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UNIT 2

Ecosystems and Population Change

Teaching Unit 2: Ecosystems and Population Change

Answers to Questions for Comprehension and notes on Figures and Web Links appear throughout the chapter.

Chapter 4 ***Mechanisms of Population Change***

Answers to Questions for Comprehension and notes on Figures and Web Links appear throughout the chapter.

Teaching Unit 2: Ecosystems and Population Change

Student Textbook pages 72-151
(30% of the course time; approximately 37 hours)

Curriculum Fit

(see the Curriculum Correlation for full listing)
Background: This unit builds on concepts from *Science 7,* Interactions and Ecosystems; *Science 8,* Freshwater and Saltwater Ecosystems; as well as *Science 9,* Biological Diversity. This unit helps prepare students for the study of population genetics and community dynamics in Biology 30.

General Outcomes

Students will

- explain that the biosphere is composed of ecosystems, each with distinctive biotic and abiotic components
- explain the mechanisms involved in the change of populations with the passage of time

Contents

Chapter 3: Ecosystems and Their Diversity
Chapter 4: Mechanisms of Population Change

Content Summary

Three of the four themes of Biology 20 are featured in this unit: energy, matter, and systems.

The ecosystem is the unit of study in ecology. An ecosystem study consists of two components—a look at the interactions among the various populations or species making up the ecosystem and an examination of the interactions between these populations and their abiotic environment. The structures of both terrestrial and aquatic ecosystems are used to illustrate these concepts. Over time, as environments change, the characteristics of ecological populations change (through the process of natural selection) to become better adapted.

In Chapter 3, students build on the knowledge of biospheres and the cycling of matter and energy from Unit 1. They will gain an understanding of the diversity of ecosystems and their organization and examine species interactions by considering terrestrial and aquatic ecosystems. To highlight the complexity of these interactions, the mountain pine beetle is used as an example of a species interacting with an ecosystem. The mountain pine beetle is introduced in the Launch Lab, and there are references to this species and its impact on its ecosystem throughout the chapter. Section 3.1 looks at individuals, populations, and communities, and how they interact with the biotic and abiotic elements around them. In Section 3.2, students review the basics of taxonomy and the binomial naming system and identify organisms through the use of dichotomous keys. In Section 3.3, students apply the knowledge from the first two sections to investigate the role that abiotic and biotic elements play in the development of ecosystems, particularly as they affect growth.

A series of activities in the chapter lead to the design of a field investigation comparing two local ecosystems. The activities show students how to plan their investigation and use appropriate concepts, field techniques, and methods to gather and analyze their data, and communicate their findings. In addition, an alternate activity, "What can you infer from a handful of soil?" on BLM 3.1.1, can be used to examine abiotic and biotic factors, and BLM 3.1.3: Every Species Counts! gives students a chance to consider the impact of the loss of species on a food web, and what that means for the sustainability of ecosystems.

Additionally, students will consider both environmental and social consequences of the impact of human activity on the environment through consideration of monoculture replanting, as well as looking at the mountain pine beetle infestation as a consequence of global warming.

Chapter 4 deals with the mechanisms in nature that cause the variation of characteristics among individual organisms within a population and how these variations lead to different adaptations within a population. Section 4.1 shows that as the individual organisms with these variations reproduce more frequently because of their enhanced ability to survive within a particular environment, these variations will be perpetuated (selected for) based on the survival advantages given to populations. Eventually, the variation will become an established adaptation of a population to its environment.

Charles Darwin formulated the theory of natural selection using the insights of many thinkers and scientists prior to his time, as well as his observations during his trip to the Galapagos Islands. The theory of evolution grew from the theory of natural selection. The supporting evidence for evolution, such as the fossil record, molecular biology, embryology, and genetics are all presented in Section 4.2. The Connections feature focusses on the role of scientific debate in developing theories such as the theory of evolution and why both scientific and public debate is important.

Section 4.3 introduces the biological definition of a species. Students learn how different scenarios, such as geographic or reproductive isolation, can produce a new species from an existing population. In addition, students will learn about adaptive radiation and be introduced to two hypotheses that explain evolutionary pace: gradualism and punctuated equilibrium. As the students complete this chapter, they will have a much better understanding of genetics, adaptations, selection, and speciation. You can emphasize the two theories of gradualism and punctuated equilibrium to help students grasp how sufficiently great changes could take place to allow a new species, as defined by biology, to emerge.

Activities and Target Skills

Activity	Target Skills
Chapter 3: Ecosystems and Their Diversity	
Launch Lab: The Mountain Pine Beetle vs an Ecosystem, p. 77	■ Considering an example of an organism that is out of control, the role that human action might have played in this development, and the impact on ecosystems
Investigation 3.A: Observing Leaves, p. 80	■ Measuring biotic characteristics of ecosystems and speculating on their relationship to abiotic characteristics ■ Working cooperatively to gather and share data
Thought Lab 3.1: Planning for Your Field Study, p. 83	■ Planning a field study to compare biotic and abiotic components of two ecosystems ■ Working cooperatively to gather and begin organizing data for a field study ■ Selecting and using appropriate technologies to aid in effective communication
Investigation 3.B: Creating a Dichotomous Key, pp. 90-91	■ Compiling and organizing data to develop a dichotomous key for identifying organisms ■ Developing, presenting, and justifying a dichotomous key for identifying organisms
Thought Lab 3.2: Forest Habitat and Bird Biodiversity, p. 99	■ Analyzing data to look for patterns between and among variables ■ Evaluating the impact of human activities on the biodiversity of an ecosystem
Investigation 3.C: Preparing for Your Field Study, p. 100	■ Defining and delimiting ideas to assist in planning a field study ■ Gathering and recording data and information
Thought Lab 3.3: Super Competitor: Knapweed, p. 102	■ Assessing the environmental impact of an introduced species in established ecosystems
Investigation 3.D: An Ecosystem Field Study, pp. 106-107	■ Performing a field study to observe and measure abiotic and biotic characteristics of ecosystems ■ Applying classification and binomial nomenclature in a practical context ■ Analyzing the interactions of connections of abiotic and biotic characteristics within investigated ecosystems ■ Evaluating the accuracy and reliability of measuring instruments used, and identifying the degree of error they introduce ■ Working cooperatively to collect and share data and ideas
Chapter 4: Mechanisms of Population Change	
Launch Lab: Could Cockroaches Rule Earth?, p. 113	■ Using the case study of cockroaches to analyze limiting factors. ■ Hypothesizing the reasons for the development of a physical trait
Investigation 4.A: Variations Great and Small, p. 116	■ Designing an investigation to describe an inherited variation in a population. ■ Gathering and recording data to demonstrate variation ■ Stating a conclusion based on analysis of collected data
Thought Lab 4.1: Evolving “Superbugs,” p. 119	■ Analyzing data and applying a conceptual model to show how antibiotic resistance could occur in a population of *Staphylococcus aureus* ■ Gathering and recording information about the rise of antibiotic resistance in bacteria

Activity	Target Skills
Thought Lab 4.2: Analyzing Changes in Beak Depth, p. 120	■ Analyzing data to show how beak depth in the medium ground finch changes with the passage of time. ■ Stating and defending a generalization based on data.
Thought Lab 4.3: Comparing the Ideas of Lamarck and Darwin, p. 127	■ Comparing Darwinian and Lamarckian explanations of evolutionary change ■ Evaluating and communicating the merits of alternatives explanations for evolutionary change
Thought Lab 4.4: Homologies of Hair, p. 131	■ Hypothesizing the adaptive significance of variations in the structure of hair ■ Using electronic research techniques to analyze and synthesize ideas related to hair as a homologous structure, in order to determine patterns and links
Thought Lab 4.5: Leopard Frogs: One Species or Seven?, p. 139	■ Using a range of tools to gather and record data and information about species of leopard frogs ■ Using appropriate modes of representation to communicate ideas

Conceptual Challenges

Chapter 3

- Science is an ongoing series of discoveries, and discoveries usually spark a reexamination of existing knowledge. Systems of classification are an example of this: systems continue to change as new technology is applied to the study of living things. The brief history of classification and naming of organisms is an illustration of the impact of new discoveries on accepted scientific knowledge. (pp. 85-87)
- The complexity of interactions in an ecosystem goes beyond simple feeding relationships. An examination of a food web in terms of what happens when a member of it disappears needs to go beyond the feeding relationship to consider what other roles the organism played in the relationship. **BLM 3.1.3 Every Species Counts!** can be used to begin the discussion about this complexity. The background for this discussion can be the 2006 report on the potential collapse of the ocean ecosystem by 2048 as too many aquatic species are lost. See Helpful Resources for references.
- Students may be familiar with the six kingdoms of life. The shift to classifying life in three domains may be a new concept that needs to be emphasized as another way that science is changing to accommodate new knowledge. The visual of the three domains has been reproduced as an overhead on **BLM 3.2.2.** (p. 87)
- Some students may wonder about the need to be so specific and exhaustive about describing and naming organisms. The case of the mountain pine beetle is an illustration of the importance of being able to precisely describe and name an organism so that relevant information can be shared on a global level. (Section 3.2)
- While it is generally agreed that the decline of species due to human interference in habitat is a bad thing, students need to understand that even within pristine settings, there will always be limits on the population growth of a species. Pages 98-103 deal with factors that limit growth: abiotic (soil type, moisture and humidity levels, temperature range) and biotic (competition, predators, parasites). This is the science related to discussions of global warming and why it matters. **BLM 3.3.1: Terrestrial Biomes According to Temperature and Precipitation** (graph in Figure 3.16 on page 94 of the student text reproduced as an overhead) can be revisited to emphasize this point. Students will be able to see that as temperature and rainfall change, locations currently classed as one type of biome could change enough to be considered in another category. (Section 3.3)
- Biodiversity is a key concept of this unit. Students should come to understand that changes in one species can have a profound effect on an ecosystem because of the interactions described here and in Unit 1. Again, the mountain pine beetle infestation can be used as an example of both anticipated (death of trees) and unforeseen (decline of species, economic losses) consequences of an event.

Chapter 4

- Students may be unclear on the significance of the term "theory" in scientific terms, as in "evolution is only a theory." While some meanings of the word relate to speculation and the abstract, as in "pet theories" or considering something "in theory" as opposed to "in practice," in the scientific world a theory is a system of ideas that explains something (atomic theory, evolution) based on general principles that have been established through the scientific method.

- The concept that it is population change rather than individual change that is at the heart of adaptation and evolution can be a difficult one for students. The impact of widespread change among individuals needs to be emphasized, along with the idea that this happens because those best suited to survive in a given set of biotic and abiotic conditions are the most likely to survive and reproduce.
- This chapter begins with a straightforward look at variation and adaptation, which leads to a consideration of natural selection and then to a discussion of evolution. Evolutionary theory is a sensitive and perhaps contentious concept for the members of some cultures. Students should be reminded that this scientific theory was developed to explain the variety of life forms that exist and why they keep changing.
- Students may wish to challenge the theory of evolution on a variety of grounds. The Connections feature "Debating Science" was developed to provide a way to frame the discussion around the need for and nature of scientific debate. The activities ask students to consider the role of debate and public participation in the development of scientific theory, as well as consider how social concerns might affect a debate about scientific findings. Evolution, global warming, or the need to protect biodiversity can be used as examples. (pp. 134-135)

Using the Unit 2 Opener and Unit 2 Preparation Feature

Unit 2 opens with a shot of researchers heading out into the field. The Focussing Questions direct attention to the biotic and abiotic elements of an environment and their effect on populations. The Unit Preparation feature has been included in order to ensure that students are familiar with the science from previous courses that relates specifically to the material they are about to study. Encourage students to take the Unit Prequiz (found at **www.albertabiology.ca,** Online Learning Centre, Student Edition) to gauge their recall, noting that if they are familiar with the background science, their experience with this unit will be much easier.

The Unit 2 Preparation feature is a brief review of mitosis and meiosis, which students can read prior to beginning Chapters 3 and 4. Understanding of these processes is particularly important for the discussion of how adaptations are passed on in Chapter 4. **BLM 3.0.1 Meiosis and Mitosis: A Comparison** can be used to support the review.

UNIT 2: COURSE MATERIALS

Chapter, Section	Item Description	Suggested Quantity	Text Activity
Chapters 3, 4	nonlatex disposable gloves	40 pairs	Investigation: 3.D
Chapter 3, Section 3.1	rulers material for recording data	1 per student pair	Investigation 3.A: Observing Leaves, p. 80 (at outdoor site)
Chapter 3, Section 3.3	paper pencils sample dichotomous keys leaves and catkins or needles and cones of Alberta tree species (optional)	 1 per student 10 copies 12 + plants per group	Investigation 3.B: Creating a Dichotomous Key, pp. 90–91
Chapter 3, Section 3.4	*Suggested materials for marking quadrats:* tape measure or rulers tent pegs string rope Hula Hoops™ (optional) flagging tape or masking tape *Suggested materials for making observations* binoculars (optional) hand lenses dissecting scopes thermometers light meters soil moisture meters pH paper nitrates/phosphates test kit trowels containers for soil/resealable bags *Suggested materials for recording observations* pens paper (observation table) clip boards sticker packs cell phone (w/photo capacity) optional *Suggested materials for reference* tree density stem maps identification keys first aid kit	 1 per group 4 per group 1 ball per group several m per group 1 per group 1 roll per group 1 per group 2 per group 1 per class 1 per group 1 per group 1 per group 1 vial per group 1 per group 1 per group 3 per group 40 40 40 1-2 pads per group 1 per group 1 per group 2 per group 2 for the class	Investigation 3.D: An Ecosystem Field Study, p. 106–107
Chapter 4, Section 4.1	rulers electronic balance bean seeds or peas graph paper	1 per group 5 30+ per group 40 sheets	Investigation 4.A: Variations Great and Small, p. 116
	coloured chips (2 colours)	100	Thought Lab 4.1: Evolving "Superbugs," p. 119

CHAPTER 3 ECOSYSTEMS AND THEIR DIVERSITY

Curriculum Correlation

Unit 2, General Outcome 1: Students will explain that the biosphere is composed of ecosystems, each with distinctive biotic and abiotic characteristics.

	Student Textbook	Assessment Options
Outcomes for Knowledge		
20–B1.1k define and explain the interrelationships among species, population, community and ecosystem	Launch Lab: The Mountain Pine Beetle vs an Ecosystem, p. 77 Section 3.1: Individuals, Populations, and Communities in Ecosystems, pp. 78-84	Launch Lab: Analysis 2, 3; Ext. 4, p. 77 Q question 4, p. 82 Try This: Ecological Organization, p. 82 Section 3.1 Review: 1, 2, 4, 5, p. 84 Chapter 3 Review: 4, p. 110 Unit 2 Review: 1, 2, p. 148 Chapter 3 Test
20–B1.2k explain how a terrestrial and an aquatic ecosystem support a diversity of organisms through a variety of habitats and niches, e.g., ■ terrestrial: *canopy, sub-canopy, forest floor, soil* ■ aquatic: *littoral, limnetic, profundal and benthic zones*	Section 3.3: Studying Organisms in Ecosystems, pp. 93- 98 Section 3.1: The Bigger Picture: Earth's Biosphere , p. 83 Section 3.1: Habitats, pp. 95-96 Habitats and Niches within Ecosystems, pp. 97-98	Web Link: Biomes, p. 95 Section 3.1 Review: 2, 7, p. 84 Thought Lab 3.1: Analysis 2, p. 99 Chapter 3 Test Section 3.3 Review: 1, 2, p. 108 Chapter 3 Review: 2, 5, 6, p. 110 Unit 2 Review: 4, p. 148
20–B1.3k identify biotic and abiotic characteristics and explain their influence in an aquatic and a terrestrial ecosystem in a local region, e.g., ■ *stream, lake, prairie, boreal forest, vacant lot, sports field*	Launch Lab: The Mountain Pine Beetle vs an Ecosystem, p. 77 Section 3.1: Organisms and Their Environment, pp. 78-81 Environments Change Over Time, pp. 81-82 Ecosystems, pp. 82-83	Launch Lab: Analysis 1, p. 77 Q questions 1-3, p. 78 Investigation 3.A: Analysis 1, p. 80 Try This: Rising Temperatures in the Arctic, p. 81 Fig. 3.6, Fig 3.7, p. 82 Section 3.1 Review: 3, 6, p. 84 Web Link: Ecoregions, p. 98 Section 3.3 Review: 3, p. 108 Chapter 3 Review: 1, 7, p. 110 Unit 2 Review: 5, p. 148 Investigation 3.C: Procedure 1, 2, p. 100 Chapter 3 Test
20–B1.4k explain how limiting factors influence organism distribution and range, e.g., ■ *abiotic factors: soil, relative humidity, moisture, ambient temperature, sunlight, nutrients, oxygen* ■ *biotic factors: competitors, predators, and parasites*	Section 3.3: Factors Limiting Growth in Ecosystems, pp. 98-100 Launch Lab: The Mountain Pine Beetle vs an Ecosystem, p. 77 Section 3.3: Abiotic Limiting Factors, pp. 100-101 Biotic Limiting Factors, pp. 101-103	Fig. 3.4 question, p. 80 Try This: Rising Temperatures in the Arctic, p. 81 Chapter 3 Test Launch Lab: Ext. 4, p. 77 Section 3.1 Review: 7, p. 84 Q question 8, p. 96; 9, p. 97; 10, p. 101; 11, p. 103 Figure 3.26 question, p. 100 Section 3.3 Review: 4, 5, p. 108 Chapter 3 Review: 8, 14, p. 110; 18(c), p. 111 Unit 2 Review: 6, 9, 10, 11, 12, 13 p. 148; 49, p. 151
20–B1.5k explain the fundamental principles of taxonomy, i.e., domains, kingdoms, and binomial nomenclature.	Section 3.2: Classifying and Naming Organisms, pp. 85-92	Q question 5, p. 87 Try This: Biological Classification, p. 87 Fig. 3.13 question, p. 89 Section 3.2 Review: 1-4, p. 92 Chapter 3 Review: 9, 10, 13, p. 110; 15, 16, 18, 19, 22 p. 111 Unit 2 Review: 3, 8, p. 148; 26, p. 149 Chapter 3 Test

	Student Textbook	Assessment Options
Outcomes for Science, Technology and Society (Emphasis on Social and Environmental Contexts)		
20–B1.1sts explain that science and technology have both intended and unintended consequences for humans and the environment, by **(STS3)**	Section 3.3: Habitats and Niches within Ecosystems, pp. 97-98	
■ *evaluating the impact that human activity has had, or could have, on the biodiversity in an ecosystem and the influence of the needs and interests of society on this practice, e.g.,* ■ *draining of wetlands* ■ *interbasin water transfer* ■ *habitat fragmentation* ■ *land use* ■ *urbanization* ■ *slash-and-burn and clear-cutting practices* ■ *monoculturing, e.g., forests, lawns, agriculture*	Investigation 3.A: Observing Leaves, p. 80 Figure 3.24, p. 98 Thought Lab 3.2: Forest Habitat and Bird Biodiversity, p. 99	Investigation 3.A: Procedure 1, Analysis 1, p. 80 Thought Lab 3.2: Analysis 4, p. 99 Chapter 3 Review: 20, 21, p. 111 Unit 2 Review: 37, p. 150
■ *assessing the environmental consequences of introducing new species to established ecosystems and the responsibility of society to protect the environment through science and technology, e.g.,* ■ *tropical fish in Banff Hot Springs, starlings, quack grass, scented chamomile, purple loosestrife*	Predators Limit Populations (Arctic Fox), pp. 102-3 Thought Lab 3.3: Super Competitor: Knapweed, p. 102	Q question 11, p. 103 Thought Lab 3.3: Analysis 1-4, p. 102 Chapter 3 Review: 11, p. 110; 18(d), p. 111
20–B1.2sts explain that conventions of mathematics, nomenclature, and notation provide a basis for organizing and communicating scientific theory, relationships, and concepts, e.g., **(NS6b)** ■ *researching the historical development of the modern classification system, e.g., the structural and molecular basis.*	Section 3.1: Populations, Fig. 3.5A and 3.5B (Collared Pika), p. 81 Section 3.2: Fig. 3.10, p. 85 Naming Systems, pp. 88 The Classification of Organisms, Classification in Transition, pp. 85-87	Q question 6, p. 89 Section 3.2 Review: 1, 3, 6, p. 92 Chapter 3 Review: 22, p. 111
SKILL OUTCOMES (FOCUS ON SCIENTIFIC INQUIRY)		
Initiating and Planning		
20–B1.1s ask questions about observed relationships and plan investigations of questions, ideas, problems, and issues, and define and delimit problems to facilitate investigation by	Thought Lab 3.1: Planning for Your Field Study, p. 83 Investigation 3.C: Preparing for Your Field Study, p. 100	Thought Lab 3.1: Procedure 2-4, p. 83 Investigation 3.C: Procedure 2, p. 100
■ hypothesizing the ecological role of biotic and abiotic factors, e.g., *competition and Chinooks* **(IP–NS3) [ICT C6–4.1]**; by	Launch Lab: The Mountain Pine Beetle vs an Ecosystem, p. 77 Investigation 3.A: Observing Leaves, p. 80 Investigation 3.C: Preparing for Your Field Study, p. 100	Launch Lab: Analysis 1, p. 77 Investigation 3.A: Analysis 3, p. 80 Investigation 3.C: Procedure 2, p. 100 Unit 2 Review: 27(a), p. 149; 35, p. 150; 45, 46, p. 151
■ *planning a field study to gather and evaluate biotic and abiotic characteristics associated with an ecosystem or ecosystems, e.g., effects that dominant plants have on abiotic conditions such as soil and microclimate* ***(IP–NS1, 2, 3, 4) [ICT C7-4.1)***	Investigation 3.A: Observing Leaves, p. 80	Investigation 3.A: Procedure 1, p. 80

