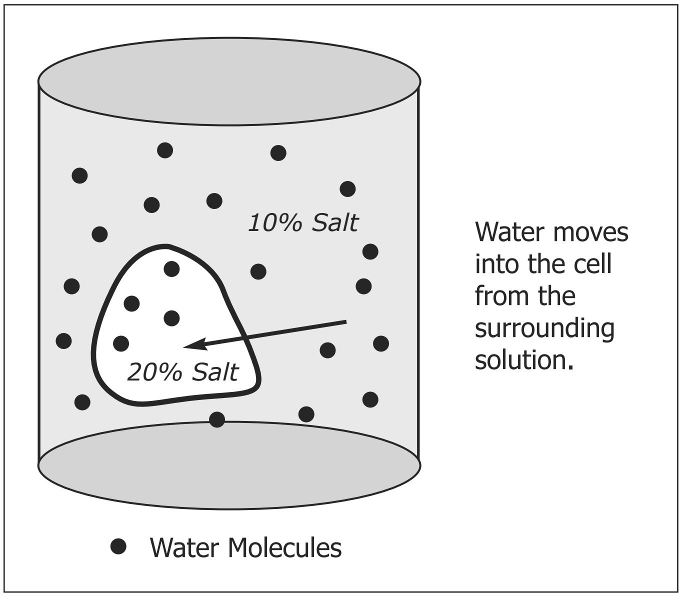
The osmotic conditions of the solutions surrounding the cell are referred to by special names. **Hypertonic** solutions are those in which there is a higher solute concentration outside the cell than inside the cell; there is "more water" inside than out. The water diffuses out of the cell in this case.

Solution is **Hypertonic**



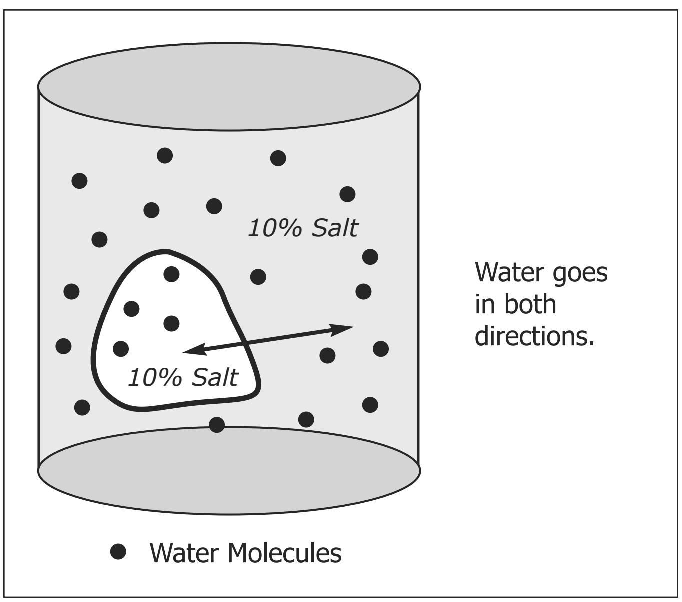
Hypotonic solutions are those in which there is a higher solute concentration inside the cell than outside the cell; there is "more water" outside than in. The water diffuses into the cell in this case.

Solution is **Hypotonic**



Isotonic solutions are those in which there are equal concentrations of substances inside and outside the cell. In this case, there will be equal amounts of water moving in and out of the cell.

Solution is **Isotonic**

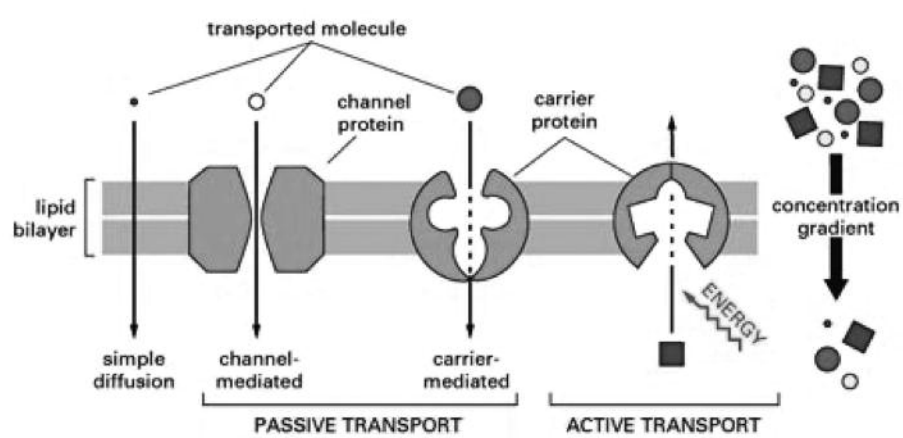


Active Transport

Other than passive transport (diffusion and osmosis), the cell can move materials across the cell membrane using **active transport**. This type of transport requires additional energy because it carries molecules **against** (not along) the concentration gradient. That is, it moves particles from areas of low concentration to areas of high concentration using transport proteins embedded in the cell membrane. In the diagram below you can see that the protein molecule binds with the molecule to be moved across the membrane. Chemical energy allows this protein molecule to change shape in such a way that the passenger molecule gets transported along to the other side of the membrane. The passenger molecule is then released either into or out of the cell.

Active transport permits cells to collect certain substances in concentrations hundreds of times higher than those outside the cell. For example, some amino acids used by the cell to make proteins are actively transported into the cell. Also, active transport allows cells to get rid of waste substances that would be harmful if they remained in the cell. Here is a diagram comparing methods of passive transport and active transport:

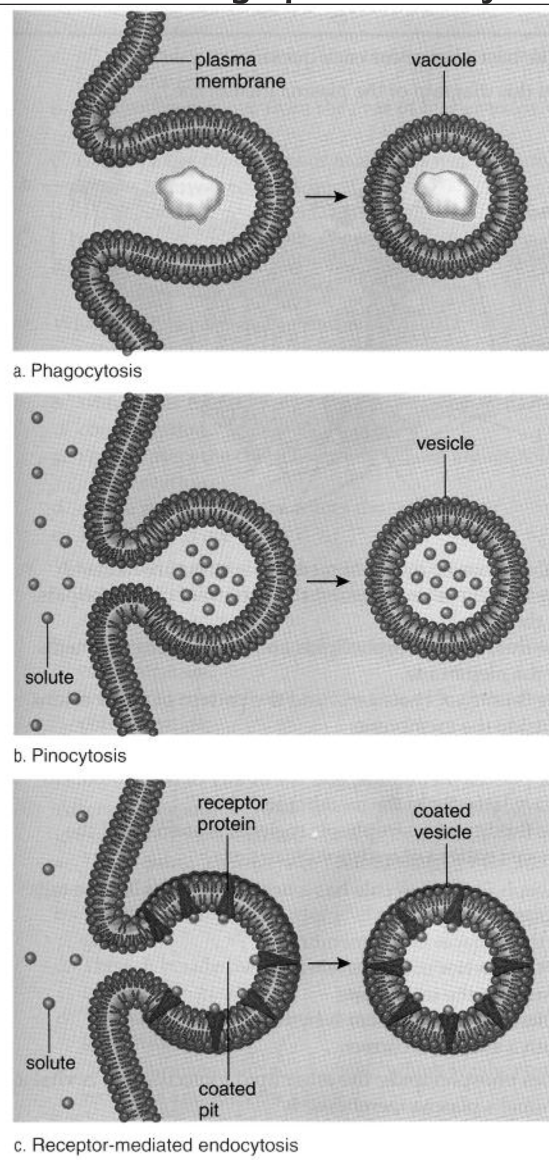
Active and Passive Transport



Active and Passive Transport: Reprinted from *Essential Cell Biology*, 2nd Ed. by Bruce Alberts, et al. London, UK: Garland Publishing, 2004. Fig. 12-4. Reprinted in accordance with *Access Copyright Elementary and Secondary School Tariff*.

Sometimes substances are too large to move across the cell membrane using protein carriers. In such cases, the cell uses a form of active transport called **endocytosis**. In the diagram below you will see the cell membrane forms a pocket or infolding which engulfs and transports the needed substance into the cell. More specifically, there are two types of endocytosis, known as **pinocytosis** and **phagocytosis**. The process of engulfing liquid food material and bringing it inside the cell is called pinocytosis. The membrane bounded vesicle (capsule) is called a pinocytotic vesicle. Pinocytotic vesicles are very small and can only be seen with an electron microscope. Look at the following picture.

Electron Micrograph of Endocytosis

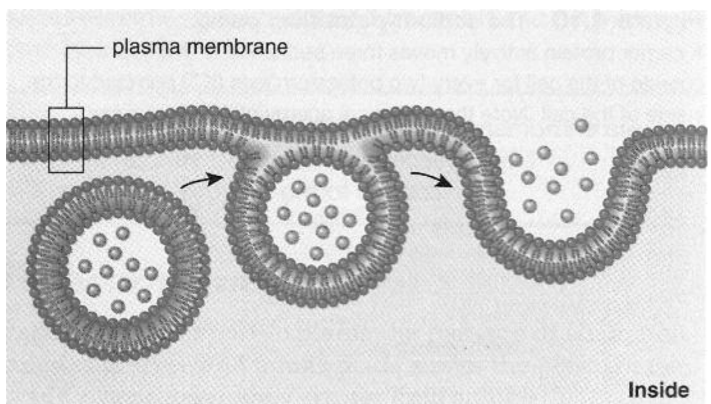


The Structure of the Cell Membrane: Reproduced, with permission from Thinkquest, from http://library.thinkquest.org/C004535/cell_membranes.html. All rights reserved.

Phagocytosis is like **pinocytosis** except that it involves larger vesicles and solid food being taken into the cell. A good example of phagocytosis is the action of white blood cells as they devour bacteria that invade the human body.

Exocytosis is the reverse of **endocytosis**. This form of active transport involves actively moving large particles out of the cell. Cells use exocytosis to expel wastes such as indigestible food materials and very large protein molecules like hormones which they produce. Look at the diagram below which illustrates exocytosis.

Exocytosis



Exocytosis: Reprinted from *Essential Cell Biology*, by Bruce Alberts, et al. London, UK: Garland Science 2004. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

Factors That Affect Movement Across the Cell Membrane

Several factors affect the movement of materials across the cell membrane:

1. The first factor is the **size of the molecule** to be transported. Small molecules can move through the cell membrane by diffusion. Larger molecules cannot move through by diffusion, even if there is a strong concentration gradient.
2. The **polarity** of the molecule determines how easily it can pass through the cell membrane. Recall that the inner and outer sides of the cell membrane are largely **hydrophilic**; that is, they attract water because water is a polar molecule. A polar molecule tends to have a positively charged "end" and a negatively charged "end." The middle layer of the membrane tends to be **hydrophobic**; that is, it tends to repel water and other polar molecules.

3. If a molecule is able to diffuse, the kinetic energy of the molecule affects how fast it will diffuse. The kinetic energy of a molecule is indicated by its **temperature**. Molecules in a system at a higher temperature will have more energy, and will move and diffuse faster.
4. The presence or absence of carrier proteins has a direct impact in the transport of large molecules that are unable to diffuse. If the correct carrier protein is not present, the substance may be unable to move across the membrane.
5. The relative **concentration** of a molecule on the inside of the cell compared to the outside of the cell is very important in determining how or if a molecule will be transported across the cell membrane. Even when the cell uses active transport to move a molecule, the concentration of that molecule inside the cell compared to its concentration outside of the cell still affects its movement. The relative concentration of a given molecule also affects the functioning of the carrier proteins that are designed to accomplish active transport.

The transport of materials across the cell membrane allows the cell to maintain a constant internal environment. If the cell is a unicellular organism, its homeostasis is achieved. If the cell is part of a multicellular organism, the homeostasis of the organism depends on the homeostasis of its constituent cells.

None of the essential life processes that you have learned about in this lesson would be possible for the cell without energy. The energy sources that cells use and the chemical reactions involved in the use of that energy are the subjects that you will learn about in the next lesson.

Learning Activity 1.3

It is now time for you to complete **Learning Activity 1.3**. It will take you quite a while to complete because its purpose is to help you review the concepts that you have learned in this lesson, as well as previous lessons. Answer the questions to the best of your ability. Then check your answers in the answer key before proceeding to the next lesson.

Learning Activity 1.3

Cell Transport

1. Match the terms on the left with the statements on the right; each statement is used once and only once. Print the letter of the correct choice in the space provided.

_______ Diffusion	a. A lipid found in the cell membrane that helps maintain the fluidity of the membrane
_______ Osmosis	b. A solution with the same solute concentration as the cell
_______ Pinocytosis	c. The transport of materials against the concentration gradient
_______ Hypertonic	d. The passive transport of materials from an area of high concentration to an area of low concentration
_______ Phospholipid	e. Consists of a phosphate group and two long tails of fatty acids
_______ Hypotonic	f. A form of active transport used to transport large molecules
_______ Cholesterol	g. A solution with a lower solute concentration than the cell
_______ Endocytosis	h. The diffusion of water
_______ Active transport	i. A method of bringing dissolved nutrients into a cell
_______ Isotonic	j. A solution with a higher solute concentration than the cell

continued

Learning Activity 1.3 (continued)

2. Define each of the following terms:
   a. semi-permeable
   b. diffusion
   c. phospholipid bilayer
   d. concentration gradient
   e. equilibrium
3. What is the main difference between active transport and passive transport?
4. Describe the fluid mosaic model of the plasma membrane.
5. How are osmosis and diffusion related terms?
6. Name and distinguish between the two types of endocytosis.
7. Explain what happens to a cell when it is placed in each of the following solutions:
   a. isotonic
   b. hypertonic
   c. hypotonic
8. Name THREE of the six essential life processes that must be managed by living things and briefly explain each one.
9. Name three types of proteins found in the cell membrane and briefly explain how each one functions.

How did you do? Remember, if you could not answer the questions correctly, then you did not learn it. So, go back and learn it before going on to Lesson 4. If you don't learn it now, you won't understand the next lesson, and you'll have to learn it later anyway.

Notes

Lesson 4: Energy

Introduction

In the previous two lessons, you learned that life is the maintenance of homeostasis and that the cell actively remains alive by effectively controlling its internal environment. Homeostasis doesn't just happen; it must be actively maintained. All systems tend to move toward a state of "maximum disorganization" if left alone. In contrast, life is the active maintenance of organization.

This necessary maintenance of homeostasis requires the expenditure of **energy**. Energy allows the cell to do "work"; that is, energy allows the cell to accomplish the six essential life processes discussed in the last lesson. Cells need energy to obtain food, to process that food and carry on necessary chemical reactions, to eliminate wastes, to reproduce, to grow and repair, and to transport materials. Without energy, cells could not maintain homeostasis and would die. Through your study of this lesson, you will

- explain why living cells require energy
- identify the ways in which living cells are able to acquire energy
- discuss the role of ATP in the use of energy by living cells

Energy and Life

So how does a living cell acquire energy?

As you may have learned already, the ultimate source of all energy on Earth is the Sun. Sunlight radiates onto the surface of the Earth and warms it. But some organisms have the ability to go beyond being warmed by the Sun; they have the ability to **capture** the energy of the Sun in the form of chemical bond energy. These organisms are **autotrophs**; they use the Sun's energy to convert carbon dioxide and water into food in the form of carbohydrates. This process is called **photosynthesis**; literally, this means "building with light energy". It is the pigment **chlorophyll** (and a large group of related chemicals) that allows plants to convert radiant energy from the Sun into chemical bond energy in the molecules that they produce. It takes energy to build a chemical bond; when a chemical bond is broken, energy is released.

Other organisms cannot capture the energy from the Sun and must acquire chemical bond energy in another way. **Heterotrophs** are organisms that must take in food that is already made. Their food comes directly from plants or from other animals that have eaten plants. When heterotrophs eat food, they break down those food molecules by breaking the bonds within them. When these bonds are broken, energy is released. That energy is then used by the heterotroph to carry on its own essential life functions. The process of releasing energy from food molecules using oxygen is called **cellular respiration**. All animals, fungi, protists, and many bacteria are heterotrophs. It is interesting that some plants such as the Venus flytrap and the pitcher plant are heterotrophs as well because they capture and digest insects.

It is important to note that plants also use cellular respiration to break down the food molecules that they produce in order to release energy. Autotrophs build food molecules and then break them down for energy. Heterotrophs eat food molecules and then break them down for energy.

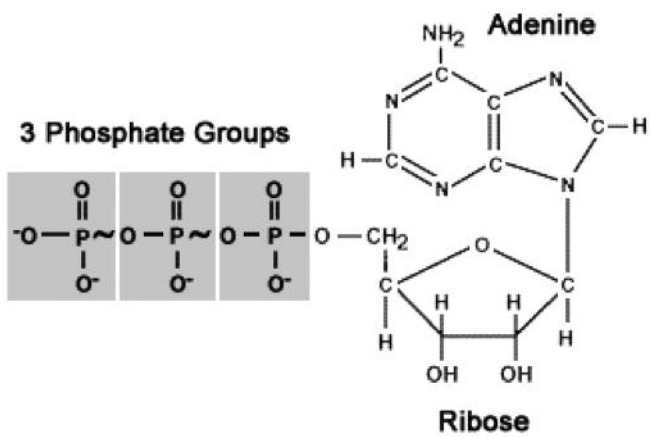
What is ATP?

Metabolism is the sum of the chemical reactions that take place in a living organism. These reactions are responsible for managing the material and energy resources of the cell. Some metabolic reactions release energy by breaking down molecules, while other metabolic reactions require energy to build complex molecules from simpler ones. So when food molecules, whether they have been produced or have been eaten, are broken down for energy, what happens to that energy? It is necessary for the essential life processes which require energy to happen. But is the energy used right away? The answer is “no”, it is not used right away. The energy released when the bonds in food molecules are broken is stored by the cell in a portable form. The storage molecule can be produced when the food molecules are broken down and their bonds broken. That storage molecule can then be moved around in the cell and used wherever it is needed. That storage molecule is called **ATP** or adenosine triphosphate.

There is a useful analogy to help you to understand this idea of energy storage. ATP is sometimes called the “energy currency” of the cell. Currency is money. When you work at a job, you are paid wages. You are given money so that you can go to other places and spend it. If you were just given some sort of credit from your employer, you would have to buy everything that you buy from that employer. Instead, the money allows you to go elsewhere to use your money or to save it if you wish to do so. Similarly, the cell uses the chemical bond energy in food molecules to make ATP molecules. Those ATP molecules can then either be “saved” or “spent” by the cell on activities that it needs to complete to stay alive. The cell’s “work” is breaking the chemical bonds in its food molecules. The cell’s “wages” are the molecules of ATP that result; the cell is free to use those ATP molecules for energy whenever and wherever that energy is needed.

ATP is a special carrier of energy. Its chemical structure is shown here:

Adenosine Triphophate (ATP)



The Structure of the Cell Membrane: Reproduced, with permission from Thinkquest, from http://library.thinkquest.org/C004535/cell_membranes.html. All rights reserved.

The bonds that exist between the three phosphate groups are highly energetic. This means that when they are broken, large amounts of energy are released. Energy stored becomes available to do work as the complex molecule is broken down into simpler components. This process of breaking chemical bonds in order to release energy is a **catabolic** process or reaction. So, first the cell builds the bonds in the ATP molecule (the two phosphate bonds that look like this: ~); the resulting ATP molecule is then available to be broken down whenever and wherever the cell needs energy to accomplish essential life processes.

Actually, ATP is built when the cell adds two phosphate groups to **AMP** (adenosine monophosphate). When one phosphate group is added to AMP, **ADP** (adenosine **di**phosphate) results; when another phosphate group is added to ADP, ATP results. The process of adding phosphate groups involves building high energy chemical bonds. This is an **anabolic** process, since the reaction involves consuming energy to build a more complicated molecule from simpler ones. The energy to do that comes from the breaking of the chemical bonds in food molecules. Sometimes, ATP is thought of as a "rechargeable battery"; when it is fully recharged, the ATP can be used for energy. When it is fully drained, it is in a modified form and must be recharged with two high energy bonds before it is useful again to the cell.

Learning Activity 1.4

It is now time for you to complete **Learning Activity 1.4**. Remember to check your answers in the Learning Activity Answer Key after you have completed the activity and before going on to Assignment 1.3, the final assignment in this module.

Learning Activity 1.4

ATP

1. Define the following terms:
   a. metabolism
   b. catabolic reaction
   c. anabolic reaction
2. Classify each of the following reactions as either *producing ATP* or *consuming ATP*:
   a. Sugar molecules are broken down.
   b. Protein molecules are produced by combining smaller amino acid molecules.
   c. The chemical bonds in a fat molecule are broken.
3. Which reactions produce ATP molecules, catabolic reactions, or anabolic reactions?
4. Find the missing term in each statement.
   a. The storage molecule is called ATP or ____________________________ ______________________________.
   b. ____________________________ eat food molecules and then break them down for energy.
   c. ____________________________ build food molecules and then break them down for energy.
   d. The necessary maintenance of homeostasis requires the expenditure of _________________.
   e. The process that converts the Sun's energy, carbon dioxide, and water into food in the form of carbohydrates is called ______________________________.

How did you do? If you knew the answers without looking, then you are ready to continue. If you didn't know the answers, then you need to go back and learn them.

Assignment 1.3

It is now time for you to complete **Assignment 1.3**, the final lesson in this module. It will help you review some of the important points in this lesson, as well as previous lessons.

Remember to look at the raw score next to each question before answering it. Make sure that you write at least that number of points in your answer. For example, question #1 is worth 4 marks. If you write at least 4 clear, distinct, correct points, your tutor/marker will be able to give you 1 mark for each.

Ask your learning partner to help you.

Assignment 1.3

Wellness and Homeostasis *(16 marks)*

1. Why do living things require energy and how do they acquire it? *(4 marks)*

2. What is ATP and how is it used by the cell to accomplish life processes? *(4 marks)*

continued

Assignment 1.3 (continued)

3. Plants are able to manufacture their own food. Why then do they also carry on cellular respiration? *(2 marks)*

4. How does the structure of the cell membrane allow active transport to occur? Use the following terms in your answer: semi-permeable, carrier proteins, concentration gradient. *(3 marks)*

continued

Assignment 1.3 (continued)

5. Explain how negative feedback functions to achieve homeostasis, using an example such as thermoregulation or osmoregulation to illustrate the process. *(3 marks)*

Notes

MODULE 1 SUMMARY

Congratulations! You have completed Module 1 of the Grade 11 Biology course.

Submitting Your Assignments

It is now time for you to submit the Module 1 assignments to the Distance Learning Unit so that you can receive some feedback on how you are doing in this course. Remember that you must submit all the assignments in this course before you can receive your credit.

Make sure you have completed all parts of your Module 1 assignments and organize your material in the following order:

- Module 1 Cover Sheet (found at the end of the course Introduction)
- Assignment 1.1: Personal Wellness Goal
- Assignment 1.2: A Walk in the Cold
- Assignment 1.3: Wellness and Homeostasis

For instructions on submitting your assignments, refer to How to Submit Assignments in the course Introduction.

Notes

Grade 11 Biology (30S)

Module 1

Learning Activity Answer Key

Module 1
Learning Activity Answer Key

Learning Activity 1.1: Wellness and Family Health History

Please note that, because of the nature of the questions, there is no answer key for this learning activity.

Learning Activity 1.2: Introduction to Homeostasis

1. Match the terms on the left with the statements on the right; each statement is used once and only once. Print the letter of the correct choice in the space provided.

e Osmoregulation	a. The maintenance of a relatively stable internal environment.
a Homeostasis	b. A living thing.
d Thermoregulation	c. The process that maintains homeostasis.
c Negative feedback	d. The control of body temperature within specific limits.
b Organism	e. The maintenance of water balance in the body.

2. Name the five factors of wellness and briefly explain each one.
   - **Physical Wellness: Caring for your body in terms of sleep, exercise, proper nutrition and hydration, exposure to various drugs and medications, and regular medical check-ups.**
   - **Emotional Wellness: The existence of healthy emotions as we experience the events in our lives and the relationships that we have with other people.**
   - **Spiritual Wellness: The human need to understand the deeper meanings of life, the forces that control our present and shape our future.**
   - **Intellectual Wellness: Being willing and able to learn new things while stimulating and challenging your mind.**
   - **Social Wellness: The degree to which a person interacts successfully with others.**

3. Name the six characteristics that identify living things and briefly explain each one.
   - **Living things show various levels of organization. The cell is the smallest unit of life. Organisms can be unicellular, colonial, or multicellular.**
   - **Living things must get energy and materials from the environment and use them in a series of reactions called matabolism. Some organisms are producers; others are consumers.**
   - **Living things must exhibit control to maintain a fairly constant internal environment. This is homeostasis.**
   - **Living things must reproduce. Organisms may reproduce sexually or asexually.**
   - **Living things grow and develop. Throughout its life span, an organism gets bigger and it continues to change in structure.**
   - **Living things must respond to changes in their environments. Various stimuli in the environment cause organisms to respond.**

Learning Activity 1.3: Cell Transport

1. Match the terms on the left with the statements on the right; each statement is used once and only once. Print the letter of the correct choice in the space provided.

   d Diffusion
   h Osmosis
   i Pinocytosis
   j Hypertonic
   e Phospholipid
   g Hypotonic
   a Cholesterol
   f Endocytosis
   c Active transport
   b Isotonic

   a. A lipid found in the cell membrane that helps maintain the fluidity of the membrane
   b. A solution with the same solute concentration as the cell
   c. The transport of materials against the concentration gradient
   d. The passive transport of materials from an area of high concentration to an area of low concentration
   e. Consists of a phosphate group and two long tails of fatty acids
   f. A form of active transport used to transport large molecules
   g. A solution with a lower solute concentration than the cell
   h. The diffusion of water
   i. A method of bringing dissolved nutrients into a cell
   j. A solution with a higher solute concentration than the cell

2. Define each of the following terms:
   a. **Semi-permeable: This term describes the cell membrane. It is a boundary that allows some, but not all, materials to enter and leave the cell. The cell membrane can distinguish between materials that should move through it and materials that should not.**
   b. **Diffusion: The passive transport of a material from an area of high concentration to an area of low concentration. Diffusion acts along the concentration gradient.**
   c. **Phospholipid Bilayer: This is the structure of the cell membrane. It is made up of two layers of fatty substances called phospholipids sandwiched together. Embedded in this double layer are proteins and cholesterol molecules.**

d. **Concentration Gradient: This gradient is the difference between the concentration of a substance on one side of a membrane and the concentration of a substance on the other side of that membrane. Movement of materials from areas of high concentration to areas of low concentration is said to be along the concentration gradient.**

e. **Equilibrium: This term can have many meanings. With respect to diffusion of materials into and out of the cell, it refers to the point at which those materials have equal concentrations inside and outside of the cell. Diffusion occurs until equilibrium is reached.**

3. What is the main difference between active transport and passive transport?

   Passive transport does not require energy to move molecules while active transport does.

4. Describe the fluid mosaic model of the plasma membrane.

   The fluid mosaic model of the cell membrane explains that the membrane is made of a double layer of phospholipid molecules sandwiched together. Embedded in this phospholipid bilayer are protein molecules and cholesterol.

5. How are osmosis and diffusion related terms?

   Diffusion involves the passive transport of any material from an area of high concentration to an area of low concentration. Osmosis is the diffusion of water in particular.

6. Name and distinguish between the two types of endocytosis.

   Pinocytosis is the process of engulfing liquid food particles and bringing them into the cell. Pinocytotic vesicles are very small. Phagocytosis is the process of engulfing larger food particles and bringing them into the cell.

7. Explain what happens to a cell when it is placed in each of the following solutions:

   a. **Isotonic: The cell remains at equilibrium with its environment. The movement of particles into the cell is the same as the movement of those particles out of the cell so no net change occurs within the cell.**

   b. **Hypertonic: When a cell is placed in a hypertonic solution, it will lose water to the environment. There is more solute dissolved in the environment than is dissolved in the cell itself, so the cell loses water.**

   c. **Hypotonic: When a cell is placed in a hypotonic solution, it will gain water from the environment. There is more solute dissolved in the cell than is dissolved in the environment so the cell swells.**

8. Name THREE of the six essential life processes that must be managed by living things and briefly explain each one.
   - **Obtaining food: Organisms may produce their own food or consume other organisms in order to get energy from breaking the food down into smaller substances.**
   - **Converting energy: Chemical bond energy stored in food is converted into energy that the organism can use to carry out the essential processes of life and to maintain homeostasis.**
   - **Eliminating wastes: Cellular processes produce waste substances that the organism must get rid of.**
   - **Reproducing: Living things must produce offspring by either sexual or asexual processes.**
   - **Growing and repairing: Living organisms must continually grow, develop, and repair body tissues as they age or are injured.**
   - **Transporting substances: Substances must be transported either between cells or between cells and their environment in order for homeostasis to be maintained.**
9. Name three types of proteins found in the cell membrane and briefly explain how each one functions.
   - **Channel proteins: Allow particular molecules to cross the membrane by providing a channel for them to pass through; certain molecules can pass through the "holes" that they create in the membrane.**
   - **Carrier proteins: Selectively interact with specific molecules so that they can cross the membrane; they "pick up" particular molecules and move them across the membrane.**
   - **Receptor proteins: Structurally "fit" molecules in the external or internal environment of the cell; when the correct molecule is present, the receptor protein attaches to it and triggers a response by the cell.**

Learning Activity 1.4: ATP

1. Define the following terms:
   a. **Metabolism refers to all of the chemical reactions that are carried out by the cell.**
   b. **Catabolic reactions break large, complex molecules into smaller ones, usually releasing energy in the process.**
   c. **Anabolic reactions assemble large complex molecules from simpler ones, usually involving the input of energy.**

2. Classify each of the following reactions as either *producing ATP* or *consuming ATP*:
   a. **The breakdown of sugar molecules results in the production of ATP.**
   b. **The synthesis of proteins requires the consumption of ATP.**
   c. **When the chemical bonds are broken, energy is released and ATP is produced.**
3. Which reactions produce ATP molecules, catabolic reactions, or anabolic reactions?

   Catabolic reactions generally release energy from ATP.
4. Find the missing term in each statement:
   a. The storage molecule is called ATP or **adenosine triphosphate**.
   b. **Heterotrophs** eat food molecules and then break them down for energy.
   c. **Autotrophs** build food molecules and then break them down for energy.
   d. The necessary maintenance of homeostasis requires the expenditure of **energy**.
   e. The process that converts the Sun's energy, carbon dioxide, and water into food in the form of carbohydrates is called **photosynthesis**.

Grade 11 Biology (30S)

Module 2

Digestion and Nutrition

This module contains the following:

- Introduction
- Lesson 1: Introduction to Digestion
- Lesson 2: Chemical Digestion and Enzymes
- Lesson 3: The Liver
- Lesson 4: Digestion and Nutrition
- Lesson 5: Disorders of the Digestive System
- Lesson 6: Making Decisions about Nutrition
- Module 2 Summary

Module 2: Digestion and Nutrition

Introduction

Welcome to Module 2. In Module 1, you learned about wellness and homeostasis, and you read about the essential life processes that every organism must manage in order to survive.

In this module, you will learn about one of those life processes—the breakdown of food molecules to obtain energy and nutrients. This is called digestion.

Assignments in Module 2

When you complete Module 2, you will submit your Module 2 assignments to the Distance Learning Unit either by mail or electronically through the learning management system (LMS). The staff will forward your work to your tutor/marker.

Lesson	Assignment Number	Assignment Title
3	Assignment 2.1	Introduction to Digestion
4	Assignment 2.2	Nutritional Considerations
5	Assignment 2.3	Digestive Disorders and Diseases
6	Assignment 2.4	Decision Making

Notes

Lesson 1: Introduction to Digestion

Lesson Focus

In this lesson, you will

- ❑ use a diagram to locate the major structures in the human digestive system
- ❑ explain the function(s) of the major structures in the human digestive system
- ❑ define mechanical digestion and identify the sites along the human digestive tract where mechanical digestion occurs
- ❑ define chemical digestion and identify the sites along the human digestive tract where chemical digestion occurs
- ❑ understand the functions of the secretions produced by the human digestive tract

Introduction

This first lesson is an introduction to the topic of digestion, one of the essential life processes that every organism must manage in order to survive.

When food is digested chemically, energy is released. That energy, which is released when chemical bonds in food molecules are broken, is stored temporarily as **ATP**. **Cellular respiration** is the process in which food molecules are broken down for energy. Virtually every cell in the human body has to carry on cellular respiration in order to stay alive.

When you eat food, the food enters your digestive system. How do the cells in your brain, in your feet, or in your fingers get some of that food so that you can carry on cellular respiration? What brings food from your digestive system to every cell in the body?

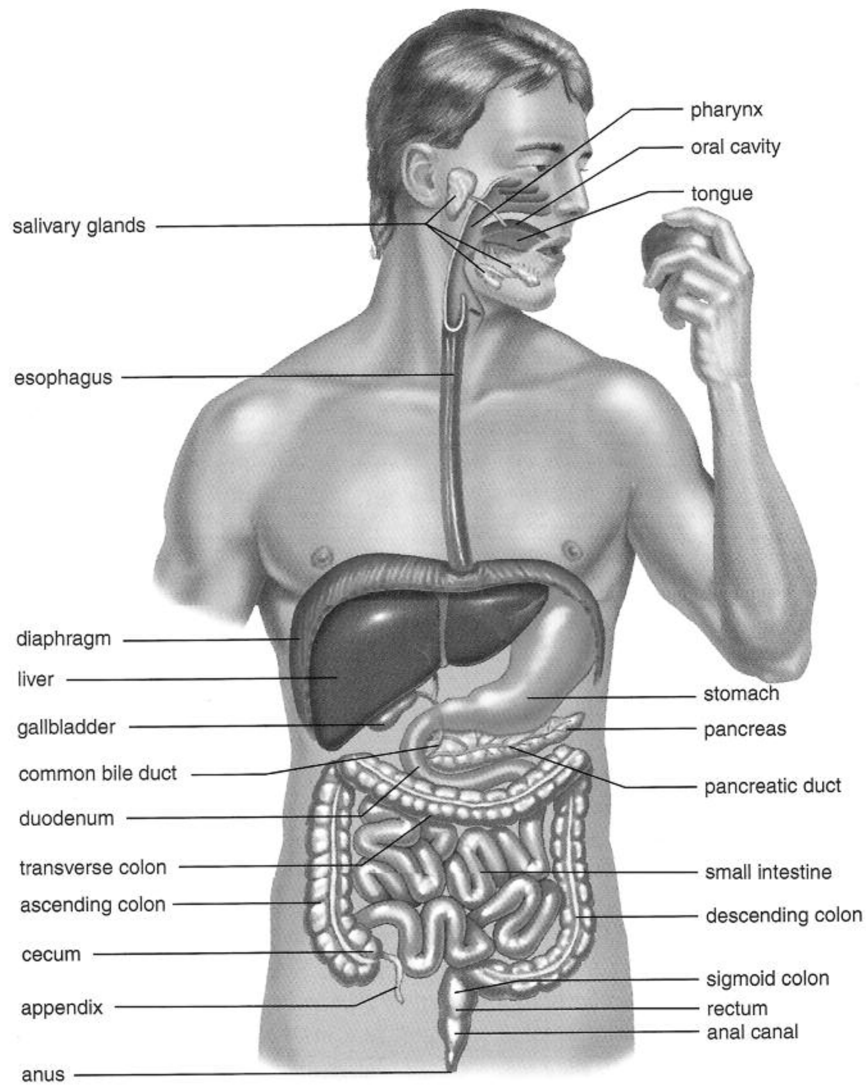
The means of transportation that your body uses to accomplish that goal is the circulatory system—the blood and lymph. Somehow, the food you eat has to be broken down into pieces small enough to be absorbed into the blood. That is the job of the human **digestive system**, the subject of this unit.

Digestion is the mechanical and chemical breakdown of food materials into pieces small enough for the body to use. The human digestive system “delivers” digested food materials to the circulatory system for distribution.

Structures in the Human Digestive System

The structures in the human body that are specialized to accomplish digestion of food materials are located along the pathway that food takes as it moves through the body. That pathway is called the digestive tract or the alimentary canal.

The Digestive System



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Tariff.

Food enters the alimentary canal through the **mouth** opening; the chamber that it enters is called the **oral cavity**. The **tongue** helps to move the food around in the oral cavity, pushing the food between the **teeth,** which chew the food. The tearing and biting of food breaks it into smaller bits before it is swallowed. This is a very important step in human digestion, known as **mechanical** digestion. The food is also lubricated in the mouth by the **saliva**, which is produced by three sets of **salivary glands**. These glands send their secretion, saliva, through small ducts into the oral cavity. Not only does saliva lubricate the food, it also begins to chemically digest carbohydrates in the food you have eaten. You will learn more about chemical digestion shortly.

The Pharynx

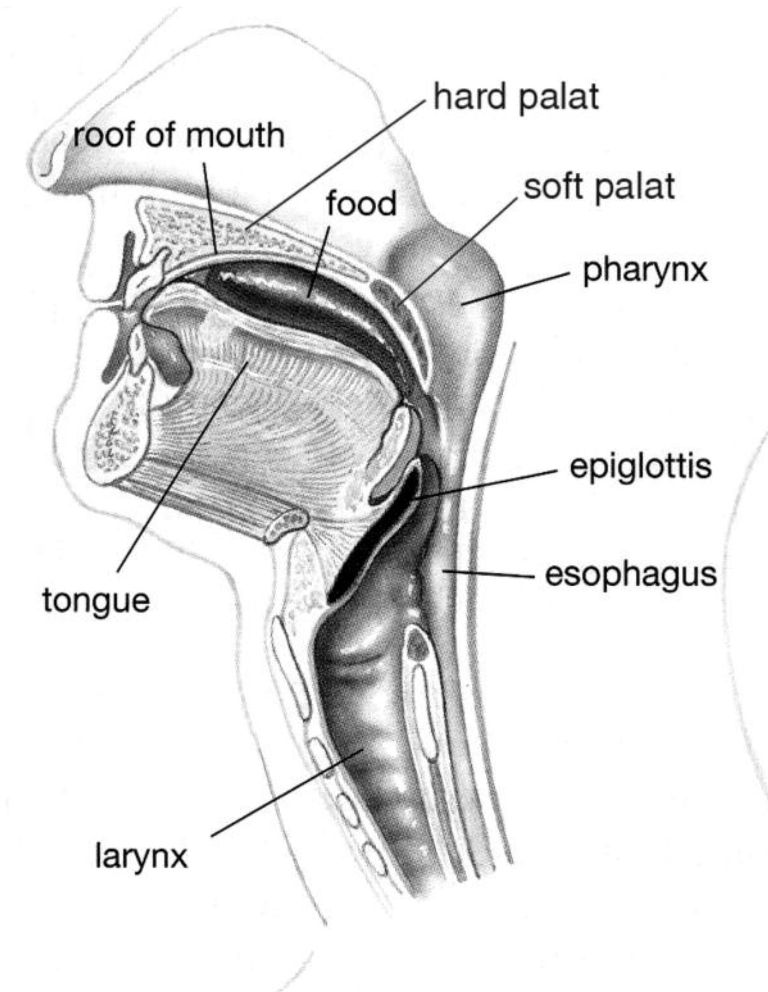
Once the food has been broken down mechanically and moistened by saliva, it is shaped into a food ball called a **bolus**. Now the bolus enters the next part of the digestive system, called the **pharynx**, located at the back of the mouth. The pharynx opens to two tubes that descend down into the neck. The **trachea**, or windpipe, connects the pharynx to the lungs and is found in front of the **esophagus**. Meanwhile, the esophagus, which is the digestive tube, connects the pharynx to the stomach. There are also openings in the back of the mouth to the ears, the Eustachian tubes, and to the nose.

You may have noticed a small mass of tissue that hangs down in the back of the mouth, called the **uvula**. The uvula is important in the creation of the sounds of the human voice. Also, when food is swallowed into the esophagus, the uvula moves up to close off the openings to the nasal cavity. In the pharynx, the roof of the mouth is soft; this soft tissue, called the **soft palate**, also functions in closing off the openings to the ears and nose as food is swallowed.

If the pharynx opens to both the trachea and the esophagus, how is it that you do not end up swallowing food into your lungs? When food is swallowed it is prevented from entering the trachea by a thin, flaplike piece of cartilage that closes over the tracheal opening. This is called the **epiglottis**. “Epi” means “above” and “glottis” refers to the opening to the esophagus. So the epiglottis lies above the esophagus and diverts food into that tube. The epiglottis is actually part of the **larynx** or voicebox.

The Esophagus

Food that has been chewed and lubricated is ready to be swallowed. The bolus is swallowed and enters the **esophagus** or food tube. Feel the front of your neck and find the ridged tube that vibrates when you speak; that tube is your trachea. Your esophagus is a collapsible tube that lies behind your trachea; it runs down the centre of your neck.



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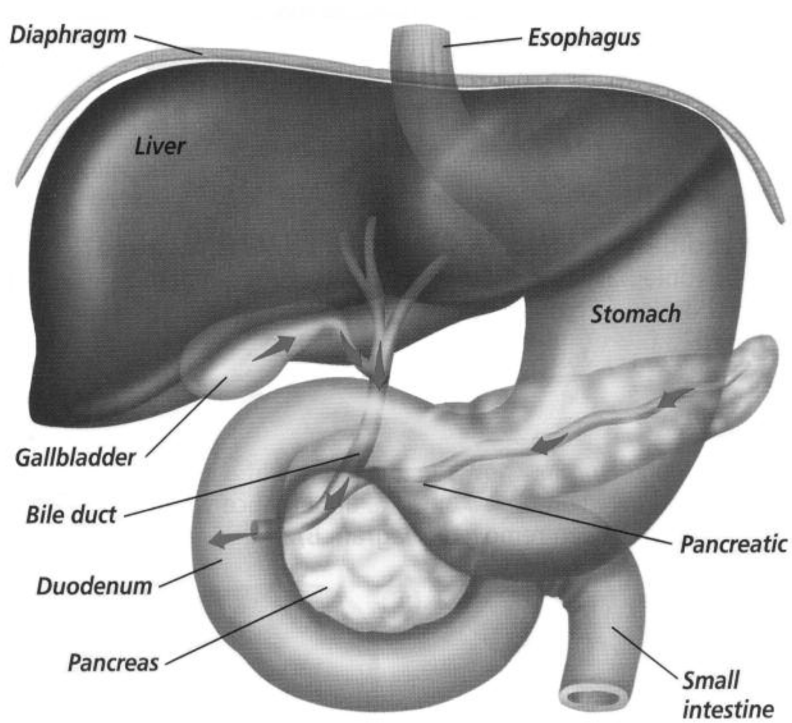
Food moves down your esophagus, pushed through by the rings of smooth muscle found in the walls of the esophagus. These muscles contract and relax in waves as they push the food along. This rhythmic contraction is called **peristalsis** and it continues through the entire length of the digestive tract.

The Stomach

The esophagus ends at the point where it joins the **stomach**. **Cardiac sphincter muscles** can close off the opening to the stomach and serve to control the movement of swallowed material into the stomach. The same sphincter muscles also keep partially digested food and stomach acid from working their way back up the esophagus, an event called acid reflux.



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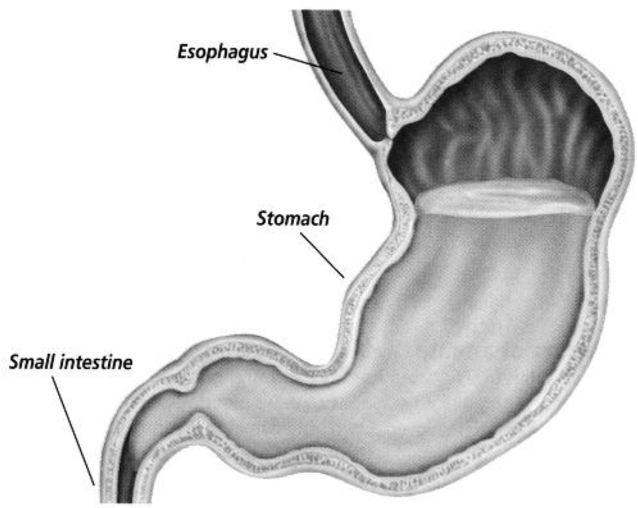
In the stomach, the bolus is churned and mixed with stomach secretions, the gastric juice. The stomach can actually secrete 2 to 3 litres of gastric fluid per day. These secretions and the stomach's mechanical churning of the food act to further soften it and break it up into smaller pieces, taking on a soup-like consistency. Chyme is the term used for food after the stomach digests it. The stomach is a powerful organ of digestion. Three layers of muscle in the wall of the stomach contract and relax to mechanically break down the stomach's contents.

In humans, the stomach is a very acidic environment. Hydrochloric acid is an important gastric secretion. Stomach acid, also called gastric acid, kills most of the bacteria in or on food and it also stimulates hunger. When protein-rich foods are consumed, the acidic environment of the stomach begins to denature or break down that protein into smaller units called amino acids. An enzyme that is produced in the stomach, called pepsin, acts chemically on the protein to further digest it. You will learn more about the chemical digestion of proteins in the next lesson.

The stomach is not primarily an organ of absorption. In other words, most materials that enter the stomach are not absorbed into the circulatory system from the stomach. Materials that are partially absorbed into the bloodstream in the stomach include water, alcohol, and some medications. The stomach is primarily an organ of digestion. The inner lining of the stomach is protected from acidic secretions and enzymes by a layer of mucous that is produced by the stomach itself. This mucous helps to lubricate the food moving through the stomach and also protects the stomach wall.



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The Small Intestine

Next, chyme moves from the stomach into the first section of the small intestine. Between the stomach and the small intestine is another sphincter muscle—the **pyloric sphincter**. It controls the movement of the chyme into the small intestine. When the small intestine is not working on any food, the stomach pushes chyme into it by peristalsis. When the intestine is full and still digesting food, the stomach acts as an organ of storage and waits to move the chyme along. Food typically spends 2 to 4 hours in the stomach.

The **small intestine** lies between the stomach and the large intestine. A significant portion of the abdominal cavity is taken up by the small intestine, which is highly folded and twisted. In adult humans, the small intestine is 5 to 6 metres in length. The small intestine can be divided into three sections—the duodenum, the jejunum, and the ileum. The main processes of digestion and absorption are accomplished by the small intestine.

The digestion that occurs in the small intestine is primarily chemical, most of which occurs in the duodenum. The enzymes that act chemically on food to digest it come from both the small intestine itself and another organ called the **pancreas**. The **pancreatic duct** connects the pancreas with the small intestine and effectively carries enzymes needed for digestion. Peristalsis continues in the small intestine, churning and pushing the partially digested food through until it reaches the large intestine. Digestion of food that enters the small intestine is usually complete after 3 to 10 hours. In the small intestine, large lipid molecules are physically broken down or **emulsified** by **bile**. The result is droplets of lipids that are more easily digested.

Bile is a product of the **liver** and is stored temporarily in the **gall bladder**. The **bile duct** carries bile into the small intestine where it acts to emulsify fats, breaking them up into tiny droplets. Enzyme action is more effective on these smaller particles since their surface area is greater. Note that emulsification is a physical process, not a chemical one.

The absorption that occurs in the small intestine is facilitated by the many tiny, finger-like projections that line the walls of this amazing organ. These tiny projections are called **villi**. Villi greatly increase the surface area inside the small intestine. That inner surface is full of tiny blood vessels, capillaries, which receive the small food molecules that are the result of mechanical and chemical digestion. Capillaries uptake those food molecules and are transported to other structures in the body via the blood. The primary types of food molecules that are absorbed at this point are derived from the digestion of carbohydrates, proteins, and lipids.

The Large Intestine

Once the digestion of food in the small intestine is essentially finished, the remaining material passes into the **large intestine** or **colon**. The large intestine is not longer than the small intestine but it is larger in diameter. It extends from the end of the small intestine to the anus and is approximately 1.5 metres long. There are three portions of the large intestine—the ascending colon, the transverse colon, and the descending colon. These three sections create an upside-down U-shape and surround the small intestine. What is left of the food after digestion is moved through the large intestine with the help of peristalsis. In the large intestine, water and essential minerals are reabsorbed into the bloodstream. Also, some nutrients, including Vitamin K, folic acid, and Vitamin B12, are absorbed at this point. Fibre and other undigested products are then excreted as feces through the **anus** by peristalsis.

A small pouch called the **appendix** is located at the point where the small intestine meets the large intestine. This organ apparently serves no function in humans. However, it becomes a concern when it becomes infected. An infected appendix could rupture and release the infection into the body cavity; a ruptured appendix can be fatal.

The end of the large intestine is the **rectum**. It primarily acts to store the feces before it is excreted by muscular contractions. The anus is the opening of the rectum to the outside of the body.

In the next lesson, you will learn how enzymes act chemically on food molecules, breaking them down into smaller pieces for absorption. Chemical digestion occurs in the mouth, stomach, and small intestine. Remember that most absorption occurs in the small intestine.

At this time, take another look at the diagram of the digestive system on page 6 of this lesson. Review the structures in the human digestive system, concentrating on the pathway that food takes as it moves through the alimentary canal.

It is now time for you to complete **Learning Activity 2.1**. First, answer the following questions to the best of your ability, without looking at the answer key. Then check your answer in the answer key at the end of this module.

Remember, these questions are similar to the ones that will be on your midterm and final examinations. So, if you were able to answer them correctly, you are likely to do well on your examinations. If you did not answer them correctly, you need to go back to the lesson and learn them.

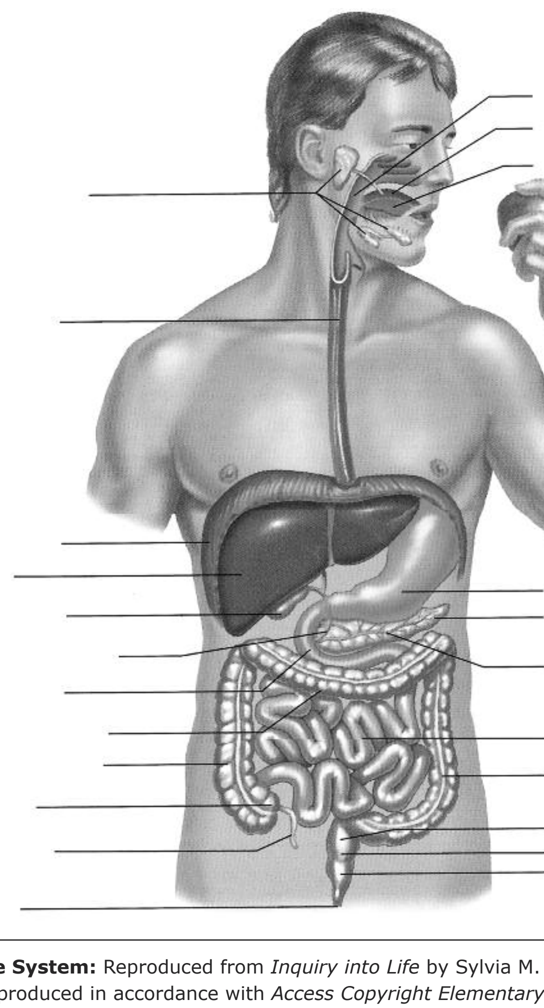
Learning Activity 2.1

Structures in the Human Digestive System

1. Put the structures that follow into the correct order in which food passes through them: small intestine, esophagus, anus, large intestine, pharynx, pyloric sphincter, rectum, cardiac sphincter, mouth, epiglottis, stomach.

2. Locate and label each of the structures named in Question #1 on the following diagram:

The Digestive System



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continued

Learning Activity 2.1 (continued)

3. Define peristalsis and explain how it functions in the digestive system.
4. What are the two types of digestion? Where, along the alimentary canal, does each type of digestion occur in humans?
5. Where are food materials absorbed into the circulatory system in the human body?
6. How does the structure of the small intestine allow it to be an effective organ of absorption in humans?
7. In your own words, explain how the pancreas is involved in the digestion of food in the alimentary canal? Which foods in particular?
8. What THREE important functions are carried out by the large intestine?

How did you do? If you answered most of the questions correctly, then you have learned the content of Lesson 1 and you should move on to Lesson 2.

Lesson Focus

In this lesson, you will

- ❑ name the locations along the alimentary canal where the digestion of each of the following types of nutrients occurs: proteins, carbohydrates, lipids
- ❑ briefly explain the chemical nature of each type of nutrient and the importance of each in human nutrition
- ❑ name the enzymes that are involved in the digestion of each type of nutrient in the human body
- ❑ define enzyme and discuss enzyme action in the process of digestion
- ❑ discuss the effect of the following factors on the action of enzymes during digestion: pH, surface area of the food, temperature, coenzymes, inhibitors
- ❑ explain the absorption of materials along the alimentary canal in the stomach, small intestine, and large intestine

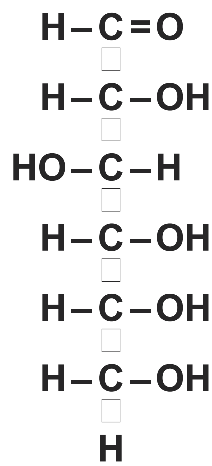
Introduction

In the last lesson, you learned about the structures in the human digestive system and the mechanical digestion of food. You learned that the human digestive system must effectively prepare food materials for their passage into the circulatory system. You learned that absorption of food materials begins in the stomach but occurs mainly in the small intestine. Mechanical digestion starts in the mouth and occurs throughout the digestive system because of the process of peristalsis. The materials that pass through the alimentary canal without being digested make up solid waste, also known as feces.

However, mechanical digestion is only part of the digestive process. **Chemical digestion** also occurs and aids in preparing food particles for absorption. Chemical digestion takes place through the action of **enzymes**. So, in this lesson, you will learn about chemical digestion and enzymes.

The types of nutrients that are digested through mechanical and chemical action are carbohydrates, proteins, and lipids. Before you learn about chemical action and enzymes, you will be introduced to these three types of nutrient molecules.

Carbohydrates: Carbohydrate molecules are made up of carbon, hydrogen, and oxygen. They are quick sources of energy and include both simple molecules like sugars and complex molecules like starches. Dietary fibre, cellulose, is also a carbohydrate. Common food sources of carbohydrates are breads, pasta, and fruit. This is what the molecular formula of glucose, a simple carbohydrate, looks like:



Proteins: Protein molecules are large complex molecules that contain carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulphur. They serve as the structural framework of most living tissue and also serve as enzymes, but are not usually used as an energy source. Enzymes are biological catalysts that speed up chemical reactions like digestion. Hemoglobin is a protein molecule in the blood that carries oxygen. Antibodies produced by the immune system are also typically proteins. Proteins are made up of smaller molecules called amino acids. Common food sources of proteins include meat, eggs, and nuts.

Lipids: Lipid molecules make up fats, oils, and waxes. They contain carbon, hydrogen, and oxygen. Lipid molecules are capable of storing great amounts of energy in their chemical bonds. Lipids are also important in the structural makeup of cell membranes. Lipids provide insulation for the body and cushion internal organs. They are also important in the transmission of nerve impulses. Common food sources of lipids include margarine, cooking oil, and animal fat found in meat.

Digestive Enzymes

Enzymes are named for the types of molecules that they act on in digestion. Enzymes are very specific; they only act on certain molecules. The molecule that an enzyme acts on is called a **substrate**. Each type of enzyme is very specific in terms of which substrate it will act on. The names for enzymes typically end in "-ase". The part of the name that precedes that ending refers to the type of substrate involved. For example, an enzyme that acts on a protein molecule is a **protease**. An enzyme that acts on a carbohydrate molecule is a **carbohydrase**. And an enzyme that acts on a lipid molecule is a **lipase**.

An analogy that is often used to understand enzyme action is the "lock and key" concept. The substrate is like the lock and the enzyme is like the key. The key will only work on a specific lock. Other locks are unaffected by it. The key must "fit" the lock just as the enzyme must structurally fit the substrate. Enzymes are typically very complex structurally and this complexity allows great specificity. Continuing with the analogy, when the key "works," it opens the lock. When the enzyme acts on the substrate, the substrate is chemically changed. The nutrient molecule is broken down into simpler units that can be more easily absorbed into the circulatory system. Like keys, enzymes are not themselves changed when they act on substrate molecules; enzyme molecules can be reused many times. More than 5,000 enzymes are known at the present time.

The following table contains a summary of the main digestive enzymes in the human body, their locations along the alimentary canal, and the substrates on which they act.

Location	Digestive Secretion	Type of Enzyme	Action
Mouth	Saliva	Amylase	Begins digestion of starch to maltose
Stomach	Gastric Juice	Protease	Begins digestion of proteins
Small Intestine	Pancreatic Juice	Amylase	Completes digestion of starch to maltose
		Protease	Continues digestion of proteins
		Lipase	Completes digestion of lipids to fatty acids and glycerol
	Intestinal Juice	Protease	Completes digestion of proteins to amino acids
		Carbohydrase	Completes digestion of carbohydrates to simple sugars

Table 2.1: Chemical Digestion in the Human Digestive Tract

You might have noticed that Table 2.1 does not include bile. Remember that bile emulsifies fat molecules but does not chemically break them down into glycerol and fatty acid molecules. Bile acts in the mechanical, not chemical, digestion of fats. Bile is produced by the liver and stored in the gall bladder; bile passes into the duodenum of the small intestine through the bile duct.

You should also note here that in addition to carbohydrates, proteins, and lipids, nucleic acids are also nutrient molecules that are broken down in the digestive system. When nucleic acids are broken down chemically, the results are nucleotides, which contain nitrogen, phosphorus, and sugars. Nucleases exist in pancreatic juice and in intestinal juice as well.

The particular carbohydrase that acts in the mouth and that acts in the small intestine because of pancreatic secretions is called **amylase**. Amylase is the carbohydrase that acts on starch. There are other carbohydrases as well, such as maltase, which acts on the disaccharide (double sugar) maltose.

Remember that pancreatic juice is made up of secretions produced by the pancreas; pancreatic juice passes into the duodenum of the small intestine through the pancreatic duct. The small intestine also possesses intestine glands that produce its own secretions—intestinal juice.

Once nutrient molecules are broken down chemically and mechanically, they are absorbed into the circulatory system, the blood, and lymph. Most absorption occurs in the small intestine. Remember that vitamins, minerals, and water are absorbed in the large intestine. The small intestine is well designed to function in absorption because of the millions of villi that line its inner surface. The folding of the intestinal surface allows the small intestine to absorb 600 times as many nutrients as it would if it were a straight smooth tube.

Factors that Affect Enzyme Action

A number of factors affect how well an enzyme is able to speed up the chemical reaction that it is designed to facilitate. Enzymes are biological catalysts, meaning they can speed up chemical reactions without themselves being altered in the process. When a key opens a lock, the key is not used up in any way; it can be used again. The same is true of enzymes.

Five of the factors that affect enzyme action are the following:

1. **pH:** The pH of a solution refers to how acidic or basic it is. You may have learned in a previous course that pH is measured on a numeric scale from 0-14. As a substance nears 0, it becomes more acidic. On the other hand, as a substance approaches 14, it becomes more basic. The pH depends directly on the chemical composition of the solution. Since enzymes are

typically proteins and since the integrity of protein molecules is very affected by pH, this property of the solution is critical.

An enzyme that is structurally changed as a result of pH is said to be denatured; a denatured enzyme almost always leads to a loss of enzymatic activity. You learned earlier that the pH in the stomach is highly acidic. The protease in the stomach, pepsin, is activated by this acidic environment. But when the chyme enters the small intestine, it is important that it be neutralized. Otherwise, the acidic chyme would harm the unprotected inner wall of the small intestine. Pancreatic juice actually neutralizes chyme as it enters the small intestine. The less acidic environment of the small intestine allows the enzymes produced by the small intestine and also those produced by the pancreas to be more effective in digestion. It is interesting as well that the pepsin from the stomach is only active in an acidic environment; therefore, it becomes deactivated when it enters the basic environment of the small intestine. Otherwise, the pepsin would start to digest the proteins in the cells that make up the inner lining of the small intestine.

2. **Surface Area:** When a food particle is mechanically broken down into a number of smaller particles, the total surface area exposed to the environment of the particles increases dramatically. The learning activity at the end of this lesson will prove that fact. When the total surface area exposed to the environment increases, enzymes are much more able to act on those food particles. This explains why it is important to chew food thoroughly before swallowing. Your digestive system can more effectively act chemically on food particles that are numerous and small than on a single larger particle. Continuing the analogy of the lock and key mechanism, when the exposed surface area increases, more identical “locks” on the substrate are available for the “key” to fit and have its effect.

3. **Coenzymes:** Many enzymes rely on the presence of small organic molecules that are not proteins for their effectiveness. Many of these molecules are made from various vitamins. These molecules are called coenzymes; when they act, they are located at the active site of the enzyme molecule and facilitate the “lock and key” action of the enzyme and substrate molecules. They are not themselves affected by the action of the enzyme on the substrate molecule.

4. **Inhibitors:** Molecules referred to as inhibitors possess shapes very similar to the shapes of the substrate molecules. Inhibitors actually compete with substrate molecules for the active sites of the enzymes. The inhibitor binds to the enzyme, rendering the enzyme ineffective on the substrate molecule that it was designed to act on. Many drugs and poisons act by inhibiting the action of enzymes. For example, aspirin inhibits the production of a molecule that causes inflammation; as a result, it suppresses pain and inflammation. The poison cyanide inhibits the action of an enzyme that is essential for cellular respiration.

5. **Temperature:** Most reactions in the human body that involve enzyme activity occur within a fairly small temperature range—usually from about 30°C to 40°C. Temperatures outside of this range can cause denaturation of the enzyme. The structure of the enzyme molecule can be changed as a result of temperature change. You are probably aware that high fevers can be very dangerous. When the body's temperature gets too high, a diversity of essential enzymes lose their ability to function.

You can see now how very important enzymes are in the human digestive system. Their production and accumulation in the body are carefully controlled so that homeostasis is maintained.

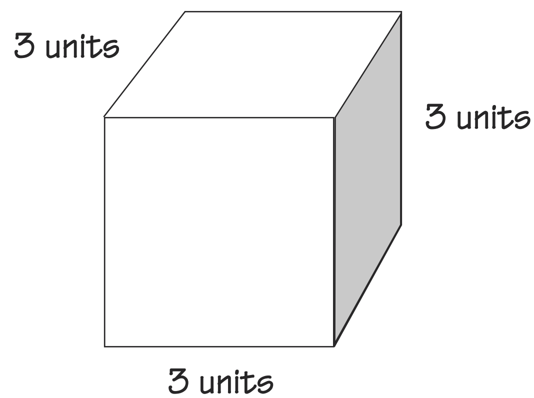
It is now time for you to complete **Learning Activity 2.2**. Remember to check your answers in the answer key before completing **Assignment 2.1**.

Learning Activity 2.2

Surface Area

The purpose of this activity is to prove that surface area dramatically increases when a particle is broken down into a number of smaller particles.

Imagine that a large particle of food is in the shape of a cube. A cube is not a very realistic shape for a food particle but it is easy to work with in terms of calculating surface area. We will say that the length of each side of the cube is 3 units.



1. Calculate the total surface area of the large food particle illustrated above. Remember that the area of each of the six faces of the cube is "length x width". After you calculate the area of each face, you will add up all six to get a total surface area.
2. Now imagine that the large cube above is divided into 27 smaller cubes, each 1 unit in each dimension. Now calculate the surface area of each of the small cubes and then multiply by 27 to get the total surface area of all of the small cubes added together.
3. The large single cube and the 27 smaller cubes have equal volumes. But the surface areas of the two differ significantly. Explain how the surface area changes when the particle is mechanically broken down into 27 smaller particles.

continued

Learning Activity 2.2 (continued)

4. Why is it important that the surface area of the food particles be increased for best enzyme activity?
5. Other than surface area, name and explain the other 4 factors that affect enzyme action in the human digestive system.
6. For each of the following types of food molecules, state the location(s) in which it is chemically digested in the human digestive system.
   - carbohydrates
   - proteins
   - lipids

Lesson 3: The Liver

Lesson Focus

In this lesson, you will

- ❑ discuss the use of hormones as regulatory substances in the human body
- ❑ explain the primary functions of the liver in the digestive process
- ❑ explain how the functions of the liver address the maintenance of homeostasis in the human body

Introduction

In the previous two lessons, you have studied the digestive process—the substances that are digested, where they are digested, and how they are digested. In this lesson, you will learn about how the human body controls digestion in order to maintain homeostasis. Specifically, the liver, the large blood-rich organ that lies beneath your diaphragm and next to your stomach, serves this homeostatic function.

You have already learned that the liver produces bile that is temporarily stored in the gall bladder. Bile acts to emulsify lipid molecules into their smaller components, a very important function in human digestion.

All of the blood in your body circulates through the liver. That blood carries the nutrient molecules that have entered it in the small intestine. When nutrient-rich blood enters the liver, it processes the nutrients, breaking them down into simpler substances and storing them. The liver also filters harmful substances out of the blood and converts them to less toxic molecules; an example of a toxin that is filtered out of the blood by the liver is alcohol.

In Lesson 1, you learned that all cells need energy; most cells acquire that energy by breaking the chemical bonds in nutrient molecules and temporarily storing that energy in the form of ATP. Many types of nutrient molecules are converted into glucose, a simple sugar. Body cells release the energy stored in glucose during cellular respiration. It is important that glucose be available to all cells all of the time. Without glucose, cells cannot acquire energy that they need to sustain life. So the glucose level in the blood must remain relatively stable.

Cells in the pancreas are sensitive to glucose levels. These cells are called **chemoreceptors** because their function is to monitor the level of a chemical, in this case glucose. When the glucose level in the blood rises, receptors in the pancreas stimulate the production of **insulin** by the pancreas itself. When insulin reaches the liver, it causes the liver to convert glucose to **glycogen** that is a storage carbohydrate. Blood glucose levels drop as a result. If blood glucose levels drop below a certain level, receptors in the pancreas stimulate the production of **glucagon** by the pancreas itself. When glucagon reaches the liver, it causes the liver to convert glycogen to glucose and the blood sugar level rises again.

In Module 1, you were introduced to the negative feedback system that safeguards homeostasis. The maintenance of adequate blood glucose levels is an example of this type of system. The key to understanding this process is noticing that when the level of glucose in the blood gets too high, the feedback system brings it down. Blood glucose levels continue to drop until they get too low. At that point the feedback system brings it back up. Body activity varies during the course of each day; as a result, the body's need for ATP also varies. It is important that excess glucose be stored so that it can be used when the body needs it.

