UNIT 1:
WELLNESS AND HOMEOSTASIS

Unit 1: Wellness and Homeostasis

Specific Learning Outcomes

B11-1-01: Increase awareness of personal wellness, as well as personal and family health history. (GLO: B3)

B11-1-02: Develop a personal wellness plan. (GLOs: B3, B5)

B11-1-03: Recognize how individual wellness choices affect others. (GLOs: B3, B5)

Examples: community, family...

B11-1-04: Describe how the body attempts to maintain an internal balance called homeostasis, recognizing that the conditions in which life processes can occur are limited. (GLOs: D1, E2, E3)

Include: thermoregulation (maintenance of body temperature), osmoregulation (water balance), and waste management

B11-1-05: Explain the principle of negative feedback and identify how the body stabilizes systems against excessive change. (GLOs: D1, E2, E3)

Include: role of receptors and effectors

B11-1-06: Identify life processes that individual cells, as well as complex organisms, need to manage. (GLOs: D1, E1)

Include: obtain food, convert energy, eliminate wastes, reproduce, grow and repair, and transport substances

B11-1-07: 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. (GLOs: D1, E2, E3)

Include: passive transport, active transport, and endo/exocytosis

B11-1-08: 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. (GLOs: D1, E2, E3)

Examples: size of molecule, concentration gradient, temperature, polarity of molecule, surface area…

B11-1-09: Explain the role of energy in maintaining an internal balance in the cell. (GLOs: D1, D4, E4)

Include: role of adenosine triphosphate (ATP) in metabolism

PERSONAL WELLNESS

SPECIFIC LEARNING OUTCOMES

B11-1-01: Increase awareness of personal wellness, as well as personal and family health history. (GLO: B3)

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Examples: community, family...

SLO: B11-1-01
SLO: B11-1-02
SLO: B11-1-03

SUGGESTIONS FOR INSTRUCTION

TEACHER NOTE

The instructional strategies suggested in this document follow the constructivist model of learning and are organized into two groups: activate and acquire/apply. By activating students' prior knowledge of a topic, teachers can

- help students relate new information, skills, and strategies to what they already know and can do
- recognize misconceptions and gaps in student knowledge
- stimulate curiosity and initiate the inquiry process

Acquiring and applying strategies are designed to assist students in processing, integrating, and consolidating their learning.

Wellness Portfolio

Wellness is a major theme in Grade 11 Biology. A recommended tool to help students explore this theme is the creation of a Wellness Portfolio. By completing their portfolios, students personalize the human body content in the Grade 11 Biology programming. The intent is to have students learn more about their medical histories and how their body works, to collect data on how their body is performing, to analyze how well they are taking care of themselves, and to make decisions about their own lifestyle to promote their wellness.

This portfolio has a number of possible assignments in a variety of formats. Each is matched up to an appropriate section of the course. Appendix 1.1: Wellness Portfolio Overview provides a summary of possible Wellness Portfolio activities or assignments. Additional assignments can be added by the teacher.

All students should complete Appendix 1.2: Wellness Checkup (BLM). Other work could be teacher assigned, a combination of teacher assigned and student selected, or all student selected.

The Wellness Portfolio activities and assignments are referenced throughout this document and can be identified by the following graphic:

SKILLS AND ATTITUDES OUTCOMES

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

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

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

ACTIVATE

Wellness Checkup

As an introduction to some of the factors that influence wellness, have students complete Appendix 1.2: Wellness Checkup (BLM).

ACQUIRE/APPLY

Once Upon a Time—Microtheme (I4)

Microthemes are short writing assignments designed to help students learn the material by looking at it in a different way (Martin). Refer to Appendix 1.3A: Microthemes (Teacher Background) for more information on microthemes, including assessment approaches.

Provide students with the following microtheme assignment:

Microtheme
Remember a time when you broke your leg sliding into home plate, or how itchy you were that summer vacation when you broke out in chicken pox? What illnesses or injuries have you experienced? Choose one of these incidents to write about. Imagine that you are now a grandparent invited to your grandson's Kindergarten class to talk to students about that illness or injury. Write down what you would tell them. Be sure to include what happened, how you were diagnosed and treated, whether you visited the hospital, and so on. Your account can be dramatic, but it must also be factual.

Option: If you suffer from a chronic disease, you may choose to write about that.

Resource

Life Is a Gift: A Manitoba Grade 11 Biology Resource for Organ Donation and Transplantation (Manitoba Education and Transplant Manitoba) provides a context in which to incorporate the science and issues surrounding organ donation into teaching and learning in each of the six units of the Grade 11 Biology curriculum.

See Organs and Tissues Available for Transplant Lesson Plan in *Life Is a Gift* for learning activities linked to Unit 1: Wellness and Homeostasis.

Suggestion for Assessment

Refer to Appendix 1.3B: Microthemes—First Draft Checklist (BLM) and Appendix 1.3C: Microthemes—Final Draft Assessment (BLM) for assessment tools.

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Examples: community, family...

Family Medical History (P2, I1, I4)

Have students conduct research on their family members (immediate and distant) to create a family medical history. Refer to Appendix 1.4: Family Medical History (BLM) for student instructions.

Diseases identified by the individuals in the class can form the basis for research projects that will take place later in the course.

Cautionary Note: While this learning activity provides a tremendous opportunity for students to connect with family members and learn medical information that might prove important to them, teachers will need to be sensitive with regard to students who may not be able to contact family members (e.g., adopted students). An alternative Wellness Portfolio activity could be substituted for anyone not comfortable with this assignment.

Suggestion for Assessment

A sample rubric is provided below. It should be modified, with student input.

Family Medical History Assessment		
1. Interview notes a) indicated individual interviewed, date of interview, and relationship to the student	0 — not done 1 — poor 2 — some information but disorganized or incomplete 3 — lots of information, organized and complete but for one interview only 4 — two excellent interviews	Weighting x 2 = /8
2. Pedigree a) used proper format to indicate relationships b) listed birth and death rates c) listed conditions d) listed cause of death	0 — not done 1 — met one criterion 2 — met two criteria 3 — met three criteria 4 — met four criteria	x 3 = /12
Total		/ 20

SKILLS AND ATTITUDES OUTCOMES

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

Alternative: Because of the sensitive nature of this information, this assignment can be ungraded or marked as pass or fail. Another approach for a student or family reluctant to submit sensitive information is to have a parent/guardian* verify that the assignment was completed and not hand in any content to the teacher.

Personal Wellness Reflection (P2)

Have students carry out a Focused Free Writing activity by writing a reflection on personal wellness. The following questions can be used to stimulate thinking:

- What is wellness?
- What is my current level of wellness or health?
- What things do people do to promote wellness?
- What other things could I do to improve my own health?
- How do my personal choices relate to my own health?
- How do they affect others around me (e.g., family, community)?

For more information on Focused Free Writing activities, refer to *Senior Years Science Teachers' Handbook* (Manitoba Education and Training, pp. 13.8–13.13)—hereafter referred to as *SYSTH*.

Throughout Grade 11 Biology, students will be learning more about wellness, culminating with the development of personal wellness goals at the end of the course. Teachers may choose to provide students with the following definition of wellness (or have students create their own).

Definition of Wellness
Wellness is not the same as health. *Health* generally refers only to the physical well-being of an individual, whereas *wellness* refers to the multi-dimensional interrelationship between the physical, emotional, spiritual, intellectual, interpersonal or social, and environmental aspects of life.

* In this document, the term *parents* refers to both parents and guardians, and is used with the recognition that in some cases only one parent may be involved in a child's education.

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Examples: community, family...

Suggestion for Assessment

This type of Focused Free Writing activity is an opportunity to enter into a dialogue with students. The teacher can respond to what the student wrote with a question, comment, sharing of a personal experience, and so on. A journal or notebook can be used to collect this type of reflective writing and can be assessed periodically. Criteria for assessment at that point might include the following:

- follows guidelines
- relates material to own experiences or expresses opinion of content
- responds critically and reflectively, showing growth and increased understanding of content

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NOTES

INTRODUCTION TO HOMEOSTASIS

SPECIFIC LEARNING OUTCOMES

B11-1-04: Describe how the body attempts to maintain an internal balance called homeostasis, recognizing that the conditions in which life processes can occur are limited. (GLOs: D1, E2, E3)

Include: thermoregulation (maintenance of body temperature), osmoregulation (water balance), and waste management

B11-1-05: Explain the principle of negative feedback and identify how the body stabilizes systems against excessive change. (GLOs: D1, E2, E3)

Include: role of receptors and effectors

SLO: B11-1-04
SLO: B11-1-05

SUGGESTIONS FOR INSTRUCTION

BACKGROUND INFORMATION

Dr. Gordon Giesbrecht, a professor at the University of Manitoba, has operated a Laboratory for Exercise and Environmental Medicine, where he studied human responses to exercise/work in extreme environments. He has conducted hundreds of cold-water immersion studies that have provided valuable information about cold stress physiology and pre-hospital care for human hypothermia.

Resource Link

Visit the following website for more information:

- University of Manitoba. "Dr. Gordon Giesbrecht." <www.umanitoba.ca/faculties/physed/research/people/giesbrecht/>.

ENTRY-LEVEL KNOWLEDGE

In Grade 8, students studied body systems, what happens when systems are not functioning properly, and the interrelatedness of systems.

ACTIVATE

How Do You Feel?—Class Discussion

Have students describe some of the things they notice happening with their bodies when they are not feeling well (e.g., running a temperature, shivering, sweating, being thirsty). This discussion can be expanded to include more long-term signs of ill health, such as blood pressure and heart rate. Have students try to identify some of the more common "normals" the body attempts to maintain, such as core body temperature and blood pressure.

SKILLS AND ATTITUDES OUTCOMES

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

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

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

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

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

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

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

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

ACQUIRE/APPLY

Word Splash (U1, U2)

Have students use a Word Splash (Saphier and Haley) to obtain information about homeostasis. Provide each group of students with Appendix 1.5A: Word Splash—Homeostasis (BLM). Have students predict and record thought/concept connections among the words on the BLM. This can be done by drawing lines to connect the words (two or more) and writing on the line the connections. Or, students may choose to write statements that show the connections between words.

