Unit 6: Wellness and Homeostatic Changes

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Unit 6: Wellness and Homeostatic Changes

Specific Learning Outcomes

B11-6-01: Analyze examples of how different body systems work together to maintain homeostasis under various conditions. (GLOs: D1, E2, E3)

Examples: cold weather, organ transplant...

B11-6-02: 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. (GLOs: D1, E2, E3)

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...

B11-6-03: Recognize the difficulties faced in defining "death" and identify some of the different definitions in use today. (GLOs: C8, D1)

Examples: medical definition, legal definition, religious viewpoint…

B11-6-04: Identify and analyze social issues related to the process of dying. (GLOs: B3, C4, C5, C8)

Examples: euthanasia, advanced directive, choice of treatments, organ donation, availability of palliative care…

B11-6-05: Describe how technology has allowed us to control our wellness, and describe the ethical dilemmas that the use of technology can create. (GLOs: B1, B2, B3, C5, C8)

Examples: reproductive technologies, stem-cell research, surgery, anaesthetic, pharmaceuticals...

BODY SYSTEM INTERRELATIONSHIPS

SPECIFIC LEARNING OUTCOMES

B11-6-01: Analyze examples of how different body systems work together to maintain homeostasis under various conditions. (GLOs: D1, E2, E3)

Examples: cold weather, organ transplant...

SLO: B11-6-01

SUGGESTIONS FOR INSTRUCTION

BACKGROUND INFORMATION

Throughout this course students have been studying homeostasis through an examination of individual human body systems. The intent of this section is to serve as a culminating look at homeostasis from a holistic perspective, without being restricted to a particular body system. Students will have the opportunity to apply what they have learned throughout the course.

ACTIVATE

Interrelationships

Have students discuss examples (from previous units) of how two or more systems must work together to help the body maintain homeostasis.

ACQUIRE/APPLY

The Homeostatic Challenges of Diabetes: Being Your Own Homeostatic Monitor (U1, U2, P3, I1, I4)

Have students describe, using print and/or electronic resources, all the human body systems that help maintain a constant blood sugar level. Then have them explain how individuals with diabetes must become their own homeostatic monitors for blood sugar by paying attention to indicators and monitoring their blood sugar levels. Examine the implications of not maintaining a constant blood sugar level.

Resource Link

For extensive information on diabetes, including complications associated with diabetes and information about living with diabetes as a First Nations person, see the following website:

- Canadian Diabetes Association. Home Page. <www.diabetes.ca/>.

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

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)

Suggestion for Assessment

Together with students, develop criteria indicating what a quality response could look like. The primary focus is on demonstrating a deep understanding of body systems, how they are involved in maintaining a constant sugar level, and implications of fluctuating blood sugar levels for diabetics. The secondary focus could be on the means of presentation (e.g., essay, poster, oral presentation).

Cumulative Assessment

Provide an opportunity for students to apply what they have learned about homeostasis and the human body systems as a cumulative assessment. Provide a particular context for students to analyze. For example, have students revisit The Swimming Race case study they analyzed in Appendix 1.7 of Unit 1. Have students revisit their responses and add more details. Students should have access to all their notes for this learning activity. Together with students, develop guidelines for this assessment activity, as well as a rubric for assessment.

Other suggested contexts for this type of assessment would be a case study related to hypothermia or a case study dealing with an organ transplant.

AGING

SPECIFIC LEARNING OUTCOMES

B11-6-02: 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.
(GLOs: D1, E2, E3)

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...

SLO: B11-6-02

SUGGESTIONS FOR INSTRUCTION

BACKGROUND INFORMATION

With aging comes a breakdown of the body's homeostatic mechanisms. A study of aging will allow students to apply the knowledge they have gained throughout the course to another aspect of human life—the aging process.

ACTIVATE

Senior Citizens

Have students generate a list of things they have noticed about older relatives or seniors they are in contact with, related to general health, day-to-day complaints, and so on.

For example, older people are often cold, have difficulty sleeping, and are not able to eat the same kinds of food they used to.

ACQUIRE/APPLY

Models of Aging (U1, U2)

Using print or electronic resources, students create a chart that describes the reasons for reduced efficiency in the three homeostatic processes as one ages: thermoregulation, osmoregulation, and waste management.