Several systems of hormonal control exist in the human body to maintain homeostasis; they all work by using a negative feedback loop like the one that exists between the pancreas and liver. As you progress through this course, you will learn about many other systems of hormonal control. As you study each one, try to see how it works to raise levels of something that have gotten too low and also works to lower levels of something that have gotten too high. One simple example is what occurs when you are startled by a loud noise or a jolt of some kind. Almost immediately, your heart rate and breathing rate both increase. The pupils in your eyes get larger. You may feel a sudden flush in your face. Adrenaline also causes an increase in blood sugar levels. This "fight or flight" response is accomplished in part because of a hormone called **adrenaline**. It is released in times of stress by the adrenal glands that lie just above each kidney. When the threat of danger passes, the production of adrenaline decreases and body functions return to their normal levels.

Hormones control a wide variety of body functions. Heart rate, breathing rate, dilation of the pupils, and the level of glucose in the blood are only a few. Another example is water balance; hormones control how much water is filtered out of the blood when urine is produced.

It is now time for you to complete **Learning Activity 2.3**. Remember to check your answers in the answer key before you proceed to **Assignment 2.1**.

Learning Activity 2.3

The Liver

1. The purpose of this activity is to give you some practice predicting how the level of glucose changes in the blood as a result of physical activity. Fill in the blank sections of each diagram:

   a. Blood sugar becomes too high:

   Following a meal, blood sugar level RISES

   Cells in the ____________ detect HIGH level and produce INSULIN

   Cells in the ____________ detect insulin and convert glucose into ____________

   Blood sugar level ____________

   b. Blood sugar becomes too low:

   Following exercise, blood sugar level DROPS

   Cells in the ____________ detect LOW level and produce GLUCAGON

   Cells in the ____________ detect GLUCAGON and convert glycogen into ____________

   Blood sugar level ____________

continued

Learning Activity 2.3 (continued)

2. In your own words, explain the difference between each of the following pairs of terms:
   a. insulin and glucagon
   b. glucagon and glycogen
   c. glycogen and glucose

It is now time for you to complete **Assignment 2.1**. In it, you will have a chance to show what you have learned in Lessons 1 to 3.

Assignment 2.1

Introduction to Digestion *(38 marks)*

1. Name the particular structure or organ that accomplishes or is associated with each of the functions given below: *(10 marks—1 mark for each correct answer)*

   a. It is an organ that produces bile.

   b. It is the fluid that lubricates the mouth.

   c. It is the muscle that controls the movement of chyme out of the stomach.

   d. It is the cartilage that closes over the trachea during swallowing.

   e. They are tiny projections in the small intestine.

   f. It is where the majority of chemical digestion and absorption occurs.

   g. It is another name for the food ball formed in the mouth.

   h. It is the tube that carries food to the stomach.

   i. It is the structure that closes off the openings to the ears and nose as food is swallowed.

   j. They are the muscular contractions that occur along the digestive tract.

continued

Assignment 2.1 (continued)

2. In each of the following situations, decide if CHEMICAL or MECHANICAL digestion is taking place. *(4 marks)*
   a. Teeth tear food into smaller pieces.

   ____

   b. Gastric juices help break down proteins.

   ____

   c. Saliva starts to digest carbohydrates in the mouth.

   ____

   d. The stomach churns to mix food with stomach acid.

   ____

3. In your own words, explain how each of the following digestive secretions is involved in the process of digestion: *(6 marks—2 for each digestive secretion)*
   - Saliva:

   ____
   ____
   ____
   ____
   ____
   ____
   ____
   ____
   ____

continued

Assignment 2.1 (continued)

3. (continued)
   - Gastric Juice:
   - Bile:
4. In your own words, explain how enzymes act like a "lock and key" to accelerate the chemical digestion of food molecules. *(4 marks)*

continued

Assignment 2.1 (continued)

5. Name the five factors that directly affect enzyme action in the human digestive system. **For each**, explain how the human body monitors and adjusts it to maintain adequate enzyme activity for homeostasis. *(10 marks—2 for each factor that affects enzyme action)*

continued

Assignment 2.1 (continued)

5. (continued)

continued

Assignment 2.1 (continued)

6. In your own words, and with the use of an example, describe how negative feedback achieves the maintenance of adequate blood sugar levels in the human body. Be specific in terms of the structures involved and the action of hormones and enzymes in this process. *(4 marks)*

LESSON 4: DIGESTION AND NUTRITION

Lesson Focus

In this lesson, you will

- ❑ explain how the human body uses each of the six basic types of nutrients to carry out the basic life processes
- ❑ identify foods that contain the six basic types of nutrients
- ❑ compare the nutrient content of the food you eat during a typical day to suggested intakes outlined by the Canada Food Guide
- ❑ consider personal dietary decision-making based on recommendations made by the Canada Food Guide

Introduction

In the previous three lessons, you have learned about the human digestive system. You learned about the structures and organs of the digestive system, as well as their functions. The healthy functioning of the digestive system is necessary for the maintenance of homeostasis. You learned how the food that you eat is processed and absorbed. In the last lesson, you studied the involvement of the liver and the pancreas in the digestive process. Keep in mind that the negative feedback systems within the digestive pathway help to maintain homeostasis; this state of balance is constantly being adjusted and is dynamic in nature.

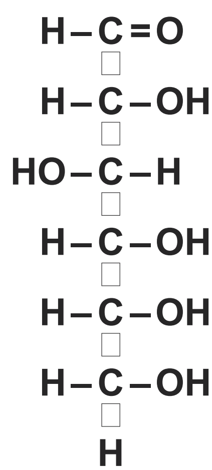
In this lesson, you will learn how each of the six basic types of nutrients (carbohydrates, lipids, proteins, vitamins, minerals, and water) is used by the human body.

Some of the uses that your body makes of nutrients are functional and others are structural in nature. As you consider each type of nutrient, you will also learn what types of foods effectively provide that nutrient to the human body. You were briefly introduced to each of the organic nutrients in Lesson 2 of this module. Each nutrient type will be considered here individually.

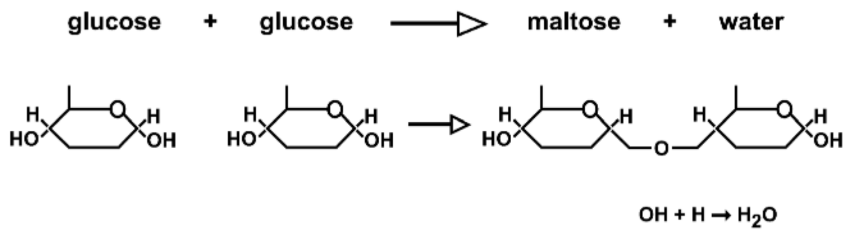
1. Carbohydrates

Carbohydrates are used by the cells of the body to produce energy. The human body cannot produce its own carbohydrates and must rely on eating other organisms to acquire them. Carbohydrates are the prime source of energy for humans, supplying 50 to 80 percent of the total energy requirement. They provide short-term energy to cells through the process of cellular respiration.

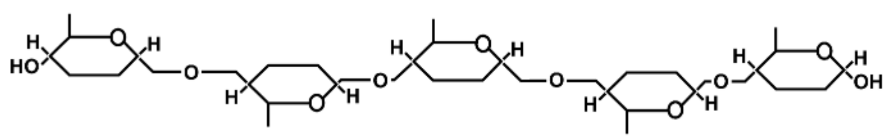
Carbohydrates are either single sugar units or polymers of many sugar units. The least complex carbohydrates are simple sugars, also called **monosaccharides**. The most common simple sugar is *glucose*, which is the main product of photosynthesis in plants. Glucose is the blood sugar that provides the energy for cellular respiration and the production of ATP. *Galactose* is another simple sugar and is found in milk and yogurt. A monosaccharide found in fruit and honey is *fructose*. All three monosaccharides have the molecular formula $C_6H_{12}O_6$, although each sugar has its own structural formula. Here is the molecular structure of a glucose molecule:



Disaccharides are double sugars; they are made by joining together simple sugars with chemical bonds. The molecular formula for a disaccharide is $C_{12}H_{22}O_{11}$. *Sucrose* is a common disaccharide; it is simple white table sugar. *Lactose* is the main disaccharide found in milk and dairy products. *Maltose* is a common product of starch digestion. This is the chemical reaction that combines two molecules of a monosaccharide to produce a disaccharide:



The third type of carbohydrate is the **polysaccharide**. Polysaccharides are complex sugars, made of many simple sugars joined by chemical bonds. Polysaccharides vary in length and in complexity. In plants, several hundred glucose molecules join together to form *starches*. Starch is the primary form of storage carbohydrate used by plants. For example, the glucose made by the leaves of a potato plant is transferred to the roots of the plant where it is converted into starch. The potatoes that we eat provide us with starch, an important energy source. *Cellulose* is another polysaccharide made from several glucose molecules. Cellulose is a very rigid substance that is found in the cell walls of plants, and generally cannot be digested by humans. Approximately 50% of all the organic carbon in the biosphere is tied up at any one time as cellulose in plants. Cellulose is what we are referring to when we talk about fibre in our diets; our digestive system requires adequate fiber to function correctly. Here is the molecular structure of cellulose:



In the last lesson, you learned about glycogen; it is the storage carbohydrate that is produced when blood sugar is higher than is required at the time. It is produced in the liver and stored until it is needed.

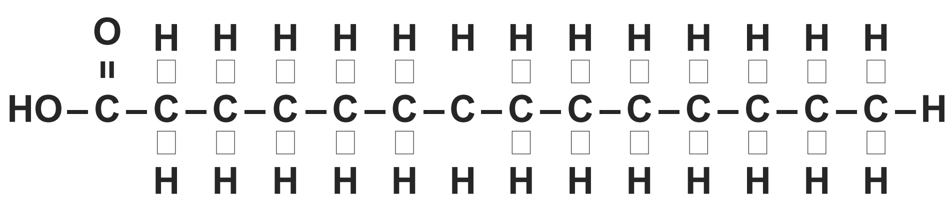
Foods containing simple carbohydrates are usually sweet-tasting like cookies, candy, pop, pastries, fruits, and juices. Although all of these types of food are good sources of carbohydrates, some of them do not also contain any vitamins or minerals. We talk about “empty carbs” when we refer to foods that provide us with energy but do not provide us with any beneficial vitamins or minerals as well. Starchy carbohydrates take longer to be digested than simple carbohydrates and therefore provide a more long-term source of energy for the body. Complex carbohydrates, or complex carbs, are found in breads, pasta, rice, and potatoes. Most vegetables like corn, tomatoes, carrots, and lettuce are also good sources of complex carbohydrates.

2. Lipids

Like carbohydrates, lipids supply energy to human body cells. Lipids are

- difficult to break down
- are only used for energy when the supply of carbohydrates in the bloodstream is low
- a stored source of excess energy for the body
- about twice as energetic as an equal mass of carbohydrate
- important in helping the body absorb vitamins effectively
- key structural components of cell membranes
- a form of insulation for the body and serve as protection for delicate vital organs
- the raw material from which hormones are produced
- an important component in the transmission of nerve impulses in the nervous system

Some lipids are liquids at room temperature; they are referred to as *oils*. These lipids are unsaturated fats and include olive oil, sunflower oil and corn oil. The chemical bonds in unsaturated fats differ from those in saturated fats. In general, *saturated fats* are more difficult for the body to break down than unsaturated fats. Saturated fats are normally solid at room temperature and look like this:



Unlike unsaturated fats, which usually come from plants, saturated fats usually come from animals. The fat found in beef, pork, chicken, and dairy products made from milk, such as butter, are examples of saturated fats.

Waxes are very large, stable molecules that are produced by both plants and animals. In plants, waxes are used to make leaf surfaces waterproof and hard. In animals, waxes are used to provide rigidity and protection in structures such as fur or feathers.

Phospholipids are lipids that are important components of cell membranes. Lecithin is an example of a phospholipid. Both animals and plants produce lecithin and it is found in foods such as egg yolks and soybeans.

Steroids are lipids that are naturally produced by the body; the most common steroid is cholesterol. It is found in all animal products and is a very important component of cell membranes. The body processes cholesterol in the diet in different ways, depending on what type of food contained the cholesterol that was ingested. Some cholesterol is in the form of "LDLs," which stands for low-density lipoproteins. These LDL particles can accumulate on artery walls and can restrict blood flow. Other cholesterol molecules are in the form of "HDLs" or high-density lipoproteins. These lipoproteins actually lower blood cholesterol by carrying LDLs back to the liver, which can break them down.

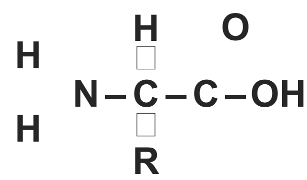
It is recommended that no more than 30% of your total energy intake should be in the form of lipids, since lipid molecules store about twice as much chemical energy as carbohydrate molecules. In addition, saturated fats in the diet have been linked to heart disease. Since saturated fats are more difficult to break down, they remain in the bloodstream longer and can start to accumulate on the inside of blood vessels, possibly causing circulatory problems.

3. Proteins

The primary structural component of all cells is protein. The protein that you eat is broken down by your digestive system into the amino acid molecules that make it up. Your body then rebuilds human protein—the structural scaffolding of all cells. Muscle, cartilage, ligaments, skin, and hair are all examples of tissues made up of protein molecules. Smaller protein molecules also play vital roles as hormones, antibodies, enzymes, and hemoglobin. Another vital role of proteins is connected to their importance as cell membrane components; recall that the cell membrane is made up of phospholipids and protein molecules. The protein molecules can act as carriers in active transport. They can also serve as "markers" that one cell uses to identify another cell. Other proteins in the cell membrane are important "receptors" that recognize certain molecules in the cell's environment.

Proteins vary tremendously in size and shape. This allows the incredible diversity of functions performed by proteins. Earlier in this unit, you learned about the "lock and key" mechanism illustrated by hormones and their target cells. The structural complexity of proteins allows the diversity of molecules that is required by this process.

When your body produces its own proteins using the amino acids that make up the proteins in your diet, it is important that exactly the right amino acids be available. Of the 20 amino acids, 9 of them cannot be made by the human body; these amino acids are referred to as the *essential amino acids* because they must be eaten. The remaining 11 amino acids can be synthesized by the human body. All 20 “building blocks” allow the synthesis of all of the many proteins that your body manufactures. All proteins are made of amino acids. Here is an example of an amino acid called glycine:



Foods that contain all of the essential amino acids are called *complete proteins*; these foods include beef, chicken, fish, eggs, milk, and many animal products. *Incomplete proteins* do not have all of the essential amino acids. They include many plant materials such as vegetables, fruits, grains, seeds, and nuts. It is recommended that you consume 0.8—1.5 grams of protein per kilogram of body weight. Two of the essential amino acids are found in very small quantities in most plant proteins; therefore, it is important that people who are on a vegetarian diet pay special attention to the foods that they eat to make sure that they acquire adequate amounts of all amino acids.

4. Vitamins

Vitamins are organic substances that are needed in very small amounts. They are part of the structure of many enzymes. If your diet is deficient in a certain vitamin, the result could be an enzyme deficiency that can in turn cause serious health problems. For example, vitamin D forms part of the enzyme that controls how much calcium is deposited in bone. A deficiency of vitamin D in the diet results in a disease called rickets. In children, rickets causes bone deformity and softness. In adults, rickets causes deterioration of bone tissue. Milk is commonly fortified with Vitamin D to ensure that most people consume an adequate supply of this vitamin. Another example of an enzyme deficiency caused by a vitamin deficiency is beriberi; this disease results from a deficiency of vitamin B1 or thiamin. Thiamin regulates the reactions in the body that remove carbon dioxide, a waste product of cellular respiration. Beriberi is a disease characterized by nerve problems and muscle weakness. Vitamins are chemicals that are necessary for normal growth and metabolism. Some vitamins are required for the chemical reactions that result in the release of energy from carbohydrates, fats, and proteins. In all, there are 13 vitamins; they may be divided into two groups: the 4 fat-soluble vitamins (A, D, E, and K) and the

There are many websites designed to provide you with useful information about nutrients, their major functions in the body, and a list of foods that contain them. If you do not have access to the Internet, use the Canada Food Guide resource that accompanied this course.

9 water-soluble vitamins (C and the B vitamins). These two groups differ in several ways. Fat-soluble vitamins are not as readily excreted from the body compared to water-soluble vitamins; as a result, water-soluble vitamins can become depleted more quickly, leading to a deficiency. Deficiencies of vitamins may result from inadequate dietary intake; they can also result from factors unrelated to diet. For instance, vitamin K and biotin (B_4) are both produced by bacteria that live in the large intestine; a person can become deficient if these bacteria are removed by antibiotics.

5. Minerals

Unlike vitamins, minerals are *inorganic*—that is, they are not based on a carbon chain. Most minerals are molecules of a single element. Minerals do not themselves provide energy for the body, but they do play very important roles in many cellular reactions. For example, minerals are vital in maintaining nervous system functions, water balance, and skeletal health.

There are about 16 essential minerals. *Sodium* is found in table salt and helps maintain proper blood pressure. *Potassium* is found in bananas and keeps nerves and muscles working properly. *Calcium* is found in dairy products and is needed to build strong bones. *Iron* is found in red meats and whole-grain vegetables; it is very important in the production of red blood cells.

6. Water

Water is the final type of nutrient that you will study in this lesson. It may seem surprising to you that water is considered a nutrient. In fact, it is included here because of the great number of life functions that would not occur in the absence of water. Water is an essential component of cytoplasm—the intracellular fluid that makes up all cells. Water is an important solvent because most chemical reactions in the body occur between molecules that are dissolved in it. Water is also an important lubricant and bathes body cells. Water is a primary component of blood and transports vital nutrients and unneeded wastes throughout the body. It also serves an important role in temperature regulation.

Water is acquired in many ways. Drinking water is the most obvious way that you obtain water. However, many foods have a high water content, such as fruit and vegetables. Also, many cellular processes involve the production of water. For these reasons, it is suggested that you drink about 8 cups of water or other non-caffeinated fluids per day to maintain adequate hydration.

Dietary Decisions

Labels on packaged foods are helpful in that they tell you what vitamins, minerals, and nutrients are contained in the foods that you buy. An informative label might look like this:

1. All the information in Nutrition Facts is based on a specific amount of food.
2. The facts table lists calories and some core nutrients.

Nutrition Facts	
Serving Size 1 cup (228 grams)	
Amount Per Serving	
Calories 260	
Calories from fat 120	
	% DV
Total fat 13 g	20%
Saturated fat 5 g	25%
Cholesterol 30 mg	10%
Total carbohydrate 31 g	10%
Dietary fibre 0 g	
Protein 5 g	

3. The % Daily Value (% DV) gives a context to the actual amount of a nutrient. It indicates at a glance how much of a nutrient is in the specific amount of food.
4. This number is the actual amount (quantity) of the nutrient in the specific amount of food. Even if the nutrient amount is zero, it is listed.

The "Nutrition Facts" table found on the label of packaged foods provides you with information about the caloric content and the nutritional value of a given food. The nutrition facts are given "per serving"; the serving size is defined on the label as well. The "% Daily Value" listed for each nutrient puts nutrients on a scale from 0% to 100%; this tells you if each nutrient is supplied to you in adequate quantities. Some of the nutrients listed should be eaten in limited quantities so a high percentage for a given nutrient may not be a good thing. For example, a high percentage of sodium or saturated fat would indicate that the food should not be consumed often, or in large quantities. The Canada Food Guide recommends that you get fewer calories from fats, especially saturated and trans fats, and that you limit your intake of cholesterol and sodium when you eat packaged foods.

The bottom line is that the number of calories contained in a package of food is not a good indicator of how nutritionally balanced that food is. A package of snack crackers that contains only 100 calories can still be high in fat and sodium, and have little nutritional value. Caloric content simply tells you how much energy is stored in the food. Therefore, if you eat more calories than your body requires, the extra energy is stored in your body, sometimes in your liver as glycogen and sometimes as fat.

Dieticians Canada has identified the following list of "Guidelines for Healthy Eating":

1. Enjoy a variety of foods.
2. Emphasize whole grain cereals, breads, other whole grain products, vegetables, and fruit.
3. Choose lower-fat dairy products, leaner meats, and foods prepared with little or no fat.
4. Achieve and maintain a healthy body weight by enjoying regular physical activity and healthy eating.
5. Limit salt, alcohol, and caffeine.

They stress that there are no "good" or "bad" foods. Consumers do not have to give up foods that they like but instead try to achieve variety and moderation in their diet.

It is now time for you to complete **Learning Activity 2.4**. You will use some of the knowledge that you have gained in this lesson to complete this activity.

Please **note** that, because of the nature of this learning activity, there is no answer key. Perform it carefully, because you will be using your results to complete Assignment 2.2, which is on page 44.

Learning Activity 2.4

Eat Well, Live Well

If you do not have access to the Internet, you can still complete this learning activity using the Canada Food Guide sent to you with the course. If you do not have one, contact the Distance Learning Unit at 1-800-465-9915.

Dietitians Canada is an organization made up of dieticians whose goal it is to promote health and well-being through informed decision-making about food and nutrition. The goal of this learning activity is to allow you to explore this very useful and accessible website, especially as it addresses good nutrition and wise dietary choices. At the time this course was written, their website was:
www.dietitians.ca/public/content/eat_well_live_well/english/index.asp

Option 1: Access to the Internet

1. First, select *"Eat Well, Live Well"* and, on the following page, choose *"Try Our Nutrition Challenges."* This site provides interesting quizzes and questions designed to help you understand the basics of good nutrition and healthy dietary choices. As you try the challenges, write down the interesting facts that you learn.
2. Next, go back to the original page and select *"Tip of the Day."* You will find an interesting fact about nutrition and can look for others when you select *"For More Tips."* As you read the information on the website write down tips that you find particularly interesting.
3. On the home page, you will see *"Let's Make a Meal"* on the left side. Choose that activity. This section is interactive and allows you to see the nutritional value of various foods that you choose to make part of an everyday meal plan. You can reset the activity any number of times as you vary the foods consumed in each meal and snack. If you do not have access to the Internet, visit local chain restaurants and ask for their Nutritional Information Fact Sheets.

continued

Learning Activity 2.4 (continued)

Option 2: NO access to the Internet

1. Browse through the Canada Food Guide and write down interesting facts that you learn.
2. Write down the tips in the Canada Food Guide that you find particularly interesting.
3. Visit chain restaurants (Subway, McDonald's, Tim Horton's, etc.) in your community and ask for their Nutritional Information Sheets. This information will indicate the nutritional value of the foods available at the restaurant.

Assignment 2.2

Nutritional Considerations *(18 marks)*

Use the Canada Food Guide and the course notes to help you complete this assignment.

1. Complete the following chart concerning nutrients. *(12 marks)*

Type of Nutrient	Ways that the Body Uses that Nutrient	Dietary Sources of that Nutrient
Carbohydrate		
Lipid		
Protein		

continued

Assignment 2.2 (continued)

1. (continued)

Type of Nutrient	Ways that the Body Uses that Nutrient	Dietary Sources of that Nutrient
Vitamins		
Minerals		
Water		

continued

Assignment 2.2 (continued)

2. After exploring the Dietitians Canada website, the Canada Food Guide, and having completed Learning Activity 2.4, you have compared your eating habits and preferences to the recommendations made by health professionals. Name three specific things about your personal dietary habits and preferences that you would **like to change**. For each of those three ideas, explain how you can personally achieve that goal. *(6 marks)*

Lesson 5: Disorders of the Digestive System

Lesson Focus

In this lesson, you will

- ❑ learn about the causes, symptoms, treatment, and strategies for prevention of three disorders of the human digestive system
- ❑ investigate another disorder of the human digestive system and report on that disorder; you will include symptoms, causes, treatment, and strategies for prevention of the disorder that you choose

Introduction

In the four previous lessons in this module, you have learned about the anatomy and the physiology of the human digestive system. The **anatomy** of the system refers to the *structure* of the organs and tissues that are involved in the digestive process. The **physiology** of the system refers to how the digestive system *functions* to accomplish digestion. You have studied the organs along the digestive tract, or alimentary canal, as well as organs that affect digestion by producing enzymes and hormones.

In this lesson, you will learn about three disorders of the human digestive system.

You will learn about each disorder separately in this lesson. For each disorder, you will learn about its

- symptoms
- causes
- treatment methods
- strategies for prevention

For each disorder that you consider in this lesson, take time to decide whether that disorder concerns mechanical digestion, chemical digestion, or the absorption of nutrients. These three processes together accomplish "digestion" in the human body.

Disorder 1: Irritable Bowel Syndrome (IBS)

Irritable bowel syndrome, or IBS, is a disorder that affects primarily the **bowel** (also called the large intestine). The bowel, as you learned earlier in this module, is responsible for storing solid waste before it is eliminated from the body. It is called a "syndrome" because it has a number of symptoms that occur together. In the case of IBS, those symptoms vary greatly from patient to patient. The International Foundation for Functional Gastrointestinal Disorders estimates that IBS, the most common disease diagnosed by gastroenterologists, affects approximately 10–15% of the general population. It is more often seen in women than in men. IBS can also be called spastic colon, mucous colitis, spastic colitis, nervous stomach, or irritable colon.

Symptoms

IBS can cause cramping, bloating, gas, diarrhea, and constipation. In an IBS patient, the muscles and nerves in the bowel are overly sensitive. The bowel muscles may contract too much, which can cause cramping and diarrhea. However, IBS does not usually cause diarrhea or cramps that awaken you during the night.

Sometimes, the bowel is overly sensitive to the stretching that is caused by gas. It is also possible for an IBS patient to notice mucous in the stool or to feel that a bowel movement is not finished. IBS, though it is painful at times, does not damage the bowel. Normally, doctors diagnose IBS because of the symptoms experienced by the patient. Diagnosis is not done in the traditional ways such as x-ray or blood test, although these tests can be used to rule out other diseases. IBS does not usually cause weight loss and is not generally accompanied by a fever.

Causes

Emotional stress is often linked to IBS. It is not caused by stress; however, if you already have IBS, stress may trigger symptoms. The cause of IBS has to date not been determined. There is no statistical evidence that IBS leads to more serious bowel diseases such as inflammatory bowel disease or colon cancer. A number of triggers have been identified but each patient is unique in terms of which triggers are particularly troublesome. The bowel is very sensitive to diet. Foods that tend to cause symptoms include chocolate, alcohol, caffeine, milk products, carbonated drinks, and foods that are high in fat. Sometimes even a large meal can trigger symptoms. Other triggers include the following:

- food allergies
- amount of fibre consumed
- neurological hyper-sensitivity
- antibiotic use
- gastrointestinal infection
- amount of physical exercise
- menstruation

Treatment Options

Before a physician diagnoses IBS, tests will be done to rule out other causes of the symptoms being experienced by the patient. Blood tests, x-rays, and colonoscopy may assist the doctor in making that decision. IBS has no cure but can usually be managed through lifestyle change and patient education. Effective treatment varies significantly from patient to patient but may include dietary modifications, medication, and stress relief. It is often suggested that patients avoid fatty foods, milk products, carbonated drinks, chocolate, and alcohol. Increasing fibre intake can usually reduce the incidence of IBS symptoms. A doctor may also suggest taking a fibre pill or drinking water mixed with a high-fibre powder. Eating more frequent, smaller meals also reduces symptoms in some patients. Laxatives can alleviate the discomfort of constipation. Antispasmodic medications can slow bowel contractions and help with diarrhea and pain. In some cases, antidepressants are prescribed to help patients deal with severe pain.

Prevention Strategies

Since it is not known what causes IBS, prevention is difficult to accomplish for many people. However, it is recommended that some dietary changes and activity regimens may help to prevent IBS symptoms from developing. For example, it is recommended that you gradually boost your fibre intake by two to three grams per day until you are consuming 20 to 35 grams of fibre per day. It is also recommended that you consume moderate amounts of foods containing high levels of sorbitol, such as prunes and raisins. Drinking enough water is also important; it is commonly suggested that you try to drink eight glasses of water each day. Flaxseed is particularly high in fibre and can be sprinkled on salads and added to bread recipes. Another suggestion is to avoid consuming foods with extreme temperatures (very hot or very cold). Broccoli, onions, and cabbage can cause gas and can be avoided if they lead to symptoms. Finally, stress management can be useful in preventing bowel attacks. Stress relief can be accomplished in many ways that include meditation, medication, exercise, and counseling.

Disorder 2: Ulcer

An **ulcer** is a sore on the inner lining of the digestive tract. Most ulcers are located in the first section of the small intestine called the **duodenum**. Sometimes, however, ulcers are found in the stomach and even in the esophagus. Ulcers are very treatable. When left untreated, however, they can lead to other complications such as bleeding, perforation, or obstruction.

Symptoms

Many people that have duodenal ulcers report that they feel better when they eat but feel worse again 1 or 2 hours after eating. On the other hand, people with gastric ulcers usually report that they feel worse when they eat or drink. Feeling full fast, having a heavy feeling, bloating, and vomiting are other signs of ulcers. The pain caused by ulcers is often referred to as a "burning" pain that can be quite intense. Patients sometimes report nausea, loss of appetite, loss of weight, tiredness, weakness, or blood in either vomit or stool. In the stool, blood appears black and "tarry." Since these can also be symptoms of a more serious condition, it is important that you see your doctor for correct diagnosis.

Causes

A bacterium, *Helicobacter pylori (H. pylori)*, is the cause of many ulcers. Acid and other digestive juices in the stomach may contribute to the symptoms of ulcers by burning the lining of the digestive tract. The stomachs of some patients produce too much acid. Physical or emotional stress is not known to cause an ulcer but it can aggravate an ulcer that already exists. Sometimes when anti-inflammatory medications, such as aspirin and ibuprofen, are taken over a long period of time they can damage the lining of the stomach.

Treatment Options

If your doctor suspects that you have an ulcer, you may receive a prescription for a medication known to alleviate your symptoms. The doctor may schedule an **endoscopy**, a procedure where a thin tube is inserted down the esophagus and into the stomach. The doctor looks into the stomach and may take a biopsy of stomach tissue to test for the presence of *H. pylori*. If the bacterium is present in the stomach, a combination of antibiotics and bismuth subsalicylate (like Pepto-Bismol) may be prescribed. The doctor may also recommend a medication to reduce, or even neutralize, the stomach's production of acid. This might be a medicine that actually coats the ulcer itself and protects it from stomach acid so that it can heal.

Prevention Strategies

Non-steroidal anti-inflammatory drugs (NSAID), such as aspirin and ibuprofen, interfere with the stomach's ability to produce protective mucus and bicarbonate, which neutralizes stomach acid. These drugs also affect blood flow to the stomach and therefore hinder cell repair. It is therefore recommended that patients avoid the overuse of these medications. Also, lifestyle factors affect the onset of ulcers. Smoking, drinking caffeine, and consuming alcohol are all linked to ulcers. Smoking cigarettes actually slows the body's ability to heal ulcers and also makes them more likely to reoccur. Caffeine stimulates the production of acids in the stomach and can thereby aggravate the pain of an ulcer. Emotional stress, while no longer believed to be a cause of ulcers, can aggravate the symptoms. Physical stress, on the other hand, has been linked to the development of gastric ulcers.

Disorder 3: Type 1 Diabetes

Over two million Canadians are estimated to have **diabetes**. There are three types of diabetes: Type-1 Diabetes, Type-2 Diabetes, and Gestational Diabetes. In this lesson, you will learn specifically about Type-1 Diabetes, which used to be called Insulin-Dependent or Juvenile Diabetes. By the end of this decade, the number of Canadians affected by Type-1 Diabetes is expected to rise to three million.

Symptoms

Type-1 Diabetes occurs when the body produces little or no **insulin**. As a result, your body cannot properly store and use food as fuel for energy. That fuel, as you have learned in past lessons, is glucose. To use glucose for energy, your body needs to have adequate amounts of insulin, which is a hormone. It is produced by the pancreas. When it is not produced in adequate amounts, glucose builds up in your blood instead of being used for energy.

High glucose levels can cause a number of symptoms such as fatigue, thirst, frequent urination, hunger, unpredictable moodiness, loss of weight, blurry vision, or a tendency to get infections. If high glucose levels are tolerated for an extended period of time, other conditions may develop such as kidney failure, heart disease, impotence, blindness, or amputation. These are very serious conditions that could lead to death.

Causes

It is not known what causes Type-1 Diabetes. There is nothing that you can do to prevent its onset, even if you visit your doctor regularly. The body's defense system, the immune system, may attack insulin-producing cells in the pancreas by accident; it is not known why that occurs when it does. People usually find out that they have Type-1 Diabetes early in life before the age of 30; the majority of people affected find out in childhood or during their teens. Type-1 Diabetes is not caused by eating too much sugar.

Treatment Options

Having diabetes does not mean that the patient has to avoid physical activity. But having Type-1 Diabetes does require that the patient checks blood glucose levels regularly and takes insulin when it is needed to regulate those glucose levels. Checking blood glucose levels is important because it gives the patient a quick measurement of blood glucose level and alerts the patient if it is too high or too low.

Food, exercise, medication, illness, and stress can all affect blood glucose levels. Checking blood glucose requires obtaining a small drop of blood, putting it on a testing strip, and placing the strip into a blood glucose meter. When insulin was first developed and used, only one type was available and it was fast-acting, requiring several injections per day. Now, we have a number of insulin products available and it is much more convenient to manage blood glucose levels. The most successful schedule used by most patients who have Type-1 Diabetes is to combine long-acting insulin, which is taken once or twice daily, with fast-acting insulin at mealtimes. The normal human pancreas follows a similar pattern, producing surges of insulin when you eat. Insulin is taken by injection.

When a person with Type-1 Diabetes has skipped a meal, not eaten enough, exercised strenuously, taken too much insulin, or consumed alcohol, he or she may experience **hypoglycemia**. Hypoglycemia occurs when blood glucose levels drop too low. A person with Type-1 Diabetes becomes very aware of the symptoms of hypoglycemia, which can include confusion, disorientation, unconsciousness, or seizure if left untreated. If it occurs, the patient should eat or drink 15 grams of carbohydrate such as glucose tablets, table sugar dissolved in water, juice, regular pop, candy, or honey.

Some dietary suggestions are made for a person with Type-1 Diabetes. It is recommended that the patient eats three meals per day at regular times no more than six hours apart. Healthy snacks may help to stabilize blood glucose levels. Sweets, sugar, jam, and honey should be consumed in limited amounts because they cause a spike in glucose levels. When thirsty, patients are better off to drink water instead of juice or pop as these drinks may elevate glucose levels suddenly. Patients with Type-1 Diabetes should wear MedicAlert® identification.

Prevention Strategies

Type-1 Diabetes does not appear to be preventable. It is not caused by consuming too much sugar. There are, however, a number of strategies that can prevent or reduce the chances of getting Type-2 Diabetes.

It is now time for you to complete **Learning Activity 2.5**. Remember to check your answers in the answer key before completing **Assignment 2.3**.

Learning Activity 2.5

Characteristics of a Digestive Disorder

1. In this lesson, you have learned about three disorders of the human digestive system—Irritable Bowel Syndrome, Ulcers, and Type-1 Diabetes. For each disorder, you discovered more about symptoms, causes, treatment options, and prevention strategies for each disorder. Now use this information to complete the following chart for the disorders introduced in this lesson. Condense the information to make the chart easier to use and understand.

Characteristic	Irritable Bowel Syndrome	Ulcers	Type-1 Diabetes
Symptoms			
Causes			

continued

Learning Activity 2.5 (continued)

Characteristic	Irritable Bowel Syndrome	Ulcers	Type-1 Diabetes
Treatment Options			
Prevention Strategies			

Notes

Assignment 2.3

Digestive Disorders and Diseases *(15 marks)*

In this lesson, you learned about three disorders and diseases of the human digestive system.

Part 1

In this assignment, you will investigate one other disorder or disease chosen from the list below. You should have at least three pieces of relevant information to report on each of the following four characteristics: symptoms, causes, treatment options, and prevention strategies of a disorder or disease. You will be marked on the clarity, completeness, relevance, and accuracy of the content. *(12 marks)* Please note that there is a rubric for this assignment, which can be found on the back of the Module 2 Cover Sheet.

These four characteristics are identical to the ones you learned in the lesson.

This assignment can be done in the format of a poster, brochure, fact sheet, PowerPoint presentation, or written paragraphs, such as the examples in the lesson. Please be aware of potential plagiarism issues when completing this assignment. Plagiarism is the use of another's words or ideas without giving credit where credit is due. Some examples are: downloading material in whole or part from the Internet, copying word-for-word from published or unpublished work, and paraphrasing published or unpublished material without bibliographic notation.

You may choose from the following list of digestive disorders and diseases; please do not choose a topic that is not on this list.

Anorexia nervosa	Cancer of the stomach
Cancer of the bowel	Appendicitis
Cirrhosis of the liver	Dysentary
Bulimia	Gall stones
Pancreatitis	Lactose intolerance
Intestinal blockage	Constipation
Crohn's Disease	Acid reflux
Diverticulitis	Celiac disease

continued

Part 2

Your assignment is to use at least three different reference sources. When you submit your assignment for marking, please include any print material or notes taken from an interview, etc., with the assignment to demonstrate the resources that you used for this assignment. *(3 marks)*

There are a number of ways to find information on your disorder. For example,

- ask a librarian
- contact the support organization for the disorder. For example, there is an organization in Manitoba that supports people with celiac disease. You could find information about them in a telephone book, or go to their website: http://www.celiac.mb.ca/. Here is the URL for an organization that supports people with Crohn's disease: www.ccfc.ca/localsites/Man_Sask/index.htm
- speak to a medical professional, like your family physician. They often have pamphlets in their offices with information on medical conditions like these.
- you may go the Health Sciences Centre Library, if you live in or near Winnipeg. It contains a section called the Consumer and Patient Health Information Service whose purpose is to help ordinary Manitobans learn more about health and medical topics, including characteristics of diseases and their treatments. This library is found at the 200 Level, 727 McDermot Ave., Winnipeg. Their website is: http://umanitoba.ca/libraries/units/health/chis/index.html

If you have trouble getting started or are not sure where to find reliable information, contact your tutor/marker for this course.

Lesson 6: Making Decisions about Nutrition

Lesson Focus

In this lesson, you will

- ❑ investigate issues related to digestion and nutrition and identify one that you would like to learn more about
- ❑ clarify the issue that you have chosen and identify possible positions related to that issue
- ❑ explain possible implications related to those positions
- ❑ learn and use the steps in the decision-making process to make a choice among different courses of action with respect to your chosen issue

Introduction

In the last five lessons, you have learned a lot of content about digestion and nutrition. This lesson is a little different in that you will not be learning much content. Instead, you will apply some of the content that you have learned in order to investigate issues related to nutrition, and make some decisions about those issues.

What are Some Nutritional Issues?

Your first task in this lesson is to "brainstorm" and make a list of several issues related to digestion and nutrition that interest you and that you would like to know more about. These issues may vary, and may include the following:

- personal issues such as weight loss, exercise routines, dietary decisions, eating disorders (self or another person), etc.
- community issues such as whether or not pop/chip machines should be present in school cafeterias or recreational facilities, the existence or absence of community food bank programs, nutrition information for new and expectant mothers, the availability of nutrition education for families, etc.
- larger issues such as hunger in developing nations, money spent by governments for nutrition and health education programs and materials, the effects of body image advertising practices (especially on young people), nutrition and lifestyle education programs in public schools, etc.

Learning Activity 2.6

Issues Relating to Nutrition

Please note that, because of the nature of this learning activity, there is no answer key.

This is a long learning activity, made up of three parts. Complete it carefully, because you will be using it to complete Assignment 2.4, the last one in this module.

Part 1

Before you identify an issue relating to nutrition that you are interested in studying, *brainstorm a list of possible issues*. There are three general types of issues that were outlined in this section. Try to think of at least three issues relating to nutrition for each category that are original ideas and are not suggested in this lesson. Use the information in this lesson for inspiration.

1. *Personal Issues:*
2. *Community Issues:*
3. *Larger Issues:*

Choose an Issue

Next, you will choose one of the issues you have identified. The issue that you choose should be interesting to you and one that you would like to know more about. For example, your issue may sound like this:

"We need to work together to prevent the predicted increase of Type-1 Diabetes in Manitoba."

You may already have a strong opinion related to that issue or you may presently be undecided about your position. Once you have chosen an issue, you will go on to investigate possible positions that people may have on that issue.

continued

Learning Activity 2.6 (continued)

Part 2

The Decision-Making Process

Choose one of the issues named in the previous question that you would like to know more about. State it clearly. Before completing this question, read the following explanation of the decision-making process.

Decision-Making Process

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 decision-making process involves a series of steps, which may include

1. identifying and clarifying the issue

   Example: Should soft drinks be banned in Manitoba schools?

2. critically evaluating the available background information relating to that issue

   Related information might include nutritional information, statistics on student consumption of soft drinks, studies that show effects of sugar and caffeine on learning, etc.

3. determining possible alternatives or positions related to the issue

   Examples: provide other drink options at school, limit soft drink availability, educate students and parents, do nothing, etc.

continued

Learning Activity 2.6 (continued)

4. evaluating the implications of possible alternatives or positions related to an issue

   Positive implications: improved health, decreased sugar consumption, reduced ecological footprint (fewer plastic bottles)

   Negative implications: decreased revenue for drink companies, unhappy students and parents who want to exercise their right to choose their own drinks

5. being aware of the values that may guide a decision

   Examples: right to make your own choices, value of health, helping students make better lifestyle choices

6. making a thoughtful decision and providing justification

   Examples: I think soft drinks should be banned because….

   I do not think soft drinks should be banned because….

7. acting on your decision

   Examples: form a student group to lobby support for your position, address parent groups, etc.

8. reflecting on the decision-making process

continued

Learning Activity 2.6 (continued)

Part 3

In this part, you will look for *background information* relating to the nutritional issue you chose in the last section of this lesson. Background information may take various forms and may come from various places and people, such as

- information that you already have from course work, pamphlets, etc.
- useful sites on the Internet
- interviews with people whom you could contact who are knowledgeable or have experience dealing with the issue that you have chosen

1. Identify the sources that were helpful and record particular information that will affect your decision.

Sources

2. *Name at least three possible viewpoints or positions* relating to the issue that you have chosen and learned more about through your search of background information. For each position, you will explain possible implications related to it. At this point, you will not have made a personal decision yet related to the position that you support on the issue that you've chosen. You do not have to agree with all of these viewpoints but you will choose from them when you make your decision regarding this issue.

   Example: Here is a sample viewpoint based on the issue described above. It dealt with banning the sale of soft drinks in Manitoba schools. One viewpoint would be that soft drinks are not illegal or controlled, like alcohol. Therefore, people have the right to decide whether or not they are going to purchase some.

continued

Learning Activity 2.6 (continued)

3. For each of the three (or more) viewpoints or positions that you identified in the previous question, *explain the implications* of each. In other words, each viewpoint or position that exists for your issue carries with it implications in terms of actions that could or should be taken by the person or people involved. Explain those implications for each of the viewpoints or positions named in Question 4.

   Example: Again, let's use the sample viewpoint above. It stated that students in Manitoba should have the right to purchase soft drinks because they are not an illegal or controlled substance. One implication of such a viewpoint would be that anything that is not illegal or controlled could be sold anywhere. Therefore, students of all ages would be able to purchase coffee, energy drinks with high amounts of caffeine, and other substances that can be detrimental to the health of children. This could result in increased health problems, which could result in increased costs to all Manitobans.

   a. Implications of ______________________________:
   b. Implications of ______________________________:
   c. Implications of ______________________________:

4. For each of the three (or more) viewpoints or positions that you identified in question 4, *explain the values* that would lead you to possess that viewpoint or position. The values that you have are the beliefs that you think are important. For example, you may think that everyone should have equal access to nutritional education programs.

At this point, complete **Assignment 2.4**. When you have completed it, you will submit it for marking along with the others from this module.

Assignment 2.4

Assignment 2.4: Decision-Making *(15 marks)*

This assignment is based on the work that you started in Learning Activity 2.6. Write three complete paragraphs, each based on the questions below. For each question, you will be marked on the accuracy, content, relevance, completeness, and clarity of your response.

1. First, clearly state the issue that you have chosen. Now, *make a thoughtful decision* regarding your issue. Clearly explain why you chose that viewpoint or position. *(5 marks)*

    ____
    ____
    ____
    ____
    ____
    ____
    ____
    ____
    ____

2. What *actions could you take* in light of the decision that you have made regarding the issue? What actions could *other people* take? *(5 marks)*

    ____
    ____
    ____
    ____
    ____
    ____
    ____
    ____

continued

Assignment 2.4 (continued)

3. Take time to *reflect on the decision-making process* that you have used in this lesson. Was it useful to you? Have you used it before? What step(s) did you find most helpful in making your decision? What step(s) did you find least helpful? *(5 marks)*

Module 2 Summary

Congratulations! You have completed Module 2 of the Grade 11 Biology course.

Submitting Your Assignments

It is now time for you to submit the Module 2 assignments to the Distance Learning Unit so that you can receive some feedback on how you are doing in this course. Remember that you must submit all the assignments in this course before you can receive your credit.

Make sure you have completed all parts of your Module 2 assignments and organize your material in the following order:

- Module 2 Cover Sheet (found at the end of the course Introduction)
- Assignment 2.1: Introduction to Digestion
- Assignment 2.2: Nutritional Considerations
- Assignment 2.3: Digestive Disorders and Diseases
- Assignment 2.4: Decision Making

For instructions on submitting your assignments, refer to How to Submit Assignments in the course Introduction.

Notes

Grade 11 Biology (30S)

Module 2

Learning Activity Answer Key

Module 2
Learning Activity Answer Key

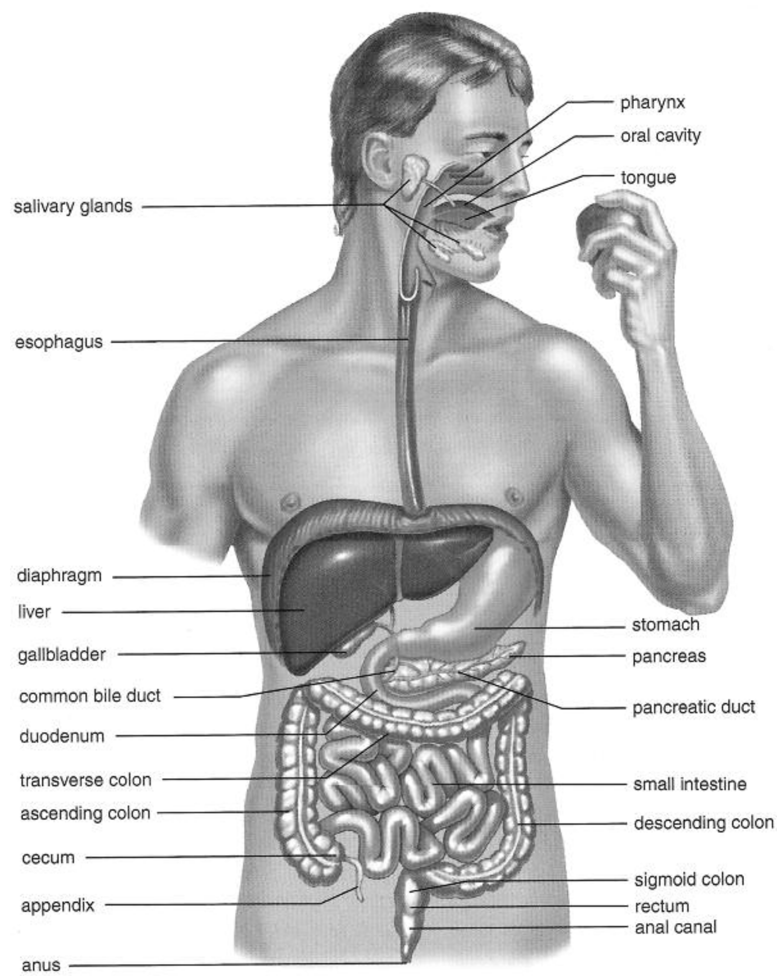
Learning Activity 2.1: Structures in the Human Digestive System

1. Put the structures that follow into the correct order in which food passes through them: small intestine, esophagus, anus, large intestine, pharynx, pyloric sphincter, rectum, cardiac sphincter, mouth, epiglottis, stomach.

   The correct order in which food passes through the digestive system is as follows: mouth, pharynx, epiglottis, esophagus, cardiac sphincter, stomach, pyloric sphincter, small intestine, large intestine, rectum, anus.

2. Locate and label each of the structures named in Question #1 on the following diagram:

The Digestive System



The Digestive System: Reproduced from *Inquiry into Life* by Sylvia M. Mader. Toronto, ON: McGraw-Hill, 2006. 260. Reproduced in accordance with *Access Copyright Elementary and Secondary School*

Tariff.

3. Define peristalsis and explain how it functions in the digestive system.

   Peristalsis is the series of muscular contractions that occurs in the human digestive system that results in the effective movement of food through that system from mouth to anus. Peristalsis is an involuntary, automatic movement accomplished by smooth muscle tissue throughout the alimentary canal.

4. What are the two types of digestion? Where, along the alimentary canal, does each type of digestion occur in humans?

   The two types of digestion are mechanical and chemical digestion. Mechanical (physical) digestion occurs in the mouth where food is chewed, in the stomach where the food is churned and mixed, and in the small intestine when large lipid molecules are broken down by bile into smaller component molecules. Peristalsis along the entire alimentary canal results in physical mixing and squeezing of the food. Chemical digestion begins in the mouth where saliva acts on food as it is chewed, continues in the stomach where gastric juices act on food, and concludes in the small intestine where intestinal and pancreatic juices complete chemical digestion.

5. Where are food materials absorbed into the circulatory system in the human body?

   Food molecules are absorbed into the bloodstream in the small intestine. Villi that line the walls of the small intestine facilitate the absorption of food molecules into blood capillaries, which carry them to the rest of the body. A smaller number of substances are absorbed in the stomach.

6. How does the structure of the small intestine allow it to be an effective organ of absorption in humans?

   The lining of the small intestine is very folded and convoluted; it is covered with tiny fingerlike projections called villi that greatly increase the surface area of the intestinal lining. Since there is a greater surface area, there is a greater ability for the lining of the small intestine to uptake food molecules. Also, the walls of the villi are very thin and are located directly beside the circulatory system, to allow easy access to the bloodstream.

7. In your own words, explain how the pancreas is involved in the digestion of food in the alimentary canal? Which foods, in particular?

   The pancreas is an organ that produces and sends digestive enzymes through the pancreatic duct to the small intestine where they chemically digest food.

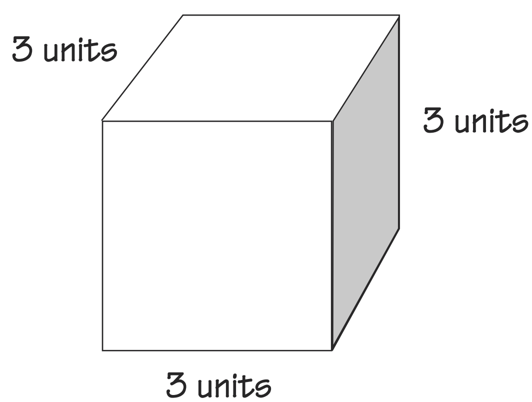
   Pancreatic amylase acts on carbohydrates, pancreatic proteases act on proteins, and pancreatic lipases act on fats.

8. What THREE important functions are carried out by the large intestine?
    a. **Water and essential minerals are reabsorbed across the wall of the large intestine into the bloodstream.**
    b. **Some beneficial bacteria inhabit the large intestine where they produce some important nutrients. These nutrients are then reabsorbed.**
    c. **The large intestine is a storage organ for the feces before it is excreted from the body.**

Learning Activity 2.2: Surface Area

The purpose of this activity is to prove that surface area dramatically increases when a particle is broken down into a number of smaller particles.

Imagine that a large particle of food is in the shape of a cube. A cube is not a very realistic shape for a food particle but it is easy to work with in terms of calculating surface area. We will say that the length of each side of the cube is three units.



1. Calculate the total surface area of the large food particle illustrated above. Remember that the area of each of the six faces of the cube is "length x width." After you calculate the area of each face, you will add up all six to get a total surface area.

   Each face of the food cube has a surface area of 3 x 3 square units or 9 square units. Since the cube has 6 identical faces, the total surface area is equal to 6 x 9 or 54 square units.

2. Now imagine that the large cube above is divided into 27 smaller cubes, each 1 unit in each dimension. Now calculate the surface area of each of the small cubes and then multiply by 27 to get the total surface area of all of the small cubes added together.

Each face of the tiny food cubes has a surface area of 1 x 1 square units or 1 square unit. Since each cube has 6 identical faces, the total surface area is equal to 6 x 1 or 6 square units. Since there are 27 small cubes, the total surface of the 27 small cubes is 27 x 6 or 162 square units.

3. The large single cube and the 27 smaller cubes have equal volumes. But the surface areas of the two differ significantly. Explain how the surface area changes when the particle is mechanically broken down into 27 smaller particles.

   When the large cube is broken down into 27 smaller cubes, the total surface area increases from 54 to 162 square units. That is a three-fold increase in surface area while the volume remains the same.

4. Why is it important that surface area of the food particles be increased for best enzyme activity?

   Enzymes act only on the surface area that is exposed to the environment of the food particle. Enzymes are chemicals that act on the molecules to which they have physical access. Therefore, more food molecules are exposed to enzyme activity when the surface area of the food particle being acted on increases.

5. Other than surface area, name and explain the other four factors that affect enzyme action in the human digestive system.

   The four other factors that affect enzyme action in the digestive system are:

   - **pH: The pH of a solution affects how well an enzyme acts on its substrate because proteins are denatured or structurally changed if the pH of the solution is too acidic.**
   - **Coenzymes: Coenzyme molecules are located at the active site of enzyme molecules. They facilitate the “lock and key” action of the enzyme and substrate molecules.**
   - **Inhibitors: Inhibitor molecules usually compete with substrate molecules for the active sites of the enzymes. Therefore, the effectiveness of the enzyme is reduced.**
   - **Temperature: The chemical integrity of enzyme molecules can be affected by temperatures that fall outside of a fairly narrow range. When an enzyme molecule is denatured or structurally changed, it is no longer effective on the substrate molecule it is designed to act on.**

6. For each of the following types of food molecules, state the location(s) in which it is chemically digested in the human digestive system:
   - **Carbohydrates: mouth (salivary amylase), small intestine (pancreatic amylase and intestinal carbohydrase)**
   - **Proteins: stomach (pepsin), small intestine (pancreatic protease and intestinal protease)**
   - **Lipids: small intestine (pancreatic lipase)**
     Note that bile does not act in chemical digestion; it emulsifies lipids.

Learning Activity 2.3: The Liver

The purpose of this activity is to give you some practice predicting how the level of glucose changes in the blood as a result of physical activity. Fill in the blank sections of each diagram:

1. a. Blood sugar becomes too high:

   Box 2: Cells in the **pancreas** detect high level and produce insulin.
   Box 3: Cells in the **liver** detect insulin and convert glucose into **glycogen**.
   Box 4: Blood sugar level **drops**.

1. b. Blood sugar becomes too low:

   Box 2: Cells in the **pancreas** detect low level and produce glucagon.
   Box 3: Cells in the **liver** detect glucagon and convert glycogen into glucose.
   Box 4: Blood sugar level **rises**.

2. In your own words, explain the difference between each of the following pairs of terms:

   a. insulin and glucagon

   Insulin is a hormone that is produced in the pancreas and has its action in the liver. In the liver, insulin causes the chemical conversion of glucose into the storage form, glycogen, to occur. This results in a drop in blood glucose levels.

   Glucagon is a hormone that is also produced in the pancreas and has its action in the liver. In the liver, glucagon causes the chemical conversion of glycogen into glucose to occur. This results in an increase in blood glucose levels.

   b. glucagon and glycogen

   Glucagon is a hormone that is produced in the pancreas and has its action in the liver. It causes the chemical conversion of glycogen into glucose to occur.

Glycogen is a storage carbohydrate in the liver.

c. glycogen and glucose

Glucose is a sugar that provides quick energy to body cells. When glucose levels are adequate, body cells have just enough energy to function.

Glycogen is a storage carbohydrate that is produced by the liver when blood glucose levels get too high. It can be converted into glucose when it is needed by body cells.

Learning Activity 2.4: Eat Well, Live Well

Please note that, because of the nature of this learning activity, there is no answer key.

Learning Activity 2.5: Characteristics of a Digestive Disorder

1. In this lesson, you have learned about three disorders of the human digestive system—Irritable Bowel Syndrome, Ulcers, and Type-1 Diabetes. For each disorder, you discovered more about symptoms, causes, treatment options, and prevention strategies for each disorder. Now use this information to complete the following chart for the disorders introduced in this lesson. Condense the information to make the chart easier to use and understand.

Characteristic	Irritable Bowel Syndrome	Ulcers	Type 1 Diabetes
Symptoms	**variable; cramping, bloating, gas, diarrhea, constipation; mucus in the stool; feeling that a bowel movement is not finished; can be painful**	**pain, often burning; feeling full fast, having a heavy feeling, bloating, and vomiting; nausea, loss of appetite, loss of weight, weakness, blood in vomit or stool**	**fatigue, thirst, frequent urination, hunger, unpredictable moodiness, loss of weight, blurry vision, tendency to get infections; symptoms may be more serious**
Causes	**Causes of IBS are not clear at this time. Some foods trigger symptoms. Other triggers include fibre content in the diet, physical exercise, antibiotic use.**	***H. pylori* is often the cause. There is an overproduction of stomach acid. Anti-inflammatory medications can cause ulcers to develop.**	**It is not known. The immune system may attack insulin-producing cells.**
Treatment Options	**No cure exists. Blood tests and x-rays rule out other causes of symptoms. Dietary changes, medications, and stress relief may help.**	**There is medication to relieve pain and antibiotics and other medications for bacterial infection. Medications may reduce stomach's acid production.**	**The patient must check blood sugar levels regularly. Insulin may have to be taken. Be aware of diet, exercise, stress, and sleep patterns.**
Prevention Strategies	**It is not well understood. Adequate fibre in the diet and adequate physical exercise may help. Stress relief may also be beneficial.**	**Prevent overuse of anti-inflammatory medications. Don't smoke or consume excessive caffeine or alcohol. Reduce stress.**	**Does not appear to be preventable.**

Learning Activity 2.6: Issues Relating to Nutrition

Please note that, because of the nature of this learning activity, there is no answer key.

Grade 11 Biology (30S)

Module 3

Transportation and Respiration

This module contains the following:

- Introduction
- Lesson 1: Introduction to Scientific Experimentation
- Lesson 2: The Blood
- Lesson 3: The Circulatory System
- Lesson 4: The Respiratory System
- Lesson 5: Circulatory and Respiratory Wellness
- Module 3 Summary
- Lesson 6: Midterm Examination Review

Module 3: Transportation and Respiration

Introduction

Welcome to Module 3. In Module 2 you learned how the digestive system delivers the necessary food molecules to all body cells so that they can carry on the process of cellular respiration. In this module, you will learn about how the respiratory system functions to deliver oxygen molecules to all body cells so that they can carry on their vital processes. You will also learn about the circulatory system. These body systems depend on blood to carry vital materials to every body cell, and both systems maintain homeostasis of the human body.

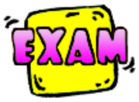
Since science is based on scientific experimentation, you will be reviewing that in the first lesson where you will design and execute an experiment on respiration.

Assignments in Module 3

When you complete Module 3, you will submit your Module 3 assignments to the Distance Learning Unit either by mail or electronically through the learning management system (LMS). The staff will forward your work to your tutor/marker.

Lesson	Assignment Number	Assignment Title
1	Assignment 3.1	Experiment: Effect of Exercise on Heart Rate
4	Assignment 3.2	Respiratory Homeostasis
5	Assignment 3.3	Circulatory and Respiratory Wellness

Writing Your Midterm Examination



You will write the midterm examination when you have completed Module 3 of this course. The midterm examination is based on Modules 1 to 3, and is worth 20 percent of your final mark in the course. To do well on the midterm examination, you should review all the work you complete in Modules 1 to 3, including all the learning activities and assignments. You will write the midterm examination under supervision.

Lesson 1: Introduction to Scientific Experimentation

Lesson Focus

In this lesson, you will

- ❏ make use of a strategy that will allow for a scientific investigation
- ❏ identify the characteristics of a controlled experiment
- ❏ discuss the relationship among scientific fact, scientific evidence, and scientific theory
- ❏ explain how sound scientific questions can lead to experimentation and observation designed to answer them
- ❏ write your own scientific question relating to transportation or respiration, and outline the steps of an experiment that you design that could be used to gather data about that question

Introduction

In the previous modules, you learned about scientific knowledge established through experimentation using the scientific method. This module will begin differently, because you will be conducting your own experiment. Before doing so, you will be introduced to one strategy that will help you conduct an investigation of a scientific question.

Introduction to the Methods of Science

Science is a way of looking at the world that has developed over at least a thousand years. Within the last 400 years, inquiring into the natural world has been transformed such that *experimental sciences* have come into being. You and I often use the term "scientific experiment" in everyday language, and we are often told that all sciences use a step-by-step method to answer questions about nature. There is no single method or way of doing a scientific investigation, and this seems to be against what you may read in most textbooks. A so-called "single scientific method" does not exist, and so scientists use many different approaches, depending on what kind of question is being asked. Scientific thinking needs to be flexible, but one thing for sure is that others should be able to duplicate your results if they use the same method you have used. In this lesson, you will be introduced to ONE such method – that of generating a hypothesis, and then testing that hypothesis by controlling certain things about the investigation. We call this a ***controlled scientific investigation***. In most cases, a scientific invetigation begins with either an observation of something that interests us, or we ask a question about something in nature that we hope has an answer once we pull together some evidence and facts. It is very important to note that science is a tool designed by humans; it cannot answer all questions that humans ask. There are important limitations to the answers that science can produce.

Any question that science is able to address must, first of all, involve information that is both observable and subject to experimentation. In other words, questions that do not deal with what can be observed and tested lie outside the realm of science. Science does not discount those questions; it simply cannot address them. For instance, "Who is the best science fiction landscape artist?"

Scientific inquiry can get started with a GOOD QUESTION that we can test. The question must be specific and clearly stated. It must be testable using our senses and the tools that we have invented to assist our senses in observing the world. Microscopes, Geiger counters, telescopes, and X-rays are all examples of such tools that people have invented.

A good question often takes the form of "How does _____ affect _____?" It focuses your attention on only one experimental factor. For example, the question, "Does Vitamin A affect the growth rate of hamsters?" is more readily testable than is the question, "What affects the growth rate of hamsters?" A good question allows you to make predictions, create a plan, conduct a fair test, and make meaningful observations and conclusions. In the case of the question concerning vitamin supplements and their effects on growth rates of hamsters, the vitamin supplement is said to be the **independent variable** because it is the factor that can be changed in the experiment. For example, Vitamin A can be omitted from the hamster's diet, it may be given in varying amounts, or it can be given at different time intervals. The hamster's growth rate is the **dependent variable** because the experiment will look at how it changes in response to changes in the independent variable. In other words, the hamster's growth rate depends on the Vitamin A. A good experiment can involve only **one independent variable**; an experiment designed to test the effect of one independent variable is a **controlled experiment**.

We may now be in the position, after doing some background research into our question, to develop a ***hypothesis***. A hypothesis is NOT an "educated guess," but is actually a possible answer to the question we have put together after a great deal of thought and careful research about what it is we are investigating. Perhaps a better phrase is "making a prediction." Think of a hypothesis as a possible explanation of the facts as we know them now, but we still need to test it out to see if the explanation we have holds together.

Once the hypothesis has been formulated, the experiment itself is designed. It is important when designing an experiment that all variables **other than the independent variable** be controlled and kept constant. These "other variables" are called **controlled variables** because they are kept constant by the researcher. For example, in the study referred to above, the hamsters receiving the supplement should not be smaller, larger, less healthy, more healthy, older, younger, a different breed, a different sex, or different in any way from the hamsters **not receiving** the supplement. They should all be treated the same way except for the supplement in the diet of some hamsters. Once variables have been identified and controlled, the next step is to design the experiment, clarify the materials and resources needed to conduct the experiment, and plan to be able to repeat the study several times. Repetition ensures that the results seen are not "flukes"; often, time and money limit the number of repetitions that can reasonably be performed.

Conducting the experiment is the next step. It is important to take accurate measurements and careful observations once the experiment is underway. It is also important to make the safety of people and animals involved in the experiment a priority. Repetitions are vital, as are repeated and frequent measurements. For instance, in our hamster example, the experiment should involve as many hamsters as possible and body size should be measured often throughout the experiment.

During the course of the experiment, frequent data collection involving as many experimental subjects as possible will result in the most reliable results. Data may be gathered and presented in a variety of formats, including tables, diagrams, observations, lists, and spreadsheets. It is important that the researcher take the time to make sure that data are recorded accurately and honestly.

Once the data are gathered, they must be organized and analyzed. In so doing, the researcher forms conclusions that refer back to the hypothesis made at the beginning of the experimental process. The conclusions are made based on the summarized data taken from the experiment itself. If the question was asked clearly and a specific hypothesis was made, then a well-designed experiment can result in meaningful conclusions. The conclusions not only refer back to the hypothesis, either supporting it or contradicting it, they also include suggestions for how the experiment could be improved and for ideas concerning sources of error in the experimental data.

Fact or Theory?

Before we begin our example of one type of "scientific method" of investigation, it is important to understand the key differences among **scientific facts**, **scientific evidence**, and **scientific theory**. A scientific fact does not exist outside human decision-making. Among the ancient Greek thinkers, it is said of Aristotle that he once proclaimed, "It is not sufficient to say that it is a fact of nature. How it BECAME a fact of nature is just as important to know." For our thinking today about what is a scientific fact, we need to realize something about where the facts of science come from. If, say, a certain event (e.g., an eclipse of the sun), or the behaviour of an object (e.g., when you drop an object, it falls to the Earth in a gravity field), or a repeated observation (e.g., Earth's atmosphere is currently warming up, and the warming is accelerating and measurable) seems always to be the case under certain conditions, we can probably then claim it is FACTUAL. Eclipses of the sun do occur, objects do fall when dropped, and Earth's atmosphere is currently warming up. So, you see, we accept that something is a scientific fact based on all the available evidence. Factual events can be observed with any of the human senses as well as by using any of the many inventions that we have devised to augment our senses. Facts are not really debatable since they are generally accepted as true. The fact that the Earth rotates on its axis once every 24 hours is generally accepted. It is a measurable quantity and is, therefore, considered to be a fact.