Following this learning activity, have students read Appendix 1.5B: Homeostasis—Background Information (BLM) and verify their predictions.

Suggestion for Assessment

Have students use a Concept Organizer Frame such as the Concept Frame or the Concept Overview to summarize learning related to the concept of homeostasis. The type of concept frame used can be determined by the teacher or by individual students. Some students may prefer to use one frame over another. The frames can be handed in and feedback provided by the teacher. As this is intended as a formative assessment to check student understanding, a mark for this learning activity is not required.

INTRODUCTION TO HOMEOSTASIS

SPECIFIC LEARNING OUTCOMES

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Include: thermoregulation (maintenance of body temperature), osmoregulation (water balance), and waste management

B11-1-05: Explain the principle of negative feedback and identify how the body stabilizes systems against excessive change. (GLOs: D1, E2, E3)

Include: role of receptors and effectors

A summary of the categories used for each frame is provided below. For more details and blackline masters, refer to *SYSTH* (pp. 11.23–11.24, 11.36–11.37).

Concept Frame	Concept Overview
• Concept • Characteristics • Examples • What is it like? • What is it unlike? • Definition • Illustration	• Keyword or concept • Figurative representation • Explanation or definition in own words • Facts • Create questions about the concept • Create an analogy

Negative Feedback (G1, G2, U1)

Have students reread the "A Cold Walk" section of Appendix 1.5B: Homeostasis—Background Information (BLM) and, in small groups, use Appendix 1.6: Negative Feedback Mechanisms (BLM) to describe what is happening to the body. Students will need to use a different BLM for each portion of the story. See the following example.

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

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

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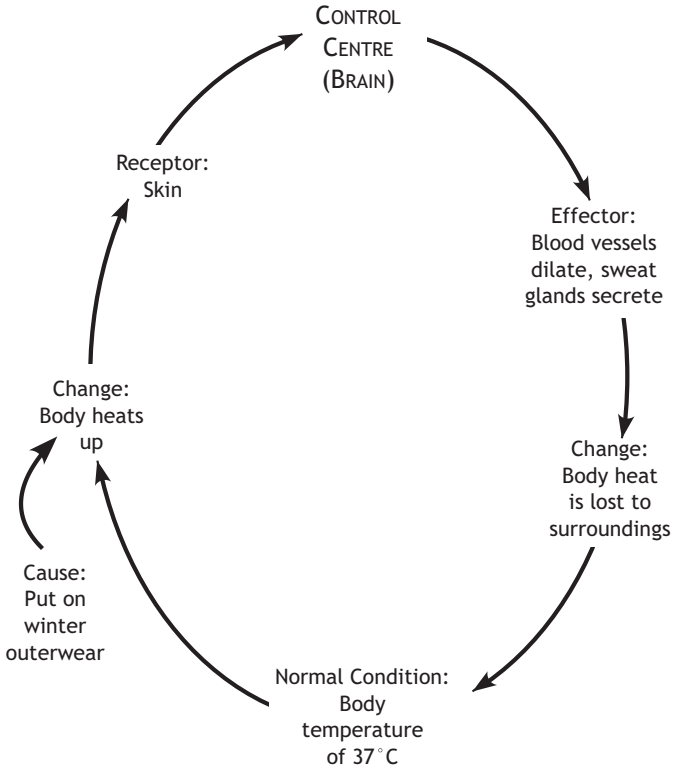
B11-0-G3: Evaluate individual and group processes used. (GLOs: C2, C4, C7)

Example:



Suggestion for Assessment

Have each group meet with another group to compare their results. Any discrepancies should be discussed and a consensus reached. Each pair of groups can then share any problem areas they encountered and what their final consensus was.

INTRODUCTION TO HOMEOSTASIS

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Case Study (G1, G2, G3, I4, U2)

Analysis of the case study Appendix 1.7: The Swimming Race allows students to apply what they have been learning about homeostasis.

Suggestions for Assessment

There are a variety of possible assessment focuses for this learning activity.

- Group-work skills can be assessed by the teacher, using observation during the activity.
- Group-work skills can be self-assessed and assessed by peers following the activity.
- The summary can be assessed for both content and effectiveness of communication/presentation. Criteria for assessment should be determined in conjunction with students.
- Students can be asked to demonstrate their understanding of how the body strives to maintain homeostasis by providing their own example. This learning activity could be given to the students one day, and the response could be written individually on another day. This would allow time for research and discussion, with the students ultimately being asked to respond to the question individually.

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NOTES

CELLS AND HOMEOSTASIS

SPECIFIC LEARNING OUTCOMES

B11-1-06: Identify life processes that individual cells, as well as complex organisms, need to manage. (GLOs: D1, E1)

Include: obtain food, convert energy, eliminate wastes, reproduce, grow and repair, and transport substances

B11-1-07: 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. (GLOs: D1, E2, E3)

Include: passive transport, active transport, and endo/exocytosis

B11-1-08: 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. (GLOs: D1, E2, E3)

Examples: size of molecule, concentration gradient, temperature, polarity of molecule, surface area…

SLO: B11-1-06
SLO: B11-1-07
SLO: B11-1-08

SUGGESTIONS FOR INSTRUCTION

ENTRY-LEVEL KNOWLEDGE

In Grade 8, students were exposed to the characteristics of living things using the five common characteristics:

- single or multicellular
- reproduce
- grow and develop
- obtain and use energy
- respond to the environment

In Grade 11, this concept should be briefly revisited, with the major learning related to the fact that cells must also manage these same life processes.

In Grade 8, students conducted investigations on the movement of nutrients and wastes across cell membranes, were introduced to the terms *osmosis* and *diffusion*, and explained the importance of transport (SLO 8-1-07). In Grade 11, students are expected to explain the transport of materials across a cell membrane in greater detail.

TEACHER NOTE

Throughout the investigations in this section, emphasize for students that the cell membrane is chiefly responsible for maintaining a balance inside a living cell using different methods to transport molecules in and out of the cell. Too much water can make a cell burst. Too many wastes inside a cell can poison it. The cell cannot tolerate any great variation in conditions. Students may be exposed to the fluid mosaic model in developing their explanations for how substances are transported in and out of the cell, but an in-depth knowledge of this model is not required. It is not necessary to give detailed descriptions of specific protein action in facilitated

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

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

B11-0-S1: State a testable hypothesis or prediction based on background knowledge or on observed events. (GLO: C2)

B11-0-S2: Plan an experiment to answer a specific scientific question. (GLOs: C1, C2)

Include: materials; independent, dependent, and controlled variables; methods; and safety considerations

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

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

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

Examples: microscopes, dissection equipment, prepared slides…

B11-0-S5: Demonstrate sensitivity toward, and respect for, living and non-living tissues, specimens, and organisms utilized for biological research. (GLOs: B5, C1)

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

Include: biological drawings

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

diffusion and active transport. A general understanding of the important role of proteins in movement of substances across a membrane is sufficient.

ACTIVATE

Life Processes

Provide students with the following:

Life Processes

Complex organisms need to carry out the following life processes:

- Obtain food.
- Convert energy.
- Eliminate wastes.
- Reproduce.
- Grow and repair.
- Transport substances.

Which of these life processes must also be carried out by individual cells? Justify your answer.

CELLS AND HOMEOSTASIS

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Include: passive transport, active transport, and endo/exocytosis

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Examples: size of molecule, concentration gradient, temperature, polarity of molecule, surface area…

What Happened?

The following question can be answered by students working individually or in small groups:

What Happened to the Egg?

Place some eggs in vinegar and soak them overnight to dissolve their shell. Give two eggs to each group of students. Have them place one egg in distilled water and one egg in a salt solution. Ask students to compare the eggs at the end of the class as well as on the following day, and have them explain any differences they observe.

Students should see the egg in the distilled water is enlarged, while the egg in the salt solution is shrunken. Lead a class discussion to encourage students to link the explanation for why this happened to what they remember about osmosis and diffusion.

ACQUIRE/APPLY

Transport Mechanisms—Direct Instruction (U1)

Illustrate passive transport, active transport, and endo/exocytosis for students, by using tools such as overheads, labelled diagrams, 3-D paper models, and video and computer animations. Use a note-taking strategy (i.e., the 10 + 2 strategy) where the teacher presents the information on each transport mechanism for 10 minutes, and students have two minutes to summarize the material.

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

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

Include: biological drawings

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Laboratory Activities (P1, S1, S2, S3, S4, S6, S8)

Have students investigate factors that influence the movement of substances across a membrane by completing one or more of the labs that follow.

- Appendix 1.9A: Investigating the Movement of Starch, Iodine, and Glucose—Student Handout (BLM) and Appendix 1.9B: Investigating the Movement of Starch, Iodine, and Glucose (Teacher Background). This lab addresses the effect of the size of a molecule on movement across a membrane.
- Appendix 1.10A: Cell Size and Diffusion—Student Handout (BLM) and Appendix 1.10B: Cell Size and Diffusion (Teacher Background). This lab addresses the effect of surface area on movement across a membrane.
- Appendix 1.11A: Effects of Osmosis on Living Tissue—Student Handout (BLM) and Appendix 1.11B: Effects of Osmosis on Living Tissue (Teacher Background). This lab addresses the effect of concentration gradient on movement across a membrane.
- Appendix 1.12A: Concentration and Diffusion—Student Handout (BLM) and Appendix 1.12B: Concentration and Diffusion (Teacher Background). This is a student-designed lab where students choose to investigate either the distance a substance travels or the time it takes to travel a given distance.

CELLS AND HOMEOSTASIS

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Examples: size of molecule, concentration gradient, temperature, polarity of molecule, surface area…

Notes:

- Additional labs may be done to address other factors.
- It is recommended that all students complete Appendix 1.12A: Concentration and Diffusion—Student Handout (BLM). This is a student-designed lab providing an opportunity for students to develop scientific inquiry skills. This lab will be referred to in Unit 3 when students design another investigation.