Sample:

Thermoregulation	Osmoregulation	Waste Management
• decreased metabolic rate • decreased efficiency in heart and lungs • less respiratory surface due to breakdown of aveoli • fewer oil and sweat glands	• decreased kidney function • urinary incontinence may occur	• decreased oxygen circulated to muscles • less efficient elimination of waste • decreased ability to uptake nutrients • fewer digestive enzymes produced in the intestines

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

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

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

B11-0-D2: Evaluate implications of possible alternatives or positions related to an issue. (GLOs: B1, C4, C5, C6, C7)

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

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

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

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

Suggestion for Assessment

As an Exit Slip, have students provide one example of a change that happens in each of the three main homeostatic processes as people age.

Living to 150 Years Old—Article Analysis (U2, P3, D1, D2, I4, G2)

Part 1

The article "Staying Alive" presents a debate about the limits of the human lifespan (see Appendix 6.1). Introduce the article by having students respond to the following question and including an explanation for their response:

Could someone alive today survive to the age of 150?

Part 2

Use a Jigsaw approach to have students address the content of the article "Staying Alive." Separate students into groups and refer to them as the "home" groups. Each group member selects (or is assigned) Section 1, 2, 3, or 4 of the article. All students begin by reading the Introduction. Students then move into the "expert" groups, based on the section they will be reading (i.e., all the 1s get together to look at Section 1, and so on). The expert groups analyze their assigned section and then students take the information back to their respective home groups. The analysis will summarize evidence for or against the argument that someone born today could live to 150 years old. Each group also has to create a heading for their section of the article. A Staying Alive Template

AGING

SPECIFIC LEARNING OUTCOMES

B11-6-02: 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. (GLOs: D1, E2, E3)

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...

is provided in Appendix 6.2. When the sharing is taking place back in the home groups, team members should be encouraged to take notes on the analysis provided by each team member.

Suggestion for Assessment

Following the sharing of all expert and home group discussions, have students revisit the question, "Could someone alive today survive to the age of 150?" Students can write an individual response that gives their opinion, justifying their opinion using facts from the article. This could be written as a persuasive piece intended to convince someone of his or her position. Regardless of what format the responses take, the responses could be assessed using criteria such as the following:

- The opinion is clearly stated.
- The opinion is supported by extensive detail from the article.
- The argument is logical and convincing.

Aging Relative—Microtheme (U2, D4, I4)

Have students respond to the following case study.

Microtheme
Six months ago, Grandma moved from her house into a retirement home. Your parents are concerned and comment that she seems to have "aged" a great deal in that time. You notice that Grandma is not involved in the same activities at the retirement home as she was in the community. Indicate how this change in lifestyle has contributed to her aging process. Based on your research into aging, what would you recommend that Grandma do?

Option: Write your response as a dialogue or an essay.

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

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

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

B11-0-D2: Evaluate implications of possible alternatives or positions related to an issue. (GLOs: B1, C4, C5, C6, C7)

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

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

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

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

Suggestion for Assessment

Refer to Appendix 1.3B: Microthemes—First Draft Checklist (BLM) and Appendix 1.3C: Microthemes—Final Draft Assessment (BLM) in Unit 1 for assessment tools.

Cumulative Assessment

Have students write a response to the following question:

> Would you want to live to 150 years old? Justify your answer using your own knowledge and what you have learned in biology.

The responses could be included in students' Wellness Portfolios.

DEATH

SPECIFIC LEARNING OUTCOMES

B11-6-03: Recognize the difficulties faced in defining “death” and identify some of the different definitions in use today. (GLOs: C8, D1)

Examples: medical definition, legal definition, religious viewpoint…

B11-6-04: Identify and analyze social issues related to the process of dying. (GLOs: B3, C4, C5, C8)

Examples: euthanasia, advanced directive, choice of treatments, organ donation, availability of palliative care…

SLO: B11-6-03
SLO: B11-6-04

SUGGESTIONS FOR INSTRUCTION

TEACHER NOTE

This set of activities provides students with the opportunity to discuss the topic of death, and to realize how something as simple as the definition of death is really not simple at all. Through the learning activities in this section, students will come to appreciate this complexity. They will begin to see death as a process, rather than as a distinct point in time. This discussion will be controversial and raise many ethical issues. It may also be very emotional for some students; teachers should be sensitive to this and provide alternative assignments for students who may not feel able to participate in specific discussions or learning activities.