	Student Textbook	Assessment Options
Performing and Recording		
20–B1.2s conduct investigations into relationships between and among observable variables and use a broad range of tools and techniques to gather and record data and information by	Investigation 3.B: Creating a Dichotomous Key, pp. 90-91 Investigation 3.C: Preparing for Your Field Study, p. 100	Investigation 3.B: Procedure 1-3, p. 90 Investigation 3.C: Analysis 1-3, p. 100 Unit 2 Review: 29, p. 149
■ performing a field study to quantitatively measure appropriate abiotic characteristics of an ecosystem or ecosystems and to gather evidence for analysis, both quantitatively and qualitatively, of the diversity of life of the ecosystem(s) studied **(PR–NS1, 2, 4, 5)** ■ *researching and developing a land reclamation strategy for a disturbed area as a solution to environmental damage, e.g., open pit mine, garbage dump, school yard reclamation* ***(PR–STS1) (PR–NS1, 4) [ICT C5–4.1, C1-4.1)***	Investigation 3.A: Observing Leaves, p. 80 Thought Lab 3.1: Planning for Your Field Study, p. 83 Investigation 3.D: An Ecosystem Field Study, pp. 106-107	Investigation 3.A: Procedure 3, p. 80 Thought Lab 3.1: Procedure 3, p. 83 Investigation 3.D: Analysis 1, p. 107
Analyzing and Interpreting		
20–B1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by	Section 3.1: Populations, Fig. 3.5A and 3.5B (Collared Pika), pp. 79-81	Fig. 3.16, p. 94
■ applying classification and binomial nomenclature systems in a field study **(AI-NS1)**	Investigation 3.D: An Ecosystem Field Study, pp. 106-107 Investigation 3.D: Exp. Plan 1, p. 106-107	Chapter 3 Review: 15, 16, p. 111
■ analyzing the interrelationship of biotic and abiotic characteristics that make up the ecosystem(s) studied in the field **(AI–NS2, 3, 5, 6)**	Investigation 3.A: Observing Leaves, p. 80	Investigation 3.A: Analysis 3, p. 80
■ evaluating the accuracy and reliability of instruments used for measurement and identifying the degree of error in the field study data **(AI-NS4)**	Investigation 3.B: Creating a Dichotomous Key, pp. 90-91 Investigation 3.C: Preparing for Your Field Study, p. 100 Investigation 3.D: An Ecosystem Field Study, pp. 106-107	Investigation 3.B: Analysis 1-3, pp. 90-91 Section 3.2 Review: 5, 6, p. 92 Investigation 3.C: Analysis 1-3, p. 100 Investigation 3.D: Conclusion 7, 8, p. 107
■ *compiling and organizing evidence from a variety of sources, for or against human activity being responsible for ecosystem change and analyzing the relationship between human activity and changing ecosystems* ***(AI–NS2, 6) (AI–STS2) (ICT C2-4.1)***	Thought Lab 3.2: Forest Habitat and Bird Biodiversity, p. 99 Thought Lab 3.3: Super Competitor: Knapweed, p. 102	Thought Lab 3.2: Analysis 1-4, p. 99 Chapter 3 Review: 17, 18(d), 20, 21, p. 111
Communication and Teamwork		
20–B1.4s work as members of a team to address problems and apply the skills and conventions of science to communicate information and ideas and to assess results, by	Investigation 3.B: Creating a Dichotomous Key, pp. 90-91	Investigation 3.B: Procedure 9; Analysis 2, pp. 90
■ *working co-operatively to gather and share data on field trip* ***(CT–NS1, 2) [ICT P2–4.1, P4–4.3]***	Investigation 3.A: Observing Leaves, p. 80 Thought Lab 3.1: Planning Your Field Study, p. 83 Investigation 3.B: Preparing Your Field Study, pp. 90-91 Investigation 3.D: An Ecosystem Field Study, pp. 106-107	Investigation 3.A: Procedure 3, p. 80 Thought Lab 3.1: Procedure 2, p. 83 Investigation 3.B: Procedure 9; Analysis 1, 2, pp. 90-91 Investigation 3.C: Exp. Plan 1-4, pp. 106-107
■ *working co-operatively to make clear and logical arguments to defend a decision on a given issue, e.g., human impact, land reclamation, wildlife habitat preservation* ***(CT–STS1, 2, 3, 4) [ICT C7–4.1, 4.3]***	Investigation 3.D: An Ecosystem Field Study, pp. 106-107	Investigation 3.D: Conclusion 6, p. 107 Unit 2 Review: 36, 37, p. 150
■ *developing, presenting and defending a strategy to improve wildlife habitats* ***(CT–STS3) [ICT C7–4.1, 4.2, 4.3]***	Connections (Social and Environmental Contexts): The Smeetons and the Swift Fox, p. 104	Connections: 1, p. 104

Chapter 3

Ecosystems and Their Diversity

Student Textbook pages 76–111

Chapter Concepts

3.1 Individuals, Populations, and Communities in Ecosystems

- The distribution and abundance of organisms depend on interactions among organisms, and between individuals and their environments.
- An organism's environment includes abiotic and biotic components.
- Interactions between organisms and their environment can be categorized based on: individuals, populations, communities, and ecosystems.

3.2 Classifying and Naming Organisms

- Organisms are organized into groups (such as kingdoms), depending on shared biological characteristics.
- Internationally, scientists use a biological system of binomial nomenclature (two-word naming systems).
- Dichotomous keys are used to identify the two-word scientific name for individuals of a species.

3.3 Studying Organisms in Ecosystems

- Each biome has a particular mix of organisms that are adapted to living in its environmental conditions.
- Organisms have habitats, ranges, and ecological niches in ecosystems.
- Limiting factors influence the distribution, range, and abundance of organisms.
- Scientists take random samples to estimate population sizes.
- Sampling techniques include censuses, transects, and quadrats.

Common Misconceptions

- Students may have a difficult time distinguishing between populations and communities, habitat and niche, quadrat and transect. Review key vocabulary on a regular basis.
- It is a common misconception that Carolus Linnaeus invented binomial nomenclature. Linnaeus invented the concept of organizing species according to shared characteristics, using a hierarchical system of classification. Binomial nomenclature dates back 200 years before Linnaeus to Gaspard Bauhin (1560–1624), a Swiss botanist who introduced the concept.

Helpful Resources

Books and Journals

- Gadd, Ben, *Handbook of the Canadian Rockies,* Corax Press, Jasper, 1999 ISBN 0969263112.
- Inside Education, *Guide to the Common Native Trees & Shrubs of Alberta,* Field Identification Book. Order from: Inside Education: http://www.insideeducation.ca/CTSWebsite/forestedresources.html.
- Inside Education, *Aquatic Invertebrate Monitoring Program.* Order from: Inside Education: http://www.insideeducation.ca/CTSWebsite/forestedresources.html
- Jarvis, Phil, *Practical Statistics for Field Biology,* John Wiley & Sons Canada, Toronto, 1998 ISBN: 0471982962.
- Ricklefs, Robert E., *The Economy of Nature,* 5th edition, W.H. Freeman and Company, New York, 2001.
- Draper, Dianne, *Our Environment: A Canadian Perspective,* Nelson: Thompson Canada, Toronto, 3rd ed., 2005, ISBN 0-17-64581-5
- Raven, P., *Biology,* 7th Edition, McGraw-Hill, New York, 2002 ISBN: 0072437316.
- Molles, Manuel, *Ecology,* 3rd edition, McGraw-Hill Ryerson, Toronto, 2005, ISBN 0072951710.

Web Sites

Web links related to information about ecosystem diversity can be found at **http://www.albertabiology.ca**. Go to the Online Learning Centre, and log on to the Instructor Edition for the links to Chapter 3.

List of Blackline Masters

Blackline masters (BLMs) have been prepared to support the material in this chapter. The BLMs are either for assessment (AST); use as overheads (OH); or use as handouts (HAND), in particular to support activities. Most handouts and all assessment tools are supported by a BLM with the answers (ANS). The BLMs are in digital form, stored on the CD that accompanies this Teacher Resource or on the web site at **www.albertabiology.ca**, Online Learning Centre, Instructor Edition, BLMs. They can be modified to suit the needs of your students.

Number (Type)

3.0.1 (HAND) Meiosis and Mitosis: A Comparison
3.0.2 (HAND) Launch Lab: The Mountain Pine Beetle vs an Ecosystem
3.0.2A (ANS) Launch Lab: The Mountain Pine Beetle vs an Ecosystem Answers
3.1.1 (HAND) Every Species Counts!

3.1.2 (HAND) What can you infer from a handful of soil?
3.1.2A (ANS) What can you infer from a handful of soil? Answers

3.1.3 (HAND) Investigation 3.A: Observing Leaves
3.1.3A (ANS) Investigation 3.A: Observing Leaves Answers
3.1.4 (HAND) Thought Lab 3.1: Planning for Your Field Study
3.1.4A (ANS) Thought Lab 3.1: Planning for Your Field Study Answers

3.2.1 (HAND): Classifying My Music
3.2.2 (OH) The Three Domains of Life
3.2.3 (HAND) Domain Characteristics Organization Chart
3.2.4 (HAND) Taxonomy Organization Chart
3.2.5 (HAND) Using Dichotomous Keys
3.2.6 (HAND) Investigation 3.B: Creating a Dichotomous Key
3.2.6A (ANS) Investigation 3.B: Creating a Dichotomous Key Answers

3.3.1 (OH) Terrestrial Biomes According to Temperature and Precipitation
3.3.2 (OH) Aquatic Biomes
3.3.3 (HAND) Ecoregions of Alberta
3.3.4 (HAND) Thought Lab 3.2: Forest Habitat and Bird Biodiversity
3.3.4A (ANS) Thought Lab 3.2: Forest Habitat and Bird Biodiversity Answers
3.3.5 (HAND) Investigation 3.C: Preparing for Your Field Study
3.3.5A (ANS) Investigation 3.C: Preparing for Your Field Study Answers
3.3.6 (HAND) Thought Lab 3.3: Super Competitor: Knapweed
3.3.6A (ANS) Thought Lab 3.3: Super Competitor: Knapweed Answers
3.3.7 (HAND) Investigation 3.D: An Ecosystem Field Study
3.3.7A (ANS) Investigation 3.D: An Ecosystem Field Study Answers
3.3.8 (AST) Challenge Analysis: Swift Fox Survey
3.3.8A (ANS) Challenge Analysis: Swift Fox Survey Answers

3.4.1 (AST) Chapter 3 Test
3.4.1A (ANS) Chapter 3 Test Answer Key

Using the Chapter 3 Opener

Student Textbook pages 76–77

Teaching Strategies

- The mountain pine beetle is a parasite that is destroying tracts of forest in British Columbia and has been found in forests in Alberta. The infestation is (unfortunately) a very good example of the effect of abiotic factors (warmer temperatures) on an organism (the mountain pine beetle), with devastating effect on the ecosystem.
- Students will be reading about the infestation throughout this chapter as they review the mechanisms that keep ecosystems healthy and the tools that scientists use to study the problem and communicate with each other.

Launch Lab: The Mountain Pine Beetle vs an Ecosystem

Student Textbook page 77

Purpose

Students identify an abiotic characteristic and explain its influence on a terrestrial ecosystem, as well as its effect on other species and communities.

Outcomes

20-B1.1k
20-B1.3k
20-B1.4k
20-B1.1s

Advance Preparation

When to Begin	What to Do
One day before	■ Photocopy **BLM 3.0.2: Launch Lab: The Mountain Pine Beetle vs an Ecosystem**

Materials
■ none

Time Required

50 minutes (15 minutes for class or small group reading and discussion of the introduction; 15 minutes to answer Analysis questions; 20 minutes to answer Extension question)

Helpful Tips

- Review the concept of biotic and abiotic factors.
- Use **BLM 3.0.2: Launch Lab: The Mountain Pine Beetle vs an Ecosystem** to support this activity. Remove sections as appropriate to meet the needs of the students in your class. The answers can be found on BLM 3.0.2A.
- Analysis questions can be done as a class or in small groups.
- Extension question could be done as an interview exercise outside class.
- Students may be interested to hear a presentation from a representative of Alberta's Public Lands and Forests Division when you begin the chapter or perhaps later during the study of the chapter.

Answers to Analysis Questions

1. Biotic factors affecting the lodgepole pine include: logging, parasites, disease; abiotic factors affecting the lodgepole pine include: fire, temperature, available moisture, sunlight, soil.

Biotic factors affecting the mountain pine beetle include: availability of food (mature trees), predators (none); abiotic factors affecting the mountain pine beetle: fire and temperature are the key ones.

2. The key reason is the occurence of warmer winter temperatures for several years, which have allowed the pine beetle to spread unhindered. Fire suppression has meant that trees are older and closer together, and thus more accessible to the insects.

3. Local reports suggest that the forest ecosystem is no longer able to support small mammals, song birds, and local plants in terms of providing food or shelter.

Answer to Extension Question

4. Students should include reference to aesthetic as well as economic and social impacts of the infestation, such as deterioration of the forest (all); disappearance of wildlife (all); loss of important medicinal plants (elder); loss of employment (logger, wilderness tour operator); disruption of local economies (logger, wilderness tour operator); disruption of communities (elder, logger, wilderness tour operator); challenge of forest management (planner).

Assessment Option

- Collect and evaluate students' answers to Analysis and Extension questions.

3.1 Individuals, Populations, and Communities in Ecosystems

Student Textbook pages 78–84

Section Outcomes

Students will:

- define and explain the interrelationship among individual organisms, populations, communities, and ecosystems
- recognize different aspects of ecosystems that ecologists might study
- plan and design an investigation to study a local ecosystem

Key Terms

biotic
abiotic
species
population
community
ecosystem
biosphere

Biology Background

- Interactions between organisms occur on 4 levels: individuals (species), populations, communities, and ecosystems.
- Populations, communities and ecosystems all have the ability to adapt (see Chapter 4) to new and changing conditions.
- Change in nature is constant, caused by both natural and human disturbance.
- Populations fluctuate, in response to 4 variables: births, deaths, immigration, and emigration. Rate of population change = (births + immigration) – (deaths + emigration). These variables are influenced by resource availability and changing environmental conditions.
- Ecological succession refers to the development of communities gradually over time, from relatively unstable, quickly changing communities, to stable, mature communities. Stable communities typically have large plants, high diversity, and many niches. Ecosystem development that begins from bare rock (for example, after a volcanic flow) is called primary succession, while ecosystem development that begins in an area where vegetation exists is called secondary succession.
- Ecosystem succession (change) is not predictable in that the exact species or community distribution is not predictable. However, it can be said that each successive stage becomes more and more stable, until the final most mature stage is reached, termed the climax community. The climax community is not permanent; rather, it too will change when the environment changes.
- Biodiversity (biological diversity) includes genetic (variation within species), species (number and abundance of species in different habitats), and ecological diversity (the variety of ecological communities).
- Biodiversity = number of species + speciation (new species) – extinction.
- Ecosystem disturbance is widespread over the globe and increases as the human population grows. When humans alter an environment, the changes cause other unpredictable effects on all other species in the environment. This process is known as the principle of connectedness.
- Human activity affects natural habitats in 4 ways: destruction (clearcutting for grazing or agriculture), pollution (oil spills, acid rain, pesticides), disruption (by human activities such as tourism), and fragmentation (by roads and increasing edge; exposing a patch to invaders).

Teaching Strategies

- Introduce this section with a slide show of different photos of ecosystems, populations, communities, and species from around the world. Discuss what factors might change populations, why ecosystems are different in different parts of the world, and how humans have affected ecosystems.
- Use Figure 3.2 on page 79 to help students differentiate among individuals, populations, communities, and ecosystems. Have students create a graphic organizer to help them distinguish the meaning of the different terms.
- An underlying theme to the chapter is that human activities have an impact on individuals, populations, communities, and ecosystems. An introductory lesson

might include creating a chart on the board (see below). Start students off with 1 or 2 examples, and encourage them to be as specific as possible. Students should be able to come up with at least 15 disturbances; they will need assistance in filling in some of the columns. Try to emphasize the solutions/mitigation column.

Ecological Disturbance (Problem)	Cause	Ecological Effects	Potential Solutions
e.g., Clearcutting in the boreal forest	Logging	Habitat fragmentation	Reforestation, selective harvesting, etc.

- As an alternative, you could use **BLM 3.1.1: Every Species Counts** to show the effect on a food web when one or more species disappears.
- As an alternative to the class discussion on the effects of ecological disturbance, use **BLM 3.1.2: What can you infer from a handful of soil?** as a classroom or demonstration activity comparing soil samples from a natural habitat and a disturbed habitat. **BLM 3.1.2A** provides answers to questions. See lab notes below.
- **Investigation 3.A: Observing Leaves**. This activity will help students observe the effects of varying abiotic factors on morphology of organisms within the same species.
- **Thought Lab 3.1: Planning for Your Field Study.** This is the first activity that students will complete in preparation for the end-of-chapter field study. Be sure to provide an overview of ecosystem characteristics to sample, as well as a description of where the class will be sampling (independent assignment or as a class trip).
- Aboriginal cultures in Canada do not divide the world into living and non-living components. Ask a local elder or Aboriginal member of the community working on supporting the environment to come in to talk about this perspective. (See Biology File: FYI on page 78)

SUPPORTING DIVERSE STUDENT NEEDS

Some of the terminology in this chapter may be challenging to some students. Plan to spend some time helping students develop the vocabulary that they will need in order to understand and communicate the concepts presented in this unit. Students may keep a vocabulary list, flashcards, or create a word wall of terms for quick reference.

Alternate Investigation: What can you infer from a handful of soil? Found on BLM 3.1.2

Purpose

Students will analyze biotic and abiotic characteristics of two soil samples from a local ecosystem.

Outcomes

- 20–B1.2s
- PR–NS1, 2, 4, 5

Advance Preparation

When to Begin	What to Do
2–3 days before	■ Obtain a sufficient quantity of samples of soil from two different locations in a local ecosystem ■ Photocopy **BLM 3.1.2: What Can You Infer from a Handful of Soil?**

Materials
■ samples of soil from two different locations ■ 2 petri dishes ■ hand lens ■ microscope (optional)

Time Required

45–60 minutes (10 minutes for set-up/clean-up; 20 minutes for observations; 15 minutes for analysis and conclusions)

Helpful Tips

- Review the concept of biotic and abiotic factors.
- Set clear behaviour expectations regarding set-up and clean-up.
- If using a microscope or dissecting scope, review proper handling and how to use it.
- Discuss organic matter, soil texture, humus, colour, and other physical descriptors of soil that students are likely to make so that they can include these terms in their observations.
- Discuss with students what evidence could be gathered to infer that animals were present, even if they are not in the soil sample.
- Create a class observation chart on the board to pool data and have a class discussion at the end of the activity comparing the two sites.
- Remind students to wash their hands at the end of the activity.

- Use **BLM 3.1.2: What can you infer from a handful of soil?** to support this activity.
- You may wish to use this activity as a demonstration activity to support planning for the field test in Investigation 3.D: An Ecosystem Field Study.

Safety Precautions

Students should wear gloves when handling soil samples.

Answers to Analysis Questions

1. Evidence of living things in soil samples will vary from site to site. Examples include: grass (or other vegetation), leaves, moulds, insects (count and classify), burrows, and scats.

2. Soil samples will be different between disturbed and nondisturbed sites. Non-disturbed sites should have a higher diversity of plants, contain more organic matter, and will be darker because of a thick humus layer. Disturbed sites will likely be more compacted, lighter in colour, and have less plant diversity and fewer insect burrows or evidence of other animals.

3. Possible inferences that will be made are: activities that take place at the site, comments on animals that use the site and why, level of development, and human use. It should be concluded that, based on the evidence gathered, one sample is from a disturbed site, and the other is from a natural site.

Assessment Options

- Collect observation tables; check for titles, column headings, diagrams, etc.
- Assess answers to Analysis questions.

Figure 3.1

Student Textbook page 78

The current abundance and distribution of pronghorns fluctuates naturally, depending on winter and summer climatic conditions (including snow depth, drought, and temperature). Populations are limited by factors that include emigration, winter mortality, mortality of kids exposed to spring storms, coyote (predator) populations, and poor primary production (food) after extreme winters. The decline of pronghorn populations in North America (from 40 million to 30 000) can be attributed to habitat loss, fragmentation, and the construction of barriers, such as fences, along roadways (unlike deer, pronghorn do not like to jump over fences; they would rather move underneath them), vehicle collisions, and illegal hunting.

Answers to Questions for Comprehension

Student Textbook page 78

Q1. Biotic components will include: population numbers of pronghorn, coyote, grasses, birds, rodents, microorganisms, soil invertebrates, etc. (Check that all listed components are living.)

Q2. Biotic components of students' environments include the food they eat, pets they have, trees in their yards, people they interact with, their families, etc. Abiotic components of students' environments include where they live (community, house), the air they breathe, the water they drink, the clothes they wear, etc.

Q3. Biotic components of the starfish's environment include sea urchins, plants, algae, microorganisms—all the other organisms in the community. The abiotic components include rocks, water, sunlight, silt, sand, sediment, and decaying plant and animal material.

Figure 3.3

Student Textbook page 79

The Banff Springs snail (*Physella johnsoni*) is found in five hot springs on Sulfur Mountain. Populations increase in December, and decrease from March to June (nobody knows why). The snails live in water that ranges in temperature from 30 °C to 36 °C. As the temperature of the water increases, snail numbers increase; as such, snails are found closest to the source of the spring. Numbers decrease with distance from the source. Also associated with high temperatures are low dissolved-oxygen levels in the springs. The snail grazes on algae and bacteria and is in competition with soldier fly larvae.

Figure 3.4

Student Textbook page 80

The glacier lilies form a group of individuals of the same species living in a specific area at the same time (in the valley in the Bugaboo mountains where the photo was taken), which qualifies them as a population. The edges look clearly defined in the photo and would be where the conditions become too inhospitable (soil runs out, it's too cold, it's too dark) for the lilies to survive. This would definitely be a boundary or barrier to increased numbers of glacier lilies.

Investigation 3.A: Observing Leaves

Student Textbook page 80

Purpose

Students will analyze the effects of abiotic factors (such as sunlight) on the leaves of plants.

Outcomes

- 20–B3.1s
- AI–NS2, 3, 5, 6

Advance Preparation

Note: You can complete this lab simply and quickly using trees on the school property, or comparing leaves on indoor plants (in the winter); or it can be completed as part of the larger field study in Section 3.4.

When to Begin	What to Do
Start of the school year	■ Find a site with the same species of plant, distributed over a distance. For example, compare aspen leaves on trees in a clearing vs aspen leaves on a tree among others (varying light conditions).
1 month before trip	■ Complete your school's paperwork for a field trip if this activity is off campus.
1 week before investigation	■ Distribute field trip form if necessary. ■ Have students consider which variables they will be analyzing and design their lab. ■ Distribute **BLM 3.1.3: Investigation 3A: Observing Leaves.**

Materials
■ ruler ■ measuring tape ■ light meter ■ thermometers (optional)

Time Required

- Will vary if time is required to travel off-site.
- 50 minutes (25 minutes for measurements; 25 minutes for analysis).