The data gathered during experimentation is referred to as scientific **evidence**. A few important notes about scientific evidence include the following:

- The observations must be recorded accurately during the course of the experiment.
- The researcher does not purposely leave out or change any data.
- The data gathered may either support or contradict the hypothesis made.

When several scientific studies result in similar conclusions about a given topic, that body of evidence may lead to the formation of a scientific theory. A theory is a broad explanation that is consistent with a large amount of experimental evidence and observations. When a theory is generated, it is beneficial if that new theory has two important characteristics: 1) the theory provides an explanation for a broad range of "facts," evidence, and observations; and 2) it anticipates new discoveries by making fresh predictions and additional hypotheses that can be tested. Strong, powerful theories pull together many different pieces of scientific evidence, and can then guide future work. Theories that are weaker, or supported by very little evidence, are immature and may just require more time to be refined – especially as new technologies allow for measurements to be made that were not possible in the past. Before we move on with our example, it is also important to recognize that good theories in science are able to be **FALSIFIED** as new evidence comes forward... and that can mean that the strong theories of the past (e.g., Earth's continents and oceans are fixed in place) can be overturned by amazing new evidence (continents do move over time, and is explained well by the new theory of plate tectonics).

Example

Let's continue with the initial question posed earlier in this lesson concerning Vitamin A and hamsters.

Question: "Does Vitamin A affect the growth rate of hamsters?"

Hypothesis: "If young hamsters are given a double dose of Vitamin A once per day for one month, then their growth rates will be 2 times faster than those of young hamsters not given a double dose of Vitamin A once per day for one month."

Experiment: There will be two experimental groups of hamsters that are **identical** in every way but one.

- **Group A** will be given 3 mg of Vitamin A once per day for 30 days.
- **Group B** will be given 1.5 mg of Vitamin A once per day for 30 days.

In all others ways, the two test groups will be identical. There will be 50 hamsters in each experimental group. Each group of hamsters will be divided between 5 identical cages, 10 hamsters per cage. All 100 hamsters will be given identical diets and identical amounts of water per day. All will be handled with the same frequency and by the same person or people. Ideally, all 100 hamsters will be approximately the same age and come from the same population of hamsters (have similar genetic properties).

Data Collection: Growth rate will be measured by weighing each hamster every 3 days for 30 days and that data will be collected by the same person using the same equipment. The data will be recorded in table form.

Conclusions: Conclusions made from the study will be based on the data collected. A graph will be constructed to illustrate the data. Possible sources of error will be identified. Predictions for further studies on this topic will be made. Limitations of the experimental design will be identified. (Perhaps the 100 hamsters were purchased at 3 different pet stores, or perhaps the vitamin supplement was placed directly into the hamsters' food and made the food unappealing to the hamsters receiving it.)

It is time now to work on **Learning Activity 3.1**. Remember to check your answers in the answer key before completing **Assignment 3.1**.

Learning Activity 3.1

Experimental Design

In this activity, you will brainstorm ways to investigate the effect of exercise on heart rate. Remember that your answers may be somewhat different from those in the answer key.

Brainstorm the following elements to help you design your experiment:

1. What exercise(s) can you accomplish easily and use to measure heart rate? How long will you do this exercise for to raise your resting heart rate?
2. Measure your resting heart rate, in other words your heart rate when you are sitting and are relaxed. This measurement will be in “beats per minute” (BPM).
3. How will you measure your heart rate? When will you measure your heart rate during and after the experiment?
4. What are the independent, dependent, and controlled variables in this experiment?
5. Design a data table to help you record your heart rate information.

continued

Learning Activity 3.1 (continued)

6. Complete the following statements involving scientific experimentation:

   a. Science as a discipline is only able to address questions involving information that can be ___________________________ and can be subject to ___________________________.

   b. A specific and clearly stated ___________________________ is the beginning of any scientific investigation.

   c. In a sound experimental design, there is only one experimental ___________________________ involved.

   d. The ___________________________ variable is the quantity that will be changed in the experiment by the person or people conducting the investigation.

   e. The ___________________________ variable is the quantity that is observed and measured if and when it changes during the experiment.

   f. "Making a prediction" in science is a(n) ___________________________.

   g. An "if-then" statement is a good format for the ___________________________ to be stated in.

   h. Variables in an experiment that are not allowed to change but are kept constant are called ___________________________ variables.

   i. A good experiment is most reliable when it is repeated ___________________________ times.

   j. During the course of an experiment, it is important that accurate ___________________________ and careful ___________________________ be recorded.

Notes

Assignment 3.1

Experiment: Effect of Exercise on Heart Rate ***(15 marks)***

In this assignment, you will design and execute a simple experiment to investigate the effect of exercise on heart rate. This process must remain rigid in terms of the steps involved but flexible in terms of the specific strategies used to complete those steps. Your experiment should investigate *how* exercise affects heart rate; you can assume that exercise is known to affect heart rate.

1. State your **question**. Be as specific as possible. *(1 mark)*

2. What is your **hypothesis**? Your hypothesis should be in the form of an "if–then" statement. *(1 mark)*

3. Outline the steps of your experiment, or your **experimental design**. There should be at least four specific steps. *(4 marks)*

4. **Data Collection:** Provide your completed table from the learning activity. *(2 marks)*

continued

Assignment 3.1 (continued)

5. **Conclusion:** Answer your question using data you collected. Your conclusion should refer to the specific question that you asked. *(2 marks)*

   ____

6. Complete the following statements involving scientific experimentation. *(5 marks)*

   a. When the experimental data has been collected and organized, meaningful ___________________________ can be formed about the initial question asked.

   b. A broad explanation that is consistent with a large body of experimental evidence and observations is called a(n) ___________________________.

   c. ___________________________ can be gathered in many ways that include tables, diagrams, observations, lists, and spreadsheets.

   d. One common first step in any ___________________________ is the formulation of a hypothesis.

LESSON 2: THE BLOOD

Lesson Focus

In this lesson, you will

- ❑ identify the components of human blood in terms of their appearance, origin, number, relative size, and function
- ❑ discuss the existence of human blood groups, concentrating on the ABO blood proteins and on the Rh factor
- ❑ discuss the effects that the various blood proteins have on blood transfusions, organ transplants, and pregnancy

Introduction

In the last lesson, you reviewed how people use science to learn about the world around them. In this lesson, you will learn about blood, upon which the body depends to carry material and maintain homeostasis.

Some biologists have long referred to human blood as "the sea within us." This analogy is a powerful one for it connects human beings to the other forms of life on our water planet. It is believed that life first evolved on our planet in the oceans. The water environment of those early cells provided them with all of the materials necessary for life. Similarly, our blood makes available to all of our body cells all of the materials necessary for life. The blood is the transportation system in the human body that carries food, oxygen, and hormones to all of the body cells, regardless of how far they are situated from the heart and lungs. The blood also carries waste products and carbon dioxide away from body cells so that the body rids itself of them. In this way, every body cell is surrounded by body fluid.

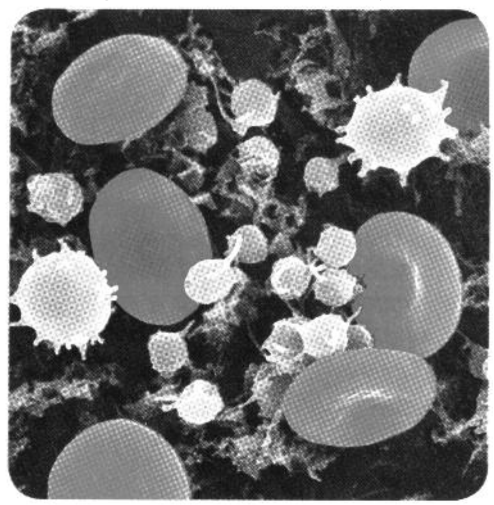
The average adult possesses about 5 litres of blood. It accounts for 6 to 8 percent of the person's body mass on average. The blood is actually a type of tissue in the human body.

The Components of Blood

Human blood is composed of water, various dissolved substances, and living cells. More specifically, the blood is composed of a yellowish fluid, called plasma, in which three basic cell types are suspended. The different blood cells work together to accomplish the role of transportation within the body. Here is more detail on the components of human blood:

- **Plasma:** Blood plasma is the liquid part of the blood. It is primarily composed of water (90%) but also contains various dissolved substances. Blood plasma makes up about 55% of blood by volume. The substances dissolved in the blood plasma include blood proteins, glucose, vitamins, minerals, dissolved gases, hormones, and waste materials. The body monitors the concentrations of these substances and makes sure that they remain within healthy limits. Blood plasma is light yellow in colour and appears somewhat cloudy due to the substances dissolved within it.
- **Red Blood Cells:** These cells are also called **erythrocytes** and are what make the blood appear red. Technically, red blood cells are not true cells as they do not have any organelles or a nucleus. Red blood cells are membranous sacs filled with a protein called **hemoglobin**, which contains iron and which accounts for their relatively high density. Hemoglobin has the ability to bond temporarily to oxygen molecules and transport them within the blood to cells that need them. This is an important function of the red blood cell, since all human cells need oxygen in order to break down food and obtain energy.

  Erythrocytes are biconcave disks, meaning they are thinner in the centre than at the edges. This "biconcave" shape allows red blood cells to possess far more surface area for gas exchange than a spherical shape. Their shape resembles a doughnut with the centre "filled in" by a thin layer of cell membrane and cytoplasm.

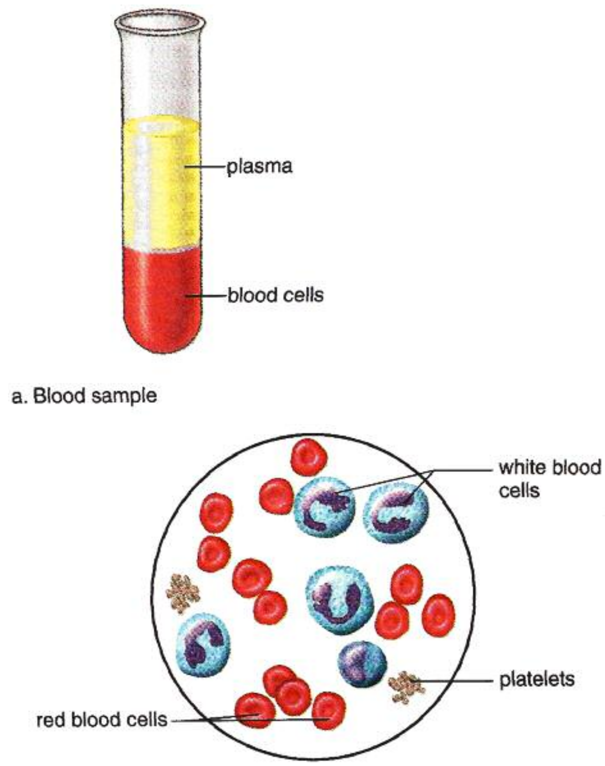


Red Blood Cells: Reprinted from *Biology* by Alton Biggs, et al. New York, NY: McGraw Hill, 2009. p. 997. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

  They are about 7 micrometres (10^{-6} metre) in diameter. These cells are very small and do not have the ability to reproduce because they do not possess nuclei. When the body needs more erythrocytes, it produces new erythrocytes instead of depending on existing red blood cells to divide. Red blood cells are produced in the bone marrow. A typical red blood cell will circulate for about 120 days before it is destroyed and excreted. Normally, there are about 5 million red blood cells in every millilitre of human blood.

- **White Blood Cells:** White blood cells are also referred to as **leucocytes**. They are far less numerous (about 7,000 cells per millilitre of blood) and much larger (about 12 to 15 micrometres in diameter) than red blood cells. Red blood cells outnumber white blood cells by a ratio of approximately 700 to 1. White blood cells contain nuclei, can reproduce, and are generated by the bone marrow. Their shape is very irregular. There are several types of white blood cells based in part on their structure and in part on their function. Some leucocytes have the ability to destroy invading microscopic organisms like bacteria. Recall that in Lesson 3 of Module 1 you learned about phagocytosis; this form of active transport involves the cell "engulfing" the food particle and creating a food vacuole as it brings the particle in to be digested. Some white blood cells, called **neutrophils**, engulf invading microbes using phagocytosis and thereby protect the body from the effects of those microbes. It is interesting that some white blood cells, called **monocytes**, have the ability to temporarily leave the blood vessels and enter the spaces in between body cells in order to engulf invading microbes. When the white blood cell has engulfed the microbe, it produces digestive enzymes to destroy not only the microbe but also itself. Other white blood cells, known as **lymphocytes**, produce **antibodies**, which are "flags" that are attached to foreign particles and invading microbes in order to label them as foreign. Other white blood cells, such as **eosinophils** and **basophils**, are believed to play a role in allergic reactions.
- **Platelets:** Platelets, also called **thrombocytes**, are the third type of cell found in human blood. Like erythrocytes, they are produced in the bone marrow and do not possess nuclei. Platelets are small and irregularly shaped cell fragments. They consist of small amounts of cytoplasm surrounded by a cell membrane. Platelets measure about 2 micrometres in diameter. There are about 150,000 to 400,000 cells per millilitre of blood. They are fragile cells and rupture easily if they encounter a rough surface such as those formed when a blood vessel is broken. When platelets rupture, they release substances that initiate the clotting process. When a blood vessel is broken, it is very important that clotting of the blood occurs in order to prevent the loss of too much blood from that vessel.
- **Dissolved substances:** Plasma is about 90% water. The other 10% is composed of various chemicals, including dissolved gases (primarily oxygen and carbon dioxide). Since most of the oxygen transported by the blood is carried by hemoglobin molecules in red blood cells, only a small amount of oxygen is carried in the plasma itself. The plasma also contains dissolved sugars and inorganic salts like sodium chloride. Waste products of cellular respiration are also carried in the plasma. Various enzymes and hormones are transported in the blood plasma, as are **plasma proteins**. There are a number of different plasma proteins with a number of different functions. Some help in blood clotting. Some fight infection. Some help to maintain an appropriate pH in the blood and others are carrier molecules. For example, **albumen** is a plasma protein that acts as a carrier for fatty acids, amino acids, and enzymes.

Consider the following diagram of a bloodsmear:



Blood, a fluid tissue: Reproduced from *Inquiry into Life* by Sylvia M. Mader. Toronto, ON: McGraw-Hill, 2006. 202. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

Blood Groups

It has been known for centuries that the practice of putting blood from one person into another person produces sometimes beneficial and sometimes fatal results. This was true whether the donor was young and the recipient was elderly or vice versa. It did not seem to be related to gender. Sometimes it seemed to be more successful if donor and recipient were related but not always.

It was discovered in the early 1900s that there are actually various human **blood types** and that sometimes they could not be successfully "mixed" in human recipients of transfusions. These blood types are due to the existence of various molecules on the membrane of red blood cells, called **glycoproteins**. There are many types of glycoproteins but this lesson will focus specifically on three of them that are found on the surface of the red blood cell. These three molecules are referred to as the "A protein," the "B protein," and the "Rh protein." These molecules have sometimes been called "markers." The word "marker" is used because it emphasizes the fact that the human body recognizes familiar markers and foreign markers. When a foreign marker is detected, the body attacks the cell possessing that marker.

In that way, the body recognizes what is foreign and tries to get rid of it. It also recognizes what is not foreign and does not attack it.

Such a "marker" on the surface of a cell is called an **antigen**. An antigen is recognized by the body as either a familiar antigen or as a foreign antigen. Foreign antigens trigger the production of **antibodies**. Antibodies attach to the foreign antigens and cause a process that leads to the destruction of the foreign cell or particle. So if a person receives a blood transfusion that contains blood with a foreign glycoprotein, that person's body will produce antibodies that will attach to those foreign antigens. As a result, the blood cells will clump in a process called **agglutination** and the transfusion will not be successful.

The A and B Proteins

Have you overheard someone refer to their blood as "Type B" or "Type O"? What does this mean? What are the other possible blood types? Here is a summary of the AB blood types:

- A person with only the A protein on the red blood cell surface is said to have **Type A** blood.
- A person with only the B protein on the red blood cell surface is said to have **Type B** blood.
- A person who possesses both A and B proteins on the red blood cell surface has **Type AB** blood.
- A person who possesses neither A nor B protein on the red blood cell surface has **Type O** blood.

The type of glycoproteins that a person possesses is an inherited trait from his or her parents.

As you have learned, a person produces antibodies in response to foreign antigens. Antibodies are not produced in response to familiar antigens. So a person who has blood type A possesses the A protein but does not possess the B protein. If that person were to encounter the B protein during a transfusion, he or she would produce antibodies against that B protein. Similarly, a person who has blood type B would produce "anti-A antibodies" against the A antigen if he or she were to encounter it in a transfusion. It follows, then, that a person with blood type AB would recognize both blood proteins as "self" or familiar and would not produce antibodies against either blood protein. Finally, a person with blood type O would recognize both blood proteins as foreign and would therefore produce both anti-A antibodies and anti-B antibodies.

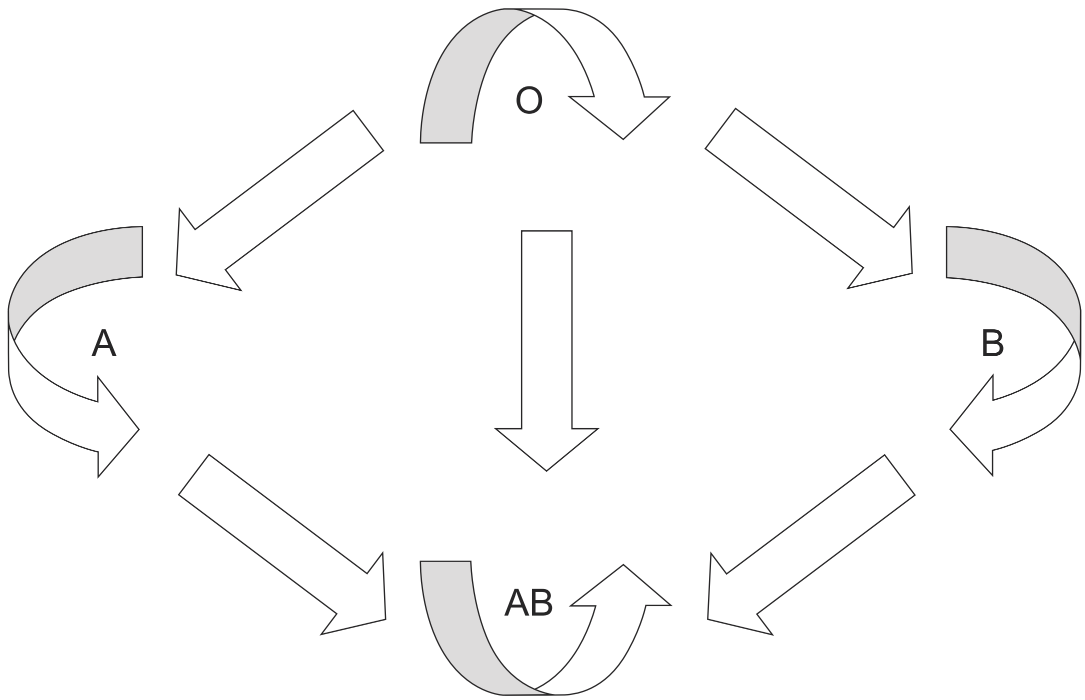
Consider the following table that summarizes the antigens present and the antibodies produced for each of the four ABO blood types:

Blood Group	Antigens Present	Antibodies Produced
A	A	Anti-B
B	B	Anti-A
AB	A and B	Neither
O	Neither	Anti-B and Anti-A

It follows that we can identify which types of blood can be successfully accepted by recipients that possess each of the blood groups:

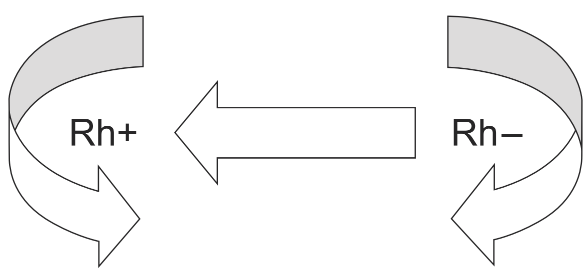
Recipient Blood Type	Donor Blood Type	Successful Transfusion?
A	A	Yes
A	B	No
A	AB	No
A	O	Yes
B	A	No
B	B	Yes
B	AB	No
B	O	Yes
AB	A	Yes
AB	B	Yes
AB	AB	Yes
AB	O	Yes
O	A	No
O	B	No
O	AB	No
O	O	Yes

Because blood type O can be successfully accepted by donors with any of the four blood types, type O is called the **universal donor** blood type. Since a person with blood type AB can successfully accept any of the four blood types, type AB is called the **universal recipient** blood type. The previous table can be summarized like this:



The Rh Factor

The Rh glycoprotein or Rh factor is another antigen on the surface of red blood cells. A person who possesses the Rh glycoprotein is said to be "Rh+" and a person who does not possess the protein is said to be "Rh-." Using the same logic that was used to determine which ABO blood groups can be used in transfusions, you can conclude that a person who is Rh+ is able to accept a transfusion of Rh- blood. However, a person with Rh- blood cannot accept Rh+ blood because the Rh antigen would be foreign to that recipient. He or she would build antibodies against that antigen and cause the transfusion to be rejected. Here is a diagram to help you remember compatible Rh donor types:



Blood Donation Practices in Canada

Canadian Blood Services is our national organization in charge of blood donation and distribution. In 1998, Canadian Blood Services was organized to provide information about the policy, management, and operations of the blood supply system in Canada and to implement safe blood donation policies and practices. It is a not-for-profit, charitable organization. Its sole purpose is to manage the blood and blood products supply for Canadians. Every year, it collects approximately 850,000 units of blood and processes it into the components and products that are administered to thousands of people. It screens every donor and tests every unit of blood or blood product collected for a variety of diseases. The website of this organization is:

www.bloodservices.ca

In the assignment for this lesson, you will use this website to find out some important information about blood donation and use in Canada.

It is now time to work on **Learning Activity 3.2**. Remember to check your answers for these questions in the answer key for this module.

Learning Activity 3.2

Blood

Part A: "Blood Donation Practices"

The following questions can be answered using information presented by the Canadian Blood Services website referred to in this lesson.

1. Donors must be within what age range if they are regular donors? They must be within what age range if they are first-time donors?

 ____

 ____

 ____

2. What is the minimum weight (in kilograms) allowed for a potential blood donor to be eligible to donate?

 ____

 ____

 ____

3. What is the minimum interval (in days) permitted between blood donations?

 ____

4. What restrictions apply to donors who have had recent dental work?

 ____

 ____

 ____

5. What restrictions apply to potential donors who have an ear or body piercing or tattooing?

 ____

 ____

continued

Learning Activity 3.2 (continued)

6. What is “leukoreduction” and when is it done?

7. What is “plasmapheresis” and when is it done?

8. What is “plateletpheresis” and when is it done?

9. What is the Unrelated Bone Marrow Donor Registry (UBMDR)?

10. What are some reasons why someone may need a blood transfusion?

continued

Learning Activity 3.2 (continued)

11. How much blood does the average adult possess? How much blood does the average recipient receive when blood is required?

12. What are some of the reasons why someone may need a blood plasma transfusion?

13. Why would a patient require a transfusion of blood platelets?

14. What is HIV? How does Canadian Blood Services make sure that blood distributed to hospitals is free from HIV?

continued

Learning Activity 3.2 (continued)

Part B: Human Blood Types

1. Complete the following chart involving the human blood types.

Blood Group	Antigens Present	Antibodies Present	Possible Donors for this Recipient	Possible Recipients for this Donor
A+				
A-				
B+				
B-				
AB+				
AB-				
O+				
O-				

continued

Learning Activity 3.2 (continued)

2. Complete the following chart involving the cells found in human blood.

	Erythrocytes	Leucocytes	Platelets
Functions			
Appearance			
Origin			
Number			
Relative Size			

Notes

Lesson 3: The Circulatory System

Lesson Focus

In this lesson, you will

- ❑ compare veins, capillaries, and arteries in terms of how they are made and in terms of how they work in the circulatory system
- ❑ explain the structure of the human heart and the two beats that make up each heartbeat
- ❑ list and discuss the materials that are exchanged between body cells and the blood
- ❑ explain how the body controls the beating of the heart using both hormones and nerves
- ❑ discuss blood pressure and the meaning of the two numbers in a blood pressure reading
- ❑ identify and discuss common factors that affect blood pressure or the beating of the heart
- ❑ explain how the circulatory system in the human body maintains homeostasis in an ever-changing environment

Introduction

Early in this module, you learned that the human circulatory system keeps all body cells in contact with the life fluid that carries oxygen and food and carries away carbon dioxide and wastes—the **blood**. In this lesson, you will learn how the circulatory system is constructed to accomplish its vital functions. The blood connects the digestive system to each body cell. It also connects each body cell to the respiratory system, an interaction that will be discussed in the next lesson. The blood also carries wastes away from every body cell and transports it to organs designed to filter it from the blood and eliminate it from the body.

The human circulatory system is made up primarily of one large, muscular pumping organ—the heart—and a series of vessels or tubes that carry the blood. Some of these vessels are large enough to see through the skin and some are microscopic in diameter. These vessels, when considered together as a system, form a network of vessels that effectively bathe all body cells in fluid.

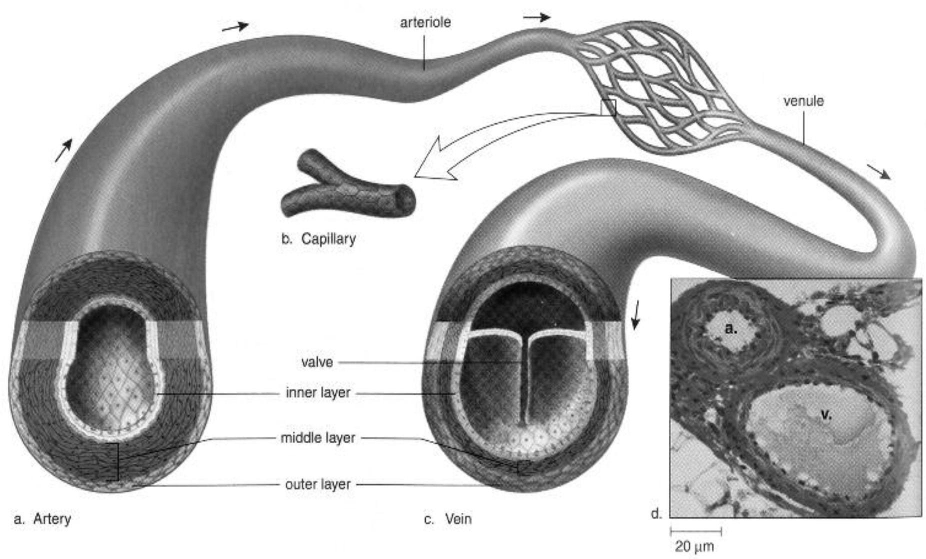
Blood Vessels

Arteries

Blood is pumped away from the heart so that it can reach distant parts of the body. It then travels back to the heart in order to be pumped once again. The vessels that are specialized to carry blood away from the heart are called **arteries**. The vessels that are specialized to carry blood back to the heart again are called veins. And the tiny, microscopic vessels that connect arteries to **veins** are called **capillaries**.

Arteries are strong blood vessels that carry blood that has just been forcefully pumped by the heart. Some characteristics of arteries are as follows:

- Arteries have thick, muscular walls composed of three layers
- The outer and the inner layers are made of tough, rigid connective tissue.
- The middle layer is made of elastic connective tissue and muscle.
- Arteries carry oxygen-rich blood, with the exception of the pulmonary arteries.



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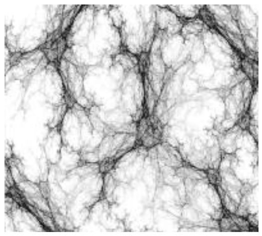
Since blood is forcefully pushed through arteries, the diameter of these vessels increases to accommodate the surge of blood. The **pulse** that you can feel on your wrist or on the side of your neck is actually caused by surges of blood through the arteries in those areas. A period of relaxation follows each surge of blood, clearly distinguishing one beat from the next.

Capillaries

As blood gets further away from the heart, it enters smaller branches of the arteries called **arterioles**. These tiny vessels further branch into still



smaller vessels called **capillaries**. The tiniest capillaries are so narrow that they only allow red blood cells to move through them in single file.

It is here in the capillaries that oxygen diffuses from the red blood cells to the body cells that line those capillaries. Similarly, carbon dioxide diffuses from those body cells back into the blood to be excreted. Food materials that are carried in the blood diffuse from the blood into body cells around the capillaries and waste materials diffuse from the body cells into the blood. Remember that all body cells are in contact with capillaries. All body cells must receive oxygen and food and must rid themselves of carbon dioxide and wastes. The microscopic size and complex network of capillaries ensure that they reach each body cell, no matter how far it is located from the heart.

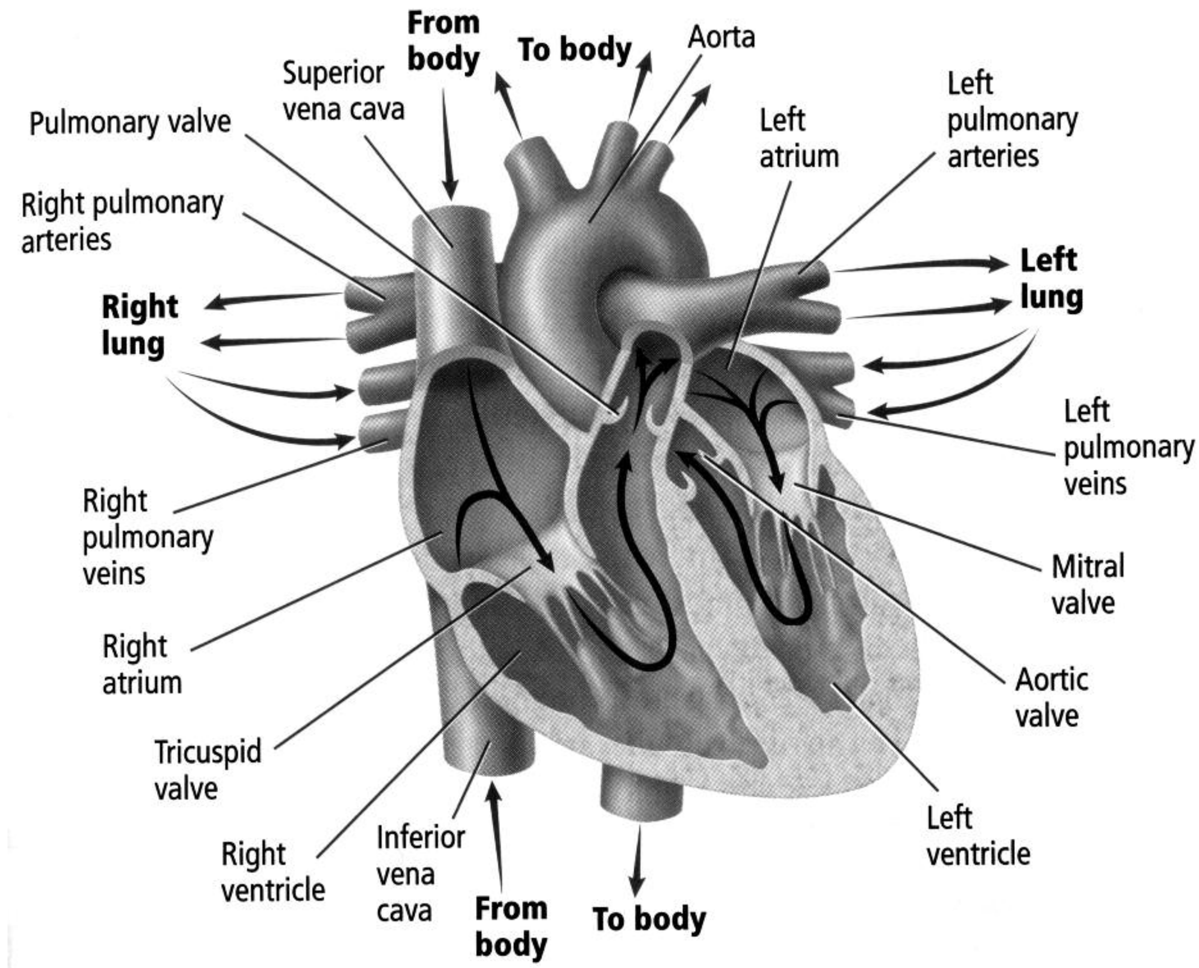
Veins

After the blood passes through the capillary network, it must return to the heart to be pumped once again. Capillaries merge into small veins called **venules**. Venules then merge into larger vessels called **veins**. Veins carry blood rich in carbon dioxide (CO_2) back to the heart so that it can be oxygenated and pumped again. The only veins that carry oxygen-rich blood are the pulmonary veins. The blood pressure in veins is much lower than that in arteries because the blood is returned to the heart instead of just leaving it. In fact, the blood pressure in veins is so low that it could not effectively get the blood back to the heart alone. Blood returning to the heart from lower body extremities (like the legs and feet) also must flow against the force of gravity. In order to keep the blood moving in the right direction, veins possess valves that allow the blood to move toward, not away from, the heart. The contraction of skeletal muscles also helps to push and squeeze blood back to the heart. At any one time, about 50% of your blood is found in veins; therefore, they act as important reservoirs for blood. During times of stress, such as physical exercise, venous blood flow can be increased; as a result, more blood is available to the body.

The Heart

The human heart is about the size of your fist. It pumps about 70 times per minute and must continue to do so for as long as you are alive. It is a muscle that we do not have conscious control over. Since you cannot make your heart pump faster or slower, its action is considered to be involuntary. The muscle tissue that makes up the heart is called cardiac muscle and does not fatigue easily. However, the beating of the heart responds to many different changes in the environment; external factors like temperature and exercise affect the beating of the heart.

Look at the following diagram of the human heart. The heart is not a single pump but is actually made up of two pumps that are separated from each other by a wall, the **septum**. The blood on the right side of the heart and the blood on the left side of the heart remain separate from each other because their compositions differ significantly in terms of oxygen content. The blood on the right side of the heart has just returned to the heart from the body through veins that empty into the right upper chamber of the heart; the right side of the heart sends carbon dioxide-rich blood to the lungs. The blood on the left side of the heart has just returned to the heart from the lungs that recharged it with a fresh blood supply; the left side of the heart sends newly oxygenated blood out to the body through arteries.



The Heart: Reproduced from *Biology* by Alton Biggs, et al. New York, NY: McGraw Hill, 2009. p. 995. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

As you can see from the diagram, there are four chambers in the human heart. The two upper chambers, one on the right and one on the left, are called **atria**. The two lower chambers, one on the right and one on the left, are called **ventricles**. Blood returning to the heart through veins enters the **right atrium**. It is then pumped into the right ventricle. From the **right ventricle**, blood is pumped to the lungs. When blood returns to the heart from the lungs, it enters the left atrium. It is then pumped into the left ventricle. The **left ventricle** is the strongest heart chamber because it pumps blood out to the rest of the body.

The blood entering the right atrium from the body travels through two large veins—the **superior (upper) vena cava** and the **inferior (lower) vena cava**.

The valve through which blood passes from the right atrium into the right ventricle is called the **tricuspid valve**. The valves in the heart are "one-way" valves and do not allow blood to pass through them in the reverse direction. Blood being pumped out of the right ventricle on its way to the lungs passes through the **pulmonary valve** and travels through the **pulmonary arteries**. These are the only arteries in the body that will carry blood rich in CO_2, rather than blood that is oxygen-rich. In the lungs, carbon dioxide is exchanged for oxygen. Oxygen-rich blood then travels through the pulmonary veins back to the left atrium. It is pumped into the left ventricle after passing through the **mitral valve**. The left ventricle pumps blood through the **aortic valve** into the **aorta**, the largest artery in the body. The aorta carries blood into the vast network of arteries and arterioles that supply capillaries with oxygen-rich blood.

The Heartbeat

Every heartbeat is actually made of two beats, one stronger than the other. The two atria contract at the same time, sending blood into the two ventricles. Then the two ventricles contract at the same time, sending blood both to the lungs and out to the body. The stronger of the two contractions is the ventricular contraction. Contraction of the ventricles is called **systole**. Contraction of the atria is less forceful and is called **diastole**. When you have your blood pressure reading taken, you see that it is made up of two numbers. The first one is larger than the second. The first number is actually a measure of the pressure inside your blood vessels during systole. The second number is a measure of the pressure inside your blood vessels during diastole. So each heartbeat is really two beats; this explains the "lub-dub" sound that is often referred to as a heart sound. The "lub-dub" sound is actually the sound of the valves in the heart closing after blood has moved through them.

A typical blood pressure reading would be about 120/80. These numbers are in the units of pressure. The "120" is the systolic reading and the "80" is the diastolic reading.

Control of Heart Rate

The muscle tissue in the heart moves involuntarily; however, the brain controls the heart beat rhythm. It has been well-documented that heart muscle can beat independently of the brain for a limited amount of time. Heart muscle is said to be a **myogenic muscle** because of its ability to contract, at least for a short time, when removed from the body. That is because the heart has two areas within its own tissues that initiate contraction of cardiac muscles. The first area is called the **sinoatrial node** (or SA node) which is located in the right atrium near the place where the superior vena cava empties into that chamber. The SA node is also called the **pacemaker** of the heart because its impulses initiate contraction of other cardiac tissue. When the SA node initiates a contraction, it induces the two atria to contract. It also sends a message to the other area of interest here—the **atrioventricular node** (or AV node). This node is located near the bottom of the right atrium. The AV node then stimulates the two ventricles to contract. The activity of the SA and AV nodes is not dependent on the brain. In essence, the heart "makes itself" beat; this adaptation is an indication of the importance of the uninterrupted beating of the heart for life to continue.

Factors that Affect Heart Rate and Blood Pressure

Heart rate is affected by two primary types of automatic or autonomic nerves. One type—the **sympathetic nerves**—causes the heart rate to increase. These nerves fire in times of stress; as a result, blood flow to body tissues increases, enabling the body to better deal with the source of stress. When the heart beats more than 100 times in one minute, or 100 BPM, it is said to be in a condition of **tachycardia**. When the cause of stress is removed, the heart rate begins to decrease. **Parasympathetic nerves** are stimulated to fire during times of relaxation. The condition in which the heart beats very slowly is called **bradycardia**.

"Stress" can refer to a number of conditions and situations. For example, physical exercise is a form of "stress" on the body. When the body perceives a state of emergency, it responds appropriately in order to handle this stress. Some drugs, like caffeine and nicotine, cause tachycardia. Other drugs can cause the heart rate to decrease. Even different types of food can cause a change in heart rate to occur.

In times of stress, the blood pressure inside vessels also increases in response to a greater flow of blood. One result of the firing of the sympathetic nerves is constriction of blood vessels; this constriction causes blood pressure to increase. When the source of stress is removed, the parasympathetic nerves cause blood pressure to drop again.

When the body is under stress, the adrenal glands release **adrenaline**, a hormone. Adrenaline travels to all of the body organs since it is in the blood. Adrenaline causes the heart muscle to contract more frequently, increasing heart rate.

Circulatory Homeostasis

Remember that homeostasis refers to a relatively stable internal environment in which various conditions are maintained within acceptable limits. Homeostasis of the circulatory system must be maintained in a number of ways:

- **Heart rate** must be maintained within acceptable limits. That is, the heart cannot beat too rapidly or too slowly. The appropriate heart rate at any one time depends on a number of factors, including physical activity and stress. Sympathetic and parasympathetic nerves affect how rapidly the heart beats. Adrenaline released by the adrenal glands in times of stress also causes the heart rate to increase.
- **Blood pressure** must also be kept within limits that can be tolerated by the body. If the blood pressure gets too high, arterial walls can be weakened. If blood pressure gets too low, the body's ability to transport blood is reduced. The brain is especially sensitive to low blood pressure. If blood pressure drops too low, the brain essentially "turns itself off" causing the person to faint. Special blood pressure sensors are located in the walls of the aorta and the carotid arteries that carry blood to the head. These sensory cells are called **baroreceptors** because they are sensitive to pressure. If blood pressure is too high, these cells send a nervous message to the brainstem telling it to "turn down" the sympathetic nerves and "turn up" the parasympathetic nerves. As a result, arterioles dilate and blood pressure drops. If the blood pressure is too low, the baroreceptors cause sympathetic nerves to fire so that cardiac output increases and arterioles constrict. As a result, blood pressure rises.
- **Breathing rate** must also be maintained within acceptable limits. Breathing rate will be addressed in the following lesson. We know that in times of stress or during physical exercise, breathing rate increases. This physiological response occurs along with an increase in blood pressure and an increase in heart rate.
- **Metabolic waste products** that are present in the blood cannot reach dangerously high levels. It is interesting that the walls of arterioles themselves are sensitive to carbon dioxide levels. If the level of carbon dioxide in the blood is too high, the smooth muscles in the walls of arterioles relax, causing dilation of those vessels. This increased blood flow carries away potentially toxic metabolic wastes and also supplies the tissue with a greater nutrient supply. As a result, tissues that are very active and therefore produce more metabolic wastes are supplied with a greater blood supply. When the levels of metabolic wastes go down, arteriolar dilation and blood flow both decrease.

It is now time for you to complete **Learning Activity 3.3**. Remember to check your answers carefully against the Answer Key.

Learning Activity 3.3

The Circulatory System

Part A: Human Circulation

Use the following bank of terms to complete each statement given below. Terms may be used more than once. Not all terms are used.

arteries	veins	capillaries	septum
venules	arterioles	systole	diastole
blood pressure	oxygen	carbon dioxide	mitral
tricuspid	pulmonary	vena cava	cardiac
atrium	ventricle	aorta	SA-node
sympathetic	parasympathetic	adrenaline	baroreceptor

1. One of the substances that moves from the capillaries out into body cells, carrying on cellular respiration, is ____________________________.
2. The largest artery in the body is the ____________________________.
3. The superior and inferior ____________________________ carry blood into the right atrium of the heart.
4. Larger veins branch into smaller veins, called ____________________________.
5. The wall that separates the right and left sides of the heart is the ____________________________.
6. As blood moves from the left atrium to the left ventricle, it passes through the ____________________________ valve.
7. The muscle in the heart is called ____________________________ muscle.
8. Blood in the right ventricle is pumped out through the ____________________________ valve and into the ____________________________ arteries.
9. Nerves that cause an increase in tissue activity are called ____________________________ nerves.

continued

Learning Activity 3.3 (continued)

10. The ____________________________ is also called the heart's pacemaker.
11. If a person's blood pressure reading is 125/85, the "125" indicates the pressure during ____________________________ and the "85" indicates the pressure during ____________________________.
12. If blood pressure becomes too high, specialized cells called ______________________________ sense the increase in pressure and they send a message to the brain telling it to "turn on" the ____________________________ nerves so that pressure will fall.
13. The upper chamber of the heart that sends blood into the right ventricle is the right ____________________________.
14. A hormone that is produced by the adrenal glands is ____________________________; it causes an increase in heart rate.
15. One of the substances that moves from the body cells into the capillaries is a waste product: ____________________________.

continued

Learning Activity 3.3 (continued)

Part B: Comparing Vessels

1. Complete the chart below that compares arteries, veins, and capillaries.

Type of Vessel	Artery	Vein	Capillary
Direction of Blood Flow			
Thickness			
Type(s) of Tissue			
Blood Pressure			
Gas Exchange, if Any			
Presence of Valves			

continued

Learning Activity 3.3 (continued)

2. What action helps blood move through the veins?

   ____

3. For each of the following vessels, comment on the oxygen content of the blood found there:

   Artery: ______________________

   Vein: ______________________

   Capillary: ______________________

4. For each of the following vessels, comment on the carbon dioxide content of the blood found there:

   Artery: ______________________

   Vein: ______________________

   Capillary: ______________________

Lesson 4: The Respiratory System

Lesson Focus

In this lesson, you will

- ❑ define and understand the difference between the three types of respiration: cellular, internal, and external
- ❑ explain the structure of the human respiratory system and link each to the function that it performs in the respiratory process
- ❑ explain how homeostasis is maintained in the human respiratory system

Introduction

In the previous lesson, you learned that the human circulatory system keeps all body cells in contact with the blood that carries oxygen, food, carbon dioxide, and wastes. The structures in the circulatory system allow it to accomplish its vital functions. In the second module of this course, you learned how food molecules are absorbed into capillaries so that the blood can transport those molecules to all of the body's cells. This is essential to the maintenance of homeostasis as all cells in the human body need food molecules from which to extract the energy necessary for life.

In this lesson, you will learn more specifically how oxygen and carbon dioxide move into and out of the blood. You will learn where these exchanges occur and how the body maintains balance in terms of oxygen and carbon dioxide levels.

Recall that, in terms of cellular respiration, oxygen is used by the cells to break the chemical bonds in food molecules. When those bonds are broken, energy is released. The body temporarily stores that energy in the form of ATP. When the bonds in organic food molecules are broken, a waste product of the process is carbon dioxide. Cells that survive using cellular respiration must rid themselves of this waste gas. Therefore, every body cell requires an adequate amount of oxygen and also must rid itself of the waste gas, carbon dioxide.

Respiration

"Respiration" is a rather general term that can be used in three main ways when we discuss the human respiratory system:

1. **Cellular Respiration:** This term refers to the process in which food and oxygen combine chemically and produce carbon dioxide and energy. This process results in the production of ATP—the "energy currency" of the cell. Every cell in the human body must be able to carry out this necessary life process if that cell is to remain alive.

2. **Internal Respiration:** Used in this way, respiration refers to the movement of oxygen molecules into body cells and the movement of carbon dioxide out of body cells. In the lungs, oxygen molecules in the air that is inhaled pass into capillaries that line the membranes inside the lung. Carbon dioxide diffuses out of those capillaries and into the lungs so that it can be exhaled. Once in the blood, oxygen travels to all body cells. When it reaches cells that need oxygen for cellular respiration, that oxygen diffuses out of the capillaries and into the body cells. Carbon dioxide diffuses from the body cells that have produced it and enters the capillaries. The red blood cells will carry the carbon dioxide back to the lungs where it can be exhaled.

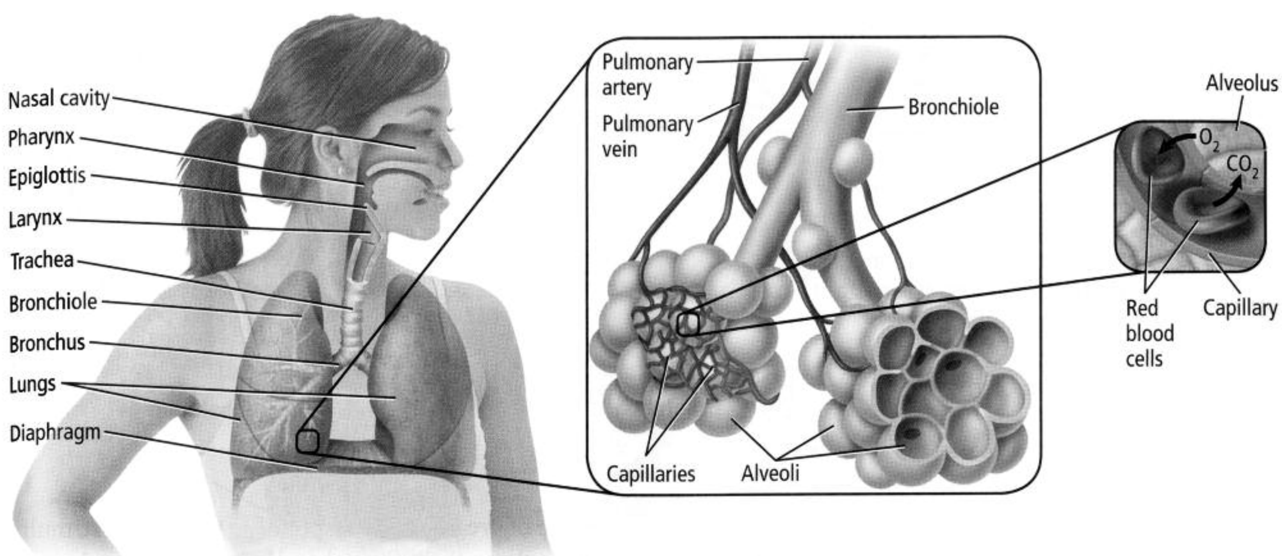
3. **External Respiration:** This type of respiration means the same thing as "breathing." It is a mechanical process of getting air into the lungs and then expelling it from the lungs. External respiration refers to inhaling and exhaling.

   It can be noted here that the body cells of some organisms possess the ability to absorb oxygen and food directly from the environment and also to release carbon dioxide and waste products directly into the environment. An example of such an animal is the sponge. But oxygen, carbon dioxide, food, and wastes cannot move across human skin that is exposed to the environment. The diffusion of oxygen and carbon dioxide only occurs across the membranes lining the lungs in human beings. The blood encounters all body cells and thereby keeps all body cells "connected" with the external environment.

The Human Respiratory System

In humans, air enters the body either through two **nasal cavities** or through the mouth. Tiny hairs and mucus that line the respiratory pathway filter and trap larger foreign particles out of the air that is inhaled so that they don't enter the body. The back of the mouth is the pharynx; air that is inhaled through either the nasal cavities or the mouth enters the **pharynx**. The pharynx then branches into two passages—the esophagus and the trachea. The esophagus leads to the stomach, as you learned in Module 2. The **trachea** is also called the windpipe. It carries inhaled air from the pharynx to the lungs. As air travels through the trachea, it passes through the voice-box or **larynx**. The larynx contains vocal cords, which are two thin sheets of elastic ligaments. When air is pushed from the lungs toward the pharynx, it passes through the vocal cords and produces sound. The trachea is reinforced with rings of cartilage that keep this air tube open and protect it from collapsing during trauma. The **epiglottis** is a flap that closes over the entrance to the trachea while swallowing occurs. The epiglottis ensures that food travels down into the esophagus instead of into the trachea. The **uvula** is a piece of soft tissue that hangs down in your pharynx from its top surface; the uvula closes over the nasal openings when food is swallowed.

Look at the following illustration of the human respiratory system:



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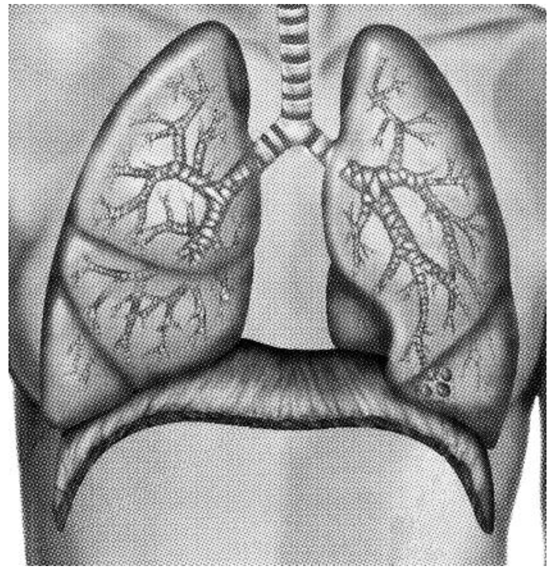
From the trachea, air entering the body passes into two tubes called the **bronchi**.



Bronchi: Reprinted from *Inquiry into Life* by Sylvia S. Mader. New York, NY: McGraw Hill, 2003. p. 282. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

Like the trachea, the bronchi are surrounded by cartilaginous rings. Each bronchus carries air into the lungs, one to each side. The bronchi continue to branch into smaller tubes called bronchioles, which are not supported by cartilaginous rings. Very small bronchioles are in fact microscopic in size. The bronchioles lead to tiny ducts that open into air sacs called alveoli. Each individual alveolus measures about 0.1 to 0.2 mm in diameter and is usually only one cell thick. Pulmonary capillaries line the walls of the alveoli. As the alveoli inflate and fill with air, oxygen diffuses into the capillaries and carbon dioxide diffuses from the capillaries into the air sacs. Each human lung contains about 150 million alveoli. Because of their shape and their number, alveoli create a huge amount of surface area for the diffusion of gases. The lining of the alveoli is moist which also facilitates gas exchange.

The outer surface of the lungs and the inner surface of the rib cage are both covered by a tough membrane called the pleura or pleural membrane. These membranes are filled with fluid that decreases the friction that occurs during breathing and movement.

Inhalation and Exhalation

Air moves into the body when it is inhaled. Air moves out of the body when it is exhaled. Although human beings are able to consciously control inhalation and exhalation, breathing is usually an automatic process. The autonomic systems of the body ensure that breathing will continue even when the individual is asleep. Even when the breathing process happens automatically, the body actively inhales and passively exhales. That is, muscles contract during inhalation and muscles relax during exhalation.

The muscles that are involved in breathing are:

1. **The diaphragm:** This is a large, dome-shaped sheet of muscle that lies below the lungs and above the stomach. The diaphragm is attached to the membrane that surrounds the lungs—the **pleura**. When the diaphragm

moves, the lungs move. During inhalation, the diaphragm contracts and moves down, pulling the lungs with it. This movement of the diaphragm causes the lung volume to increase because the lung tissue is pulled down. During exhalation, the diaphragm relaxes and moves up again, returning the lungs to their smaller size. Lung volume decreases, forcing air out of the nose or mouth.

2. The **intercostal muscles** that lie in between the ribs: These muscles are attached to the ribs and control their movement. During inhalation, intercostal muscles contract and move the ribs out and up. Since the pleura is attached to the ribs, lung volume increases and air is pulled into the body to fill the newly-created space. During exhalation, the intercostal muscles relax and the ribs move in and down. The lung volume decreases and air is forced out of the nose or mouth.

Respiratory Homeostasis

The human body must maintain homeostasis of the respiratory process. Breathing rate and breathing volume must both match the need that the body has at any one time for oxygen. During periods of stress or exercise, the body needs more oxygen because it needs more energy; the body also produces more carbon dioxide during these times and must rid itself of this waste gas. How does the body "recognize" that its need for oxygen has increased during stress or physical activity?

Specialized cells in the medulla oblongata of the brain are sensitive to oxygen and carbon dioxide levels. Oxygen **chemoreceptors** detect low levels of oxygen in the blood as it passes through this section of the brain. Carbon dioxide or acid chemoreceptors detect high levels of carbon dioxide. The carbon dioxide chemoreceptors are the main regulators of breathing movements.

When carbon dioxide levels in the blood reach a high level, the chemoreceptors are activated. They send a nervous message to the diaphragm and the intercostal muscles to contract and increase the breathing rate. This increase in the breathing rate causes a decrease of carbon dioxide levels in the blood. This inactivates the chemoreceptors and the breathing rate returns to normal.

There are also oxygen chemoreceptors located in the carotid artery and in the aorta. The carotid artery leads up the neck into the head. When these specialized cells detect low oxygen levels, they send a nervous message to the medulla oblongata. The brain then sends a nervous message to the diaphragm and intercostal muscles to increase the breathing rate. As a result, oxygen levels in the blood return to normal.

The carbon dioxide receptors are more sensitive to blood chemistry than the oxygen receptors are. Therefore, the oxygen receptors are actually a "back-up" system for the body as it maintains homeostasis. The oxygen receptors respond when oxygen levels fall and carbon dioxide levels remain within the normal range. An example of when this would occur is when you are at a high altitude where there is less oxygen in the air that you breathe. The carbon dioxide level would remain fairly normal. However, the oxygen levels in your blood would drop and the chemoreceptors in the carotid and aortic arteries would react, causing an increase in oxygen levels in the blood.

It is now time to complete **Learning Activity 3.4**. Please remember to check your answers with those found in the answer key.

Learning Activity 3.4

Human Respiration

1. Put the following terms in the correct order in which air moves through them during inhalation: larynx, bronchioles, pharynx, trachea, alveoli, bronchi, mouth or nose.
2. What are the two types of cells that control breathing rate? Where is each type located?
3. What effectors are called into action when the cells referred to in the previous question detect a change in oxygen or carbon dioxide levels in the blood? How are these effectors "notified" that they need to react?
4. Carbon monoxide is a deadly gas because it competes with oxygen for hemoglobin in the pulmonary capillaries that line the walls of the alveoli. In fact, hemoglobin more rapidly attaches to carbon monoxide than it does to oxygen. When the person affected inhales air with a dangerous level of carbon monoxide, the red blood cells in the pulmonary capillaries carry carbon monoxide to the body cells instead of oxygen. Why is this person's life at risk?

When you have completed this learning activity, proceed to **Assignment 3.2**. Remember to include it with your assignment packet that you mail in for marking with Module 3.

Assignment 3.2

Respiratory Homeostasis *(20 marks)*

1. Clearly explain in your own words how both oxygen chemoreceptors and carbon dioxide chemoreceptors work together to maintain respiratory homeostasis. Include information on the locations of these chemoreceptors, the stimuli that cause them to react, and the specific effects that these chemoreceptors have when they are stimulated. *(6 marks)*

2. Explain how the structure of the inner lining of the lungs is specially adapted to maximize gas exchange across it. *(3 marks)*

continued

Assignment 3.2 (continued)

3. What are the three ways that the term "respiration" is used in biology? What is the meaning of each of these three terms? *(6 marks)*

4. Describe the action of the diaphragm during inhalation and exhalation. *(4 marks)*

5. Name one structure of the respiratory system that is made up of cartilage. *(1 mark)*

Lesson 5: Circulatory and Respiratory Wellness

Lesson Focus

In this lesson, you will

- ❑ learn about three human medical conditions involving the circulatory system, respiratory system, or both
- ❑ identify the early symptoms of cardiovascular distress
- ❑ reflect on the personal lifestyle choices that you make now or could make in the future to improve your cardiovascular wellness

Introduction

Now that you have learned about the circulatory and respiratory systems in the first four lessons in this module, you will now learn about cardiovascular fitness. You will also learn about cardiovascular disorders, their symptoms, and treatment.

Heart Trauma

A **heart attack** can also be called a **myocardial infarction**. When a heart attack occurs, one of the three major coronary arteries (right coronary artery, left anterior descending coronary artery, or left circumflex artery) becomes partially or totally blocked. Usually, this occurs because a **blood clot** or **thrombus** is blocking it. A more rare cause of coronary occlusion is an artery spasm that shuts down blood flow to the heart. This can occur with cocaine use and severe emotional stress. Other rare causes of heart attack include sickle cell crisis, allergic reactions, carbon monoxide poisoning, extreme hypoxia (a shortage of oxygen in the body), and an unmet increased need for blood flow to the heart such as may occur during extreme physical exertion, shock, or hemorrhage. Heart cells can live for about 20 minutes without oxygen. The loss of oxygen-rich blood to the heart cells during a heart attack leads to cell damage, which may be permanent and lead to cell **necrosis** (death), depending on the severity of the attack and the amount of heart tissue that the blocked artery supplies. The area of infarction is where cell necrosis occurs, if it does occur. Surrounding it is the area of injury, which may or may not suffer permanent damage. The outermost affected area is weakened but regains function within two to three weeks.

It is possible that a myocardial infarction may lead to **cardiac arrest**; this term is used when the heart muscle literally stops pumping blood. Besides cardiac arrest, other possible complications of a heart attack include **cardiogenic shock**, which is when the heart is too weak to adequately pump blood. **Pulmonary edema**, where a weakened heart causes blood backup and leakage of plasma into the lungs, may also occur. Other complications include **arrhythmia** which is irregular beating of the heart, rupture of a heart wall or valve, or even death.

The primary cause of heart trauma is **coronary heart disease** and accompanying **atherosclerosis**, the hardening and narrowing of blood vessels. When atherosclerosis affects coronary arteries, it causes them to be lined with **plaque**, which is hardened material composed mainly of lipids, cholesterol, and calcium. Cholesterol is carried through the bloodstream by two main types of lipoproteins: **high-density lipoproteins (HDLs)** or "good cholesterol" and **low-density lipoproteins (LDLs)** or "bad cholesterol." It has been shown through research that HDLs help prevent heart disease by transporting lipids and cholesterol from the arteries to the liver. LDLs, which contain more fat and less protein, are unstable and stick to artery walls to help contribute to plaque formation.

The build-up of plaque is a gradual process. Over time, some of the plaque can develop a thick, hard, calcified fibrous cap and is called stable plaque. It causes the arteries to become narrower and harder. Sometimes, plaque formations can rupture, producing thrombosis, which may lead to a heart attack.

Signs of Cardiovascular Distress

The early signs that a heart attack will occur are highly variable. It is even possible for a person to experience a "silent" or asymptomatic heart attack. They differ significantly between men and women. Consider the following list of symptoms:

Women's Symptoms	Men's Symptoms
1. Angina (chest pain that may radiate into the jaw and down the left shoulder and arm)	1. Sudden immense pain or pressure in the chest centre (may persist or occur on and off)
2. Breathlessness (especially at night)	2. Pain that radiates from chest centre to neck, shoulders, and arms
3. Chronic fatigue (overwhelming)	3. Dizziness, nausea, sweating
4. Dizziness or even blackouts	4. Sudden onset of rapid heartbeat
5. Edema or swelling, especially in the ankles	
6. Fluttering, rapid heartbeat	
7. Pallor	
8. Gastric upset and sweating	

Asthma

Asthma is a respiratory system disease in which the bronchioles become inflamed and the airway becomes constricted. Excessive amounts of mucus block the pathway that air takes out of the body. More effort is required to exhale than to inhale. Often, asthma symptoms are triggered by

- allergens that cause swelling of the tissues that line the bronchioles
- stress
- upper respiratory infection
- physical exercise

A person experiencing asthma shows symptoms such as wheezing, shortness of breath, chest tightness, and coughing. In addition to wheezing, the patient may experience periods of rapid breathing, prolonged exhalation, rapid heart rate, and overinflation of the lungs.

During especially severe attacks, the patient may actually turn blue from lack of oxygen and may experience chest pain or loss of consciousness. It may even lead to respiratory arrest and death. Every year, about 500 Canadians die from asthma. Many of these patients could have survived with proper education and management of their symptoms.

Hypertension

Hypertension is also called high blood pressure. Hypertension causes the highest risk of stroke or heart attack than any other disease. Specifically, the blood pressure is abnormally high in the patient's arteries. Essential hypertension is high blood pressure that occurs with no known specific medical cause. Secondary hypertension is the result of another medical condition like kidney disease or cancer.

"Normal blood pressure" is somewhere between 115/75 mm Hg to 120/80 mm Hg. However, this measure is highly variable, both from patient to patient and from one period of time to the next. Many environmental factors affect blood pressure and may cause periodic jumps. Stress is caused by innumerable environmental factors. Other factors such as obesity, chosen occupation, alcohol intake, and even crowding may lead to elevated blood pressure readings. Hypertension becomes a concern when the reading is abnormally high and is consistently so.

Hypertension is often inherited; its heritability averages about 30%. More than 50 genes have been examined in association with hypertension. High blood pressure increases the risk of a number of other medical conditions including strokes, heart attack, heart failure, damage to the retina of the eye, and chronic renal (kidney) failure.

It is now time for you to complete **Learning Activity 3.5** for this module. Check your answers with the ones in the answer key once you have completed the exercise.

Learning Activity 3.5

Cardiovascular Wellness

Answer the following True or False questions about cardiovascular health and wellness. If you are unsure of an answer, you can use the information found at these three websites to help you:

The Public Health Agency of Canada
www.phac-aspc.gc.ca/ccdpc-cpcmc/cvd-mcv/index_e.html

The Heart and Stroke Foundation of Manitoba
www.heartandstroke.mb.ca

The Manitoba Lung Association
www.mb.lung.ca

Answer "T" or "F" for each of the statements found below:

________ 1. One of the risk factors of cardiovascular disease is physical inactivity.

________ 2. A diet high in fibre increases your risk of cardiovascular disease.

________ 3. Over time, hypertension can lead to hardening of arteries, which increases risk of heart attack.

________ 4. Congenital heart disease affects people 65 and over primarily.

________ 5. Consumption of egg yolks is not related to blood cholesterol levels.

________ 6. Nicotine in cigarettes elevates blood pressure and increases heart rate.

________ 7. Trouble speaking and vision problems are both early warning signs of stroke.

________ 8. Heart transplants in humans have not yet been successful.

continued

Learning Activity 3.5 (continued)

________ 9. The skin on chicken and turkey is a source of cholesterol; both should be removed before the chicken or turkey is consumed.

________ 10. If a person is experiencing early signs of heart attack, taking aspirin (ASA) may reduce the symptoms.

________ 11. Maintaining a healthy weight is one of the best ways to keep cardiovascular health.

________ 12. There are no effective treatments for sleep apnea.

________ 13. Eating fish more often can lower your blood cholesterol level.

________ 14. There is no way to treat a stroke even if early warning signs are recognized.

________ 15. Children whose mothers smoked while pregnant have a greater risk of having asthma.

________ 16. Over time, toxins found in cigarettes can cause hardening of the arteries, which increases risk of heart attack.

________ 17. Not all cholesterol is "bad" cholesterol.

________ 18. Cigarette smoke contains more than 4,000 toxic chemicals.

________ 19. Whole grain pasta can cause hypertension.

________ 20. Exposure to second-hand smoke can be equally as harmful as smoking.

When you have completed this learning activity, proceed to **Assignment 3.3**.

Assignment 3.3

Circulatory and Respiratory Wellness ***(20 marks total)***

Use the information that you have reviewed in this module, as well as any other sources you have access to. The Canadian Fitness and Lifestyle Research Institute website, among others, could be helpful for this assignment: www.cflri.ca/.

Reflect on the following questions and write two paragraphs:

1. What lifestyle choices can you identify in your own life that you would like to reconsider because of the effects they have on your circulatory and respiratory wellness? Name FIVE lifestyle choices that you want to change *(5 marks)* and explain why they are important to you to make *(5 marks)*.
2. What is your plan to accomplish those lifestyle goals? For each of the above goals, provide a specific action plan to help you implement the lifestyle change *(2 marks each)*. You may identify dietary changes, physical activity changes, ways of dealing with stress, etc. There should be FIVE parts to your action plan, one for each lifestyle change you hope to accomplish.

The assignment should be clearly written and should be free of grammatical and spelling errors.

continued

Assignment 3.3 (continued)

Module 3 Summary

Congratulations! By completing the Module 3 and writing your midterm examination, you will have completed half of the course!