Suggestions for Assessment

- Refer to Appendix 1.8: Student Lab Skills (Teacher Background) for information on assessing and evaluating student lab skills.
- Refer to Appendix 1.13A: Lab Skills Checklist—General Skills (BLM) and to Appendix 1.13B: Lab Skills Checklist—Thinking Skills (BLM).
- In order to have students apply their learning about osmosis and diffusion, ask them to respond to the following questions:
  - Why are you thirsty after eating a bag of potato chips?
  - Why is the grass dead on the side of the road in the spring?
  - Why do your toes and fingers wrinkle in the bath?

Student responses can be used as a formative assessment to determine the level of student understanding of osmosis and diffusion and to guide further teaching/activity selection (if needed).

SKILLS AND ATTITUDES OUTCOMES

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

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

11-0-U2: Demonstrate an in-depth understanding of biological concepts. (GLO: D1)

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

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

B11-0-S1: State a testable hypothesis or prediction based on background knowledge or on observed events. (GLO: C2)

B11-0-S2: Plan an experiment to answer a specific scientific question. (GLOs: C1, C2)

Include: materials; independent, dependent, and controlled variables; methods; and safety considerations

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

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

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

Examples: microscopes, dissection equipment, prepared slides…

B11-0-S5: Demonstrate sensitivity toward, and respect for, living and non-living tissues, specimens, and organisms utilized for biological research. (GLOs: B5, C1)

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

Include: biological drawings

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

Analogy (U2)

Review the concept of an analogy and then have students explain the following analogy to describe how the cell membrane functions.

A cell is like a prison.

Endocytosis Investigation (S3, S4, S5, S6)

The *Amoeba proteus* is a larger protozoan. Students can observe these organisms digesting coloured starch granules through endocytosis.

Note: Cultures of *Amoeba proteus* can be purchased from a biological supply company. Place the *Amoeba* into a petri dish. Make a solution of starch, distilled water, and a few drops of blue food colouring. Add a few drops of the food colouring to the petri dish. Leave the *Amoeba* in this solution for a few minutes before students place it on a slide. Use a microscope to observe the *Amoeba* digesting the blue starch granules. At the end of the lab the solution can be safely disposed of down the sink.

Students record their observations by drawing and describing what they saw and relate this to what they know about cell membranes.

CELLS AND HOMEOSTASIS

SPECIFIC LEARNING OUTCOMES

B11-1-06: Identify life processes that individual cells, as well as complex organisms, need to manage. (GLOs: D1, E1)

Include: obtain food, convert energy, eliminate wastes, reproduce, grow and repair, and transport substances

B11-1-07: 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. (GLOs: D1, E2, E3)

Include: passive transport, active transport, and endo/exocytosis

B11-1-08: 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. (GLOs: D1, E2, E3)

Examples: size of molecule, concentration gradient, temperature, polarity of molecule, surface area…

Note: This lab involves using the microscope and creating a biological drawing. Prior to carrying out this lab, students may need to review proper techniques. Microscope diagrams for this purpose can be found in most biology texts. A blackline master can also be found in *Grades 5 to 8 Science: A Foundation for Implementation* (Manitoba Education and Training, BLM 8–A).

A variety of approaches are commonly used for the creation of biological drawings. One approach can be found in Appendix 1.14A: Biological Drawing (BLM).

Suggestions for Assessment

The focus for assessment of this learning experience can be on two skill areas, as well as on the understanding demonstrated by the students' ability to relate observations to the function of a cell membrane. Specify, in advance, what the focus will be. For tools to assess the skills involved, refer to Appendix 1.14B: Rating Scale for Biological Drawing (BLM) and Appendix 1.15: Microscope Skills Checklist (BLM).

Students can be asked to demonstrate their understanding of movement of substances across a cell membrane with the following:

- Using unlabelled diagrams of active transport, diffusion, and osmosis, identify what each represents and explain what is happening.
- Compare and contrast passive and active transport.
- Draw a Concept Map to illustrate how materials move in and out of a cell.
- Explain why the ability to regulate the movement of materials into and out of the cell is important. (Students should make reference to life processes and homeostasis in their response.)

SKILLS AND ATTITUDES OUTCOMES

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

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

11-0-U2: Demonstrate an in-depth understanding of biological concepts. (GLO: D1)

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

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

B11-0-S1: State a testable hypothesis or prediction based on background knowledge or on observed events. (GLO: C2)

B11-0-S2: Plan an experiment to answer a specific scientific question. (GLOs: C1, C2)

Include: materials; independent, dependent, and controlled variables; methods; and safety considerations

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

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

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

Examples: microscopes, dissection equipment, prepared slides…

B11-0-S5: Demonstrate sensitivity toward, and respect for, living and non-living tissues, specimens, and organisms utilized for biological research. (GLOs: B5, C1)

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

Include: biological drawings

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

NOTES

ENERGY

SPECIFIC LEARNING OUTCOMES

B11-1-09: Explain the role of energy in maintaining an internal balance in the cell. (GLOs: D1, D4, E4)

Include: role of adenosine triphosphate (ATP) in metabolism

SLO: B11-1-09

SUGGESTIONS FOR INSTRUCTION

ENTRY-LEVEL KNOWLEDGE

In Grade 7, students compared photosynthesis to cellular respiration. The cellular respiration equations used in this grade is:

$$\text{sugar} + \text{oxygen} \longrightarrow \text{water} + \text{carbon dioxide} + \text{energy}$$

ACTIVATE

Where Does the Energy Come From?

Provide students with the following question:

> We've seen in the previous learning experience that the cell uses energy during active transport. Where does this energy come from?

(Hint: Use the formula for cellular respiration to support your answer).

ACQUIRE/APPLY

ATP and Energy—Direct Instruction

Provide students with more detail on the role of ATP as the mechanism for storing energy. Using simplified diagrams, show the breakdown of macromolecules and the release of ATP. A computer animation could also be used to show the breakdown of macromolecules and ATP release.

Resource Link

A variety of websites can be used to help students learn about difficult concepts. For example, the following website provides a series of animations and games students can use to learn difficult biochemical concepts:

- Wiley. "Interactive Animations." *Interactive Concepts in Biochemistry*. 2002. <www.wiley.com/legacy/college/boyer/0470003790/animations/animations.htm>.

SKILLS AND ATTITUDES OUTCOMES

11-0-U2: Demonstrate an in-depth understanding of biological concepts. (GLO: D1)

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

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

Microtheme/Case Study (U2, I4)

Provide students with the following microtheme:

Microtheme
On your family vacation this summer, you drive into a gas station to fill up. Your younger brother asks where all that gas from the last fill-up went. You explain that it is a fuel that gets converted to another kind of energy to power the car. He replies, "How do we get our power?" Explain this to him by referring to food, ATP, and muscle action.

Suggestion for Assessment

Refer to Appendix 1.3B: Microthemes—First Draft Checklist (BLM) and Appendix 1.3C: Microthemes—Final Draft Assessment.

Creative Presentation (U2, I4)

Have students carry out a performance task to bring together their understanding of the concepts presented in the Cells and Homeostasis portion of this unit. This performance task can take on a variety of forms, and students should be given the opportunity to select which form they wish to use to share their understanding. One example is to have students develop a song (which could be performed) or a poem. Refer to Appendix 1.16: Those Magic Membranes (BLM) for a sample song.

Suggestion for Assessment

Develop assessment criteria with students. The criteria should include both content and presentation components and may be similar, regardless of which presentation form students choose. Each criterion could be assigned a point value, or a simple rating scale can be used (e.g., excellent, good, fair, poor) for each.

Notes

Unit 1:
Wellness and Homeostasis
Appendices

Appendix 1.1: Wellness Portfolio Overview

Unit	Assignment
Unit 1: Wellness and Homeostasis	• Wellness Checkup • Once Upon a Time—Microtheme • Family Medical History • Personal Wellness Reflection
Unit 2: Digestion and Nutrition	• Nutrition Labelling—Information and Learning Activities • What Am I Eating? What Is My Lifestyle? • Creating a Meal
Unit 3: Transportation and Respiration	• Debating an Issue • Exercise and Wellness—Reflective Self-Study
Unit 4: Excretion and Waste Management	• Organ Donation—Reflection
Unit 5: Protection and Control	• Personal Records • Concussions Follow-Up
Unit 6: Wellness and Homeostatic Changes	• Blood Sugar Fluctuations • Two Cumulative Assessments • Science Saves the Day!—Reflection

Appendix 1.2: Wellness Checkup (BLM)

Wellness is more than not being ill. Wellness is having a healthy body, mind, and spirit.

Are you monitoring your wellness? Do so by completing this checklist. Put a check mark (✓) beside each statement that applies to you.

General Information	
	I am aware of diseases that run in my family.
	I know what types of illnesses I have had.
	I can explain the types of diagnostic tests I have had.
	I know what types of treatments I have had.
	I know the story of my birth.
	I spend time with people much younger or much older than I am.
	I have supportive family and friends.
	I like school.
	I am involved in extracurricular or community activities.
	I am a lifelong learner.
	I can cope with stress.
	I laugh easily.
	I know how to relax.
	I sleep well.
	I like myself.
	I consider how my actions will affect others.

Digestion and Nutrition	
	I eat a variety of foods.
	I limit my fast-food intake.
	I choose low-fat items in my daily diet (e.g., low-fat dressing, low-fat milk).
	I include high-fibre foods in my diet (e.g., whole wheat breads, fruit with peel).
	I consume at least seven servings of fruit and vegetables per day.
	I consume at least three servings of milk and alternatives per day (e.g., milk, cheese, yogurt).
	I consume at least six servings of grain products per day (e.g., toast, cereal, pasta).
	I consume at least two servings of meat and alternatives per day (e.g., meat, eggs, peanut butter).
	I know what a single serving size is for most food items.
	I limit my junk food intake.

(continued)

Digestion and Nutrition (continued)	
	I taste my food before I add salt.
	I limit my salt intake.
	I limit my sugar intake.
	I make sure that I get enough iron and calcium in my diet.
	I don't drink alcohol.
	I don't go on fad diets.