Helpful Tips

- Use BLM 3.1.3: Investigation 3.A to support this activity. Modify it as necessary.
- It is not necessary to leave the school grounds, as long as there are trees in the field or plants in the lab.
- Be sure that students are comparing within the same species (e.g., for the purpose of this lab, do not compare spruce needles to lodgepole pine needles).
- It is useful to compare leaves on the same tree when comparing surface area with varying light intensity ($\frac{1}{2}$ that are south-facing and $\frac{1}{2}$ that are north-facing) to show that differences are not necessarily because of individual variations.
- Measure leaves while leaving them on the trees when possible.
- Discuss precision of the rulers (for example, if mm are shown on the ruler between cm markings, then data can be recorded to two decimal places).
- Introduce the concept of sample size, and ask the class why it is important to take more than one measurement from each of the two data points (see Section 3.3, page 105 for background).
- Distinguish between length and surface area; ensure students are consistent with their frame of reference throughout the lab. Surface area will be logical for broadleaf leaves; length for needles.
- Show students how to estimate surface area for their leaves (simply multiply length × width in the widest spot of the leaf).
- In addition to surface area or length, students could also measure and compare leaf mass between sites or temperature differences between sites.

SUPPORTING DIVERSE STUDENT NEEDS

- Some students may require a review on how to calculate averages.
- If students are strong in mathematics, you may want to have them calculate the statistical difference (variance) between the two data sets in addition to calculating averages.

Answers to Analysis Questions

1. Abiotic conditions will vary between the two sites (light is the abiotic factor that will be most relevant). Ensure that students are able to describe these differences quantitatively when possible, and explain why the differences occur. They should describe other abiotic factors (e.g., temperature) as well.
2. Have students calculate averages for their two sites separately, then compare results of the differences in needle length or leaf surface area. If there is no difference between sample sites, have students look at another measurable variable (for example leaf mass) or formulate a new research question.
3. Differences in leaf morphology will occur when light levels vary. Leaves with greater light exposure will likely be larger in order to maximize photosynthetic rates. Plants will arrange their leaves in an attempt to maximize light interception and minimize photoinhibition.

Assessment Options

- Assess answers to Analysis questions.
- Have students write up a full laboratory report. Use Assessment Checklist 2: Laboratory Report (See Appendix A.)

Biology File: Try This

Student Textbook page 81

As temperatures increase, melting the ice pack, the reproductive success of species for which ice platforms are crucial habitat (e.g., polar bears and walrus) is threatened. Both of these organisms are at the top of their arctic food chains (top predators). If the populations of these predators decline, then the populations of their prey organisms, such as seals and arctic cod, will potentially increase; they will be limited again by the amount of food available to them. To have students construct an arctic food web or investigate other arctic organisms, have them visit: **http://www.arctic.uoguelph.ca/** or use the link at **www.albertabiology.ca**, Online Learning Centre, Instructor Edition, Teacher Web Links.

Figure 3.6

Student Textbook page 82

What this meadow will look like in 200 years entirely depends on the interaction and influences of abiotic and biotic factors, coupled with natural (or human) disturbance. Factors to consider include climate change, development, fires, glaciation, landslides, avalanches, or pest or disease outbreaks. As temperatures continue to warm and carbon dioxide levels continue to increase, it is possible that what is now a meadow may likely be covered by the dominant tree of the area, such as white spruce; or if there is no drainage outlet in the area, and the glaciers in the background continue to melt, the area may become a lake.

Figure 3.7

Student Textbook page 82

One would not expect trees to grow on a site that was freshly exposed by glacier retreat because change takes time. How much time that change takes will vary. When a new area is exposed, it will attract species—colonizers (pioneers) that can stand environments with high light intensity and low soil quality and quantity; this begins at the microscopic level. The next group of species will be slower at colonizing but more successful than the previous group. As meadows change, becoming more diverse with a variety of plants and small shrubs, the new plants add detritus to the soil community and shade it from the sun, thereby increasing soil moisture. This allows shade-tolerant plants, like spruce trees, to grow. For further reading on models of succession, visit: **http://www.utoronto.ca/env/jah/ace/C61_lc02.htm**.

Answers to Question for Comprehension

Student Textbook page 82

Q4. Key points to include are interactions between two different species (e.g., predator-prey) and interactions within species (e.g., wheat plants compete with each other for light and nutrients). Students will likely come up with ideas regarding symbiosis. Examples include mutualism, commensalisms (further discussed in Biology 30), and parasitism (see Section 3.3).

Biology File: Try This

Student Textbook page 82

Assess students' understanding of the ecological levels of organization. If they chose coins: Individual = penny; population = 25 pennies; community = pennies, dimes, nickels, and quarters; ecosystem = pennies, dimes, nickels, quarters, and a $5 bill (coins are biotic components; bills are abiotic components).

Thought Lab 3.1: Planning for Your Field Study

Student Textbook page 83

Purpose

Working as members of a group, students will plan a field study to compare biotic and abiotic components of two ecosystems. Students will choose an ecosystem; consider which individuals, populations, and communities exist within it; and decide how to organize and store the information they gather.

Outcomes

- 20–B1.1s
- ICT P6–4.1

Advance Preparation

When to Begin	What to Do
Start of the school year	■ Choose location for field study. Book field trip if necessary. Complete your school's paperwork for a field trip if this activity is off campus.
1 week before investigation	■ Copy **BLM 3.1.3: Planning for Your Field Study.** ■ Book the library or computer lab.

Time Required

45 minutes (20 minutes for discussion; 25 minutes for research)

Helpful Tips

- Have students read through **Investigation 3.C: Preparing for Your Field Study** (page 100) and **Investigation 3.D: An Ecosystem Field Study** (pages 106–107) so they can plan accordingly.

- You may need to create a short list of suitable locations for field study, if the class is to do the study at the same time. Or you may want to plan to split the class up and have extra supervisors on hand for the field study. Another option may be to work with someone from Alberta's Public Lands and Forests Division or other related institution and have students assist in a local field study.
- Have students justify their choice of ecosystems in terms of location and suitability, and ask them to describe how the two ecosystems are similar and how they are different.
- Have students outline how they will store and organize their findings.
- Go to Teacker Web Links at the Instructor's Edition at the Online Learning Centre for a list of sites where students can research their chosen species.

Answer to Analysis Question

1. Students should demonstrate clear understanding of the difference between the terms population, community, and ecosystem, as well as be able to express how these terms are interrelated. Refer to question 5 in Section 3.1 Review for an example answer.

Assessment Option

- Assess species paragraph. Assess students' paragraphs on their chosen species for a full discussion on the interactions of the organism with other species, biology, nutrition requirements. Be sure that students include the references to the ecosystems they have chosen.

Section 3.1 Review Answers

Student Textbook page 84

1. A population includes all interacting members of a particular species occupying the same geographical space. A community consists of all individuals in all interacting populations in the same geographical area.
2. A fallen tree could have many interacting organisms of different species (fungi, bacteria, mosses, lichen, etc.) living upon it. All of these organisms interact with the physical environment and are influenced by abiotic factors, such as light availability, moisture, nutrients, and temperature.
3. Limber pine trees grow with their branches pointed in the direction of the prevailing winds. The dry, windy conditions would limit the height the tree could reach. The silver bark would help to reflect the intense rays of the sun, helping to keep the tree cool on a sunny, summer day. Students' answers should show a clear awareness of an abiotic factor and some suggestion of how it might influence the physical characteristics of the species.
4. **(a)** The three components of a population are all the members of the same species living in a specific area at a specific time.

   (b) All of the coyotes can be considered a single population because they are the same species (*Canis latrans*) located within a particular boundary (that of the national park), in June 2006.

   (c) All of the families of coyotes in WLNP can be considered separate populations. The national park boundary is political; it is not based on ecological boundaries (and although coyotes may live in the park, their ranges do cross over the political boundary of the park). As such, this human-constructed boundary of the park cannot be considered a natural boundary for a coyote population. Many ecosystems exist within the boundaries of WLNP, and within these ecosystems exist several populations of coyotes.

   Note: The following is additional information for students and can be used to help explain the answer to Part (C).

   Families of coyotes are commonly referred to as packs. Coyote packs are highly territorial, and they defend their range from other packs. Packs do not overlap in territory, and breeding occurs within packs between the alpha male and the alpha female. Based on this biological information, individual families of coyotes can be considered separate populations.

   (d) Students will likely argue that their second response is more reasonable because all the coyotes in WLNP can interbread.
5. Any species in Great Slave Lake is part of a larger population. For example, an individual pike belongs to the population of all pike in the lake. In turn, the pike population interacts with other populations of different species including other fish, algae, plankton, etc., through predator-prey relationships and competition. These lake communities, coupled with the abiotic factors of the lake, make up the Great Slave Lake ecosystem.
6. An ecologist studying plants that are eaten by bighorn sheep would also study the nutrient contents in soils because soils affect animals indirectly. The soil composition will dictate which plants grow; if the soil does not grow the right plants, the sheep will not eat there. Since bighorns also eat soil for the salt content, ecologists would analyze soil samples for both nutrient and salt content. This will help them determine the relationship between nutrient content and plant growth, and then analyze predicted ranges for bighorn sheep.
7. Students could include natural disturbances such as a fire, tsunami, volcanic eruption, flood, changing precipitation patterns, climate change, etc. These natural disturbances can affect the distribution and range of living things.

   Students could also look at the impact of human activities on the distribution and range of living things. Examples may include: deforestation; over-fishing; poaching, hunting, and trapping; extirpation of the buffalo; clearing lands for agriculture; damming rivers; open-pit mining; urban sprawl; use of pesticides; habitat fragmentation; fish-farming; releasing pollutants into waterways; breeding organisms and releasing them into the wild; or the arrival of invasive species.

8. All the ecosystems in the world and their interactions make up the biosphere. The biosphere includes all parts of Earth that are inhabitable by some type of life—all the land surfaces and bodies of water on Earth—and extends several kilometres into the atmosphere and under Earth's crust. All living things that inhabit these environments, as well as the abiotic components with which they interact, are part of the biosphere.

3.2 Classifying and Naming Organisms

Student Textbook pages 85–92

Section Outcomes

Students will:

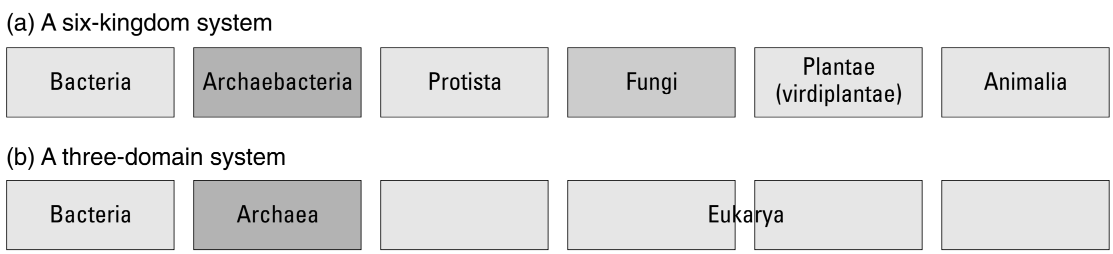
- explain how organisms are classified in domains and kingdoms
- explain how organisms are named using a two-name system called binomial nomenclature
- identify species using a dichotomous key

Key Terms

taxonomy
kingdom
domain
binomial nomenclature
dichotomous key

Biology Background

- Typically, taxonomists divide organisms into 7 taxa (groups; sing.taxon) (kingdom, phylum, class, order, family, genus, species). Increasingly, scientists use an 8th level of classification—the broadest, domain. Three domains are recognized: Archaea (Archaebacteria), Bacteria, and Eukarya (Eukaryotes).
- Each taxon implies both a group of characteristics and a group of organisms belonging to the same taxon (except at the species level, in which only one group of organisms belongs).
- Binomial nomenclature—the current naming system—identifies living organisms with a "scientific name" that consists of 2 names. The first name (*Capitalized*) identifies the genus of the organism, and the second name (*lowercased*) identifies the species. The first name applies to all species in the genus, and the second to a single species. Typically, only species and genus names are italicized; all others are capitalized only. The roots of the names are derived from Latin or Greek bases. The system is universal, and binomial names are written in italics. For example, humans are named *Homo sapiens,* domestic cats are named *Felis silvestris,* and Alberta's provincial tree, the lodgepole pine, is *Pinus contorta.* Only one species can have a particular binomial. This gives consistency and universality to the naming system.
- Dichotomous keys are used in the field and in the laboratory to identify various organisms. This tool is arranged in a series of two mutually exclusive descriptions at each level. After a decision is made at one level, one proceeds to the next set of choices and so on, until one arrives at a species name. One of the common errors associated with dichotomous keys is the assumption that the organism you are trying to identify is in the key; it is therefore important to have students identify only organisms that are in the key.



Teaching Strategies

- Use **BLM 3.2.1 (HAND) Classifying My Music** to remind students of the principles of classification. Levels could include format, (MP3, CD), type of music (pop, heavy metal, classical, r&b, rap), artist, collection title, track. The key point is to have students create increasingly narrow levels of classification until they have isolated individual tracks. (Students may also wish to include information about where the music is stored at either the collection title or track level in order to make a useful catalogue. This exercise could be done as a chart in a Word Processing program or in a more sophisticated database management program. This demonstration of classification should shed some light on how databases are created.)
- Extend the idea of classification to life forms with a brief discussion of the characteristics of living things (living things are made up of cells, obtain and use energy, grow and develop, reproduce, respond to environmental stimuli, and adapt to their environment) and how they too can be divided into categories. Pages 85-88 of the student text give a brief outline of the history and development of the classification of life forms.

- Use **BLM 3.2.2 (OH) The Three Domains of Life** to show students the most recent classification scheme for organisms.
- Use the portion of the dichotomous key (reproduced as Table 3.2 on page 89 of the student text) to confirm the identity of the mite shown in Figure 3.13 on the same page. If desirable, practise using dichotomous keys with students by identifying unknown specimens. Use **BLM 3.2.3 Using Dichotomous Keys** to remind students of the process, in preparation for **Investigation 3.B: Creating a Dichotomous Key**.
- Complete **Investigation 3.B: Creating a Dichotomous Key** on pages 90-91 of the student text. Students need to understand that each step in the key must contain a mutually exclusive choice between two possibilities.

Figure 3.11

Student Textbook page 86

The first system of classification, used by Aristotle, divided living things into plants or animals. Since Euglena can photosynthesize, it would be classified as a plant. However, since Euglena can also eat other things and swim, this classification is not satisfactory. As classification systems became more sophisticated, Euglena moved into a class with other microscopic organisms such as paramecia and amoeba, known as Protists.

Answer to Question for Comprehension

Student Textbook page 87

Q5. Fungi are placed in a different category than plants because, although they are sessile, fungi cannot photosynthesize. Fungi are eukaryotic heterotrophs; they obtain their food by digesting their food outside their bodies and absorbing released molecules.

Biology File: Try This

Student Textbook page 87

A successful mnemonic enables recall. Check students' recall at the end of the class or in a later class to find out if they remembered their mnemonic and what it stands for.

Answer to Question for Comprehension

Student Textbook page 89

Q6. Binomial nomenclature clarifies communication among members of the scientific community (and others), because it is universal. No two species have the same scientific (binomial) name. A species binomial name is the same everywhere in the world.

Figure 3.13

Student Textbook page 89

Characteristics of the red velvet mite that will aid in its identification include its colour, lack of wings, number of legs, dense velvety hair, body length, and number of claws.

Investigation 3.B: Creating a Dichotomous Key

Student Textbook pages 90–91

Purpose

In this lab, students will create a dichotomous key.

Outcomes

- 20–B1.2s
- 20–B.1.4s

Advance Preparation

When to Begin	What to Do
2 days to 1 week before investigation	■ If the class will be working from specimens, collect sample species to be used in the investigation (12 or more plants are required). ■ Obtain Field Guides to enable students to identify samples (optional)

When to Begin	What to Do
1 day before investigation	■ Photocopy **BLM 3.2.4: Investigation 3.B: Creating a Dichotomous Key.** ■ Photocopy **3.2.3: Using Dichotomous Keys** (optional)

Materials
■ paper, pencil ■ sample Dichotomous Keys ■ needles, catkins, leaves, and cones of Alberta tree species (optional) (12 or more samples) ■ field Guides for identifying specimens of Alberta trees (optional)

Time Required

80 minutes

Helpful Tips

- Have students work through sample dichotomous keys to identify organisms to ensure they understand how the keys work. Use **BLM 3.2.3: Using Dichotomous Keys** to give students practice.
- If students are required to identify the specimens, use *Guide to Common Native Trees and Shrubs of Alberta* from Inside Education. (See Helpful Resources list.)
- Students can either do this investigation at their desks using the photos provided on page 91 or make it another part of practice for the field study and work from samples.
- Reiterate the importance of following the instructions in the procedure. If they take the appropriate steps in the correct order, they will not have trouble creating a key.
- Have students try each other's keys before they submit them; this will iron out any errors that they made. If the dichotomous key is not easy to use, or if there are errors in the key, have students make the necessary changes so that the key is clear and easy to use before they submit their final copy.
- Have students identify the 12 samples using the dichotomous keys provided, and add the names (both common and scientific) at the final step of their own keys that they created.

Answers to Analysis Questions

It is important that at each step choices are mutually exclusive; for example, choosing between broad leaves and needles.

1. Students will compare their key to those of other students; look for explanations as to why differences in the keys occur.
2. Problems or errors will arise when students have used general, subjective observations rather than specific, objective observations. (For example: "needles attached to the stem in groups" is not as clear as "needles attached to the stem in pairs.")
3. Likely responses are: colour of leaves (unless using variegated plants, or species that have leaves other than green; for example, wolf willow); or any other characteristic common to all plants to be identified.

Answer to Conclusion Question

4. Dichotomous keys must have two mutually exclusive choices at each step. By definition "dichotomous" means "divided into two parts." Having only two choices that are mutually exclusive ensures that each step throughout the key will lead the user, with confidence, to the correct identification of the organism, assuming that the user understands the vocabulary used in the key.

Answer to Extension Question

5. Links for student research:

   http://www.invasiveplants.ab.ca/photogallery.htm

   http://www.invasivespecies.gov/profiles/main.shtml

   http://www.agf.gov.bc.ca/cropprot/weedguid/weedindx.htm

   Example Key:

   1a. round stem (go to 2)
   1b. square stem (with 4 sides); purple loosestrife
   2a. toothed leaves (go to 3)
   2b. leaves not toothed (go to 4)
   3a. flowers up the stem; creeping bell flower
   3b. flower at terminal end of the stem; ox-eye daisy
   4a. button shaped flowers, yellow; common tansy
   4b. other (go to 5)
   5a. leaves long, thin, and flat; reed canary grass
   5b. other (go to 6)
   6a. leaves with 2–5 veins and 5 cm long; leaves opposite; common soapwort

Assessment Options

- Assess answers to Analysis and Conclusion questions.
- Assess the dichotomous key for the plants provided.
- Assess the dichotomous key created in the Extension activity.

Section 3.2: Review Answers

Student Textbook page 92

1. The categories in which organisms are grouped have changed over the last 2000 years as our understanding and knowledge of living things increases, and our abilities to apply new tools, such as more powerful microscopes, improve.
2. The challenge of identifying, classifying, and naming the organisms that make up the diversity of life on Earth has existed since humans first began to observe the environment around them. Taxonomy is the practice of classifying (grouping) living things.
3. Identifying a group as "flying animals" would not be useful to a biologist. Many different phyla of animals have particular species that can fly included in them (and not all members of these phyla can necessarily fly). A biologist would not know if you were talking about birds, bats, butterflies, mosquitoes, flying squirrels, flying fish, trapeze artists, or all—or none—of the above.

4. The chart below is an example of a chart summarizing the six kingdoms of living things.

Kingdom	Cell Type (prokaryotic or eukaryotic)	Unicellular or Multicellular	Obtain Nutrients	Sessile or Mobile	Example
Archea	prokaryotic	unicellular	chemosynthetic	most sessile	methane-producing bacteria
Bacteria	prokaryotic	unicellular	some heterotrophic others are photosynthetic	most sessile	disease-causing bacteria blue-green algae
Protista	eukaryotic	unicellular and multicellular	some photosynthetic others are heterotrophic	some sessile while others are mobile	amoeba, paramecium, Euglena (mobile)
Fungi	eukaryotic	unicellular and multicellular	heterotrophic	most sessile	mushrooms, yeast, moulds
Plantae	eukaryotic	multicellular	autotrophic (photosynthetic)	sessile	flowering plants
Animalia	eukaryotic	multicellular	heterotrophic	most mobile but some groups (sponges) are sessile	insects, mammals, birds

5. **(a)** Squirrel: 1a; Tufted Puffin: 2a; Lamprey Eel: 3b; Trout: 5a; Shark: 5b; Snake: 6a; Frog: 6b.

   (b) Squirrel → Step 1a. (Class Mammalia)

   Tufted Puffin → Step 1b.→ Step 2a. (Class Aves)

   Lamprey eel → Step 1b. → Step 2b. → Step 3b., (Class Agnatha)

   Trout → Step 1b. → Step 2b. → Step 3a. → Step 4a.→ Step 5a.→ Class Osteichthyes

   Shark → Step 1b. → Step 2b. → Step 3a. → Step 4a. → Step 5b. → Class Chondrichthyes

   Snake → Step 1b. → Step 2b. → Step 3a. → Step 4b. → Step 6a. → Class Reptilia

   Frog → Step 1b. → Step 2b. → Step 3a.→ Step 4b. → Step 6b. → Class Amphibia

6. It is useful and logical for all scientists to use the same system of classification to ensure that scientists from different parts of the world can collaborate on research and share information. The universal classification system allows scientists to name new discoveries in a way that other scientists can understand and incorporate into their own research.