Resources

The following resource provides a description of medical definitions of death, the processes involved in organ harvesting, and the ethical issues involved in donation and transplantation:

- *Life Is a Gift: A Manitoba Grade 11 Biology Resource for Organ Donation and Transplantation* (Manitoba Education and Transplant Manitoba)

The following website looks at death from various perspectives:

- ThinkQuest. *Death and How People Go about It*. 2001. Oracle Education Foundation. <http://library.thinkquest.org/C0122781/index.htm>.
  - — Science—biological process (including definitions)
  - — Psychology—how the mind reacts to death, coping
  - — Anthropology—cultural and religious differences in how death is treated around the world
  - — Sociology—social implications of death

ACTIVATE

Criteria for Death

Have students respond to the following statement:

> Describe what you think the criteria are to determine when a person is dead.

Skills and Attitudes Outcomes

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

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

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

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

B11-0-D2: Evaluate implications of possible alternatives or positions related to an issue. (GLOs: B1, C4, C5, C6, C7)

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

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

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

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

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

Acquire/Apply

"Substituted Sammy"—Case Study (U2, D1, D2, D3, D4, D5, G1, G2)

Introduce a case study related to an issue associated with the process of dying (see *SYSTH*, pp. 4.14–4.17). Appendix 6.3: "Substituted Sammy": An Exercise in Defining Life provides a sample case study. Students should be given the opportunity to work with others to discuss and answer the questions provided in the case study. However, each student may record his or her individual responses, which could be different from someone else's. Students must decide at what point "Sammy" died.

Resource

See Organ Donation in Relation to Society Lesson Plan in *Life Is a Gift* (Manitoba Education and Transplant Manitoba) for learning activities related to Unit 6: Wellness and Homeostatic Changes.

Suggestion for Assessment

Observe students as they read and debate this issue, which can be emotionally charged. Observe students' willingness to listen to others and their openness to other opinions.

DEATH

SPECIFIC LEARNING OUTCOMES

B11-6-03: Recognize the difficulties faced in defining “death” and identify some of the different definitions in use today. (GLOs: C8, D1)

Examples: medical definition, legal definition, religious viewpoint…

B11-6-04: Identify and analyze social issues related to the process of dying. (GLOs: B3, C4, C5, C8)

Examples: euthanasia, advanced directive, choice of treatments, organ donation, availability of palliative care…

Ask the Doctor (I1, W1)

Invite a medical professional to speak to students about the physiology of dying, palliative care, the medical definition of death, advanced directives, and life supports.

Suggestion for Assessment

As a formative assessment, have students write a summary of key points mentioned during this presentation. It can be presented in the form of text, or a graphic representation such as a Concept Map. This assessment will help ensure that students understand some of the key issues/questions on the topic of death, prior to moving on to further learning activities.

SKILLS AND ATTITUDES OUTCOMES

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

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

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

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

B11-0-D2: Evaluate implications of possible alternatives or positions related to an issue. (GLOs: B1, C4, C5, C6, C7)

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

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

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

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

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

NOTES

TECHNOLOGY AND WELLNESS

SPECIFIC LEARNING OUTCOMES

B11-6-05: Describe how technology has allowed us to control our wellness, and describe the ethical dilemmas that the use of technology can create. (GLOs: B1, B2, B3, C5, C8)

Examples: reproductive technologies, stem-cell research, surgery, anaesthetic, pharmaceuticals…

SLO: B11-6-05

SUGGESTIONS FOR INSTRUCTION

ACTIVATE

Using Technology

Have students respond to the following question:

In what ways have you used technology to maintain your life so far?

Create a class list of all the ways the people in the classroom have prolonged their lives. Ensure that a broad definition of technology is employed. The list could include examples such as hospital medical equipment to assist in births, routine vaccinations, thermometers, and so on.

ACQUIRE/APPLY

Technology News (D1, D4, I1, I2, I4, W1, W2)

Create a classroom newspaper that contains student research about a biotechnology in which they are interested. The research should contain information such as

- the inventor(s) of the biotechnology
- the history of discovery
- a description of how it works in the human body
- an argument for its use or cessation of its use

Have students individually write an editorial or a letter that could be placed in the newspaper.

Suggestion for Assessment

Assessment criteria for this performance-based task could include the following:

- The main idea is clearly stated.
- Supporting details and information related to the main idea are accurate.
- References to source information are given for added emphasis and effect.
- The tone of the editorial/letter is rational and logical.
- The editorial/letter style is maintained throughout.
- The editorial/letter is well organized.