Transportation and Respiration	
	I maintain a healthy body weight by balancing regular physical activity and healthy eating.
	I get 20 to 30 non-stop minutes of moderately intense exercise three or more times per week.
	If I am unable to do 30 minutes of activity, I am still active for 10 to 15 minutes throughout the day.
	I do activities to make myself more flexible.
	I do activities to make myself stronger.
	I do activities to improve my cardiovascular fitness.
	I know if my blood pressure is in a normal range.
	When I exercise, my heart rate is in the target zone.
	I avoid the dangers of smoking.
	I avoid the dangers of drugs.

Excretion and Waste Management	
	I know the signs of urinary tract infection.
	I drink six to eight glasses of non-caffeinated drinks per day (e.g., water, juice, milk).

(continued)

Protection and Control	
	I stay current on necessary immunizations.
	I do self-examinations (breast and/or testicular).
	I go for regular physical examinations.
	I go for eye examinations.
	I practise abstinence.
	I practise safe sex.
	I follow directions for any medications that I take.
	I wear sunscreen.
	I wear a helmet when riding (e.g., bicycle, motorcycle, snowmobile).
	I wear safety gear when participating in sports.
	I wear a seat belt when in a vehicle.
	I travel only with a sober driver.
	I don't speed when driving.

Other Things I Do to Promote Wellness	

Appendix 1.3A: Microthemes (Teacher Background)

Microthemes are writing assignments designed to help students learn the science material by looking at it in a different way (Martin). This involves more than simply reading the textbook or memorizing notes. Students must examine a particular case study about human biology and interpret what is going on. Afterwards, they express their ideas in a short, written work. Their writing must be concise, detailed, and accurate.

Each microtheme is based on a case study related to the unit of study and poses a question or gives a particular task. A microtheme may require specific thinking skills (e.g., create an analogy, analyze data, write from a particular point of view, examine more than one point of view).

WP Microthemes can be included in students' Wellness Portfolios.

Assessment of microthemes is usually approached differently than assessment of traditional classroom activities. Microtheme tasks require higher-level thinking. It is preferable to have students complete only a few microthemes but to rework them until they have met the standard set. This usually requires a minimum of two drafts. The standard relates to science content, task completion, and communication, and may reflect a particular grade (e.g., 70%). Editing of the first (and subsequent) draft may be done by the teacher or by other students in the class, with the feedback provided being formative in nature.

Students may be given the opportunity to count microthemes for a greater value, and then devalue other categories (i.e., tests, if students exhibit test anxiety). Microthemes might also be given to students who need to be absent for a period of time (e.g., illness, vacations) but still need to work with the material.

Appendix 1.3B: Microthemes—First Draft Checklist (BLM)

(For Teacher or Peer Editing)

Name of Student _____ Microtheme _____

Science Content ❑ Accurate ❑ Complete/sufficient detail provided ❑ Uses appropriate scientific vocabulary ❑ Uses appropriate examples and/or diagrams – *detail should reflect high-school level* – *use of biological terms enhances the writing (correct use of terms, doesn't detract from flow)*	**Feedback**
Task Completion ❑ Task completed effectively (e.g., explanation given, question answered, argument made, point of view represented) – *last paragraph should provide a concise summary of problem and solution, statement of recommendation, etc.* **Provide additional criteria related to specific microtheme:** ❑ ❑ ❑	**Feedback**
Communication ❑ Communicates effectively (spelling, grammar, flow) ❑ Format or voice appropriate to the task or audience – *clear sentence structure* – *writing is clear and unambiguous* – *no spelling or grammatical errors*	**Feedback**

Appendix 1.3C: Microthemes—Final Draft Assessment (BLM)

Name of Student _____ Microtheme _____

Science Content ❑ Accurate ❑ Complete/sufficient detail provided ❑ Uses appropriate scientific vocabulary ❑ Uses appropriate examples and/or diagrams – *detail should reflect high-school level* – *use of biological terms enhances the writing (correct use of terms, doesn't detract from flow)*	**Possible Points** 5 – met all criteria 3–4 – met most criteria 1–2 – met few criteria **Score** _____	**Comments**
Task Completion ❑ Task completed effectively (e.g., explanation given, question answered, argument made, point of view represented) – *last paragraph should provide a concise summary of problem and solution, statement of recommendation, etc.* **Provide additional criteria related to specific microtheme:** ❑ ❑ ❑	**Possible Points** 5 – met all criteria 3–4 – met most criteria 1–2 – met few criteria **Score** _____	**Comments**
Communication ❑ Communicates effectively (spelling, grammar, flow) ❑ Format or voice appropriate to the task or audience – *clear sentence structure* – *writing is clear and unambiguous* – *no spelling or grammatical errors*	**Possible Points** 5 – met all criteria 3–4 – met most criteria 1–2 – met few criteria **Score** _____	**Comments**
	Overall Score _____	

Appendix 1.4: Family Medical History (BLM)

When you visit a doctor she or he will ask you if any medical conditions persist in your family. You must be able to answer questions such as these:

- ✓ How long did your longest surviving relative live?
- ✓ Do any conditions persist in your family (e.g., hypertension)?
- ✓ When were your parents and grandparents born?
- ✓ Did they experience any medical conditions during their lifetime (e.g., diabetes)?
- ✓ If they have died, when did that occur? Did any known conditions cause this?
- ✓ Do you have any medical conditions?
- ✓ Have you had any hospital visits? What for?
- ✓ Do you have any allergies? Do these run in your family?

Task

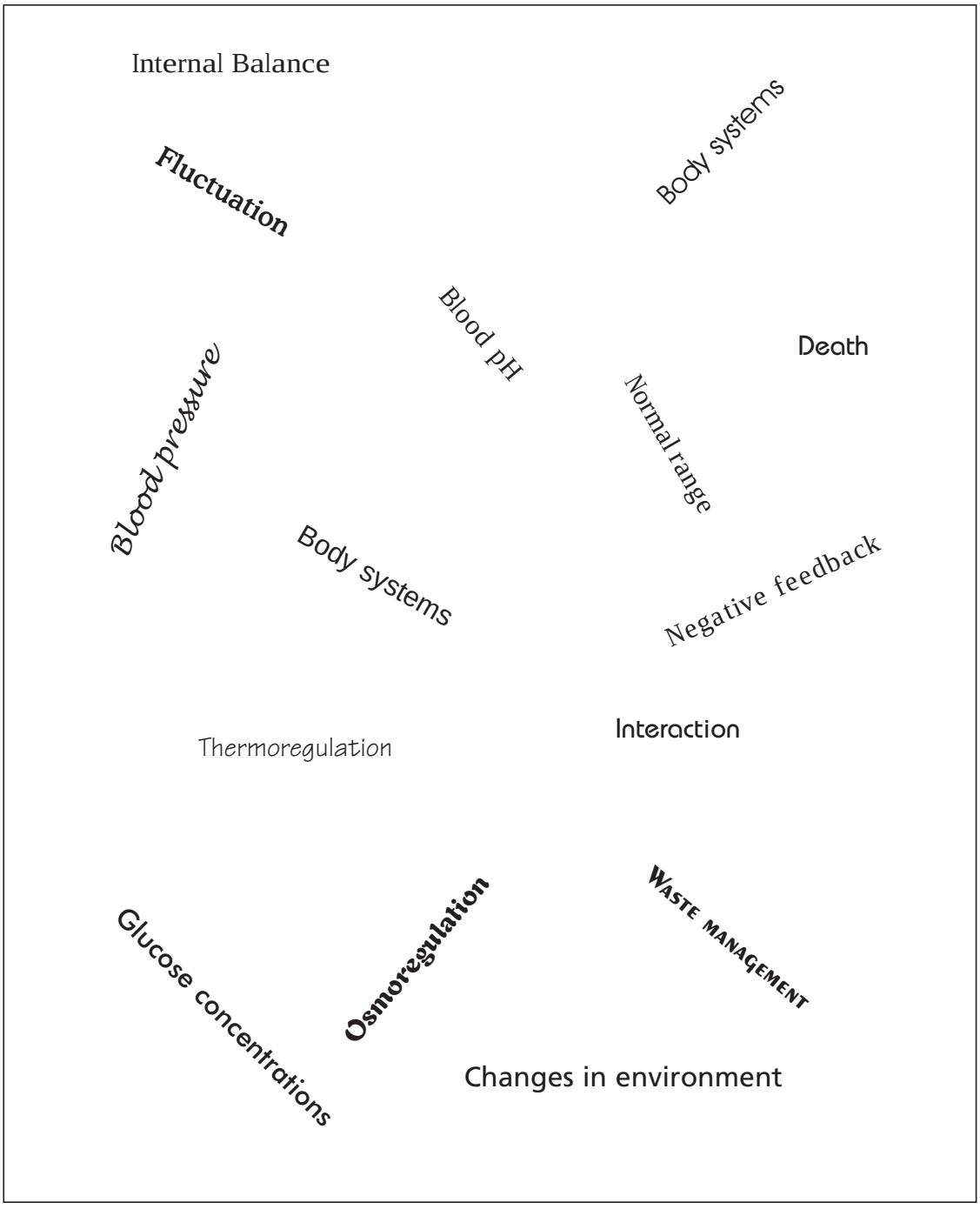
1. Ask these questions of your family members, digging back as far as you can in your family history.
2. Make notes of these interviews and include them in your Wellness Portfolio. Be sure to include at least two interviews.
3. Summarize your work as a medical family tree. Note each person, how the individuals are related, and relevant information about them.

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

Assessment

This assignment is intended to give you as complete a picture as you can have. You will be graded on inclusion of interview notes and completeness of the medical family tree. There is no prize for having the family with the most disorders!

Appendix 1.5A: Word Splash—Homeostasis (BLM)



Appendix 1.5B: Homeostasis—Background Information (BLM)

Introduction

At any given time, our bodies are working to maintain their internal physiological environment in a stable state, or a constant internal balance. The example that comes readily to most people's minds is our relatively constant body temperature. Think about the adjustments your body must make to maintain this constant body temperature during an everyday activity such as walking to school on a brisk winter morning in Manitoba.

A Cold Walk

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 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're late, so you run the rest of the way to school. When you arrive you're glad to find the run has warmed up your fingers and toes; however, as you walk through the hallway to your locker you find yourself beginning to sweat again. You remove your winter outerwear at your locker and head to class. A few minutes later you find yourself becoming cold and you begin to shiver as your body tries to warm up.