3.3: Studying Organisms in Ecosystems

Student Textbook pages 93–108

Section Outcomes

Students will:

- identify abiotic and biotic characteristics, and explain how they affect ecosystems
- explain how ecosystems support a diversity of organisms because of a variety of niches and habitats
- explain how limiting factors can affect the distribution and size of a population of organisms
- design an investigation to study a local ecosystem
- research the impacts of an introduced species in western Canada
- explain the use of sampling techniques, such as quadrats and transects
- investigate and study a local ecosystem

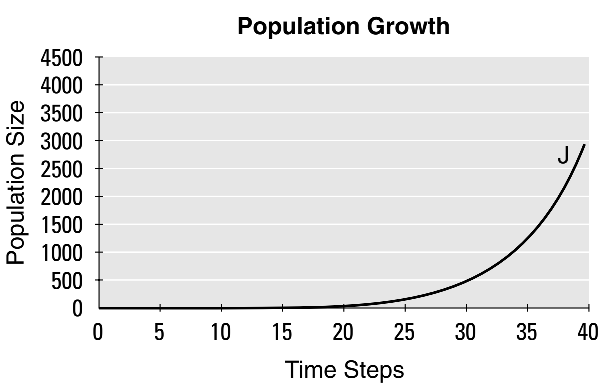
Key Terms

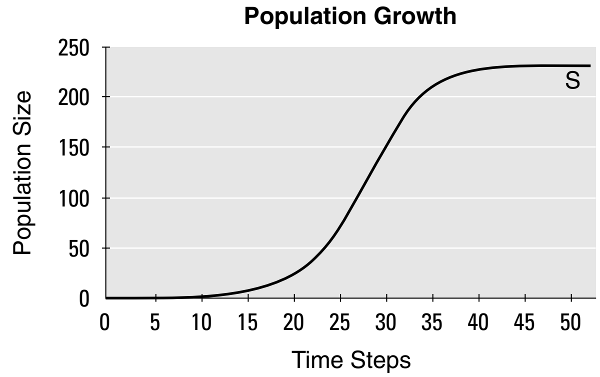
climate
biome
habitat
range
ecological niche
biodiversity
limiting factor
samples
transect
quadrat
density

Biology Background

- Energy from the Sun drives air currents that distribute water vapour through the atmosphere. Winds interact with other land features, such as mountains, forcing air upward, where it cools and loses moisture as precipitation. The interior of a continent will experience less rain, as will higher latitudes, than will coastal and equatorial regions around the globe.

- Biomes are classified using one of two systems. One system uses the climate zone system (developed by German ecologist Heinrich Walter). This system uses annual temperature and precipitation to establish boundaries of climatic zones that correspond to conditions caused by drought and stress. Another system (developed by Robert Whittaker) defines biomes on the basis of vegetation structure, coupled with average temperature and vegetation. When either of these methods is plotted on a graph, a triangle area is formed. The three corners of the triangle are interpreted as warm-moist, warm-dry, or cool-dry. (Cool regions with high rainfall are rare, since water does not easily evaporate at low temperatures). In addition to temperature and rainfall, plant communities are also influenced by topography, soils, fire, seasonal variation, and number of herbivores.
- A habitat is a place, or physical setting, in which an organism lives. Habitats are characterized by the predominant form of life (for example, a forest habitat, a desert habitat, or a coral reef habitat).
- An ecological niche is a representation of the ranges of conditions that an organism can tolerate. Additionally, the term refers to the role a species plays in the ecological system, including conditions it needs to survive, interact, reproduce, and adapt to ecosystem changes.
- Populations fluctuate. Change is regulated by both density-dependant and density-independent factors. As populations grow and approach carrying capacity, competition increases. These factors result in decreased birth rate, increased death rate, and increased toxin accumulation. Some factors that affect populations are not related to population size; these are known as density-independent factors, and they include environmental changes such as drought, fire, floods, and volcanic eruptions.
- The maximum rate at which a population can increase under ideal conditions (no limits) is called biotic potential. Under these conditions, populations will expand exponentially, following a J-shaped curve of growth. In nature, no population will continue to grow indefinitely; because of environmental resistance (limiting factors), populations will reach the carrying capacity of the environment (S-shaped curve).





- Cyclic population changes occur when a population undergoes sharp increases and decreases in populations. The influences on the rise and fall cycles are complex, often mirrored by both predators' population patterns and the cycles of the plants preferred by the herbivores.
- The carrying capacity of an ecosystem is the largest population an environment can support; it is determined by limiting factors, which include predation, competition, migration, and climatic changes. Occasionally, because of time lag, population growth will overshoot its carrying capacity, and then crash, fluctuating around the carrying capacity of the ecosystem.
- Species interactions include predator-prey relationships (such as predation and parasitism), as well as symbiotic relationships (such as mutualism and commensalism).
- The law of tolerance states that most species have an optimal quantity for most abiotic factors, and above or below that level the species will suffer. Typically, organisms have low tolerance in the juvenile and reproductive stages of their lives, when they are most sensitive to environmental changes.
- The limiting factor principle states that too little or too much of an abiotic factor (including temperature, precipitation, humidity, wind, light, shade, fire, salinity, dissolved oxygen, space, and nutrients) can limit or prevent the growth of a population even if all other limiting factors are abundant.
- Extinction affects the distribution and abundance of species on Earth; species become extinct when they can no longer adapt genetically (see Chapter 4) to reproduce in a changing environment. Continuous, low-level extinction, termed background extinction, has occurred throughout the history of time. Mass extinction, however, is the loss of numerous species over a short period of geologic time. Extinction events, although devastating for some species, provide new opportunities for successor species to evolve.
- Over-exploitation has been a major cause of extinction historically (bison, passenger pigeons, mahogany trees, commercial fishing); habitat loss is the primary cause of extinction today. Typically, populations become isolated and reduced in size because of habitat loss and fragmentation. Over time, smaller populations and

increased inbreeding result in decreased population fitness, and ultimately, the demise of the species.

- Ecologists use censuses, random samples, transects, and quadrats to determine population densities of organisms.
- Random samples ensure that every individual in a population has the same chance of being sampled.
- It is impractical to count every organism in a population, so different methods of sampling populations must be used. Quadrats are used for sessile organisms (plants); several quadrats are counted, populations averaged, and population density is extrapolated over the study area. Indirect counting is used for organisms that move around a lot; evidence of activity is recorded (nests, burrows, and tracks are counted rather than individuals). Transect lines are used to estimate populations of plants or animals in an area.
- The mark-recapture method is used to estimate animal populations. Animals are trapped, tagged, and then released. After a period of time, animals are trapped again and marked and unmarked animals are counted. Populations are estimated using the formula: total population = (number in first capture × number in second capture) / number of marked animals recaptured.
- Accuracy is limited in estimates of population size. For example, if a population is clumped, and the quadrat misses a clump in the survey, estimates will be too low. The mark-recapture method assumes that animals have the same likelihood of being trapped or surviving between captures.
- Population dispersal patterns: Ecologists classify populations' dispersion patterns in 3 different ways: clumped (e.g., schools of fish, flocks of birds, prides of lions), uniform (e.g., walnut trees), and random (i.e., unusual in nature). In reality, populations fall on a continuum of these patterns, rather than in one of the three classifications. Dispersal patterns are mirrored and determined by the distribution of limiting resources (such as food sources or water distribution).

Teaching Strategies

- Use Figure 3.14 on page 93 of the student textbook (aerial view of the Badlands) to lead the discussion of diversity and abundance of life forms on Earth. Students who have been there can add their observations.
- Students often confuse the terms "habitat" and "ecological niche." Use an analogy to introduce the terms, and review vocabulary often. A simple analogy can be: a student's habitat is the school. His or her niche would include the student's role in the school; for example, the student's schedule, classes, and extracurricular activities. A cougar's habitat is the forest, but its niche within the forest includes the types of prey it can eat, and its mating and hunting behaviours. In other words, "niche" includes not only where an organisms lives, but what it does.
- Use **BLM 3.3.1 Terrestrial Biomes According to Temperature and Precipitation** (Figure 3.16 in the student text on page 94) during the discussion of classifying regions according to abiotic and biotic characteristics. Use the data provided in the handout version to place various locations within an appropriate biome according to the graph. This visual may be revisited during any discussion of the impact of global warming and the resulting change in the environment.
- **BLM 3.3.3: Ecoregions of Alberta** can then be used to encourage students to observe abiotic conditions in their own environment (climate (particularly precipitation and temperature), geography, soil, predominant vegetation, wildlife, human impacts, etc.) and present their findings to the class.
- Use **BLM 3.3.4: Thought Lab 3.2: Bird Biodiversity**, to support the activity and emphasize the importance of habitat continuity and the negative effects of replanting an entire area with a monoculture instead of a diversity of species. The Connections feature, about the re-introduction of the Swift Fox, page 104, looks at another aspect of the importance of habitat.
- **Investigation 3.C: Preparing for Your Field Study** gives the students a chance to do background research on their chosen ecosystem and choose suitable tools for gathering information. Challenge students to justify their choices and perhaps test them prior to the field study.
- Use **Thought Lab 3.3: Super Competitor: Knapweed** to illustrate both the concept of limiting factors and the effect when a species that is not subject to any limiting factors arrives in a habitat. The textbook coverage of limiting factors, both abiotic and biotic, pages 100-103, introduces the concept of competition for resources, which will be featured in Chapter 4: Mechanisms of Population Change.
- Use Figure 3.31 on page 105 to demonstrate the concept of sampling (as opposed to taking a census) and ask students to apply the concept to their plans for the field study. You could use the Canadian government's long and short census forms as examples of census taking compared to sampling. While Statistics Canada does an actual count by issuing census forms to all households, only 10% of the population fills in the long form and answers questions relating to various social determinants. The latter is an example of a sample that is then extrapolated to make assumptions about the whole population.
- For **Investigation 3.D: An Ecosystem Field Study** make sure that all groups have the planning activities they completed earlier in the chapter available when they are constructing their field study plan. The groups should have organized themselves so that every member has a role to ensure that all objectives of the field study are met. Those who are responsible for setting up quadrats should be encouraged to either practise beforehand or write out the procedure they will use to set them up.

Figure 3.14

Student Textbook page 93

Geographic distributions of plants are determined primarily by climate, where local distributions vary with topography and soil composition. Different climatic regions around the world have characteristic types of vegetation that differ in leaf form, morphology, and seasonality. Temperate desert areas, like Alberta's badlands, have less species diversity than tropical rain forests. The key differences between these eco-regions are the average annual rainfalls and the seasonal variations in temperatures.

Figure 3.16

Student Textbook page 94

This figure has been reproduced for use as an overhead as **BLM 3.3.1: Terrestrial Biomes According to Temperature and Precipitation**. This graph can be used with local data on mean annual temperature and precipitation to predict what biome a particular location is in. This would allow students to predict the types of soils, vegetation, and life forms that could be found at that location. Plotting the data for a number of locations would allow students to assess the prevalence of the various biomes around the world.

The graph can be revisited during the discussion of abiotic limiting factors on page 100-101, with a consideration of the impact of global warming. As temperatures rise and precipitation either rises or falls, abiotic factors will change, and the number and size regions identified by the biomes indicated in the upper and left regions of the graph will increase, while areas such as tundra, taiga, temperate rainforest, and tropical rainforest will tend to shrink or disappear. **BLM 3.3.1** could be used as a handout for students who wish to pursue this subject further.

Answer to Question for Comprehension

Student Textbook page 95

Q7. The biomes found in Alberta are the mountain zone, taiga, and temperate grassland. The limitations to dividing the world into broad biomes are that the boundaries of biomes are not clearly defined (there is a gradual transition from one biome to the next) and there is a wide range of habitats within the larger biome classification that do not necessarily fit the general trends of the biome.

Biology File: Web Link

Student Textbook page 95

Look for detailed responses describing prevailing climate (precipitation and temperatures), geology, soil type, predominant vegetation, and wildlife. There should be a thorough discussion of why plants and animals are found in some biomes and not in others that refers to characteristics that suit the abiotic elements.

Figure 3.21

Student Textbook page 96

Possible responses: The hoary marmot is not found outside the range depicted in Figure 3.21 because its range is limited by its preferred habitat: high elevations. This habitat includes alpine and subalpine mountain slopes and meadows and rocky outcroppings, which have long summer days that allow for rapid plant growth of foods eaten by the marmot. Hoary marmots are dependant on large boulders near abundant vegetation (grasses, sedges, and broad-leafed herbs) in moist surroundings; their range is limited to areas where these boulders exist (in the mountains) and precipitation is sufficient to support preferred vegetation.

Answers to Questions for Comprehension

Student Textbook page 96

Q8. A species' habitat is determined by its required biotic and abiotic conditions and is located within its range. A species' range is the geographical extent of where it can be found. The species will not be found in all places within its range. It will only be found within its desired habitat.

Student Textbook page 97

Q9. Suggested answer: If the species that eats only two types of food loses one of its food sources because of a natural disturbance, human impact, or competition, it will experience increased pressure, and its niche will become smaller, threatening the species with extinction.

Figure 3.24

Student Textbook page 98

A reforested monoculture, which has been planted with a single species of tree, is very different than a natural forest ecosystem—it has fewer habitats and niches. The understory species are not replanted. Large trees and snags that provide habitat and shelter are lost. Plantation stands will support fewer native species than a natural stand at the same site.

Biology File: Web Link

Student Textbook page 98

BLM 3.3.3: Ecoregions of Alberta can be used as an overhead or a handout to encourage students to observe abiotic conditions in their own environment (climate (particularly precipitation and temperature), geography, soil, predominant vegetation, wildlife, human impacts, etc.) and present their findings to the class. Specific details regarding information from the Agro Atlases should be available if students are referring to the Alberta government web site, Ministry of Agriculture, Food, and Rural Development or use the link at **www.albertabiology.ca**. Online Learning Centre, Instructor Edition, Teacher Web Links.

Figure 3.25

Student Textbook page 99

Aspen growth is limited by sunlight; plants are extremely shade-intolerant. Aspen is not tolerant of hot temperatures. Aspen prefer well-drained, moist soils and don't tolerate long-term flooding or waterlogged soils, as the trees will develop a fungus that reduces stem life. Aspen has thin, soft bark and is susceptible to a wide variety of diseases, infestations, and especially fire. Grazing animals threaten aspen, as they eat away at the bark, exposing the tree to fungal infections.

Thought Lab 3.2: Forest Habitat and Bird Biodiversity

Student Textbook page 99

Purpose

Students will analyze data comparing the bird diversity in a single species stand (after reforestation) and a natural mixed forest stand.

Outcomes

- 20–B1.3s
- 20–B1.1sts

Advance Preparation

When to Begin	What to Do
1 day before investigation	■ Photocopy **BLM 3..3.4 Forest Habitat and Bird Biodiversity.**

Time Required

60 minutes

Helpful Tips

- Use **BLM 3.3.4: Thought Lab 3.2: Forest Habitat** to support this activity. Modify it as necessary.
- At the start of the investigation, have a brief discussion of forestry practices in Alberta. Discuss how a clearcutting differs from a forest fire in its ecosystem disturbance (it would be helpful to have a slide show of photos comparing both disturbances).
- Statistical analysis is not necessary (it's not possible given the data set, other than to calculate averages); however, you may like to have a brief class discussion of statistical analysis in ecology. (See reference at the start of the chapter.)

SUPPORTING DIVERSE STUDENT NEEDS

- Have students graph the data to see the difference between pure and mixed stands.

Answers to Analysis Questions

1. Communities in mixed stands are more diverse and have a greater abundance of species than communities in pure stands.
2. The reason that mixed stands have greater biodiversity is because these forests, with a higher variety of trees, will provide larger possibilities for habitats, and in turn support a greater number of niches. With more habitat and niches available, more species will be attracted to the area.
3. Students' answers must describe the accuracy of three of the methods.
   - Count stations being separated by 250 m ensures that two researchers are not counting the same individual at the same time.
   - Count stations being 100 m from the edge of the study area ensures that species counted were located within the boundaries of the study area rather than on the outside of the study area (if surveyors hear a bird, they do not have to guess if it is on the proper side of the boundary).
   - All birds heard or seen during a 10-minute early morning count ensures that maximum numbers of individuals in a given area are recorded.
   - Observers are tested beforehand to ensure that they can accurately identify the birds that they are likely to encounter by sight, call, and song. Observers have to know what they are counting to ensure that the diversity numbers are accurate and sources of error are reduced.
   - Counts are taken twice, once in early June and once in late June. Bird surveys are to be conducted during the breeding season, which is mid-May to late June for most species. It is important to have sampling occurring on at least two different days to have a sufficient sample size and to ensure that the weather or some other factor is not skewing results.
   - Observers counted at each station only once, and for the second survey, different observers would be at each station. This distributes potential observer error equally between stations.
4. A bird study would be helpful in identifying appropriate conservation measures when planning when and where to harvest trees. Information from bird surveys will produce data that indicate if there are any threatened or endangered bird species in a given stand.
5. The patchy burning of a forest fire creates new habitat and niches for forest organisms.

Assessment Option

- Assess answers to Analysis questions.

Figure 3.26

Student Textbook page 100

Populations of bacteria are limited by a number of factors, including increased crowding caused by overpopulation (space), food (nutrients), water, temperature, and the concentration of their waste products (toxins). The availability of required resources determines the carrying capacity of the population.

Investigation 3.C: Preparing for Your Field Study

Student Textbook page 100

Purpose

In preparation for the field study, students will gather background information to define and identify abiotic components of their selected ecosystem and determine appropriate field methods to gather and quantify their data.

Outcomes

- 20–B1.1s
- 20–B1.2s

Advance Preparation

When to Begin	What to Do
Week before investigation	■ Book the computer lab and/or library.
1 day before investigation	■ Photocopy **BLM 3.3.5: Investigation 3.C: Preparing for a Field Study.**

Materials
■ BLM 3.3.5: Investigation 3.C: Preparing for a Field Study

Time Required

80 minutes

Helpful Tips

- Review abiotic characteristics that influence ecosystems and methods that will allow one to quantitatively measure the factors.
- Discuss accuracy, precision, error, and other related terms with the class prior to beginning the activity. Refer to Appendix A: Measurement in Science page 74B.
- Discuss the importance of sample size in a field study to ensure reliability
- Have the Agroclimate Atlas link posted on the course web site or on the board for easy access, or have students search the term Agroclimate Atlas on the Alberta government site. See **www.albertabiology.ca**, Online Learning Centre, Instructor Edition, Teacher Web Links.

Answer to Procedure Question

2. Students will choose a variety of abiotic factors to measure and then describe relevant methods. Some tests will include:

- Ambient air and water temperatures: students should also research seasonal averages.
- Precipitation: Students can use a rain gauge to collect a week's worth of data if the site is nearby.
- Soil moisture: For a given soil sample, weigh the sample when it is fresh; place in an oven to dry and then weigh again. The difference in the samples will yield the moisture volume of sample.
- pH tests, conductivity, nitrates and phosphates, and flow rate: Collect water samples and analyze in the field with kits or back in the lab at school.
- Water clarity: Use a Secchi disk to measure how far a person can see into the water.
- Average abiotic factors (e.g., rainfall, climate, soils): Students can collect long-term data from Agroclimate Atlas.

Answers to Analysis Questions

1. (a/b) Data collection in the field is more accurate for precise spatial information on a specific site than information from a database. However, information gathered in the field will be from one particular time and will lend little information to trends and averages, so the field data should be coupled and presented with data from databases or maps.

2. It is important to have a number of samples from each of the sites, and to take an average of the values. Even within ecosystems, there is great variation of both biotic and abiotic characteristics. If students would like to make generalizations about their ecosystems, the more samples the better. This will increase the reliability of their data. Three samples from each ecosystem for each test will be sufficient.

3. Students should have a clear and credible plan for obtaining whatever measurement tools they need, and the team should indicate where the responsibilities have been assigned.

Answer to Extension Question

4. Answers should include name and contact information of the person who supplied the information, as well as a detailed list of the tools used in the field.

Assessment Option

- Assess answers to Analysis questions.

Answer to Question for Comprehension

Student Textbook page 101

Q10. Potential answers include nutrients available through the soil; space restrictions (bound by pot size and surrounding individuals); the amount of carbon dioxide in the air; incoming solar radiation (as plants get larger, there will be less light available to shaded plants); and the amount of water available to the plants.

Thought Lab 3.3: Super Competitor: Knapweed

Student Textbook page 102

Purpose

Students will assess the environmental impact of knapweed (an introduced species) on established ecosystems.

Outcomes

20–B1.1sts

Advance Preparation

When to Begin	What to Do
1 week before	■ Book library or computer lab. ■ Photocopy **BLM 3..3.6: Thought Lab 3.3: Super Competitor: Knapweed.**

Materials
■ BLM 3.3.6: Thought Lab 3.3: Super Competitor: Knapweed

Time Required

45 minutes

Helpful Tips

- Review the concept and consequences of invasive species (origins, why they pose a threat, control measures, environmental and economic impacts).
- Have students research another invasive species for class discussion.
- Use **BLM 3.3.6: Thought Lab 3.3: Super Competitor: Knapweed.** Modify as necessary.

Answers to Procedure Question

Background biology of spotted knapweed (*Centaurea biebersteinii*)

- Introduction: European explorers and settlers brought with them cattle, goats, and other domestic animals, along with crops. Along with these came other foreign organisms (bacteria, influenza, rats, and other pests, including knapweed) carried in ballast water (water from Europe used to stabilize large ships) and shipping crate wood.
- Knapweed was introduced unintentionally into North America from Europe in the 1800s; there are 15 introduced *Centaurea* species established in Canada today. Alien species continue to be introduced into Canada today by agriculture, floral, horticulture, and other trade industries.
- Identification: Plants have a deep taproot, alternate leaves, up to 35 stems, and purple or pink flowers.
- Reproduction: seed; self-compatible; pollinated by flies and bees.
- How it is spread: seed dispersal (August–October) by wind, ruminants, squirrels, vehicles; seed yield increases with increasing soil moisture or disturbance and decreases dry conditions.
- Predators: insects; biologically controlled by *U. affinis* and *U. quadrifasciata* seed-head flies (although attacks result in increased seed production).
- Habitat: common on gravel streambeds (i.e., irrigation ditches), roadsides, pipelines, power lines, railways, and spread to adjacent fields by wind and vehicle distribution.
- Success: due to higher than usual replacement requirements of seed production; flexible germination and life cycle; great competitor; ability to regenerate; deep taproot sustains growth in dry conditions; discourages grazing by bitter anti-microbial substance (cnicin).

Answers to Analysis Questions

1. **(a)** Over the last century, the population of spotted knapweed has increased steadily. The species has an S-shaped invasion curve and will grow at an increasing rate until the carrying capacity is reached (8.4–10.7 million hectares in western Canada are threatened).

(b) Students will extrapolate the data on the graph. In the year 2020, populations will likely cover 40 000 hectares of the province (a hectare is 10 000 m^2) unless the spread is brought under control.

2. Some introduced species become so invasive because they are removed from their original habitat and natural parasites or predators no longer control populations.