SKILLS AND ATTITUDES OUTCOMES

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

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

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

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

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

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

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

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

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

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

WP

Science Saves the Day!—Reflection (W1, D4)

Present students with the following statement:

> Because of the advances in science and technology I don’t need to work so hard at maintaining my personal wellness—science can fix whatever goes wrong!

Students can be asked to agree or disagree with the statement and share their opinions in a number of ways:

- classroom or small-group discussion
- written response
- debate

Whatever method is used, students should also be asked to complete a reflective piece on this topic for their Wellness Portfolios.

Suggestion for Assessment

Assessment will vary depending on the type of learning activity used and the focus of the assessment (e.g., group discussion skills, debating skills, justification of position).

NOTES

Unit 6:
Wellness and Homeostatic Changes

Appendices

Appendix 6.1: Staying Alive* (BLM)

A century ago, most Americans lived to be about 50. Today people over 100 make up the fastest-growing segment of the population. As some researchers bet that children born today will live to be 150, others say there is no upward limit on longevity.

by Karen Wright

Introduction**

A few years back, biodemographer Jay Olshansky called his friend Steve Austad, a gerontologist, after reading an outrageous quote attributed to Austad about aging. Olshansky, at the University of Illinois, and Austad, at the University of Idaho, have long shared an interest in the human life span. But they differ on some points. Austad had been quoted as saying that someone alive today could survive to the unprecedented age of 150.

“You don’t really mean that,” Olshansky told his friend.

“Oh yes, I do,” Austad replied. In fact, he would bet on it. Before long he and Olshansky had agreed to put $150 each into an investment fund, to be distributed to the relatives of the winner in 2150. They agreed that, in order for Austad’s progeny to collect, the 150-year-old has to be in reasonably good health and that proof of the person’s age has to be impeccable. By adding $10 each every year, they figure that by 2150, the $300 fund will grow to be worth $500 million.

Austad isn’t worried about his kin collecting: “We’ve made phenomenal progress in understanding aging in other animals in the last 10 years. I can’t believe we won’t make improvements in [human] antiaging treatments in the next hundred.”

Most students of human longevity agree that exercise, antioxidants, low-fat diets, and prostate exams will join forces with a battery of new techniques to extend the lives of seniors and improve their quality of life. But that amiable projection raises a tough question: If medical science were to eliminate geriatric infirmity and disease entirely, how long would the human body last? Is there some built-in expiration date for each member of our species beyond which no one will ever survive? If so, what is it, and why does it exist?

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* Source: Wright, Karen. “Staying Alive.” *Discover Magazine* 24.11 (November 2003): 64, 66, 68, 70. Reproduced by permission of Discover Media LLC.

** Note: The section headings are not part of the original article.

Section 1

Demographics of the last two centuries seem to be on the side of soaring life spans. Worldwide, average life expectancy has increased from about 27 years to more than 65. In the United States, a person born in 1900 lived, on average, less than 50 years; now the average life span is 78. Japanese women, the longest-lived people ever known, now have a life expectancy of 85 at birth.

These unprecedented gains are reflected in the number of people surviving to extreme ages. The longest-lived human whose age has been unequivocally documented is Jeanne Louise Calment, a Frenchwoman who died six years ago at age 122. Although people of such advanced age are still rare, they're becoming more commonplace by the minute. The United States now boasts a population of more than 40,000 people aged 100 and older. In 1950 there were only 2,300 centenarians in this country. James Vaupel of the Max Planck Institute for Demographic Research in Rostock, Germany, says the number of centenarians in many industrialized nations is doubling every decade.

Vaupel has shown that the maximum life expectancy among such countries has risen steadily by more than two years each decade since 1840. The increase is "so extraordinarily linear that it may be the most remarkable regularity of mass endeavor ever observed," Vaupel wrote in a 2002 paper coauthored by Jim Oeppen of Cambridge University. If that pace continues, Vaupel maintains, the average life span in industrialized countries in 2150 will be 122.5, making 150-year-olds common.

Demographer Ronald Lee of the University of California at Berkeley says Vaupel's analysis came as "a big surprise. We just did not expect to see a linear increase in life expectancy. It's hard to resist extrapolating that line. That's a 25-year gain every century."