This example shows how your body works to maintain one specific aspect of its internal environment—a body temperature of approximately 37°C. In fact, if your body fluctuates too much from this temperature, it could lead to death. Homeostasis is the ability of the body to maintain its internal environment within acceptable ranges despite the changing external environment.

In addition to knowing that a body temperature of about 37°C is relatively constant, you may be familiar with some other body constants. These include a blood pressure of about 160/106 kPa, a blood pH near 7.4, blood glucose concentrations at about 100 mg/mL. While these "normals" do vary, there is a very limited range within which the body can function, and death can result if these normal ranges are exceeded.

To function properly, homeostatic mechanisms must allow the body to

- regulate respiratory gases
- maintain water and salt balance
- regulate energy and nutrient supply
- maintain constant body temperature
- protect against pathogens
- make repairs when injured

Homeostasis depends on the action and interaction of a number of body systems to maintain a range of conditions within which the body can best operate. Because the external environment is constantly changing and homeostatic reactions respond to the change and bring the body back to a given set point, it is often referred to as a *dynamic equilibrium*. A dynamic equilibrium is a condition that remains stable within fluctuating limits. Many homeostatic reactions begin with the body's sensing of changes in the external environment.

Negative Feedback Mechanisms

Negative feedback systems are important mechanisms used to maintain homeostasis, or dynamic equilibrium. There are many examples of negative feedback systems around us. In your home you set the thermostat to the "normal" temperature you would like your house to stay at. If the temperature drops below this temperature, a sensor notes this change and causes the furnace to come back on until the house has heated up to the set temperature. A negative feedback mechanism in your body also makes adjustments to bring things back to within an acceptable range.

Feedback mechanisms have three main components: a sensor, a coordinating centre, and an effector. The sensor is responsible for detecting variation in the set point and will send messages to the coordinating centre, which will then send a message to a specific effector to rectify any variation from a set point.

Example:

- Temperature in house set to 20°C (NORMAL CONDITION)
- Internal house temperature drops to 17°C (CHANGE)
- Thermostat detects drop in temperature (SENSOR)
- Thermostat turns on furnace (COORDINATING CENTRE)
- Furnace starts and begins to warm house (EFFECTOR)
- Temperature returns to 20°C (NORMAL CONDITION)

The coordination and regulation of homeostasis through negative feedback mechanisms in the body are most often achieved by a combination of nervous and hormonal mechanisms.

Homeostatic Systems

Three important homeostatic systems in the human body that depend upon negative feedback mechanisms to maintain equilibrium are:

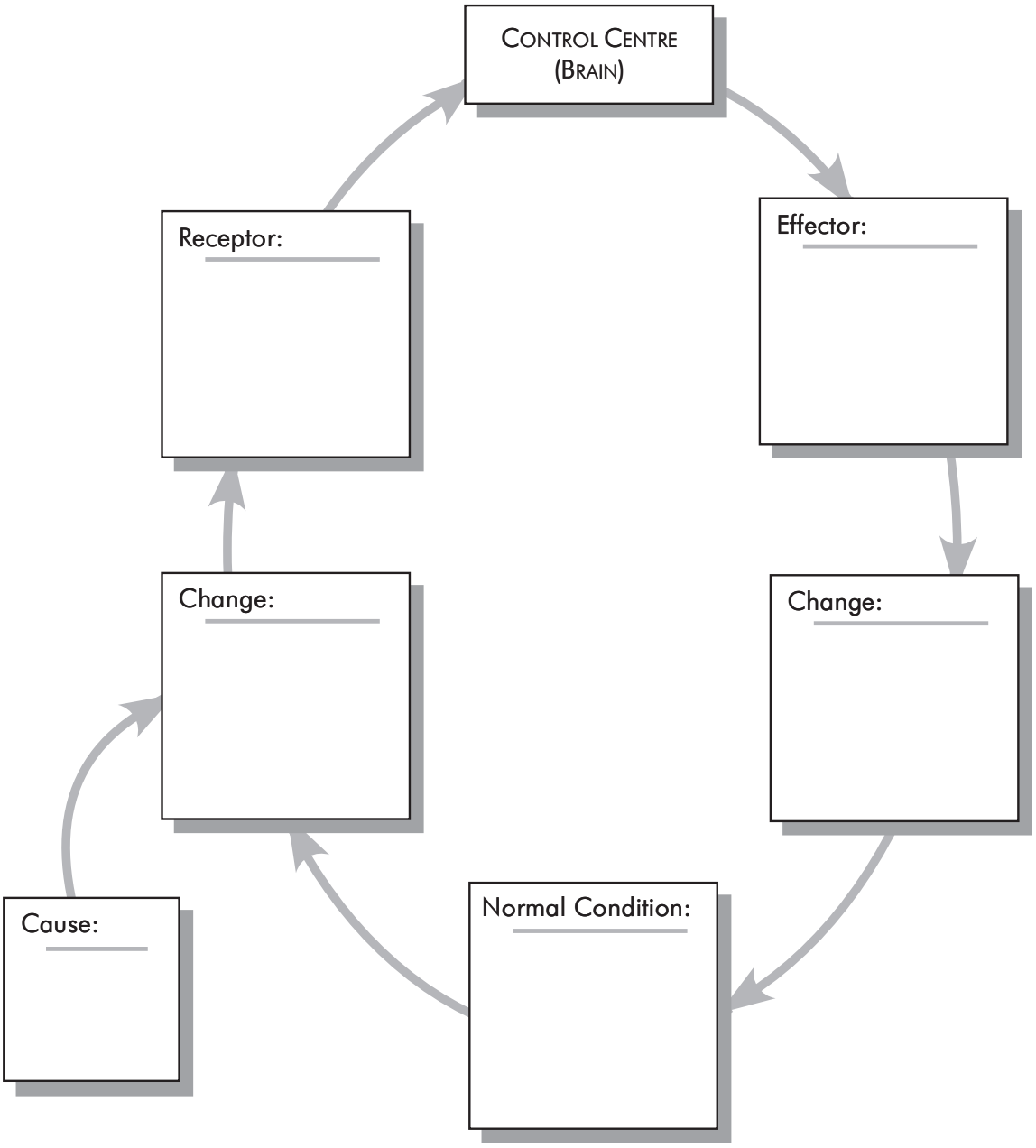
- thermoregulation (the maintenance of body temperature)
- osmoregulation (water balance)
- waste management

Thermoregulation is the ability to maintain a **constant body temperature**. The constant body temperature for humans is 37°C, although there are individual variations. Humans are able to maintain a constant body temperature despite changes in the external environmental temperature (endotherm). The hypothalamus, a part of the human brain, is the coordinating centre for the body's temperature regulation. When there is a change in the external temperature the hypothalamus will release hormones that target specific effectors such as sweat glands.

Osmoregulation is the ability to maintain a constant **water balance**. For the body to maintain water balance, humans must consume fluids daily. A drop in fluid intake by as little as 1% of your body mass will cause thirst, a decrease of 5% will result in extreme pain and collapse, while a decrease of 10% often results in death. The hypothalamus is the coordinating centre for water balance and can detect changes in the fluid concentrations of the blood. When the fluid concentration of the blood decreases (dehydration) the hypothalamus will trigger the release of a hormone to increase water absorption.

Waste management, or the ability of the body to rid itself of harmful wastes, is essential for the maintenance of homeostasis. One example of a harmful waste product is the ammonia produced during the breakdown of proteins. Ammonia is extremely toxic to the body. The liver is the most important organ involved in the elimination of ammonia. Various organs, such as the kidneys, lungs, liver, skin, and stomach are involved in the elimination of various other waste products.

Appendix 1.6:
Negative Feedback Mechanisms (BLM)



Appendix 1.7: The Swimming Race* (BLM)

Case Study

Debra was sitting quietly along the side of the pool. She was anticipating the swimming race that she would be competing in shortly—400 metres of intense physical activity, pushing her body to the very limits of its capabilities. She was calm and relaxed, mentally willing her heart and respiratory rate down. She had done some stretching and warm-up exercises, her heart rate was just 65 beats per minute, and she was breathing 12 breaths per minute. Her body temperature was 37°C. She was well hydrated. Her weight was 65 kg.

➞ That was an hour ago. Now, she was standing on the lane 4 starting block ready to go. She could see two swimmers to her left and three to her right. The swimmers all looked bigger than she, but then they always did. The starter on the pool deck was saying something over the loudspeaker but Debra wasn't paying attention. These last few seconds before the race were the most stressful—you could feel the tension in the air. She was sweating, although the air was cool. Her heart rate was now 85 beats per minute and she was breathing 18 breaths per minute. She felt a nervous excitement.

"Take your mark," the starter announced, and with the sound of the horn the swimmers dove into the water.

After a short glide through the water, Debra surfaced stroking at maximum power. She was putting all her strength into each stroke.

➞ Thirty seconds later, she had travelled just over 50 metres. Debra was completely focused on shutting out the external distractions and concentrating on keeping the power up. She was giving each stroke about 80% of her maximum power. Her heart rate was 201 beats per minute. Her respiratory rate was also up slightly. Her body temperature was 37.5°C.

At the end of that first minute, Debra's heart rate was 180 beats per minute. She was taking breaths every six strokes, fast and forced. Her body temperature was 38°C.

With 100 metres to go to the finish line, Debra had been swimming for just over three minutes. Debra could see she was even with the swimmer in lane 2. Debra knew she needed to push herself if she wanted to win. She focused completely on the placement and pull of each stroke. She was breathing faster, one breath every three strokes. Her heart rate was 195 beats per minute and her body temperature was 38.5°C.

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* Source: Strong, Nathan. "The 2000-Meter Row: A Case in Homeostasis." <www.sciencecases.org/crew/crew.asp>. Adapted by permission of the National Center for Case Study Teaching in Science, University at Buffalo, State University of New York.