3. Spotted knapweed is not a pest in its native habitat (Europe) because some native European insects, weevils, and moths are resistant to cnicin, the lethal substance produced by knapweed species, and these herbivorous organisms can control knapweed populations.

4. **(a)** Spotted knapweed could continue to be spread through Alberta by seed dispersal by wind, seeds carried on vehicles, hay farming, ruminant and rodent dispersal, etc.

(b) **(i)** As knapweed invades fields, the numbers of native grasses of rangelands are decreased, and in turn, there is less forage for cattle. (Also, herbicide costs and application increases, degrading soil quality and increasing seed production of knapweed).

(ii) In native habitats, plant species diversity decreases over time, as knapweed out-competes native species. As knapweed populations increase, soil erosion and stream sedimentation also increase.

These factors result in a decline in herbivore populations in both terrestrial and aquatic habitats.

Assessment Options

- Assess answers to Procedure and Analysis questions.
- Assess student "mini-presentations" on their additional researched invasive species by using Assessment Checklist 8: Presentation Skills from Appendix A.

Figure 3.29

Student Textbook page 103

It can be inferred that the two species of barnacles have various adaptations to survive in and out of the water as tides go out and come in. Barnacles cement themselves to rocks. When the tide is out, barnacles must conserve water by becoming inactive. Their hard shell also aids in preventing desiccation until the tide comes back in.

Answer to Question for Comprehension

Student Textbook page 103

Q11. Students' answers should focus on the predator-prey relationship between the Arctic foxes and the seabirds on the islands, noting that the introduction of the foxes "limited" the populations of seabirds almost to the point of extinction. Their answer should also include the impact of the loss of the seabirds, as their guano no longer fertilized the grasslands. The loss of the seabirds and their guano led to the loss of the grasslands and all the organisms that depended on the grassland habitat for survival.

Connections: Social and Environmental Contexts

The Smeetons and the Swift Fox

Student Textbook page 104

Teaching Strategies

- Visit www.speciesatrisk.gc.ca for the latest information on endangered species and what is being done to protect them; in 2006, the Swift Fox remained on the list.

Answers to Questions

1. Student responses should include arguments supporting their point of view, with evidence to back up their opinions. Example argument: It is true that species have been dying out for millions of years. Extinction is a natural process, providing new habitat for rising species. However, it is important to realize the new rates at which species are becoming extinct. Mass extinctions are now occurring faster than ever before, and it is important that people and governments take action to reduce the rate of habitat destruction, which is at the root of extinction causes. If habitats can be protected, then the species living in them will be protected as well.

2. Alberta's threatened or endangered species:

ENDANGERED (2001)

Bison (*Bison bison*)

Ord's kangaroo rat (*Dipodomys ordil*)

Whooping crane (*Grus americanus*)

Sage grouse (*Centrocercus urophasianus*)

Piping plover (*Charadrius melodus*)

THREATENED (2001)

Woodland caribou (*Rangifer tarandus caribou*)

Barren ground caribou (*Rangifer tarandus groenlandicus*)

Leopard frog (*Rana pipiens*)

Trumpeter swan (*Cyganus buccinator*)

Ferruginous hawk (*Buteo regalis*)

Burrowing owl (*Athene cunicularia*)

Peregrine falcon (*Falco peregrinus*)

Penalties for hunting, trapping, or trafficking an endangered species in Alberta include fines of up to $100 000 or two years in prison.

Figure 3.31

Student Textbook page 105

Have students select their five quadrats. Students can use their graphing calculators (TI 83 plus) to generate a list of five random numbers between 1 and 25. Here's how:

- On
- Math
- Over to (PRB) probability
- Down to (5) randInt
- Enter
- enter extreme values (1, 25)
- Enter five times—this will generate five random numbers

Investigation 3.D: An Ecosystem Field Study

Student Textbook pages 106–107

Purpose

- Students will, as a group, perform a field study to measure and analyze biotic and abiotic characteristics of two local ecosystems by applying appropriate field techniques and assessing the accuracy and reliability of such measurements.
- Students will classify and identify unknown organisms using a dichotomous key and assess the interactions and relationships of these organisms to each other and the abiotic factors of the environment

Outcomes

- 20-B1.2s
- 20-B1.3s
- 20-B1.4s

Advance Preparation

When to Begin	What to Do
Start of the semester or school year	■ Book field trip location and complete appropriate paperwork.
1 week before	■ Copy and distribute field trip permission forms.
1 or 2 days before	■ Copy **BLM 3.3.7: Investigation 3.D: An Ecosystem Field Study.** ■ Class discussion/planning for procedures for field trip.

Materials
■ gloves ■ masking tape ■ flagging tape ■ tree density stem maps ■ sticker pack ■ hand lenses ■ dissecting scopes (optional) ■ thermometers ■ pH paper ■ nitrates/phosphates test kit ■ trowels ■ tape measure ■ identification keys ■ rope (for transects) ■ binoculars (optional) ■ light meter (optional) ■ soil moisture meter ■ rulers ■ containers for soil samples ■ first aid kit ■ cell phone (optional) ■ camera (optional)

Time Required

1/2 to a full day; depending on location and extent of study

Helpful Tips

- Use **BLM 3.3.7: Investigation 3.D: An Ecosystem Field Study** to support this activity. Modify as required.
- Review the concept of biotic and abiotic factors.
- Set clear behaviour expectations regarding field sampling and field trips.
- Discuss with students what evidence could be gathered implying that animals were present, even if they are not seen in the field.
- Remind students of which tests will be conducted in the field and which will be conducted back in the classroom.
- It will be helpful to build field kits so that every group has a kit with necessary material; include inventory checklists to ensure no materials are left behind in the field.
- Put flagging tape on all materials so that when they are set on the ground, students will be able to find them.

Safety Precautions

- Students should wear gloves when handling soil samples and wash their hands upon completion of the activity.
- Environmental considerations: Replace all soil pits when finished with them to minimize impact on organisms (sample *in situ* when possible).

Experimental Plan

Check student plans to ensure that they have included the following:

- background information concerning the chosen site(s)
- description of the roles of various group members
- a list of materials
- a description of the methods to be used to collect the data, particularly the population estimates
- blank data tables to organize findings as a comparison of two ecosystems, including comparing abiotic factors measured (temperature, light availability, soil profiles, dissolved oxygen, etc.)
- descriptions of the plants and species to be studied, and how they will be studied
- a description of how the safety of the participants will be protected, as well as the integrity of the site

Answer to Analysis Question

1. The written report, poster, or presentation (students may use presentation software), should include detail of the following: location and size of study area; brief site history; a description of methods and tools used; list and analysis of abiotic components; list and analysis of biotic components.

Evidence and examples of living things in soil samples include grass (or other vegetation), leaves, moulds, insects (count and classify), burrows, and scats.

Answers to Conclusion Questions

2. Sample areas must be randomly selected in order to prevent as much bias and influence as possible, so that the most accurate representation of the sample area can be obtained. If one was to sample only a few selected sites, it is very unlikely that these sites would give a good overall picture of the sample area. Someone interpreting the data would base their assumptions on a very small, biased analysis.

3. If only one area was sampled in an ecosystem, would it truly portray a representative sample of the ecosystem? We can only find out by sampling numerous sites, and then quantifying and qualifying our data based on these observations. From this collected data, trends and species analysis can be found, and then a more accurate and comprehensive description of the ecosystem can be created.
4. Limiting factors that will influence study areas include moisture content of soils, light availability, competition, and predation.
5. Comparison of diversity and abundance between disturbed and undisturbed sites highlight the differences between the sites. Disturbed sites will typically have less species diversity and fewer numbers of larger organisms. Students will refer back to their collected data to (b) compare and (c) contrast the two sites.
6. Human influences in the study areas will include recreational uses, mowing, pest control, compaction because of use, removal of native species, invasive species, watering of particular areas, protection of habitat from ATV use, and hunting.
7. Students should be able to rate the tools and methods they used, noting which were easy to use and gave them useful results and which were cumbersome, inaccurate, or unreliable.
8. Improvements for the study will address sources of experimental error, identification error, impatience in sampling, precision of instruments used, etc.

Assessment Options

- Assess planning activities completed throughout the chapter as well as final experimental field plan.
- Collect report; check for titles, column headings, diagrams, and properly labelled tables.
- Assess answers to Analysis questions.
- Assess group presentations on their findings comparing the two ecosystems. Use Assessment Checklist 8: Presentation Skills.

Section 3.3 Review Answers

Student Textbook page 108

1. Niche refers to an organism's function and position within an ecological community. It includes the combination of all biotic and abiotic factors that affect an organism. The niche of an organism is found within its habitat requirements. No two species will have the same niche. Habitat is the place where an organism usually lives, characterized by the dominant characteristics of the area (e.g., stream habitat or tropical forest).
2. This graph shows the relationship among temperature and precipitation and biomes. The warmer average annual temperature and lack of precipitation in southern Alberta would put it in the grassland biome. The colder average annual temperature and higher precipitation in northern Alberta support the growth of the coniferous forests characteristic of the taiga biome.
3. Student answers may include optimum temperature and precipitation for early life cycle changes in the spring and summer. The gradual cooling/freezing in the fall and winter reduce the mosquito population to a point where larval and adult mosquitoes can no longer survive. However, the adult female mosquitoes have laid eggs that will survive until the optimum temperature and precipitation conditions return in the spring.
4. Trees, like all living things, compete for resources such as sunlight, water, and nutrients in the soil.
5. The vole population is controlled by abiotic and biotic limiting factors. Biotic limiting factors include competition, predation, and parasites. The size of the population will tend to increase when there is little competition, there are fewer predators, and individual animals have low numbers of parasites. The size of the population will tend to decrease when there is more competition for resources, there are more predators, and individual animals have a higher number of parasites.

   Abiotic limiting factors include availability of food, water, shelter, and space. The size of the population will tend to increase if there is an abundance of food and water. The size of the population will also tend to increase if the animal has shelter and sufficient space.

Chapter 3 Review Answers

Student Textbook pages 110–111

Answers to Understanding Concept Questions

1. Sample answer: Five abiotic factors in an ecosystem could include any five of the following: average annual rainfall, seasonal temperature variation, soil moisture, topography, altitude, latitude, solar radiation, concentration of atmospheric gases (such as carbon dioxide levels), dissolved oxygen concentration, and prevailing winds.

   Five biotic factors in an ecosystem could include any five of the following: producers, consumers (including herbivores, carnivores, omnivores), decomposers, predator-prey relationships, the numbers of organisms, biological interactions (individuals, populations, communities, ecosystems), and biological rhythms (including nocturnal behaviour, seasonal behaviour of plants, mating seasons).
2. Particular organisms live within habitats for which they are adapted. These organisms occupy a particular niche within the habitat, which includes living requirements, as well as the organism's relative trophic activities (such as

predator-prey relationships, feeding activities, and daily behaviours).

3. Parasitism is an interaction in which one organism (the parasite) derives its nourishment from another organism (the host), which is harmed in some way. In parasitism, the host is not always permanently harmed or entirely consumed. In this example, the leech (parasite) feeds on and harms the fish (host). The leech does not entirely consume the fish (host).
4. A community of populations, together with the abiotic factors that surround and affect it, is called an ecosystem. An ecosystem includes all the non-living parts of the environment in a particular area and all the living organisms, as well as the interactions among them. A biome is a particular mix of plants, animals, and other organisms that are adapted to living under certain environmental conditions. Biomes consist of large ecosystems or groups of ecosystems. Ecosystems and biomes are similar in that they both have specific abiotic factors and biotic communities.
5. The physical structure of a coral reef provides a variety of habitats and niches for its inhabitants. Corals (animals) are responsible for building the framework of the reef. The primary component of the reef is limestone. Because the coral is closer to the ocean's surface than the ocean bed, organisms that need more light, such as plants, can grow on the reef. Some fish feed on these plants. Other fish feed on the plant-eating fish.
6. The tree swallow and little brown bat both have similar habitats, however their niches differ. Although they breed in similar habitats and both catch insects while in flight, the two species feed at different times of the day, on different insects, and live in different locations.
7. Ecosystem change can be sudden or gradual. Sudden changes in ecosystems may be brought on by natural events such as flooding, tornadoes, fire, volcanic activity, or tsunamis, or can be brought on by human activities such as deforestation, habitat fragmentation, oil spills, etc. These ecosystem changes will be followed by a natural process of gradual ecosystem recovery, where ongoing changes in the microclimate of an area will result in changes in the flora and fauna over time. Over time, however, any ecosystem will succumb to change as a result of succession, as the organisms living there create conditions favourable for other organisms. For example, after a forest fire, a succession of grasses, shrubs, and quick-growing, sun-loving trees create conditions for slower-growing, shade-loving trees.
8. Plants in a forest compete for sunlight, soil nutrients, soil moisture, and sufficient space to grow.
9. A single-celled, eukaryotic autotroph would be grouped in the kingdom Protista.
10. Resources that can be used to find the scientific name of a species include using a specific dichotomous key, the Internet, science resource books, the library, and the zoo.
11. Two species with similar niches will compete with one another if they feed on the same organisms, live in similar locations, and interact with similar organisms. If they require the same limiting resources, they will be in competition with each other for these resources. Introduced species can cause the decline of native populations because introduced species can out-compete other species for limited resources (food, space, light, moisture), and it is unlikely that the introduced species will have a natural predator to control its population.
12. In order to have an understanding of geochemical processes that occur in various environments, one must have an understanding of chemistry, meteorology, and geology. To understand the influence that these abiotic factors have on biotic relationships, one must have a good understanding of microbiology, zoology, biology, and population and community ecology. All of these disciplines are interconnected when ecologists try to synthesize ecosystem models and gain an understanding of biosphere processes.
13. The three domains used in this text are Bacteria, Archaea, and Eukarya. Students' answers must include an organism from each one. Representative organisms found in the domain Bacteria include heterotrophic bacteria and cyanobacteria. Representative organisms found in the Archaea include chemosynthetic, unicellular organisms. Representative organisms found in the Eukarya can be any plant, animal, protist, or fungi.
14. **(a)** The following factors control the size of a population:
    - *interspecific competition* is competition between two or more populations. Two species with similar niches may compete with each other for food, water, or other resources found in the habitat. The result of competition is a reduction in the growth rate of both populations. In some cases, one species will eventually out-compete the other and the "losing" species will disappear.
    - *intraspecific competition*—this type of competition occurs when members of the same population compete with each other for a limited resource. Members of a population may not only compete for food. They may compete for other resources including water, sunlight, soil nutrients, shelter, mates, breeding sites. Regardless of the resource, the result of the competition is always the same—a reduction in the population's growth rate.
    - *predation* is a biotic interaction that involves the consumption of one organism by another. In this type of interaction, the consumer organism is referred to as a predator and the consumed organism is called the prey. If the population of predators increases, the result will be a reduction in the population of prey. The prey population size will likely increase if the population of predators decreases.

- *parasitism* is an interaction in which one organism (the parasite) derives its nourishment from another organism (the host), which is harmed in some way. Parasitism is similar to predation because one organism benefits from the interaction and the other organism does not. In parasitism, however, the host is not always permanently harmed or entirely consumed. An increase in the density of the host population makes it possible for the parasites to increase in number. The increased number of parasites decreases the host's ability to survive or reproduce and may lead to a decrease in the density of the host population.

(b) The abiotic components of an ecosystem limit the distribution and size of the populations that live there. Plants, for example, have an optimum set of abiotic requirements including soil type, moisture and humidity levels, and temperature range. Their population is controlled by these factors. The population of animal populations may decrease in times of severe drought, if there is a drastic temperature change, or a widespread natural disaster occurs.

Answers to Applying Concepts Questions

15. (a) The two most closely related individuals in this table are the dog and the coyote. Both animals belong to the genus *Canis*.

(b) The praying mantis is least closely related to the other five animals. The praying mantis belongs to the Phylum Arthropoda while all of the other organisms belong to the Phylum Chordata.

(c) Sample answer: the house cat. Binomial nomenclature is a two-name system. The first name of an organism identifies its genus. The second name of an organism identifies its species. The binomial name for the house cat is *Felix* (genus) *domesticus* (species).

(d) The genus of a wolf is *Canis*—it is related to dog and coyote. The genus of the lion is *Felix*—it is closely related to the house cat.

(e) Animals in the Order Carnivora are meat-eating consumers. All of the animals listed in this category are primarily meat eaters, although most eat plant material at different times.

(f) From closest related to farthest removed: dog, coyote, cat, skunk, bat, praying mantis. The dog and coyote are separated at the species level (and therefore most closely related); the cat, dog, coyote, and skunk are separated at the family level (order = carnivores); the cat, skunk, coyote, dog, and bat are from the same class (mammals); the praying mantis is separated from the others as it belongs to a different phylum (the arthropods).

16. (a) Sample answer: this multicellular, heterotrophic organism is from kingdom Animalia. Students may also select the kingdom Fungi. Rationale for this decision: Since the organism was discovered on a field trip, it is likely that the organism is large enough to be viewed with the naked eye (therefore this rules out Protista). Since the organism is multicellular, Archaebacteria and Eubacteria would both be ruled out. Since the organism does not have chloroplasts, plants are ruled out.

(b) Students should cite the other choice, i.e., Animalia if they chose Fungi and vice versa.

17. Student diagrams will show two scenes: one mowed area and one left to grow wild. The area left to grow wild will include a variety of grasses, plants (weeds), and small shrubs, which should provide food and habitat for a greater variety of insects and other animals.

The first paragraph should focus on the abiotic factors, including the amount of moisture, nutrients, and light available to the plants in both areas. Their answers may note that a manicured lawn requires regular watering and fertilizing in order to sustain plant growth. The natural area has plants specifically adapted to the abiotic conditions in that area and would not require watering or fertilizing (they may recall the biogeochemical cycles mentioned in previous science courses).

In the second paragraph, students should note that the variety of habitats and ecological niches, and thus the variety, or biodiversity, of species, can vary widely in different areas depending on the specific abiotic and biotic components. In this example, the wild area will have a greater diversity of plant species. The diversity of species results in a diversity of habitats and niches as well.

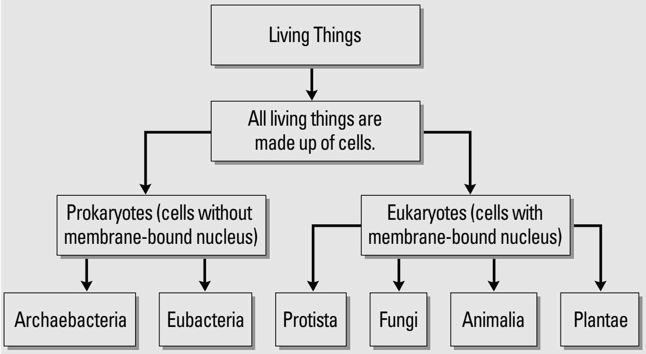
18. (a) Scientists use the binomial system, called binomial nomenclature. To make it universal, scientists agreed to use a language that is spoken by no country but forms the basis of many languages—Latin. Using these two-part scientific names allows scientists from all around the world to be sure they are talking about the same species when they are communicating.

(b) Students may predict that the term "arctos" was used because the scientist that named these bears first noted them in northern regions of Europe and Asia.

(c) Natural factors that may limit the population could include food shortages, predation on young, competition, parasites, or diseases.

(d) Human activities that would limit the grizzly population would include hunting and habitat destruction/fragmentation (housing developments, golf courses, major highways, ski resorts).

19. The following is an example of a graphic organizer:



Answers to Making Connections Questions

20. Changes to ecosystems caused by the action of people include draining of wetlands, interbasin water transfer, habitat fragmentation, land use, urbanization, slash-and burn, clearcutting, and monoculturing (e.g., forests, lawns, agriculture). Effects will include habitat destruction and loss of species diversity.

21. It can be argued that everything we do in a day affects the ecosystem we live in. Student answers should give an example of a normal daily activity and one effect. Examples may include the following: use of water by brushing teeth, flushing toilet, laundry, which removes water from the river, contributing to loss of aquatic habitat; use of electricity, which comes mostly from coal generators that release $CO_2(g)$; and driving vehicles, which results in wildlife fatalities and habitat fragmentation; the release of air pollutants; heating homes, which results in heating up the atmosphere; generating waste which may or may not be biodegradable, which encroaches on habitat.

22. (a) Politically, in order for organisms to be protected, they need to be identified and classified as endangered. This is unfortunate, as scientists suggest that there are many species that have not been identified or catalogued. Typically, wildlife legislation protects large mammals that are familiar to us. Public pressure placed on governments protects them because of how we feel about them, not because of the importance of their ecological role. These feelings may be based on how an organism looks (we grow up with teddy bears, so we have an affinity for pandas), or based on what is portrayed by the media (seeing elephants poached for their ivory instils feelings of sympathy and we are likely to rally for their protection). Other organisms that may be smaller, or unheard of, or unattractive to the general public are not typically protected, even though they have just as much, if not more, ecological importance. We must protect all species and operate based on precautionary principles, especially since scientists do not have a full understanding of the important role that all organisms play in our biosphere.

(b) The use of the name "*horribilis*" is likely to instill a fear of these animals in people who have never even observed them. This fear could easily be translated into indiscriminate killing of these bears just because of their name. Students may also relate this same problem to other animals such as the Killer Whale.

CHAPTER 4 MECHANISMS OF POPULATION CHANGE

Curriculum Correlation

General Outcome 2: Students will explain the mechanisms involved in the change of populations over time.