Still, Olshansky has reason to be skeptical. The astounding improvements in public health between 1900 and 1950, aided by such factors as refrigeration, sewage treatment, and safer working environments, produced many of the increases in life expectancy in the last century. The advances helped young people most of all by greatly reducing infectious and parasitic diseases that decimated infants and children. Each young life saved added decades to the raw numbers from which life-expectancy averages are drawn, since a person who survived childhood at the turn of the last century was likely to live decades more.

"Once you've accomplished that, you've accomplished your easy gain in life expectancy," Olshansky says.

Around 1950, he says, the pattern reversed, and most medical gains helped prolong the lives of older people. Medical interventions headed off many ills of the aged, especially the number one killer: heart disease. But saving those who are living out the last years of their lives adds only a few months or years to the actuarial tables. Olshansky therefore believes that even major advances in geriatric care won't push life expectancy much past 85—at least not in the lifetime of anyone alive right now.

"There are no lifestyle changes, surgical procedures, vitamins, antioxidants, hormones, or techniques of genetic engineering available today with the capacity to repeat the gains in life expectancy that were achieved during the 20th century," he and his collaborator Bruce Carnes, of the University of Chicago, have declared.

"Will the maximum human life span increase in the future? Probably," Olshansky says. "It's possible someone might make it to 130. But to go another 20 years? I don't see it happening."

Vaupel says Olshansky belongs to "a sorry saga of distinguished people" who postulate that some maximum age will never be exceeded, only to see it exceeded within five to seven years. "If life expectancy were close to reaching a maximum, then the increase in the record expectation of life should be slowing," he and Oeppen wrote. "It is not."

When Vaupel's daughter was born in 1984, he claimed often and in writing that she would live to see 100. Olshansky's daughter was also born in 1984. While wishing her no ill, he says she most likely won't live to be 100. "Purely mathematical extrapolation of a biological phenomenon is inherently dangerous," he warns. And so it has gone, with Vaupel and Olshansky trading fire in the scientific literature for decades.

Section 2

Statistics might well be misleading when it comes to predicting trends in aging, so another kind of analysis seems in order. What's needed is a model that describes how and why age kills us—a model that explains what it means to die of "natural causes." So far, that model doesn't exist. Biomedical research has produced vast stores of knowledge about the diseases of old age, but scientists still don't understand why our bodies begin to deteriorate when we reach our thirties. It's not even clear that aging, as a process, can be separated from its pathologies.

"Opinions go from nothing ever dies from old age to everything dies from old age," says Austad. "We don't really know very well why people age to death."

Most researchers agree that the biggest boost in human life expectancy will not come from curing diseases. Instead, the rate of aging itself has to be slowed down. Richard Miller, a biogerontologist at the University of Michigan, says Olshansky's research shows that the average 50-year-old woman would live to be 95 if cancer, heart disease, stroke, and diabetes were curable. But studies with rodents, Miller says, indicate that if her aging could be retarded, she'd live to be 115. Most important, those extra years would be lived in good health.

There is tantalizing evidence from laboratory studies that aging can be slowed. Experiments with mice, fruit flies, yeast cells, and tiny worms called nematodes, or roundworms, have pointed to environmental modifications that can extend life span dramatically. Mice fed an austere low-calorie diet, for example, will live up to 40 percent longer. Fruit flies kept in refrigerators can live six times as long as unrefrigerated flies. Cats, dogs, and even humans live years longer than average when they are castrated. And the bonus years seem to be truly golden: Methuselan mice are strong, healthy, and alert.

Those interventions entail sacrifices that most people probably aren't willing to make. But further research may yield more palatable strategies. In August researchers announced that a compound called resveratrol, found in red wine, mimics calorie deprivation and prolongs the life span of yeast cells by 70 percent. Some scientists doing that work said they had taken to drinking a glass of red wine each day.

In the last decade, animal studies also turned up dozens of genes that can extend life span. For example, a single mutation in a roundworm can extend its life 600 percent. The genes involved code for proteins that control basic physiological processes such as energy consumption, growth rate, and cell division. Some of the genes protect critical proteins from damage due to stress. Scientists speculate that mild, chronic stress—like a low-calorie diet or a cold room—may spark these genes into action.

Nonetheless, not a single life-extending gene has been found in the human genome yet. "We know a lot about genes that make humans live shorter lives," says Austad. "But we don't know any genes that make humans live to extreme old age."