➞The winner of this race was going to be whoever touched the wall first. As Debra touched the edge of the pool, four minutes and 15 seconds after starting and one-tenth of a second behind the swimmer from lane 2, her heart rate was 208 beats per minute. She slumped over the lane marker, breathing nearly 60 times per minute but still not feeling like she could get enough air. It felt like her arms and legs were on fire. She felt light-headed. Her body temperature was 39°C.

➞Ten minutes later after a cool-down, Debra's heart rate and respiratory rate were almost back to normal. She weighed 64 kg. Her body temperature was still half a degree above normal. She felt drained of energy. She was thirsty. She had allowed herself only small sips of water during the cool-down.

Instructions to Students

1. Working in assigned study groups, each group will describe what is going on in Debra's body during each of the moments highlighted by an arrow (➞). Specifically, what conditions are changing as a result of the race? What responses are made by the body to try to maintain homeostasis? What are the *results* of those responses? You should concentrate on changes in the *nervous* system, the *respiratory* system, the *cardiovascular* system, and the *urinary* system.

2. One suggestion would be for each student to take one or two body systems and report to the group on the activities of those systems throughout the course of the race. Another approach would be for each student to take one of the moments highlighted by an arrow (➞) and describe the stresses encountered and the responses made.

   Note: Ensure that the answers to these questions are included in your report. Your report should not consist only of the answers to these questions.

   Study Questions

   a) On the starting block, what is responsible for raising Debra's heart and respiratory rate and for stimulating sweating before the race?

   b) Thirty seconds after the start, swimming hard is putting new demands on Debra's body. What are these new demands and how does the body respond to them?

   c) At the finish, Debra has stopped swimming and her muscles are now at rest. Why are her heart and breathing rates still so high?

   d) What changes have occurred in the last 10 minutes after a cool-down to allow Debra's heart and respiratory rates to come down?

3. Prepare a summary of your group's findings to present to the class. This presentation can take on any form you select that is agreed upon by the teacher.

Appendix 1.8: Student Lab Skills (Teacher Background)

Students' lab skills consist of two parts: students' actions in the lab and the report that they produce. All too often, teachers have put more energy into evaluating the latter rather than assessing student thinking and actions during the lab. Do students understand why they are conducting the lab? Are they getting the results they expected? Do they trust their lab technique when they see others getting different results? Consider the following suggestions when designing your assessment approach for student lab work.

Pre-lab

Traditionally, teachers outline purpose, procedure, methods of data collection, and safety considerations during the pre-lab talk. They also pose questions to the group to check comprehension. Do the students know what they are to do and why that approach is being used? Addressing the whole group continues to be the most appropriate approach for an introduction.

During the Lab

At this point, you may have an opportunity to do individual student assessment. General lab skills, such as recording observations or using equipment properly, could be marked on a checklist. You could also interview students between procedures, to check the depth of their understanding. This could be done by posing a series of questions to the individual. How does this lab relate to what you have studied in class? What was the rationale behind your hypothesis? Are you getting the results you expected? Have you had any difficulties with the procedure?

This type of assessment may seem very time-consuming but can be alleviated by using checklists and choosing to meet with a limited number of students during each lab. By using the same checklist for each student throughout the course, you could note improvements each time you evaluate.

Post-lab

You would conduct your traditional post-lab activity. Most of the analysis would be discussed by the larger group before students did their individual write-ups. You would lead the group to an understanding of the big picture and support this with details from the group experience. After this, you might consider posing questions to certain students to check comprehension. What can you conclude from your results? Give me a specific piece of evidence to support this. What sources of error occurred in your case? What would you do differently next time?

Although these questions may be written in the lab report, taking the time to discuss these with individuals allows you to probe and draw out more understanding. Again, perhaps only certain students would be questioned on a rotational basis.

Appendix 1.8:
Student Lab Skills (Teacher Background) *(continued)*

Redoing the Lab

Students are often asked to identify possible sources of error. Rarely are they given the opportunity to tighten up their control variables and repeat the lab. Perhaps they want to change their approach to solving the initial problem completely and re-test. Consider the possibility of having your students do one less new lab during the course and redoing a lab they have already tried. Students need to test their analytical skills by doing more than one trial. Don't we always tell them that a bigger sample size is more accurate?

A Variety of Products

Students can summarize their experience in a lab report. You might also consider using lab frames or lab notebooks. Lab frames allow the teacher to draw out very specific responses. Lab notebooks allow students to record their work as they conduct the lab, which reflects more of the process than the product. Analysis, answering questions, and drawing conclusions can be done after the post-lab.

The following table provides a general suggestion for a lab report. There are numerous alternative formats that could also be used. Refer to *SYSTH* (pp. 11.26–11.29 and 14.11–14.12) or other resources for more ideas.

Lab Report Format (Sample)	
Introduction	• purpose or question • hypothesis or prediction—may be supported by a rationale (What do you think will be found, and why?)
Methodology	• materials • methods/procedures Note: In many labs this information will be provided. In student-designed labs this section increases in importance and is developed by the student.
Results	• general observations—may include the following: — data tables — graphs and calculations
Analysis	Include any of the following items that are appropriate to the lab: • interpretation/discussion of results • indication of whether hypothesis was supported • implications of results • linking of results to prior knowledge • answers to questions • error analysis/sources of error • summary

Appendix 1.9A: Investigating the Movement of Starch, Iodine, and Glucose—Student Handout (BLM)

Purpose

To determine which substances are capable of moving across a cell membrane.

Method

- Test #1: Cut a piece of dialysis tubing of approximately 20 cm in length. Tie one end of the tubing and fill it with a mixture of water and molasses. Tie the other end of the tubing and place it into a beaker of water.
- Test #2: Cut another piece of dialysis tubing and tie one end. This time, pour water into the tubing. Tie the other end of the tubing and place it into a beaker containing a mixture of water and molasses.
- Test #3: Place a dilute iodine solution into a piece of dialysis tubing. Tie the other end of the tubing and place it into a beaker containing a starch and water mixture.
- Test #4: Pour a starch and water mixture into a piece of dialysis tubing. Place the tubing into a beaker containing a dilute iodine solution.
- Test #5: Pour a glucose solution into a piece of dialysis tubing. At the end of the class, place a glucose test strip into a beaker containing water to test for the presence of glucose. Repeat this test the following day.

Results

Describe the appearance of each solution or mixture before the procedure. Record detailed observations at the end of the class as well as the following day. Your results can be recorded in a table such as the following.

Observations	**Test #1** Molasses and water in tubing, water in beaker	**Test #2** Water in tubing, molasses and water in beaker	**Test #3** Iodine solution in tubing, starch and water in beaker	**Test #4** Starch and water in tubing, iodine solution in beaker	**Test #5** Glucose solution in tubing, water in beaker
Initial					
End of Class					
Following Day					

Analysis

For each of the procedures, indicate which molecules cross the membranes and which molecules do not. Explain how you came to this conclusion. Use the following terms to explain why each type of molecule is capable or incapable of crossing the membrane and how the movement takes place:

- semi-permeable membrane
- concentration
- hypertonic
- isotonic

Conclusion

Under the heading Conclusion, write an interpretation of your results.

Appendix 1.9B: Investigating the Movement of Starch, Iodine, and Glucose (Teacher Background)

In this investigation, students will observe osmosis and diffusion. They should be able to determine which substances are and which are not able to cross a cell membrane. Students should record this investigation using a lab report, lab notebook, or lab frame. To help students develop an in-depth explanation of what they see happening in this lab, have them use the following terms:

- semi-permeable membrane
- concentration
- hypertonic
- isotonic

Note: Students may need to do some research to explain the movement of molecules in this investigation.

Dialysis tubing and glucose test strips can be purchased from a biological supply company. Plastic sandwich bags can be used instead of the tubing.

Results

The following are some general descriptions of what students should observe for each test.

- Test #1: The amount of liquid in the tubing gradually increases. The mixture in the tubing becomes paler.
- Test # 2: The amount of liquid in the dialysis tubing gradually decreases. The mixture in the tubing becomes darker.
- Test #3: The mixture in the beaker turns black and the solution in the dialysis tubing gradually becomes paler.
- Test #4: The mixture in the dialysis tubing turns black and the solution in the beaker gradually becomes paler.
- Test #5: The glucose test strips change colour to indicate the presence of glucose. The glucose concentration should slowly increase.

Appendix 1.9B:
Investigating the Movement of Starch, Iodine, and Glucose (Teacher Background) *(continued)*

Analysis

- Test #1: Molasses molecules are too big to cross the membrane, but water molecules can cross freely. The water and molasses mixture is hypertonic; therefore, water molecules will migrate from an area of higher concentration (water in the beaker) to an area of lower concentration (dialysis tubing). This movement will continue until the two systems are isotonic.
- Test #2: The water and molasses mixture is hypertonic. Water molecules will migrate from an area of higher concentration (dialysis tubing) to an area of lower concentration (molasses and water mixture in the beaker).
- Test #3: When iodine and starch interact, the iodine turns black. The starch molecules stay in the beaker because they are too big to cross a membrane. Iodine molecules can cross freely because they are small. They will move from an area of higher concentration (dialysis tubing) to an area of lower concentration (beaker).
- Test #4: The starch molecules stay in the dialysis tubing. Because the iodine molecules can cross the membrane, they will move from an area of higher concentration (beaker) to an area of lower concentration (dialysis tubing).
- Test #5: The glucose test strips indicate a slow increase of glucose concentration. Glucose molecules cross the membrane slowly, moving from a higher concentration (dialysis tubing) to a lower concentration (beaker).

Conclusion

When cells grow to a certain size, their rate of growth slows down until they stop growing entirely. When they have reached their size limit, one of these larger cells divides into two smaller cells. The rate of growth in these small cells again increases.

Materials needed for cell activity and growth must in some way gain entrance into the cell, and waste products must leave.

Appendix 1.10A: Cell Size and Diffusion— Student Handout (BLM)

The following two questions will be explored in this dry lab situation:

1. What is the relationship between the surface area and the volume of a cell?
2. How does this relationship affect the rate of diffusion?

Purpose

To investigate the mathematical relationship between diffusion and the size of a cell.

Material

- 27 sugar cubes
- metric ruler
- calculator

Method

Part 1

1. Obtain 27 sugar cubes and assume that their dimensions are 1.0 cm per side. These cubes will be combined in different arrangements to represent cells.