	Student Textbook	Assessment Options
Outcomes for Knowledge		
20–B2.2k discuss the significance of sexual reproduction to individual variation in populations and to the process of evolution	Section 4.1: Variation within a Species, pp. 115-118 Investigation 4.A Variations Great and Small, p. 116 Natural Selection, pp. 118-120	Q question 2, p. 115 Investigation 4.A: Conclusion 3, p. 116 Section 4.1 Review: 2, 3, 7, p. 121 Chapter 4 Review: 3, p. 144 Chapter 4 Test
20–B2.1k explain that variability in a species results from heritable mutations and that some mutations may have selective advantage(s)	Launch Lab: Could Cockroaches Rule Earth?, p. 113 Section 4.1: Adaptations and Survival, pp. 114-115 Variation within a Species, pp. 115-118 Biology File FYI: mutated genes and diseases, p. 117 Biology File FYI: sickle cell and resistance to malaria, p. 118 Thought Lab 4.1 Evolving "Superbugs", p. 119 Thought Lab 4.2 Analyzing Changes in Beak Depth, p. 120	Launch Lab: Analysis 3, 4, p. 113 Q question 3, p. 118 Thought Lab 4.1: Procedure 2; Analysis 1-2, p. 119 Q questions 4, 5, p. 120 Thought Lab 4.2: Analysis 1-3, p. 120 Section 4.1 Review: 1, 4, 5, 6, 8, p. 121 Chapter 4 Review: 1, 2, 4, p. 144 Unit 2 Review 14, 21, p. 148; 31, p. 149; 40, p. 150 Chapter 4 Test
20–B2.3k compare Lamarckian and Darwinian explanations of evolutionary change	Section 4.2: Lamarck: The Inheritance of Acquired Characteristics, pp. 123-124 Darwin's Evidence, pp. 124-125 Darwin and Wallace and the Theory of Evolution by Natural Selection, p. 126 Biology File FYI: Why Natural Selection Does Not Demonstrate Progress, p. 126 Thought Lab 4.3 Comparing the Ideas of Lamarck and Darwin, p. 127	Q questions 8, 9, p. 124 Table 4.1 Darwin's Observations and Questions Arising from Them, p. 125 Q question 10, p. 126 Thought Lab 4.3, p. 127 Section 4.2 Review: 2, 4, 5, 6, p. 133 Chapter 4 Review: 5, 6, 7, p. 144 Unit 2 Review: 17, p. 148 Chapter 4 Test
20–B2.4k summarize and describe lines of evidence to support the evolution of modern species from ancestral forms, i.e., fossil record, Earth's history, embryology, biogeography, homologous and analogous structures, biochemistry	Section 4.2: Further Evidence of Evolution, pp. 126-133 Thought Lab 4.4 Homologies of Hair, p. 131	Web Link: The Burgess Shale, p. 128 Q question 11, p. 129 Web Link: Plate Tectonics, p. 130 Thought Lab 4.4: Procedure 3; Analysis 1, p. 131 Q questions 12, 13, p. 132; 14, p. 133 Section 4.2 Review: 3, 5, 8, 9, 10, p. 133 Chapter 4 Review: 8, 9, 10, p. 144; 17, 19, p. 145 Unit 2 Review: 16, 19, 24, p. 148; 39, p. 150, 43, p. 151 Chapter 4 Test
20–B2.5k explain speciation and the conditions required for this process	Section 4.3: What Is a Species?, p. 136 Forming a New Species, pp. 136-137 Biology File FYI: DNA evidence to support speciation, p. 137 Keeping Populations Separate, pp. 137-138 Speciation Occurs in Reproductively Isolated Populations, pp. 139-140 Adaptive Radiation, p. 140	Q question 15, p. 137 Try This: global warming and the evolution of species, p. 137 Web Link: speciation in greenish warblers, p. 138 Q question 16, p. 139 Thought Lab 4.5: Analysis 1-2, p. 139 Q question 17, p. 140 Section 4.3 Review: 1, 2, 3, 4, 5, 7, 8, p. 142 Chapter 4 Review: 11, p. 144 Unit 2 Review: 33, p. 150 Chapter 4 Test

	Student Textbook	Assessment Options
20–B2.6k describe modern evolutionary theories, i.e., punctuated equilibrium versus gradualism.	Section 4.3: The Pace of Evolution, pp. 140-141	Section 4.3 Review: 6, p. 142 Chapter 4 Review: 11, p. 144 Unit 2 Review: 32, p. 149 Chapter 4 Test
OUTCOMES FOR SCIENCE, TECHNOLOGY, AND SOCIETY (EMPHASIS ON THE NATURE OF SCIENCE)		
20–B2.1sts explain that scientific knowledge and theories develop through hypotheses, the collection of evidence through experimentation, observation, and the ability to provide explanations, e.g., (**NS2**)	Section 4.2: Connections: Debating Science, pp. 134-135	Connections Questions 1-4, p. 135 Section 4.2 Review: 1, 4, 7, p. 133 Unit 2 Review: 18, p. 148
■ *discussing the nature of science as a way of knowing, e.g., contributions of Georges Buffon, Charles Lyell, Thomas Malthus and Alfred Russel Wallace to evolution; contributions of Aristotle, Bacon and Popper to the philosophy of science*	Developing the Theory of Evolution by Natural Selection, pp. 122-125	Q question 7, p. 123; 9, p. 124; 14, p. 133 Chapter 4 Review: 15(c), 19, p. 145 Unit 2 Review: 20, p. 148, 41, 42, p. 150
■ *describing how paleontology and the role of evidence in the accumulation of knowledge has provided invaluable data for theories explaining observable variations in organisms over time, e.g., Burgess Shale*	Career Focus: Ask a Paleontologist, p. 146	Q question 6, p. 123 Web Link: The Burgess Shale, p. 128 Q question 11, p. 129 Web Link: Plate Tectonics, p. 130 Career Focus: 2, p. 147
■ *discussing probable causes and geological evidence for past mass extinctions and contrasting these to the forces driving the current decline in species*		Try This: Global Warming and the Evolution of Species, p. 137 Career Focus: 3, p. 147
Skill Outcomes (Focus on Scientific Inquiry)		
Initiating and Planning		
20–B2.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by	Launch Lab: Could Cockroaches Rule Earth?, p. 113	Launch Lab: Analysis 3, 4, p. 113
■ designing an investigation to measure or describe an inherited variation in a plant or animal population **(IP–NS1, 2, 3, 4)[ICT C7–4.1]**	Investigation 4.A: Variations Great and Small, p. 116	Investigation 4.A: Exp. Plan 1-6, p. 116 Chapter 4 Review: 12, 14, p. 144; 19, p. 145 Career Focus: 1, p. 147 Unit 2 Review: 30, p. 149
■ hypothesizing the adaptive significance of the variations in a range of homologous structures in extant and extinct organisms **(IP–NS3)[ICT C6–4.1]**	Thought Lab 4.4: Homologies of Hair, p. 131	Thought Lab 4.4: Analysis 1, p. 131
Performing and Recording		
20–B2.2s conduct investigations into relationships between and among observable variables and use a broad range of tools and techniques to gather and record data and information by	Investigation 4.A: Variations Great and Small, p. 116	Investigation 4.A: Data and Obs. 1-4, p. 116
■ *gathering data, actual or simulated, on organisms to demonstrate how inherited characteristics change over time, e.g., Darwin's finches, peppered moth, bacteria, domesticated plants and animals* **(PR–NS1, 4) [ECT C1–4.1]**	Thought Lab 4.4: Homologies of Hair, p. 131	Thought Lab 4.4: Procedure 3, p. 131

	Student Textbook	Assessment Options
Analyzing and Interpreting		
20–B2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by	Investigation 4.A: Variations Great and Small, p. 116 Thought Lab 4.5: Leopard Frogs: One Species or Seven?, p. 139	Investigation 4.A: Analysis 1; Conclusion 2-4, p. 116 Thought Lab 4.5: Analysis 2, p. 139
■ analyzing data, actual or simulated, on plants and animals to demonstrate how morphology changes over time, e.g., Darwin's finches, peppered moth, bacteria, domesticated plants or animals **(AI–NS2) [ICT C6–4.4, C1–4.1]**	Thought Lab 4.1: Evolving "Superbugs", p. 119	Thought Lab 4.1: Procedure 1; Analysis 1, p. 119
■ *analyzing DNA sequences from online or other sources to infer the relationship between different organisms at various classification levels such as kingdom, phylum, species, and subspecies* **(AI–NS2) [ICT C1–4.1]**	Section 4.3 Molecular Biology, p. 132	Section 4.2 Review: 10, p. 133 Unit 2 Review: 19, p. 148
■ *stating a conclusion or generalization based on research data, suggesting how it supports or refutes an explanation for biological change such as the case of the peppered moth and identify new questions or problems that arise from what was learned* **(AI–NS5, 6) [ICT C7–4.2]**	Thought Lab 4.2: Analyzing Changes in Beak Depth, p. 120 Thought Lab 4.3: Comparing the Ideas of Lamarck and Darwin, p. 127 Thought Lab 4.4: Homologies of Hair, p. 131	Thought Lab 4.2; Analysis 1-3, p. 120 Thought Lab 4.3: Analysis 1-2, p. 127 Thought Lab 4.4: Analysis 3, p. 131
Communication and Teamwork		
20–B2.4s work as members of a team in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by	Launch Lab: Could Cockroaches Rule Earth?, p. 113 Thought Lab 4.1: Evolving "Superbugs", p. 119 Thought Lab 4.3: Comparing the Ideas of Lamarck and Darwin, p. 127	Launch Lab: Analysis 3, p. 113 Thought Lab 4.1: Analysis 2, p. 119 Thought Lab 4.3: Analysis 2, p. 127
■ *using appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results* **(CT–NS1, 2) [ICT P2–4.1]**	Investigation 4.A: Variations Great and Small, p. 116 Thought Lab 4.4: Homologies of Hair, p. 131	Investigation 4.A: Exp. Plan 1-6, p. 116 Thought Lab 4.4: Procedure 1; Analysis 2, p. 131

Chapter 4

Mechanisms of Population Change

Student Textbook pages 112–145

Chapter Concepts

4.1 Adaptation, Variation, and Natural Selection

- Sexual reproduction and inherited mutations contribute to variation among individuals in populations.
- Individuals in a population have a selective advantage over other individuals if their mutations allow them to better survive and reproduce under selective pressures.

4.2 Developing a Theory to Explain Change

- Fossil evidence shows that species change over time and that species eventually become extinct.
- To develop the theory of natural selection, which explains evolutionary change, scientists have gathered and organized many pieces of evidence.
- There is evidence that modern species evolved from ancestral forms.

4.3 How Species Form

- A species consists of reproductively compatible populations.
- New species can form when populations become reproductively or geographically isolated from each other.
- The process of adaptive radiation occurs when a common ancestor diversifies into a variety of species.
- Two models for the pace of evolution are gradualism and punctuated equilibrium.

Common Misconceptions

- Students may ask, or state, "Humans come from apes or chimps." This is not true. Humans and chimps share a common ancestor on the phylogenetic tree. But we branched off at different points and have evolved differently in response to our environments and adaptive variations. Also this blanket statement assumes that evolution is a "step-by-step" progression from "lower" forms of life to higher forms. This is not true, and it also promotes a view of humans as somehow being "superior" life forms.
- Students may challenge the validity of "the theory of evolution" by stating it is only a theory and therefore not to be believed. It is important to explain how a "theory" is created in science and differentiate it from the non-scientific use of the word. A scientific theory results from the application of the scientific method. In short, it is developed through hypotheses, extensive observations, and experiments. If all of the information gathered from the experiments and observations supports the hypothesis, it will eventually become accepted as a theory. (See Connections: Debating Science pp. 134–135). The theory of evolution is the only theory that accounts for the fossil, molecular, embryological, behavioural, and geographical evidence.
- Students may then direct their thoughts towards the impossibility of testing the theory. A theory such as evolution can be tested. It is accepted by scientists (and even now by many religions) as a process that does occur, and that has been observed to occur. For example, antibiotic-resistant strains of bacteria have undergone a very short evolutionary process. Creationism, on the other hand, cannot be tested and is not a scientific theory. It may be personally useful, but it is not part of science.
- An excellent link to some common misconceptions about evolution is: **www.plantbio.uga.edu/courses/pbio1210/evolutionmyths.html**
- Evolution is not the same thing as natural selection—both are separate, on-going processes. If a student truly understands these ideas, then the student will also understand that evolution results from natural selection. Evolution is a process: the evidence for which includes fossils and is supported by science such as embryology, molecular biology, and genetics. Natural selection is an observable force at work, which can be seen in such examples as pesticide and antibiotic resistance.
- Students often misunderstand the term "evolve." An individual cannot evolve; only a population or a species can evolve.

Helpful Resources

Books and Journals

- Alters, *Handbook on Teaching Evolution: A Guide to The Creation/Evolution Controversy.* (Jones and Bartlett Publisher, 2002) ISBN 0763711187
- Gould, Stephen Jay. *Wonderful Life: The Burgess Shale and the Nature of History* (W. W. Norton, 1989).
- Conway Morris, Simon. *The Crucible of Creation: The Burgess Shale and the Rise of Animals* (Oxford University Press, 1998).
- Simon Conway Morris and Stephen Jay Gould, "Showdown on the Burgess Shale," *Natural History* magazine, 107 (10): 48-55. Also found at www.stephenjaygould.org/library/naturalhistory_cambrian.html features a debate between the two researchers on the interpretation of the findings at the Burgess Shale.
- All of Charles Darwin's notebooks, diaries, sketches, and publications, as well as audio presentations of his work have been posted at **darwin-online.org.uk**. The site is being maintained by the University of Cambridge, and site managers promise 50 000 searchable texts and 40 000 images.

Web Sites

Web links related to the mechanisms of population change can be found at **www.albertabiology.ca.** Go to the Online Learning Centre, and log on to The Instructor Edition. Choose Teacher Web Links for the links to Chapter 4.

List of Blackline Masters

Blackline masters (BLMs) have been prepared to support the material in this chapter. The BLMs are either for assessment (AST); use as overheads (OH); or use as handouts (HAND), in particular to support activities. Most handouts and all assessment tools are supported by a BLM with the answers (ANS). The BLMs are in digital form, stored on the CD that accompanies this Teacher Resource or on the web site at **www.albertabiology.ca**, Online Learning Centre Instructor Edition BLMs. They can be modified to suit the needs of your students.

Number (Type)
4.0.1 (HAND) Launch Lab: Could Cockroaches Rule Earth?
4.0.1A (ANS) Launch Lab: Could Cockroaches Rule Earth? Answer Key

4.1.1 (HAND) Investigation 4.A: Variations Great and Small
4.1.1A (ANS) Investigation 4.A: Variations Great and Small Answer Key
4.1.2 (HAND) Thought Lab 4.1: Evolving "Superbugs"
4.1.2A (ANS) Thought Lab 4.1: Evolving "Superbugs" Answer Key
4.1.3 (HAND) Thought Lab 4.2: Analyzing Changes in Beak Depth
4.1.3A (ANS) Thought Lab 4.2: Analyzing Changes in Beak Depth Answer Key
4.1.4 (AST) Adaptations, Variation, Mutations, and Natural Selection Quiz
4.1.4A (ANS) Adaptations, Variation, Mutations, and Natural Selection Quiz Answer Key

4.2.1 (HAND) The Work of Lamarck and Wallace
4.2.2 (HAND) Contributions of Various Scientists to the Theory of Evolution by Natural Selection
4.2.3 (HAND) Answering Darwin's Questions
4.2.4 (HAND) Thought Lab 4.3: Comparing the Ideas of Lamarck and Darwin
4.2.4A (ANS) Thought Lab 4.3: Comparing the Ideas of Lamarck and Darwin Answer Key
4.2.5 (OH) Geologic Time Scale
4.2.6 (HAND) Evidence for Evolution: Homologous vs. Analogous Structures
4.2.7 (HAND) Thought Lab 4.4: Homologies of Hair
4.2.7A (ANS) Thought Lab 4.4: Homologies of Hair Answer Key
4.2.8 (HAND) The Peppered Moth Debate
4.2.9 (HAND) Scientific Debate Organizer
4.2.10 (HAND) Summarizing Evidence for the Theory of Evolution

4.3.1 (HAND) Biological Barriers
4.3.2 (OH) Finches of the Galapagos Islands
4.3.3 (HAND) Thought Lab 4.5: Leopard Frogs: One Species or Seven?
4.3.3A (ANS) Thought Lab 4.5: Leopard Frogs: One Species or Seven? Answer Key
4.3.4 (HAND) Modelling Adaptation and Natural Selection
4.3.5 (HAND) Speculating about Speciation

4.4.1 (AST) Chapter 4 Test
4.4.1A (ANS) Chapter 4 Test Answer Key

Using the Chapter 4 Opener

Student Textbook pages 112-113

Teaching Strategies

- Students may be shocked to find out that cockroaches alone represent 4000 species, which can lead to speculation on what constitutes a species.
- The fossil record of the 300-million-year-old cockroach can be used to open discussions about how we know what we know about what has happened to life on Earth over time.
- The Launch Lab is an introduction to the mathematics of reproduction. Depending on how well students can recall reproduction, you may wish to use **BLM 3.0.1 Meiosis and Mitosis: A Comparison** as an overhead or a handout to refresh their memories. You could then have your students create a concept map, or Venn diagram for the following comparisons: sexual reproduction versus asexual reproduction with an example of a species that uses each; secondly, have the students compare a population versus a species using a Venn diagram and formally define each.
- The development of scientific theory is an underlying topic in this chapter. Have your students create a sequential concept map that shows the scientific process required to formulate a hypothesis, test the hypothesis, publish it for review, and ultimately create a theory.

Launch Lab: Could Cockroaches Rule Earth?

Student Textbook page 113

Purpose

Students will analyze why individual species do not overrun Earth and contemplate how insecticide resistance might occur.

Outcomes

- (General) Interest in Science
- 20–B2.1k

Advance Preparation

When to Begin	What to Do
One day before investigation	■ Photocopy **BLM 4.0.1: Launch Lab: Could Cockroaches Rule Earth?**

Time Required

30 minutes

Helpful Tips

- Use **BLM 4.0.1: Launch Lab** to support this activity. Modify as necessary.
- To introduce this activity, discuss cockroach adaptations.
- Interesting cockroach information: the reason cockroaches are disliked to such a degree is valid, given the threat they pose to human health. They can transmit or aggravate diseases, such as salmonella, E. coli, food poisoning, dysentery, asthma, and Hepatitis E.
- Pose the question in the lab: Why do individual species not take over the planet? What limits population numbers?

SUPPORTING DIVERSE STUDENT NEEDS

- Some students may require assistance with the math in Analysis Question #1. Show them how to set up a ratio and solve for the unknown.

Answers to Analysis Questions

1. Assuming that in 2 months there are 61 days, the female can lay

$\frac{16 \text{ eggs}}{5 \text{ days}} = X \text{ eggs} \times 61 \text{ days} \quad X = 195.2$ eggs (round down to 195).

2. **(a)** If 50% of these offspring are female (97 females) these females will produce

(97 females × 195 eggs) = 18 915 eggs in the second generation.

(b) This is an accurate number in theory, and if conditions are right, it is possible that cockroach populations will reach this number. However, not all of the eggs in an egg capsule mature into adults and reproduce. Some of the eggs will not develop, and then some of the eggs that do develop into cockroaches will not make it to reproductive age (due to predation, disease, lack of food, etc.).

3. The factors that limit the population growth of cockroaches are habitat, predators (human exterminators with insecticides), temperature range (cooler preferred), light levels, moisture availability, access to food (organic debris), etc.

4. Gene mutations will cause insecticide-resistance to develop in a population. Initially when a population is sprayed with insecticide, some members of the population may survive because of genetic variability. This variability enables natural section to take place. The application of an insecticide will favour individuals with insecticide-resistant genes. These organisms will survive to reproduce and pass their genes along. As doses of insecticide increase, organisms in later generations will have increased resistance to the insecticide; in time, chemicals that at one time controlled insect populations will no longer be effective. The mechanisms behind natural section will be the focus in Chapter 4.

Assessment Options

- Assess answers to Analysis questions.
- Use Assessment Checklist 6: Using Math in Science, from Appendix A

4.1 Adaptation, Variation, and Natural Selection

Student Textbook pages 114–121

Section Outcomes

Students will:

- describe how sexual reproduction and changes in genetic information result in variation within populations
- design an investigation to measure variations in a population
- describe how some mutations may improve an individual organism's chance for survival and reproduction
- define natural selection

Key Terms

variation
biological species
mutation
selective advantage
natural selection
selective pressure

Biology Background

- Sexual reproduction is when two parents contribute half of the genetic material (DNA) to the offspring. The offspring, as a result, has a unique set of genetic traits that are a combination of both parents. Offspring from the same parents can vary greatly in their genetic make-ups because of all the processes that aid in creating variation in sexual reproduction.
- An overview of meiosis and mitosis is presented in the Unit Preparation feature on pages 74–75 of the student text.
- The variations within a population, including their adaptations and unique genetic combinations, allow for

individuals within populations to have selective advantages. These selective advantages are determined by which individuals have the adaptive traits needed to succeed and be the most fit (according to Darwin) to survive, and thus produce the most offspring. The successful genotypes and adaptations will increase in genetic frequency with subsequent generations as long as they continue to have a selective advantage. A variation is defined as any visible difference among the individuals within a population.

- Adaptations within individuals can be structural, behavioural, or physiological. An example of a structural adaptation would be the excellent eyes of an eagle because of its enhanced optic chiasma and more cones; some owls' hunting during the day is a behavioural adaptation; and a physiological adaptation is a bear's ability to store fat and slow its heart rate during the winter.
- A mutation is anything that permanently changes an organism's DNA. If the mutation is heritable (transmitted through the gametes to its offspring), then it can have negative or positive effects on the resultant offspring. A negative mutation will select against the individual and it will be less able to compete for the limited resources, whereas a positive mutation will give the individual adaptations that have selective advantages.
- Neutral mutations are passed on from generation to generation, until they serve a purpose.
- The theory of natural selection is based on the principles that organisms reproduce more offspring than the environment can support; this in turn forces competition because of the limited resources within ecosystems, and the most fit individuals (those with the adaptations best suited for the environment) will reproduce more often and pass these successful traits on.

Teaching Strategies

- Start your discussion by referring to Fig. 4.3 on page 115 or placing a picture of a dog and her litter of puppies on an overhead, or projector. Ask the students to look at the mother and each of the puppies and to come up with as many differences as they can between their phenotypes.
- Ask students to record answers to: "What do you believe evolution is? What are the forces behind it? How rapidly does it occur?"
- Students often have difficulties grasping the origin and survival of new traits in a population. You should devote some time to discussing mutations and sexual reproduction and how these processes introduce and create new gene combinations and new adaptations and variations. Many students believe that only the environment causes change over time and fail to recognize these two separate, distinct processes.
- Have the students brainstorm ideas as to how variation is created among populations of species.
- Additional terms used in this section are: "genotype," which refers to the genetic make-up of an organism, and "phenotype," which refers to the visible, physical characteristics of an organism.
- An extra quiz has been prepared for this section. You will find it with the Chapter 4 BLMs on the CD that accompanies this Teachers' Resource or at **www.albertabiology.ca**, Online Learning Centre, Instructor Edition, BLMs.