Lesson 6: Midterm Examination Review isprovided to help you prepare for your midterm examination while you wait to receive your feedback from your tutor/marker.

Submitting Your Assignments

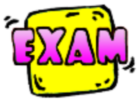
It is now time for you to submit the Module 3 assignments to the Distance Learning Unit so that you can receive some feedback on how you are doing in this course. Remember that you must submit all the assignments in this course before you can receive your credit.

Make sure you have completed all parts of your Module 3 assignments and organize your material in the following order:

- Module 3 Cover Sheet (found at the end of the course Introduction)
- Assignment 3.1: Experiment: Effect of Exercise on Heart Rate
- Assignment 3.2: Respiratory Homeostasis
- Assignment 3.3: Circulatory and Respiratory Wellness

For instructions on submitting your assignments, refer to How to Submit Assignments in the course Introduction.

Midterm Examination



Congratulations, you have finished Module 3 in the course. The midterm examination is out of 100 marks and worth 20% of your final mark. In order to do well on this examination, you should review all of your learning activities and assignments from Modules 1 to 3.

You will complete this examination while being supervised by a proctor. You should already have made arrangements to have the examination sent to the proctor from the Distance Learning Unit. If you have not yet made arrangements to write it, then do so now. The instructions for doing so are provided in the Introduction to this module.

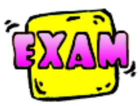
A maximum of 2.5 hours is available to complete your midterm examination. When you have completed it, the proctor will then forward it for assessment. Good luck!

Lesson 6: Midterm Examination Review

Lesson Focus

This lesson does not address any specific learning outcomes.

Introduction



You are now ready to write the midterm examination, which is based on Modules 1 to 3. When you have completed Module 6, you will write the final examination, which is based on Modules 4 to 6. The midterm and final examinations are each worth 20 percent of the final mark for this course, for a total of 40 percent.

This lesson suggests some strategies you can use to study for the midterm examination now that you have finished Module 3. It also explains the examination format. You will learn what types of questions will appear on the midterm examination and what material will be assessed. Remember, your mark on the midterm examination determines 20 percent of your final mark in this course.

Instructions for making arrangements to write the midterm examination are provided below, as well as in the course Introduction.

Making Arrangements

You are responsible for making arrangements to have the midterm examination sent to your proctor from the Distance Learning Unit. Please make arrangements to write the midterm examination. When you write your examination, you will be supervised by a proctor.

To write your examinations, you need to make the following arrangements:

- **If you are attending school,** your examination will be sent to your school as soon as all the applicable assignments have been submitted. You should make arrangements with your school's ISO school facilitator to determine a date, time, and location to write the examination.

- **If you are not attending school,** check the Examination Request Form for options available to you. Examination Request Forms can be found on the Distance Learning Unit's website, or look for information in the learning management system (LMS). Two weeks before you are ready to write the examination, fill in the Examination Request Form and mail, fax, or email it to

  Distance Learning Unit
  500–555 Main Street
  PO Box 2020
  Winkler MB R6W 4B8
  Fax: 204-325-1719
  Toll-Free Telephone: 1-800-465-9915
  Email: distance.learning@gov.mb.ca

Study Strategies

In preparing for the midterm examination, use the following study strategies:

- **Review all learning activities and assignments:** Revisit the work you completed in Modules 1 to 3. You could answer the questions in those exercises again, and then compare your answers with your original responses and with the Learning Activity Answer Key provided at the end of each module and with your tutor/marker's assessment of your completed assignments.
- **Review vocabulary:** A review of vocabulary terms is also an effective way to review concepts. You could practise defining terms from Modules 1 to 3, perhaps by using index cards (using one side for a term and the other side for its definition). Keep in mind that one section of the examination asks you to connect pairs of terms by explaining how they are related, so try to connect vocabulary terms to one another as you study their definitions.
- **Review/study concepts including but not limited to the following**—please remember that the following list is only a **partial** list:
  - homeostasis—its dependence on negative feedback systems
  - characteristics of living organisms
  - aspects of personal wellness and health
  - cell structure as it is related to homeostasis
  - the organ systems in the human body and their structures and function
  - the structures in the human digestive system
  - the types of nutrients and how the body utilizes each of them
  - the structure and function of enzymes

- the cell types in the human circulatory system
- the structures in the human circulatory system
- the meanings of the term "respiration"
- human blood types and blood transfusions

Please call or email your tutor/marker if you have any questions or concerns about the examination or any content in Modules 1 to 3. Good luck.

Examination Format

The midterm examination consists of the following six types of questions, the values of which combine to a total of 100 marks. You have a maximum of 2.5 hours to complete your examination.

True or False ***(15 marks)***

In this section of the examination, you will decide whether each of the 15 statements is true or false, and you will indicate your choice by printing either T or F in the space provided for each statement.

Multiple Choice ***(15 marks)***

In this section, you will choose the single best answer to each of the questions given.

Matching ***(15 marks)***

In this section, you will match a list of 15 terms with their corresponding definitions. Each definition will be used only once.

Fill-in-the-Blanks ***(15 marks)***

In this section, you will use the correct word or words to complete statements in a paragraph.

Definitions and Connections ***(10 marks)***

In this section, you will choose five pairs of terms (out of seven pairs given). For each pair, you will define each term and then explain how the two terms are related.

Long Answer ***(30 marks)***

In this section, you will choose six long-answer questions (of the eight questions given). You will be asked to answer each selected question clearly and thoroughly in the space provided.

Summary

Good luck as you prepare for the midterm examination. If you have completed all the learning activities and assignments from Modules 1 to 3, and have used the suggested strategies in studying for the examination, you have prepared yourself well. The examination will provide an opportunity for you to show what you know.

Grade 11 Biology (30S)

Module 3

Learning Activity Answer Key

Module 3
Learning Activity Answer Key

Learning Activity 3.1: Experimental Design

Brainstorm the following elements to help you design your experiment:

1. What exercise(s) can you accomplish easily and use to measure heart rate? How long will you do this exercise in order to raise your resting heart rate?

   Examples: jumping, push-ups, skipping rope, etc.

   Exercise for 2-5 minutes continuously before recording heart rate data.

2. Measure your resting heart rate—in other words, your heart rate when you are sitting and are relaxed. This measurement will be in "beats per minute" (BPM).

   Answers will vary, but should be below 100 BPM.

3. How will you measure your heart rate? When will you measure your heart rate during and after the experiment?

   Measurements can be taken at the wrist, the neck, or using a heart rate monitor.

   Measurements can be taken at whatever interval you choose.

4. What are the independent, dependent, and controlled variables in this experiment?

   Independent variable: **time and type of continuous exercise**

   Dependent variable: **heart rate**

   Controlled variables: **external temperature, amount of clothing worn during activity, etc. (any conditions that are kept constant from one trial to the next)**

5. Design a data table to help you record your heart rate information.

   Example:

Time Interval	Heart Rate (BPM)
Immediately after activity	
30s after activity	
60s after activity	
90s after activity	

6. Complete the following statements involving scientific experimentation:
   a. Science as a discipline is only able to address questions involving information that can be __**observed**__ and can be subject to __**experimentation or testing**__.
   b. A specific and clearly stated __**question**__ is the beginning of any scientific investigation.
   c. In a sound experimental design, there is only one experimental __**variable or factor**__ involved.
   d. The __**independent**__ variable is the quantity that will be changed in the experiment by the person or people conducting the investigation.
   e. The __**dependent**__ variable is the quantity that is observed and measured if and when it changes during the experiment.
   f. An "educated guess" in science is a(n) __**hypothesis**__.
   g. An "if-then" statement is a good format for the __**hypothesis**__ to be stated in.
   h. Variables in an experiment that are not allowed to change but are kept constant are called __**controlled**__ variables.
   i. A good experiment is most reliable when it is repeated __**many, several**__ times.
   j. During the course of an experiment, it is important that accurate __**measurements**__ and careful __**observations**__ be recorded.

Learning Activity 3.2: Blood

Part A: "Blood Donation Practices"

The following questions can be answered using information presented by the Canadian Blood Services website referred to in this lesson.

1. Donors must be within what age range if they are regular donors? They must be within what age range if they are first-time donors?

   Regular donors: 17 – 71 **First-time donors: 17 – 61**

2. What is the minimum weight (in kilograms) allowed for a potential blood donor to be eligible to donate?

   Minimum weight is 50 kg. (110 lb.)

3. What is the minimum interval (in days) permitted between blood donations?

   56 days

4. What restrictions apply to donors who have had recent dental work?

   For cleaning or dental filling: the day after is acceptable. For extraction, root canal, or dental surgery: 72 hours given full recovery.

5. What restrictions apply to potential donors who have an ear or body piercing or tattooing?

   Cannot donate for 6 months following the procedure.

6. What is “leukoreduction” and when is it done?

   White blood cells are removed because they often carry viruses and bacteria that could be detrimental to the recovery of the recipient. It is done for all whole blood donations.

7. What is “plasmapheresis” and when is it done?

   Whole blood is processed through an apheresis machine that extracts plasma. The rest of the blood is returned to the donor.

8. What is “plateletpheresis” and when is it done?

   Whole blood is processed through an apheresis machine that extracts platelets. The rest of the blood is returned to the donor.

9. What is the Unrelated Bone Marrow Donor Registry (UBMDR)?

   This registry keeps track of blood proteins that make a donor’s blood unique. It is used to identify potential bone marrow donors if a transplant is needed.

10. What are some reasons why someone may need a blood transfusion?

    People who may need transfusions include: victims of accidents, surgical patients, cancer patients, patients who receive burn therapy or have hemophilia or other blood-related diseases.

11. How much blood does the average adult possess? How much blood does the average recipient receive when blood is required?

    On average, about 5 litres. When blood is received, it is usually about 450 ml x 4.6 = 2.1 litres.

12. What are some of the reasons why someone may need a blood plasma transfusion?

    Patients who may need plasma transfusions include people with the following conditions: some bleeding disorders, liver diseases, shock, some operations, cancer, and bone marrow therapy.

13. Why would a patient require a transfusion of blood platelets?

    Patients with prolonged bleeding associated with some diseases like cancer need large quantities of platelets as part of their treatment.

14. What is HIV? How does Canadian Blood Services make sure that blood distributed to hospitals is free from HIV?

    HIV is the virus that causes AIDS. HIV (human immunodeficiency virus) attacks the immune system, resulting in a chronic, progressive illness and leaving infected people vulnerable to opportunistic infections and cancers. Canadian Blood Services tests every donation for HIV. Two tests are used. Only blood that passes both tests is distributed to hospitals.

Part B: Human Blood Types

1. Complete the following chart involving the human blood types. *(16 marks total – ½ mark per cell in the table)*

Blood Group	Antigens Present	Antibodies Present	Possible Donors for this Recipient	Possible Recipients for this Donor
A+	**A, Rh**	**Anti-B**	**A+, A-, O+, O-**	**A+, AB+**
A-	**A**	**Anti-B, Anti-Rh**	**A-, O-**	**A+, A-, AB+, AB-**
B+	**B, Rh**	**Anti-A**	**B+, B-, O+, O-**	**B+, AB+**
B-	**B**	**Anti-A, Anti-Rh**	**B-, O-**	**B+, B-, AB+, AB-**
AB+	**A, B, Rh**	**None**	**A+, B+, O+, AB+, A-, B-, O-, AB- (all)**	**AB+**
AB-	**A, B**	**Anti-Rh**	**A-, B-, AB-, O-**	**AB+, AB-**
O+	**O, Rh**	**Anti-A, Anti-B**	**O+, O-**	**A+, B+, O+, AB+**
O-	**O**	**Anti-A, Anti-B, Anti-Rh**	**O-**	**A+, A-, B+, B-, AB+, AB-, O+, O- (all)**

2. Complete the following chart involving the cells found in human blood. *(15 marks – 1 mark per cell)*

	Erythrocytes	Leucocytes	Platelets
Functions	**carry oxygen (hemoglobin)**	**destroy invading organisms (phagocytosis); produce antibodies**	**initiate the clotting process**
Appearance	**disk-shaped, biconcave, red**	**irregular in shape**	**small, fragile, irregular in shape**
Origin	**bone marrow**	**bone marrow**	**bone marrow**
Number	**about 5 million cells per millilitre of blood**	**about 7,000 cells per millilitre of blood**	**150,000 to 400,000 per millilitre of blood**
Relative Size	**about 7 μm in diameter (1 μm = 1 micrometre = 10^{-6} metre)**	**about twice as large as red blood cells; 12 – 15 μm in diameter**	**very small – about 2 to 4 μm in diameter**

Learning Activity 3.3: The Circulatory System

Part A: Human Circulation

Use the following bank of terms to complete each statement given below. Terms may be used more than once. Not all terms are used.

arteries	veins	capillaries	septum
venules	arterioles	systole	diastole
blood pressure	oxygen	carbon dioxide	mitral
tricuspid	pulmonary	vena cava	cardiac
atrium	ventricle	aorta	SA-node
sympathetic	parasympathetic	adrenaline	baroreceptors

1. One of the substances that moves from the capillaries **out** into body cells carrying on cellular respiration is **oxygen**.
2. The **largest artery** in the body is the **aorta**.
3. The superior and inferior **vena cava** carry blood into the right atrium of the heart.
4. Larger veins branch into smaller veins called **venules**.

5. The wall that separates the right and left sides of the heart is the **septum**.
6. As blood moves from the left atrium to the left ventricle, it passes through the **mitral** valve.
7. The muscle in the heart is called **cardiac** muscle.
8. Blood in the right ventricle is pumped out through the **pulmonary** valve and into the **pulmonary** arteries.
9. Nerves that cause an increase in tissue activity are called **sympathetic** nerves.
10. The **SA-node** is also called the heart's pacemaker.
11. If a person's blood pressure reading is 125/85, the "125" indicates the pressure during **systole** and the "85" indicates the pressure during **diastole**.
12. If blood pressure becomes too high, specialized cells called **baroreceptors** sense the increase in pressure and they send a message to the brain telling it to "turn on" the **parasympathetic** nerves so that pressure will fall.
13. The upper chamber of the heart that sends blood into the right ventricle is the right **atrium**.
14. A hormone that is produced by the adrenal glands is **adrenaline**; it causes an increase in heart rate.
15. One of the substances that moves **from** the body cells into the capillaries is a waste product: **carbon dioxide**.

Part B: Comparing Vessels

1. Complete the chart below that compares arteries, veins, and capillaries.

Type of vessel	Artery	Vein	Capillary
Direction of Blood Flow	**away from the heart**	**toward the heart**	**between arteries and veins**
Thickness	**thick (three layers)**	**thin (one layer)**	**very thin**
Type(s) of Tissue	**two tough, rigid layers of connective tissue surround a middle layer made of smooth muscle**	**very little smooth muscle tissue, no connective tissue**	**no connective tissue or smooth muscle tissue**
Blood Pressure	**high – blood has just been forcibly pumped by the heart**	**low – decreases as blood nears the heart**	**very narrow so blood pressure is high**
Gas Exchange, if any	**none**	**none**	**exchange of oxygen and carbon dioxide gases**
Presence of valves	**none**	**present – help direct blood back to the heart**	**none**

2. What action helps blood move through the veins?

   skeletal muscle contractions

3. For each of the following vessels, comment on the oxygen content of the blood found there:

   Artery: **high**

   Vein: **low**

   Capillary: **decreasing**

4. For each of the following vessels, comment on the carbon dioxide content of the blood found there:

   Artery: **low**

   Vein: **high**

   Capillary: **increasing**

Learning Activity 3.4: Human Respiration

1. Put the following terms in the correct order in which air moves through them during inhalation: larynx, bronchioles, pharynx, trachea, alveoli, bronchi, mouth, or nose.

   mouth or nose, pharynx, larynx, trachea, bronchi, bronchioles, alveoli

2. What are the two types of cells that control breathing rate? Where is each type located?

   oxygen chemoreceptors—in the carotid and aortic arteries

3. What effectors are called into action when the cells referred to in the previous question detect a change in oxygen or carbon dioxide levels in the blood? How are these effectors "notified" that they need to react?

   The effectors called into action are the diaphragm and the intercostals muscles. They are both told to contract or relax through a nervous system message from the brain.

4. Carbon monoxide is a deadly gas because it competes with oxygen for hemoglobin in the pulmonary capillaries that line the walls of the alveoli. In fact, hemoglobin more rapidly attaches to carbon monoxide than it does to oxygen. When the person affected inhales air with a dangerous level of carbon monoxide, the red blood cells in the pulmonary capillaries carry carbon monoxide to the body cells instead of oxygen. Why is this person's life at risk?

   Cellular respiration cannot occur without oxygen. Carbon monoxide is useless to body cells and cannot be used in respiration. The body is unable to carry on cellular respiration and break down food molecules for energy. Without a supply of energy, cells die.

Learning Activity 3.5: Cardiovascular Wellness

Answer the following true or false questions about cardiovascular health and wellness. If you are unsure of an answer, you can use the information found at these three websites to help you:

The Public Health Agency of Canada
www.phac-aspc.gc.ca/ccdpc-cpcmc/cvd-mcv/index_e.html

The Heart and Stroke Foundation of Manitoba
www.heartandstroke.mb.ca

The Manitoba Lung Association
www.mb.lung.ca

Answer "T" or "F" for each of the statements found below:

T 1. One of the risk factors of cardiovascular disease is physical inactivity.

F 2. A diet high in fibre increases your risk of cardiovascular disease.

T 3. Over time, hypertension can lead to hardening of arteries, which increases risk of heart attack.

F 4. Congenital heart disease primarily affects people 65 and over.

F 5. Consumption of egg yolks is not related to blood cholesterol levels.

T 6. Nicotine in cigarettes elevates blood pressure and increases heart rate.

T 7. Trouble speaking and vision problems are both early warning signs of stroke.

F 8. Heart transplants in humans have not yet been successful.

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T 15. Children whose mothers smoked while pregnant have a greater risk of having asthma.

T 16. Over time, toxins found in cigarettes can cause hardening of the arteries, which increases risk of heart attack.

T 17. Not all cholesterol is "bad" cholesterol.

T 18. Cigarette smoke contains more than 4,000 toxic chemicals.

F 19. Whole grain pasta can cause hypertension.

T 20. Exposure to second-hand smoke can be equally as harmful as smoking.

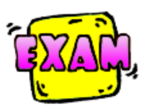
Notes

Lesson 6: Midterm Examination Review

Lesson Focus

This lesson does not address any specific learning outcomes.

Introduction



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Instructions for making arrangements to write the midterm examination are provided below, as well as in the course Introduction.

Making Arrangements

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Study Strategies

In preparing for the midterm examination, use the following study strategies:

- **Review all learning activities and assignments:** Revisit the work you completed in Modules 1 to 3. You could answer the questions in those exercises again, and then compare your answers with your original responses and with the Learning Activity Answer Key provided at the end of each module and with your tutor/marker's assessment of your completed assignments.

- **Review vocabulary:** A review of vocabulary terms is also an effective way to review concepts. You could practise defining terms from Modules 1 to 3, perhaps by using index cards (using one side for a term and the other side for its definition). Keep in mind that one section of the examination asks you to connect pairs of terms by explaining how they are related, so try to connect vocabulary terms to one another as you study their definitions.

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  - homeostasis—its dependence on negative feedback systems
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  - the structures in the human digestive system
  - the types of nutrients and how the body utilizes each of them
  - the structure and function of enzymes

- the cell types in the human circulatory system
- the structures in the human circulatory system
- the meanings of the term "respiration"
- human blood types and blood transfusions

Please call or email your tutor/marker if you have any questions or concerns about the examination or any content in Modules 1 to 3. Good luck.

Examination Format

The midterm examination consists of the following six types of questions, the values of which combine to a total of 100 marks. You have a maximum of 2.5 hours to complete your examination.

True or False ***(15 marks)***

In this section of the examination, you will decide whether each of the 15 statements is true or false, and you will indicate your choice by printing either T or F in the space provided for each statement.

Multiple Choice ***(15 marks)***

In this section, you will choose the single best answer to each of the questions given.

Matching ***(15 marks)***

In this section, you will match a list of 15 terms with their corresponding definitions. Each definition will be used only once.

Fill-in-the-Blanks ***(15 marks)***

In this section, you will use the correct word or words to complete statements in a paragraph.

Definitions and Connections ***(10 marks)***

In this section, you will choose five pairs of terms (out of seven pairs given). For each pair, you will define each term and then explain how the two terms are related.

Long Answer ***(30 marks)***

In this section, you will choose six long-answer questions (of the eight questions given). You will be asked to answer each selected question clearly and thoroughly in the space provided.

Summary

Good luck as you prepare for the midterm examination. If you have completed all the learning activities and assignments from Modules 1 to 3, and have used the suggested strategies in studying for the examination, you have prepared yourself well. The examination will provide an opportunity for you to show what you know.

Grade 11 Biology (30S)

Module 4

Excretion and Waste Management

This module contains the following:

- Introduction
- Lesson 1: Introduction to Waste Management
- Lesson 2: The Human Urinary System
- Lesson 3: Excretory Homeostasis
- Lesson 4: Urinalysis and Urinary Wellness
- Module 4 Summary

Module 4: Excretion and Waste Management

Introduction

Welcome to Module 4. In Module 2, you learned how the digestive system delivers the necessary food molecules to all body cells so that they can carry on the process of cellular respiration. In Module 3, you learned about how the respiratory system functions to deliver oxygen molecules to all body cells so that they can carry on their vital processes. Both of those body systems depend on the blood to carry vital materials to every body cell, and both systems maintain homeostasis on the human body.

In this module, you will learn about how the human body eliminates the waste materials that are produced during the process of cellular respiration.

Assignments in Module 4

When you complete Module 4, you will submit your Module 4 assignments to the Distance Learning Unit either by mail or electronically through the learning management system (LMS). The staff will forward your work to your tutor/marker.

Lesson	Assignment Number	Assignment Title
3	Assignment 4.1	Osmoregulation
4	Assignment 4.2	Urinalysis and Kidney Transplantation

Notes

Lesson 1: Introduction to Waste Management

Lesson Focus

In this lesson, you will

- ❑ identify the metabolic wastes from the human body and name the source(s) of each of those metabolic wastes
- ❑ identify the structures that are specialized to eliminate metabolic wastes
- ❑ explain how the process of waste management helps to maintain homeostasis, particularly explaining the role of the liver

Introduction

This first lesson is an introduction to the process that the body uses to eliminate the waste produced during cellular respiration. If these waste products were to accumulate in the human body over time, they would effectively act as poisons. Therefore, the body must be equipped to recognize wastes, collect them, and then rid itself of them.

You know from previous modules that living things require energy to carry on vital life processes. Humans, like all animals, obtain this energy source by ingesting food molecules. These **complex organic molecules** are then broken down into **smaller molecules** in a series of catabolic reactions. The chemical bond energy released in the process is temporarily stored in the form of ATP. The cells in the human body then use ATP to perform the necessary life processes, such as growth and repair, that involve a series of anabolic reactions as new molecules are synthesized. The problem is that most of the smaller molecules that are by-products of cellular respiration are harmful to the body and must be effectively eliminated.

Waste Products

There are five primary metabolic wastes that are produced by the body:

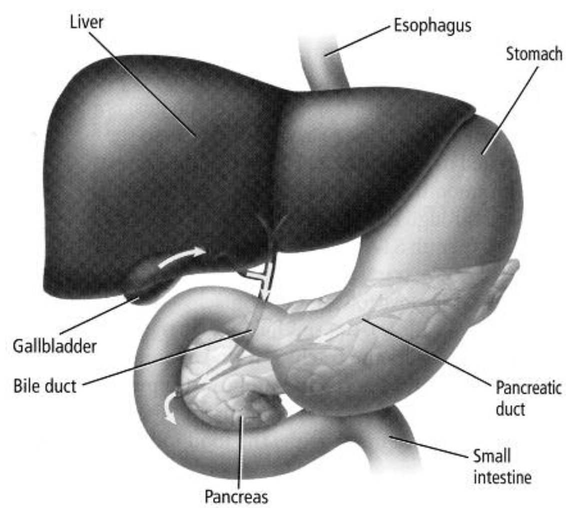
- **Ammonia:** Recall that proteins are broken down by enzymes (called proteases) into smaller units called amino acids. All amino acids are made of nitrogen-containing **amino groups**. When proteins are broken down for energy, or converted to carbohydrates or fats, the nitrogen is removed in a process called deamination. The nitrogenous waste product that remains is called **ammonia**, a small and extremely toxic molecule. Only 0.005 mg of ammonia is fatal to a human being and would have to be diluted with huge amounts of water to be excreted. In the human body, the liver converts ammonia into a much less toxic molecule—urea. Some animals excrete their ammonia directly while others must convert it to a less toxic form of waste.
- **Urea:** In the liver, ammonia is converted into **urea**. This form of nitrogenous waste can be handled in a much more concentrated form because it is about 100,000 times less toxic than ammonia. Excreting urea instead of ammonia enables an organism to conserve more water, which is important to hydration and osmoregulation. In the liver, two molecules of ammonia and one molecule of carbon dioxide are combined to form **urea**. It is then released back into the bloodstream and is later filtered out of the blood by the **kidneys**. It is excreted from the body in the form of urine, which is produced by the kidneys, and in the form of sweat, which is eliminated by the **skin**. Although it is toxic to the body, urea is much less toxic than ammonia. The human body also produces uric acid which is a by-product of the breakdown of nucleic acids.
- **Mineral Salts:** Through the ingestion of food and water, humans acquire many mineral salt molecules that are not needed for life processes. They must be recognized, filtered out, and eliminated from the body. The body maintains careful control over the concentration of various mineral salts in the blood. Mineral salts are necessary for many cellular processes and must be at adequate levels in the blood. Excess mineral salts are excreted from the body by the **kidneys** in the form of urine, and by the **skin** in the form of sweat.
- **Carbon Dioxide:** You have learned that carbon dioxide gas is the by-product of many different catabolic reactions. Carbon dioxide gas that is dissolved in the blood is a toxin, in the form of carbonic acid. Carbon dioxide must be eliminated from the cells that produce it and from the blood that carries it back to the **lungs**. When carbon dioxide-rich blood reaches the alveoli in the lungs, carbon dioxide diffuses out of the capillaries and into the lungs so that it can be exhaled as gas.

- **Water:** Water is a substance that must be kept in careful balance by the body. Water is ingested and then used in many ways by the human body. It is necessary as a solvent, as a reactant in many cellular chemical reactions, and as a means of transportation within the body. Excess water, however, must be eliminated from the body and is often used again as a mode of transportation for other waste molecules dissolved in it. The body maintains water balance by eliminating excess water in the forms of urine, sweat, and moist air exhaled from the lungs. Urine becomes more concentrated when the body needs to conserve water, and becomes more diluted when there is an excess of fluid to excrete.

  In the human body, the **kidneys** and the **intestines** continuously reabsorb water. Most reabsorption of water occurs with uptake of nutrients along the small intestine. The colon, or large intestine, then reabsorbs most of the water that remains from the digestion process. Together, the small and large intestines reabsorb about 90% of the water that enters the digestive tract.

The Role of the Liver

Only one human organ is larger than the liver—the skin. The liver is a very important organ whose functions are essential for life. One of the most important functions of the liver is the elimination of harmful substances that have been ingested or inhaled. Toxins may enter the body through the food you consume, the water you drink, or the air you breathe. Examples of such toxins include fertilizers, automobile emissions, pesticides, industrial contaminants, and food additives. The liver effectively changes many harmful substances into less toxic forms that can safely be eliminated from the body.



The Liver: Reprinted from *Biology* by Glencoe Science. New York, NY: McGraw-Hill, 2007. p. 1022. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff.*

The liver uses a two-level detoxification process to eliminate wastes from the body:

1. **Phase One:** The body's enzymes act on toxins that are in the blood to make those molecules less toxic.

2. **Phase Two:** Other enzymes act to convert toxins to more water-soluble forms that can be eliminated either through urine or through solid waste. This involves a process called "conjugation" in which toxic substances are chemically combined with other molecules in the body. The resulting substance is then eliminated safely from the body.

Recall that bile is produced by the liver and temporarily stored in the gall bladder. It is then sent to the small intestine where it acts to emulsify fat molecules. Bile is also used as a vehicle to transport toxins into the small intestine. Once in the digestive system, those toxins are excreted in solid waste (stool or feces).

If the liver is not functioning, toxins can build up in the bloodstream. Eventually, those toxins are stored in fatty tissue—especially in the brain and central nervous system. They can be released and circulate again throughout the body, causing several health problems. Toxins and various environmental chemicals have been linked to cancer development, immune system failure or dysfunction, heart disease, and neurological diseases such as Alzheimer's, dementia, and Parkinson's disease.

Please work now on completing **Learning Activity 4.1**. Remember to check your answers in the answer key at the end of this module.

Learning Activity 4.1

Overview of Waste Management

1. Why is solid excrement (feces or stool) not included in the list of metabolic wastes listed in this lesson?
2. Complete the chart below:

Waste Product	Origin of Waste Product	Excretory Organ
Ammonia		
Urea		
Mineral Salts		
Carbon Dioxide		
Water		

continued

Learning Activity 4.1 (continued)

3. Explain the role of the liver in the excretion of toxins.
4. Complete the following table, placing all the terms under the heading(s) that they relate to. You can use the terms in more than one category and in any order.

Ammonia	Enzyme(s)	Water	Protein(s)	Excretory
Carbon Dioxide	Urea	Mineral Salt(s)	Toxin(s)	Urine

Lungs	Skin	Intestines	Kidney	Liver

5. Answer the following questions about the excretion of metabolic wastes:
   a. List all the substances that are excreted by the skin.
   b. What organ excretes carbon dioxide gas?
   c. What organ is responsible for deactivating toxins in the body, and then excreting them?
   d. Which organs re-absorb water back into the body?
   e. Which organs excrete extra water that the body does not need?
   f. Why does the body not directly excrete ammonia?

LESSON 2: THE HUMAN URINARY SYSTEM

Lesson Focus

In this lesson, you will

- ❑ learn to identify the structures that make up the human urinary system on a diagram
- ❑ explain the functions performed by each of those structures
- ❑ discuss the three processes that occur in each nephron of the kidney—filtration, reabsorption, and secretion

Introduction

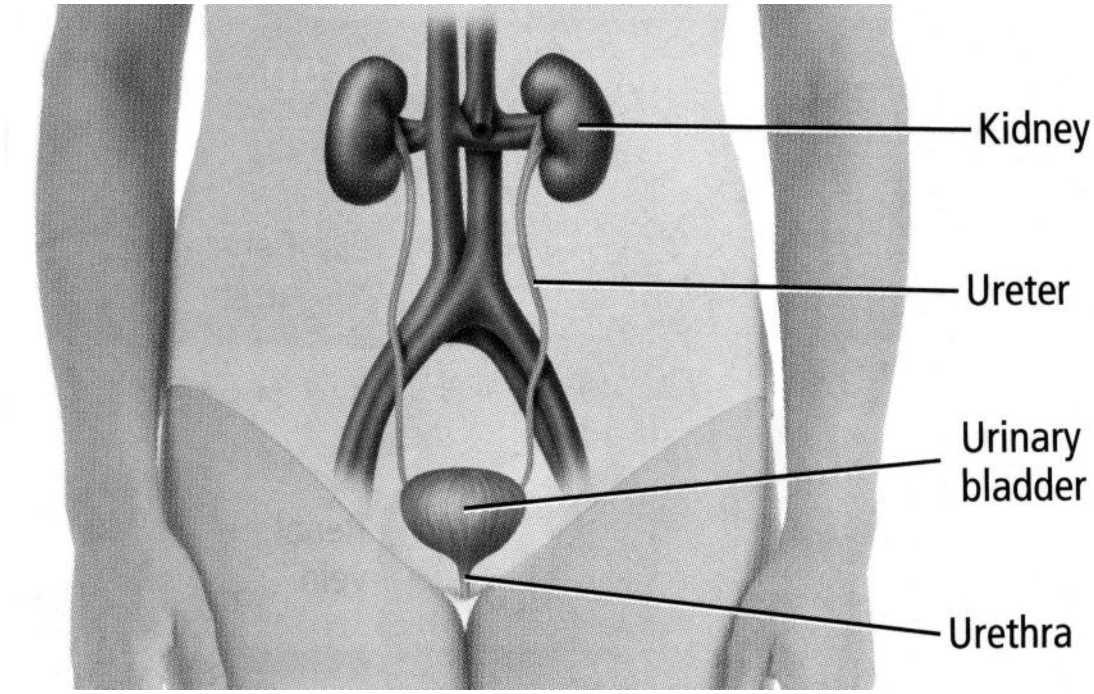
Now that you have learned about waste management in general terms, it's time to examine some of the specifics. You'll start by studying the human urinary system.

Before looking at the structures that make up the human urinary system, it is important to recall the overall function of this body system. Waste products build up in the blood because living cells produce them as by-products of metabolic reactions. In some cases, waste products are ingested in food and drink, or inhaled in the air. In all cases, if these waste products were not filtered out of the blood and eliminated, they would poison the body. In the previous lesson, you read an overview of the five types of metabolic wastes that the body must recognize, collect, and eliminate.

The Human Urinary System

The urinary system is the organ system that filters impurities and waste molecules out of the blood and eliminates them from the body. The organ that is specialized to carefully filter out unneeded and harmful molecules is the kidney.

Normally, humans possess two kidneys—one on either side of the spinal column and in the back of the body just below the waist.



Organs of Excretion: Reprinted from *Biology* by Glencoe Science. New York, NY: McGraw-Hill, 2007. p. 1005. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff.*

Each kidney weighs about 0.5 kg and is “bean-shaped.” **Renal arteries** branch off of the descending aorta and supply the kidneys with a blood supply. At any one time, the kidneys may hold about one-quarter of the body’s blood. Each kidney receives an arterial blood supply that is rich in oxygen and also rich in waste molecules. Blood is filtered by the kidneys and then returns to the circulatory pathway through **renal veins**.

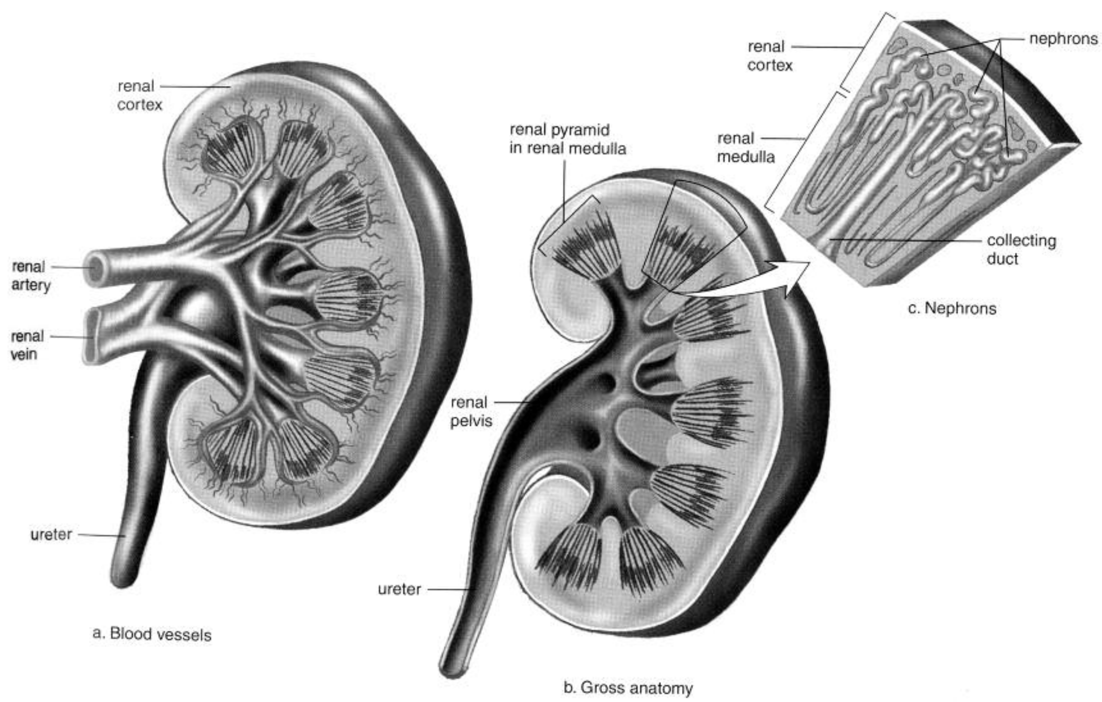
The waste products that the kidneys screen out of the blood are dissolved in water, which has also been filtered out of the blood. This liquid waste is then sent from the kidneys to the **urinary bladder** for temporary storage. The left and right **ureters** are the tubes through which liquid waste travels between the kidneys and the urinary bladder. The **urinary sphincter muscles** are at the base of the urinary bladder and allow it to store urine until it can be excreted through the **urethra**.

When the urinary bladder has been stretched to hold about 200 mL of urine, sensory cells fire messages to the brain communicating the need to urinate. The fuller the bladder becomes, the more sensory cells are firing—and the more urgent the message to the brain becomes.

The urinary system is somewhat different in males and females. In males, the urethra passes through the penis. The urethra carries both urine and semen out of the body, and is therefore shared by the reproductive and excretory systems. In females, the urethra has a separate body opening from the reproductive tract, near the vagina. In addition, the urethra in males is longer than it is in females, making females more prone to urinary tract infections.

The Structure of the Kidney

If you were to take a cross-section of the human kidney, you would see a structure that resembled the following diagram:



Kidney: Reprinted from *Inquiry into Life* by Sylvia S. Mader. New York, NY: McGraw Hill, 2003. p. 305. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

An outer layer of connective tissue is called the **cortex**. An inner layer, the **medulla**, is located beneath the cortex and toward the centre of each kidney. A hollow chamber in the centre of each kidney, the **renal pelvis**, is connected to the ureter and serves to collect urine before it is sent to the urinary bladder. The renal artery leads into the kidney and the renal vein leads out of the kidney.

The outer layer of the kidney is fibrous and tough, protecting the kidney from injury. The entire kidney is also surrounded by a layer of fatty tissue to further protect it.

The renal medulla of each kidney contains about one million slender tubules called **nephrons**. The microscopic nephron is the functional unit of the kidney. It is the site of renal function as the kidney filters impurities and unnecessary materials from the blood.

The Nephron

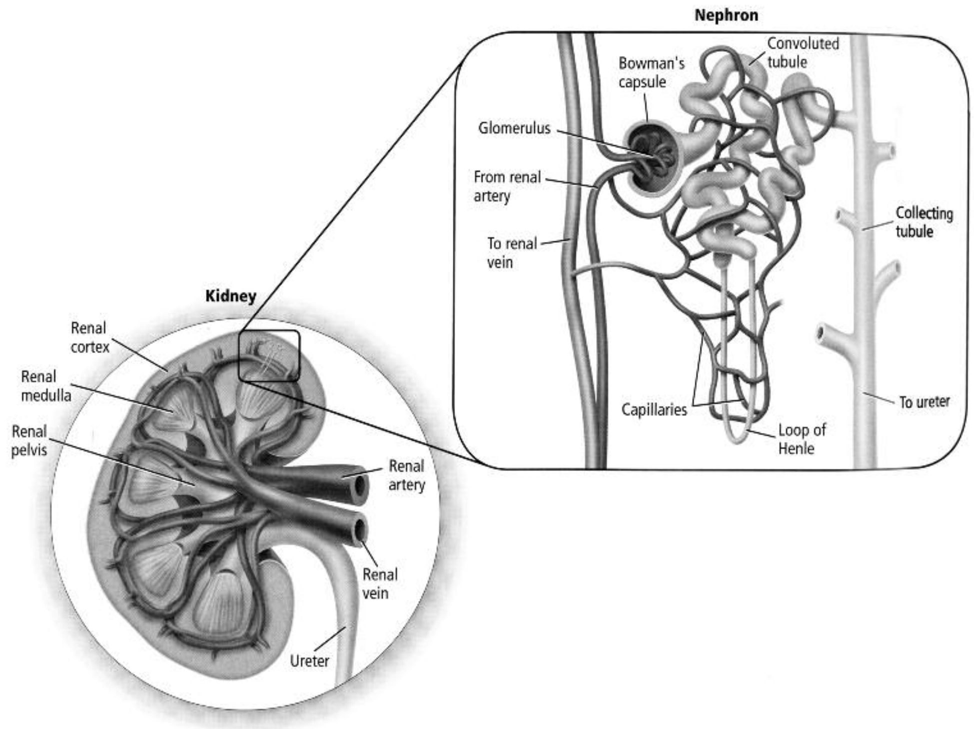
The functional unit of the kidney is the nephron, and each kidney contains about a million of them. Each microscopic nephron has the important function of filtering materials out of the blood and then sending the filtrate on to a collecting area, the renal pelvis. Every nephron must identify which materials should be removed from the blood and which materials should be left in the blood. It must also determine how much water is filtered out of the blood; this water maintenance function is crucial if homeostasis is to be achieved. From the 1100 to 2000L of blood that circulate through the kidneys each day, the nephrons process about 1.5L of urine.

Composition of plasma, filtrate, and urine (each in g/100 ml of fluid): These are representative values that will vary, depending on salt and water intake.

Component	Blood Plasma	Filtrate	Urine	Concentration	% Reclaimed by the body
Urea	0.03	0.03	1.8	60X	50%
Uric acid	0.004	0.004	0.05	12X	91%
Glucose	0.1	0.1	None	-	100%
Amino acids	0.05	0.05	None	-	100%
Total inorganic salts	0.9	0.9	<0.9–3.6	<1–4X	99.5%
Proteins and other macromolecules	8.0	None	None	–	–

As the above table shows, filtrate is essentially blood plasma minus almost all of the plasma proteins. Note that there should be no glucose, proteins, or amino acids in urine. When materials are initially filtered from the blood, the resulting fluid is the filtrate; once necessary materials are reabsorbed back into the blood, the portion of the filtrate remaining becomes urine.

Consider the following diagram of a nephron:



Nephron: Reprinted from *Biology* by Alton Biggs, et al. New York, NY: McGraw Hill, 2009. p. 1006. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff.*

It is clear, then, that the microscopic nephron must have a blood supply; blood arrives at the nephron through the afferent arteriole. The **afferent arteriole** carries blood from the renal artery. The blood is carried away from the nephron through the **efferent arteriole**. You can see from the diagram above that the afferent arteriole branches into a complicated mass of capillaries called the **glomerulus**.

The nephron itself possesses a structure called **Bowman's capsule,** which surrounds the glomerulus like a cup. Bowman's capsule leads to a slender tube called the **proximal tubule**. Materials that have moved from the blood into Bowman's capsule pass into this tubule, dissolved in water. This waste-containing fluid in the proximal tubule is further filtered in the next section of the nephron, the **loop of Henle** (or Henle's loop). In this "U-shaped" structure, some materials are returned to the blood from the filtrate and some materials are filtered from the blood into the filtrate. From the loop of Henle, the filtrate is sent through the distal tubule to the collecting duct, which will ultimately lead to the renal pelvis. The filtrate is stored there temporarily and is then sent to the urinary bladder through the ureter.

The tubules that make up the nephron are surrounded by capillaries. This is an essential aspect of the design of the nephron. The blood maintains close contact with the nephron so that materials can move easily to and from the circulatory system. The nephron removes materials that are not needed by the body or are harmful to the body and yet leaves materials that the body needs. There are three distinct processes that occur in the **nephron** during the production of urine: filtration, reabsorption, and secretion.

Urine Formation

- **Filtration:** The blood pressure inside the capillaries that make up the glomerulus is about four times as high as the blood pressure inside other capillaries in the body. This explains why the glomerulus, working inside **Bowman's capsule**, is an effective high-pressure filter. Dissolved solutes, such as salts, glucose, vitamins, and nitrogenous wastes, pass from the blood in the glomerulus into Bowman's capsule. At this point, filtration is non-selective, meaning that any solute small enough will be forced through the capillary wall. However, not all solutes enter the capsule. Larger molecules like proteins and cells, such as erythrocytes and platelets, do not move into the capsule from the blood. Some of the solutes that move from the glomerulus into the capsule because of the pressure differential between them should not be removed from the body. Reabsorption of those solutes must occur.
- **Reabsorption:** About 600 ml of blood passes through each kidney per minute. About 120 ml of that fluid is filtered out from the glomerulus. If that volume of urine were produced every minute, water balance would become a major concern for human beings. In reality, only about 1 ml of that fluid is actually sent to the urinary bladder as urine. In other words, most of the fluid, 119 ml, that is filtered out of the blood in the glomerulus is reabsorbed from the proximal tubule back into the blood. This reabsorption occurs specifically in the convoluted tubules and the loop of Henle, as well as in the collecting duct.

  At this point, filtration is selective. It is important that the body reabsorb substances that are essential to the maintenance of various salt concentrations. Some materials are selectively transported into the blood by active transport and others by passive transport. Sodium ions, sugar, vitamins, chlorine ions, bicarbonate ions, glucose, and amino acids are selectively returned to the blood. Another very important molecule that is reabsorbed is water. As a result, the solutes in the filtrate become very concentrated in the tubule. Some waste materials may actually move back into the blood because of this concentration gradient; these waste materials must again be filtered out of the blood. This occurs in the next step of urine formation: secretion.

- **Secretion:** At this point, blood plasma solutes are added to the filtrate within the tubule. One of the materials secreted from the blood into the nephron during secretion is nitrogen-containing waste like urea. The controlled secretion of hydrogen ions (H+) is important in maintaining a proper pH balance in body fluids. Other materials like minerals are kept in balance by being secreted as needed back into the nephron. Unlike the non-selective filtration that occurs in the glomerulus, secretion is a very selective process involving both passive and active transport. This stage in urine formation occurs in the proximal and distal convoluted tubules.

As a result of these three processes, a filtrate containing materials to be eliminated from the body is collected in the renal pelvis. This fluid, known as urine, then travels through the ureter to the urinary bladder. There are millions of microscopic nephrons in each kidney that work to filter blood and form urine on a continual basis. The rich blood supply entering each kidney is effectively cleaned and filtered before it returns to circulation. All of the body's blood cycles through the kidneys in order to be cleaned in this way.

Now it is time for you to complete **Learning Activity 4.2**. Remember to check your answers using the answer key before proceeding to **Assignment 4.2**.

Learning Activity 4.2

The Urinary System

1. Use the following list of terms to match with the descriptions of the structures given. Each term may be used more than once.

Ureter	Urethra	Renal artery	Afferent arteriole
Renal medulla	Renal cortex	Sphincter	Loop of Henle
Urinary bladder	Bowman's capsule	Nephron	Renal vein
Efferent arteriole	Kidney	Glomerulus	Filtrate
Proximal tubule	Distal tubule	Renal pelvis	

________________________ a. It supplies the kidney with blood from the aorta.

________________________ b. It carries urine from the kidney to the urinary bladder.

________________________ c. This muscle controls the elimination of urine from the urinary bladder.

________________________ d. It is the liquid that has been removed from the blood by the nephrons.

________________________ e. It is the microscopic functional unit of the kidney.

________________________ f. It is surrounded by Bowman's capsule.

________________________ g. It carries blood away from the glomerulus.

________________________ h. It carries blood away from the kidney and returns it to circulation.

________________________ i. It is the hollow central section of each kidney where filtrate is collected.

________________________ j. It temporarily stores urine before it is eliminated from the body.

continued

Learning Activity 4.2 (continued)

_______________ k. It carries urine out of the body.

_______________ l. It carries blood to the glomerulus.

_______________ m. It connects the proximal tubule to the distal tubule.

_______________ n. It receives filtrate from Bowman's capsule.

_______________ o. It is the outer layer of the kidney.

_______________ p. It is the middle layer of the kidney.

_______________ q. It is the organ responsible for cleaning the blood and producing urine.

_______________ r. It is the site of secretion, one of the three processes in urine formation.

_______________ s. It surrounds the glomerulus.

2. Each of the structures named below carries or stores either blood or filtrate. Write "B" if the structure carries blood and "F" if it carries filtrate.

_________ a. Ureter

_________ b. Glomerulus

_________ c. Distal tubule

_________ d. Renal vein

_________ e. Efferent arteriole

_________ f. Bowman's capsule

_________ g. Urinary bladder

_________ h. Afferent arteriole

_________ i. Loop of Henle

_________ j. Renal pelvis

_________ k. Proximal tubule

_________ l. Renal artery

continued

Learning Activity 4.2 (continued)

3. The three steps in urine formation are filtration, reabsorption, and secretion. Complete the following chart that summarizes these three steps:

Step	Location where it occurs in the nephron	Materials that are moving during this step	Do the materials move from the filtrate into the blood, or from the blood into the filtrate?	Is filtration selective or non-selective?
Filtration				
Reabsorption				
Secretion				

4. The nephron is known as the "functional unit" of the kidney. Describe its structure and function.

Lesson 3: Excretory Homeostasis

Lesson Focus

In this lesson, you will

- ❑ learn how homeostasis with respect to water and salt concentrations in the blood is effectively maintained
- ❑ discuss the consequences that may occur if excretory homeostasis is not maintained

Introduction

In the previous lesson, you learned about the human urinary system. In this lesson, you will learn how it relates to homeostasis, one of the major themes of this entire course. Earlier in this module, you learned that the kidney is the primary organ involved in maintaining water balance, or **osmoregulation**, in the human body. This is a very important life function that must be monitored and maintained continuously. Human beings are able to survive for several days without food, but would die within just a few days without water. The average adult human loses about two litres of water every day through urine, sweat, and exhaled moist air. When body activity increases or external temperature increases, even more water is lost. The volume of water that is lost must be replaced. If fluid intake were to drop by 1%, thirst would result. If it were to drop by 5%, the person would be in distress and may collapse. And a drop of about 10% can cause death.

It is clear, then, that the body must be able to keep enough but not too much water. The body must also be able to keep adequate salt concentrations in the blood and body fluids. At the same time, the body must be able to identify waste products and effectively eliminate them from the body in the forms of urine, sweat, and exhaled moist air. During a typical day, the body must continually adjust to changing conditions and activity levels to maintain homeostasis.

Osmoregulation

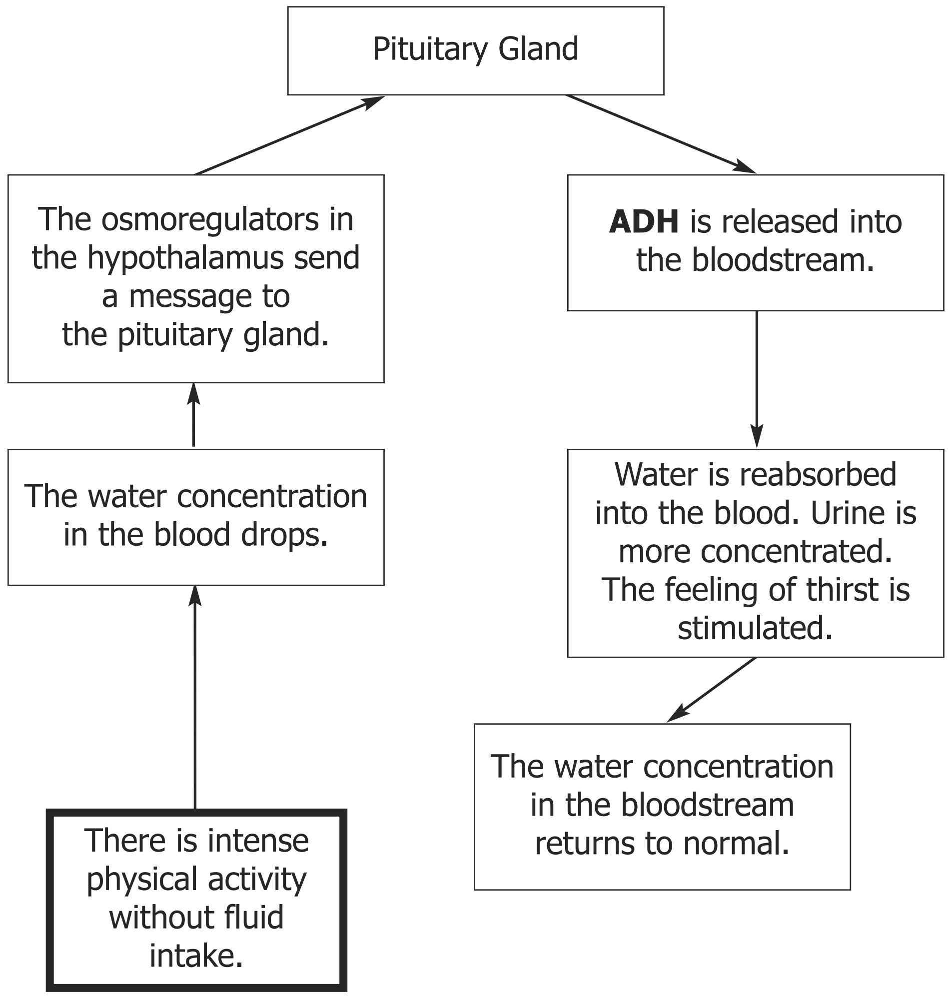
It may not surprise you to learn that the two organ systems most closely involved in osmoregulation are the **nervous system** and the **endocrine system**. The nervous system refers to the brain and spinal cord, while the endocrine system is composed of glands that secrete hormones directly into body fluids. These two monitoring systems are sensitive to water balance and can cause the kidneys to regulate body fluid levels.

The **hypothalamus** is a region of the brain, the main component of the nervous system. The hypothalamus is made of specialized nerve cells that are sensitive to salt concentrations in the blood. These specialized nerve cells, called **osmoreceptors**, are stimulated by changes in blood solute concentration as it passes through the hypothalamus. Let's say that you either decrease water intake or experience an increase in water loss. In both cases, the blood becomes more concentrated in terms of dissolved salts. As the concentrated blood moves through the hypothalamus, the osmoreceptors lose water to the blood because of osmotic pressure, causing them to shrink. When the hypothalamus cells shrink, a nerve message is sent to another region of the brain, the **pituitary gland**. When the hypothalamus detects a change in salt concentration, it stimulates the pituitary gland to release ADH. The **pituitary gland** then releases a hormone called **antidiuretic hormone (ADH)** into the blood. ADH is produced in the hypothalamus, but is stored in the pituitary gland. ADH travels through the blood to the kidneys where it stimulates the kidneys to reabsorb more water from the filtrate back into the blood. As a result, the filtrate or urine becomes more concentrated. The body loses less water through urine because it needs to conserve its water supply.

Interestingly, the shrinking cells of the hypothalamus also cause another response—thirst. This automatic response in the brain may prompt you to drink fluid, thus replenishing your water supply. When the blood carrying that increase of water reaches the hypothalamus, its cells swell and the message to the pituitary gland to produce ADH stops. The kidneys no longer reabsorb as much water and the concentration of salts in the urine returns to normal.

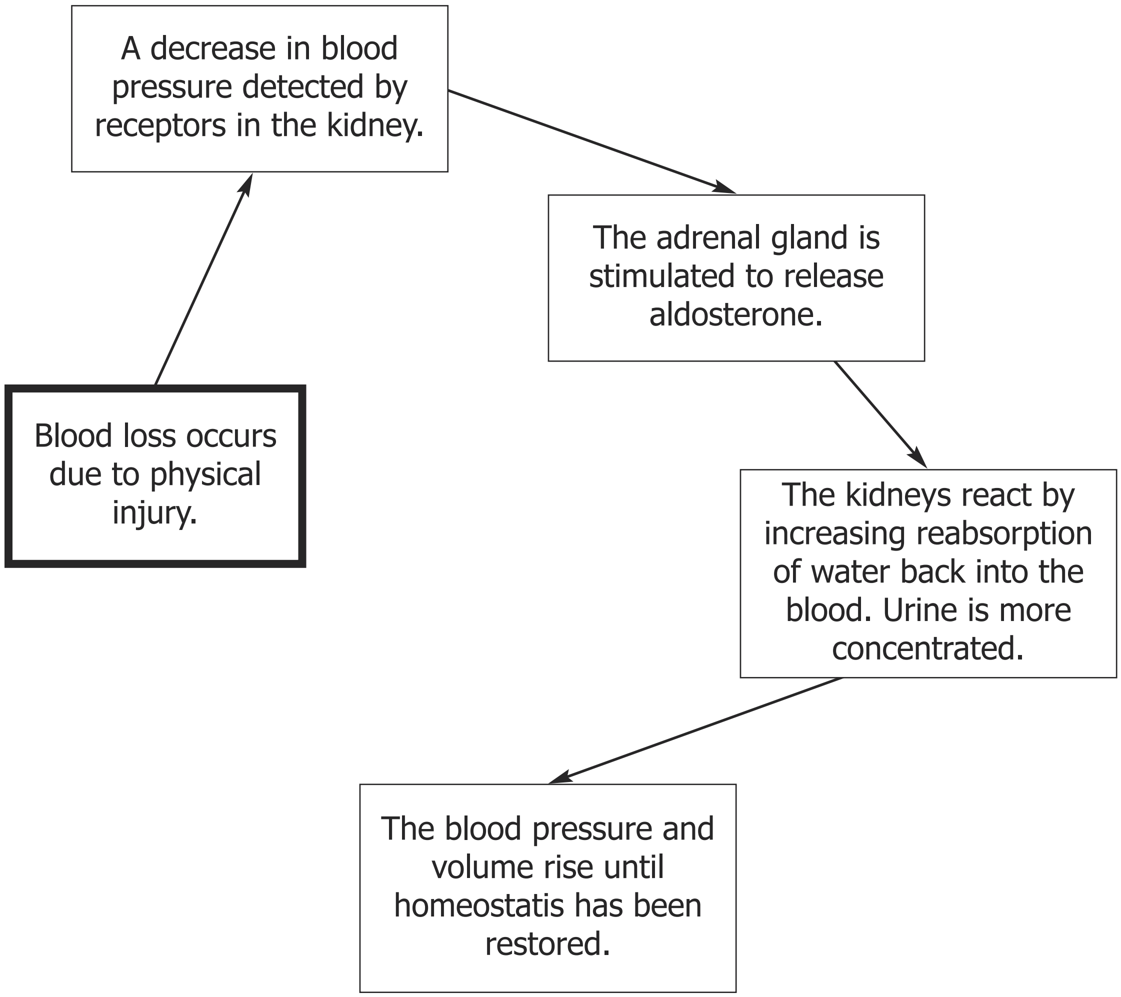
Another hormone involved in osmoregulation is called **aldosterone**. This hormone is produced by the **adrenal glands**, which lie above the kidneys. Instead of responding to changes in the salt concentration in the blood, this mechanism responds to changes in blood pressure. If a person has not been drinking adequate amounts of fluids or has lost a large amount of blood due to injury, blood volume decreases along with blood pressure. To restore homeostasis, the body should conserve water and produce more highly concentrated urine. When specialized cells near the glomerulus in each nephron detect a drop in blood pressure, they stimulate the adrenal gland to produce and release aldosterone into the blood. When aldosterone reaches the kidneys, it causes an increase in water reabsorption into the blood. Blood volume and blood pressure rise as a result.

Consider the following diagrams that illustrate the homeostatic effect of anti-diuretic hormone (ADH):



You can see in this diagram that a feedback system controls the concentration of solutes in the blood. Both the nervous system and the endocrine system are involved in this maintenance of homeostasis. It is important to notice that there is a mechanism for sensing the concentration of solutes in the blood and also a mechanism for reacting to changes in that concentration once they are detected. Once the solute concentration in the blood returns to a normal level, the sensory cells detect that change and cause a response by the body that maintains that level.

The other hormone that is involved in osmoregulation is aldosterone. Consider the following diagram:



You can see in the diagram above that blood pressure rises as a result of the action of this feedback loop. As a result, homeostasis is maintained.

It is now time for you to complete **Learning Activity 4.3**. Remember to check your answers in the answer key before you proceed to the assignment for this lesson.

Learning Activity 4.3

Excretory Homeostasis

Answer each of the following questions involving the maintenance of homeostasis in the excretory system:

1. It is known that drinking alcohol inhibits the secretion of ADH by the pituitary. What would be the effect of ingesting alcohol on the process of excretion?
2. It is known that ingesting caffeine causes an increase in blood pressure in the glomerulus and also decreases the reabsorption of water in the nephron. What would be the effect of ingesting caffeine on the process of excretion?
3. Why does urine sometimes appear to be darker in colour than it normally appears?
4. Use your understanding of excretory homeostasis to explain why humans cannot safely drink salt water instead of fresh water.
5. Sometimes athletes consume salt pills during periods of exercise in very hot weather. Explain what effect this practice has on excretory homeostasis.

When you have completed **Learning Activity 4.3**, proceed to **Assignment 4.1**.

Notes

Assignment 4.1

Osmoregulation *(16 marks)*

1. The two hormones that are involved in maintaining homeostasis in the excretory system are ADH and aldosterone. Complete the following chart that summarizes the characteristics of these two hormones. Each of the eight spaces in the chart is worth *1 mark for a total of 8 marks.*

Hormone	Location where it is produced	Factors that trigger its release	Location(s) of its target tissue(s)	Effect(s) on the target tissue(s)
ADH				
Aldosterone				

continued

Assignment 4.1 (continued)

2. Explain how each of the following events or situations alters homeostasis of the excretory system and then explain how it is dealt with by the body so that homeostasis is maintained. Each of the answers is worth a total of 2 marks for a total of 8 marks.

   a. Vigorous physical activity:

   b. Not drinking adequate amount of water:

continued

Assignment 4.1 (continued)

c. Blood loss due to injury:

d. Excessive water loss due to diarrhea:

Notes

Lesson 4: Urinalysis and Urinary Wellness

Lesson Focus

In this lesson, you will

- ❑ name and explain how information can be obtained through urinalysis, including the presence of performance enhancing drugs and recreational drugs
- ❑ discuss how information can be obtained through urinalysis about the following conditions or illnesses: *pregnancy, kidney failure, kidney damage, diabetes, infection*
- ❑ discuss the following issues related to urinary health and wellness: *organ transplant, personal lifestyle choices, kidney dialysis*

Introduction

In the previous lesson, you learned about how the human urinary system relates to homeostasis, one of the two major themes of this course. In this lesson, you will learn about urinary wellness. Remember that wellness is the other major theme in this course. Urinalysis is a laboratory test that can reveal a great deal of information about the health of the patient. Some diseases do not have striking signs or symptoms, especially early in their onset. Also, some substances ingested or injected into the bloodstream are passed out of the body in the urine; a wide variety of such substances can be monitored through urinalysis of the individual involved.

Typically, the patient is asked to provide a urine sample for analysis. A midstream, clean-catch urine specimen is usually best. The external area around the urinary opening is gently cleaned and the patient is asked to allow about half of the bladder's content to be excreted before the container is introduced into the urinary stream. It is best if the collection vessel captures the second half of the bladder contents. The first half of the urinary stream flushes contaminating cells and microbes from the external area around the urinary opening. If the patient is either comatose or uncooperative for a variety of reasons, a catheter may be used to collect urine. Urinalysis should typically follow collection within an hour; delaying analysis may introduce errors into the findings.

Urinalysis and Drug Testing

A number of **legal and illegal drugs** can be detected using urinalysis. It is important to note that the reasons for drug testing are highly variable. An athlete may be tested for performance-enhancing drug use. If a patient has a known medical condition, it is important to know which drugs the patient has used. Urine testing for the presence of certain drugs must be specifically requested since it is not part of routine urinalysis. Sometimes these tests are requested for employment reasons; an employer may need to avoid hiring people using certain drugs, either for safety reasons or for legal and public relations reasons. Police or probation services may request urine analysis through a court order or as part of a court-ordered drug treatment program.

The presence of some drugs that are sold and used illegally can be detected using urinalysis. These drugs include: amphetamines, barbiturates, cannabis, cocaine, methadone, methamphetamines, opiates, tricyclic antidepressants, sleeping pills, PCP, Ecstasy, and morphine. Notice that some of these drugs may be prescribed by medical doctors for legitimate medical conditions as well.

Other drugs that can be detected through urinalysis include muscle-building drugs such as **anabolic steroids**. One such drug, stanozolol, is an anabolic steroid that has been used for decades; like all anabolic steroids, it is a synthetic testosterone that increases strength and decreases fat. The use of anabolic steroids may lead to serious cardiovascular, central nervous system, gastrointestinal, liver, and reproductive disorders. A relatively new type of urine test that has become available detects the presence of a metabolite of beverage alcohol for up to 80 hours after consumption.

Urinalysis and Medical Conditions

Many women learn that they are pregnant by using **home pregnancy tests**. These tests check for the presence of a hormone, human chorionic gonadotropin (HCG), which is produced by the placenta. These tests may be sensitive to the presence of that hormone as early as the first day of the missed menstrual period. Home pregnancy tests are not as accurate as tests conducted by a medical lab.

Higher than normal levels of glucose in the urine may indicate uncontrolled **diabetes mellitus**. Usually less than 0.1% of the glucose filtered by the nephrons of the kidney appears in urine. The presence of other substances, known as ketones, in the urine may also indicate diabetes. A type of diabetes that occurs only in pregnant women is called **gestational diabetes**. Often, the women have no previous history of diabetes and are no longer affected by it after childbirth.

Abnormally high levels of protein found in the urine may indicate kidney disease. One protein, **bilirubin**, in the urine indicates either liver or bile duct disease. If the bile ducts are obstructed, bilirubin will build up in the liver and some of it will escape into the blood. If levels are high enough, some of it will be present in the urine. Increased bilirubin in the urine may also indicate cirrhosis of the liver, gallstones in the bile duct, hepatitis, or the presence of a tumour in either the liver or gall bladder.

The presence of protein in the urine of pregnant women indicates a condition called **toxaemia** or **pregnancy-induced hypertension**. Higher than normal blood pressure causes protein molecules to be filtered out of the blood and into the urine in the kidneys. This is a serious condition that affects a variety of body organs.

Blood cells are not normally found in the urine. **Red blood cells** may be present in the urine and may have entered it from the vagina in menstruation or from the trauma of bladder catherization. Other possible causes include kidney damage, tumours eroding the urinary tract, urinary tract stones, and urinary tract infections. Vigorous physical exercise may result in blood being present in the urine. Cancer of the urinary tract may be revealed by the presence of malignant cells in the urine. **White blood cells** from the vagina or the opening of the urethra may contaminate a urine sample. However, the presence of abnormal numbers of white blood cells in the urine is an indication that there is either kidney disease or an infection of the kidney, bladder, ureters, or urethra.