Given Olshansky's confidence that humans won't live to be 150, it may be surprising to learn that he thinks there's no predetermined biological limit to the human life span. He agrees with Austad and other researchers that there aren't any physiological determinants of mortality: no molecular switch that gets thrown, no ticking chromosomal clock that says your time is up, no somatic schedule for checkout. There are no death genes that terminate life the way that countless other genes orchestrate growth, metabolism, and reproduction.

And nature supplies ample evidence that the rate of aging is flexible rather than predetermined. The evidence comes from comparisons between species. A fruit fly lives three weeks, a mouse three years, a quahog clam 200 years, and a bristlecone pine 4,000 years. In each of these species, the same cellular processes are at work.

"To me," says Austad, "the interesting thing has always been, why does [life span] differ so much in different species?" A number of theories have addressed that question. One notion, the influential rate-of-living theory first advanced about 100 years ago, is that the speed of an animal's metabolism limits its life span. Hence, cold-blooded animals like turtles live longer than warm-blooded ones like hares, and fast-living creatures die young. Body size also seems to have something to do with it. Larger animals have slower metabolisms and tend to have longer lives than small animals.

The rate-of-living model gives rise to some seductively simple ideas. It suggests, for example, that all species of mammal have the same number of heartbeats in a lifetime. And it was buttressed by evidence that the normal metabolic consumption of energy generates reactive molecules called free radicals that damage DNA, enzymes, and cell membranes. The damage accumulates over time and results in an organism's increased susceptibility to cancer, or its inability to repair clogged arteries, or a slide into senility. The free-radical model is now a leading theory of aging, and it fits neatly with the rate-of-living theory of life span: The faster the metabolism, the faster free radicals do their damage.

But the rate-of-living theory succumbed to the weight of exceptions. Birds, for example, have metabolisms twice as fast as those of mammals, yet they can live much longer. Parrots can outlive elephants; hummingbirds have been known to survive to 14—the equivalent, in terms of energy consumption per pound, of a human living to 500. A species of North American bat half as big as a mouse can live 30 years in the wild. Opossums, on the other hand, rarely last more than two years, even in captivity. Yet they are the size of house cats and cannot by any measure be accused of living fast.

There is one more glaring exception: Humans live four times longer than they should based on their size and metabolic rate.

Section 3

A new perspective on mortality came in the 1950s from distinguished British immunologist Sir Peter Medawar. Inspired by evolutionary theory, Medawar pointed out that death and disease are staved off by natural selection, which impels all living things to survive long enough to reproduce. Natural selection favors any trait, genetic or otherwise, that helps an organism live to reproductive age: mechanisms for DNA repair, robust immune systems, good eyesight, strong bones, quick thinking. The downside, of course, is that natural selection doesn't promote an individual's survival past reproductive age. In people there's no evolutionary advantage to fending off cancer, heart disease, stroke, arthritis, cataracts, Alzheimer's, and other banes of the aged, because these conditions usually show up long after genes have been passed on to the next generation.

Investigators have shown that life span and reproduction are intimately linked in many species of mammal and bird. In general, the earlier an organism reaches sexual maturity, the sooner it dies. Life span also correlates with the number of offspring an animal has. Longer-lived animals tend to have fewer young per year, in part because their continued presence helps ensure their brood's survival. Evolution tends to pick either quantity—short-lived beasts with superbroods—or quality, as exemplified by long-lived creatures with low fecundity but highly conscientious parenting. Because the young of humans, whales, and many other mammals require substantial parental care, natural selection continues to protect the health of adults for some time after they've produced offspring. If the adults are around, the offspring are much more likely to make it.

Experiments with fruit flies published in the 1980s proved there was a causal connection between the timing of reproduction and the evolution of life span. By culling and fertilizing eggs from only older females for many generations, Michael Rose of the University of California at Irvine managed to double his flies' life span. If an environment allows or requires fecundity late in life, then life gets longer. Austad speculates that a similar experiment performed on humans would produce a measurable increase in life expectancy in 10 generations, or about 250 years.

Although people would never tolerate Rose's draconian methods, women in some developed countries are voluntarily delaying the age at which they start having children. "[Rose's] experiment might be going on right now," says gerontologist George M. Martin of the University of Washington in Seattle, "though we won't see the results for hundreds of years." The evolutionary theory of longevity "clearly predicts plasticity," he says. "Given the right conditions, nature can evolve longer and longer life spans."