Number (Type)
4.1.4 (AST) Adaptations, Variation, Mutations, and Natural Selection Quiz
4.1.4A (ANS) Adaptations, Variation, Mutations, and Natural Selection Quiz Answer Key

SUPPORTING DIVERSE STUDENT NEEDS

Some students may need terms such as adaptation, variation, and mutations emphasized. Refer to Unit 2 Preparation, pages 74–75 for meiosis, showing large chromosomes with genes on them, and how these genes can move throughout meiosis and the resultant gametes contain unique combinations. Or, use manipulatives such as licorice and candies to model meiosis so that the kinesthetic learners will also comprehend how sexual reproduction can create variation. Have students design an activity or simulation that would demonstrate selective advantage by individual traits within a population. For example, create a population within the class that is depredating upon coloured licorice and give each of them different adaptations. As the students manipulate the adaptations, some will clearly be more successful (explain this as fitness) and be more able to reproduce.

Answers to Questions for Comprehension

Student text page 115

Q1. An adaptation is a trait that helps an individual survive. A shark with a keen sense of smell will be better at finding food and will therefore be more likely to survive and produce healthy offspring. These offspring will be more likely to have their parent's keen sense of smell.

Q2. Sexual reproduction takes the gametes from two parents and produces a resultant variant in their offspring. Each offspring gets a different combination of the parents' genetic material, so each offspring will be unique. Sexual reproduction is also influenced by increased variability because of events in meiosis, such as crossing over, that create new genetic combinations. The offspring will always be a variant of its parents.

Investigation 4.A: Variations Great and Small

Student Textbook page 116

Purpose

Students will design an investigation to measure inherited characteristics in two populations and determine if there are differences among individuals of the same species.

Outcomes

- 20–B2.1s
- 20–B2.2s
- 20–B2.3s

Advance Preparation

When to Begin	What to Do
One week before investigation	■ If you will be using bean seeds, pick them up at a local hardware store. ■ Have students consider which organisms they will be investigating.
1–2 days before	■ Photocopy **BLM 4.1.1: Investigation 4.A**

Materials
■ ruler ■ balance scale ■ callipers ■ microscope ■ microscope slides ■ checklists 1 (Designing an Experiment) and 2 (Lab Report) ■ beans, shells, leaves, or other objects to measure ■ string ■ graph Paper

Time Required

80 minutes (30 for planning; 20 for data collection; 30 for analysis)

Helpful Tips

- Use **BLM 4.1.1: Investigation 4.A: Variations Great and Small** to support this activity. Modify as necessary.
- Have students complete a formal write-up. Use Assessment Checklists 1 and 2 as guides.
- Students may have trouble deciding which characteristics to measure. To get them thinking about specific characteristics (traits), have an opening discussion about variations in humans or another common organism.
- If students are using the microscopes, review microscope use and slide preparation from Appendix C on page 756.
- Review variables with the class (manipulated, responding, and controlled), and have students identify their variables before they begin the investigation.
- Review how to write a hypothesis (a good hypothesis will include reference to the problem and the variables).
- Data should be presented in a table and graphed, if possible, to show results. Assess data tables and graphs for required components (titles, units, labels, etc.). Students can calculate mean, median, mode, and range of their data if it varies among organisms (i.e., bean seed length).

Answer to Analysis Question

1. Students should identify the variables they measured, the units they used to measure the variables, and the maximum and minimum measurements they got.

Answers to Conclusion Questions

2. Students are analyzing 2 traits so they will draw 2 conclusions. Concluding statements should refer back to observations and calculations, and have a quantitative component. For example, "It was found that the mass of the bean seeds ranged from .23 g to .43 g, with seeds equally distributed through this range." Typically, results will show a range of traits (i.e., hair colour, stem length in leaves, etc.); some traits will have only two variations (i.e., earlobes, no earlobes). Students can construct graphs showing a frequency distribution curve.

3. Students should expect to see a smaller variation in the range of data if all the specimens come from the same parent.

4. Size will have advantages in some species. For example, a large seed will be advantageous in times of drought or when soil nutrient conditions are poor. A larger seed will be able to provide more nutrients to a sprouting plant, allowing quicker growth, and sustain it for a longer period of time if the plant is under stress. Student responses should be logical and specific to the measured characteristic, state advantages (or disadvantages), and provide an explanation.

Assessment Options

- Assess the experimental plan and the full laboratory report. Use Assessment Checklists 1 and 2 (see Appendix A.)
- Assess answers to Analysis and Conclusion questions.

Answer to Question for Comprehension

Student Textbook page 118

Q3. When a student is discussing a mutation that provides a selective advantage, the response should point out that individuals with this advantage will be favoured to produce more offspring for the next generation.

Individuals with a selectively disadvantaged mutation will reproduce less frequently or their offspring will be less likely to survive.

For example, a selective advantage could be one that gives certain individuals within a population increased hunting success. These individuals will be selected for as mates because of this success. Individuals that have other variations that do not promote hunting success will be selected against (survival of the fittest).

Thought Lab 4.1: Evolving Superbugs

Student Textbook page 119

Purpose

Students will investigate the ability of the bacteria *Staphylococcus aureus* to adapt quickly to changing environmental conditions and analyze data to see how antibiotic resistance can develop over time.

Outcomes

- 20–B2.3s
- 20–B2.4s

Advance Preparation

When to Begin	What to Do
Day before investigation	■ Photocopy **BLM 4.1.3: Thought Lab 4.1: Evolving "Superbugs"**

Materials
■ coloured chips

Time Required

80 minutes (20 minutes for the activity and analysis;
60 minutes for ICT follow-up)

Helpful Tips

- Use **BLM 4.1.2: Thought Lab 4.1: Evolving "Superbugs"** to support this activity. Modify as necessary.
- Remember, antibiotics treat bacterial infections only, not viruses.

Answers to Analysis Questions

1. If a patient stops taking an antibiotic before the prescription is complete the patient may develop antibiotic resistance. The use (and misuse) of antibiotic drugs promotes the development of antibiotic-resistant bacteria. Resistance occurs when bacteria change on the genetic level, becoming resistant to the antibiotic. Resistance reduces the effectiveness of antibiotics.

Bacterial genes change when mutations occur or if a microbe acquires a gene from another individual. If this genetic change allows the organism to survive, it will reproduce and pass along the antibiotic-resistant gene, and quickly this gene will become dominant in the population. If a person does not finish a prescription, drug-resistant bacteria not killed in the first few days of treatment will proliferate.

2.
- The overuse of antibiotics can cause bacteria to develop resistance not only in humans, but in agricultural animals as well. Bacteria are commonly spread from animals to humans. When these bacteria are antibiotic-resistant, the resistance can be passed to human pathogens, making the pathogen antibiotic-resistant. This causes problems for the treatment of the disease.
- Agricultural practices introduce both plant and insect species to herbicides and insecticides respectively. Certain individuals within the populations of each species exposed to the chemicals will survive the applications. These individuals will now be the "most fit" and will pass on the heritable genotype that allowed them to survive through the applications. These genetic variations are also found on many bacteria as they are inadvertently being exposed to the chemicals used in antibiotics. As they develop resistance to these chemicals through exposure, this renders their ability to be used as possible antibiotic medicines useless.

Assessment Options

- Assess answers to Analysis questions.
- Assess presentation of the research report using Assessment Checklist 8: Presentation Skills from Appendix A.

Answers to Questions for Comprehension

Student textbook page 120

Q4. One example is the beaks on the finches; some finches may have longer beaks and some may have wider beaks. These phenotypic differences were caused by mutations and selective pressures. A second example is drought-resistance in fescue. At one point, individuals within a population had the mutation for drought resistance occur within their genes and it was a heritable trait. Once it was passed on to the next generation because of its reproductive and selective success, it became more and more predominant.

Q5. Insecticide acts as a selective force within the environment. Because of the variations within the population of insects, some will survive the insecticide application. When these individuals reproduce, the next generation will have more individuals that are able to survive because they have inherited the genes necessary for the insecticide resistance. This change in environment, with different selection pressures, is natural selection because the most "fit" individuals for the particular environment successfully reproduce.

Thought Lab 4.2: Analyzing Changes in Beak Depth

Student Textbook page 120

Purpose

Students analyze trends in the beak-depth of a Galápagos finch and correlate changes in the finch polulation to changes in the environment.

Outcomes

- 20–B2.1k
- 20–B2.2s
- 20–B2.3s.a
- 20–B2.4s

Helpful Tips

- Use **BLM 4.1.3 Thought Lab 4.2: Analyzing Changes in Beak Depth** to support this activity. Modify as necessary.

Answers to Analysis Questions

1. The average beak depth is less in times of greater precipitation, such as 1984.
2. The limiting factor of food changed during dry years and wetter years. In wetter years, it can be surmised that the shorter beak length had an advantage in collecting food and aiding in survival. It was because of this, the selective pressure, that the individuals with these traits would breed more often and more successfully. This in turn would direct evolutionary change over time. If the conditions had persisted to be either dry or wet, we would have seen a shift in the beak size of the population that could have possibly led to speciation later on.
3. The possible adaptation would help the individual finch survive during drought years. However, this physical change through exercise will not affect the bird's genes and therefore will not be passed on to offspring.

Assessment Options

- Assess answers to Analysis questions.
- Use Assessment or Checklist 3: Performance Task Safe Assessment from Appendix A.

Biology File: Web Link

Student Textbook page 121

Health professionals recommend that patients finish complete courses of antibiotics and that patients take only prescribed antibiotics for bacterial infections in order to reduce the spread of antibiotic-resistant bacteria.

Section 4.1 Review Answers

Student Textbook page 121

1. An adaptation is a structure, behaviour, or physiological process that helps an organism survive and reproduce in a particular environment. Five adaptations of the grizzly bear would include claws and powerful muscles for subduing prey animals or digging up roots; long, sharp teeth and powerful jaw muscles for killing and consuming prey; varied diet (grizzlies are omnivores); powerful sense of smell to locate dead animals; fast running speed, which helps them catch prey; and hibernation during the winter to avoid having to find food during cold, winter months.

> Note to the teacher.
> A common misconception is that grizzly bears do not hibernate. However, the following rejects that misconception:
> Grizzly bears do hibernate! Years ago some scientists didn't consider bears to be "true hibernators" because, unlike most hibernating mammals, bears only drop their body temperatures a few degrees (about 11 degrees to approximately 31 degrees C) during winter dormancy. Many mammals that hibernate drop their body temperatures to approximately 5 degrees C.
> Today, most scientists refer to hibernating mammals that drop their body temperatures down to about 5 degrees C as "deep hibernators." Deep hibernators have to wake up periodically to eat, urinate, and defecate. Most bear biologists refer to bears as "super hibernators" because bears can hibernate the entire winter (as long as 6 months) without eating, urinating, or defecating. In addition, since bears maintain a relatively high body temperature during dormancy, they can fairly quickly wake up and defend themselves against threats.

2. A variation is a visible or invisible difference between individuals in a population. Any variation that helps an individual in a population survive is likely to be passed on from survivor to survivor. Through generations of survivors, this variation will become more common, perhaps so common that it is considered to be a characteristic, or trait, of the population. Variations arise in sexually reproducing organisms because the offspring have a combination of genetic material from both parents. Through sexual reproduction, parents pass on distinct units of hereditary information (genes) to their offspring. The number of possible combinations of genes that offspring can inherit from their parents results in a great genetic variation among individuals within a population.
3. Students could use the example of mutations in household flies, which made them resistant to the insecticide DDT, or they could discuss the California ground squirrels that have the mutation that makes them able to withstand the rattlesnake's venom.

4. (a) Population change over time. An abiotic environmental condition can be said to select for certain characteristics in some individuals and select against different characteristics in other individuals. In this way, the environment exerts selective pressure on a population. The selective pressure is being determined by the gardener. As she continually selects only the largest pumpkin and uses its seeds for the following year, the selective pressure is based on size.

(b) Possible student responses: No—this is an example of artificial selection in which desired traits are being selected for by people. This is not natural selection taking place in response to finding the most successful and fit individuals with their adaptive traits, but rather the pumpkin is being selected for size by humans. It is not being selected for its success within this environment.

Students may also answer yes—assuming the most successful pumpkins are the largest, then the gardener is selecting the adaptive trait that is most successful. By selecting for this trait and ensuring these most-fit pumpkins are given the opportunity to reproduce, natural selection is taking place.

5. This statement is very true; natural selection is not about introducing new genetic material, as mutations do, but rather selecting for the most advantageous traits within an existing gene pool. Within the existing gene pool in a population, certain genes coding for different adaptations will be selected for in certain environmental conditions. Editors have to work with what material is given to them, and, from this, select what is best suited to meet the demands of the task given. They select the most "fit" adaptations (resources) to work with.

6. The diversity within the species will allow for different adaptive traits to become selected for. For example, if the sparrows are feeding on the seeds of grasses and the optimal length of beak is 10 mm, these sparrows have an advantage. If grass supplies become short, and the sparrow population is forced to rely on tree seeds for their survival, longer beaks are an advantage. Birds with beaks that work well in the environment will be selected for because of their adaptive advantages. This in turn will result in an increased number of individuals in the population displaying this trait.

7. Variations within a population assume that many individuals of a population will be sampled so that the phenotypic and genotypic diversity of adaptive traits can be better measured. Measuring only one tree ensures that the same genetics are being measured again and again; it does nothing to identify the variability within the existing population.

8. Natural selection is a process that results when the characteristics of a population or organisms change because individuals with certain inherited traits survive specific local environmental conditions and, through reproduction, pass on their traits to their offspring. Natural selection takes place in the example presented in this question because populations of insects contain, among their vast numbers of individuals, considerable variation in their genetic material, primarily as the result of mutations. Some members of the population may have the gene(s) to resist pesticides such as DDT. These insects have a selective advantage in the population. In other words, the insects that have this resistance are more likely to survive and reproduce, thus potentially passing on this now-helpful mutation to their offspring.

9. Individuals in a population cannot change their genetic makeup and do not change even if local environmental conditions change. However, it is unlikely that all of the individuals in a population will be killed or adversely affected by this environmental change. These individuals will pass on the traits (genes) that enabled them to survive the changing conditions, resulting in the population changing over time. An abiotic environmental condition can be said to select for certain characteristics in some individuals and select against different characteristics in other individuals. In this way, the environment exerts selective pressure on a population.

4.2 Developing a Theory to Explain Change

Student Textbook pages 122–133

Section Outcomes

Students will:

- compare different explanations for changes in populations over time
- describe evidence to support the theory of evolution
- explain how scientific knowledge is accumulated and organized to develop theories
- analyze data to determine relatedness among organisms

Key Terms

theory of evolution by natural selection
paleontology
inheritance of acquired characteristics
fossil record
transitional fossils
biogeography
homologous structures
analogous structures

Biology Background

- Original scientific thought, as expressed by early philosophers such as Plato and Aristotle, was that life was unchanging because it was already perfected. It was not until the publication of Buffon's *Histoire Naturelle,* in which he compared similarities of beings such as humans and apes, that these ideals were challenged. Buffon stated that similarities between humans and apes might suggest they had a common ancestor.

- Charles Darwin used the ideas, readings, and works of Jean Lamarck, Charles Lyell, and Thomas Malthus to help him create his "Theory of Natural Selection," which is accepted today as a guiding theory to explain evolutionary pathways and forces. Alfred Wallace developed similar theories during the same time period.
- Stratification of the fossil layers means the older fossils will be found in the deeper rocks and the younger fossils will be closer to the surface. If different fossils exist at different levels, it is evidence that not all life forms came into existence at the same time.
- Lamarck is credited with creating a theory of evolution, "Inheritance of Acquired Characteristics."
- The fossils found within the sedimentary rock layers are just a fraction of what used to occupy Earth; many species' remains were simply destroyed. For example, marine animals are most often soft-bodied masses, and their remains are unlikely to be preserved. The evolutionary tree that we try to create is an umbrella that is missing many links of species because of the extreme conditions needed to fossilize many of the species successfully.
- Modern biologists have been able to identify about 1.5 million living species. The paleontologists examining the fossil records have been able to identify and categorize about 250 000 species over a time span of about 540 million years (Erwin, 1993).
- The Burgess Shale is a middle Cambrian site (dating to about 540 million years ago) in the Rocky Mountains. It is unique in that it is one of the few places in the world where the difficult-to-preserve soft-bodied organisms of our past were preserved. For a complete overview of the formation of the Burgess Shale, visit www.geo.ucalgary.ca/~macrae/Burgess_Shale/.
- Archaeopteryx, once thought to be an example of a transitional organism, is about the size of a crow and exhibits many characteristics that make it look like a relative of the dinosaurs. Scientists have recently discovered that it had feathers, and they now believe it is a transitional species between reptiles and crows. It provides evidence that some dinosaurs, in a way, may not be extinct, but rather evolved into birds.
- Biogeography is the study of how organisms are spatially distributed throughout the world. Scientists in this field try to discover what causes changes in spatial distribution, and how they will evolve in the future. Darwin and Wallace used these studies to help in the formation of their theories.
- A homologous structure is derived from common descent regardless of the diverse number of uses it may serve for different species, whereas analogous structures are similar in structure and function and are the result of morphological convergence. Examples of homologous structures can be found in the leg of a horse, the fin of a whale, and the wing of a bat. An example of analogous structures would be the fin of a penguin, dolphin, and fish.
- The Synthetic Theory of Evolution is a new, comprehensive theory established using progress in the study of genetics, largely resulting from Gregor Mendel's work, along with the principles guiding the theory of natural selection. Combined with advances in microscopy and gene sequencing it has allowed for a greater understanding of the mechanisms behind evolution and inheritance. The findings from using these advanced techniques currently seem to support the original hypotheses from observations of fossils, anatomy, biogeography, and embryology.

Teaching Strategies

- A number of overhead masters and handouts have been prepared for this section. You will find them with the Chapter 4 BLMs on the CD that accompanies this Teachers' Resource or at **www.albertabiology.ca**, Online Learning Centre, Instructor Edition, BLMs.

  Number (Type)
  4.2.1 (HAND) The Work of Lamarck and Wallace
  4.2.2 (HAND) Contributions of Various Scientists to the Theory of Evolution by Natural Selection
  4.2.3 (HAND) Answering Darwin's Questions
  4.2.5 (OH) Geologic Time Scale
  4.2.6 (HAND) Evidence for Evolution: Homologous vs. Analogous Structures
  4.2.8 (HAND) The Peppered Moth Debate
  4.2.9 (HAND) Scientific Debate Organizer
  4.2.10 (HAND) Summarizing Evidence for the Theory of Evolution
  The handouts can be used as supplemental or reinforcement activities.
- Have students write down how they believe inheritable adaptations are created in a population. When the students reach the comparison of Darwinian and Lamarckian viewpoints, have them look at their entry, to see which point of view supports theirs. Most will have had a Lamarckian approach to evolution.
- There are numerous photos of different types of fossils found online; in order to illustrate the principles, it would be best to find some from different strata of rock at the same site. These photos or models should show that many species only existed for one stratum of rock. Ask the students to surmise what this might mean.
- Have the students compare fossils from the same species over hundreds of years. Do they see any differences?
- Use Figure 4.13 (page 131) to illustrate homologous structures. Use B**LM 4.2.6: Evidence for Evolution: Homologous vs. Analogous Structures** to show students the similarities and make the link back to a common ancestor.
- Have the students make a concept map for the theory of natural selection. The concept map should have the theory

of natural selection in the middle, and include the 4 essential components of the theory around it.

SUPPORTING DIVERSE STUDENT NEEDS

- The contributions of the different scientists that helped Darwin form his theory of natural selection, and served as the basis for the theory of evolution, are difficult for many to understand or to see how each contribution factored in. Have the students create a timeline, draw a cartoon picture of each scientist, and briefly explain their contribution to Darwin's theory.
- When possible, arrange a field trip to the Royal Tyrell Museum so that students can see how many of the fossil records support the theory of evolution.

Answers to Questions for Comprehension

Student Textbook page 123

Q6. Cuvier would have suggested the species of fish had become extinct, possibly due to a natural catastrophe such as a flood or volcanic eruption.

Q7. Lyell rejected the idea of catastrophism and guessed that the Earth changed slowly and continuously over time. His idea also suggested that the Earth was older than 6000 years. He believed that slow, continuous change would amount to large changes over time. This influenced other thinkers such as Charles Darwin, who wondered if the same sort of processes and timelines were occurring in populations also.

Student Textbook page 124

Q8. Using Lamarck's hypothesis of inheritance of acquired characteristics, because the farmer's ability to develop dark-tanned skin served a favourable purpose (adaptation) it would be passed onto her offspring. According to Lamarck, the offspring would all be born with darker than normal skin, so that they would have this advantage to begin with and continue possibly getting darker during their lifetime and passing this increased darkness onto their offspring as well.

Students should also indicate that while this would have been a reasonable hypothesis in Lamarck's time, now that scientists understand the distinction of heritable traits and the role of genes, it would no longer be considered.

Q9. Charles Darwin surmised that species could change over time after looking at the tortoises and finches on the Galápagos Islands. When he discovered that the finches had different beaks that allowed them to eat different food, and that the finches whose beaks were different lengths were not interbreeding, he surmised that these were different species, which must have been descended from a common ancestral finch, and which changed slowly over time to adapt to new environments. His observations were also supported by his knowledge of breeding of dogs, pigeons, and flowers. His research here showed that variations could be passed on through sexual reproduction and that many new variations could be produced. This helped emphasize that change could happen within a species over time.

Student Textbook page 126

Q10. Competition for limited resources accounts for the "struggle for existence" part of Darwin's theory of natural selection. Certain members of a species with the better adaptations and variations will out-compete others for the limited resources. Those that are able to out-compete will also be the ones that produce more offspring because of their successful traits.

Thought Lab 4.3: Comparing the Ideas of Lamarck and Darwin

Student Textbook page 127

Purpose

Theories of evolution have changed over time. Students will compare Darwinian and Lamarckian explanations of evolutionary change and comment on explanations of evolutionary change.

Outcomes

- 20–B2.3k
- 20–B2.4s

Advance Preparation

When to Begin	What to Do
One day prior to investigation	■ Photocopy **BLM 4.2.3: Thought Lab 4.3: Comparing the Ideas of Darwin and Lamarck**

Time Required

30 minutes

Helpful Tips

- Use **BLM 4.2.3: Thought Lab 4.3** to support this activity. Modify as necessary.