Chemicals called nitrites are indicators that there are significant numbers of bacteria in the urine. This indicates infection somewhere along the urinary tract.

In women, the presence in the urine of a hormone known as follicle-stimulating hormone (FSH) indicates that **menopause** has begun or that it may begin in the near future.

Some **sexually-transmitted diseases**, such as gonorrhea and chlamydia, can also be detected through urinalysis.

Issues Related to Urinary Tract Health

Diabetes mellitus is a disease caused by inadequate secretion of insulin from cells in the pancreas. This low level of insulin causes blood sugar levels to rise. Some of this sugar is excreted in the urine. Because high levels of sugar create an osmotic imbalance, large amounts of water are also voided from the body in the urine. This explains why patients suffering from this disease are often thirsty.

Diabetes insipidus results from the destruction of the ADH-producing cells of the hypothalamus or of the nerves leading from the hypothalamus to the pituitary gland. Without ADH to regulate water balance, urine production increases dramatically. This results in extreme thirst.

Nephritis or "Blight's disease" is a term that describes a wide range of diseases that are all characterized by inflammation of the nephrons. If the nephrons are not functioning correctly, the composition of the urine becomes abnormal. Too much water is lost from the body. Proteins may be present in high quantities in the urine; loss of blood proteins can result in a number of health problems including swelling, excessive water retention, and increased danger of blood clots. Back pain, vomiting, and fever commonly signal an attack.

Kidney stones are caused by the precipitation of mineral solutes from the blood. These stones can either become lodged in the renal pelvis or may move into the narrow ureter. They can cause extreme pain because they may tear delicate tissues. The stones may travel as far as the urethra, where they can also cause extreme pain as they are passed.

Since the late 1960s, **kidney dialysis** has been used to treat patients whose kidneys have been lost to disease, birth defects, or injury. Dialysis can be used temporarily until the kidneys resume function or the patient receives a kidney transplant, or for years if those options are not available. As you have learned in this module, the kidneys normally remove waste materials from the blood and also remove excess fluid in the form of urine. Therefore, dialysis treatments must duplicate both of these functions.

One form of kidney dialysis is **hemodialysis**; the patient's blood is pumped through a dialyzer where it is exposed to a semipermeable membrane. Undesired solutes and excess water pass from the blood into the dialysis solution. The cleansed blood is then returned back to the patient's body. Normally, a patient has three treatments per week for about three to four hours per treatment. These treatments typically occur in outpatient centres.

Another form of kidney dialysis is **peritoneal dialysis**. In this procedure, a sterile solution containing minerals and glucose is run through a small tube into the abdominal (peritoneal) cavity around the intestine. The solution is allowed to remain in the body cavity for a period of time where it absorbs waste products; it is then drained out through the tube. This procedure must be repeated four to five times per day, often when the patient is asleep. This procedure may be done at home and frees patients from the routine of reporting to a clinic for dialysis. However, it requires commitment and support.

Kidney transplantation is an option for patients who suffer from chronic renal failure. The kidney used as the transplanted organ may either come from a deceased donor or from a living donor. A transplant from a living donor may be from a related individual or from a non-related individual.

The first successful kidney transplantation operations were performed in 1954 in Boston and in Paris. Each of these early procedures was done with identical twins as the donor and recipient in order to decrease immune rejection. Kidney transplants were rarely done until after 1964 when the first medications to suppress immune reaction were introduced.

A person suffering from end-stage renal disease (ESRD) suffers from little or no kidney function. This may result from hypertension, infections, diabetes mellitus, or genetic kidney disease. Most renal transplant recipients are using some form of dialysis at the time of transplantation. About half of the kidneys used for transplantation come from living donors. Overall, recipients of kidneys from living donors do very well in comparison to recipients of kidneys from deceased donors. The use of medications to prevent organ rejection allows donors to be unrelated to recipients. The donor and recipient have to be ABO blood group compatible. It is best if the donor and recipient share as many blood antigens as possible.

It is interesting that in most cases the diseased or low-functioning kidney is not removed when another kidney is transplanted into the body of the recipient. The new kidney is usually placed in a location different from the original kidney, often in the iliac fossa, which is the large, smooth, concave surface on the internal surface of the hip bone.

Recent studies have indicated that the typical patient will live 10 to 15 years longer with a kidney transplant than if they stay on dialysis. Patients generally have more energy, a less restricted diet, and fewer complications with a transplant than if they stay on dialysis.

Unchecked high blood pressure may put a patient in danger of developing kidney disease. Therefore, having blood pressure checked periodically is a good preventative measure. Other symptoms that can be early signs of kidney disease include:

- puffiness of the eyes, hands, and feet
- passing bloody, cloudy or tea-coloured urine
- protein in the urine
- excessive foaming of the urine
- frequent urination during the night
- infrequent urination or difficulty passing urine
- fatigue
- loss of appetite or weight
- persistent generalized itching

It is now time for you to complete **Learning Activity 4.4**. Remember to check your answers in the answer key before you proceed to the assignment for this lesson.

Learning Activity 4.4

Urinary Tract Wellness

The Mayo Clinic is a centre for medical research and treatment. Its website is full of information about a wide variety of medical diseases and conditions. Go to the Mayo Clinic's website, http://www.mayoclinic.com/, to answer the following questions about kidney disease and treatment.

Look in the tab called, "***Diseases and Conditions,***" and look under "**K**". Choose "**Kidney Failure, acute**" to answer the following questions:

1. Acute kidney failure is most common in what group of medical patients?
2. How is acute kidney failure different from chronic kidney failure?
3. What are the two most common causes of chronic kidney failure?
4. Name five signs and symptoms of acute kidney failure.

Now, again under "**K**," choose "**Kidney Infection**" to help you to answer the following questions:

5. What is a "UTI" and where do they start?
6. Name five signs and symptoms of kidney infection.
7. Does the presence of bacteria in the urine always signal kidney infection? Why or why not?
8. Explain why kidney infections are more common in women than they are in men.
9. What is the most common treatment for kidney infection?

continued

Learning Activity 4.4 (continued)

Return again to "**K**" and choose "**Kidney Stones**." The information in that section will help you to answer the following questions:

10. Is it common for kidney stones to be passed out of the body in a patient's urine without the patient being aware of them? Why or why not?
11. Other than pain, what are four other symptoms that may indicate the presence of kidney stones?
12. Name three risk factors that increase a patient's chances of developing kidney stones.

At this point, go on to **Assignment 4.2**.

Notes

Assignment 4.2

Urinalysis and Kidney Transplantation *(15 marks)*

1. Give three different reasons why a person who visits the doctor may be asked to provide a urine sample for analysis. *(3 marks)*

2. Kidney transplantation is needed by patients who suffer from chronic kidney failure; kidneys from living donors are more successfully transplanted than kidneys from deceased donors. *What factors influence a person's decision* regarding donation of one kidney to another person? Name and discuss three factors that affect the decision that a potential donor makes regarding kidney donation. *(6 marks)*

continued

Assignment 4.2 (continued)

3. Explain how hemodialysis helps extend the life of people with impaired kidney function. *(3 marks)*

4. List three substances that should NOT appear in the urine of a healthy individual. *(3 marks)*

Module 4 Summary

Congratulations! You have completed Module 4 of the Grade 11 Biology course.

Submitting Your Assignments

It is now time for you to submit the Module 4 assignments to the Distance Learning Unit so that you can receive some feedback on how you are doing in this course. Remember that you must submit all the assignments in this course before you can receive your credit.

Make sure you have completed all parts of your Module 4 assignments and organize your material in the following order:

- Module 4 Cover Sheet (found at the end of the course Introduction)
- Assignment 4.1: Osmoregulation
- Assignment 4.2: Urinalysis and Kidney Transplantation

For instructions on submitting your assignments, refer to How to Submit Assignments in the course Introduction.

Notes

Grade 11 Biology (30S)

Module 4

Learning Activity Answer Key

Module 4
Learning Activity Answer Key

Learning Activity 4.1: Overview of Waste Management

1. Why is solid excrement (feces or stool) not included in the list of metabolic wastes listed in this lesson?

   Solid excrement is a waste product of the digestive process; it is largely composed of food material that could not be digested. The excretory system that you are learning about in this unit excretes metabolic waste that is produced by the kidneys or by the lungs.

2. Complete the chart below:

Waste Product	Origin of Waste Product	Excretory Organ
Ammonia	**Produced when proteins are broken down and amino acids, which contain nitrogen, are further broken down. This is deamination and occurs in the liver.**	**liver**
Urea	**In the liver, two molecules of ammonia are combined with one molecule of carbon dioxide to form one molecule of urea. Urea is much less toxic and is filtered out of the blood in the kidneys. It may also be passed out of the body in perspiration by the skin.**	**kidneys, skin**
Mineral Salts	**Any mineral salts that the body has ingested but does not need are either filtered out of the blood in the kidneys or excreted from the body in perspiration by the skin.**	**kidneys, skin**
Carbon Dioxide	**Carbon dioxide is a by-product of cellular respiration, which occurs in every body cell. From body cells, carbon dioxide passes into the blood, in which it is carried to the lungs. Carbon dioxide then passes into the alveoli in the lungs and is exhaled.**	**lungs**
Water	**Water is ingested and is not always all needed. Excess water is eliminated as urine (by the kidneys), as sweat (by the skin), and in moist exhaled air (by the lungs).**	**kidneys, skin, lungs**

3. Explain the role of the liver in the excretion of toxins.

   The liver is a very important organ for a number of reasons. In terms of digestion, the liver produces bile, which emulsifies fats. In terms of excretion, the liver is where deamination occurs, in which ammonia is removed from digested amino acids; that ammonia is then converted into urea. As blood passes through the liver, toxins are filtered from it. The liver breaks down some of these toxins and places the by-products into the bile. Bile then passes into the digestive system. The toxic substances are eliminated then from the body in the feces.

4. Complete the following table, placing all the terms under the heading(s) that they relate to. You can use the terms in more than one category and in any order.

Ammonia	Enzyme(s)	Water	Protein(s)	Excretory
Carbon Dioxide	Urea	Mineral Salt(s)	Toxin(s)	Urine

Lungs	Skin	Intestines	Kidney	Liver
Carbon dioxide	**Urea**	**Water**	**Urine**	**Enzyme**
Excretory	**Water**	**Excretory**	**Excretory**	**Ammonia**
Water	**Excretory**		**Water**	**Toxins**
	Mineral salts		**Urea**	**Excretory**
			Mineral salts	**Urea**

5. Answer the following questions about the excretion of metabolic wastes:
   a. List all the substances that are excreted by the skin.

      Water, mineral salts, urea

   b. What organ excretes carbon dioxide gas?

      The lungs

   c. What organ is responsible for deactivating toxins in the body, and then excreting them?

      The liver

   d. Which organs reabsorb water back into the body?

      The intestines, the kidney

   e. Which organs excrete extra water that the body does not need?

      Skin, kidney

   f. Why does the body not directly excrete ammonia?

      It is so toxic that the amount of water required to dilute it is too great.

Learning Activity 4.2: The Urinary System

1. Use the following list of terms to match with the descriptions of the structures given. Each term may be used more than once.

Ureter	Urethra	Renal artery	Afferent arteriole
Renal medulla	Renal cortex	Sphincter	Loop of Henle
Urinary bladder	Bowman's capsule	Nephron	Renal vein
Efferent arteriole	Kidney	Glomerulus	Filtrate
Proximal tubule	Distal tubule	Renal pelvis	

Renal artery a. It supplies the kidney with blood from the aorta.

Ureter b. It carries urine from the kidney to the urinary bladder.

Sphincter c. This muscle controls the elimination of urine from the urinary bladder.

Filtrate d. It is the liquid that has been removed from the blood by the nephrons.

Nephron e. It is the microscopic functional unit of the kidney.

Glomerulus f. It is surrounded by Bowman's capsule.

Efferent arteriole g. It carries blood away from the glomerulus.

Renal vein h. It carries blood away from the kidney and returns it to circulation.

Renal pelvis i. It is the hollow central section of each kidney where filtrate is collected.

Urinary bladder j. It temporarily stores urine before it is eliminated from the body.

Urethra k. It carries urine out of the body.

Afferent arteriole l. It carries blood to the glomerulus.

Loop of Henle m. It connects the proximal tubule to the distal tubule.

Proximal tubule n. It receives filtrate from Bowman's capsule.

Renal cortex o. It is the outer layer of the kidney.

Renal medulla p. It is the middle layer of the kidney.

Kidney q. It is the organ responsible for cleaning the blood and producing urine.

Distal tubule r. It is the site of secretion, one of the three processes in urine formation.

Bowman's capsule s. It surrounds the glomerulus.

2. Each of the structures named below carries or stores either blood or filtrate. Write "B" if the structure carries blood and "F" if it carries filtrate.

F	a. Ureter	F	g. Urinary bladder
B	b. Glomerulus	B	h. Afferent arteriole
F	c. Distal tubule	F	i. Loop of Henle
B	d. Renal vein	F	j. Renal pelvis
B	e. Efferent arteriole	F	k. Proximal tubule
F	f. Bowman's capsule	B	l. Renal artery

3. The three steps in urine formation are filtration, reabsorption, and secretion. Complete the following chart that summarizes these three steps:

Step	Location where it occurs in the nephron	Materials that are moving during this step	Do the materials move from the filtrate into the blood, or from the blood into the filtrate?	Is filtration selective or non-selective?
Filtration	**Bowman's capsule**	**water and dissolved solutes**	**from the blood into the filtrate**	**non-selective**
Reabsorption	**the convoluted tubules and the loop of Henle, as well as in the collecting duct**	**water, sodium ions, glucose, vitamins, sugars, amino acids, chlorine and bicarbonate ions, urea and uric acid**	**from the filtrate back into the blood**	**selective**
Secretion	**proximal and distal tubules of the nephron**	**nitrogen-containing wastes, histamine, excess hydrogen ions, and other minerals**	**from the blood back into the filtrate**	**very selective**

4. The **nephron** is known as the "functional unit" of the kidney. Describe its structure and function.

   The nephron is a microscopic unit. There are millions of nephrons in each human kidney. Each nephron is connected to the circulatory system and is also connected to the urinary system. The main functions of the nephron are filtration, secretion, and reabsorption using millions of tiny filters. The blood is thoroughly and systematically cleaned and the concentrations of necessary dissolved materials and water are kept at adequate levels.

Learning Activity 4.3: Excretory Homeostasis

Answer each of the following questions involving the maintenance of homeostasis in the excretory system:

1. It is known that drinking alcohol inhibits the secretion of ADH by the pituitary. What would be the effect of ingesting alcohol on the process of excretion?

   Alcohol reduces the release of ADH by the pituitary. ADH causes the kidneys to reabsorb more water from the filtrate. So the reduction in ADH causes less reabsorption of water from the filtrate. More water lost from the body and excreted in urine, possibly resulting in dehydration.

2. It is known that ingesting caffeine causes an increase in blood pressure in the glomerulus and also decreases the reabsorption of water in the nephron. What would be the effect of ingesting caffeine on the process of excretion?

   Caffeine causes glomerular blood pressure to increase, which results in less aldersterone being secreted. As a result, more water moves into Bowman's capsule and is excreted, rather than reabsorbed. Therefore, caffeine causes more water to be excreted in urine.

3. Why does urine sometimes appear to be darker in colour than it normally appears?

   This dark colour indicates a higher concentration of solutes in the urine. This can be due to reduced water intake, physical activity, or illness.

4. Use your understanding of excretory homeostasis to explain why humans cannot safely drink salt water instead of fresh water.

   The amount of salt in the nephron exceeds the threshold level for the amount of salt that can be actively transported. As a result, a higher salt concentration remains in the filtrate, which creates high osmotic pressure. Water moves into the filtrate as a result and excess water is lost from the body along with the salt. The body becomes dehydrated.

5. Sometimes athletes consume salt pills during periods of exercise in very hot weather. Explain what effect this practice has on excretory homeostasis.

   By taking salt pills, the athlete actively increases the salt content of the blood. As a result, the hypothalamus recognizes this high solute concentration and initiates the thirst reaction. As a result, the athlete drinks more. Athletes lose a great deal of water during exercise, especially salt during warm or hot weather. By taking salt pills, the athlete replaces the salts lost during physical activity, especially those lost in sweat. By replacing those salts, the body is able to control water loss.

Learning Activity 4.4: Urinary Tract Wellness

The Mayo Clinic is a centre for medical research and treatment. Its website is full of information about a wide variety of medical diseases and conditions. Go to the Mayo Clinic's website, <http://www.mayoclinic.com/>, to answer the following questions about kidney disease and treatment.

Look in the tab called ***"Diseases and Conditions,"*** and choose to look under "**K**". Choose "**Kidney Failure, acute**" to answer the following questions:

1. Acute kidney failure is most common in what group of medical patients?

   Acute kidney failure is most common in people who are already hospitalized, particularly people who need intensive care. Acute kidney failure tends to occur after complicated surgery, after a severe injury, or when blood flow to your kidneys is disrupted.

2. How is acute kidney failure different from chronic kidney failure?

   Acute kidney failure is the *sudden loss* of your kidneys' ability to perform their main function—eliminate excess fluid and waste material from your blood. When your kidneys lose their filtering ability, dangerous levels of fluid and waste accumulate in your body. Loss of kidney function may also develop *gradually over time*, with few signs or symptoms in the early stages. In this case, it's referred to as chronic kidney failure.

3. What are the two most common causes of chronic kidney failure?

   High blood pressure and diabetes are the most common causes of chronic kidney failure.

4. Name five signs and symptoms of acute kidney failure.

   Signs and symptoms of acute kidney failure may include

   - **decreased urine output, although occasionally urine output remains normal**
   - **fluid retention, causing swelling in your legs, ankles, or feet**
   - **drowsiness**
   - **shortness of breath**
   - **fatigue**
   - **confusion**
   - **seizures or coma in severe cases**
   - **chest pain related to pericarditis, an inflammation of the sac-like membrane that envelops your heart**

Now, again under "**K**," choose "**Kidney Infection**" to help you to answer the following questions:

5. What is a "UTI" and where do they start?

   Kidney infection (pyelonephritis) is a specific type of urinary tract infection (UTI) that generally begins in your urethra or bladder and travels up into your kidneys.

6. Name five signs and symptoms of kidney infection.

   Kidney infection may cause one or more of the following signs and symptoms:

   - **frequent urination**
   - **strong, persistent urge to urinate**
   - **burning sensation or pain when urinating**
   - **abdominal pain or pressure**
   - **cloudy urine with a strong odour**
   - **pus or blood in your urine (hematuria)**
   - **inability to urinate (urine retention)**
   - **need to urinate during the night (nocturia)**
   - **back, side (flank), or groin pain**
   - **fever**

   Severe kidney infection also may involve the following:

   - **high fever—body temperature of 101° F (38.3° C) or greater**
   - **shaking chills**
   - **night sweats**
   - **extreme fatigue**
   - **nausea or vomiting**

7. Does the presence of bacteria in the urine always signal kidney infection? Why or why not?

   Bacteria in the urine don't always signify an infection. Some people, especially older adults, may have bacteria in the bladder that don't cause any signs or symptoms or harm, and therefore doesn't require treatment. This condition is known as asymptomatic bacteriuria.

8. Explain why kidney infections are more common in women than they are in men.

   Women have a greater risk than men do of developing kidney infection. A key factor is anatomy. Women have a much shorter urethra than men have, which decreases the distance bacteria must travel from the outside of the body to reach the bladder. Once in the bladder, any infection can spread to the kidneys. Hormonal changes during pregnancy and after menopause also can increase a woman's risk of kidney infection. Most kidney infections are caused by bacteria commonly found in the anal area.

9. What is the most common treatment for kidney infection?

   If your symptoms are typical and you're generally in good health, antibiotics are the first line of treatment for kidney infection. Which drugs you use and for how long depends on your health condition and the bacteria found in your urine tests.

Return again to "**K**" and choose "**Kidney Stones**." The information in that section will help you to answer the following questions:

10. Is it common for kidney stones to be passed out of the body in a patient's urine without the patient being aware of them? Why or why not?

    If you've ever passed a kidney stone, you're not likely to forget the experience—it can be excruciatingly painful. The most common symptom is an intense, colicky pain that may fluctuate in intensity over periods of five to 15 minutes. The pain usually starts in your back or your side just under or below the edge of your ribs. As the stone moves down the ureter toward your bladder, the pain may radiate to your lower abdomen, groin, and genital structures on that side.

11. Other than pain, what are four other symptoms that may indicate the presence of kidney stones?

    Other signs and symptoms may include

    - **bloody, cloudy, or foul-smelling urine**
    - **nausea and vomiting**
    - **persistent urge to urinate**
    - **fever and chills, if an infection is present**

12. Name three risk factors that increase a patient's chances of developing kidney stones.

    The risk factors that increase a patient's chances of developing kidney stones include the following (the risk factors listed are not explained here but you may wish to explain them in your notes from this website):

    - **insufficient fluid intake**
    - **personal or family history**
    - **age, sex, and race**
    - **certain diseases**
    - **certain medications**
    - **diet**
    - **limited activity**

Notes

GRADE 11 BIOLOGY (30S)

Module 5

Protection and Control

This module contains the following:

- Introduction
- Lesson 1: Overview of the Immune System
- Lesson 2: Immunity, Disease, and Public Health
- Lesson 3: Overview of the Nervous System
- Lesson 4: The Neuron
- Lesson 5: Nervous and Endocrine Interaction
- Lesson 6: Wellness and the Endocrine and Nervous Systems
- Module 5 Summary

Module 5: Protection and Control

Introduction

Welcome to Module 5. So far in this course, you have learned all kinds of things about the human body, like the digestive system, transportation, respiration, excretion, and waste management. You have also learned how each of these contributes to wellness and homeostasis.

In this module, you will learn how your body protects and controls itself. You will learn about immunity, public health, and the human nervous system. Again, you will learn how these things contribute to wellness.

Assignments in Module 5

When you complete Module 5, you will submit your Module 5 assignments to the Distance Learning Unit either by mail or electronically through the learning management system (LMS). The staff will forward your work to your tutor/marker.

Lesson	Assignment Number	Assignment Title
2	Assignment 2.1: Option A	Vaccination Policies in Canada OR
	Assignment 2.1: Option B	Disease Investigation
3	Assignment 5.2	The Nervous System
6	Assignment 5.3	Investigation: Nervous or Endocrine Disorder

Notes

Lesson 1: Overview of the Immune System

Lesson Focus

In this lesson, you will

- ❑ identify and discuss the types of harmful foreign agents that may enter or invade the human body
- ❑ explain the difference between non-specific defences and specific defences against foreign agents
- ❑ discuss the types of specific and non-specific defences that the human body possesses to prevent harmful agents from entering
- ❑ explain the body's reaction to foreign antigens, particularly the inflammatory and immune responses
- ❑ discuss the structure and function of the lymphatic system

Introduction

A number of substances, organisms, and other foreign agents are harmful to the human body. The focus of this lesson is how the body protects itself from these invaders in order to maintain homeostasis.

Foreign Agents and the Immune Response

Foreign invaders vary greatly both in terms of how they enter the body and in terms of how they affect the body. Below is a list of some disease-causing agents **(pathogens)** that the body attempts to protect itself against:

- **Bacteria:** Bacterial cells are very simple and microscopic. Some bacteria are beneficial to the human body, but others can cause diseases such as anthrax, tuberculosis, tetanus, syphilis, pneumonia, and bacterial meningitis.
- **Viruses:** These tiny particles are not cellular but do contain genetic material and are capable of reproducing using the machinery of living cells that they invade. Some diseases caused by viruses include influenza (e.g., H1N1 pandemic of 2009/2010), the common cold, HIV, herpes, and rabies.
- **Protozoans:** These organisms are simple and usually microscopic. The protozoans that cause human disease are parasitic, causing sicknesses such as malaria, sleeping sickness, and toxoplasmosis.

- **Fungi:** Fungal cells cause illnesses such as ringworm, yeast infections, thrush, and athlete's foot. Most fungal infections are external.
- **Parasites:** Parasitic organisms are either ectoparasites, which affect the outside of the host's body, or endoparasites, which live in the host's digestive tract. Ectoparasites include leeches, mites, and ticks. Endoparasites include tapeworms and pinworms.

These pathogens can enter the body in a number of ways:

- **Skin:** Pathogens may enter through a break in the skin or may be capable of entering the body through unbroken skin.
- **Respiratory System:** Some pathogens are in the air we breathe and enter our bodies when we inhale.
- **Digestive System:** Other pathogens are in contaminated food that we eat or contaminated beverages that we drink.
- **Body Openings:** Some pathogens enter the body through the other body openings such as the ear, eye, anus, vagina, and urethra. Some of these pathogens enter the body when sexual contact with someone else that is infected has occurred.

These pathogens are transmitted to new hosts in a variety of ways as well:

- **Soil and water contamination:** The practice of releasing untreated sewage into cropland or waterways is a principal cause of contamination by pathogens of the soil—and therefore of water and food. Some pathogens that live in the soil can also contaminate plants—which humans may encounter either through casual contact or because those plants are eaten. In developing countries, most sewage is directly discharged into the environment. Even in developed countries, raw sewage sometimes overflows into the environment when system failures occur.
- **Food contamination:** The contamination of food can cause illness in two ways. The food may be contaminated with a toxin or contaminating chemical that may have been produced by an organism that had come in contact with that food. The other type of contamination occurs when the food is actually infected with one of a variety of pathogens, such as bacteria, viruses, fungi, or parasites. Such contamination usually results from unsafe preparation, handling, or storage of food.
- **Body contact:** Some pathogens move from one human host to another by body contact, such as touching, kissing, biting, or sexual contact. The pathogen involved may be present in the host's saliva, blood, or body fluids or may be on the host's skin or other body surface.
- **Air contamination:** Some air-borne pathogens are present in the air and move from host to host in that way.

- **Vectors:** Common vectors that transfer disease, without getting sick themselves, from one host to another include several arthropods, such as fleas, ticks, or mosquitoes. These vectors often transfer the disease from either a domestic or wild animal to humans. Diseases caused by such transmission include Lyme disease and West Nile Virus.

Non-Specific Defences

Defences that are "non-specific" in nature are those that prevent the entry of many types of pathogens into the human body; they do not recognize any pathogen in particular. There are a number of non-specific lines of defence that the human body uses to protect itself from invasion:

- **Skin:** The skin provides a protective barrier from infection. Very few bacteria and parasites are able to penetrate unbroken skin. Skin is actually made up of a number of layers, the topmost layer continually sloughing off and being replaced by cells beneath it. The outermost layer develops a tough, waterproof surface through a process known as keratinisation. The outermost layer of skin consists of 25 to 30 layers of dead cells. Skin that has been broken may allow the entry of pathogens into the bloodstream. Also, the hair follicles in skin secrete acidic substances that inhibit the growth of some pathogens.
- **Mucus:** In the respiratory passage, bits of foreign debris and invading pathogens are caught in the mucus layer lining that passage. Cilia are tiny hair-like structures that trap and sweep the mucus away from the lungs. Mucus that reaches the top of the trachea is then swallowed. Coughing and sneezing quickly expels invaders from the respiratory system.
- **Stomach Acid:** The stomach is an unsuitable environment for most pathogens when they are swallowed. Many invading organisms are destroyed in such an acidic environment. They may have been swallowed because they were on food that was eaten, were in liquid that was consumed, or entered the mouth when fingers, pencils, or other objects were placed in the mouth.
- **Tears:** Human tears contain a special type of enzyme called a lysozyme. Lysozymes have the ability to destroy foreign bacteria. In this way, they protect the eyes. Lysozymes are also found for the same purpose in saliva, nasal secretions, and perspiration.
- **Other body openings:** Urinary, excretory, and reproductive openings are protected in a variety of ways. In some cases, the opening is a passageway through which a substance exits the body; and invading organisms would be carried out at the same time. In some cases, the chemical environment of the tissues forming the opening is not hospitable to foreign organisms. For example, vaginal secretions are slightly acidic, thereby inhibiting the growth of invading organisms. Other protective enzymes are found in sperm and also in breast milk.

- **Phagocytosis:** Some white blood cells (**neutrophils** and **monocytes**) recognize foreign cells and destroy them by *phagocytosis*. That is, the pathogen is surrounded and digested by the white blood cell. **Leukocytes** of this type are present in the blood, in interstitial fluid around body cells, in lymph, and in the mucus that lines body openings. **Macrophages** are phagocytic cells found in the liver, spleen, brain, and lungs. Natural killer cells, another type of white blood cell, carry out phagocytosis of cells that have become cancerous or infected by viruses.

Specific Defences

Some defences that the human body possesses are very specific in terms of which pathogens they attack or protect the body from. These lines of defence are good at recognizing particular pathogens. In general, this type of defence is referred to as the *"immune response."* There are a number of types of specific defences that the body possesses:

- **Lymphocytes:** This specialized type of white blood cell reacts to invading organisms by producing *antibodies*. There are two types of lymphocytes, classified on the basis of where they mature. B lymphocytes (B cells) mature in the bone marrow, while T lymphocytes (T cells) mature in the thymus gland.

  All body cells normally possess particular proteins embedded into their membranes. The body's immune system recognizes those proteins are "self" and does not attack them. When foreign proteins are detected, the cells on which they are located are judged to be foreign and therefore dangerous. Recall that protein "markers" like this are called *antigens*. When foreign antigens are recognized by lymphocytes, those cells produce antibodies. Antibodies are very specific and only "fit" certain antigens. It has been estimated that the normal human adult carries antibodies for about 100,000 different antigens. The invading organism is then surrounded by antibodies and is more easily recognized by leucocytes as "foreign." The antigen-antibody complex signals the leucocyte to destroy the cell by phagocytosis.
- **Plasma proteins:** These molecules are sometimes called complementary proteins. The human body possesses about 20 different types of these proteins. These molecules are usually in the blood in an inactive form. But when a foreign antigen is detected, complementary proteins are activated. Plasma proteins can act in a variety of ways. Some dissolve the cell membranes of invading organisms. Others attract leucocytes. And still others may trigger the formation of a protective coating around the pathogen that renders it less harmful.

- **Interferons:** These protein molecules are produced by the cells of the immune system. They assist the immune system by acting to inhibit the replication of viruses in other cells of the body.

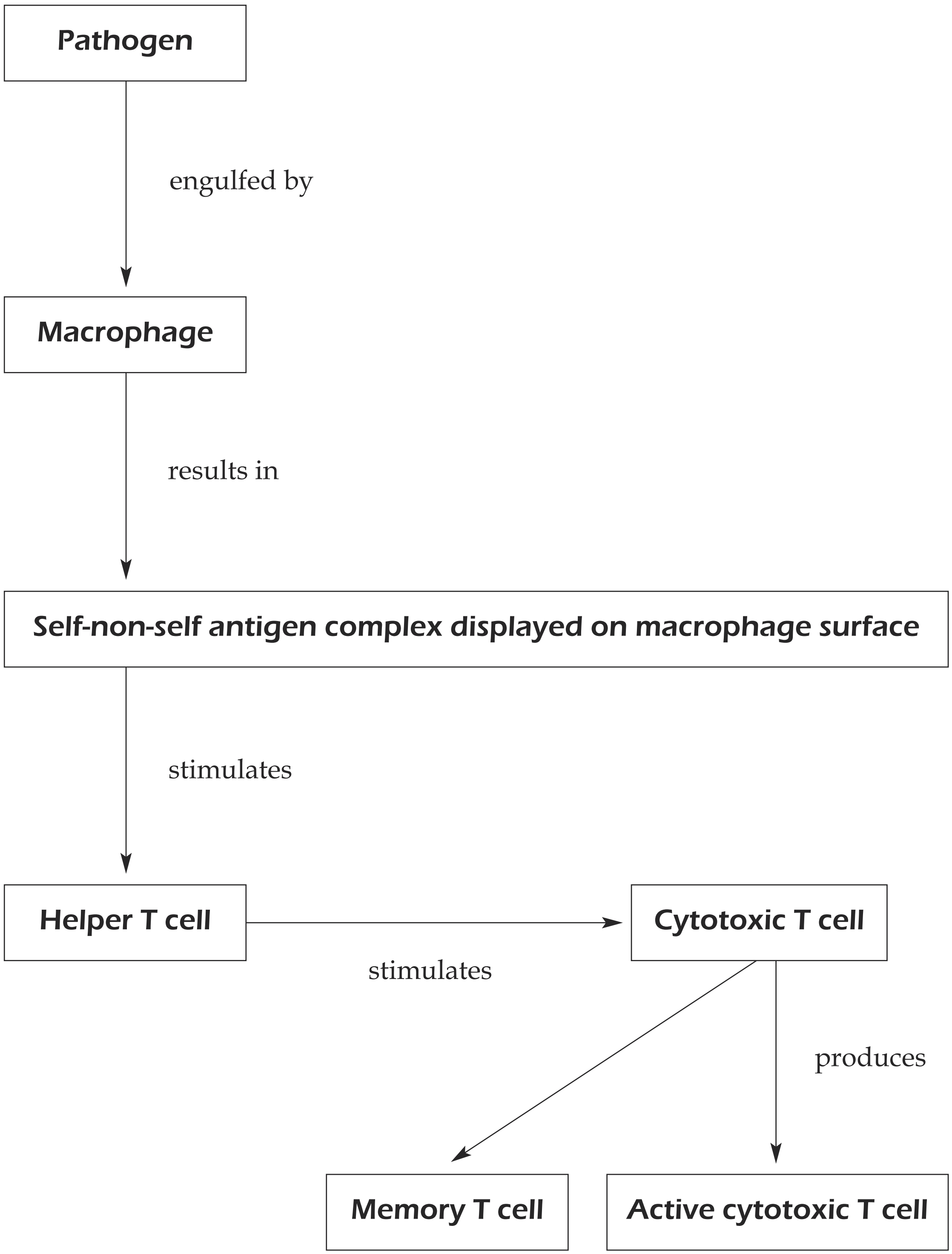
It should be noted that a wide variety of organisms, bacteria in particular, inhabit the human body with no adverse effects. Most of these inhabit the large intestine. Others live in the nose and mouth, the skin, and the stomach and small intestine. These resident cells produce a variety of chemicals that inhibit the growth of other bacteria in their place. The body's regular inhabitants may cause problems if they invade spaces in the body in which they are not meant to be. For example, antibiotics often kill off the normal bacteria living in the large intestine; this presents an opportunity for invading organisms to take over that space. These foreign pathogens may cause medical conditions, such as colitis, as a result.

Cellular Immunity

B cells and T cells work in partnership to attack and destroy pathogens. **Cellular immunity** is primarily a function of T cells, while **antibody immunity** is primarily a function of B cells. However, both types of immunity are controlled by T cells and begin with the macrophages being activated. Here are the steps involved in cellular immunity:

1. A **macrophage** engulfs a **pathogen**, breaks it down, and places part of the antigen on its own cell surface.
2. Next, the macrophage binds to the antigen receptor on **helper T cells**, activating **cytotoxic T cells** to differentiate and produce identical clones. This is how a large number of T cells are rapidly produced when needed by the body. At this point, helper T cells also give off chemicals to stimulate other macrophages, B cells, and T cells.
3. A number of T cells stay behind in the lymph nodes to serve as **memory T cells**, ready to strike if the same pathogen invades again.
4. Active **cytotoxic T cells** travel to infected tissue to destroy the pathogen on-site, by binding to the infected cell, and puncturing holes in its cell membrane.
5. **Suppressor T cells** slow the immune response and stop the cellular immunity process when the pathogen has been destroyed.

Note that cytotoxic T cells can also be triggered by a foreign antigen bound to a cell that has been invaded by a virus. This results in the cytotoxic T cells being immediately and directly activated, rather than going through the process described above.


Pathogen
engulfed by
Macrophage
results in
Self-non-self antigen complex displayed on macrophage surface
stimulates
Helper T cell
stimulates
Cytotoxic T cell
produces
Memory T cell
Active cytotoxic T cell

Antibodies and Immunity

You have already learned in this lesson that the body's immune system reacts to the presence of foreign antigens by producing antibodies. Foreign antigens are "markers" on foreign invaders that indicate that they are foreign. The antibodies that lymphocytes make in response to their presence are capable of inactivating the antigen in four primary ways:

1. **Complement fixation:** The antibody attaches to the antigen surface and causes "holes" to form so that the invading cell membrane breaks and the cell dies.
2. **Neutralization:** The antibody attaches to the active site of the antigen, thus preventing the antigen from attaching to body cells and harming them.
3. **Agglutination:** The antibody attaches to the antigen and causes clumping; clumping makes it easier for leucocytes to recognize the invading organism.
4. **Precipitation:** The antibody attaches to the antigen and causes it to be insoluble and to settle out of solution.

Some of the antibodies formed by a mother's body during pregnancy are capable of crossing the placental barrier to the fetus. These antibodies can give the newborn three to six months of immune protection after birth.

Vaccines are weakened or inactive forms of the pathogen that are intentionally given to a person who may encounter the active pathogen in the future. The antigen that is present on the weakened or inactive form of the pathogen is the same as the antigen that is present on the pathogen itself. Therefore, if the body produces antibodies when it encounters the vaccine, it will possess antibodies already if it later encounters the actual pathogen. The first time that the body is exposed to the antigen causes a *primary immune response*; the subsequent immune response to the same antigen is a *secondary immune response*. The secondary response occurs faster following exposure to the antigen, results in a more rapid build-up of antibodies, and provides a more specific "fit" to the invading antigen.

Sometimes it is possible to use a similar but not identical antigen in the vaccine; for example, cowpox is a much less serious illness than smallpox. The virus that causes cowpox can be used in a vaccine for smallpox. Because the vaccine provides such a good "fit," it is very effective and provides immunity for about 20 years.

Consider the following chart that presents the various types of immunity that are possible in humans.

Type of Immunity	Characteristics
Active Natural	Results from direct exposure to the pathogen; develops slowly, is long-term, and is antigen-specific
Active Artificial (Immunization)	Results from vaccine; develops slowly, lasts for several years, and is specific to the antigen for which the vaccine was given
Passive Natural	Transplacental; passed across the placenta from mother to child before birth; is temporary and affects all antigens to which the mother has immunity
Passive Artificial	Injection of antibodies; develops immediately; is temporary, and affects all antigens to which the donor has immunity

Allergies

An allergy is an inflammatory response to an antigen; in most cases, that antigen is harmless to most people and does not cause an allergic reaction. But in people who are allergic to a particular antigen, the symptoms can vary.

- The nose may become runny and swollen.
- The eyes may become red, watery, and sensitive.
- The airway may become constricted due to swelling; wheezing, asthma, and even anaphylaxis may occur.
- Painful or uncomfortable ear symptoms may develop.
- The skin may develop rashes, hives, eczema, or dermatitis.
- Headaches may result.

Severe allergic reactions can lead to anaphylaxis in which various organ systems can be involved. The digestive system, the respiratory system, and the circulatory system are most often affected. The person may develop a severe rash or case of hives, may be unable to breathe, may experience swelling of various parts of the body, and may even pass into a coma or die. Typically a second exposure to the antigen, should it occur, causes a more severe reaction than the first exposure caused.

One example of a very common and relatively minor allergy is hay fever. Airborne pollen is the primary cause of this allergy. Allergies have been referred to as the body's attempt to defend itself too vigorously against an antigen that is harmless to most other people. Other common allergens are mould spores; dust mites; various foods such as nuts, shellfish, eggs, and wheat; insect stings; medications such as Penicillin; and materials such as latex.

The Inflammatory Response

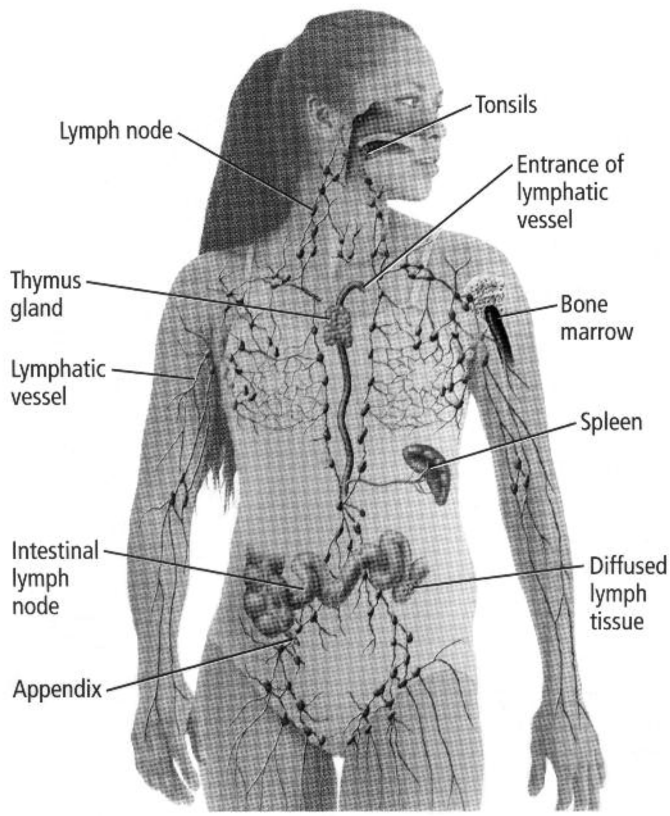
When a pathogen has invaded the body, the body reacts in several ways. One response is called the *inflammatory* response because a reddening or inflammation characterizes it. You have likely experienced the response when you have had a rash, an allergic reaction, or an insect bite. The area of the infection may become hot and swollen. The body attempts to bring as many leucocytes to the area of infection as possible, causing the area to swell as lymph bathes the site of infection. White blood cells and dead pathogens make up what we call "pus," which often forms at the site of infection. The heat that is sometimes produced and that may lead to the person having a fever is the body's attempt to inactivate the pathogen by making the body "too hot" to be a favourable environment to thrive in.

When an infection by a pathogen has occurred, cells called mast cells release histamine, which is a chemical that enters the surrounding capillaries. **Histamine** causes these blood vessels in the injured area to dilate and to "leak." As a result, the area appears red and begins to swell as lymph enters the interstitial spaces between the cells. Leucocytes flood the area to kill pathogenic organisms using phagocytosis. You may have used an **antihistamine** to lessen the effects of the histamine, which effectively reduces the inflammation and reddening.

The Lymphatic System

As the blood passes from arteries to arterioles to capillaries, the pressure inside these vessels increases as the vessel diameter decreases. As a result, some of the fluid in blood is forced out of the capillaries and into the tissue surrounding the capillaries. This fluid is called **interstitial fluid**. In effect, it bathes body cells in this salty solution, which is very similar in composition to blood plasma. The organ system that collects that fluid and returns it to the circulatory pathway is called the **lymphatic system**.

Consider the following diagram of the lymphatic system:



The Lymphatic System: Reprinted from *Biology* by Alton Biggs, et al. New York, NY: McGraw Hill, 2009. p. 1086. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

The vessels of the lymphatic system are similar in some ways to the vessels of the circulatory system. A system of interconnecting vessels (including veins and capillaries) carries lymph throughout the body. However, unlike the circulatory system, the lymphatic system consists of vessels that end blindly; lymph is not "circulated" like blood is throughout the body. Lymph is not "pumped" by the heart or any similar organ, but rather is squeezed along by skeletal muscle contractions. There are one-way valves within the lymphatic capillaries that ensure the continued flow of the lymph away from the tissues, without collecting or pooling in one area.

Lymph capillaries meet to form larger vessels called lymph veins. Since the flow of lymph is only in the direction of the heart, there are no arteries in the lymphatic system. The veins of the lymphatic system merge to form two major ducts. Lymph is then returned to the circulatory pathway at two points in the upper chest; these two large lymph ducts empty into the superior vena cava. Along the way, lymphatic vessels carry lymph through **lymph nodes**. Lymph nodes are concentrated in particular areas of the body, such as the neck, armpits, and groin. Lymph nodes are roughly the size of a pea but are occasionally as large as a lima bean.

Lymph nodes remove foreign particles and dead cells from the lymph before it returns to the blood. Lymph nodes are also the location where lymphocytes are produced. The human body on average produces about 10 billion lymphocytes per day. The lymph nodes also contain leucocytes, which are ready to attack bacteria and other pathogens in the lymph. On a visit to see your doctor for a sore throat, you doctor may have felt the tissue under your jaws and on the sides of your neck; the lymph nodes become enlarged when you have an infection because the leucocytes are working hard to clean pathogens out of the blood and lymphocyte production has also increased.

Here is a summary comparison of the cardiovascular and lymphatic systems:

Cardiovascular System (Blood)	Lymphatic System (Lymph)
It circulates vital nutrients, oxygen, and hormones to the tissues of the entire body via the blood.	It collects and removes waste products left behind in the tissues via the lymph.
Blood flow is cycled throughout the body via the arteries, capillaries, and veins. It is a closed system.	Lymph flows in an open circuit from the tissues into lymphatic vessels. Once within these vessels, lymph flows in only one direction.
Blood is pumped by the heart.	Lymph is not pumped but is moved by body movements and the squeezing of muscles.
Blood consists of the liquid plasma, red and white blood cells, and platelets.	Lymph that has been filtered is clear or straw-coloured.
Damage to blood vessels causes obvious signs such as bleeding or bruising.	Damage to the lymphatic system causes swelling.
Blood is filtered by the kidneys.	Lymph is filtered by lymph nodes.

It is interesting to note that surgeons often remove lymph nodes in the area where they have found cancerous tumours. Sometimes, cancer cells can "break away" from the tumour and travel in the lymph. When they are filtered out of the lymph in the lymph nodes, removing the nodes implies removing the cancerous cells.

It is now time for you to complete **Learning Activity 5.1**. Check your answers to the questions in the answer key at the end of this module.

Learning Activity 5.1

Overview of the Immune System

Match the terms in the list below to the statements that follow; each term is used only once.

A. Protozoan	F. Cilia	K. Inflammatory
B. Interferons	G. Anaphylaxis	L. Virus
C. Vaccination	H. Transplacental	M. Vector
D. Lysozymes	I. Stomach acid	N. Antibodies
E. Non-specific	J. Ectoparasite	O. Phagocytosis

1. Leucocytes kill foreign pathogens using this process of surrounding and digesting them. __________
2. Lymphocytes produce these molecules in response to the presence of foreign antigens. __________
3. This is the type of pathogen that causes malaria and sleeping sickness. __________
4. These defense mechanisms protect against many types of pathogens, without recognizing one in particular. __________
5. It is a very severe allergic reaction, which can be life-threatening. __________
6. It is a weakened or dead form of a pathogen given to protect against a future encounter of the active pathogen. __________
7. It is a passive natural immunity. __________
8. This type of response occurs when the body has been invaded by a foreign organism; it results in reddening and swelling of the area affected. __________
9. They are enzymes found in tears and saliva that kill invading bacterial cells. __________

continued

Learning Activity 5.1 (continued)

10. It is a pathogen that is not cellular; it invades a living cell and uses its machinery to reproduce. __________
11. Mites and ticks are examples of this type of organism. __________
12. This substance destroys many potential pathogens that are swallowed. __________
13. They protect the lungs from pathogens that are inhaled; they beat upward and move the captured material toward the top of the trachea. __________
14. For example, an organism that transfers a pathogen from a wild animal to a human being. __________
15. They are protein molecules produced by some cells in the body to prevent pathogenic viruses from replicating in other cells of the body. __________
16. How is passive immunity different from active immunity? Give examples of each type of immunity.
17. How is natural immunity different from artificial immunity? Give examples of each type of immunity.

continued

Learning Activity 5.1 (continued)

18. Complete the following compare and contrast table. First, list at least two similarities and two differences between blood and lymph. Then, list at least two ways in which blood and the circulatory system are different from lymph and the lymphatic system and two ways they are the same.

	Blood and Lymph	Lymphatic System and Circulatory System
Similarities		
Differences		

continued

19. Each of the following pairs of terms is related to each other in some ways, but also different from each other in other ways. Explain those similarities and differences as completely and clearly as you can:

Terms	Similarities	Differences
Non-specific Immune Defenses and Specific Immune Defenses		
Bacterial Pathogens and Viral Pathogens		
Histamines and Lymphocytes		
Active Immunity and Passive Immunity		

20. Name and explain two types of non-specific defenses the human body uses to protect from pathogen invasion.
21. What is the main function of a lymph node?
22. List all the locations where you can find lymph nodes in the human body.
23. In what way is the antibody-antigen function similar to a lock-and-key?

Notes

Lesson 2: Immunity, Disease, and Public Health

Lesson Focus

In this lesson, you will

- ❑ discuss disease outbreaks in the past and present and the impact that they have had on society
- ❑ discuss diseases that have been partly or almost entirely controlled due to the development of effective vaccines
- ❑ research the impact of another contagious disease on public health (e.g., flesh-eating disease, AIDS, avian influenza, H1N1 influenza [swine flu], and Lyme disease)

Introduction

You learned in the previous lesson that the presence of pathogens in the human body triggers many types of immune reactions to occur. You also know that certain illnesses can be prevented or reduced by the use of vaccines. **Vaccination** is one method used to prepare the body for attack, as it stimulates the production of antibodies. This way, if the pathogen itself is encountered, the body already possesses the necessary antibodies to launch the immune response.

Unfortunately, we do not possess vaccinations for all diseases. Sometimes, diseases are highly contagious and can affect a large area and a large number of people in a short period of time. In this lesson, you will learn about two particular cases of disease outbreaks that have occurred relatively recently in North America: Severe Acute Respiratory Syndrome (SARS) and West Nile virus. We will use these outbreaks to gain an understanding of how pathogens originate, how they spread, and how they can be controlled effectively.

SARS

SARS is an acronym that stands for Severe Acute Respiratory Syndrome. The first case of SARS appeared in November of 2002. It is a viral respiratory illness that is quite contagious and spreads when someone comes in close contact with someone who is infected. People who are most at risk are

- those living in the same house as a patient with SARS
- those providing care to a patient with SARS
- anyone who comes into contact with the respiratory secretions or body fluids of an infected person.

People who have been infected develop a fever, followed by respiratory symptoms such as cough, shortness of breath, or difficulty breathing. In some cases, these respiratory symptoms become quite severe. Other symptoms include muscle aches, headaches, sore throat, and diarrhea. We now believe that people with SARS are not contagious until they develop symptoms; this may take up to 10 days after exposure to the pathogen. At the time of the outbreak, SARS was a very new disease. Health professionals had little knowledge about how to diagnose it quickly or how to prevent or treat it.

In Canada, the first cases of the 2003 outbreak of SARS occurred in March. These cases involved people who had recently traveled to Hong Kong and then returned to Canada. Subsequent cases in Canada were traced either to the original cases through close contact or to affected travellers who had been in affected areas of Asia themselves. Most of these cases occurred in Ontario but some cases were also reported in British Columbia, New Brunswick, Prince Edward Island, Alberta, and Saskatchewan. As of early September 2003, there were 438 confirmed cases of SARS reported in Canada. At the time of the outbreak, many hospitals and clinics across Canada required visitors to wear protective masks to reduce the danger of infection. People who had recently travelled to Asia were not allowed in some areas to visit hospitals. The screening that occurred varied greatly from one location to the next but in some areas of Ontario, patients were asked to fill out questionnaires, to have their temperatures taken, and to use alternate entrances prior to seeing a health professional.

The global outbreak of SARS that year was largely over by July. However, China identified four new cases in December 2003 and January 2004, and another two cases in April of 2004. Globally, there were about 8,100 reported cases of SARS and it caused 800 deaths. Of those, 44 deaths were in Toronto. Scientists around the world are currently working on the development of antiviral drugs and vaccines that may be effective against SARS. There are no vaccines currently available. The flu shot does not offer any protection against SARS. The main precaution that you can take to minimize your chances of coming in contact with the SARS virus is to check with Health Canada for travel advisories before you leave the country. A travel advisory is issued to describe potential danger involved in travelling to a particular geographic location.

West Nile Virus

The virus that causes this disease is primarily transmitted to people who have been bitten by an infected mosquito. It is believed that these mosquitoes become infected when they feed on the blood of birds that are carrying the virus. It is possible but improbable that the virus can be spread through blood transfusions and organ or tissue transplants. There is some evidence that the virus can be transferred from mother to child in breast milk and across the placenta before birth. Laboratory workers who work with specimens infected with the virus can become infected themselves through needle punctures or small cuts. There is no evidence that the virus is transferred by touching or kissing an infected person.

Most people who are infected by this virus have very few if any symptoms. Some infected people develop flu-like symptoms, including fever, headache, and body aches. Some may also develop a mild rash or swollen lymph glands. However, this virus can cause severe illness that sometimes results in hospitalization and even death.

Some individuals, especially those who have a weak immune system, may develop meningitis, which is an inflammation of the lining of the brain or spinal cord; or encephalitis, which is inflammation of the brain. Symptoms of this disease include the rapid onset of a severe headache, high fever, stiff neck, vomiting, drowsiness, confusion, loss of consciousness, muscle weakness, and paralysis.

Long-term effects of this virus are not yet fully understood; however, studies indicate that prolonged health effects are possible. They may include physical effects such as long-term muscle weakness and paralysis, fatigue and headache, confusion, depression, problems with concentration, memory loss, and an inability to perform everyday tasks.

The first confirmed cases of West Nile in Canada occurred in 2002. The season when mosquitoes pose a particular risk to Canadians is from May to October. During those months, the Centre for Infectious Disease Prevention and Control (CIDPC) issues weekly West Nile Virus MONITOR reports and maps to help people avoid contact with West Nile virus.

Other Disease Outbreaks

Historically, there have been many outbreaks of infectious disease all over the world. Outbreaks vary tremendously in terms of location, type of pathogen involved, method of transmission, vulnerability of certain people to the disease, and fatalities caused. We will consider a few examples in recent history:

- The **influenza** outbreak of 1918: This disease killed about 50 million people worldwide over a two-year period. This devastating outbreak aimed its worst blow at people who were young and relatively healthy. The age group that had the highest death rate was people in their 20s and 30s. Because this outbreak was global in its impact, it is referred to as a *pandemic*. It has also been referred to as the Spanish Flu pandemic, because Spain was one of the first countries to acknowledge that some of its residents had been stricken by this disease.

  If you would like to read more about how this pandemic affected life in Winnipeg, you may be interested in reading *Influenza 1918, Disease, Death, and Struggle in Winnipeg* by W. Jones Esyllt, from the University of Toronto Press. ISBN: 9780802094391.
- **Poliomyelitis (polio):** This disease crippled many children in the first half of the 20th century. It was most commonly seen in children between 4 and 16 years of age. In the outbreak of 1951, there were 2,568 reported cases in Canada. Of those, 162 patients died; most of the victims were under the age of 15 and male. Polio caused paralysis, deformed limbs, and in the most severe cases, death by asphyxiation. In 1955, Dr. Jonas Salk developed a vaccine that proved effective against polio. As a result, polio has been successfully controlled in countries where vaccination is practiced.
- **Meningococcal Disease:** In 1998, the United Kingdom reported 150 deaths, primarily of children, due to meningococcal disease. This disease is caused by bacteria; infection can include meningitis, which is the inflammation of the fluid and lining of the brain and spinal cord. A vaccine has been developed that is very effective against this pathogen; it is now widely administered.

Successful Vaccines

Vaccines have been developed for a number of diseases that affect humans. Current research continues to work to develop new vaccines and to improve the effectiveness of current vaccines. Vaccines that are now available include:

- **Smallpox:** Smallpox was virtually eradicated in 1980 due to the long-term push for immunization worldwide. Unfortunately, since most of the world's current population has not been vaccinated, if the smallpox pathogen were used in an act of hatred or terrorism, widespread infection could follow.

- **Polio:** Between 1988 and 2000, there was a 99% reduction in the number of deaths due to polio worldwide. There are now less than ten countries in which crippling cases of polio still occur.
- **Measles:** Before an effective measles vaccine was developed, there were about six million deaths due to measles every year worldwide. By 1998, that number had dropped to fewer than 900,000. The mortality rate continues to fall.
- **Diphtheria:** In the early 1900s, diphtheria was a widespread disease. It was serious and often fatal, especially to children. As many as one in ten people became victims of diphtheria. Fatalities were due to suffocation, paralysis, and heart failure. This disease is highly contagious and is caused by a bacterium. A very effective vaccine was developed in the 1930s and it is widely used today.
- **Hepatitis B:** This disease is caused by a virus that attacks the liver. Adults who get hepatitis B usually survive and recover. However, most infants affected at birth become chronic carriers; they carry the virus and can spread the infection to others over the course of many years. The vaccine for hepatitis B is very safe and highly effective.

It is now time for you to complete **Learning Activity 5.2**. Remember to check your answers to the questions in the answer key at the end of this module.

Learning Activity 5.2

Immunity and Public Health

For this activity, go to Health Canada's website at www.hc-sc.gc.ca. From the list on the left of the screen, choose "Diseases and Conditions." From the list on the left of that screen, choose "Sexually Transmitted Infections (STIs)." Use the information found at that site to answer the following questions:

1. What can you do to protect yourself from contracting an STI? Name 5 suggestions.
2. Name seven STIs.
3. The most common bacterial STI in Canada is ______________________.
4. Name 3 symptoms of Chlamydia in women and 3 symptoms in men.
5. What is PID? What are its symptoms?
6. How is genital herpes transmitted?
7. What pathogen causes genital herpes?
8. Why is the rate of gonorrhea infection recently rising in Canada?
9. How is gonorrhea diagnosed?
10. How is HIV related to AIDS?
11. Name 5 ways in which HIV is transmitted from person to person.
12. What is HPV and what causes it?
13. What are the symptoms of HPV?
14. Why is syphilis called the "great imitator?"

When you have completed this learning activity, proceed to **Assignment 5.1: Option A** or **Assignment 5.1: Option B**. You will only complete one of these options, so read them both carefully before you choose the one you like the best.

Assignment 5.1: Option A

Vaccination Policies in Canada ***(20 marks)***

Every four years in Canada, the National Advisory Committee on Immunization (NACI) and the Immunization and Respiratory Infections Division of the Public Health Agency of Canada develop the *Canadian Immunization Guide*. It is available at the following website: www.naci.gc.ca.

If you do not have Internet access, the publishing site for this immunization guide can be contacted by phone: 1-800-635-7943. You can ask that a guide be sent to you.

From the information in the current immunization guide, answer the following questions regarding vaccination policies in Canada:

1. According to the current Canadian Immunization Guide, what is a technical definition of a vaccine? *(1 mark)*

2. In general, why are vaccinations currently used in Canada considered to be safe? *(1 mark)*

3. When is the diphtheria, tetanus, acellular pertussis, and inactivated polio virus vaccine (DTaP-IPV) administered to infants and small children? Describe the vaccination schedule. *(2 marks)*

continued

Assignment 5.1: Option A (continued)

4. When is the measles, mumps, and rubella vaccine (MMR) administered to infants and small children? Describe the vaccination schedule. *(2 marks)*

5. If diphtheria, polio, and measles are already rare in occurrence in Canada, why are children still vaccinated against these diseases? *(2 marks)*

6. When are vaccinations for hepatitis B usually given in Canada? Describe the vaccination schedule. *(2 marks)*

continued

Assignment 5.1: Option A (continued)

7. What vaccinations are given to a 30-year-old adult who has not received any vaccines in the past and who has just moved to Canada? *(2 marks)*

8. Should all adults be vaccinated against chicken pox according to this immunization guide? Why or why not? *(2 marks)*

9. Should all adults be vaccinated against rabies according to this immunization guide? Why or why not? *(2 marks)*

continued

Assignment 5.1: Option A (continued)

10. Is it possible to recommend one standard list of vaccines for healthy adults who plan to travel outside of Canada? Why or why not? *(2 marks)*

11. Some people are against the practice of vaccination for a variety of reasons. What is your opinion on vaccinating children against the pathogens discussed in this module? *(2 marks)*

Remember, you only need to complete **one** of **Assignment 5.1: Option A** or **Assignment 5.1: Option B**. So, if you have already completed Assignment 5.1: Option A, you do **not** have to complete Assignment 5.1: Option B.

Assignment 5.1: Option B

Disease Investigation *(20 marks)*

In this assignment, you will investigate a disease not already discussed in this module, and its impact on public health.

Step 1

Choose a contagious disease or a disease that has affected public health. Examples include: AIDS, Mad Cow, flesh-eating disease, avian influenza, Lyme disease. You may choose another disease but be sure it is either contagious or can be spread by infected vectors. If you are not sure, contact your tutor/marker for help.

Step 2

Research the disease you have chosen, recording all of your information sources.

Step 3

Answer the following questions about that disease:

a. What pathogen causes the disease? Give both the name and the nature of the pathogen. *(2 marks)*

b. How does the disease-causing pathogen move from one host to another? Describe all the ways the disease can be transmitted. *(2 marks)*

continued

Assignment 5.1: Option B (continued)

c. Who is susceptible to this pathogen? In other words, what sector of the population is most at-risk? *(2 marks)*

d. What are the symptoms of this disease? Describe at least four symptoms. *(4 marks)*

e. Is there currently an effective vaccine against this disease? If not, is one being researched? *(2 marks)*

f. What is done and what can be done to prevent the continued spread of this disease? List at least three steps that have been taken in the past, and/or are currently practiced. *(3 marks)*

continued

Assignment 5.1: Option B (continued)

g. How is this disease diagnosed? List at least 4 symptoms. *(2 marks)*

h. How are victims of this disease treated medically? List at least two treatment options. *(2 marks)*

i. List all your sources of information (websites, brochures, articles, etc.). *(1 mark)*

Notes

LESSON 3: OVERVIEW OF THE NERVOUS SYSTEM

Lesson Focus

In this lesson, you will

- ❑ explain how the structure and organization of the nervous system allows it to carry on the diversity of functions that it performs
- ❑ describe the roles of the central and peripheral nervous systems, the autonomic and somatic nervous systems, and the sympathetic and parasympathetic nervous systems
- ❑ explain the connection between the right and left hemispheres of the brain and how it is connected to ideas about lateralization in the human brain
- ❑ discuss concussions in terms of how they occur, what effect they have on the brain, and how multiple concussions can cause additional injury

Introduction

The remainder of this module deals with the **nervous system**, a complex system that allows you to **receive** information and also allows you to **react** to that information. Here are some instances that involve the nervous system. When you look at a bright light, the pupils in your eyes become small. When you hear a sudden loud noise, your heart rate suddenly increases. You are looking at this page now and reading the words on it, understanding the content, and hopefully storing it for later use. A mosquito lands on your forearm and you swat at it. You have just finished a basketball game and you are thirsty.

Introduction to the Nervous System

The ability to receive stimuli and react to it is essential if your body is to maintain homeostasis. Many aspects of the external and internal environment are subject to change. As a result, it is important that your body can recognize and react to those changes. Some of those reactions are automatic and instantaneous, like blinking, while other reactions require some thought before they are initiated, like putting on a sweater when you are cold. In other words, some responses are **automatic** behaviours and others are **conscious** decisions.

In general, the part of the nervous system that receives information is called the **receptor**. Examples include the taste buds on your tongue and the pain receptors in your skin. The part that acts on that information is called the **effector**. Effectors are primarily muscles and glands. There are other specialized cells that connect receptors to effectors. The message that is sent is electrical in nature and is very fast. Nerve signals are also called **impulses**.

In general, the human nervous system is made up of two parts, the Central Nervous System (CNS) and the Peripheral Nervous System.

Peripheral Nervous System

Consists of the…

Somatic Nervous System
Relays information to and from skin and skeletal muscle, under conscious control (voluntary).

And the…

Autonomic Nervous System
Relays information to internal organs, not under conscious control (involuntary).

Sympathetic Nervous System
Controls organs in times of stress ("fight or flight").

Parasympathetic Nervous System
Controls organs when body is at rest.

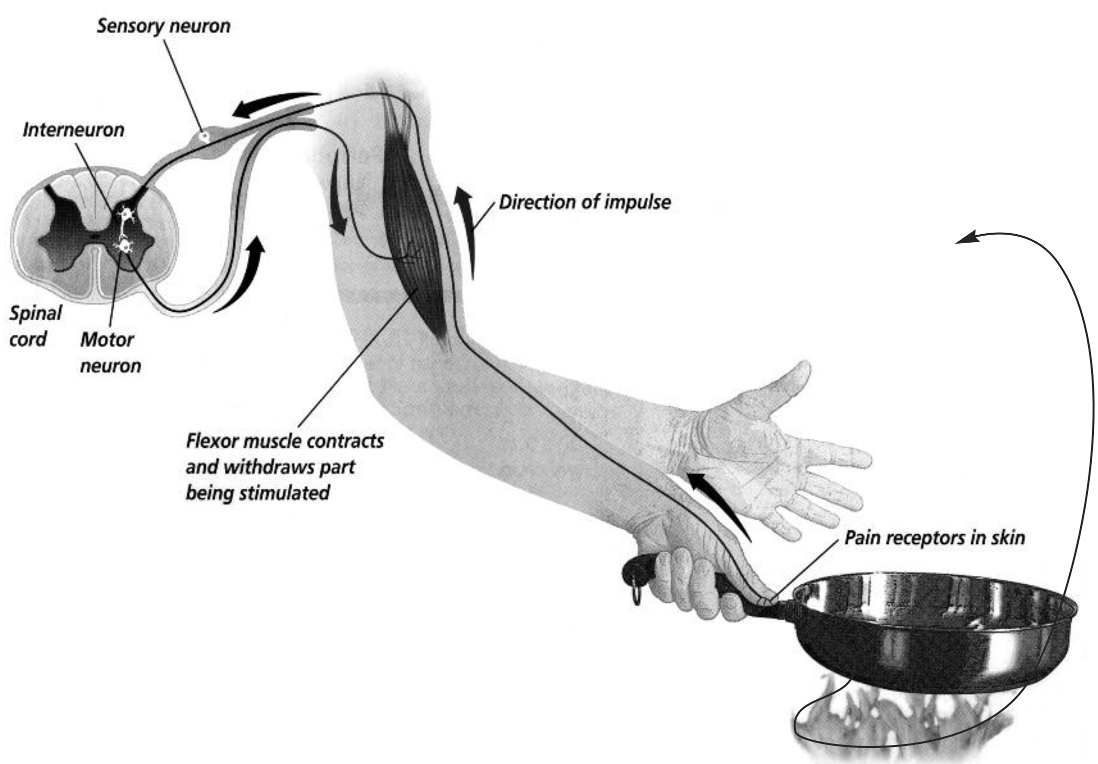
Including the stomach, eyes, intestines, heart, and liver

The Central Nervous System

The CNS is made up of two parts, the **brain** and the **spinal cord**. The spinal cord is connected to the base of the brain. The brain is protected by the skull, and the spinal cord is protected by the vertebrae in the spinal column. As well, the CNS is protected by protective membranes called **meninges**. **Cerebrospinal fluid** fills the spaces between the CNS and the meninges, acting as a cushion to help protect the brain and spinal cord from trauma. The central nervous system is the primary structure that is responsible for our abilities to understand and change our surroundings.