2. a) Arrange the cubes in the following manner:

   3 x 3 cube (27 sugar cubes in total)

   b) Calculate the volume, total surface area, and surface area to volume ratio of the arrangement. Express all ratios in their simplest form (e.g., 3:1 and not as 9:3.)

3. Repeat step 2 for the following arrangements (each arrangement contains a total of 27 sugar cubes—sugar cubes will need to be cut for one arrangement):

   3 x 9 rectangle
   1 x 27 rectangle
   2 x 13.5 rectangle

Part 2

4. a) Using 8 sugar cubes, build a cell that is a 2 x 2 cube.
   b) Calculate the volume, total surface area, and surface area to volume ratio of the arrangement.
5. Divide this cell in half; this will simulate cell division. Calculate the volume, surface area, and surface area to volume ratio for this "baby cell."

Analysis

1. What advantage is gained by a cell having a rectangular shape instead of a cuboidal shape?
2. What happens to the surface area to volume ratio when a cell undergoes division?
3. From the point of view of diffusion, is there an advantage for cells to divide?
4. What happens to the surface area to volume ratio of a cell as the cell grows?
5. Propose a hypothesis to explain why the growth rate of a cell slows down as it gets larger.
6. Based on what you have learned in this lab, explain why cells must remain small to survive.
7. Write a statement(s) summarizing your findings in this lab.

Appendix 1.10B: Cell Size and Diffusion (Teacher Background)

Purpose

To investigate the mathematical relationship between diffusion and the size of a cell.

Method

Part 1

Sample student data table:

Cube Dimensions	Total Surface Area (cm^2)	Volume (cm^3)	Ratio (SA:V)
3 x 3 cube	54	27	2:1
3 x 9 rectangle	84	27	3:1
1 x 27 rectangle	110	27	4:1
2 x 13.5 rectangle	85	27	3:1

Part 2

Sample student data:

Cell Types	Surface Area (cm^2)	Volume (cm^3)	Ratio (SA:V)
original	24	8	3:1
"baby"	16	4	4:1

Analysis

1. What advantage is gained by a cell having a rectangular shape instead of a cuboidal shape?

   The surface area increases.

2. What happens to the surface area to volume ratio when a cell undergoes division?

   It increases.

3. From the point of view of diffusion, is there an advantage for cells to divide?

   Yes. Dividing increases SA:V ratio and improves movement of molecules in and out of the cell.

4. What happens to the surface area to volume ratio of a cell as the cell grows?

   It decreases.

5. Propose a hypothesis to explain why the growth rate of a cell slows down as it gets larger.

   It becomes more difficult to exchange waste products and required molecules.

6. Based on what you have learned in this lab, explain why cells must remain small to survive.

   If a cell grows too large, its surface area gets smaller. The cell cannot take in the nutrients it needs to survive.

7. Write a statement(s) summarizing your findings in this lab.

   As cells grow, their increased size reduces their ability to exchange required molecules and waste products. Dividing increases the SA:V ratio and increases the ability to complete the needed exchanges.

Appendix 1.11A: Effects of Osmosis on Living Tissue—Student Handout (BLM)

Purpose

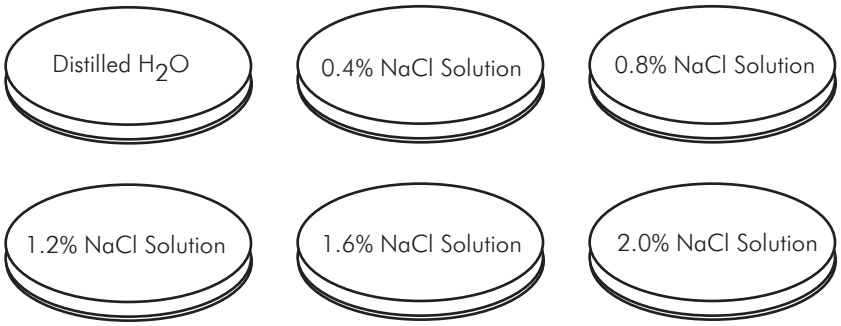
To measure the effect of osmosis on celery tissue and use this data to estimate the concentration of dissolved substances in the cytoplasm of a cell.

Method

Work as a team. One member should do steps 1 and 2 while the other is doing steps 3 to 6.

Material

- 3 petri dishes
- marking pencil
- distilled H_2O
- 0.4% NaCl solution
- 0.8% NaCL solution
- 1.2% NaCl solution
- 1.6% NaCl solution
- 2.0% NaCl solution
- metric ruler
- scalpel
- razor blade
- fresh celery stalks (100 mm length)



Method

1. Obtain 3 petri dishes. Label the bases and lids (6 separate pieces) as follows: distilled water; 0.4% NaCl; 0.8% NaCl; 1.2% NaCl; 1.6% NaCl; 2.0% NaCl.

2. Add enough of the appropriate liquids to nearly fill each of the petri dishes.

3. Obtain one or two fresh celery stalks at least 100 mm in length. Examine the cut end of the celery stalk. Note the concave and convex surfaces. Just inside the convex epidermis you will find a series of darker green circles, the vascular bundles. The vascular bundles run lengthwise in the celery stalk and are composed of rigid, thick-walled cells forming tough "strings."

Caution: Use extreme care when cutting with a razor blade or scalpel.

4. Place the stalk, concave side down, on a cutting surface (not the table surface). Use a dissecting razor blade or scalpel to cut the stalk lengthwise into at least six strips about 3 mm thick.

5. Select six strips of celery tissue. Lay them on their side. Then, cutting lengthwise, carefully remove the outer epidermis (skin) and vascular tissue (darker green "string") if present. The remaining tissue is composed of parenchyma cells, thin-walled and flexible.
6. Trim each strip to a width of 2 to 3 mm, if necessary. Attempt to keep the strips as uniform as possible.
7. Angle cut one end of each strip to a point.
8. Measuring from the tapered end, *carefully and precisely* angle cut each strip to a length of 70 mm so that both "points" are on the same side of the strip.
9. Place one measured celery tissue strip into each of the prepared petri dishes. Leave them undisturbed for a minimum of 25 minutes.
10. After 25 minutes, remove the strips of celery, one at a time, immediately measuring the length (mm) of each.
11. Record any variations in the rigidity of the strips relative to the concentration of the solutions. Compare with the strips before they were placed in the solutions. Use "more," "similar," and "less" to describe the condition.

Results

1. Create a data table in your notebook to record the initial length (l_i) of the celery strips, the final length, and observations on the rigidity of the strips, for each solution.
2. Calculate and record the change in length (Δl) of each strip in millimetres.

$$\Delta l = l_f - l_i$$

Indicate an increase in length with a positive (+) sign and a decrease with a negative (–) sign.

3. a) Graph your own results by plotting the change in length against the concentration of the solution.
   b) Plot the class averages on the same graph. It will be necessary to draw a "zero" line halfway up the paper in order to plot points indicating an increase (+) or a decrease (–) in length.
   c) Identify the manipulated (independent) variable and the responding (dependent) variable in the title of the graph.
   d) Draw a straight line through the points.
   e) Record the points (concentration) at which each line intersects the zero axis.
   f) Answer the question: *What information is provided by the points along the zero axis?*

Analysis

1. Which of the six solutions used has the highest percentage of water? the lowest? Explain.
2. From your investigation, is there supporting evidence to suggest that water has entered or left the celery cells? Explain.
3. How can osmosis account for the changes in length of the celery tissue?
4. What term is given to a solution that has the same concentration as the cytoplasm of a cell?
5. Which would provide the more reliable information, the class average graph or your own data graph? Explain your reasoning.
6. Predict what would happen to a plant cell placed in a 1% salt solution. Justify your prediction.

Appendix 1.11B: Effects of Osmosis on Living Tissue (Teacher Background)

Purpose

To measure the effect of osmosis on celery tissue and use this data to estimate the concentration of dissolved substances in the cytoplasm of a cell.

Pre-lab Suggestions

Before proceeding with this investigation, help students become familiar with the scientific terms used to describe activities or conditions associated with living membranes. Use text and reference books.

Have students clearly define each of the following terms:

- permeable
- semi-permeable
- non-permeable
- diffusion
- isotonic
- hypertonic
- hypotonic

Encourage students to use these terms during the investigation.

Results

Specifics of student data will vary, but students should find that the higher the salt concentrations in the water, the greater the decrease in length will be.

The graph should include responses to the following questions:

- Which is the manipulated (independent) variable?

  Concentration of NaCl

- Which is the responding (dependent) variable?

  Change in length

- What information is provided by the intersection points in (j)?

  No change in the cell length

Appendix 1.11B: Effects of Osmosis on Living Tissue (Teacher Background) *(continued)*

Analysis

1. Which of the six solutions used has the highest percentage of water? the lowest? Explain.

   Highest percentage of water: Distilled H_20

   Lowest percentage of water: 2.0% NaCl solution

2. From your investigation, is there supporting evidence to suggest that water has entered or left the celery cells? Explain.

   Yes. Cells changed in length – some expanded and some shrank.

3. How can osmosis account for the changes in length of the celery tissue?

   Water flows in and the cell is stretched (increases in tonicity); when water flows out, tonicity decreases.

4. What term is given to a solution that has the same concentration as the cytoplasm of a cell?

   Isotonic

5. Which would provide the more reliable information, the class average graph or your own data graph? Explain your reasoning.

   Class average graph – more data improves reliability, cancellation of errors is possible.

6. Predict what would happen to a plant cell placed in a 1% salt solution. Justify your prediction.

   Cell should shrink. Base answer on graphical interpolation.

Appendix 1.12A: Concentration and Diffusion—Student Handout (BLM)

Introduction

This lab investigation presents a problem. Your task is to plan and conduct an experiment to solve the problem. A list of materials is provided, but you must determine which variables you will study, the procedure you will follow, as well as what observations you will record and how you will record them.

Problem

Diffusion is a process by which substances enter and leave cells across a semi-permeable membrane. Your problem is to design an experiment to study the effects of concentration on either the distance that potassium permanganate diffuses into potato cubes OR the time that potassium permanganate takes to diffuse into potato cubes.