Austad got a hint of what the right conditions might be 20 years ago. During a stay at a field station in Venezuela, he had his first exposure to the accelerated aging of the opossum. He trapped healthy 18-month-old opossums, then trapped them again just a few months later, and found them lame, half blind, balding, and full of parasites. Austad decided that opossums age and breed relatively quickly because they are easy targets for predators.

"Because they are slow moving and not terribly well armed with claws, teeth, brains, or agility, opossums will be killed by nearly every type of predator—owls, coyotes, wolves, feral dogs, cougars, bobcats. . . . " Austad wrote in his 1997 book *Why We Age*. "If a predator is likely to kill you in the next few weeks or months, it makes little sense to waste resources on a long-lasting, effective immune system or an array of free-radical defenses. It is better evolutionarily to reproduce copiously, and the sooner the better."

To test his theory, Austad located a group of opossums that had been isolated for thousands of years on an island off the coast of Georgia. The island had almost no natural opossum predators. He found that the animals' reproductive systems aged more slowly than their mainland relations' did: More than half enjoyed a second breeding season, a luxury for opossums. Brood sizes were smaller, too, in accordance with the quality versus quantity hypothesis. And sure enough, the average life expectancy was about 25 percent greater, while maximum life span—the longest any individual lived—was 50 percent longer.

Austad's findings have been generalized to encompass any external cause of death. Whether the hazards are from accidents, weather, food shortages, or predators, species and organisms that live in dangerous environments will breed sooner, have more young more quickly, and die earlier than species and organisms in safe environments. Mice are lucky if they make it through a few months before an owl snags them. Pacific salmon die immediately after spawning because reproducing, for them, entails a literally upstream battle they are never to repeat. Birds and winged mammals, on the other hand, can escape many hazards because they can fly. The stability of temperature on the ocean floor shelters the bottom-dwelling quahog clam; the Galápagos tortoise has impenetrable armor.

And people? Austad ascribes our anomalous longevity to the low-risk environment we have created for ourselves. Human beings live twice as long as captive chimpanzees, he notes, despite the fact that the two species share 99 percent of their genes: "I think the key has been our social system—our mutual means of support and our ability to manipulate the environment." Because one of the abiding aims of civilization is to make life safer for people, Austad says, the trend toward a longer life span will continue, and the luxury of long life, afforded by a civilized lifestyle, will eventually become encrypted in our DNA. Nurture becomes nature; culture dictates biological destiny.

"Evolution has definitely modified life span—it's happening even as we speak," says Judith Campisi, a molecular biologist at the Buck Institute for Age Research in Novato, California. "We're already living 50 years beyond the natural life span determined by the environment in which we evolved."

Therefore, Austad, unlike Olshansky, is unwilling to put a cap on the possible increase in life span that humans can achieve. "We can expect that within the next 20 to 30 generations, evolution will slow human aging considerably, by about 25 percent," Austad says. That's quick enough to demonstrate the flexibility of life span, but too slow to guarantee his heirs will beat out Olshansky's. "I'm not counting on evolution to help out with the bet," he admits.

So what is he counting on? Austad reasons that medical science can figure out ways to slow aging without waiting on generations of natural selection. The free-radical theory of aging offers helpful hints. Most of the nasty molecules produced by routine energy consumption in the body are oxidants. In 1998 Austad, his colleague Donna Holmes, an evolutionary gerontologist at the University of Idaho, and Martin demonstrated that bird cells suffer less oxidative damage than the cells of mice when exposed to free-radical stressors. Either birds have enzymes that combat oxidation better than mammalian enzymes do, or they produce fewer oxygen radicals. Until our physiology catches up, humans may be able to soften free-radical damage with antioxidants—compounds such as vitamin E that are found in foods and supplements.

Section 4

Geriatrician Tom Perls of the Boston University School of Medicine runs the world's largest ongoing study of people who are at least 100 years old, with more than 750 participants. His research has convinced him that, with proper care, the contemporary human's genetic endowment will support a healthy life into the mid to late eighties. Centenarians, in contrast, seem to have congenital advantages. Perls calls them "genetic booster rockets." He suspects that centenarians lack genes that predispose them to geriatric diseases and possess genes—as yet unidentified—that protect them from the ravages of time.

"We have a small number of people, particularly guys, who do everything short of throwing an atomic bomb at their bodies and still live to 100," Perls says. Many members of his group ignore dietary guidelines and refuse to exercise; some have been smoking three packs a day for 50 years. "They have genes that allow them to get away with things that aren't very good for them. We'd like to understand what's going on."