There are 31 pairs of spinal nerves that leave the spinal cord and travel to receptors and effectors in various parts of the human body. Information is gathered by receptors and is sent to the CNS; the information is processed and instructions are sent to the effectors as to how they should react.

The spinal cord is not only the information highway to and from the brain, but it is also the centre for body **reflexes**. Not all responses involve the brain. Sometimes information is gathered by receptors that must be reacted to right away. In those instances, the message is sent to the spinal cord, is processed, and is quickly acted on without involvement of the brain. Consider this diagram of the **reflex impulse**:



The Central Nervous System: Reprinted from *Biology*: The Dynamics of Life by Alton Biggs, et al. New York, NY: McGraw Hill, 2004. p. 949. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

The diagram shows three general types of **neurons** or nerve cells:

- Receptor cells collect the information, and **sensory neurons** transmit the message to the CNS.
- **Interneurons** connect the sensory neuron to the motor neuron.
- **Motor neurons** then carry commands from the interneuron to the effector (muscle).

An example of a situation involving the reflex arc is when you pick up a hot frying pan. Pain receptors in your hand recognize the heat, and send a message to the spinal cord. As a result, motor neurons carry a message to the effectors commanding the muscles in your hand to contract and release the hot handle.

When the brain is involved in behaviours, the reflex arc is not used. The brain processes information sent to it and then sends commands about how the body should react. Behaviours such as this are more complex than reflexes. These conscious actions are affected by learning and adaptation.

The Peripheral Nervous System

Nervous tissue outside of the brain and spinal cord is peripheral nervous tissue. There are two general types of peripheral nervous tissue:

- **Autonomic nervous system:** This system carries impulses from the CNS to the involuntary muscle tissue responsible for functions such as digestion, circulation, excretion, and respiration. These are necessary life processes but occur involuntarily; your body accomplishes these tasks without involving your conscious thought. There are two subdivisions of this autonomic system:
  - **Sympathetic nervous system:** Nerves in this system stimulate various parts of the body. This system causes the "fight-or-flight" response that allows you to react quickly to danger.
  - **Parasympathetic nervous system:** Nerves in this system signal the organs to stop contracting or to stop releasing hormones. This system comes into play when the danger is no longer present.
- **Somatic nervous system:** This system directs the voluntary muscles of the body; you have conscious control over voluntary muscles such as your biceps or your quadriceps.

Sensory neurons in the peripheral nervous system are specialized structures that are sensitive to certain kinds of stimuli in the environment. Sensory neurons can convert different environmental stimuli into nerve impulses that eventually are transmitted to the CNS. The sense organs, such as the eyes and skin, are each sensitive to a certain type of stimulus. Whether the body senses the smell of a fire, the taste of a lemon, or the sound of music, the message is sent to the CNS in the same manner—from a sensory neuron to the CNS to a motor neuron. Smell, taste, and sound are all interpreted by different areas in the brain. The nature of nervous messages is the subject of the next lesson.

The Human Brain

The brain is the most complex organ of the human body. Typically, a human brain weighs about 1.4 kg and contains about 100 billion cells. The bones of the skull form the **cranial cavity** and serve as protection for the delicate brain tissue. The brain is also protected and cushioned by the moist **meninges**, which are membranes that lie between the brain tissue itself and the skull.

The human brain is divided into three general sections:

1. the hindbrain
2. the midbrain
3. the forebrain

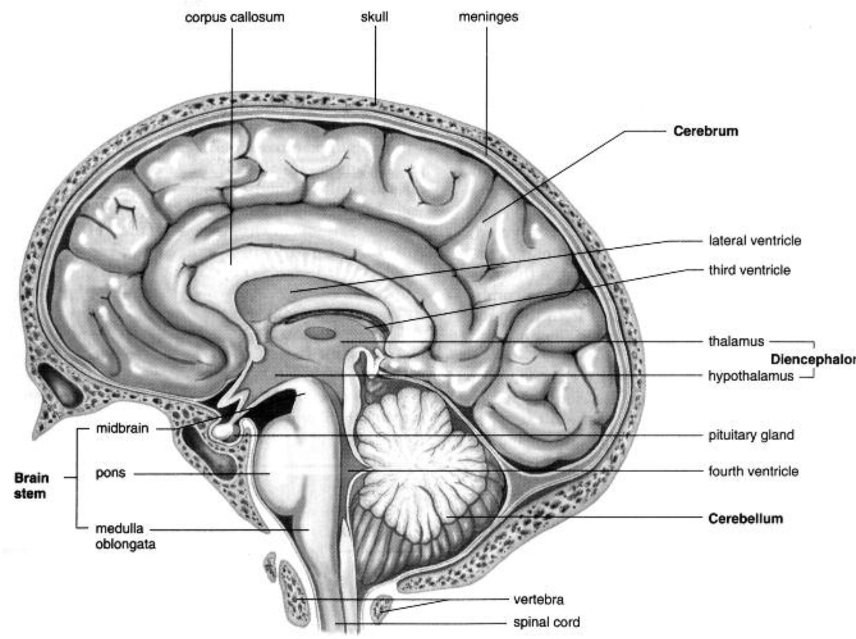
The **hindbrain** is further divided into three parts:

a. The **medulla oblongata**: This portion of the brain is sometimes called the brain stem. It connects the spinal cord to the rest of the brain. It is responsible for automatic processes like breathing, swallowing, and coughing.

b. The **cerebellum**: Located at the base of the skull, its functions include coordination of voluntary movement, balance and equilibrium, and some memory for reflex motor acts. The exterior of the cerebellum is covered by convolutions or ridged surfaces. There are two parts of the cerebellum, divided between left and right sides.

c. The **pons**: This is a small oval structure that is actually a bridge between the cerebellum and the medulla oblongata.

The **midbrain** is a short section of the brain found between the pons and the forebrain. It works with the cerebellum to control muscle coordination. It also contains relay centres for balance, vision, and hearing.

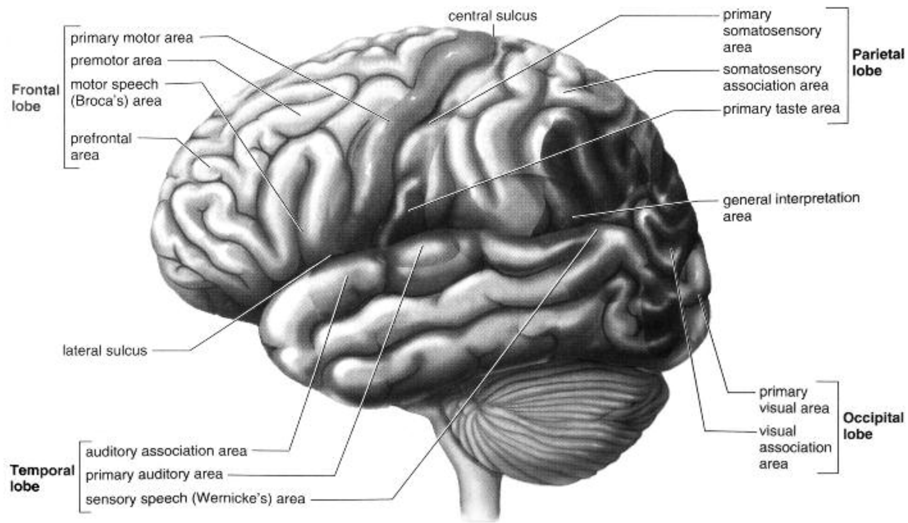


The Brain: Reprinted from *Inquiry into Life* by Sylvia S. Mader. New York, NY: McGraw Hill, 2003. p. 326. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

The **forebrain** is made up of three parts:

1. The **cerebral cortex (also called the cerebrum)**: The outermost layer of the cerebral hemisphere is composed of gray matter. This section is the largest part of the human brain and occupies the very top of the cranial cavity of the skull. It is by far the most complex part of the human brain. Its surface is covered by folds and convolutions. There are two parts of the cerebrum—the **right** and **left hemispheres**. The two hemispheres are connected by the **corpus callosum**. Each hemisphere of the cerebrum is further divided into four lobes that you can observe on the following diagram:

   - The **frontal lobes** (forehead) dictate how we know what we are doing within our environment (consciousness), how we initiate activity in response to our environment, and judgments we make about what occurs in our daily activities. Its functions also include controls of emotional response and memory for habits and motor activities.
   - The **occipital lobes** (back) control vision.
   - The **parietal lobes** (top) control sensory activity like visual attention, touch perception, goal-directed voluntary movements, manipulation of objects, and the integration of different senses that allows for understanding a single concept.
   - The **temporal lobes** (sides) control hearing, memory acquisition, categorization of objects, and speech. Within the temporal lobe is an almond-shaped structure called the **amygdala** that responds to severe traumas with an un-erasable fear response. The amygdala is the portion of the brain concerned with emotion.

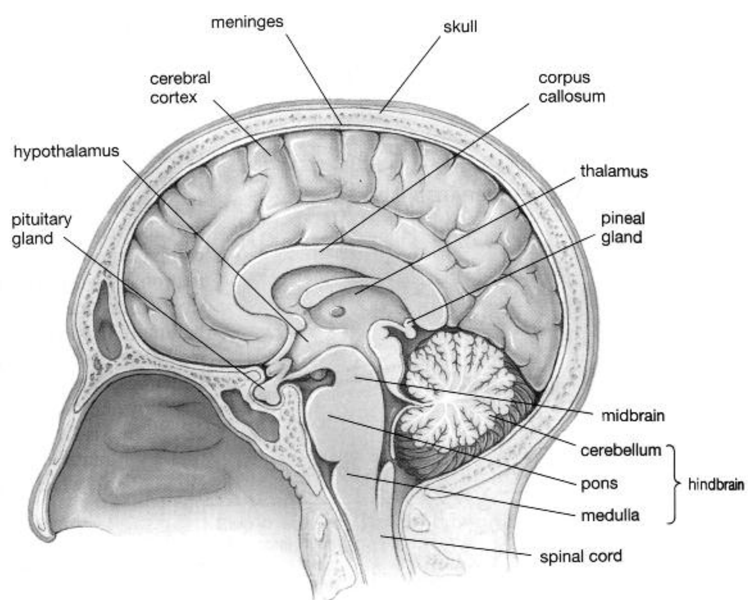


The Brain: Reprinted from *Inquiry into Life* by Sylvia S. Mader. New York, NY: McGraw Hill, 2003. p. 327. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

2. The **thalamus**: This tiny structure is attached to the base of the cerebrum. It acts as a relay station, receiving all impulses from the body and transferring each of them to the correct part of the cerebrum for processing.

3. The **hypothalamus**: This structure is also attached to the base of the cerebrum. It contains reflex centres for various internal organs. It is the control centre for body temperature, smooth muscle activity (involuntary), water balance, appetite, and blood pressure. It also contributes to the control of behaviour (fear, sleep, aggression, etc.).

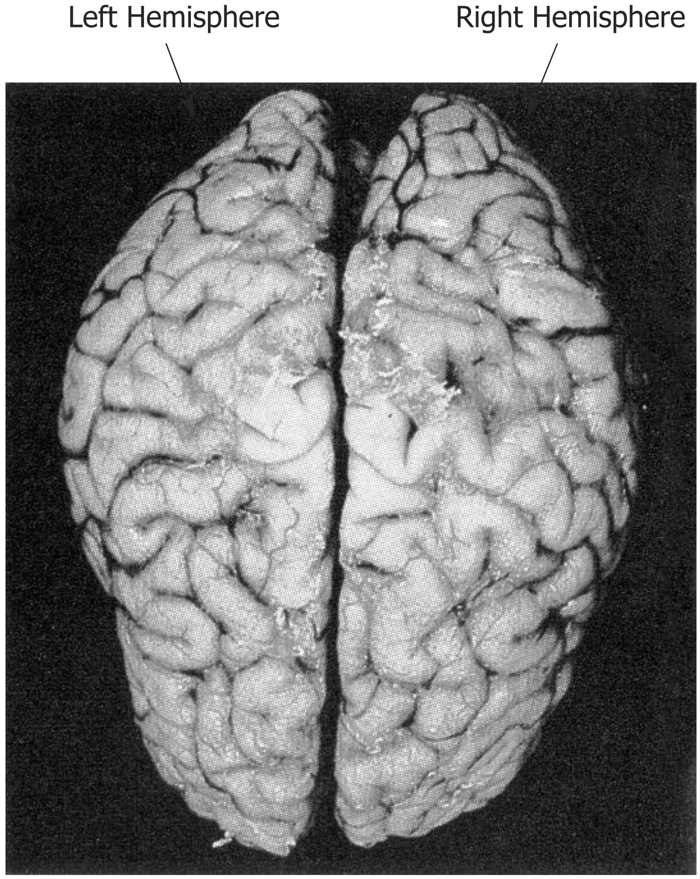
Consider the following diagrams of the human brain:



The Brain: Reprinted from *Biology: Life on Earth* by Teresa Audesirk, et al. Upper Saddle River, NJ: Prentice Hall, 2002. p. 678. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

Hemispheres of the Brain

What does it mean to be "left-brained" or "right-brained"? The term **brain lateralization** refers to the fact that the right and left halves of the human brain are not exactly alike. Each hemisphere has its own **specialized** functions. In other words, some functions possess neural mechanisms that are localized primarily in one half of the brain. Recall that the **corpus callosum**, a layer of white matter made up of nerve cells, is the structure that connects the left and right hemispheres of the brain, as shown below:



The Brain: Reprinted from *Inquiry into Life* by Sylvia S. Mader. New York, NY: McGraw Hill, 2003. p. 326. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

Functions that tend to occur preferentially on one side of the brain or the other include complex cognitive, sensory, linguistic, and voluntary processes. One example of lateralization of the human brain involves the area of human language. In the human brain, one important functional difference between the right and left sides of the brain is that speech and language abilities can be traced to a particular area of the left hemisphere. It has been estimated that 70% to 95% of humans have a left-brain language specialization. In general, the left side of the brain functions in writing, logic, speech, and mathematics.

Artistic ability, recognition of musical stimuli, spatial manipulation, facial perception, symbol interpretation, and imagination are all examples of functions that tend to be lateralized to the right hemisphere of the brain.

It has been long understood that motor control of the right side of the body originates in the left side of the brain. Conversely, motor control of the left side of the body originates in the right side of the brain. Broad generalizations of how body functions are lateralized in the brain are difficult to make. While both hemispheres of the brain process the same information from the environment, each individual brain processes information differently. Here is a summary of right and left brain functions:

Left Brain	Right Brain
■ Uses symbols to represent things ■ Uses words in description ■ Relies on facts and reasoning ■ Good sense of number ■ Poor sense of spatial relationships ■ Logical	■ Uses gestures and pictures in descriptions ■ Poor sense of number ■ Relies on instinct and intuition ■ Sees patterns linking ideas as a whole ■ Makes analogies and sees likenesses ■ Good sense of spatial relationships

Brain Injury

The human brain is protected by the skull and by fluid that is contained within the membranes that surround the brain. When someone gets a head injury that causes a blow to the skull, the brain can actually move around within the skull. This movement can cause bruising of the brain, breaking of blood vessels, and damage to the nerves in the area of the injury. This type of injury is called a **concussion**, which is actually a temporary loss of complete brain function. Concussions vary in their severity and in their impact on human health.

Sports injuries are probably the most common cause for concussions, especially in young people. This is particularly true of contact sports such as football, soccer, and hockey. Concussions may occur even though the player wears protective headgear. Other situations in which concussions may occur include biking, roller blading, car accidents, and physical fighting. If it is suspected that a person may have suffered a concussion, it is important that that individual not continue the activity. If the brain is not given enough time to repair itself following a concussion and that person receives another brain injury, it can be very serious. Repeated brain injuries can lead to long-term disability, swelling, and even death.

A person does not have to have lost consciousness to have received a concussion. Typical symptoms include dizziness, light-headedness, delayed memory, nausea, vomiting, headache, blurred vision, slurred speech, difficulty with coordination or concentration, and feeling very tired. It is important that someone who has suffered a concussion see a doctor promptly.

Postconcussion syndrome (PCS) is a condition in which someone receives a concussion and does not recover from its symptoms for a few months. Some of the symptoms given above for concussions may even become permanent. Rehabilitation is possible for these individuals and may minimize the effects that these symptoms have on their lives.

It is now time for you to complete **Learning Activity 5.3**. Remember to check your answers to the questions in the answer key at the end of this module.

Learning Activity 5.3

Concussions in Hockey

Read the accompanying article, *"Bodychecking and Concussions in Ice Hockey: Should Our Youth Pay the Price?"*

Complete the "Article Analysis Frame" that accompanies the article. Refer to the explanations below as you complete the form.

Issue: What issue does this article concern?

Summary: Summarize the main points of the article.

Author's Opinion (Evidence): State the author's opinion on the issue and the reasons that explain why he/she holds that opinion.

Your Opinion: What do you think about the issue?

Questions: After reading the article, what questions do you still have on the issue? (Give at least 3 questions.)

Relevance Today: How important is this issue in today's world? In your community? In your own life?

continued

Bodychecking and Concussions in Ice Hockey: Should Our Youth Pay the Price?

Anthony Marchie and Michael D. Cusimano

Ice hockey, considered Canada's national sport, has more than 500 000 registered players, many of whom aspire to play in the National Hockey League (NHL). With the drive to win at any cost permeating the game, it is not surprising that aggression is a commonly used tactic and has helped to turn hockey into a collision sport. Nor is it surprising that youth often idolize and emulate the professional enforcers who protect their team's leading scorers.

Bodychecking, thought by some a useful skill for winning games, is a major risk factor for injury. With the rising incidence of traumatic brain injury in hockey, too many Canadian youth are exposed to the lasting effects of such injuries, some of which are not fully realized until the brain completes its maturation.

Before the start of the 2002–2003 season, Hockey Canada (previously known as the Canadian Hockey Association), reversed its 20-year stance and decided to permit players as young as 9 years old to bodycheck in games. Although the research that was used to justify this policy was later deemed flawed by its author and others, the policy stood. This ignited a debate that resounded throughout arenas, homes and league boardrooms across the country. Previously, only those aged 12–13 years and older could bodycheck, although some provinces such as British Columbia had a threshold of 14–15 years. Hockey Canada reversed its decision in May 2003 and decided to raise the starting age to 11; however, it continues to allow bodychecking starting at age 9 in an "experimental" fashion in 4 of some of the largest hockey associations in Canada. The meaning of "experimental" does not appear in Hockey Canada news releases.

Those in favour of bodychecking claim that the game of hockey demands it; youth exposed to bodychecking at only a later age will be ill equipped to avoid injury. They believe that injuries result from improperly delivered or taken bodychecks and that poor technique should not deter leagues from permitting checking. They argue that the focus should be on educating coaches and teaching bodychecking skills at all levels of hockey.

continued

Learning Activity 5.3 (continued)

Physicians are often called upon to assess youth with hockey-associated traumatic brain injury and to counsel players and their parents about subsequent return to play. Although recommendations about return to play are numerous, none has been extensively validated. A considerable number of youth who return to play on the goodwill of these recommendations sustain repeated traumatic brain injuries. None of the recommendations emphasizes the importance of counselling children and their families about the risks of returning to play or the option of not playing in a body-contact league. In our opinion, too much emphasis is placed on when to return to play and not enough on whether to return after an initial traumatic brain injury. To properly counsel players and inform the debate on allowing bodychecking in hockey, physicians must fully appreciate the medical risks associated with bodychecking in hockey.

What is the relation between bodychecking, injury and concussions?

Bodychecking, the most common cause of trauma in hockey, accounts for 86% of all injuries among players 9–15 years old. Players in contact leagues are 4 times as likely to be injured (among those 9–15 years old) and 12 times as likely to receive a fracture (among those 12–13 years old) as players in non-contact leagues. Of reported injuries among players 9–15 years old, 45% are caused by legal bodychecks and 8% by illegal checks, without a significant difference in the injury profiles between the 2 types of checking. Stricter enforcement of rules would not, therefore, have much impact on injury rates.

A comparison with football injuries helps highlight the issue of serious injury in hockey. Direct fatality and injury rates for football are half those for hockey: 1.8 per 100 000 football players in high school and 7.0 per 100 000 in college. Nonfatal catastrophic spinal cord and brain injury rates are 2.6 per 100 000 hockey players and 0.7 per 100 000 football players among high school athletes.

Among the serious injuries caused by bodychecking, concussions are of particular concern because of the risk of permanent sequelae. In studies involving youth and adults, concussions have ranged from a brief period of neural dysfunction to loss of consciousness and amnesia. There may be headache, cognitive, memory and executive-function disturbances, visual abnormalities, motor and sensory changes, and seizures. Permanent electrophysiological changes in brain function have been observed in injured junior hockey players 16–20 years old who had recovered and returned to play. Some reported concussions are shown to be contusions on CT scanning.

continued

Learning Activity 5.3 (continued)

Repeated mild brain injuries in youth and adults occurring over months or years can result in cumulative deficits. High school athletes with a history of 3 concussions are 9 times more likely than those with no history of concussion to have changes in their mental status. These patients have “long-lasting alterations in neurological motor functions,” and some have had to relearn how to stand.

The younger developing brain is at an even higher risk of injury. Repeated concussions may lead to permanent learning disabilities and other neurological and psychiatric problems. Pre-adolescent youth with a traumatic brain injury may never fully develop the social and cognitive skills characteristic of adults and may be more violent than those without such an injury.

Each season, 10%–12% of minor league hockey players 9–17 years old who are injured report a head injury, most commonly a concussion. Concussions are most often caused by bodychecking and rarely by being struck with a puck.[38] A review of the literature published between 1966 and 1997 revealed that youth aged 5–17 years had about 2.8 concussions per 1000 player-hours of ice hockey; the number per 1000 player-hours was about the same among high school players, as high as 4.2 among university hockey players and 6.6 among elite amateurs. Among Canadian amateur hockey players over 18 years old, the rate is 4.6–6.0 concussions per 1000 player-hours. When 14 years was the age at which bodychecking was first allowed in British Columbia, 15 years was the average age at which players had their first concussion. Undoubtedly, this threshold age will decline as the new rules about bodychecking are implemented across the country.

Reports of injuries involving youth and adult hockey players show that, despite advances in equipment design, the number of concussions is increasing. Based on these findings and Hill’s criteria for causal association, the link between bodychecking and injury and concussion is convincing. It makes sense, given our knowledge of the disease process. The link is analogous to the association between smoking and lung cancer. Findings from meta-analyses and prospective and retrospective studies support the association between bodychecking and concussion. In addition, the incidence rates of concussion and other hockey-related injuries increase with increasing age, when more bodychecking is expected, and with higher levels of play, which suggests a dose–response effect. Learning to bodycheck when young does not reduce a player’s rate of injury as he or she ages, and it prolongs the risk exposure.

continued

Learning Activity 5.3 (continued)

Return to play?

Even minor concussions are serious injuries because they can lead to second-impact syndrome or cumulative effects in the event of another concussion. Second-impact syndrome is often the main reason for delaying a sports player's return to play after a concussion. The syndrome is caused when players who remain symptomatic sustain a second blow to the head. Even if this second blow is minor, the brain may swell rapidly, resulting in extensive further injury, or uncal herniation and death, probably because of the loss of auto-regulation of the cerebral vasculature.

There are expert guidelines on when players can return to play, without specific reference to age, but no mention of *if* players should return to play. Our experience indicates that players who have had a second concussion, or their parents, often wished they had been given the option of whether to return to play at all. Physicians should counsel patients and their families about the risks and benefits of continued play and should explain the importance of being realistic about ambitions for a future in hockey—only 1 of every 4000 minor league hockey players will ever play in the NHL, and only 1.3 of every 1000 will earn an athletic scholarship to an American university. Because symptoms often worsen with exercise and because the length of time the brain is vulnerable after a concussion is unknown, prudence dictates erring on the side of caution when deciding on when or whether athletes should return to play.

Should bodychecking be allowed in youth hockey?

Many proponents of bodychecking argue that it is an important skill that allows players to take control of the puck, creates scoring opportunities and helps with defensive positioning and coverage, making it valuable to overall team play. Teams often have a checking line of 3 players who play against an opposing team's top scoring line to minimize their scoring opportunities and tire them out. As is evident in any playoff series, this checking is often used as physical and mental intimidation to gain control of the game.

However, the relation between aggressive play and winning is much weaker than the proponents of bodychecking believe. In a study of 1462 recorded penalties in all 18 Stanley Cup final series from 1980 to 1997, teams playing with less violence were more likely to win. Compared with more violent teams, they had on average over 7 more shots on goal per game and 53 more shots on goal over a 7-game series. Losing teams engaged in more violence early in the game, which suggests that their motivation was not frustration of defeat but, rather, the mistaken belief that violence contributes to winning.

continued

Learning Activity 5.3 (continued)

Although the contribution of bodychecking to a team's success is questionable, it is such an integral part of the game at the professional level that it is unlikely to be eliminated soon. However, players should not be introduced to bodychecking until they can make a mature, informed choice regarding the issue. Enforced league policies that disallow bodychecking are still the best hope for reducing young players' injuries.

The risks of bodychecking make it clear that checking is not necessary for play at the Canadian minor league hockey level—a position supported by the Canadian Academy of Sport Medicine. The American Academy of Pediatrics recommends limiting bodychecking among players 15 years of age and less. Variations in body size and strength occur in all age groups, but they are most pronounced from 13 to 15 years; differences of 53 kg in body mass and 55 cm in height between the smallest and largest players have been reported in this age group. Since most physical growth is not complete before a person is 17 or 18 years old, bodychecking and hitting should be banned until at least that age. Leagues with players old enough to give consent should obtain informed consent from players before they join the body-contact league. The standard waiver that players are asked to sign to release leagues of all responsibility in the event of injury does not reach the standard of consent expected in activities with more than minimal potential harm. Also, it is unclear how informed consent will be obtained from the 9-year-old players in the 4 hockey associations who will be participating in Hockey Canada's "experiment" 15 and whether the process conforms to Tri-Council Policy.

Awareness of injury prevention is fortunately being raised through programs such as the recently implemented Fair Play in minor hockey leagues. Such programs have been shown to reduce injury rates. Another strategy for maximizing player safety is education. Hockey Canada has recognized this need and has launched 2 programs to help coaches improve their skills: the Competency Based Educational Program and the Coaches Mentorship Program.

Although coaches have a responsibility to teach safety techniques and coaches and parents should act as role models for good sportsmanship, these actions rarely happen consistently. Recently, 22 of 34 minor league coaches refused to participate in a video about concussion prevention because they thought that watching the video would make their players less aggressive and successful as a team. In one community, players 14–15 years old were less likely than younger players to believe that sportsmanship was "real important." Moreover, 26% of players 12–15 years old who understood that bodychecking from behind could cause serious injury or death reported that they would be willing to do so if they were angry or wanted "to get even."

continued

Learning Activity 5.3 (continued)

In addition, parents may be encouraging their children to win at all costs in the hope of their pursuing scholarships and professional contracts. In one study, 32% of injured players said that they would continue to bodycheck to ensure a win; an additional 6% said they would do so in order to injure another player. Since aggression may be a learned behaviour rewarded in sport, youth and the public in general must be educated about its dangers and social unacceptability. Ideally, as role models for youth, professional players and media personnel should emphasize nonviolence.

Moreover, although the use of protective equipment may prevent some injuries, it may foster the attitude that it can prevent all injuries, it may lead to more lenient enforcement of the rules and, paradoxically, it may increase the number of serious injuries.

Education and the elimination of bodychecking remain the most effective strategies for preventing concussions and other hockey-related injuries. Eliminating bodychecking could refocus the game on fun and skill—on skating, shooting, passing and team play. Physicians must play their roles as socially responsible citizens: the future of our youth and the game depend on it.

Marchie, Anthony and Michael D. Cusimano. "Bodychecking and concussions in ice hockey: Should our youth pay the price?" *Canadian Medical Association Journal*, Jul 2003; 169: 124–128. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

Article Analysis Frame

Issue

Author's Opinion (Evidence)

Summary

Your Opinion

Questions

Relevance Today

At this point, complete **Assignment 5.2**. It will give you a chance to demonstrate what you have learned about the nervous system.

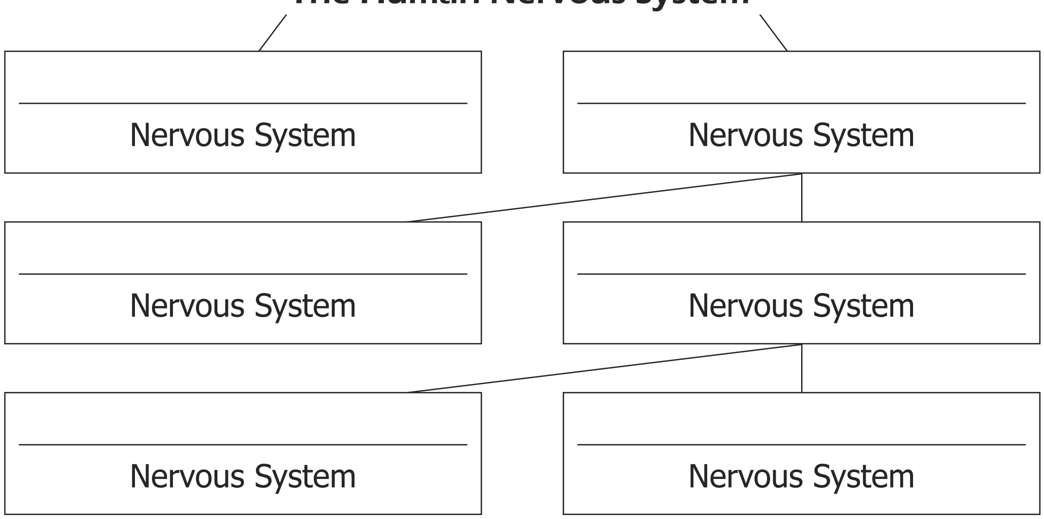
Assignment 5.2

The Nervous System *(30 marks)*

1. Use this list of terms to fill in the diagram below: *(6 marks)*

Central	Parasympathetic	Somatic
Autonomic	Peripheral	Sympathetic

The Human Nervous System



2. Use this list of terms to complete the statements below. Terms can be used more than once. Each term is worth 1 mark for a total of 20 marks.

frontal lobes	thalamus	pons
hindbrain	parietal lobes	cerebellum
medulla oblongata	hypothalamus	forebrain
midbrain	cerebrum	occipital lobes
corpus callosum	temporal lobes	amygdala

a. The three parts of the forebrain are:

____

____

continued

Assignment 5.2 (continued)

b. The structure in the brain responsible for emotions is:

____

c. The three sections of the human brain are:

____

d. The three parts of the hindbrain are:

____

e. The structure that lies between the pons and the forebrain is:

____

f. The tiny structure that lies at the base of the cerebrum that sends each message to the correct part of the cerebrum is:

____

g. The tiny structure that connects the cerebellum and the medulla oblongata is:

____

h. The structure that connects the right and left hemispheres of the brain is:

____

i. The tiny structure that is the control for various body functions such as blood pressure, thirst, and appetite is:

____

j. The four lobes of the cerebrum are:

____

k. This structure is also called the brainstem:

____

continued

Assignment 5.2 (continued)

3. For each of the following scenarios, decide whether the somatic nervous system or the autonomic nervous system is at work. *(4 marks)*

   a. Your heart continues to beat all day, even when you are asleep.

   ____

   b. After you go outside, your pupils contract and you squint in the bright sunlight.

   ____

   c. You run as fast as you can to catch the bus.

   ____

   d. You swerve to avoid another car, your heart beats rapidly, and your pupils dilate.

   ____

Notes

Lesson 4: The Neuron

Lesson Focus

In this lesson, you will

- ❑ describe the structure and function of a neuron
- ❑ explain the electrical nature of a nerve impulse as it travels through one neuron
- ❑ explain the chemical nature of a nerve impulse as it travels from neuron to neuron

Introduction

In the last lesson, you learned some general things about the nervous system. In this lesson, you will learn more about an important part of the nervous system—the neuron.

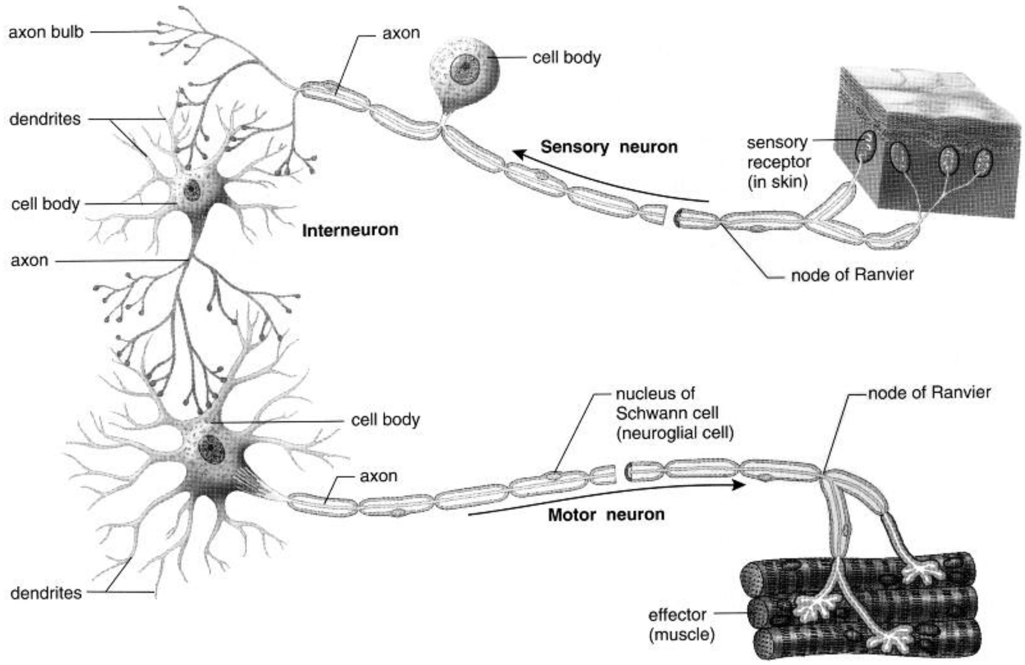
The Neuron

Neurons are nerve cells. They have a very unique structure that is connected to the function they perform in the human body. Consider the diagram on the next page.

Neurons are very specialized cells because they carry messages in the form of nerve **impulses**. They convert the message from receptors into an **electrochemical signal**.

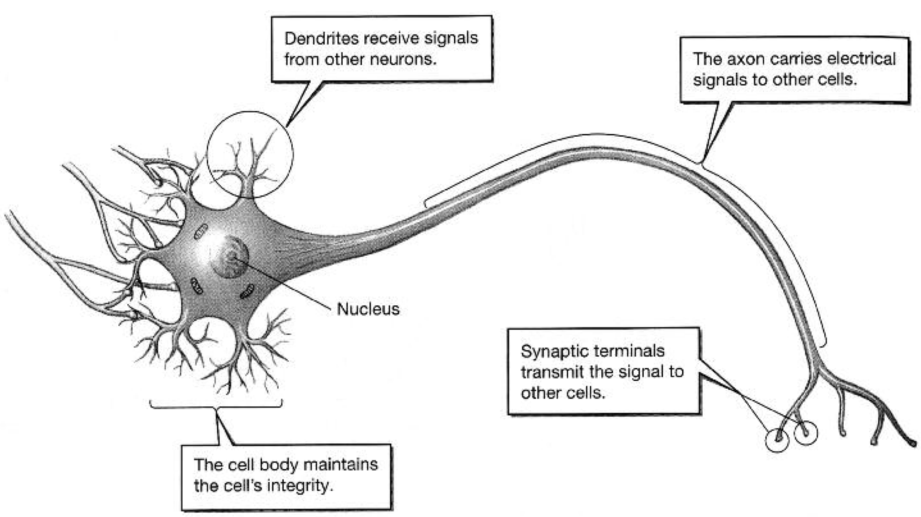
A neuron has several parts that you can observe on this diagram:

- The **cell body** contains the cell nucleus and most of the cell's organelles as well. The cytoplasm of a neuron is called its **neuroplasm**. The shape of the cell body can vary.
- Fibres that extend from the cell body vary in length as well. The numerous, tiny branches are called **dendrites**. Some neurons have as many as 200 dendrites. Dendrites pick up impulses from other neurons.
- The single larger fibre that extends from the cell body is the **axon**. The axon transmits the electrical impulse away from the cell body and towards the dendrites of other neurons to which it is connected.



Types of Neurons: Reprinted from *Inquiry into Life* by Sylvia S. Mader. New York, NY: McGraw Hill, 2003. p. 319. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

- **Schwann Cells** along the length of the axon form a fatty layer called the **myelin sheath**. This substance speeds up the function of the neuron. In addition, Schwann cells also allow neurons to regenerate themselves if damage is not too severe. However, it should be noted that as mature cells, most neurons are incapable of reproducing themselves.
- Between each Schwann cell is a **node of Ranvier**, where the membrane of the axon is exposed. At these gaps, the nerve impulse "jumps" from one node to the next, speeding up the function of the neuron.

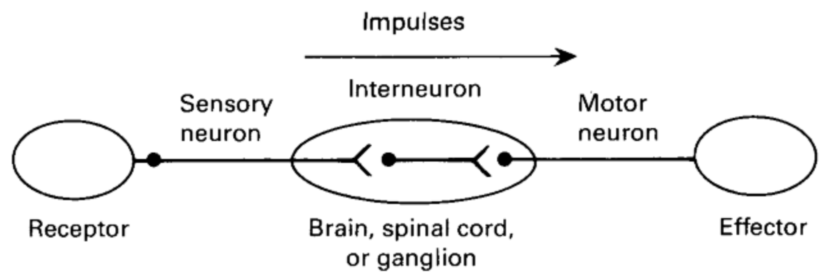


A Nerve Cell: Reprinted from *Biology: Life on Earth* by Teresa Audesirk, et al. Upper Saddle River, NJ: Prentice Hall, 2002. p. 542. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

Types of Neurons

Some neurons, such as those in the brain, are very small and short in length. Others, such as those found in the leg, can be over a metre in length. Whatever their length, neurons are capable of surviving for about 100 years, since they generally do not undergo cell division after adolescence. There are three types of neurons found in the human body:

1. *Sensory neurons* are directly connected to receptor cells receiving information from the environment. The information they collect is sent to the CNS.
2. *Association neurons*, also known as interneurons, are in the CNS and receive impulses from sensory neurons and from other interneurons.
3. *Motor neurons*, like the one in the diagram above, receive impulses from the CNS and relay them to effectors, such as glands or muscle tissue.



Here is an example to illustrate these three neuron types at work:

> You touch something hot. Dendrites of the **sensory neurons** in your hand are activated and send a message to the spinal cord.
>
> ↓
>
> **Interneurons** in the spinal cord link the sensory neuron's message to the motor neuron's action.
>
> ↓
>
> **Motor neurons** receive the message from the spinal cord to pull the hand away. At the same time, interneurons send a message to the brain alerting you of what just occurred.

This example is a reflex, and can be triggered without direct instruction from the brain.

How the Neuron Works

As it travels along a neuron, an impulse is electrical in nature. An impulse is also called an **action potential**. As a result, it is very fast. Chemical substances called ions are the primary carriers of the signal along the axon. Ions are electrically charged particles. When ions move, they change the electrical charge in the area they are in. The two types of ions are positive (+) and negative (-).

When a neuron is at rest, it is not carrying an impulse; it is not "firing." At that time, the positive and negative ions inside and outside of the cell membrane of the axon are not equally distributed. As a result, the membrane is said to be **polarized**. The main ions involved in an impulse are potassium (K^+), chlorine (Cl^-), and sodium (Na^+). When the membrane is in this resting state, positive ions are more common on the outside of the membrane and negative ions are more common on the inside. When a nerve impulse is received by the neuron, the polarity of the membrane changes. The inside of the axon becomes more positive and the outside more negative. This is primarily because of the movement of sodium ions into the cell. This increased permeability of the membrane to sodium ions causes a "wave" of depolarization to travel down the axon. When the impulse has passed, the cell moves potassium ions to the outside of the cell membrane and also actively pumps sodium ions back to the outside of the membrane. The small interval of time between impulses is called the **refractory period**. During this brief time, usually about 0.001s, the membrane repolarizes and readies itself to receive the next impulse. Consider the diagram below showing a nerve impulse as it travels along an axon:

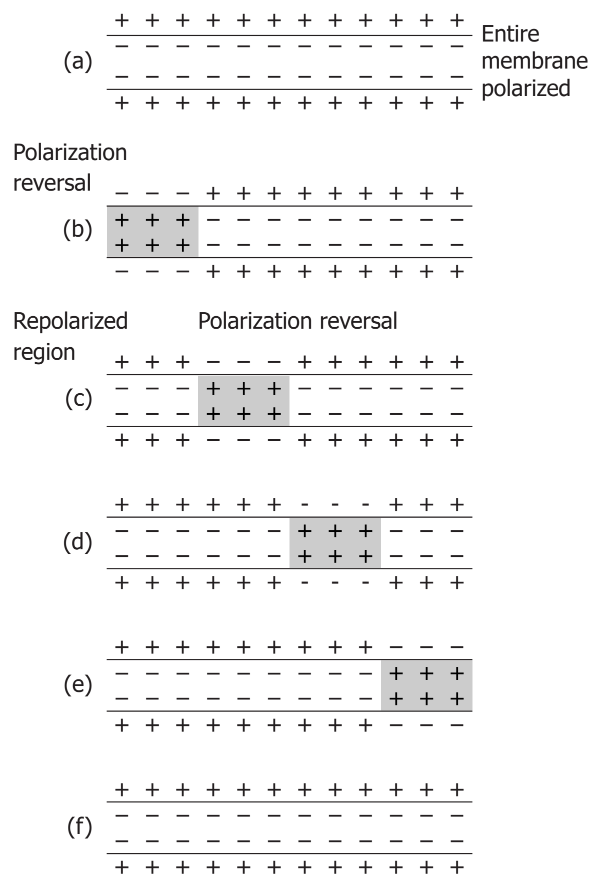
Transmission of a nerve impulse along a portion of a neuron.

a. Resting neuron with positive charges on the outer surface of the membrane and negative charges on the inner surface.

b. to e.

Electrochemical impulse moves along the neuron as the outer surface becomes negatively charged and the inner surface becomes positively charged.

f. Neuron returns to resting condition.



The action potential moves down the axon from left to right. You can see that the impulse is actually a section of the axon that has become depolarized because of the movement of charged ions. Once the impulse has passed, the axon repolarizes and begins a period of "resting potential."

A neuron must receive a minimum amount of stimulation before initiating an impulse. The minimum amount of stimulation needed is called the neuron's **threshold**. If the stimulus is equal to or greater than the threshold level, the neuron will send an impulse or "fire." This is an "all-or-nothing" mechanism since the neuron either fires or it doesn't fire; there is no "intensity level" of the message carried by a single neuron.

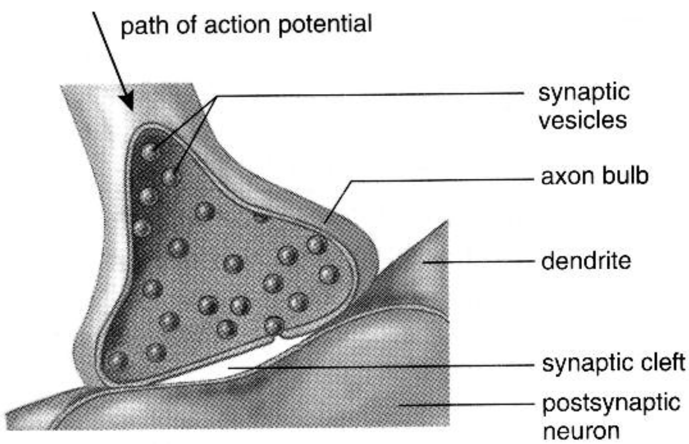
The Synapse

When one neuron sends an impulse to another neuron, the cell membranes of the two cells come very near one another. However, neurons do not touch one another but rather are separated by a small gap. The space between the neurons is called the **synapse**. If the electrical impulse had to "jump" across that space, the transmission of the impulse would be very slow at that point. Instead of an electrical transmission from one neuron to the next, the method of transmission is **chemical**.

At the end of an axon is a structure called the "synaptic knob." It meets the membrane of the dendrite of the next neuron. The synaptic knob contains many small sacs, called **synaptic vesicles**, that are filled with chemicals called **neurotransmitters**. Neurotransmitters are chemicals that stimulate neuron action. When an impulse reaches the end of the axon, the small sacs are stimulated to release their transmitter into the synapse. This chemical then binds rapidly to a receptor molecule on the surface of the next dendrite or cell body.

Neuron communication is also **electrical**. When the neuron that carries a wave of depolarization reaches the synapse, it triggers the opening of special **calcium ion** gates. This movement of calcium ions stimulates the synaptic **vesicles** to release **neurotransmitters** into the **synaptic gap**.

Each synaptic knob affects the dendrites of many other neurons. Similarly, the synaptic knobs of many other neurons affect the dendrites of one neuron. As a result, many neurons are interconnected in many complex ways. Consider the following diagram. Neurotransmitter molecules released by the synaptic knob of one neuron travel across the synapse and cause depolarization of the next neuron.



Synapse Structure and Function: Reprinted from *Inquiry into Life* by Sylvia S. Mader. New York, NY: McGraw Hill, 2003. p. 322. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

This illustrates why the nerve impulse is said to be **electrochemical** in nature. Within a given neuron, the message travels electrically down the axon. Between neurons, the message travels chemically from one cell to another.

One example of a neurotransmitter is **acetylcholine**. This chemical affects the voluntary movement of skeletal muscles but inhibits cardiac muscle. Another neurotransmitter is **dopamine**; it affects not only voluntary movement but also emotional intensity. A third neurotransmitter is **serotonin**, which affects several body functions such as memory, emotions, alertness, sleepiness, and thermoregulation. A number of other neurotransmitters also exist, all having varying effects on the human body.

Drugs have been developed to stimulate or inhibit specific neurotransmitters. For example, some antidepressants stimulate the action of serotonin to elevate mood.

It is now time for you to complete **Learning Activity 5.4**. Remember to check your answers to the questions in the answer key at the end of this module.

Learning Activity 5.4

The Neuron

Decide whether each statement from 1-10 is true or false. Print either "T" or "F" in the space provided. If the statement is false, rewrite it in the space below that statement to make it true.

________ 1. The resting state of a neuron is a state of depolarization.

________ 2. When an impulse travels along an axon, the inside of the cell membrane becomes temporarily negatively charged.

________ 3. If a given neuron is to pass an impulse to a second neuron, the cell membranes of the two neurons must be in direct contact with one another.

________ 4. All neurons possess exactly the same shape and size.

________ 5. A neuron never has more than 10 dendrites.

________ 6. A nerve impulse is a wave of depolarization.

________ 7. Acetylcholine is an example of a neurotransmitter.

________ 8 The greater the intensity of the stimulus, the greater the "charge" or "strength" of the impulse produced.

________ 9. Neurotransmitters are highly negatively charged molecules that carry the charge across the synapse.

________ 10. All neurotransmitters serve the same purpose in the human body.

continued

Learning Activity 5.4 (continued)

11. What do we mean when we say that a neural impulse is "all-or-nothing"?
12. Draw a picture of a neuron and label the following parts:
    a. Cell body
    b. Axon
    c. Dendrite
    d. Nucleus
    e. Synaptic knob
    f. Region of resting potential (membrane at rest)
    g. Region of action potential (region where impulse is travelling)
    h. Arrow indicating the direction in which the impulse is travelling
13. Why are nervous messages in the human body said to be transmitted by electrochemical means?
14. For each of the following functions, name the associated structure.
    a. Forms a myelin sheath: ______________________________
    b. Collects information from receptors: ______________________________
    c. Gaps where the impulse jumps: ______________________________
    d. Specialized vacuoles containing neurotransmitters: ______________________________
    e. Relays instructions to glands and muscles: ______________________________
    f. A fatty substance that wraps around an axon: ______________________________
15. Explain the concepts of **threshold** and **refractory period** as they pertain to a neuron.

Lesson 5: Nervous and Endocrine Interaction

Lesson Focus

In this lesson, you will

- ❑ explain the ways in which the nervous system and the endocrine system are similar in terms of how they function to maintain homeostasis
- ❑ explain the ways in which the nervous system and endocrine system are different in terms of how they function to maintain homeostasis
- ❑ explain how the nervous system and endocrine system interact with and affect each other

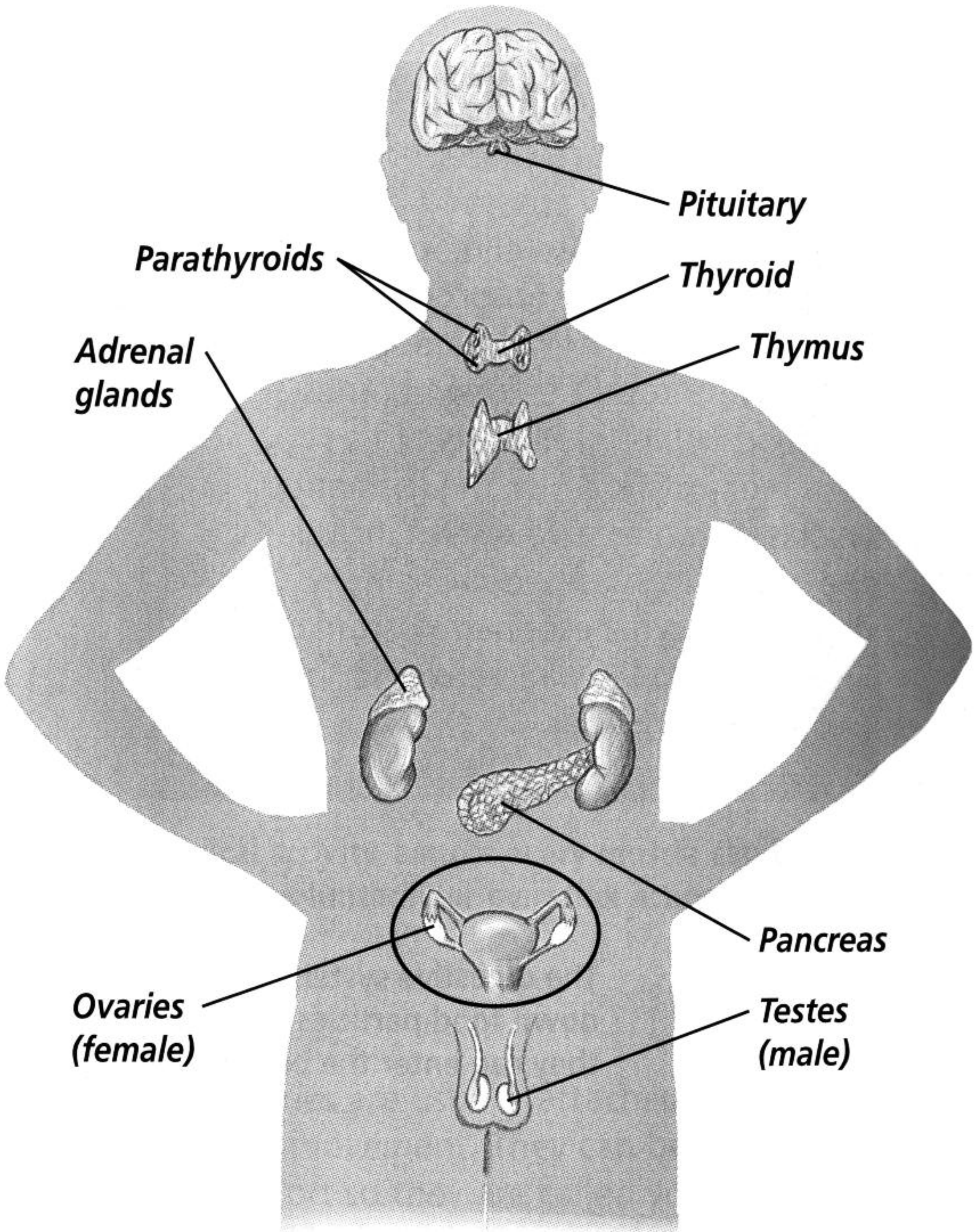
Introduction

So far, you have learned about how the nervous system functions. In this lesson, you will learn about how the nervous system and another system called the endocrine system interact to maintain body temperature. This is an extension of Module 1, where you were introduced to the way that the body controls its temperature and maintains homeostasis. You will first explore how the endocrine system functions and its effect on the nervous system.

The Endocrine System

This body system consists of a number of ductless glands that are located in various parts of the body. **Endocrine glands** produce chemical messengers called **hormones**. Hormones are released directly into the bloodstream and are not transported through ducts or tubes. Endocrine glands are **effectors** because they respond to messages from the central nervous system. When endocrine glands are stimulated to produce their hormones, they accomplish a response that is deemed necessary by the CNS. Hormone production is controlled by feedback loops that help the body to adjust to changes in the environment and to maintain homeostasis. Another important point to consider is that hormones only have an effect on a specific part of the body. That **target tissue** is the tissue that "recognizes" the hormone and reacts in whatever manner it must to maintain homeostasis. Let's consider an example.

One hormone that is important to the body when it is under stress is **adrenaline**, which is also called epinephrine. This hormone is produced by the adrenal gland, which is located just above each kidney. When the body perceives stress, the adrenal gland is stimulated by the nervous system to produce adrenaline, which then enters the bloodstream. The type of stress encountered can vary; for example, when a fire alarm rings, the brain receives that sensory information and a nervous message is sent to the adrenal gland via the sympathetic nervous pathway. When adrenaline circulates in the blood, it causes blood sugar levels to rise because glycogen stored in the liver and muscles is converted into glucose. Glucose is a readily usable form of energy and is supplied in case physical exertion is necessary. Other changes that occur include an increased heart rate, increased breathing rate, and increased cell metabolic rate. Blood vessels dilate and the iris of the eye also dilates. The body is preparing itself for the stress that has been registered by the CNS. This response is also known as "fight or flight."



The Endocrine System: Reprinted from *Biology: The Dynamics of Life* by Alton Biggs, et al. New York, NY: McGraw Hill, 2004. p. 1052. Reproduced in accordance with *Access Copyright Elementary and Secondary School Tariff*.

Consider the chart below that contains a *partial* list of endocrine glands, their secretions, and their effects on the body. Note that there are many other hormones that are not listed below.

Gland	Hormone	Function
Adrenal Gland (Medulla)	Adrenaline	Increases various body functions such as heart rate, breathing rate, and blood glucose levels
Adrenal Gland (Cortex)	Cortisol	Increases the level of amino acids in the blood to help the body recover from stress
Adrenal Gland (Cortex)	Aldosterone	Increases the body's retention of water to maintain body fluid levels
Pituitary Gland	Growth Hormone	Promotes growth, especially of cartilage and bone cells
Pituitary Gland	Oxytocin	Initiates strong contractions of muscles in the uterus
Pituitary Gland	Antidiuretic Hormone	Increases water reabsorption in the kidney
Testes	Testosterone	Promotes the onset of male secondary sex characteristics
Pancreas	Insulin	Increases glucose utilization by body cells
Ovary	Estrogen	Promotes the onset of female secondary sex characteristics

Nervous and Endocrine Interaction

You have just learned that the adrenal gland produces adrenaline when it is prompted by the nervous system to do so in response to stress of some kind. That is an example of how the nervous and endocrine systems interact. The nervous and endocrine systems are the "control" systems of the body because they help the other body systems to maintain homeostasis.

The nervous and endocrine systems are similar in some ways and different in other ways. Consider the chart below:

Nervous System	**Endocrine System**
Similarities	
Nerve cells secrete chemical substances called neurotransmitters.	Endocrine glands secrete chemical substances called hormones.
The nervous system helps to maintain homeostasis.	The endocrine system helps to maintain homeostasis.
Differences	
Nervous responses are *rapid* and of *short duration*.	Endocrine responses are *slow* but last for a *long time*.
Nerves transmit impulses via neurons.	Hormones are carried by the blood.

These two body systems are similar in that they both produce chemicals. Neurotransmitters are released by one neuron and are received by other neurons. Neurotransmitters allow the nerve impulse to "jump" the gap between neurons. On the other hand, hormones are produced by endocrine glands and enter the bloodstream as blood passes through those glands. Hormones affect target tissues only.

Because the nerve impulse is electrical, it is both fast and temporary. In contrast, because hormones need time to reach target tissues, the effects that they have are slow but can last for a longer period of time. Both systems are sensitive to environmental stimuli and both systems depend on the body's ability to distinguish between important and unimportant stimuli.

The example above of how the nervous and endocrine systems interact in the production of adrenaline clearly shows how these two systems work together to accomplish homeostasis. Another example involves a response that you studied in Module 1—**thermoregulation**. The **autonomic nervous system** is involved in the body's response to a change in temperature as follows:

- **Receptors** in the skin detect external temperature, and receptors in the hypothalamus detect the temperature of the blood. When the body is exposed to cold, receptors send a nervous message to the hypothalamus.

↓

- The **hypothalamus** sends messages to muscles in arterioles, which constrict to decrease blood flow to extremities and therefore decrease heat loss.

↓

- Nervous messages are sent to **muscles** in the skin, which cause goose bumps. This erects the tiny hairs on our skin to trap heat.

↓

- Messages are also sent to our skeletal muscles, which contract and relax quickly to cause shivering.

The **endocrine system** also gets involved in thermoregulation:

- The **hypothalamus** sends a message to the pituitary gland in the brain.

↓

- The **pituitary** gland releases a hormone called TSH in the blood, which causes the release of the hormone thyroxin by the thyroid gland.

↓

- **Thyroxin** increases the body's metabolic rate.

It is now time to complete **Learning Activity 5.5**. Check your answers in the answer key before proceeding to Lesson 6, the final lesson of this module.

Learning Activity 5.5

Comparing the Nervous and Endocrine Systems

1. Use the understanding that you have gained so far in this module to complete this chart comparing the nervous system and the endocrine system.

	Nervous System	Endocrine System
Communication Method		
Response Speed		
Duration		
Target Pathway		
Action		

continued

Learning Activity 5.5 (continued)

2. Write a couple of sentences explaining each of the interactions that occurs between the nervous and endocrine systems. Use the table in the lesson to help you.
   a. How are the two systems different in terms of how they affect other body systems?
   b. How do the two systems interact and affect each other?
   c. Give one example showing the endocrine system affecting the nervous system.
   d. Give one example showing the nervous system affecting the endocrine system.

Lesson 6: Wellness and the Endocrine and Nervous Systems

Lesson Focus

In this lesson, you will

- ❑ explain how four particular lifestyle choices affect the healthy functioning of the nervous and/or endocrine systems: drug use, anabolic steroid use, sleep habits, and diet
- ❑ investigate one particular example of a disorder that affects either the nervous system or the endocrine system

Introduction

Many aspects of our everyday lives affect our nervous and endocrine systems. As we encounter a constantly changing environment, our body constantly re-adjusts in response. In this lesson, you will learn about four particular lifestyle choices that affect the two control systems in our bodies.

Wellness and the Endocrine and Nervous System

1. **Drug Use:** There are many drugs available to the public; some of these drugs are illegal and some are legal. Some of the effects of these drugs are good or necessary for the body and some are not.

   - **Methamphetamine:** Methamphetamine is sometimes called meth, chalk, crystal meth, and ice, among other names. It is an illegal drug that is highly addictive. It increases the release of very high levels of the neurotransmitter dopamine, which stimulates brain cells and enhances body movement and mood. High and frequent use of this drug causes damage of neuron cell endings. As a result, changes in the brain result, specifically in the areas of motor speed, verbal learning, emotion, and memory. Other effects of this drug on the body include increased wakefulness, increased respiration, rapid heart rate, decreased appetite, irregular heartbeat, and increased blood pressure.

- **Acetaminophen:** This legal, over-the-counter drug belongs to a class of drugs called analgesics, which are pain relievers, and to a class called antipyretics, which are fever reducers. Acetaminophen raises a person's pain threshold; a greater amount of pain is needed to initiate a message of pain to the person's brain. It also tells the thermoregulatory part of the brain, the hypothalamus, to "turn down" the body's temperature when it becomes elevated. Acetaminophen is not as effective as ibuprofen in treating inflammation.

2. **Anabolic Steroid Use:** Anabolic steroids are synthetic substances that are related to male sex hormones. These chemicals promote growth of skeletal muscle and the development of male sexual characteristics. Anabolic steroids are available legally only by prescription. Some users obtain these chemicals illegally, as they are made in hidden laboratories, sold illegally or are smuggled. The International Olympic Committee and many other amateur and professional sports organizations have banned the use of anabolic steroids. The use of anabolic steroids is often linked to the desire to build muscles and improve sports performance.

3. **Sleep Habits:** When sleep deprivation occurs routinely and for many successive nights, the effects on a person's health are profound. It has long been understood that short-term sleep deprivation affects mental performance, alertness, and mood. But recently, it has been found that long-term sleep deprivation causes remarkable changes in metabolic and endocrine function similar to some of the symptoms of aging. For example, it has been found that prolonged sleep deprivation causes an impaired ability to process glucose; the blood glucose level remains elevated as a result. This prompts the body to produce more and more insulin. This is a typical symptom of adult-onset diabetes. The brain is less able to process glucose as well, leading to impairment of critical thinking, memory, and mental sharpness. Blood cortisol levels also become elevated during periods of sleep deprivation; this leads to insulin resistance and memory impairment.

4. **Diet:** There are many examples of how the nutrients, vitamins, and minerals that you consume affect your health. Some examples to consider are:

   - **Anemia:** Good nutrition is very important to ensure adequate red blood cell production by the body. One of the necessary components of red blood cells is hemoglobin. One of the necessary components of hemoglobin is iron. If your diet does not contain adequate amounts of iron, you may become anemic and may not possess as many red blood cells in your blood as your body needs. Iron deficiency results in muscle impairment, which can affect physical exercise and endurance. The inability to maintain body temperature in a cold environment is another effect of anemia.

- **Obesity:** Obesity is the condition characterized by having excess body fat. Obesity increases a person's chances of developing many other diseases, such as heart disease, stroke, diabetes, and cancer. Overeating is clearly a contributor to obesity. Consuming more calories than are used is the most common cause of obesity.
- **Osteoporosis:** This disease is characterized by a decrease in the amount of bone mass in the body that may lead to fractures after minimal trauma. Osteoporosis is definitely linked to diet. Adequate amounts of calcium, vitamin D, and phosphorus in the diet are essential. Building strong bones, particularly before the age of 30, may be the best defense against developing osteoporosis. Taking a calcium supplement may help some people who have difficulty getting enough calcium in their diets.

The examples that you have just studied illustrate the connection between lifestyle choices and wellness of the nervous and endocrine systems. Clearly, some aspects of our lives are under our control and some are not. The aspects that are under our control and that affect our health and wellness are important to concentrate on. By making changes to our lifestyle decisions, we can affect our health and wellness directly, both in the immediate and more distant future.

It is time now for you to complete **Learning Activity 5.6**. Please remember to check your answers in the Answer Key before proceeding to **Assignment 5.3**.

Learning Activity 5.6

Lifestyle Choices and Homeostasis

In this learning activity, you will choose three lifestyle choices that you believe most affect the health and wellness of your body's nervous and endocrine systems. For each lifestyle choice, you will decide whether your actions are having a positive or a negative effect on your body's health and wellness. Try to be as specific as you can. Explain also the reasons for your decisions regarding each lifestyle choice. After careful consideration of the lifestyle decisions that you make, discuss any changes that you could make to those decisions.

Possible Lifestyle Choices:

Smoking Cigarettes	Illegal Drug Use	Sleep Patterns
Physical Exercise	Diet	Anabolic Steroid Use
Alcohol Consumption	Stress	Vitamin Supplements
Use of Leisure Time	Medical Examinations	Pain Reliever Use

Assignment 5.3

Investigation: Nervous or Endocrine Disorder ***(20 marks)***

In this assignment, you will choose one of the disorders listed in order to learn more about it. Research that disorder and answer the following questions. Choose a different disorder other than the one you chose to research in Lesson 2 of this module.

List of Disorders:

Allergies	Parkinson's Disease
AIDS	Huntington Disease
Epilepsy	Myasthenia Gravis
Depression	Arthritis
Cerebral Palsy	ALS
Kreutzfeld Jacob Disease	Tourette Syndrome
Lupus	Hyperthyroidism
Alzheimer's Disease	Stroke

1. Which disease or disorder did you choose? *(1 mark)*

2. What are the primary symptoms of this disorder or disease? List at least four. *(4 marks)*

3. Explain how this disease or disorder affects the nervous system and/or the endocrine system. List at least three of the major effects. *(3 marks)*

continued

Assignment 5.3 (continued)

4. How does this disease or disorder disrupt homeostasis? Give a specific example. *(2 marks)*

5. What treatment options exist for this disease or disorder? List at least two. *(2 marks)*

6. Can this disease or disorder be prevented? *(1 mark)* If not, why not? If so, how? *(2 marks)*

7. Can lifestyle choices affect whether or not a person has this disease or disorder? *(1 mark)* Why or why not? Be specific in terms of which lifestyle choices have an impact. *(2 marks)*

8. List at least 2 information sources that you used to complete this assignment. *(2 marks)*

Module 5 Summary

Congratulations! You have completed Module 5 of the Grade 11 Biology course.

Submitting Your Assignments

It is now time for you to submit the Module 5 assignments to the Distance Learning Unit so that you can receive some feedback on how you are doing in this course. Remember that you must submit all the assignments in this course before you can receive your credit.

Make sure you have completed all parts of your Module 5 assignments and organize your material in the following order:

- Module 5 Cover Sheet (found at the end of the course Introduction)
- Assignment 5.1: Option A: Vaccination Policies in Canada OR
  Option B: Disease Investigation
- Assignment 5.2: The Nervous System
- Assignment 5.3: Investigation: Nervous or Endocrine Disorder

For instructions on submitting your assignments, refer to How to Submit Assignments in the course Introduction.