Material

- 2 firm potatoes
- metric ruler (30 cm)
- 1%, 5%, and 10% solutions of potassium permanganate ($KMnO_4$) (in beakers)
- paper towels
- waste container
- stopwatch/clock
- 3 small beakers (approximately 150 mL)
- forceps
- scalpel
- experiment display sheet
- graph paper

Procedure

1. **Beginning ideas:** State the question that you want to answer during this investigation. Predict what will be the effects of concentration on the distance that potassium permanganate diffuses into potato cubes or on the time that potassium permanganate takes to diffuse into potato cubes. Explain reasons for your prediction.

2. **Tests:** What will you do to help answer your question? List, in order, the steps you will use to solve the problem. You may include a diagram to help illustrate your plans for the experiment. Include *safety procedures* you will follow. Perform the experiment by following the steps outlined in your procedure.

3. **Observations:** Record your observations and measurements for the experiment. What did you see when you were performing your experiment? Use written statements, descriptive paragraphs, tables of data, and/or graphs, where appropriate.

4. **Claims and evidence:** Write an interpretation of your results. Explain what you have concluded and support it with evidence that helped you come to that conclusion. (What is your claim? What is the evidence to support your claim? How do you know? Why are you making this claim? How do your findings compare with your prediction?)
5. **Reflection:** Compare your results and interpretation of results with those of other groups. How do your ideas compare with the ideas of other students? Compare your results with information about concentration and diffusion from a textbook. Have your ideas changed after comparing your results and interpretations?

Appendix 1.12B: Concentration and Diffusion (Teacher Background)

This lab investigation presents a more student-centred approach. Students will be provided with a list of materials, but they must determine which variables they will study—the effect of concentration on distance of diffusion or the effect of concentration on time of diffusion—as well as the procedure they will follow. Teachers may choose to give students either distance or time to study, or have half the class study one variable, while the other half studies the second variable.

The lab report suggested for this investigation is different than the traditional format. It uses a tool called the *science writing heuristic*, which focuses on helping students make connections between questions, procedures, data, claims, and evidence (support for the claims). Students are also encouraged to verify their explanations with other students as well as with textbooks or other sources of information, in order to develop their conceptual understanding.

Encourage students to construct graphs (if they are not doing so already) as part of recording and interpreting data. The graph will present the relationship between either the distance $KMnO_4$ moved into the potatoes and the concentration of the $KMnO_4$ solution or the relationship between the time it took for $KMnO_4$ to move into the potatoes and the concentration of the $KMnO_4$ solution.

Many scientific inquiry skills are targeted in this inquiry. Students must develop a procedure in order to test this hypothesis, control variables, and determine how their observations will be recorded and displayed. Because students develop their own procedure, results may vary greatly from group to group. Discussions with other groups is a good way for students to understand that there is no set procedure for conducting a scientific investigation and that ideas based on evidence can change and be refined through discussion and debate.

References

Hand, B., and C. W. Keys. "Inquiry Investigation: A New Approach to Lab Reports." *The Science Teacher* 66.4 (1999): 27–29.

Keys, Carolyn W., et al. "Using the Science Writing Heuristic as a Tool for Learning from Lab Investigations in Secondary Science." *Journal of Research in Science Teaching* 36.10 (1999): 1065–1084.

Appendix 1.13A: Lab Skills Checklist—General Skills (BLM)

General Skills	Expectations	Not Yet Meeting Expectations	Meeting Expectations
Is prepared to conduct the lab	Reads lab outline ahead, creates tables, asks questions that clarify the task, instead of asking "What do I do next?"		
Sets and uses equipment properly	Chooses the correct equipment, sets up properly (e.g., ring height on ring stand), and uses equipment properly (e.g., lighting a Bunsen burner or anaesthetizing fruit flies)		
Follows safety procedures	Demonstrates general safety procedures as well as specifics outlined in pre-lab		
Records observations	Records own observations as the action is occurring, uses quantitative and qualitative approaches as directed, records in an organized fashion (e.g., uses a table or key)		
Works independently (individual labs) or works cooperatively (group labs)	Knows task and gets right to work or shares tasks and observations, is a good listener, and is receptive to the other student's point of view		
Manages time efficiently	Divides and orders tasks to meet deadlines		
Cleans up adequately	Leaves table and sink clean, puts away all equipment, washes table top, washes hands		

Appendix 1.13B: Lab Skills Checklist—Thinking Skills (BLM)

Thinking Skills	Questions	Understanding of Lab		
		Limited	General	Specific
Knowledge/ Comprehension	• What is the purpose of doing this lab? • How does this relate to what you are studying in class? • What is the rationale for your hypothesis? • Why do you need special safety considerations for this lab? • What chemical disposal guidelines have you been given?			
Application/ Analysis	• How did you decide on this procedure? • Are you having any difficulties with this procedure? • Are you getting the results that you expected? • How would you set up a graph, diagram, or flowchart to depict these results? • Do you see a pattern in your data? • Do any data points not follow the pattern?			
Synthesis/ Evaluation	• What can you conclude from your results? • Give a specific piece of evidence to support your conclusion. • What sources of error occurred in this trial? • What would you do differently in a second trial? What would you do the same? • How do your two trial results compare?			

Appendix 1.14A: Biological Drawing (BLM)

Making a Biological Drawing

1. What to Use
   a) Use a sharp pencil.
   b) Use a clean sheet of unlined paper.
2. What to Draw
   a) Draw only what you see.
   b) Draw only what is necessary.
3. How to Draw
   a) Centre your diagram.
   b) Draw a large enough diagram to show details clearly (approximately one-half page).
   c) Make your proportions accurate.
4. Showing Depth
   a) Do not shade.
   b) Show depth with stippling.
5. Label Your Drawing
   a) In your title, include the name of the slide, the total magnification, the date observed, the field diameter, and the size of the object.
   b) Label specific information. Labels should be printed, written horizontally, and placed to the right of the drawing.
   c) Use a ruler to draw labelling lines and do not cross the lines.

Appendix 1.14B:
Rating Scale for Biological Drawing (BLM)

Title of Drawing or Lab _____

	Possible Points	Self-Assessment	Teacher Assessment
1. Tools/Material (What to Use) a) Used sharp pencil. b) Used clean sheet of unlined paper.			
2. Content (What to Draw) a) Drawing includes only what was observed. b) Drawing includes only what is necessary.			
3. Approach (How to Draw) a) Diagram is centred. b) Diagram is large enough to show details clearly. c) Proportions are accurate.			
4. Showing Depth a) Did not shade. b) Used stippling to show depth .			
5. Labelling (Label Your Drawing) a) Title includes the name of the slide, the total magnification, the date observed, the field diameter, and the size of the object. b) Specifics on diagram are labelled. c) Labelling lines are drawn with a ruler and do not cross the lines.			
Totals			
Comments			

Appendix 1.15: Microscope Skills Checklist (BLM)

Teacher Notes: Use one page per student and use throughout the entire course. Either a check mark or a date reference can be placed in the appropriate column to indicate whether the student is meeting or not yet meeting expectations. Anecdotal comments can be recorded in the space provided below the table (be sure to include a date with the comment).

While these skills could be assessed through a Pencil-and-Paper Task, that approach would not provide feedback on the *skill level* of students in performing the required tasks. It would only provide information as to a student's *knowledge* of what the steps/procedures are. Performance tasks and observational assessments should be used whenever possible.

Appendix 1.15:
Microscope Skills Checklist (BLM) *(continued)*

Name _____ Date _____

Skills	Not Yet Meeting Expectations	Meeting Expectations
1. General Microscope Skills a) Handles and cares for microscope properly. b) Selects proper magnification to see the object (i.e., cell or tissue). c) Uses only fine focus on medium and high power. d) Watches from the side when bringing object and lens together. e) Uses diaphragm and/or mirror to adjust light properly.		
2. Proper Technique to Focus Object under Various Magnifications (i.e., parfocal) a) Starts on low power with coarse adjustment. b) Centres object. c) Adjusts fine focus. d) Moves up to medium or high power using only fine focus.		
3. Preparing a Wet Mount Slide a) Places specimen and drops of water on slide. b) Lowers cover slip at a 45° angle.		
4. Staining a Wet Mount Slide a) Prepares the wet mount slide. b) Places a drop of stain on one side of the cover slip. c) Draws through with a paper towel.		
5. Oil Immersion Technique (Optional) a) Properly focuses slide on high power. b) Swings lens to the side. c) Puts drops of oil on slide. d) Positions oil immersion lens and focus.		
6. Technical Skills a) Determines total magnification. b) Determines object size.		
Comments (include date)		

Appendix 1.16:
Those Magic Membranes* (BLM)

(Short version—the one recorded)
by Arthur W. Siebens, Ph.D., Copyright 1995
(to the tune of "La Bamba" by Richie Valens and "Twist and Shout," by Medley and Russell)

How do things get into cells?
How do things get out?
Transport across cell membranes
Is what this song's about.

Diffusion, osmosis
Active transport, too.
To make your cells and organs work right
The right solutes must get through.

CHORUS
Oh, those magic membranes
In each and every cell
Differences between solutes may be small
But membrane transporters can tell.

Oh those magic membranes!

They let the good stuff in
Get the bad stuff out
Through transporters made of protein
There's lots of different routes.

Membranes are mainly made of lipid
Most solutes can't penetrate
Proteins transport specific solutes
Many change their shape (conformational state).

Facilitated diffusion
(From) high concentration to low.
In co-transport a solute going "downhill"
Moves another "uphill" as it goes (secondary active transport).

There's also (primary) active transport
And that takes energy
Solutes are moved uphill
Energy from ATP.

CHORUS

*Source: Siebens, Arthur W. "Those Magic Membranes." *Bio-Rhythms I* (1995): <www.biosongs.com/4.htm>. Reproduced by permission.

If solutes can't cross a membrane
But water can diffuse
It will cross 'til equilibrium (the water concentration is the same)
Osmosis is when water moves (across cell membranes).

CHORUS

Oh those magic membranes! Yeah!