Perls says chance also plays a role in determining life span. Chance chooses the genes in which random mutations show up; chance takes the fatal step in front of the crosstown bus. And the longer you live, the more opportunity for misfortune. "It's not just nature-nurture," Martin agrees. "It's nature, nurture, and luck. There is a lot of luck in being a centenarian."

Thus Olshansky and other scientists like him say that while there may be no biological limits to the human life span, there are practical ones. In addition to luck, these include the amount of money society is willing to invest in antiaging research and the amount of time and effort that individuals are willing to spend on treatments that result from the research. Olshansky says that plenty of cheap, simple life-extending measures are already being ignored by a significant percentage of the general public. People still smoke, and most don't exercise. In fact, Olshansky says, the threats posed by obesity and emerging infectious diseases such as AIDS are largely responsible for his pessimism about 150-year life spans.

"Technically, anything is possible," he says. "But in the real world, we're just getting fatter."

Appendix 6.2:
Staying Alive Template (BLM)

Someone alive today could survive to the age of 150.

Article Section Title ____________________

Evidence/Arguments For	Evidence/Arguments Against

Summary	
Key Terms	Questions
I was surprised to learn...	

Appendix 6.3: "Substituted Sammy": An Exercise in Defining Life* (BLM)

by Donald F. Shebesta

"Substituted Sammy" was a normal, healthy boy. There was nothing in his life to indicate that he was any different from anyone else. When he completed high school, he obtained a job in a factory, operating a press. On this job he had an accident and lost his hand. It was replaced with an artificial hand that looked and operated almost like a real one.

Soon afterward, Sammy developed a severe intestinal difficulty, and a large portion of his lower small intestine had to be removed. It was replaced with an elastic silicone tube.

Everything looked good for Sammy until he was involved in a serious car accident. Both his legs and his good arm were crushed and had to be amputated. He also lost an ear. Artificial legs enabled Sammy to walk again, and an artificial arm replaced the real arm. Plastic surgery and the use of silicone plastic enabled doctors to rebuild the ear.

Over the next several years Sammy was plagued with internal disorders. First, he had to have an operation to remove his aorta and replace it with a synthetic vessel. Next, he developed a kidney malfunction, and the only way he could survive was to use a kidney dialysis machine. (No donor was found to give him a kidney transplant.) Later, his digestive system became cancerous and was removed. He received his nourishment intravenously. Finally, his heart failed. Luckily for Sammy, a donor heart was available, and he had a heart transplant.

It was now obvious that Sammy had become a medical phenomenon. He had artificial limbs. Nourishment was supplied to him through his veins; therefore, he had no solid wastes. All waste material was removed by the kidney dialysis machine. The heart that pumped his blood to carry oxygen and food to his cells was not his original heart.

But Sammy's transplanted heart began to fail. He was immediately placed on a heart-lung machine. This supplied oxygen and removed carbon dioxide from his blood, and it circulated blood through his body.

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* Source: Shebesta, Donald F. "'Substituted Sammy': An Exercise in Defining Life." *The American Biology Teacher* (May 1972): 286–287. Reproduced by permission of the National Association of Biology Teachers.

Appendix 6.3: "Substituted Sammy": An Exercise in Defining Life (BLM) *(continued)*

The doctors consulted bioengineers about Sammy. Because almost all of his life-sustaining functions were being carried on by machines, it might be possible to compress all of these machines into one mobile unit, which could be controlled by electrical impulses from the brain. This unit would be equipped with mechanical arms to enable him to perform manipulative tasks. A mechanism to create a flow of air over his vocal cords might enable him to speak. To do all this, they would have to amputate at [Sammy's] neck and attach his head to the machine, which would then supply all nutrients to his brain. Sammy consented, and the operation was successfully performed.

Sammy functioned well for a few years. However, slow deterioration of his brain cells was observed and was diagnosed as terminal. So the medical team that had developed around Sammy began to program his brain. A miniature computer was developed; it could be housed in a machine that was humanlike in appearance, movement, and mannerisms. As the computer was installed, Sammy's brain cells completely deteriorated. Sammy was once again able to leave the hospital with complete assurance that he would not return with biological illnesses.

Question

Obviously Sammy ceased living sometime during the story. When do you consider Sammy to have ceased living? Cite specific examples in the story and use the characteristics of life discussed in class to help explain your answer.