Notes

Grade 11 Biology (30S)

Module 5

Learning Activity Answer Key

MODULE 5
LEARNING ACTIVITY ANSWER KEY

Learning Activity 5.1: Overview of the Immune System

Match the terms in the list below to the statements that follow; each term is used only once.

A. Protozoan	F. Cilia	K. Inflammatory
B. Interferons	G. Anaphylaxis	L. Virus
C. Vaccination	H. Transplacental	M. Vector
D. Lysozymes	I. Stomach acid	N. Antibodies
E. Non-specific	J. Ectoparasite	O. Phagocytosis

1. Leucocytes kill foreign pathogens using this process of surrounding and digesting them. **O**
2. Lymphocytes produce these molecules in response to the presence of foreign antigens. **N**
3. This is the type of pathogen that causes malaria and sleeping sickness. **A**
4. These defense mechanisms protect against many types of pathogens, without recognizing one in particular. **E**
5. It is a very severe allergic reaction, which can be life-threatening. **G**
6. It is a weakened or dead form of a pathogen given to protect against a future encounter of the active pathogen. **C**
7. It is a passive natural immunity. **H**
8. This type of response occurs when the body has been invaded by a foreign organism; it results in reddening and swelling of the area affected. **K**
9. They are enzymes found in tears and saliva that kill invading bacterial cells. **D**
10. It is a pathogen that is not cellular; it invades a living cell and uses its machinery to reproduce. **L**
11. Mites and ticks are examples of this type of organism. **K**
12. This substance destroys many potential pathogens that are swallowed. **I**

13. They protect the lungs from pathogens that are inhaled; they beat upward and move the captured material toward the top of the trachea. **F**

14. For example, an organism that transfers a pathogen from a wild animal to a human being. **M**

15. They are protein molecules produced by some cells in the body to prevent pathogenic viruses from replicating in other cells of the body. **B**

16. How is passive immunity different from active immunity? Give examples of each type of immunity.

    Passive immunity is acquired when the patient receives antibodies without producing them; transplacental immunity and the injection of antibodies are both passive. Active immunity is acquired when the patient produces antibodies; vaccinations and exposure to the pathogen itself both result in active immunity.

17. How is natural immunity different from artificial immunity? Give examples of each type of immunity.

    Natural immunity means that no vaccine or serum was used; transplacental immunity and exposure to the pathogen itself are both natural forms. Artificial immunity means that either a vaccine or an injection of antibodies was used to provide protection from the pathogen.

18. Complete the following compare and contrast table. First, list at least two similarities and two differences between blood and lymph. Then, list at least two ways in which blood and the circulatory system are different from lymph and the lymphatic system and two ways they are the same.

	Blood and Lymph	Lymphatic System and Circulatory System
Similarities	**Both blood and lymph** ■ **are liquids** ■ **are primarily water** ■ **are circulated throughout the body** ■ **are contained within vessels in the body** ■ **have dissolved solutes in them**	**Both systems** ■ **circulate vital fluids throughout the body** ■ **are systems of inter-connected vessels** ■ **use the superior vena cava as a major transport canal** ■ **contain valves** ■ **play an important role in immunity**

continued

(continued)

Differences	**Blood contains blood cells; which lymph does not.** **Blood is red because of red blood cells; lymph is clear.** **Blood circulates in blood vessels while lymph circulates in lymphatic vessels.**	**Blood circulates through the heart, which pumps it to all body cells; lymph returns to the blood and leaves the blood repeatedly as it moves through the lymphatic vessels and through body tissues.** **The lymphatic system includes lymph nodes; there are no nodes in the circulatory system.**

19. Each of the following pairs of terms is related to each other in some ways, but also different from each other in other ways. Explain those similarities and differences as completely and clearly as you can.

Terms	Similarities	Differences
Non-specific Immune Defenses and Specific Immune Defenses	**Both protect the body from pathogens.** **Both types of defense systems include several mechanisms.** **Both defense systems operate inside and outside of the body.**	**Non-specific: Defend against all pathogens.** **Specific: Target particular pathogens.**
Bacterial Pathogens and Viral Pathogens	**Both attack the body and cause disease.** **Both are microscopic.** **Immunity can help protect against some viral and bacterial pathogens.**	**Bacteria are cellular.** **Viruses are not cellular.** **They cause different diseases.** **Viruses take over the cell they invade, bacteria do not.**
Histamines and Lymphocytes	**Both protect the body from foreign particles.** **Both recognize foreign antigens.**	**Histamines are chemical in nature and are involved in the inflammatory response to allergens.** **Lymphocytes are a type of white blood cell. They produce antibodies in response to foreign antigens in the immune response.**
Active Immunity and Passive Immunity	**Both protect the body from pathogens.** **Both involve the production of antibodies.**	**Active: The body itself produces antibodies through exposure.** **Passive: Antibodies are given to the body, from mother to fetus.**

20. Name and explain two types of non-specific defenses the human body uses to protect from pathogen invasion.
    - **Skin: The skin provides a protective barrier to infection. Very few bacteria and parasites are able to penetrate unbroken skin. The outermost layer develops a tough, waterproof surface of keratin.**
    - **Mucus: In the respiratory passage, bits of foreign debris and invading pathogens are caught in the mucus layer lining that passage. Cilia trap and sweep the mucus away from the lungs.**
    - **Stomach Acid: Many invading organisms are destroyed in the acidic environment of the stomach.**
    - **Tears: Human tears contain a special type of enzyme called lysozymes, which have the ability to destroy foreign bacteria.**
    - **Phagocytosis: Some white blood cells recognize foreign cells and destroy them by phagocytosis, whereby the pathogen is surrounded and digested by the white blood cell.**

21. What is the main function of a lymph node?

    Lymph nodes remove foreign particles and dead cells from the lymph before it returns to the blood.

22. List all the locations where you can find lymph nodes in the human body.

    neck, armpits, stomach, and groin

23. In what way is the antibody-antigen function similar to a lock-and-key?

    When foreign antigens are recognized by lymphocytes, those cells produce antibodies. Antibodies are very specific and only "fit" certain antigens to deactivate them.

Learning Activity 5.2: Imunity and Public Health

For this activity, go to Health Canada's website at <www.hc-sc.gc.ca>. From the list on the left of the screen, choose "Diseases and Conditions". From the list on the left of that screen, choose "Sexually Transmitted Infections (STIs)." Use the information found at that site to answer the following questions:

1. What can you do to protect yourself from contracting an STI? Name five suggestions.
    a. **Learn about safer sex methods.**
    b. **Make informed decisions and talk to your partner(s) about their STI status and the use of protection.**
    c. **Use condoms consistently and correctly.**
    d. **Get tested for STIs if you are sexually active.**

e. **If you are diagnosed and treated for an STI, be sure to follow your health care provider's treatment and follow-up recommendations. You can easily be reinfected if your partner is not treated as well.**

2. Name seven STIs.

   Chlamydia, Genital Herpes, Gonorrhoea, HIV/AIDS, Human Papillomavirus (HPV), Lymphogranuloma Venereum (LGV), and Syphilis.

3. The most common bacterial STI in Canada is **Chlamydia**.

4. Name three symptoms of Chlamydia in women and three symptoms in men.

   In women: a vaginal discharge; a burning sensation when urinating; pain in the lower abdomen, sometimes with fever and chills; pain during sex; and vaginal bleeding between periods or after intercourse

   In men: A discharge from the penis; a burning sensation when urinating; burning or itching at the opening of the penis; and pain and/or swelling in the testicles

5. What is PID? What are its symptoms?

   For up to 40 percent of infected women, untreated chlamydia can lead to pelvic inflammatory disease (PID). PID effects include abdominal pain, fever, internal abcesses, and long-lasting pelvic pain; effects also include scarring of the fallopian tubes, which can cause infertility and increase the chance of potentially life-threatening ectopic or tubal pregnancies.

6. How is genital herpes transmitted?

   Genital herpes can be transmitted during vaginal, anal, or oral sex even if the infected person has no open sores or any other symptoms of infection. Although it is rare, pregnant women can pass the infection onto their babies during or after birth.

7. What pathogen causes genital herpes?

   Herpes simplex virus, the virus that causes genital herpes, belongs to the same family of viruses that cause cold sores, chickenpox, shingles, and other diseases.

8. Why is the rate of gonorrhea infection recently rising in Canada?

   After 20 years of constant decline in Canada, the rates of infection for gonorrhea have risen more than 40 percent over the past five years. The recent rise in gonorrhea infection is attributed to people not consistently using safer sex methods. In addition, drug-resistant strains of the disease are being found across the country. The proportion of samples resistant to ciprofloxacin, one of the leading antibiotics for gonorrhea, has risen more than two hundredfold in the last decade.

9. How is gonorrhea diagnosed?

   Testing for gonorrhea infection can be done with a urine test or swab for culture. Gonorrhea can be treated with a single dose antibiotic. Again, resistance of gonorrhea to antibiotic treatment is increasing.

10. How is HIV related to AIDS?

    The Human Immunodeficiency Virus (HIV) is the virus that causes Acquired Immunodeficiency Syndrome (AIDS).

11. Name five ways in which HIV is transmitted from person to person.

    Unprotected sexual intercourse (vaginal, anal, oral); Shared needles or equipment for injecting drugs; Unsterilized needles for tattooing, skin piercing, or acupuncture; Pregnancy, delivery, and breast feeding (from an HIV-infected mother to her infant); and occupational exposure in healthcare settings.

12. What is HPV and what causes it?

    Human Papillomavirus (HPV) causes the illness that we call "HPV."

13. What are the symptoms of HPV?

    Ano-genital warts (also called Condylomata) are one symptom of HPV infection. They may look like a small cauliflower or they may be flat. In women, the warts may appear on the vulva, cervix, thigh, anus, rectum, or in the vagina or urethra. In men, they may appear on the penis, scrotum, thigh, anus, rectum, or in the urethra. During pregnancy the number and size of warts can increase, but they usually decrease after delivery. HPV is often a 'silent' infection, because many people with HPV will have no obvious signs of infection. Sometimes warts can be present but may not be visible if they are inside your body or if they are on the skin but are too small to be seen. For women, the cervix is a common place for HPV infection. This infection can be either active or inactive. With an inactive infection, the cells appear normal under a microscope and the woman may never know she was infected. However, with an active infection, changes can be seen in the cervical cells under a microscope during a Pap test.

14. Why is syphilis called the "great imitator?"

    Syphilis is often referred to as "the great imitator" because of the wide range of symptoms that infected people may experience. These symptoms can easily be confused with those of other conditions. Also, a doctor may overlook syphilis as a possible diagnosis because the rate of infection in Canada has been low until recently.

Learning Activity 5.3: Concussions in Hockey

Read the accompanying article, *"Bodychecking and concussions in ice hockey: Should our youth pay the price?"*

Complete the "Article Analysis Frame" that accompanies the article. Refer to the explanations below as you complete the form.

Issue: What issue does this article concern?

Bodychecking in hockey leads to concussions and other related injuries; it should be either restricted or eliminated in the game of hockey.

Summary: Summarize the main points of the article.

Bodychecking is a major risk factor for injury in the game of hockey. Traumatic brain injuries are serious and can have lasting effects on the victim's health. This is particularly true for very young players. Players are often not informed about the risks of returning to the ice too soon, if at all. Numerous long-term health effects have been linked to concussions in hockey. Since there is such a strong link between bodychecking, and injury and concussion in the game of hockey, it is suggested that the practice of bodychecking be re-evaluated and perhaps restricted or prohibited.

Author's Opinion (Evidence): State the author's opinion on the issue and the reasons that explain why he/she holds that opinion.

The authors of this article cite several research studies. The evidence includes, but is not limited to, the following points:

- **86% of all hockey injuries among players 9-15 years of age are due to bodychecking.**
- **Of reported injuries among players 9-15 years of age, 45% are caused by legal bodychecks and only 8% by illegal checks.**
- **Players in contact hockey leagues are 4 times as likely to be injured as players in non-contact leagues and are 12 times more likely to receive a fracture.**
- **Research studies support the link between concussions and later neural dysfunction, loss of consciousness, amnesia, headache, cognitive, memory and executive-function disturbances, visual abnormalities, motor and sensory changes, seizures, permanent electrophysiological changes, learning disabilities, and other neurological and psychiatric problems.**
- **Studies show that the number of concussions is increasing despite advances in equipment design.**
- **Studies involving Stanley Cup final series data show that teams playing with less violence were more likely to win.**
- **Variations in player body size are greatest between 13 and 15 years of age; this variation can result in greater injuries.**

Your Opinion: What do you think about the issue?

You should speak to whether or not bodychecking should be restricted or eliminated in minor hockey in Canada, given the connection that exists between bodychecking and concussions.

Questions: After reading the article, what questions do you still have on the issue? (Give at least 3 questions.)

Your questions should be pertinent and clear and should refer specifically to the information discussed in the article.

Relevance Today: How important is this issue in today's world? In your community? In your own life?

The relevance of this topic should be discussed in terms of Canadian society, local practices, and personal experiences.

Learning Activity 5.4: The Neuron

Decide whether each statement from 1-10 is true or false. Print either "T" or "F" in the space provided. If the statement is false, rewrite it in the space below that statement to make it true.

F 1. The resting state of a neuron is a state of depolarization.

F 2. When an impulse travels along an axon, the inside of the cell membrane becomes temporarily negatively charged.

F 3. If a given neuron is to pass an impulse to a second neuron, the cell membranes of the two neurons must be in direct contact with one another.

F 4. All neurons possess exactly the same shape and size.

F 5. A neuron never has more than 10 dendrites.

T 6. A nerve impulse is a wave of depolarization.

T 7. Acetylcholine is an example of a neurotransmitter.

F 8. The greater the intensity of the stimulus, the greater the "charge" or "strength" of the impulse produced.

F 9. Neurotransmitters are highly negatively charged molecules that carry the charge across the synapse.

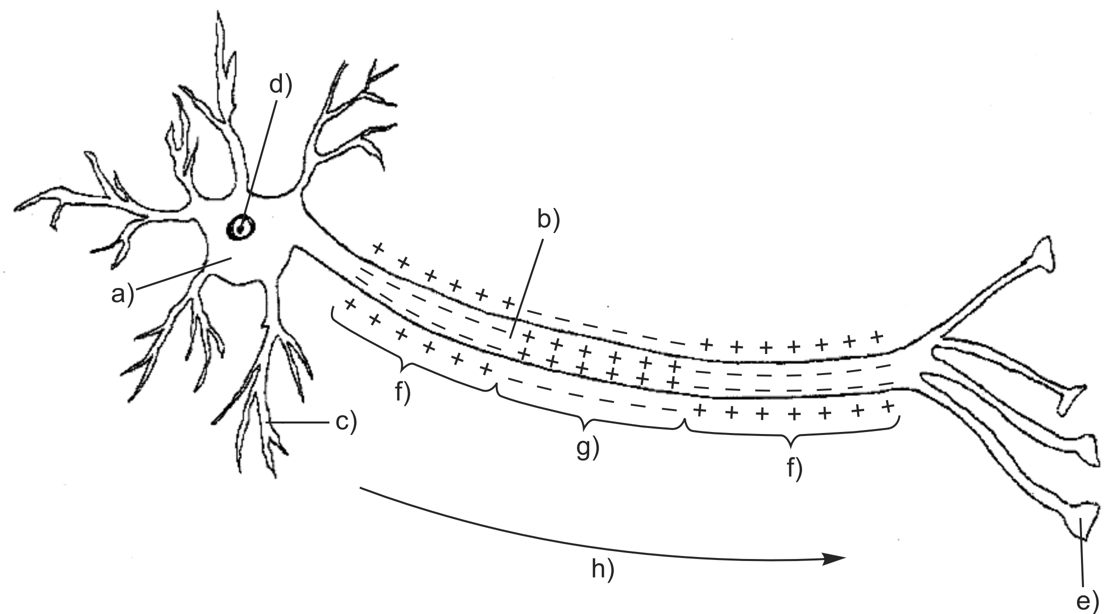
F 10. All neurotransmitters serve the same purpose in the human body.

11. What do we mean when we say that a neural impulse is "all-or-nothing?"

    The neuron either fires or it doesn't fire. There is not an "intensity level" setting on a neuron. The intensity of the stimulus causing the impulse is communicated by the number of neurons firing and/or the frequency with which neurons fire, not by the firing intensity of each neuron.

12. Draw a picture of a neuron and label the following parts:
    a. Cell body
    b. Axon
    c. Dendrite
    d. Nucleus
    e. Synaptic knob
    f. Region of resting potential (membrane at rest)
    g. Region of action potential (region where impulse is travelling)
    h. Arrow indicating the direction in which the impulse is travelling

    See the following page for a scan of a picture that adequately answers this question.



13. Why are nervous messages in the human body said to be transmitted by electrochemical means?

    Along the dendrites, cell body, and axon, the impulse moves as a wave of depolarization—an electrical signal. But between neurons, the message travels across the synapse when neurotransmitters are released by the first neuron and recognized by the second neuron. Neurotransmitters are chemical in nature. The electrical signal continues through the second neuron.

14. For each of the following functions, name the associated structure.
    a. Forms a myelin sheath: **Schwann cells**
    b. Collects information from receptors: **Sensory neurons**
    c. Gaps where the impulse jumps: **Node of Ranvier**
    d. Specialized vacuoles containing neurotransmitters: **Synaptic vesicles**
    e. Relays instructions to glands and muscles: **Motor neurons**
    f. A fatty substance that wraps around an axon: **Myelin (sheath)**
15. Explain the concepts of **threshold** and **refractory** period as they pertain to a neuron.

    A neuron must receive a minimum amount of stimulation before initiating an impulse. The minimum amount of stimulation needed is called the neuron's threshold. If the stimulus is equal to or greater than the threshold level, the neuron will send an impulse or "fire." The small interval of time between impulses is called the refractory period. During this brief time, usually about 0.001s, the membrane repolarizes and restores itself to receive the next impulse.

Learning Activity 5.5: Comparing the Nervous and Endocrine Systems

1. Use the understanding that you have gained so far in this module to complete this chart comparing the nervous system and the endocrine system.

	Nervous System	Endocrine System
Communication Method	**Impulses across synapses and electrical waves of depolarization (neurochemical)**	**Hormones in the blood travel from glands, where they are produced, to target tissues**
Response Speed	**Very rapid typically (within a few milliseconds)**	**Relatively slow (over the course of minutes, hours, or days)**
Duration	**Very short term until the neuron is able to fire again**	**Longer lasting effects because the hormone remains circulating in the blood**
Target Pathway	**Very specific—from one neuron to the next neuron that it is connected to in the neural pathway**	**Hormones circulate in the bloodstream so they encounter all body cells; they have their effect on specific target tissues**
Action	**Stimulate muscles to contract or glands to secrete their hormones**	**Stimulate many types of metabolic activity changes; each hormone has a unique effect on its target tissue**

2. Write a couple of sentences explaining each interaction that occurs between the nervous and endocrine systems. Use the table in the lesson to help you.

   a. How are the two systems different in terms of how they affect other body systems?

      The paragraph given here must contain all four of the essential points stated in the lesson. Some suggestions include: The nervous system operates using electrochemical impulses that travel very quickly throughout the body. The neural impulses are relatively short in duration. The endocrine system operates using hormones that travel rather slowly in the blood. Hormonal effects last longer.

   b. How do the two systems interact and affect each other?

      Endocrine glands are often the "effectors" that the nervous system stimulates into action. Hormones can also have effects on neural processes.

   c. Give one example showing the endocrine system affecting the nervous system.

      Examples will vary. Adrenaline is a hormone secreted by the adrenal glands that stimulates the heart to beat faster, and causes an increase in the metabolic rate as well the dilation of pupils.

   d. Give one example showing the nervous system affecting the endocrine system.

      Examples will vary. When the brain recognizes danger, it stimulates the production of the hormone adrenaline.

Learning Activity 5.6: Lifestyle Choices and Homeostasis

In this learning activity, you will *choose three* lifestyle choices that you believe most affect the health and wellness of your body's nervous and endocrine systems. For each lifestyle choice, you will decide whether your actions are having a *positive* or a *negative* effect on your body's health and wellness. Try to be as specific as you can. Explain also the reasons for your decisions regarding each lifestyle choice. After careful consideration of the lifestyle decisions that you make, discuss any changes that you could make to those decisions.

Possible Lifestyle Choices:

Smoking Cigarettes	Illegal Drug Use	Sleep Patterns
Physical Exercise	Diet	Anabolic Steroid Use
Alcohol Consumption	Stress	Vitamin Supplements
Use of Leisure Time	Medical Examinations	Pain Reliever Use

Answers for this section will vary.

- ❑ **Have you chosen three of the choices that were listed in the question?**
- ❑ **Have you written about how each choice affects the health and wellness of your nervous and/or endocrine system?**
- ❑ **Have you also written about the reasons that you have for the lifestyle choices that you make concerning the three examples that you've identified?**
- ❑ **Finally, have you written about possible changes that you could make regarding these lifestyle choices?**
- ❑ **This learning activity does not have to be mailed in for marking.**

Grade 11 Biology (30S)

Module 6

Wellness and Homeostatic Changes

This module contains the following:

- Introduction
- Lesson 1: Body System Interrelationships
- Lesson 2: The Aging Process
- Lesson 3: Death
- Lesson 4: Technology and Wellness
- Module 6 Summary
- Lesson 5: Final Examination Review

Module 6: Wellness and Homeostatic Changes

Introduction

Welcome to the last module. So far in this Biology course you have learned about the structure and function of several organ systems in the human body. You have seen that, although there are important differences that exist between these organ systems, they all work to maintain homeostasis. You now know that without homeostasis, the body cannot survive.

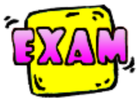
In this final module of this course, you will learn about how the body ages and gradually loses its ability to maintain homeostasis. Through this study of aging and dying, you will recognize that death is actually a loss of homeostasis.

Assignments in Module 6

When you complete Module 6, you will submit your Module 6 assignments to the Distance Learning Unit either by mail or electronically through the learning management system (LMS). The staff will forward your work to your tutor/marker.

Lesson	Assignment Number	Assignment Title
2	Assignment 6.1: Option A	Understanding Alzheimer's Disease
	Assignment 6.1: Option B	Investigation into Aging
4	Assignment 6.2	Advances in Medical Technology
4	Assignment 6.3	Wellness Summary

Writing Your Final Examination



You will write the final examination when you have completed Module 6 of this course. The final examination is based on Modules 4 to 6, and is worth 20 percent of your final mark in the course. To do well on the final examination, you should review all the work you complete in Modules 4 to 6, including all the learning activities and assignments. You will write the final examination under supervision.

Lesson 1: Body System Interrelationships

Lesson Focus

In this lesson, you will

- ❑ explain how multiple organ systems work together to maintain homeostasis in the human body, exploring specific examples

Introduction

In this first lesson, you will learn about organ donation, and you will study two homoeostatic processes that illustrate how the body's organ systems work together to maintain homeostasis. The first process is thermoregulation, and the second is the control of the body's blood sugar level.

Organ and Tissue Donation

The following organs and/or tissues can be transplanted:

- heart
- lungs
- liver
- kidney
- pancreas
- cluster (liver/stomach/bowel/pancreas)
- islet cells
- small intestine
- heart valves
- eyes for corneas
- bone and joints
- skin
- bone marrow

After transplant, however, recipients have to remain on anti-rejection (immunosuppressive) drugs for the rest of their lives in order to prevent their body from rejecting the organ. This is a very serious concern. The human body has Human Leukocyte Antigens (HLA) that combine with small fragments of antigens the body considers to be "foreign," such as tumour cells or viruses. These combined particles then travel to the surface of the cell, where they are destroyed by the body's immune system.

A transplant donor must therefore be a similar match with the recipient so that the body, with the aid of immunosuppressive drugs, does not see the donated organ as foreign and reject it. Identical twins make perfect donors for their twin siblings, and in these cases immunosuppressive drugs are not even necessary. Close family members are often the best available donors, but there are also tests that can be done to match unrelated donors and recipients as closely as possible. When living relatives donate an organ, this is called a Living-Related Donor transplant (LRD); when a person who is not a relative donates an organ, this is called a Living-Unrelated Donor transplant (LURD).

In the case of vital organs, before they can be "harvested," donors must be declared "brain dead" by two physicians not associated with the transplant program. These donors are called "cadaveric donors." Although they are considered brain dead, their heart must still be beating when the organ is removed. This means the donor must be kept on a ventilator until the organ removal is complete. In Manitoba, brain death is defined as "the time at which irreversible cessation of all brain function has occurred." These types of organ donations are called "cadaveric transplants." For tissue donation, however, it is not necessary for the heart to be beating when the tissue is retrieved. These tissues are the heart valves, the corneas, the bone and joints, and the skin.

Many individuals have given permission for their own bodies to be used to save lives in this way should they be in the situation where they are declared brain dead. They have told their family about this wish, and they have signed the Organ and Tissue Donation Card, which can be found at www.transplantmanitoba.ca/documents/DonorCard.pdf.

Thermoregulation

You learned in Module 1 about the negative feedback system that regulates temperature in the human body. The body can tolerate a range of temperature that has a lower limit and an upper limit. These limits vary somewhat from individual to individual and also from one situation to another. However, it is clear that the body cannot survive changes in body temperature that are beyond these limits.

While the human body's optimal temperature is often stated to be 37°C, a range of temperatures between 36.1°C and 37.5°C is well accepted. Why is there a range of acceptable temperatures? Several factors can temporarily change your body temperature, including:

- hormonal fluctuations
- exercise
- increased or decreased metabolic rate
- illness
- external temperature

Within this range of body temperature, enzymes work best and chemical reactions proceed at optimal speed. At temperatures much below that level, reactions are slower, confusion increases, and the person may lose consciousness or even die as tissues die. If body temperature increases much above 39.5ºC, tissue damage occurs in the liver and in the brain, eventually causing death.

A number of mechanisms function together to maintain body temperature. The body's reaction to increased or decreased temperatures is an example of a **negative feedback loop**. In a negative feedback loop, the body detects a negative change and works to reverse it. If body temperature *drops*, the negative feedback loop would proceed as follows:

1. Sensory receptors in the **hypothalamus** in the brain, called thermoreceptors, are sensitive to the temperature of the blood as it passes through that structure. If the blood is too hot or too cold, the hypothalamus sends nerve impulses to the skin.
2. Erector muscles in the skin are instructed to pull up the hairs on the skin to an upright position if the body is too cold, thereby creating an insulating layer of air between the skin and the environment.

It is important to note that the hypothalamus also receives information from other parts of the body when they get too hot or too cold, not just the blood. Nerve impulses are sent from these thermoreceptors to the hypothalamus, which then acts to moderate body temperature. If body temperature *increases*, the negative feedback loop would proceed as follows:

1. **Thermoreceptors** detect the increased temperature of the blood as it passes through that hypothalamus. The hypothalamus sends nerve impulses to the skin.
2. **Glands** under the skin secrete sweat onto the surface of the skin in order to increase heat loss by evaporation. Blood vessels in the skin can grow in diameter or **dilate** so that heat carried by the blood can more easily be lost to the environment if the body is overheated. These dilated blood vessels give the flushed appearance you may have when you are too warm.

3. The hypothalamus also senses nerve impulses to various body muscles causing them to contract, which results in shivering, increasing the **basal metabolic rate** by as much as three times.

The body's "basal metabolic rate" or **BMR** is the minimum amount of energy required to sustain the body's vital functions. The basic chemical reactions carried on in the body result in this level of heat production by the body. Muscular activity of any type produces heat as a side effect of the work that is done. Strenuous and prolonged physical activity can increase the body's BMR up to five times its normal level. Eating food causes an increase in metabolic rate as the body works to digest the food. The hormones of the sympathetic nervous system, such as adrenaline, also cause an increase in metabolic rate and a rise in body temperature. Recall that **adrenaline** is produced by the adrenal glands. **Thyroxine**, which is produced by the thyroid gland, also causes an increase in metabolic rate. Conversely, the parasympathetic nervous system acts to decrease metabolic rate and cool the body off.

When a person consciously becomes aware of feeling either too hot or too cold, they also react **behaviourly** to moderate body temperature. Either putting more clothes on or taking some clothes off can affect body temperature, as can moving into a hotter or cooler area. Physical exercise warms the body up when it is cold. Drinking water can also cool the body as it allows the body to sweat more easily and thereby lose excess heat.

As you have seen, tissues in the skin, muscles, nervous system, endocrine system, and circulatory system interact to maintain body temperature within acceptable limits. In so doing, thermoregulation is achieved and homeostasis is maintained.

Blood Sugar Level

You have learned in previous modules that the human body regulates blood sugar levels. When the body loses its ability to regulate blood sugar levels, illnesses like diabetes can result. In turn, diabetes can lead to other serious medical conditions. A normal blood glucose level before meals is roughly 80 to 120 mg/dL and less than about 180 mg/dL after meals.

The body needs glucose to produce ATP—the molecule that temporarily stores energy until it is needed. The body must have quick access to ATP when it needs energy. Insufficient glucose in the blood is very dangerous; in the extreme, it can result in coma or even death. Even at slightly low levels, insufficient glucose can lead to confusion and shakiness. Without ATP, cells die. The maintenance of life requires continual input of energy. The body regulates blood sugar levels in various ways, including:

- Following a meal, glucose levels in your blood rise and the pancreas secretes **insulin**, a hormone. Insulin transports glucose to all body cells and allows those cells to absorb glucose and use it for cellular respiration. Insulin has the effect, therefore, of decreasing blood glucose levels.
- The opposite effect is produced when another hormone, **glucagon**, increases blood sugar levels by increasing the conversion of stored carbohydrates into glucose. Glycogen is a storage carbohydrate in the liver and muscle tissue that is converted into glucose when glucagon is released.
- The **autonomic nervous system** is also involved in the release of insulin and glucagon in response to eating food. In fact, food intake, not just of glucose or carbohydrates, triggers this reaction by the pancreas.
- The **parasympathetic nervous system** causes an increase in insulin production and release while the **sympathetic nervous system** inhibits the release of insulin. The hormone **adrenaline**, for example, strongly inhibits the release of insulin and increases the release of glucagon.
- If the blood sugar level drops too low, impaired functioning of the central nervous system can result. For example, the person may become dizzy or lose the ability to speak or walk normally. As a result, that person may **react behaviourally** by drinking a sugary beverage or eating candy.

Diabetes is a disease that results when the body cannot make or use insulin correctly, resulting in too much sugar left in the blood. Tissues in the body that are most sensitive to high levels of insulin are the brain, heart, eyes, nerves, and kidneys. There are three main types of diabetes:

- **"Juvenile diabetes"** occurs when the body cannot make insulin; this type of diabetes can appear at any age but is most common in children and adolescents. The immune system has actually destroyed the insulin-producing cells in the pancreas; therefore, this form of diabetes is actually an autoimmune disease. This is also referred to as **Type 1 Diabetes**.
- Another type of diabetes results if the body cannot use the insulin that it makes, the insulin that it makes does not work properly, or the body does not make enough insulin. This is known as **Type 2 Diabetes**.
- **"Gestational diabetes"** occurs during pregnancy only and in most cases resolves once the baby is delivered.

The cause of diabetes remains a mystery but genetic factors and lifestyle choices are both involved. In particular, obesity and lack of physical exercise are definitely contributing factors to Type 2 Diabetes. As you have seen, cells in the endocrine system, circulatory system, digestive system, and nervous system are all involved in maintaining blood sugar levels within an acceptable range.

It is now time for you to complete **Learning Activity 6.1**. Remember to check your answers in the answer key before proceeding to **Assignment 6.1**.

Learning Activity 6.1

Body System Interrelationships

1. Name 10 human organs or tissues that can be transplanted from one person to another.
2. Why does a recipient of a transplanted organ or tissue have to take medication for the rest of his/her life following surgery?
3. Explain why it is not possible for a recipient to receive the tissue or organ of any recipient.
4. A vital organ donor must be declared "brain dead" before transplantation surgery can proceed. How is "brain death" determined?
5. If a person dies in an accident and has indicated that he/she would like to be an organ donor, which tissues can be used even if his/her heart has already stopped beating when the decision is made?
6. What is a "cadaveric donor"?
7. What is the difference between an LRD and an LURD?
8. When someone decides that he/she would like to be an organ donor in case of an accident in which he/she is seriously injured, how does that person let others know of that decision?
9. Would you consider donating a lung or kidney to a relative with whom you are genetically compatible? What about to a non-relative with whom you are genetically compatible? Why?
10. What organ systems are involved in restoring and maintaining homeostasis after an organ transplant?

continued

Learning Activity 6.1 (continued)

11. In this lesson, you have learned how **blood sugar levels** and **body temperature** are both maintained within tolerable limits through the teamwork of multiple organ systems. In this learning activity, you will consider a number of other body functions that are controlled by more than one organ system working together to achieve homeostasis.

    For each body function, name at least two organ systems involved in its control. Next, explain how each system responds in order to maintain homeostasis. Look back through the course notes to find information to help you answer these questions. Each body function may have more than two organ systems involved in its control.

    For each body function, name at least two organ systems involved in its control. Next, explain how each system responds in order to maintain homeostasis For each answer there are more than two organ systems that could be named and explained.

    Function 1 – Urine production: the volume of urine produced in a given amount of time, its concentration, and its composition

    Function 2 – Breathing: the volume of air inhaled and exhaled, and the breathing rate

    Function 3 – Movement of food materials through the digestive tract: rate of movement that is efficient and allows absorption of nutrients

    Function 4 – Solid waste production: Material that passes out of the digestive system has had nutrients removed and has the right amount of water left in it.

    Function 5 – Immune reaction: The body reacts to foreign particles or organisms and destroys them while leaving healthy body cells alone.

Notes

Lesson 2: The Aging Process

Lesson Focus

In this lesson, you will

- ❑ explain aging in terms of the body's decreased ability to maintain homeostasis of basic body functions
- ❑ list and explain a number of body functions that become impaired with age, including muscle tone, tissue repair, and cardiovascular efficiency

Introduction

You have been learning how the different body systems interact with each other. In this lesson, you will learn how they change with time—something we call, aging.

Aging

The process of **aging** or **senescence** affects the body's structure and functioning. Aging occurs little by little during each person's lifetime and its progression is inevitable. The rate at which aging progresses varies greatly from one individual to another. Similarly, the particular effects of aging on each individual depend on a number of factors, some genetic and others environmental. Aging affects cells, tissues, and organ systems. All of the body functions that you have learned about in this course are affected.

Several genetic diseases can cause a dramatic increase in the rate of aging or increase the physiological effects of aging. Hutchinson-Gilford progeria syndrome, for example, causes the rapid appearance of aging during childhood. Children that are affected typically have a normal appearance at birth and during early infancy; however, their appearance then begins to change. Their hair begins to fall out, they suffer from chronic hardening of the arteries, and their skin rapidly ages. The average age of death is 16 years.

Less dramatic genetic factors that affect aging depend on the particular genetic makeup of the individual involved. Many traits combine to affect a person's appearance and the healthy functioning of his or her organ systems. These traits can depend in part on genetic factors inherited from each parent.

Environmental factors that affect aging are numerous and varied. The quality of health care that a person receives during his or her lifetime can have a dramatic effect on the aging process. Exposure to pollutants and other toxins can have an effect on aging. Finally, a variety of lifestyle choices also affect aging, such as cigarette smoking, alcohol consumption, weight management, exercise, stress, diet, and sleep patterns.

Physiologically, the aging process is characterized by a reduced ability to handle stress, increased homeostatic imbalance, and heightened risk of disease. "Stress" in this context refers to an environmental force or event that challenges the body's ability to maintain homeostasis. The changes that occur during the aging process can be considered at two levels:

- **Cellular changes:** Cells change as aging continues. For example, the rate at which cells divide and multiply typically slows down. Also, some cells don't function as effectively; for example, some lymphocytes that are responsible for the healthy functioning of our immune system do not work as well. **Apoptosis** is the normal process in which cells are programmed to self-destruct when they are no longer needed or are being replaced by new cells. As people age, apoptosis does not continue to occur as effectively. Some cells that should die are allowed to survive and multiply, causing illness. Likewise, some cells that should survive are destroyed. Alzheimer's disease occurs when brain cells die prematurely due to the build-up of a chemical that is toxic to those cells.
- **Systemic changes:** Changes that occur in the heart and blood vessels can result in a decreased ability to control blood pressure. Thermoregulation becomes impaired, as does the body's ability to develop a fever to fight infection. The body's ability to regulate the composition and volume of urine is impaired. The thirst response does not occur as quickly as a person ages. Muscle tone is reduced. The proportion of body mass composed of fat increases. Reaction time in response to a variety of environmental stimuli increases. Wounds take a longer time to heal. The body's ability to combat pathogens decreases. Digestive processes slow down. Sleep disturbances occur.

Various theories exist as to why biological aging occurs in people. Some of these theories are based on the "wear-and-tear" concept that damage to cells and tissues accumulate during a person's lifespan and that it eventually leads to death. Some theories suggest that cumulative changes made to the genetic code during a person's lifespan eventually impair vital life functions. Some theories suggest that as a body ages, its immune system loses its ability to distinguish "self" from "foreign"; as a result, the body may ignore a pathogen or may destroy its own healthy cells. Other theories suggest that "aging genes" exist that shut down some chemical reactions that are necessary for the maintenance of homeostasis.

All of the theories agree that aging is a natural process that occurs as the body gradually loses its ability to repair itself. Progressively, cells die and are not replaced. Existing cells do not function as efficiently over time. The body increasingly tolerates inefficiency and malfunction. In other words, the body loses its ability to maintain homeostasis.

Other than the examples already given in this lesson, these are some of the changes that occur during the normal aging process in humans:

- Decreased metabolic rate
- Decreased efficiency in heart and lungs
- Less respiratory surface due to breakdown of alveoli
- Fewer functional oil and sweat glands
- Decreased kidney function
- Urinary incontinence
- Decreased oxygen circulated to muscles
- Less efficient elimination of waste
- Decreased ability to absorb nutrients
- Fewer digestive enzymes produced in the intestines
- Reduced flexibility of the skin, which causes wrinkles to develop
- "Age spots" develop on the skin
- Hair turns gray or white; hair loss
- Increased bruising due to fragile blood vessels
- Reduced muscular strength due to fibrosis or degeneration of muscle fibres
- Reduced range of movement in some joints due to degeneration of connective tissue
- Decrease in the calcium content of bones, increasing the chance of fracture
- Decrease in immune system efficiency because thymus gland gets smaller

It is now time for you to complete **Learning Activity 6.2**. Remember to check your answers in the answer key before proceeding to **Assignment 6.1 Option A or B**.

Learning Activity 6.2

The Aging Process

1. Name at least three lifestyle choices that tend to accelerate the aging process in human beings.
2. Explain the statement: "Aging occurs because the body loses its ability to maintain homeostasis."
3. Explain each of the body changes that occur during aging in terms of its physical cause:
   a. Difficulties digesting some foods
   b. Increased frequency of bone fractures
   c. Increased fatigue
   d. The appearance of wrinkles in the skin
   e. Increased frequency of colds and minor illnesses

At this point, go on to **Assignment 6.1**. When you have completed it, you will submit it for marking along with the others from this module.

Assignment 6.1: Option A

Understanding Alzheimer's Disease ***(14 marks)***

The following questions pertain to the symptoms and causes of Alzheimer's disease, as well as its treatment. There are a number of websites and publications available that will help you answer these questions. The Alzheimer Society website at www.alzheimer.ca is just one of the resources that you may use to complete this assignment

1. How are Alzheimer's disease and dementia related? Are they different words for the same condition related to aging? *(2 marks)*

continued

Assignment 6.1: Option A (continued)

2. Although we don’t yet know what causes Alzheimer’s disease, a number of risk factors have been identified for the disease. Name two of the possible risk factors for Alzheimer’s disease **other than aging**. *(2 marks)*

continued

Assignment 6.1: Option A (continued)

3. What is the usual duration of Alzheimer’s disease in patients from initial onset until death? *(2 marks)*

4. Who was the researcher who first identified the disease and in what year was that discovery made? *(2 marks)*

continued

Assignment 6.1: Option A (continued)

5. What are the physical changes that occur in the brain of a patient who is known to have Alzheimer's disease? *(2 marks)*

6. Does a cure for Alzheimer's disease currently exist? If so, what is it? If not, what are the treatment options for patients with Alzheimer's disease? *(2 marks)*

continued

Assignment 6.1: Option A (continued)

7. State and briefly explain two pieces of information that you have learned by studying the disease that you found especially interesting or surprising. *(2 marks)*

Assignment 6.1: Option B

Investigation into Aging *(14 marks)*

Please note that you do **not** need access to the Internet to complete this option.

Part 1: The Medical Condition *(12 marks)*

In this assignment, you will investigate a medical condition that is associated with aging, and describe *how* it is related to aging. The following is a breakdown of how you will be assessed:

1. Give a brief introduction to the condition. Describe the risk factors or causes, symptoms, and diagnosis. *(2 marks)*
2. Describe some of the changes that take place in the *body systems* when people are afflicted by this condition. In other words, describe how this condition affects a person's circulatory system, respiratory system, etc. *(3 marks)*
3. Explain any tissue changes or behavioural changes that can occur with this condition. *(2 marks)*
4. Explain how this condition relates to the body's homeostatic response. In other words, describe how this condition is a degenerative condition. Make sure that you describe how the body progressively fails when a person has this condition. Be specific in your answer. *(3 marks)*
5. Describe some of the treatments used, whether they are traditional (like surgery or drugs) or alternative (like acupuncture or naturopathy). *(2 marks)*

Make sure that your assignment is clear, complete, relevant, and accurate.

This assignment can be done in the form of a poster, a brochure, a fact sheet, a *PowerPoint* presentation, or written paragraphs. Please be aware of potential plagiarism issues when completing this assignment. Plagiarism is the use of another's words or ideas without giving credit where credit is due. Examples of plagiarism include the following: downloading material in whole or part from the Internet, copying word-for-word from published or unpublished work, and paraphrasing published or unpublished material without bibliographic notation.

continued

Assignment 6.1: Option B (continued)

You may choose the medical condition you wish to investigate from the following list or you can choose another condition, as long as it is associated with the aging process.

Alzheimers Disease, Angina, Arthritis, Behaviour Problems, Contractures, Type II Diabetes, Fibromyalgia, Gastro-Intestinal Disorders, Glaucoma, Hearing Loss, Hypermytropia, Hypertension, Immobility and Inactivity, Incontinence, Mutism, Osteoporosis, Pneumonia, Presbyopia, Urinary Incontinence, Urinary Tract Infection

Part 2: References *(2 marks)*

Use at least two different reference sources. When you submit your assignment for marking, please include with the assignment any print material or notes taken (e.g., from an interview) to demonstrate the resources that you used.

There are a number of ways to find information on your medical condition. For example,

- ask a librarian
- contact the support organization for the disorder. For example, there is an organization in Manitoba that supports people with Alzheimer's disease. You could find information about them in a telephone book.
- speak to a medical professional, like your family physician. They often have pamphlets in their offices with information on medical conditions like these.
- If you live in or near Winnipeg, you may go the Health Sciences Centre Library. It contains a section called the Consumer and Patient Health Information Service whose purpose is to help ordinary Manitobans learn more about health and medical topics, including characteristics of diseases and their treatments. This library is found at the 200 Level, 727 McDermot Ave., Winnipeg. Their website is here: http://umanitoba.ca/libraries/units/health/chis/index.html

If you have trouble getting started or are not sure where to find reliable information, contact your tutor/marker for this course.

Notes

Lesson 3: Death

Lesson Focus

In this lesson, you will

- ❑ identify and explain various definitions of the term "death"
- ❑ identify various social issues related to the process of dying
- ❑ discuss and analyze the social issues that have been identified

Introduction

In this lesson, you will learn about various definitions of death. You will also look at various social issues related to the process of dying. You will deal with some ethical issues in this lesson as well. In general, you will learn to see death as a process instead of a distinct point in time.

Medical Definition of Death

When does death occur? This question is surprisingly difficult to answer in a complete and understandable manner. It is perhaps easier to identify something that was alive and has died than it is to identify the signs that signal the instant of death. Perhaps this is because death is a process. It is sometimes rapid and sometimes quite gradual. Perhaps this explains how differently death can appear in different individuals.

Regardless of the variety of ways in which people can die and of the physiological causes of death that exist, we must be able to define death. It is essential that we know when death has occurred. Many legal ramifications occur when someone has died. Many human emotions surround the death of a loved or respected person. We must be capable of pronouncing death with certainty.

This difficulty that we have deciding when someone is actually dead has been a problem for human beings for centuries. For example, prior to the invention of the stethoscope and other medical instruments, it was sometimes difficult to tell if a person's heart had stopped beating. In some places, traditions involved a waiting period after death in part to be sure that the person was really dead. The fear of premature burial resulted in the invention of "safety coffins" that were designed to help a person survive burial and to help signal that they were still alive. Today, of course, the medical community has many instruments and a variety of machines that can be used to extend life. It is these technological advances that have made death difficult to define in our modern society.

MedicineNet.com is an online health-centred publishing company. It posts articles that are easy to read, current, and informative. Professionals in the areas of medicine and health care provide comprehensive information. The **medical definition** of death according to the MedicineNet website is:

Death: 1. The end of life. The cessation of life. (These common definitions of death ultimately depend upon the definition of life, upon which there is no consensus.) **2.** The permanent cessation of all vital bodily functions. (This definition depends upon the definition of "vital bodily functions.") See: Vital bodily functions. **3.** The common law standard for determining death is the cessation of all vital functions, traditionally demonstrated by "an absence of spontaneous respiratory and cardiac functions." **4.** The uniform determination of death. The National Conference of Commissioners on Uniform State Laws in 1980 formulated the Uniform Determination of Death Act. It states that: "An individual who has sustained either (1) irreversible cessation of circulatory and respiratory functions, or (2) irreversible cessation of all functions of the entire brain, including the brain stem is dead. A determination of death must be made in accordance with accepted medical standards."

You can see from the complexity of that definition that concensus in the medical community on the subject of human death is difficult.

Dorland's Illustrated Medical Dictionary, 31st Edition, defines death as

> **death** (death) (deth) the cessation of life; permanent cessation of all vital bodily functions. For legal and medical purposes, the following definition of death has been proposed-the irreversible cessation of all of the following: (1) total cerebral function, usually assessed by EEG as flat-line (2) spontaneous function of the respiratory system, and (3) spontaneous function of the circulatory system.
>
> **brain death** irreversible brain damage as manifested by absolute unresponsiveness to all stimuli, absence of all spontaneous muscle activity, including respiration, shivering, etc., and an isoelectric electroencephalogram for 30 minutes, all in the absence of hypothermia or intoxication by central nervous system depressants. Called also irreversible coma and cerebral death.

This definition is not significantly easier to interpret. However, in general, the medical community concentrates on the cessation of vital bodily functions, of which three are most important: cerebral functioning (determined using an EEG), respiratory functioning without mechanical assistance, and circulatory functioning also without mechanical assistance. All three of these systems must have stopped functioning for death to be declared.

Legal Definition of Death

In 2003, the Planning Committee for the Forum of Severe Brain Injury to Neurological Determination of Death commissioned a document called, *Legal Foundations for the Neurological Determination of Death.* In this document, made available by the Canadian Council for Donation and Transplantation, "the definition of death is irreversible cessation of all functions of the entire brain including the brainstem" and it also states "that the validity of this definition is incontrovertible."

A "brain death" definition of death has been endorsed by a number of medical associations, including the World Medical Association, the Canadian Medical Association, the American Medical Association, and the American Electroencephalographic Society.

The growing trend to define death in terms of brain death has been fuelled by two important events. The first is the invention and use of various instruments and machines like respirators that can keep the body alive after the brain ceases to function. The second is the continually growing study and application of organ transplantation. Many organs are more successfully transplanted if they are taken from a donor whose body systems are functioning at the time of surgery.

A further complication is that a variety of EEG readings are possible from different patients. Injury can cause a variety of medical problems and our current medical knowledge is not sufficient to predict with certainty whether or not a patient's current status will be permanent. There is also some discussion about whether the EEG is the best tool to use to ascertain brain function.

Obviously, from a legal standpoint, it is important that death be clearly defined. Decisions regarding organ donation, autopsy options, post-mortem procedures, and the reading and executing of wills must all be made—and they depend on a clear and indisputable definition of death.

Religious Perspectives

When a person dies, many people are influenced profoundly by religious beliefs and traditions. Decisions about organ donation, funeral arrangements, burial options, and many other considerations are affected by the religious views of the deceased and his or her relatives who are in a decision-making position. Some religions prohibit the use of life-support machines and instead believe that death should take its natural course. Some religions prohibit organ donation. The members of some religions seek to protect life even during its final stages and postpone the removal of life-support machinery, believing that death will occur in its own time. Various religious customs surround death. The medical community is keenly aware of the importance of recognizing religious priorities. However, when the medical practitioner and the dying individual's family do not agree about when death has occurred, the issue becomes difficult. This is especially true because, from a practical standpoint, timely decisions must be responsibly made.

Social Issues Related to Death and Dying

A number of social issues exist that are related to the occurrence of death and the process of dying:

- **Euthanasia:** From the Greek, euthanasia means "good death." It is, in general, the practice of terminating the life of a person in a minimally painful manner. It can occur through the use of lethal injection. Globally, laws with regard to euthanasia vary tremendously. In some nations it is a legal act, while in others it is a criminal act. Someone may assist the dying patient in the act of euthanasia. Sometimes, the dying patient is no longer aware of what is happening and someone carries out the act without the patient's involvement. Much controversy exists over the act of euthanasia. In fact, there is some debate over the very definition of euthanasia. For example, is removing life support from a terminal patient appropriately referred to as euthanasia? It is easy to see how religious beliefs affect this issue. It also raises important legal questions.
- **Physician-Assisted Suicide:** Medical advances have clearly made it possible for people to live longer and to enjoy good health longer. However, for some, lengthening of lifespan actually means living with pain, discomfort, or difficulty for a longer period of time; patients with incurable diseases or degenerative conditions live longer which means that their suffering is extended. Medical technology and its application have made it possible for us to prolong life, to change the dying process itself, and to question our definitions of "death." Patients suffering from debilitating or incurable diseases and their families have, as a result, sought a greater amount of control over how and when death occurs. The cessation of

medical treatment is a debatable practice. The involvement of physicians in medically assisted death is perhaps even more debatable. Much of the disagreement and dialogue surrounding this topic centres on the issue of "quality of life" and on whose right it is to determine when quality of life has deteriorated to the point at which death seems to be the best option.

- **Choice of Treatments:** In the time that follows a medical diagnosis involving terminal illness or critical injury, patients and their families have many decisions to make regarding the impact it will have on their lives. Social workers are often involved in the process of dealing with such difficult news. In part, the social worker's goal is to help the patient and his/her family try to keep some control over the "quality of life" during the dying process. One difficulty is that different people have different opinions and values regarding "quality of life." So the medical community makes options that are available known to the patient and, within some legal limits, the patient makes decisions regarding his or her own medical treatment and his or her own death.
- **Organ Donation:** There are many instances, unfortunately, in which patients are told that they will die unless a "suitable donor" can be found. This is particularly true of the "vital organs"—the heart, lungs, liver, kidneys, pancreas, and small intestine. A donor of a vital organ must legally be declared "brain dead" and must also have a beating heart at the time of organ acquisition. Essentially, this means that the donor must be on life support that circulates blood through his or her vital organs before one of those organs can be removed. In Manitoba, the irreversible cessation of all brain function needs to have occurred before that patient is considered as a donor. In order for a patient to be a suitable recipient of a transplanted organ, he or she needs to have been told by a physician that organ failure has occurred, needs to want to have a transplant to prolong life or improve the quality of his or her life, and must also be medically fit enough to undergo transplant surgery. Legal consent must be given in order for an organ to be removed from a potential donor. This either occurs because the patient has signed a "donor card" or because the patient's relatives make the decision based on what they know of the patient's wishes.
- **Availability of Palliative Care:** Palliative care is medical and psychological treatment that aims to reduce the symptoms of a disease without addressing whether or not the disease is curable. It can be given in a hospital, in a primary care setting, or even in the patient's home. Palliative care is designed in many cases to make the dying process less painful and difficult for the terminal patient and his or her family. Unfortunately, palliative care is not available everywhere. Furthermore, the quality of care available varies greatly. Sometimes, palliative care is spiritual in nature. From their physicians, patients can receive referrals to palliative care professionals. Clearly, many patients are able to survive longer periods of illness, pain, and discomfort with the help of palliative care workers.

There is no Learning Activity or assignment for this lesson.

Lesson 4: Technology and Wellness

Lesson Focus

In this lesson, you will

- ❑ identify various ways in which technology has prolonged your life so far
- ❑ identify some applications of technologies that prolong human life in general and also reduce pain and discomfort
- ❑ discuss some ethical dilemmas that the use of technology creates involving such things as reproductive technologies, surgical advances, the discovery of anaesthetics and pharmaceuticals, chemotherapy and radiation therapy for cancer patients, and the use of life-support equipment

Introduction

Over the centuries, there have been many discoveries made and many inventions devised to prolong human life and improve human health. In some cases, these advances have been developed to reduce pain and suffering. In other cases, they have been developed to improve quality of life. You will now consider a few medical advances and their applications in our society.

Reproductive Technologies

There are many types of reproductive technologies available for use today. Some of these technologies are the following:

1. **In vitro fertilization (IVF):** Eggs are collected from the woman and mixed with donated sperm from either the woman's partner or from another donor. These embryos are cultured and then implanted into the uterus. This method sometimes results in multiple births.
2. **Intracytoplasmic sperm injection:** Sperm are microinjected into the cytoplasm of the egg. The egg has been retrieved from the mother and it is returned to her uterus after fertilization.

3. **Frozen embryos:** Sometimes more embryos are produced as a result of IVF or intracytoplasmic injection than are implanted into the uterus. These extra embryos are sometimes frozen and may be used at a later time for implantation.
4. **Artificial insemination:** Sperm are strategically placed into the woman's uterus or cervix using artificial means.
5. **Gamete intrafallopian transfer (GIFT):** Eggs are removed from the woman's ovaries and are placed in one of the Fallopian tubes along with the sperm.
6. **Fertility medications:** A variety of drugs have been developed that improve a couple's chances of successfully conceiving. One example is Clomid, which induces ovulation by affecting the woman's reproductive hormones. Multiple births sometimes result.

Surgical Advances

There have been a multitude of surgical advances during the history of medicine. Surgery has continued to become more sophisticated, less painful, and safer. It has been estimated that surgery today is about 50 times safer than it was 20 years ago.

Two surgical advances that have had particular impact on human health care are endoscopy and microsurgery. Endoscopy is surgery in which the doctor inserts an endoscope into the patient through a very small opening, perhaps an inch or so in length. The endoscope has a very small flexible tube that contains lights, optical fibres that allow the surgeon to see inside the patient, forceps, and balloons that can be inflated to clear obstructions. The surgeon can use laser surgery to make bloodless incisions or to destroy tumours. The recovery time for this type of surgery is a fraction of what it is for more invasive surgeries.

Surgery that requires the use of a microscope is microsurgery. Research into this field exploded in the 1960s. It is perhaps best known as a technique used to reattach severed body parts by reconnecting tiny blood vessels and nerves. There have been a number of surgical specialties that have developed to use this technology. One involves microsurgery on the structures of the inner ear. Another application involves the removal of cataracts in the eye and corneal transplants.

Anaesthetics

The development of various forms of anaesthesia designed to reduce the perception of pain has had a great impact on human health care. Anaesthesia has allowed surgery to be possible for many medical conditions or injuries. General anaesthesia affects the entire body. It can be administered either through inhalation of a gaseous medication or through injection. Regional anaesthesia can be administered to a specific part of the body, such as a spinal block used for Caesarean births. These medications can be administered through injection or through the placement of a catheter, which delivers continuous pulses of anaesthetic. Local anaesthesia, or “freezing,” is similar to regional anaesthesia but involves a smaller area of the body. You may have had this procedure done prior to dental work that may otherwise have been painful. Sometimes, surgical techniques do not require anaesthesia. Sedation is another option. Sedatives relax the patient and also may result in mild amnesia concerning the surgical procedure.

Pharmaceuticals

A pharmaceutical is a drug used in medicine. Drugs are chemicals, synthetic or naturally occurring, that alter the functioning of the patient’s body systems. Many drugs have been synthesized and sold for medicinal purposes. Some drugs are “over the counter” or OTC medications. Others are dispensed by a pharmacist without a doctor’s prescription; these are called “behind the counter” or BTC medications. And other drugs are “prescription only medicines” or POM. The definitions of these three categories vary from country to country since drug regulations vary significantly in different parts of the world.

Drugs can be taken into the body in a variety of ways

- orally as a liquid or a pill
- inhaled into the lungs as a vapour
- injected into the body as a liquid
- rectally as a suppository
- vaginally as a suppository

The purposes for which medicinal drugs are used vary greatly. Some reduce the perception of pain. Others reduce inflammation, swelling, or fever. Some are designed to play a particular role in the body’s biochemistry, like insulin. Some are anaesthetics. Others stimulate body systems and increase metabolic rate. Some cause blood pressure to drop while others cause it to rise. Medical research has repeatedly developed drugs to meet human health needs as they arise.

Cancer Treatment

Cancer is the uncontrolled growth of abnormal cells. Cancer sometimes presents itself as a tumour. Medical treatment methods for cancer patients sometimes involve surgery. Sometimes they involve chemotherapy or radiation therapy. Surgery can remove most or the entire tumour as it is recognized by the surgeon. Often a biopsy is done of suspicious tissue to confirm that it is cancerous before it is removed.

Chemotherapy is the use of chemicals to kill cancerous cells in the body. Chemotherapy is generally administered at regular intervals intravenously. It has side effects that are difficult for the cancer patient such as hair loss, nausea, and fatigue. Sometimes chemotherapy follows surgery as a safety measure designed to kill any cancerous cells that remain after surgery.

Radiation therapy or radiotherapy is the use of bursts of radiation aimed at a cancerous growth to destroy it. Like chemotherapy, radiotherapy may follow surgery. The radiation used kills the cells that it is directed toward. This procedure has side effects as well; they include fatigue, redness, soreness, and itching of the skin where the radiation was focused, and reduced appetite.

Ethical Dilemmas

A great variety of ethical dilemmas arise as advances in medical technology are researched and made available. Some technologies are made available to the public, and the decision as to whether they will be used or not depends on the individual patient. Other technologies are regulated and their use has political repercussions; candidates running for office sometimes take a stand on such regulatory or legal decisions as a tool to earn votes. It is clear then that some ethical dilemmas remain personal and others become very public.

One example of such a situation is related to the use of life-support technology with patients who require it due to illness or injury. You saw in the previous lesson that "death" is not easily defined in a single way that will be applicable in every possible situation. So when a person is injured or has a fatal illness and is put on life-support machines, when death occurs comes into question. If the person cannot survive without the use of the machines, is he or she actually alive anyway? If there is no brain function, should the machines be removed? What about a small amount of brain activity? What if a spinal injury leaves a patient unable to move, breathe, or eat independently? What if the person wants to die even though machines can keep him or her alive? Whose choice is it when it comes to turning off life support? These are all examples of questions about which different people will have dramatically different viewpoints.

Another example is the use of reproductive technologies with human patients. If, for example, in vitro fertilization results in five unique embryos and three are implanted, what happens to the remaining two embryos? If they are frozen, who decides what will happen to them? Can they be implanted into a different woman? Can they be sold? Can they be cultured and used for other types of research? Some people feel that conception is an event that humans have no right manipulating with such tools as fertility medication or artificial insemination. The related topic of stem cell research has attracted a huge amount of interest and disagreement in recent years. The practice of cloning is another topic that often leads to disagreement.

A final example is the use of vaccinations, especially when they are used with children. Some people feel that vaccines can cause injury to some patients instead of preventing illness. Some people feel that such a drug is wrong in part because it is "unnatural." The use of vaccinations is highly controlled and vaccines themselves are thoroughly researched before they are used. However, some carry a small risk that the patient may contract the illness that he or she is being vaccinated against. While this risk is typically very small, it is enough that some patients opt not to be vaccinated.

It is now time for you to work on **Learning Activity 6.3**. Please remember to check your answers in the answer key before proceeding to the assignment for this lesson.

Learning Activity 6.3

Technological Advances

1. Make a list of at least five technological advances that you believe have increased your chances of living longer. An example could be surgical techniques that allowed the removal of your appendix (if you have had an appendectomy) to be successfully done.

2. Make a list of at least five technological advances that you believe have made events in your life less painful or particular periods of time more comfortable. An example could be the use of an anaesthetic during surgery.

It is now time to complete **Assignment 6.2**. It is to be submitted for marking with the other assignments from this module when you have finished Module 6.

Assignment 6.2

Advances in Medical Technology *(25 marks)*

In this assignment, you will research the work of a particular Canadian researcher in the field of biotechnology. Next, you will report on the accomplishments of that researcher and comment on the ethical implications of his or her research. If you need help getting started, contact your tutor/marker.

Your report should be about two pages in length, either typewritten double-spaced using a font no larger than 12 points, or neatly handwritten. These are the criteria in which your assignment will be marked:

- **Background Information:** Your report should include the **name** of the researcher *(1 mark),* **where** this researcher is located *(1 mark)*, and a brief **history** of his or her research *(2 marks)*. Is this research current or was it done in the past *(1 mark)* ?
- **Content:** Expand on the **accomplishments** that have been made by this researcher *(4 marks)*. How has this research affected other areas of biology *(2 marks)* ? How has this research affected the community *(2 marks)* ? Include some discussion of **why** that researcher chose that particular area of study *(2 marks)* .
- **Ethical Implications:** Discuss five possible ethical issues surrounding the technological advances connected to the research that you've reported on *(5 marks)* . Attempt to consider and report on **all viewpoints** related to the research. Since this is a research paper, do not indicate your own ethical opinion related to your topic.
- **Extensions of the research:** Predict three possible lines of research that may follow from the research that you've reported on *(3 marks)* . Some of these predictions may follow from statements made by the researcher and some may be your own predictions.
- **References:** Aim to use reputable sources, and list all information references *(2 marks)* . Possible information sources include websites, articles, journals, and interviews. Please see the notes provided below on how to cite sources.

continued

Assignment 6.2 (continued)

Below is a list of some major areas of biotechnology research. These terms may provide a good starting point to help you find Canadians that are working on research in these areas.

tissue engineering

embryonic stem cells

organ transplantation

cloning of human embryos

cancer and chemotherapy

gene therapy

Remember that the list above consists of suggestions only; ***you may choose another topic***.

Top Tips to Writing

1. Stay on topic and avoid the use of colloquial language and slang.
2. Fully explore your chosen question or topic.
3. Do not go off on tangents without a specific purpose that is clear to the reader.
4. Do not plagiarize. Use left and right indents and blank lines to separate quotes of two or more sentences or lines. Always quote exactly from the source and reference it appropriately. (See the section on plagiarism.)
5. Write clearly, without ambiguity. Clarity is the foundation of good writing.
6. Avoid unnecessary "padding." Use the active voice rather than the passive voice whenever possible (e.g., "Marine biologists discovered…" rather than "It was discovered by marine biologists that…").
7. Write in the third person. Avoid personal expressions such as "I feel" or "you should." Avoid "you," "I," and "we."
8. Use formal writing style and form. Avoid contractions and abbreviations.
9. Opinion can only be expressed in the conclusion.
10. Use the present verb tense whenever possible when discussing works or a writer, regardless of when it was written.
11. Read your paper aloud before submitting it. This will help you to catch most small errors.

Citing Sources

It doesn't matter where you find your information. Whether it is a book, an interview, an electronic resource, or from the Internet, when you use the work of others, you must give them the credit they deserve. When in doubt, cite your source.

Include

- who wrote or created it
- what it is called
- where and by whom it was published or produced
- when it was published or produced

Bibliography

A bibliography is a list of all the sources used to find information for your paper. You must include a bibliography with your mid-term research paper.

Bibliographic Form

- Do not number items in the bibliography.
- Arrange the list alphabetically by the author's last name (if there is more than one author, use the first one listed).
- Indent the second line of an item.
- Single-space each item. Double-space between items.
- Carefully follow rules for punctuation—see examples that follow.
- Websites with no title or author are unacceptable.
- Entries are not grouped according to category (the list should be arranged alphabetically, not in categories such as books, websites, etc.).

Examples of Bibliographic Citations

Books

Author's last name, initial(s), (copyright date). Title (ed). City: Publisher.

Example:

Mitchell, T.R., and Larson, J.R. Jr. (1987). People in Organizations: An *Introduction to Organizational Behaviour* (3rd ed.). New York: McGraw-Hill.

Periodicals (journals, magazines, newspapers)

Author's last name, initial(s), (date). Title of Article. Name of Journal, Vol. No. (Issue No.), page numbers

Example:

Marx, J.R. (1986). Gene Therapy—So Near and Yet So Far. *Science*, 45(2), 10-15.

Encyclopedias and Dictionaries

Editors, et al. (Year). Title of Article. Name of Encyclopedia. (Volume, pages). City: Publisher.

Example:

Sadie, S. (Ed.). (1985). Genetic Engineering. *World Book Encyclopedia*, (6th ed., Vol. 8, 85-87). London: Macmillan.

Interviews

Interviewee's Last Name, First Name, Type of Interview, Place of interview, Date.

Example:

Brown, D.L. Personal interview, Winnipeg, MB, May 10, 2001.

Audiovisual Media

Producer's Name, and Director's Name. (Year). Title of Film [medium]. (Location and Name of the Distributor).

Example:

Harrison, J. (Producer), and Schmiechen, R. (Director). (1992). *Changing Our Minds* [Film]. (Available from Changing Our Minds, Inc., New York).

Shocked, M. (1992). *Over the Waterfall*. On Arkansas Traveller [CD]. New York: PolyGram.

CD-ROM

Author's Last Name, Initial(s). (Year). Title of Article. Title of CD-ROM, Publisher.

Example:

Griffiths, A.J.K. (1999). Genetics. *New Grolier Multimedia Encyclopedia* [CD-ROM]. Grolier Electronic Publishing.

Website

Author or Owner of the Website if Available, Title of Website. Web Address. (Date of Access).

Example:

Diving into the Gene Pool. *http://www.exploratorium.edu/genepool/genepool home.html*. (20 March 1996).

Fisher, William A. Adolescents, Sex and Contraception. *http://www.questia.com/PM.qst?a=o&d=76829073*. (22 October 2004).

Bibliographic Sample

BIBLIOGRAPHY

Brown, D.L. Personal interview, Winnipeg, MB, May 10, 2001.

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Assignment 6.3

Wellness Summary

This summary can be done in a written or alternate format. Please consult your tutor/marker for pre-approval on an alternate format. Suggestions on alternative formats could be preparing a Powerpoint presentation, recording a presentation that responds to the questions, or preparing a collage with a write-up.

Personal Wellness Summary *(20 marks)*

1. Name **and** explain *five concepts* that you have learned during your study of this course *regarding your own health and wellness*. Try to choose concepts that were new to you and that made a lasting impression on you. One mark will be allocated for the five topics named, including the accompanying explanation. *(5 marks)*

continued

Assignment 6.3 (continued)

2. Name **and** explain *five particular topics* that you learned about in your study of this course that you would like to learn *more* about. Try to choose topics that caught your attention and that you are curious about. One mark will be allocated for the five topics named, including the accompanying explanation. *(5 marks)*

continued

Assignment 6.3 (continued)

Contributions of Science to Wellness

3. What are the two medical advances that you believe have had the most effect on human health and wellness in the past several years? Explain each medical advance and also explain why you chose it in particular. Each of the two medical advances is worth 1 mark for each medical advance identified and 1 mark for each of the accompanying justifications. *(4 marks total)*

continued

Assignment 6.3 (continued)

4. Have you decided to make any lifestyle changes after studying the material in this course? If so, what are those changes and why did you decide to make those changes? If not, are there lifestyle changes you recognize you should be making? (*3 marks*—3 clear distinct points *should* be evident)

5. Lastly, why do you think people sometimes *know* that they *should* make certain lifestyle changes (affecting their health and wellness) *but* they still choose not to make those changes? You may choose to discuss more than one reason. The answer to the final question regarding human decisions about health and wellness is worth 3 marks. The question will be marked on the merit of the answer and on how well it is explained. *(3 marks)*

MODULE 6 SUMMARY

Congratulations! You have completed the last module of Grade 11 Biology. All you need to do now is write your final exam.

Lesson 5: Final Examination Review is provided to help you prepare for your final examination while you wait to receive your feedback from your tutor/marker.

Submitting Your Assignments

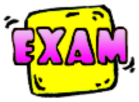
It is now time for you to submit the Module 6 assignments to the Distance Learning Unit so that you can receive some feedback on how you are doing in this course. Remember that you must submit all the assignments in this course before you can receive your credit.

Make sure you have completed all parts of your Module 6 assignments and organize your material in the following order:

- Module 6 Cover Sheet (found at the end of the course Introduction)
- Assignment 6.1: Option A: Understanding Alzheimer's Disease
Option B: Investigation into Aging
- Assignment 6.2: Advances in Medical Technology
- Assignment 6.3: Wellness Summary

For instructions on submitting your assignments, refer to How to Submit Assignments in the course Introduction.

Final Examination



Congratulations, you have finished Module 6 in the course. The final examination is out of 100 marks and worth 20% of your final mark. In order to do well on this examination, you should review all of your learning activities and assignments from Modules 4 to 6.

You will complete this examination while being supervised by a proctor. You should already have made arrangements to have the examination sent to the proctor from the Distance Learning Unit. If you have not yet made arrangements to write it, then do so now. The instructions for doing so are provided in the Introduction to this module.

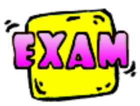
A maximum of 2.5 hours is available to complete your final examination. When you have completed it, the proctor will then forward it for assessment. Good luck!

Lesson 5: Final Examination Review

Lesson Focus

This lesson does not address any specific learning outcomes.

Introduction



At the end of Module 3 of this course, you wrote a midterm examination, which was based on Modules 1 to 3. Now that you have completed Module 6, you will write the final examination, which is based on Modules 4 to 6. The midterm and final examinations are each worth 20 percent of the final mark for this course, for a total of 40 percent.

This lesson suggests some strategies you can use to study for the final examination now that you have finished Module 6. It also explains the examination format. You will learn what types of questions will appear on the final examination and what material will be assessed. Remember, your mark on the final examination determines 20 percent of your final mark in this course.

Instructions for making arrangements to write the final examination are provided below, as well as in the course Introduction.

Making Arrangements

You are responsible for making arrangements to have the final examination sent to your proctor from the Distance Learning Unit. Please make arrangements to write the final examination. When you write your examination, you will be supervised by a proctor.

To write your examination, you need to make the following arrangements:

- **If you are attending school,** your examination will be sent to your school as soon as all the applicable assignments have been submitted. You should make arrangements with your school's ISO school facilitator to determine a date, time, and location to write the examination.

- **If you are not attending school,** check the Examination Request Form for options available to you. Examination Request Forms can be found on the Distance Learning Unit's website, or look for information in the learning management system (LMS). Two weeks before you are ready to write the examination, fill in the Examination Request Form and mail, fax, or email it to

  Distance Learning Unit
  500–555 Main Street
  PO Box 2020
  Winkler MB R6W 4B8
  Fax: 204-325-1719
  Toll-Free Telephone: 1-800-465-9915
  Email: distance.learning@gov.mb.ca

Study Strategies

In preparing for the final examination, use the following study strategies:

- **Review all learning activities and assignments:** Revisit the work you completed in Modules 4 to 6. You could answer the questions in those exercises again, and then compare your answers with your original responses and with the Learning Activity Answer Key provided at the end of each module and with your tutor/marker's assessment of your completed assignments.
- **Review vocabulary:** A review of vocabulary terms is also an effective way to review concepts. You could practise defining terms from Modules 4 to 6, perhaps by using index cards (using one side for a term and the other side for its definition). Keep in mind that one section of the examination asks you to connect pairs of terms by explaining how they are related, so try to connect vocabulary terms to one another as you study their definitions.
- **Review/study concepts including but not limited to the following—**please remember that the following list is only a **partial** list:
  - metabolic wastes—what they are and where they are produced
  - osmoregulation—the production of ADH and aldosterone
  - pathogens—types and examples of diseases caused by them
  - allergies—what causes them and how the body reacts
  - neurons—in terms of structure and function
  - comparison of the nervous system and the endocrine system
  - aging—what happens to the body and what causes those changes to occur

- the various types of immunity (active, passive, natural, artificial)
- the structure and function of the human nervous system
- the types of defense against pathogens that the human body possesses and uses
- the various types of cells involved in cellular immunity
- advances in medicine that have allowed an increase in the length of human life
- the structure and function of the nephrons—including the 3 stages involved in its functioning
- how various body systems are involved in thermoregulation

Please call or email your tutor/marker if you have any questions or concerns about the examination or any content in Modules 4 to 6. Good luck.

Examination Format

The final examination consists of the following six types of questions, the values of which combine to a total of 100 marks. You have a maximum of 2.5 hours to complete your examination.

True or False ***(15 marks)***

In this section of the examination, you will decide whether each of the 15 statements is true or false, and you will indicate your choice by printing either T or F in the space provided for each statement.

Multiple Choice ***(15 marks)***

In this section, you will choose the single best answer to each of the questions given.

Matching ***(15 marks)***

In this section, you will match a list of 15 terms with their corresponding definitions. Each definition will be used only once.

Fill-in-the-Blanks ***(15 marks)***

In this section, you will use the correct word or words to complete statements in a paragraph.

Definitions and Connections ***(10 marks)***

In this section, you will choose five pairs of terms (out of seven pairs given). For each pair, you will define each term and then explain how the two terms are related.

Long Answer ***(30 marks)***

In this section, you will choose six long-answer questions (of the eight questions given). You will be asked to answer each selected question clearly and thoroughly in the space provided.

Summary

Good luck as you prepare for the final examination. If you have completed all the learning activities and assignments from Modules 4 to 6, and have used the suggested strategies in studying for the examination, you have prepared yourself well. The examination will provide an opportunity for you to show what you know.

Grade 11 Biology (30S)

Module 6

Learning Activity Answer Key

Module 6
Learning Activity Answer Key

Learning Activity 6.1: Body System Interrelationships

The following questions deal with information found in the supplemental curriculum document *Organ and Tissue Donation: A Fact of Life*, published by the Manitoba transplant program Novartis.

1. Name 10 human organs or tissues that can be transplanted from one person to another.

   The human organs or tissues that can be transplanted are: heart, lung, liver, kidney, pancreas, stomach, small intestine, pancreas, islet cells (pancreas), heart valves, cornea, bone, joint, skin, and bone marrow (10 required).

2. Why does a recipient of a transplanted organ or tissue have to take medication for the rest of his/her life following surgery?

   The medication that must be taken is anti-rejection medication; the recipient's immune system will always recognize the transplanted organ or tissue as "foreign" and will attempt to reject it. The medication suppresses (but can't eliminate) that immune response.

3. Explain why it is not possible for a recipient to receive the tissue or organ of *any* recipient.

   First of all, there must be blood group compatibility. The size of the organ to be donated must also be compatible with the body size of the recipient. Sometimes, HLA-typing must also be done; this type of compatibility deals with the donor's immune type. The closer the two individuals are genetically, the more likely there will be a good match. Some transplants require closer compatibility than others.

4. A vital organ donor must be declared "brain dead" before transplantation surgery can proceed. How is "brain death" determined?

   The first requirement is that the patient shows no evidence of hypothermia, drugs, or other toxins. There can be no brain stem reflexes such as corneal and pupillary response to light and touch, or oculocephalic and vestibular response (involving an automatic response to cold water in the patient's ear). Also, the person must show no signs of spontaneously breathing when a respirator is turned off.

5. If a person dies in an accident and has indicated that he/she would like to be an organ donor, which tissues can be used even if his/her heart has already stopped beating when the decision is made?

   The tissues that can still be used are the heart valves, the corneas, bone and joints, and skin.

6. What is a "cadaveric donor"?

   A cadaveric transplant occurs when organs and/or tissues are retrieved from a donor who has been pronounced brain dead.

7. What is the difference between an LRD and an LURD?

   An LRD is a living-related donor and an LURD is a living-unrelated donor.

8. When someone decides that he/she would like to be an organ donor in case of an accident in which he/she is seriously injured, how does that person let others know of that decision?

   A person can sign the donor card on the back of his/her driver's license, obtain a donor card from the Manitoba Transplant Program, and/or let his/her family know about that decision to donate.

9. Would you consider donating a lung or kidney to a relative with whom you are genetically compatible? What about to a non-relative with whom you are genetically compatible? Why?

   This question does not have a clear right or wrong answer. However, your opinion should refer to both an LRD transplant and to an LURD transplant situation. Your opinions should be explain clearly.

10. What organ systems are involved in restoring and maintaining homeostasis after an organ transplant?

    The organ systems involved are the circulatory system (blood proteins and other antigens are circulated), nervous system (recognizes new organ and either accepts or rejects it), and immune system (must be suppressed to avoid rejection of the new organ).

11. In this lesson, you have learned how **blood sugar levels** and **body temperature** are both maintained within tolerable limits through the teamwork of multiple organ systems. In this learning activity, you will consider a number of other body functions that are controlled by more than one organ system working together to achieve homeostasis.

    For each body function, name at least two organ systems involved in its control. Next, explain how each system responds in order to maintain homeostasis. Look back through the course notes to find information to help you answer these questions. Each body function may have more than two organ systems that could be named and explained.

Function 1 – Urine production: the volume of urine produced in a given amount of time, its concentration and its composition

The *nervous system* and the *endocrine system* are the two primary organ systems involved in maintaining homeostasis of urine production by the kidneys *(2 marks)***. Circulatory and excretory systems are also involved and could be named.**

The hypothalamus contains osmoreceptors that are sensitive to the solute content of the blood. A behavioural response of thirst also results *(1 mark)***.**

or

The hypothalamus sends a nervous message to the pituitary gland which in turn sends a regulatory hormone in the blood to the kidneys *(1 mark)***.**

or

Therefore, the *circulatory system* is also involved and could be named as an alternative as it circulated hormones *(1 mark)***.**

or

Cells in the capillaries leading to the glomerulus are also sensitive to blood pressure and release rennin, which is an enzyme that affects blood pressure. The kidneys are part of the *excretory system* *(1 mark)***.**

Function 2 – Breathing: the volume of air inhaled and exhaled and breathing rate

The *nervous system* and the *circulatory system* are both involved in this control *(2 marks)* **because chemoreceptors in the brain are sensitive to the level of dissolved carbon dioxide in the blood as it passes through the brain** *(1 mark)***. We also have conscious control over our rate of breathing** *(1 mark)***. Chemoreceptors that are sensitive to oxygen levels in the blood are located in the carotid and aortic arteries. The lungs are part of the *respiratory system*, which could be listed as an alternative.**

Function 3 – Movement of food materials through the digestive tract: rate of movement that is efficient and allows absorption of nutrients

The mechanical process of swallowing initiates involvement of the *nervous system* *(1 mark)***. When nervous messages are sent to the muscles lining the esophagus, peristalsis begins when those muscles begin to rhythmically contract** *(1 mark)***. A nervous message is also sent to the stomach, part of the *digestive system*,** *(1 mark)* **where digestive enzymes begin to be secreted. Gastric secretions are also secreted when food is seen, smelled, or tasted; the nervous system is again responsible for this reaction** *(1 mark)***. A hormone, gastrin, is produced by cells of the stomach; therefore, the *endocrine system* is also involved. Another hormone is produced by the small intestine and acts to slow peristalsis when fats have been consumed; fats are difficult to digest. The pancreas and gall bladder are also under hormonal control.**

Function 4 – Solid waste production: Material that passes out of the digestive system has had nutrients removed and has the right amount of water left in it.

CNS, circulatory and digestive systems are involved *(any 2 for 1 mark each)*. **Receptor cells (part of the** ***nervous system*****) in the wall of the colon provide information to the CNS about the presence of solid waste in the colon; this stimulates a bowel movement to occur** *(1 mark)*. **What a person eats (the** ***digestive system*****) also impacts how solid waste moves through the colon; consumption of cellulose (roughage) is important to solid waste elimination** *(1 mark)*. **Water that is reabsorbed from the feces enters the blood (the** ***circulatory system*****). Viral infections and bacterial toxins can both cause the large intestine to allow excess water to remain in the feces; this causes diarrhea, which can be quite severe. Therefore, the** ***immune system*** **is sometimes involved.**

Function 5 – Immune reaction: The body reacts to foreign particles or organisms and destroys them while leaving healthy body cells alone.

Both the ***circulatory system*** **and the** ***lymphatic system*** **are involved in this type of homeostatic control** *(2 marks)*. **White blood cells and antibodies are present in both of these body systems. The** ***immune system*** **is involved when antibodies are produced and when other cellular components in the blood are produced to combat infection** *(1 mark)*. **The** ***nervous system*** **is also involved because the body has several behavioural responses to infection as well as several autonomic responses such as the onset of high fever** *(1 mark)*.

Learning Activity 6.2: The Aging Process

1. Name at least three lifestyle choices that tend to accelerate the aging process in human beings.

   Some of the lifestyle choices that tend to accelerate the aging process in humans are cigarette smoking, alcohol consumption, poor body weight maintenance, little or no physical exercise, excessive stress, poor dietary choices, and inadequate sleep.

2. Explain the statement: "Aging occurs because the body loses its ability to maintain homeostasis."

   This statement reflects the emphasis on homeostasis in this course. Life requires the maintenance of homeostasis. As the body ages, it loses its ability to maintain homeostasis because it loses the ability to repair itself, to eliminate abnormal cells, to recognize abnormal functioning of body organs and to adequately replace cells that die. Negative feedback systems do not work as efficiently as aging proceeds.

3. Explain each of the body changes that occur during aging in terms of its physical cause:
   a. Difficulties digesting some foods:

      There are fewer digestive enzymes produced in the intestines as a person ages. Also, there is a decreased ability to absorb nutrients from food into the bloodstream and a reduced ability to eliminate waste from the body efficiently.
   b. Increased frequency of bone fractures:

      There is a decrease in the calcium content of bones that results in an increased chance of fracture. Also, there is a reduction in muscular strength. Falls may become more frequent.
   c. Increased fatigue:

      The heart and lungs are not as efficient as they had been. There is less respiratory surface due to the breakdown of alveoli in the lungs. Less oxygen is circulated to muscles.
   d. The appearance of wrinkles in the skin:

      The skin becomes much less flexible and does not "bounce back" as well as it had.
   e. Increased frequency of colds and minor illnesses:

      The immune system is not as effective as it had been; this is largely due to a decrease in the functioning of the thymus gland.

Learning Activity 6.3: Technological Advances

1. Make a list of at least five technological advances that you believe have increased your chances of living longer. An example could be surgical techniques that allowed the removal of your appendix (if you have had an appendectomy) to be successfully done.

   Your answer for this question will depend on the medical care that you have received during your life so far. Some examples other than surgery may include vaccinations for serious illnesses, your use of antibiotics when you have been seriously ill or have had an infection, medications to decrease an allergic reaction to something like insect stings, blood transfusions, etc.

2. Make a list of at least five technological advances that you believe have made events in your life less painful or particular periods of time more comfortable. An example could be the use of an anaesthetic during surgery.

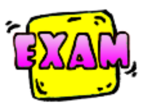
   Other than anaesthetics during surgery, you could name a number of other possibilities. Some examples may include pain relievers, anti-inflammatory medications, sleep aids, seizure medications, ultrasound technology that is used for a variety of purposes, X-rays, blood tests, etc.

Lesson 5: Final Examination Review

Lesson Focus

This lesson does not address any specific learning outcomes.

Introduction



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  Email: distance.learning@gov.mb.ca

Study Strategies

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- how various body systems are involved in thermoregulation

Please call or email your tutor/marker if you have any questions or concerns about the examination or any content in Modules 4 to 6. Good luck.

Examination Format

The final examination consists of the following six types of questions, the values of which combine to a total of 100 marks. You have a maximum of 2.5 hours to complete your examination.

True or False ***(15 marks)***

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Multiple Choice ***(15 marks)***

In this section, you will choose the single best answer to each of the questions given.

Matching ***(15 marks)***

In this section, you will match a list of 15 terms with their corresponding definitions. Each definition will be used only once.

Fill-in-the-Blanks ***(15 marks)***

In this section, you will use the correct word or words to complete statements in a paragraph.

Definitions and Connections ***(10 marks)***

In this section, you will choose five pairs of terms (out of seven pairs given). For each pair, you will define each term and then explain how the two terms are related.

Long Answer ***(30 marks)***

In this section, you will choose six long-answer questions (of the eight questions given). You will be asked to answer each selected question clearly and thoroughly in the space provided.

Summary

Good luck as you prepare for the final examination. If you have completed all the learning activities and assignments from Modules 4 to 6, and have used the suggested strategies in studying for the examination, you have prepared yourself well. The examination will provide an opportunity for you to show what you know.

Grade 11 Biology (30S)

Glossary

GLOSSARY

acetylcholine

One of the neurotransmitters in the human nervous system; it carries a neural impulse across a synapse between neurons.

action potential

A neural impulse as it travels along the membrane of a neuron; a wave of depolarization.

active immunity

Immunity that results when the body actively produces antibodies in response to the presence of foreign antigens.

active transport

Transport of materials across the cell membrane that requires energy in order to be accomplished; it may involve the movement of molecules against a concentration gradient or the movement of large molecules into or out of the cell.

ADH (antidiuretic hormone)

This is a hormone produced by the pituitary gland; its release is triggered by osmoreceptors in the hypothalamus. It causes an increase in water reabsorption into the blood.

ADP (adenosine diphosphate)

A molecule that releases large amounts of energy when it is used in biological reactions.

adrenaline

A hormone produced by the adrenal glands; it acts to increase metabolic rate during periods of increased activity, danger, or other stress.

aerobic

Refers to cellular respiration in which oxygen is required; produces more energy than anaerobic respiration.

afferent arteriole

The tiny artery that carries blood from the renal artery to the glomerulus in each nephron.

aldosterone

This hormone is involved in osmoregulation; it is produced by the adrenal glands. Its release is triggered by low blood pressure and stimulates an increase in water reabsorption into the blood.

alimentary canal

The pathway that food takes as it moves through the body; it starts in the mouth and ends at the anus. Also called the food tube or the digestive tract.

allergen

A foreign protein that triggers an inflammatory response; the person experiencing the symptoms is said to be "allergic" to that particular antigen.

amino acid

The small subunits of which proteins are made; there are 20 amino acids found in nature.

ammonia

A very toxic compound produced by deamination in the liver. When proteins are converted into carbohydrates, the resulting amino acids are converted into ammonia.

amygdala

The part of the human brain responsible for emotion.

amylase

The enzyme that acts on starch molecules to break them down into simpler and smaller carbohydrates; amylase is present in saliva.

anabolic steroid

A synthetic substance that is related to male sex hormones; these chemicals promote growth of skeletal muscle and the development of male sexual characteristics.

anaerobic

Refers to a process, such as respiration, that does not involve oxygen; anaerobic respiration produces less energy than aerobic respiration produces.

anaphylaxis

A severe allergic reaction that occurs rapidly and can lead to difficulty breathing and shock, ultimately resulting in death.

anatomy

The structure of the human body or the study of the structure of the human body.

anemia

A condition where a low red blood cell count decreases oxygen delivery to every tissue in the body.

angina

Chest pain that may radiate into the jaw and down the left shoulder and arm; angina is sometimes a symptom of cardiovascular distress.

antibody

Produced by lymphocytes; provide immunity to specific pathogens because antibodies are made in response to specific foreign antigens. Antibodies may also pass across the placenta before birth and are also found in breast milk.

antigen

Protein "markers" found on the cell membrane; they are recognized as either "self" or "foreign" by the immune system. Foreign antigens trigger the production of specific antibodies by the immune system.

anus

The body opening at the end of the alimentary canal where feces leave the body after the digestive process is complete.

aorta

The largest artery in the human body; it leads out of the left ventricle and carries oxygenated blood to the body.

appendix

A small pouch located at the point where the small intestine meets the large intestine; it serves no vital function in humans.

arteriole

A small artery; arterioles lead to capillaries all over the body.

artery

A blood vessel that carries freshly oxygenated blood from the heart to the rest of the body. Arteries are muscular and strong. They branch into arterioles.

artificial immunity

Refers to immunity that is present as a result of either vaccination or injection of antibodies into the bloodstream; artificial immunity is not natural immunity.

artificial insemination

Occurs when sperm are medically placed into the female's uterus or cervix using artificial means.

atherosclerosis

The hardening and narrowing of blood vessels that accompanies coronary heart disease. Arteries that are affected become narrower and therefore restrict blood flow through them.

ATP (adenosine triphosphate)

An energy-storing molecule that has one more phosphate group than a molecule of ADP. Energy stored in the chemical bonds of this molecule can be used quickly and easily by body cells.

atrioventricular node (AV node)

Located in the bottom of the right atrium, the AV node stimulates the two ventricles to contract during each beat of the heart; its functioning is not controlled by the brain.

atrium

One of the upper chambers in the human heart.

autonomic nervous system

The part of the nervous system that carries impulses from the central nervous system to the involuntary muscle tissue and organs; responsible for functions such as digestion, circulation, excretion, and respiration.

autotroph

An organism capable of producing its own food; some organisms produce food using photosynthesis. Literally, it means "self-feeder."

axon

The part of the neuron that extends out from the cell body; it carries an electrical impulse from the cell body of one neuron toward the dendrites of other neurons.

baroreceptor

A nerve cell that is sensitive to pressure; baroreceptors are located in various places throughout the body and perform a number of functions. Baroreceptor cells located in the glomerulus are sensitive to blood pressure and stimulate the adrenal glands to produce aldosterone if blood pressure drops.

bile

Substance that is produced by the liver and stored in the gall bladder; it passes through the bile duct into the small intestine where it acts to emulsify fat molecules.

biology

The study of living things.

blood

The transportation system in the human body that carries food, oxygen, and hormones to all of the body cells and also carries waste products and carbon dioxide away from those cells; blood is a liquid that contains various cells and dissolved substances.

blood pressure

The pressure that the blood produces in arteries as it is pumped from the heart; it must be kept within certain limits in order for homeostasis to be maintained. Systolic blood pressure occurs when the ventricles contract, and diastolic blood pressure occurs when the atria contract.

BMR (basal metabolic rate)

The amount of energy used by the body while at rest. The production of this amount of energy is only enough for the functioning of the vital organs and must be maintained within certain limits.

bolus

The food after it has been chewed, mixed with saliva, and swallowed; it passes through the esophagus and into the stomach where digestion continues.

Bowman's capsule

The part of the nephron that surrounds the glomerulus like a cup; it carries filtrate from the glomerulus and leads to the proximal tubule.

bronchi

The two tubes that extend from the trachea and lead to the bronchioles in the lungs; a right bronchus leads to the right lung and the left bronchus leads to the left lung.

bronchiole

One of the many small tubes that lead from the two bronchi into microscopic alveoli in the lungs; like bronchi, bronchioles carry air into and out of the body.

capillary

A small blood vessel that connects arterioles to venules in the circulatory system; capillaries are microscopic and numerous. Exchange of materials between the blood and body tissues occurs across capillary walls.

carbohydrase

An enzyme that acts on carbohydrates to break them down into simpler molecules.

carbohydrate

The group of organic molecules that includes sugars, starches, and polysaccharides; these molecules are typically quick sources of energy.

cardiac muscle

Muscle located in the heart; cardiac muscle is involuntary but is also striated. For life to continue, it must continuously contract and relax.

carrier protein

Located in cell membranes; carrier proteins selectively interact with specific molecules so that they can cross the membrane; the action of carrier proteins is an example of active transport.

cell

The smallest unit of life on earth; cells possess cell membranes and contain cytoplasm. Cells vary greatly in appearance, size, and function.

cell body

The part of a neuron that contains the genetic material and most of the cell's organelles; the axon leads out of the cell body. Dendrites lead toward the cell body and carry messages to it.

cell membrane

The cell membrane is a semipermeable structure that serves as a boundary for the cell; some substances are able to move across it and others are not. The cell membrane is made of a phospholipid bilayer and has glycoproteins embedded into its structure.

cellular respiration

The process in which energy is produced from food molecules; it can occur either aerobically or anaerobically.

cellulose

A complex carbohydrate present in plants; cellulose provides the fibre in a healthy diet. The human digestive system is unable to digest cellulose.

central nervous system (CNS)

The central nervous system is comprised of the brain and the spinal cord; it is protected by the skull and the spinal column.

cerebellum

The part of the brain that controls muscle activity; it is part of the hindbrain. The cerebellum is divided into two hemispheres. It is the second largest section of the human brain.

cerebral cortex

The largest and most complex part of the human brain; it is responsible for motor activity, vision, hearing, taste, smell, sensory activity, memory, and judgement.

channel protein

Molecules in the cell membrane that allow particular molecules to cross the membrane by providing a channel for them to pass through; only certain molecules are allowed to pass through these channels.

chemoreceptor

A nerve cell that is sensitive to the presence of a particular molecule; when that molecule is present, the chemoreceptor sends a message to the appropriate location. For example, chemoreceptors in the medulla oblongata of the brain are sensitive to oxygen and carbon dioxide levels and help to control breathing rate.

chyme

The food after the stomach digests it; chyme passes next into the small intestine. It has a liquid-like consistency because of the digestion that occurs in the stomach.

coenzyme

Small organic molecules that are not proteins that help to facilitate the enzyme-substrate connection; they are often produced from various vitamins.

concussion

Brain injury that causes temporary loss of complete brain function; they vary in severity. It is the result of bruising of the brain and involves blood vessel and nerve damage.

controlled experiment

An experiment designed to test the effect of one independent variable; other variables are controlled so that sound conclusions can be made.

corpus callosum

The structure that connects the left side of the brain to the right side.

cortex

The outer layer of connective tissue in each kidney.

dendrite

The part of the neuron that carries impulses toward the cell body; dendrites are affected by impulses from other neurons. Some cells have as many as 200 dendrites.

dependent variable

The factor in an experiment that changes in response to changes made to the independent variable.

diabetes

A disease that results from the body's inability to produce enough insulin; without insulin, the body is unable to break food molecules down to release the energy stored in their bonds. The types of diabetes that exist vary in terms of typical age of onset, symptoms, and treatment.

dialysis

A treatment option for a patient who is suffering from renal distress or renal failure; there are two types of dialysis – hemodialysis and peritoneal dialysis.

diaphragm

The large muscle that separates the chest cavity from the abdominal cavity; the contraction of the diaphragm occurs during inhalation and relaxes during exhalation.

diastole

The part of each heartbeat that involves the contraction of the atria; of the two numbers given in a blood pressure reading, the diastolic reading is the second number and is normally lower than the systolic reading.

diffusion

Passive transport that does not involve energy expenditure; diffusion occurs through barriers that are permeable to the substance involved. Molecules move from areas of high concentration to areas of low concentration by diffusion.

digestion

The breakdown of food molecules so that they can move out of the digestive system and into the blood; both physical and chemical digestion occurs.

disaccharide

A double sugar like sucrose or maltose.

distal tubule

The part of the nephron that carries filtrate from the loop of Henle to the collecting duct; it is the site of secretion.

duodenum

The first section in the small intestine; the duodenum leads out of the stomach and is the site of chemical digestion. Compared to the environment of the stomach, the duodenum is much less acidic.

ectoparasite

A parasite on the outside of the body; examples include leeches, mites, and ticks; ectoparasites can be vectors of disease.

effector

Either a gland or a muscle that carries out the command from the central nervous system; muscles contract and glands produce hormones. Effectors are important in the process of maintaining homeostasis.

efferent arteriole

The tiny artery that carries blood away from the glomerulus; this small vessel wraps around the tubules of the nephron where filtration, reabsorption, and secretion occur.

electrochemical signal

Refers to the nature of nervous messages in the human body. Along the cell wall of the neuron, the signal is electrical as the wave of depolarization passes. Between neurons, the impulse is chemical because neurotransmitters are released and travel across the synapse between neurons.

emotional wellness

The existence of healthy emotions as we experience the events in our lives and the relationships that we have with other people.

endocytosis

Active transport of materials across the membrane that involves the infolding of the cell membrane as particles are brought into the cell. Endocytosis that involves solid substances is called phagocytosis, and endocytosis that involves liquid substances is called pinocytosis.

enzyme

Chemical substances that act on food molecules and break them down into simpler molecules; enzymes are named for the type of molecules that they act on in digestion.

epiglottis

The flap of tissue that closes over the trachea when food is swallowed; it prevents food from entering the trachea and directs it instead into the esophagus.

erythrocyte

A red blood cell; erythrocytes are very numerous in the blood; they carry oxygen and are disc-shaped.

esophagus

The food tube that connects the pharynx to the stomach; the esophagus is a soft, collapsible tube in which peristalsis moves the food downward toward the stomach.

exocytosis

Active transport of materials out of the cell across the membrane; it involves expelling large molecules such as waste materials and hormones after they have been "packaged" in tiny vesicles.

external respiration

Means "breathing"; it is the mechanical process of getting air into the lungs and then expelling it from the lungs.

fibre

Largely indigestible plant material; it is an important part of a healthy diet because it keeps the human digestive system working smoothly.

filtrate

The liquid that remains after the nephrons of the kidney filter and clean the blood; the filtrate is sent to the urinary bladder and is excreted as urine.

filtration

The step in urine formation that occurs in the glomerulus and Bowman's capsule; the high blood pressure in the glomerulus causes dissolved solutes to pass from the blood into Bowman's capsule.

fluid mosaic model

Describes the structure of the cell membrane; a phospholipid bilayer exists that has a wide variety of proteins and cholesterol embedded in it.

forebrain

The part of the brain consisting of the cerebrum, the thalamus, and the hypothalamus.

gall bladder

The organ that stores bile; from the gall bladder, bile passes through the bile duct into the small intestine.

gestational diabetes

Diabetes that occurs only during pregnancy; often the woman has no medical history of diabetes and is not affected by it again after childbirth.

glomerulus

The ball of capillaries in each nephron that is located inside Bowman's capsule; the site of filtration in the kidney.

glucagon

A hormone that is produced by the pancreas and that acts in the liver to convert glycogen to glucose when blood sugar levels are too low.

glucose

A simple sugar that is broken down by living cells during the process of cellular respiration; glucose is a carbohydrate.

glycogen

A storage carbohydrate; excess glucose is converted into glycogen in the liver.

glycoprotein

Molecules on the surface of red blood cells that are antigen markers; they cause the production of specific antibodies by the body's immune system.

health

The physical and mental well-being of an individual.

hemisphere of the brain

One of the two halves of the human brain; a right hemisphere and a left hemisphere are joined by the corpus callosum.

hemoglobin

The iron-containing protein in red blood cells that carries oxygen in the blood; hemoglobin gives erythrocytes their red colour.

heterotroph

Literally means "other eater"; a heterotroph is an organism that cannot make its own food. Heterotrophs eat other organisms to get the energy they need to live.

hindbrain

The part of the human brain consisting of the medulla oblongata, the cerebellum, and the pons.

homeostasis

The delicate state of balance of a number of physiological factors that must be maintained in order for living things to survive.

hormone

A chemical produced by an endocrine gland; hormones travel throughout the body in the bloodstream and have target tissues where they have their effect. An example of a hormone is adrenaline.

hydrophilic

Means "water loving"; molecules that are hydrophilic are attracted to water and other polar molecules. The polarity of a molecule determines how easily it is able to pass through the cell membrane.

hydrophobic

Means "afraid of water"; molecules that are hydrophobic are not attracted to water or to other polar molecules. The polarity of a molecule determines how easily it is able to pass through the cell membrane.

hypertension

High blood pressure; it causes a higher risk of stroke or heart attack than any other disease.

hypertonic

Refers to a solution that has a high solute concentration; cells that are placed in a hypertonic environment tend to lose water.

hypoglycemia

Occurs when blood glucose levels drop too low; hypoglycemia may occur if a person with type 1 diabetes has skipped a meal or has not eaten enough. It can lead to confusion, disorientation, unconsciousness, or seizure.

hypothalamus

The hypothalamus is located in the forebrain and is attached to the base of the cerebrum. It contains reflex centres for various internal organs.

hypothermia

Occurs when the body gets too cold; the body's ability to maintain a fairly constant body temperature has been challenged. Hypothermia can lead to death.

hypothesis

An "educated guess" made during scientific experimentation; the data gathered during the experiment may either support or contradict the hypothesis.

hypotonic

Refers to a solution that has a low solute concentration; cells that are placed in a hypotonic environment tend to gain water and swell.

IBS (Irritable Bowel Syndrome)

A disorder that affects the large intestine and has a wide variety of symptoms; it is also called "spastic colon." IBS can cause cramping, bloating, gas, diarrhea, and constipation.

immunity

The body's ability to protect itself from pathogens by producing or possessing specific antibodies against those pathogens.

independent variable

The variable in a scientific experiment that is changed in order to detect the effect these changes have on the dependent variable; a well-designed experiment should only have one independent variable.

inflammatory response

Can occur when a pathogen has invaded the body; it is characterized by reddening, inflammation, or swelling.

inhibitor

Molecules that compete with substrate molecules for the active sites of enzymes; they render the enzyme ineffective on that substrate.

insulin

The hormone, produced by the pancreas, which allows the body to break sugar molecules down for energy; diabetes is the disease that results when the body's ability to produce insulin is reduced.

intellectual wellness

Being able and willing to learn new things while stimulating and challenging the mind.

interferon

Protein molecules that are produced by the cells of the immune system; they inhibit the replication of viruses in other cells of the body.

internal respiration

The movement of oxygen molecules into body cells and the movement of carbon dioxide out of body cells; internal respiration occurs in the lungs.

interstitial fluid

The liquid that bathes body cells; it is similar in composition to lymph.

isotonic

Refers to a solution that has the same solute concentration as the cell within it; cells that are placed in an isotonic environment tend to lose water and gain water at the same rate.

IVF (in vitro fertilization)

A reproductive technology in which the eggs are collected from the woman and fertilized with the donated sperm; the resulting embryos are then implanted in the uterus.

kidney

The organ that is specialized to filter unneeded and harmful molecules from the blood and to produce urine.

large intestine

The organ that carries the material remaining after food is digested out of the body; it connects the small intestine to the rectum. Water and essential minerals are reabsorbed back into the bloodstream in the large intestine.

larynx

The voice box; the larynx is located in the trachea.

lateralization

Refers to the fact that the right and left halves of the brain are not exactly alike structurally or functionally; each hemisphere has specialized functions.

leucocyte

White blood cells; leucocytes are less numerous and are larger than red blood cells. There are several types of leucocytes. They are important cells in the immune system.

lipase

An enzyme that acts on a lipid molecule.

lipid

A group of organic molecules that includes fats, oils, and waxes; these molecules are capable of storing large amounts of energy as they are digested.

liver

An important organ in the human body; it produces bile, which passes into the small intestine where it emulsifies fat molecules. It is also the site where glycogen is converted to glucose as a result of glucagon production, and where glucose is converted into glycogen as a result of insulin production. The liver has a very large blood supply.

loop of Henle

The part of the nephron that connects the proximal tubule and the distal tubule; it carries filtrate and is "U-shaped."

lymph

The clear liquid that passes out of blood vessels, bathes body cells, and is recollected by the vessels of the lymphatic system to be returned to the bloodstream. Lymph carries cells and other materials out of the blood vessels and delivers them to body tissues.

lymph node

A concentrated mass of tissue along lymphatic vessels; lymph nodes are located in particular areas of the body such as the neck, armpits, and groin. Lymph nodes remove foreign particles and dead cells from the lymph and may swell during periods of illness.

lymphatic system

The organ system that collects interstitial fluid, cleans it, and returns it to the circulatory pathway; this system consists of lymph, lymph vessels, and lymph nodes.

lymphocyte

A specialized type of white blood cell that reacts to pathogens by producing antibodies; the antibodies produced by lymphocytes are specially suited to battle pathogens with specific antigen markers.

lysozyme

An enzyme that destroys foreign bacteria; lysozymes are located in human tears, saliva, nasal secretions, and perspiration.

medulla

The inner layer of the kidney located beneath the cortex and toward the centre of each kidney.

medulla oblongata

A part of the human hindbrain; it is also called the "brainstem." The medulla oblongata connects the spinal cord to the rest of the brain. It is responsible for automatic processes like breathing, swallowing, and coughing.

meninges

Moist membranes that surround the human brain and protect it; the meninges lie between the skull and the brain itself.

midbrain

The part of the human brain that is found between the pons and the forebrain. It works with the cerebellum to control muscle coordination. It also contains relay centres for balance, vision, and hearing.

mineral

Inorganic molecules that are necessary for many important life processes; minerals are not nutrients since they don't provide energy for the body when they are broken down.

mitral valve

The valve between the left atrium and the left ventricle in the human heart.

monosaccharide

A simple sugar such as glucose.

mucus

The thick, wet layer that lines the respiratory passage; invading pathogens and foreign debris are caught in the mucus lining and are unable to enter the body any further. Mucus is a non-specific defence against pathogens.

multicellular

Refers to living organisms that are made up of many cells that are organized into tissues; multicellular organisms are more complex than unicellular organisms.

myocardial infarction

Heart attack; one of the three major coronary arteries becomes partially or totally blocked. As a result of this interrupted blood supply, heart cells begin to die.

myogenic muscle

Refers to heart muscle because of its ability to continue contracting, at least for a time, when separated from the rest of the body.

natural immunity

Refers to immunity that does not result after a vaccination is given; natural immunity is either active or passive. Active natural immunity results when a person has been exposed to the pathogen and builds antibodies against it; those antibodies protect the person if he/she encounters the pathogen again. Passive natural immunity results when antibodies pass from mother to child before birth across the placenta or when the baby receives antibodies from the mother in breast milk.

negative feedback

Refers to the process that maintains homeostasis in the organ systems in the human body. The body's sensory centres detect levels that are either too high or too low and send messages directing change to re-establish homeostasis.

nephritis

This term describes a wide variety of diseases that are all characterized by inflammation of the nephrons in the kidneys.

nephron

The microscopic functional unit of the kidney that removes wastes from the blood and maintains osmoregulation.

nerve impulse

A nerve message; an impulse is a wave of depolarization that passes quickly along the cell membrane of neurons. It is electrochemical in nature.

neuron

A nerve cell; its shape is very distinctive. The long axon varies in length and extends out from the cell body.

neuroplasm

The cytoplasm inside a neuron.

neurotransmitter

One of the chemicals that allow nerve impulses to travel across the synapse between neurons; an example of a neurotransmitter is acetylcholine.

osmoreceptors

These are nerve cells that are sensitive to the solute concentration in the blood; some osmoreceptors are located in the hypothalamus.

osmoregulation

Water balance in the body; it is one of the aspects of homeostasis that must be maintained within acceptable limits.

osmosis

The diffusion of water; it is an example of passive transport.

palliative care

Medical and psychological treatment that aims to reduce the symptoms of a disease without addressing whether or not the disease is curable; it is often designed to make the dying process less painful.

pancreas

The organ that produces the hormone insulin and also digestive enzymes that are carried to the small intestine where they act on food molecules. It is located on the left side of the body under the diaphragm.

parasympathetic nervous system

The part of the autonomic nervous system that causes body functions to "slow down" and return to a normal state; this system comes into action when a danger is no longer present or the situation causing stress is over.

passive immunity

Refers to immunity acquired passively; the patient does not actively produce antibodies in response to an antigen. Passive immunity can be artificial or natural.

pathogen

Any disease-causing organism; pathogenic invaders include bacteria, viruses, protozoans, fungi, and parasites.

peripheral nervous system

Refers to the part of the nervous system that is not part of the CNS; the peripheral nervous system sends messages to the CNS and also carries messages away from the CNS. The peripheral nervous system consists of the somatic nervous system and the autonomic nervous system.

peristalsis

The rhythmic, involuntary contraction of smooth muscle in the digestive system that moves food through the alimentary canal. Peristalsis also occurs in the intestine to move waste materials out of the body.

permeable

Refers to a cell membrane that will allow a certain molecule to diffuse across it; a membrane permeable to a substance allows it to pass freely across it.

phagocytosis

Endocytosis that involves the engulfing and capturing of food particles by the cell; phagocytosis is used by leucocytes when they encounter dead pathogens or other foreign material.

pharmaceutical

A drug used in medicine; many new pharmaceuticals have been developed for a variety of uses.

pharynx

The back of the mouth; leads into both the trachea and the esophagus.

phospholipid bilayer

Describes the structure of the cell membrane; the membrane is made of two layers of phospholipids oriented so that their lipid components face the water-filled environments within and outside of the cell.

photosynthesis

The process in which light energy from the Sun is used to build organic molecules out of carbon dioxide and water; some autotrophs use photosynthesis to make their own food.

physical wellness

Caring for the body in terms of sleep, exercise, proper nutrition and hydration, exposure to various drugs and medications, and regular medical check-ups.

physiology

The functioning of the human body or the study of the structure of the human body; anatomy and physiology are very related in the biological world.

pinocytosis

Endocytosis that involves the movement of liquid into the cell; the other type of endocytosis is phagocytosis, which involves the movement of solid matter.

pituitary gland

Part of the brain; it releases a number of hormones including ADH. It is connected to and stimulated by the hypothalamus.

plaque

Material made up mostly of lipids, cholesterol, and calcium that can line blood vessels and cause circulatory problems; plaque formation is gradual and can cause blood vessels to become hard and narrow.

plasma

The liquid part of blood; blood plasma is about 90% water and also contains various dissolved substances. Cellular components of blood are suspended in the plasma. About 55% of blood by volume is plasma.

plasma membrane

The cell membrane.

plasma protein

Proteins that are carried in the blood plasma; a wide variety of plasma proteins exist and they serve a number of functions.

platelet

A cellular component of human blood that is involved in blood clotting; platelets are very small, are produced in the bone marrow, and do not possess nuclei.

pleura

The membrane that surrounds and protects the lungs; it lies between the lung tissue and the rib cage.

polysaccharide

A complex sugar like starch, cellulose, and glycogen.

pons

Part of the hindbrain that is a small oval structure that is a bridge between the cerebellum and medulla oblongata.

protease

An enzyme that acts on proteins.

protein

A group of organic molecules that are made up of chains of amino acids; proteins act as enzymes and also as structural molecules in living things.

proximal tubule

The part of the nephron that leads out of Bowman's capsule and carries filtrate into the loop of Henle; it is the site of reabsorption.

pulmonary circulation

The circulatory pathway that carries blood from the heart to the lungs for oxygenation and back to the heart again; pulmonary arteries carry blood from the right ventricle to the alveoli in the lungs, and pulmonary veins carry newly oxygenated blood back to the left atrium of the heart.

pulse

The surge of blood through the arteries near the skin surface that occurs after each heartbeat; a pulse is most easily detected on the side of the neck and on the inner wrist.

reabsorption

The step in urine formation that occurs in the proximal tubule and follows filtration; in this step, much of the filtrate returns to the bloodstream. Some of the reabsorbed substances are moved by active transport back into the blood.

receptor

A cell in the nervous system that receives information; receptor cells are located on the sensory organs such as the skin.

rectum

The end of the large intestine that ends in the anus; it primarily acts to store the feces before it is excreted from the body.

reflex

An automatic response that occurs without involvement of the brain; a reflex arc carries a very rapid impulse so the reflex action occurs almost immediately.

renal artery

Carries blood to the kidney so that it can be filtered; one renal artery leads into each kidney.

renal pelvis

The hollow chamber in the centre of each kidney; it is connected to the ureter and collects urine before it is sent to the urinary bladder.

renal vein

Carries blood away from the kidney after it has been filtered; one renal vein leads from each kidney.

response

A reaction to a stimulus in the environment; living things respond to stimuli.

saliva

Produced by salivary glands and carried by small ducts into the oral cavity. It lubricates the food and begins to chemically digest it as well.

secretion

This step in urine formation occurs in the distal tubule and follows reabsorption; in this step, materials such as urea are moved by active transport from the blood back into the tubule.

selectively permeable

Refers to a membrane that is only permeable to a select group of substances; only certain molecules are able to diffuse across the membrane.

senescence

The aging process; senescence occurs gradually during a person's lifetime and occurs at different rates in different people.

septum

The wall that separates the left and right sides of the human heart.

sexual reproduction

Refers to reproduction involving two parents; the genetic material of both parents is combined in the offspring.

sinoatrial node (SA node)

The area located in the right atrium that stimulates the two atria to contract; the SA node is also called the heart's pacemaker.

small intestine

The organ that lies between the stomach and the large intestine; it serves two primary functions – digestion of food and absorption of nutrients into the bloodstream.

social wellness

The degree to which a person interacts successfully with others; humans are interdependent upon each other.

soft palate

The roof of the pharynx in the back of the mouth; this soft tissue functions in closing off the openings to the nose and ears as food is swallowed.

somatic nervous system

The part of the nervous system that directs the voluntary muscles of the body; the somatic nervous system allows conscious control over voluntary muscles.

sphincter muscles

Muscles that control the passage of materials from one structure into another. For example, sphincter muscles that are found in the stomach keep partially digested food from moving back up into the esophagus.

spinal cord

The nerve cord that runs down the back from the base of the brain; it is protected by the vertebrae.

spiritual wellness

The human need to understand the deeper meanings of life, the forces that control our present and shape our future; it is unique to each individual.

STI (Sexually Transmitted Infection)

Infections that are transmitted from person to person through intimate physical contact; examples include chlamydia, herpes, and AIDS.

stimulus

A condition in the environment that requires an organism to adjust; stimuli are recognized by the sensory organs.

stomach

The organ into which food passes after it passes through the esophagus from the oral cavity; proteins are digested in the acidic environment of the stomach.

stroke

The sudden loss of brain function due to an interruption in the blood supply to all or part of the brain.

substrate

The molecule that an enzyme acts on; each enzyme-substrate connection is very specific.

sympathetic nervous system

The part of the autonomic nervous system that causes body functions to "speed up"; this system comes into action when a danger is present or a situation causing stress occurs.

synapse

The gap between neurons; neurotransmitters carry the impulse across the synapse from neuron to neuron.

systole

The part of each heartbeat that involves the contraction of the ventricles. Of the two numbers given in a blood pressure reading, the systolic reading is the first number and is normally higher than the diastolic reading.

tachycardia

A condition that occurs in times of stress when the heart beats very rapidly; tachycardia occurs when the heart beats more than 100 times in one minute.

target tissue

The particular tissue that a given hormone has its effect on; each hormone only affects its particular target tissue.

thalamus

The part of the human forebrain that is attached to the base of the cerebrum; the thalamus acts as a relay station, receiving all impulses from the body and transferring each of them to the correct part of the cerebral cortex for processing.

theory

A broad explanation that is consistent with a large amount of experimental evidence and observations; theories vary in terms of how much evidence supports them.

thermoregulation

The regulation of internal body temperature; thermoregulation is one example of how homeostasis must be maintained to sustain life.

trachea

The windpipe; this tube is supported by rings of cartilage and carries air from the nose and mouth into the bronchi.

tricuspid valve

The valve that lies between the right atrium and the right ventricle in the human heart.

ulcer

A sore on the inner lining of the digestive tract. While most ulcers are located in the duodenum of the small intestine, some do occur in the stomach or esophagus.

unicellular

Refers to an organism that consists of only one cell.

universal donor

Refers to blood type "O-"; blood of this type does not contain ABO blood proteins and also does not contain the Rh blood protein.

universal recipient

Refers to blood type "AB+"; blood of this type possesses both ABO blood proteins and also possesses the Rh blood protein, so none of these proteins present in blood transfusions will cause an immune response.

urea

Toxic ammonia is converted into a less-toxic form called urea. Urea is filtered out of the blood by the kidneys and is excreted in urine and in sweat.

ureter

The tube that carries urine from the kidney to the urinary bladder for storage; the human body has two ureters, one leading from each kidney.

urethra

The structure that carries urine out of the body from the urinary bladder.

urinalysis

A laboratory test that can reveal a great deal of information about the health of a patient; a wide variety of substances can be monitored through urinalysis.

urinary bladder

The organ that temporarily stores liquid waste (urine) before it is excreted from the body.

uvula

The small mass of tissue that hangs down in the pharynx; it is important in the creation of the human voice and also closes off the openings to the nasal cavity when food is swallowed.

vaccination

Injections that contain weakened or inactive forms of a pathogen. Vaccines are intentionally given so that the person possesses antibodies against the pathogen in case it is encountered in the future, thus building immunity.

vector

Agents that transfer disease from one host to another; common vectors include fleas, ticks, and mosquitoes.

vein

A blood vessel in the human circulatory system that returns deoxygenated blood to the heart after it has circulated throughout the body.

vena cava

The two large veins that empty deoxygenated blood into the right atrium of the heart; there are two vena cava – the superior vena cava and the inferior vena cava.

ventricle

One of the two lower chambers of the human heart; blood enters each ventricle from the atrium that is directly above it. The left ventricle pumps blood out to the body through the aorta and the right ventricle pumps blood out to the lungs.

venule

A very small vein; capillaries lead into venules, which then lead to veins as blood returns to the heart from the systemic circulation.

villi

The tiny finger-like projections in the small intestine that increase the surface area for absorption of nutrients.

vitamin

Organic molecules that are needed in small amounts by the body; they are part of the structure of many enzymes.

voluntary muscle

A muscle that is under conscious control; voluntary muscle is striated skeletal muscle found in arms, legs, and other body parts.

wellness

The relationship between the five factors of well-being, which are physical, emotional, spiritual, intellectual, and social well-being; it is a broader term than "health."

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Appendix

List of Specific Learning Outcomes by Lesson

Appendix: List of Specific Learning Outcomes by Lesson

This appendix has been developed for classroom teachers who are interested in knowing which specific learning outcomes are taught in each lesson in this Independent Study course.

Module 1: Wellness and Homeostasis

Lesson 2: Personal Wellness

S3B-1-01	Increase awareness of personal wellness and family health history.
S3B-1-02	Develop a personal wellness plan.
S3B-1-03	Recognize how individual wellness choices affect others.
S3B-0-I1	Synthesize information obtained from a variety of sources. Include: print and electronic sources, resource people, different types of writing.
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.

Lesson 3: Introduction to Homeostasis

S3B-1-04	Describe how the body attempts to maintain an internal balance called homeostasis, recognizing that the conditions in which life processes can occur are limited. Include: thermoregulation (maintenance of body temperature), osmoregulation (water balance), waste management.
S3B-1-05	Explain the principle of negative feedback and identify how the body stabilizes systems against excessive change. Include: role of receptors, effectors.

S3B-0-U1	Use appropriate strategies and skills to develop an understanding of biological concepts. *Examples: using concept maps, sort-and-predict frames, concept frames…*
S3B-0-U2	Demonstrate an in-depth understanding of biological concepts. *Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, creative presentations…*

Lesson 4: Cells and Homeostasis

S3B-1-06	Identify life processes that individual cells, as well as complex organisms, need to manage. Include: obtain food, convert energy, eliminate wastes, reproduce, grow and repair, transport substances.
S3B-1-07	Explain how cell membranes regulate movement of materials into and out of cells and recognize the importance of this regulation in managing life processes and maintaining homeostasis. Include: passive transport, active transport, endo/exocytosis.
S3B-1-08	Identify factors that influence movement of substances across a membrane, recognizing that movement of these substances is important for the internal balance of the cell. *Examples: size of molecule, concentration gradient, temperature, polarity of molecules, surface area…*
S3B-0-U1	Use appropriate strategies and skills to develop an understanding of biological concepts. *Examples: using concept maps, sort-and-predict frames, concept frames…*

Lesson 5: Energy

S3B-1-09	Explain the role of energy in maintaining equilibrium in the cell. Include: role of ATP in metabolism.

Module 2: Digestion and Nutrition

Lesson 1: Introduction to 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.

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-0-U2 Demonstrate an in-depth understanding of biological concepts.

Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, create presentations…

Lesson 2: Chemical Digestion and Enzymes

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.

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…

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.

S3B-0-U1 Use appropriate strategies and skills to develop an understanding of biological concepts.

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

S3B-0-U2 Demonstrate an in-depth understanding of biological concepts.

Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, create presentations…

Lesson 3: 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.

S3B-0-U1 Use appropriate strategies and skills to develop an understanding of biological concepts.

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

S3B-0-U2 Demonstrate an in-depth understanding of biological concepts.

Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, create presentations…

Lesson 4: Digestion and Nutrition

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

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

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-I1	Synthesize information obtained from a variety of sources. Include: print and electronic sources, resource people, different types of writing.
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.

Lesson 5: Disorders of the Digestive System

S3B-2-11	Investigate and describe conditions/disorders that affect the digestive process.
S3B-0-I1	Synthesize information obtained from a variety of sources. Include: print and electronic sources, resource people, different types of writing.
S3B-0-P3	Appreciate the impact of personal lifestyle choices on general health and make decisions that support a healthy lifestyle.

Lesson 6: Making Decisions About Nutrition

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 your 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 you or others to arrive at a decision.

S3B-0-I1 Synthesize information obtained from a variety of sources. Include: print and electronic sources, resource people, different types of writing.

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.

S3B-0-W1 Demonstrate a continuing, more informed interest in biology and biology-related careers and issues.

Module 3: Transportation and Respiration

Lesson 1: Introduction to Scientific Experimentation

S3B-3-01 Design and execute an experiment to investigate an aspect of the transportation or respiratory system.

Examples: the effect of exercise on heart and/or respiratory rate, the effect of adrenalin on blood pressure, carbon dioxide production as an indicator of metabolism. . .

S3B-0-S1 State a testable hypothesis or prediction based on background knowledge or observed events.

S3B-0-S2 Plan an experiment to answer a specific scientific question. Include: materials, independent, dependant and controlled variables, methods, safety considerations.

S3B-0-S6 Record, organize, and display data and observations using appropriate format. Include: biological drawings.

S3B-0-S8 Analyze data or observations in order to draw a conclusion that explains the results of the experiment, and identifies implications of these results.

Lesson 2: The Blood

S3B-3-02 Compare the characteristics of blood components in terms of appearance, origin, number, relative size and function in the body.

S3B-3-03 Compare and contrast the characteristics of different blood groups. Include: ABO, Rh factor.

S3B-3-04 Predict the physiological consequences of blood transfusions involving different blood groups.

S3B-3-05 Describe the blood donation process and investigate related issues.

Examples: Compatible blood groups, screening procedure, frequency of donation, use of donated blood products, blood-borne diseases. . .

S3B-0-I1 Synthesize information obtained from a variety of sources. Include: print and electronic sources, resource people, different types of writing.

S3B-0-U1 Use appropriate strategies and skills to develop and understanding of biological concepts.

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

S3B-0-W2 Appreciate the contributions of Canadian scientists and institutions, past and present, to the field of human biology.

Lesson 3: The Circulatory System

S3B-3-06 Compare the structure and function of blood vessels.

Examples: diameter, elasticity, muscle layers, valves, what they transport. . .

S3B-3-07 Identify the materials transported between cells and capillaries. Include: carbon dioxide, oxygen, hormones, nutrients, and nitrogenous wastes.

S3B-3-08 Describe the cardiac cycle. Include: systole, diastole.

S3B-3-09 Describe, in general terms, the nervous and chemical control of the heartbeat.

S3B-3-10 Explain the meaning of blood pressure readings and identify the normal range. Include: given as a ratio of systolic over diastolic.

S3B-3-11 Identify factors which affect blood pressure or cardiac function and describe their effects.

Examples: exercise, caffeine, nicotine, shock, betablockers, diuretics, hormones, stress, low blood pressure, high blood pressure, increased heart rate. . .

S3B-3-12 Explain how transport systems help to maintain homeostasis in the body. Include: transport nutrients, oxygen, carbon dioxide, wastes, help maintain fluid balance, regulate body temperature and assist in the defence of the body against invading organisms.

S3B-0-I1 Synthesize information obtained from a variety of sources. Include: print and electronic sources, resource people, different types of writing.

S3B-0-U1 Use appropriate strategies and skills to develop and understanding of biological concepts.

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

Lesson 4: The Respiratory System

S3B-3-13 Distinguish between cellular respiration, internal respiration and external respiration.

S3B-3-14 Identify major structures and functions of the human respiratory system from a diagram, model or specimen. Include: lungs, pleura, nasal cavity, epiglottis, bronchi and bronchioles, alveoli, pulmonary capillaries, diaphragm, interpleural fluid, pharynx, larynx, trachea, uvula, ribs and intercostal muscles.

S3B-3-15 Describe how breathing is controlled to help maintain homeostasis in the human body. Include: chemoreceptors, medulla oblongata.

Lesson 5: Circulatory and Respiratory Wellness

S3B-3-16 Investigate and describe conditions/disorders associated with transportation and/or respiration in the human body.

Examples: cardiovascular diseases…

S3B-3-17 Identify personal lifestyle choices that contribute to cardiovascular and respiratory wellness.

Examples: active lifestyle, not smoking, etc.…

S3B-0-I1 Synthesize information obtained from a variety of sources. Include: print and electronic sources, resource people, different types of writing.

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

S3B-0-W2 Appreciate the contributions of Canadian scientists and institutions, past and present, to the field of human biology.

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

Module 4: Excretion and Waste Management

Lesson 1: Introduction to Waste Management

S3B-4-01 Identify the primary metabolic wastes produced in the human body and the source of each. Include: ammonia, urea, mineral salts, carbon dioxide, and water.

S3B-4-02 Describe the roles of the major excretory structures in eliminating wastes and helping the body maintain homeostasis. Include: kidneys, lungs, skin, intestines.

S3B-4-03 Describe the important role of the liver in the process of excretion and the maintenance of homeostasis.

S3B-0-U1 Use appropriate strategies and skills to develop an understanding of biological concepts.

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

S3B-0-U2 Demonstrate an in-depth understanding of biological concepts.

Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, create presentations…

Lesson 2: The Human Urinary System

S3B-4-04 Identify structures of the human urinary system from a diagram, model, or specimen, and describe the function of each. Include: kidneys, renal cortex, renal medulla, renal pelvis, renal arteries and veins, ureters, urinary bladder, urethra, and urinary sphincters.

S3B-4-05 Explain the processes of filtration, re-absorption, and secretion in the nephron.

S3B-0-U2 Demonstrate an in-depth understanding of biological concepts.

Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, create presentations…

Lesson 3: Excretory Homeostasis

S3B-4-06 Describe the feedback mechanisms associated with water and salt balance and their role in the maintenance of homeostasis in the human body.

S3B-0-U1 Use appropriate strategies and skills to develop and understanding of biological concepts.

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

S3B-0-U2 Demonstrate an in-depth understanding of biological concepts.

Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, create presentations…

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

Lesson 4: Urinalysis and Urinary Wellness

S3B-4-07 Describe what types of information can be gained through urinalysis.

Examples: performance enhancing drugs, diabetes, recreational drugs, pregnancy, infections, kidney failure or damage. . .

S3B-4-08 Investigate and describe issues related to kidney failure and treatment options available.

Examples: organ transplant, personal lifestyle, dialysis…

S3B-0-I1 Synthesize information obtained from a variety of sources. Include: print and electronic sources, resource people, different types of writing.

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.

Module 5: Protection and Control

Lesson 1: Overview of the Immune System

S3B-5-01 Describe the body's defence mechanisms for protection from foreign agents. Include: non-specific and specific defences.

S3B-5-02 Describe the body's response to allergens, vaccines, viruses/bacteria. Include: inflammatory response, immune response.

S3B-5-03 Explain the role of the lymphatic system in protecting the human body. Include: lymph nodes, lymph vessels, lymph.

S3B-0-U2 Demonstrate an in-depth understanding of biological concepts.

Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, creative presentations…

Lesson 2: Immunity, Disease, and Public Health

S3B-5-04 Investigate issues related to the immune system and the protection of public health. Include: immunization, travel bans and advisories, epidemics.

S3B-0-I1 Synthesize information obtained from a variety of sources. Include: print and electronic sources, resource people, different types of writing.

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.

Lesson 3: Overview of the Nervous System

S3B-5-05 Describe the major organization of the nervous system. Include: central nervous system and peripheral nervous system (autonomic and somatic).

S3B–5-06 Identify the functional regions of the brain on a diagram.

Examples: general anatomy such as cerebrum, specific regions responsible for speech and other functions, left-brain/right-brain concept…

S3B-5-07 Identify possible implications of concussions on brain function.

Examples: multiple concussions in sport, second impact syndrome…

S3B-0-U2 Demonstrate an in-depth understanding of biological concepts.

Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, creative presentations…

Lesson 4: The Neuron

S3B-5-08 Explain how a nerve impulse travels a particular pathway using chemical and electrical signals. Include: synapse.

S3B-0-U1 Use appropriate strategies and skills to develop an understanding of biological concepts.

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

S3B-0-U2 Demonstrate an in-depth understanding of biological concepts.

Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, creative presentations…

Lesson 5: Nervous and Endocrine Interaction

S3B-5-09 Compare the general roles of nervous and hormonal controls recognizing that nervous and endocrine systems interact to maintain homeostasis. Include: communication, speed, duration, target pathway, action.

S3B-0-U1 Use appropriate strategies and skills to develop an understanding of biological concepts.

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

S3B-0-U2 Demonstrate an in-depth understanding of biological concepts.

Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, creative presentations…

Lesson 6: Wellness

S3B-5-10 Describe how personal lifestyle can influence well-functioning protection and/or control systems.

Examples: impact of drugs, anabolic steroids, lack of sleep, inadequate diet…

S3B-5-11 Investigate and describe conditions/disorders that affect protection and/or control in the human body.

S3B-0-U1 Use appropriate strategies and skills to develop an understanding of biological concepts.

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

S3B-0-U2 Demonstrate an in-depth understanding of biological concepts.

Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, creative presentations…

S3B-0-I1 Synthesize information obtained from a variety of sources. Include: print and electronic sources, resource people, different types of writing.

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.

Module 6: Wellness and Homeostatic Changes

Lesson 1: Body System Interrelationships

S3B-6-01 Analyze examples of how different body systems work together to maintain homeostasis under various conditions.

Examples: cold weather, organ transplant…

S3B-0-U2 Demonstrate an in-depth understanding of biological concepts.

Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, creative presentations…

S3B-0-I1 Synthesize information obtained from a variety of sources. Include: print and electronic sources, resource people, different types of writing.

Lesson 2: The Aging Process

S3B-6-02 Recognize that aging is a progressive failure of the body's homeostatic responses and describe some changes that take place in different body systems as we age.

Examples: less blood and oxygen delivered to muscles and other tissues due to decreased efficiency of heart and lungs, lower calorie requirement due to decreased metabolic rate, increased susceptibility to autoimmune diseases due to fall in number of T cells and decreased activity of B cells…

S3B-0-I1 Synthesize information obtained from a variety of sources. Include: print and electronic sources, resource people, different types of writing.

S3B-0-U1 Use appropriate strategies and skills to develop an understanding of biological concepts.

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

S3B-0-U2 Demonstrate an in-depth understanding of biological concepts.

Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, creative presentations…

Lesson 3: Death

S3B-6-03 Recognize the difficulties faced in defining "death" and identify some of the different definitions in use today.

Examples: medical definition, legal definition, religious viewpoint…

S3B-6-04 Identify and analyze social issues related to the process of dying.

Examples: euthanasia, advanced directive, choice of treatments, organ donation, availability of palliative care.

S3B-0-I1 Synthesize information obtained from a variety of sources. Include: print and electronic sources, resource people, different types of writing.

S3B-0-U1 Use appropriate strategies and skills to develop an understanding of biological concepts.

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

S3B-0-U2 Demonstrate an in-depth understanding of biological concepts.

Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, creative presentations…

S3B-0-P4 Demonstrate an understanding of and respect for a diversity of cultural perspectives and approaches to maintaining health and treating illness.

Lesson 4: Technology and Wellness

S3B-6-05 Determine how technology has allowed us to control our wellness and the ethical dilemmas that the use of technology can create.

Examples: reproductive technologies, surgery, anaesthetic, pharmaceuticals…

S3B-0-U1 Use appropriate strategies and skills to develop an understanding of biological concepts.

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

S3B-0-U2 Demonstrate an in-depth understanding of biological concepts.

Examples: use accurate scientific vocabulary, explain concept to someone else, make generalizations, compare/contrast, identify patterns, apply knowledge to new situations/contexts, draw inferences, create analogies, creative presentations…

S3B-0-I1 Synthesize information obtained from a variety of sources. Include: print and electronic sources, resource people, different types of writing.

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.

S3B-0-W1 Demonstrate a continuing, more informed interest in biology and biology-related careers and issues.

S3B-0-W2 Appreciate the contributions of Canadian scientists and institutions, past and present, to the field of human biology.

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