Answers to Procedure Questions

1. (Students have to rewrite the quotes in their own words. Here is a bit of background for you). Lamarck stated that time and favorable conditions have given rise to the diversity of organisms on the earth. He argued that if the environment of an organism changes, the organism will change its behaviour and adapt to fit the new environment. Use of an organ or appendage would cause

growth in that structure, whereas disuse would result in the structure shrinking or disappearing. Lamarck said that the results of these changes accumulated over a lifetime were heritable, and could be passed on to their offspring. Darwin states that natural selection acts on individuals with favorable variations. All species have a variety of traits, some of which have a genetic link. Since organisms differ and are capable of producing a great number of offspring, the chances of individuals in a species surviving and passing on traits to the next generation is very good. Change in species over time will occur when these favoured forms provide a selective advantage over others, and these changes will be passed on to later generations.

2. Lamarck says that it is the use and disuse of traits that result in inheritance. Traits in individuals can change over a lifetime, and these changes will be passed on to descendants. Darwin says that there is "descent with modification," implying that individuals vary from one to the next, and the ones that survive can pass their traits on to the next generation.

Answers to Analysis Questions

1. (a) Lamarck would state that flying fish arose from simpler fish, and over time developed a large pectoral fin because they needed it to outrun predators or hunt for insects above the water. Since the fin was used over and over, the fin got larger and larger, and the modifications were passed on to the next generations of offspring.

(b) Darwin would suggest that variation in fin size occurs in the population of fish, and at some point in time, the fish with the larger fins were able to survive, while fish with small fins did not. Those fish with the larger fins reproduced, passing along their large fin traits to their offspring.

2. Natural selection does not imply that species are becoming more and more complex (complexity is not the goal, survival and reproduction are); if this was the case, "simple" bacteria would be long extinct. It is not assumed that each generation is improving; populations change because of selective pressures from the environment.

Assessment Option

- Assess answers to Procedure and Analysis questions.

Biology File: Web Link

Student Textbook page 128

The Burgess Shale gave paleontologists their first specimens of fossil invertebrates—the fine mud that encased them preserved the soft body parts. The Joggins fossil cliffs, which were visited by Charles Lyell in 1851, also contain a rich variety of fossils, this time from the Carboniferous Period. Fossils include the world's first reptiles, thought to be the precursors of the dinosaurs.

Answer to Question for Comprehension

Student textbook page 129

Q11. (1) Stratification has shown that most often the fossils found in the younger layers (those closest to the surface) are more similar to the species living today than those found within the older or deeper layers. (2) Another thing the fossil record shows is that not all organisms appear in the fossil record at the same time. For example, by comparing different fossil beds, scientists were able to show that fish are the oldest vertebrate fossil, and in turn, amphibians developed from ancestral fish, reptiles evolved from ancestral amphibians, and mammals and birds both evolved from different groups of reptiles.

Biology File: Web Link

Student Textbook page 130

While the theory of plate tectonics explained the development of related species in places that are now very far apart, until Tuzo Wilson solved two key holes in the theory, little progress was made. Wilson proposed the idea of hotspots in Earth's mantle, which explained the existence of phenomena such as the Hawaiian Islands. He also hypothesized the existence of "transform faults," which explained horizontal slip. Both ideas were proven by tests in the field.

Thought Lab 4.4: Homologies of Hair

Student Textbook page 131

Purpose

Students will hypothesize the adaptive significance of variations in the structure of hair using electronic research techniques.

Outcomes

- 20–B2.1s
- ICT C7–4.2

Advance Preparation

When to Begin	What to Do
One week before investigation	■ Book computer lab or library ■ Photocopy **BLM 4.2.5: Thought Lab 4.4: Homologies of Hair**

Time Required

80 minutes

Helpful Tips

- Use **BLM 4.2.5: Thought Lab 4.4: Homologies of Hair** to support this activity. Modify as necessary.
- Discuss the structure of hair of common mammal ancestors.
- For Analysis Question 3, have the students set up their answers in a visual organizer.
- Hair is characteristic of all mammals. Mammal body hair has 3 basic parts—a shaft, root, and follicle. The most common theory regarding the evolution of mammal hair is that it has evolved from reptile scales; however there are no intermediate structures between scales and hair. It is believed that hair evolved to retain body heat; however, this is speculation.

SUPPORTING DIVERSE STUDENT NEEDS

- Some students may require assistance with search strings in Internet search engines; help them to find a list of specific words they will use to begin their search. Go to www.albertabiology.ca, Online Learning Centre, Instructor Edition, Teacher Web Links for suggestions.

Answers to Analysis Questions

1. (a) The structure of the organism's hair is related to its survival in its environment. For example, the hair of a polar bear is hollow, trapping air inside, providing extra insulation and warmth. This helps the polar bear survive in the Arctic.

(b) Student answers should hypothesize that all hair shares a characteristic that points to a shared common ancestor.

2. Presentation of findings.

Hairs of the *Porcupine:* porcupines cannot run fast nor are they big, so they use quills to defend against predators. Quills are modified hairs with modified barbs on the end that can be driven into the muscle of predators.

Underfur for *Sea Otters:* Sea otters have more hair follicles per square inch than any other mammal. Unlike whales and walruses, sea otters do not have thick blubber to keep them warm; their thick fur coats protect them from cold temperatures. The fur consists of two layers, a protective outer layer and a fine "underfur." The underfur remains dry by trapping air bubbles in the oily fibres.

Cat Whiskers: Cats have long, specialized hairs that have nerve endings in them. They are very sensitive, increasing the cat's sense of touch and helping cats feel their way around at night.

Mane of a Lion: Only male lions have manes. The mane develops at sexual maturity, and then the lion is removed from the pride by the dominant male. In terms of social structure within a pride, the mane is very important, making the lion larger in appearance and adding to his display in front of females. Dark manes are preferred by females; however, this presents a disadvantage for the male regarding temperature control. In the hottest climates, males have very small manes, or no mane at all.

Thick hair of a Woolly Mammoth: The woolly mammoth was adapted to the Ice Age climate. The coat of a mammoth was similar to that of muskox. The hair was long (90 cm) and thick, with dark guard hairs and fine underwool. The mammoth likely moulted in the summer.

Horn of a Rhinoceros: The function of the horn of a rhino is not fully understood; however, removal can be detrimental. The horn is made of tightly packed hairs called keratin (this is what our fingernails are made from).

Scales of a pangolin: This animal looks like a pine-cone-textured lizard. When attacked, it can curl up into an armoured ball (it is said that it can deflect a .303 bullet from 100 m), and it can harm an enemy with the sharp scales on its tail.

Qiviut of the Muskox: The coat of the muskox has two layers; the qiviut is the soft underwool found underneath the longer outer wool. This is the layer that is shed each spring. Qiviut is stronger than sheep's wool, eight times warmer than sheep's wool, and does not shrink in water no matter what the temperature. In addition, it is considered to be softer than cashmere or vicuna.

3. A comparison/contrast of similarities and differences between organisms studied by the group could be set up as a chart or some other visual organizer. Look for comparisons of both form (structure) and function.

Assessment Options

- Assess answers to Analysis questions.
- Assessment Checklist 8: Presentations from Appendix A.

Answers to Questions for Comprehension

Student Textbook page 132

Q12. Bird wings and bat wings are analogous structures. They serve the same function, but birds and bats come from different common ancestors and developed independently of one another.

Q13. Similarities in embryological development point to a common ancestral origin. As the development occurs, similarities such as the paired pharangeal pouches, which develop into gills in fish and amphibians, and ears and throat in humans, show that all vertebrates have a common ancestral origin.

Biology File: Try This

Student Textbook page 132

The term "pre-adaptation" is misleading because it suggests—with the prefix "pre" (before)—that the adaptation was somehow in anticipation of the need. In fact, some adaptations only co-incidentally confer selective advantage, depending on the change in abiotic conditions.

Answer to Question for Comprehension

Student Textbook page 133

Q14. Embryology, Molecular Biology, Paleontology, Comparative Anatomy (homologous and analogous structures), and Genetics have contributed to the theory of evolution by natural selection.

Embryology—similarities in development and developmental structures show relatedness to a common ancestor.

Molecular Biology—the presence of similar patterns on different species' DNA shows that the patterns were most likely inherited from a recent common ancestor. The farther apart the similarities, the more distant the common ancestor.

Paleontology—the fossil record shows the progression of species, their extinctions, possible transition species, and the order that they appeared in history.

Comparative anatomy—by examination of structures and bone make-up and functions, scientists can discover if the structures are homologous (which implies a common ancestry, but not necessarily a common function) or analogous (perform the same function, but developed independently of each other).

Genetics—the study of gene sequences has allowed scientists to make discoveries such as the relationship of dogs to bears, and whales to hippopotamuses. The study of the mechanisms of heredity and mutations allows scientists to surmise where and how these events transpired.

Section 4.2: Review Answers

Student Textbook page 133

1. (a) Cuvier—credited with helping to develop the science of paleontology, which is the study of ancient life through the examination of fossils. He determined that different fossils are found in each layer of rock or soil and concluded that some species disappeared and new ones appeared over time, and that some have become extinct. His observations were supported by his idea of natural disaster events, which he called "revolutions"—violent shifts in the environment that caused numerous species to become extinct.

(b) Malthus—wrote "Essay on the Principle of Population," in which he explained that plants and animals of the world produce more offspring than will be able to survive. His essay was integral in helping both Wallace and Darwin support and develop their theories.

(c) Wallace—outlined a theory almost identical to Darwin's in a paper that Darwin reviewed in 1858.

(d) Lyell—Darwin credits the reading of Lyell's work in leading him to develop and support his theory of natural selection. He rejected catastrophism and developed the theory of uniformitarianism, which stated that geological processes operate at the same rate in the past as they do today.

2. Both of these scientists realized that the environment has a great influence over animals which survive. Both scientists realized that the best traits will continue to be passed on to the next generation. They both came to the conclusion that, over time, individuals and populations change in response to changes in the environment.

3. Birds and bats have wings that are very similar in their function, but their bone structures are very different. This implies that these organisms do not have a common evolutionary origin, but instead they developed similar traits because of available ecological niches within their environment. In other words, these analogous structures were designed for a similar purpose, regardless of their ancestral origin. The bat and the mouse demonstrate homologous structures. They are both mammals, so they are more closely related than bats and birds. The bat's wing bone is homologous with a digit on the mouse's forelimb.

4. (a) Animals on the islands evolved from migrants from the mainland. Any observable changes in the organisms were because of the environmental conditions of the new area.

(b) All individuals within a species have phenotypic and genotypic differences caused by the variation processes within meiosis and sexual reproduction, as well as the many mutations that occur within DNA.

(c) Because resources such as food are limited, species compete both within the species and with other species. Those individuals with the most successful adaptations will out-compete in this environment and will be the ones that reproduce the most. Resources in limited amounts are known as selective pressures.

5. Student answers may include similarities between embryos in related groups, evolutionary relationships and common ancestry that can be traced back through DNA and proteins by the study of molecular biology, fossil similarity, anatomy and observing mutations in gene sequences.

6. This is not an example of how particular traits are passed from one generation to the next. For an adaptation to be passed on (such as the broken leg and limp) it has to be an inheritable trait. This means that the gametes of the organism must contain the genes that code for this trait so that the offspring will develop the adaptive trait.

7. One would find the oldest fossils in the lower layers, and the youngest ones closer to the surface of the fossil bed (in the upper layers), as long as there are no folds in which the layers have been uplifted in certain areas. This would then cause the fossil layers to change, and the oldest fossils might be more towards the top.

8. Transitional fossils are fossils that show intermediary links between groups of organisms. Transitional fossils have helped scientists better understand the relationships between groups of organisms. They link the past with the present.
9. The following chart can be used to compare homologous structures to analagous structures:

	Structure	Function	Origin
Homologous Structure	have similar structural elements and origin e.g., forearms of human, frog, bat, porpoise, horse	similar structural elements do not have the same function e.g., limbs of animals used for grasping, jumping, flying, swimming, running	inherited from a common ancestor
Analogous	similarity in structure based on adaptation for the same function	body parts perform a similar function e.g., body shape and flippers in dolphins, penguins, and fish	do not have a common evolutionary origin

10. In all organisms, all cells that can replicate contain DNA. Since DNA carries genetic information, scientists can determine how closely related two organisms are by comparing their DNA. If two species have similar patterns in portions of their DNA, this similarity indicates that these portions of their DNA were most likely inherited from a recent common ancestor.

Connections (Social and Environmental Contexts)

Debating Science

Student Textbook pages 134-135

Teaching Strategies

This feature can provide a few avenues of discussion.

- Students can focus on the role of scientific debate and the resulting stream of apparently contradictory pronouncements. Students can discuss the validity of this way of establishing facts and theories in view of the explosion of knowledge and the difficulty of vetting everything that is published. (They may note that it is not unlike the guiding principle of Wikipedia, which relies on sharp-eyed critics to correct misinformation.)
- Students can also use this piece to frame scientific debates of their own that they may wish to have—over evolutionary theory, climate change, or the importance of preserving biodiversity at the cost of prosperity. **BLM 4.2.9 Debate Organizer** can be used to prepare for such discussions.
- As an extension activity, students may wish to review the controversy over the studies of the peppered moth, using **BLM 4.2.8 The Peppered Moth Debate**.

Answers to Questions

1. The journals should be related to health, heart disease, or scientific research in order to ensure that the findings will reach an audience able to assess them or interested in testing them.

   Students should be able to profile the average readers, the size of the readership, and the journal's sponsor. The process for submitting research papers may be the subject of discussion if the process varies much from publication to publication. The last question is intended to direct the students' attention to any potential bias within the publication organization that may prejudice their chances of getting a review, e.g., how much influence do key funders have? Or how will the reputation of the publication affect the credibility of the research being published?
2. Answers should reflect thought given to the role of the general public in a scientific debate, perhaps reinforcing the need for the general public to be scientifically literate in order to be able to make a meaningful contribution and understand what is at stake. Suggestions on how to engage the public in important scientific debates should reflect the variety of ways that people gather and discuss information.
3. Complaints about earlier studies of the peppered moth focussed on the design of the experiment rather than the conclusions.
4. The biggest benefit of the publication of failed investigations is to save researchers from wasting valuable time and resources on incorrect hypotheses. Alternatively, those determined to pursue the line of inquiry can modify their procedures in an effort to find success if they can find out how others failed.

   Also, it has often been said that the greatest discoveries in science have been made by accident, when researchers have set out to prove something else. A catalogue of failed experiments would be a rich source of information and potential.

4.3 How Species Form

Student Textbook pages 136–142

Section Outcomes

Students will:

- explain ways in which species can become reproductively isolated
- describe how new species form
- compare two models that explain the rate of evolution

Key Terms

speciation
geographical barriers
biological barriers
adaptive radiation
gradualism
punctuated equilibrium

Biology Background

- Biologists used to define species by examining their physical forms; now the definition of a species encompasses an examination of its physiology, biochemistry, behaviour, and genetics. A species is defined as a population of interbreeding, or potentially interbreeding, organisms that are reproductively isolated from other species in nature. The interbreeding within a population must produce viable and fertile offspring.
- Geographical barriers restrict gene flows between two populations. If this gene flow is blocked for a period of time, speciation may occur.
- Vicariance is the separation of a population by a geographical barrier, which can result in speciation. A second type of barrier, a dispersal barrier, occurs when only some members of a population cross an already existing physical barrier, and no other members do, so that gene flow is stopped. Geographical isolation can also occur if the range (distance between populations) is just too great for the separated populations to interbreed.
- Biological barriers are divided into two categories: pre-zygotic mechanisms, and post-zygotic mechanisms. Pre-zygotic means that the barriers that exist prevent the exchange and union of the gametes. These barriers include behavioural, geographical, and physiological mechanisms. Post-zygotic mechanisms occur after the union of the gametes. Either the developing embryo will die, or the resultant offspring will be sterile, such as a liger (offspring of a male lion and female tiger).
- Speciation occurs when a subset of a population isolates itself and its adaptations become genetically different enough that interbreeding is no longer possible between the two populations.
- Adaptive radiation is the diversification of species from a common ancestor so that all new species have different adaptations. Darwin's finches are an example of adaptive radiation because of the differences in their size and beaks. These differences, originally promoted by intra-specific competition, forced subsets within the population to minimize competition by finding new food sources. The island has very limited resources, and if the finches had not gone through natural selection that promoted adaptive radiation, the island would not have supported the population of finches for long.
- Humans show examples of adaptive radiation, including bipedal movement, limbs and fingers that allow for fine-motor coordination, and differences in skin colour (darker skin, which has more melanin, is an adaptation to hotter climates in which humans have more exposure to the sun).
- There are two hypotheses regarding evolutionary change. The first theory, supported since Darwin's time, is a model of gradualism in which change occurs steadily, linearly, and continually. Speciation is the accumulation of many small changes over time. As Ernst Mayer stated in his book, *Animal Species and Evolution* (1963), "all evolution is the accumulation of small genetic changes" (pg. 586). This lends support to this first theory, which was founded much earlier than the second theory of "Punctuated Equilibrium."
- The second model, "Punctuated Equilibrium," proposed by Niles Eldredge and Stephen Jay Gould, criticized Darwin's traditional theory of evolution. Gould and Eldredge suggested that evolution need not be slow, accumulated changes over time, but rather could happen very quickly, or happen in very short bouts and remain dormant for long periods of time. These long periods of time were interrupted or punctuated in history by brief periods of speciation. This model surmises that most of the change a species undergoes when it diverges from the parent species happens almost immediately; after that, there is very little change. Their study is based upon the fossil records in which, when strata are examined, there are long intervals when nothing changed, and then short revolutionary transitions "punctuated" by some species becoming extinct, and being rapidly replaced by whole new forms.

Teaching Strategies

- Begin the class with a picture of a liger or a mule. Ask the students what these two animals have in common. Direct the students towards the answer that both of these animals are sterile and according to biology cannot be classified as a species.
- Have students define what they believe a species to be. After the concept is formally introduced in class at a later point, have them look at their definitions and see if their answers were complete.
- Assign **BLM 4.3.3: Thought Lab 4.5: Leopard Frogs** to help students realize that even though frogs may look remarkably similar, they can be different species. Remind them of the 4000 species of cockroaches discussed in the chapter opener.

- Have the students create a flip-chart book that identifies, with a diagram and supporting definitions, all the barriers that can exist that will help lead to speciation. At the beginning of the flip-chart book, have the students define speciation, and for their last page, have them cut out pictures that show that speciation has occurred (ie. Darwin's finches).
- The following overhead masters and activities have been prepared for this section. You will find them with the Chapter 4 BLMs on the CD that accompanies this Teachers' Resource or at **www.albertabiology.ca**, Online Learning Centre, Instructor Edition, BLMs.

  Name (Type)
  4.3.1 (HAND) Biological Barriers
  4.3.2 (OH) Finches of the Galapagos Islands
  4.3.4 (HAND) Modelling Adaptation and Natural Selection
  4.3.5 (HAND) Speculating about Speciation
  BLMs 4.3.1, 4.3.4, and 4.3.5 can be used as supplemental activities.
- Have students research the two lines of thought for evolution, gradualism and punctuated equilibrium, and create a summary of each. If they find any scientific evidence that attempts to refute either model, have them record it and then discuss it as a class. Make sure that the source they are getting this information from is credible first, or use it as an example in class to show why some information is more hearsay, rather than observed relationships.

Answer to Question for Comprehension

Student Textbook page 137

Q15. Speciation is the formation of a new species. The two pathways that can produce a new species are:
(1) Transformation: Accumulated changes over a long period of time: a new species develops while the ancestral or founder one slowly becomes extinct. (2) Divergence: One or more species arise from the parent species, and the parent species continues to exist, allowing for increased species diversity.

Biology File: Try This

Student Textbook page 137

There is a great deal of information available about global warming. Students' answers should focus on evolution by natural selection rather than extinction, noting that there may be a few organisms with traits that will enable them to survive, reproduce, and pass the traits that enhance survival in a radically changed environment on to their offspring. If the climate change is abrupt, there will likely be a small number of these organisms. Those who were perfectly adapted to the old conditions will likely have a very hard time surviving and passing their genes on to the next generations.

Suggested Web links can be found at **www.albertabiology.ca**, Online Learning Centre, Instructor Edition, Teacher Web Links,

Biology File: Web Link

Student Textbook page 138

The greenish warblers are an example of a ring species, much sought-after by evolutionary researchers as a key exemplar of the process. The warbler populations in question are found in a ring around the Tibetan Plateau. The variations in the populations indicate that the birds arrived in one location originally, and, as they extended their range in both directions around the obstacle, the populations developed different traits. Where the two diverging populations meet on the other side, they are sufficiently different, particularly in terms of their song, that they do not mate, thus forming separate species.

Other differences include subtle variation in wing bars and differences in genetic characteristics.

Answer to Question for Comprehesion

Student Textbook page 139

Q16. A bird's call is considered to be a biological barrier that keeps species reproductively isolated. Bird calls are a key part of the mating process, and the distinctive calls of each species of bird ensure that they only mate with members of their own species.

Thought Lab 4.5: Leopard Frogs: One Species or Seven?

Student Textbook page 139

Purpose

Students will use a variety of sources to gather and record information about various species of leopard frogs and communicate their findings.

Outcomes

- 20–B2.2s
- 20–B2.4s

Advance Preparation

When to Begin	What to Do
One week before investigation	■ Book computer lab or library ■ Photocopy **BLM 4.3.3: Thought Lab 4.5: Leopard Frogs**

Time Required

80 minutes

Helpful Tips

- Use **BLM 4.3.3: Thought Lab 4.5: Leopard Frogs: One Species or Seven?** Modify as necessary.
- Links to slides of the various species of leopard frogs and sound clips can be found at **www.albertabiology.ca**, Online Learing Centre, Instructor Edition, Teacher Web Links.
- Show images of the various species of leopard frogs and ask students if they think they are related. Play the sound clips a few times and continue the discussion. Have students conduct their own research in the library or computer lab.

Answers to Analysis Questions

1. Male frogs use distinctive calls to attract mates of the same species. Females will respond only to the mating calls of males of their own species.
2. Summary of differences/similarities between the species

   Background:

   Northern Leopard Frog (*Rana pipiens***)**

   - 50 – 100 mm long, dark spots surrounded with lightly coloured rings (halos); whitish belly; green (or sometimes brown) background.

   Southern Leopard Frog (*Rana sphenocephala***)**

   - 75 – 125 mm long; distinguished from the northern leopard frog by light spot in centre of tympanum (external "frog eardrum"), longer pointed head and only a few dark spots on the side of its body; breeding occurs all year:

   Florida (*Rana sphenocephala sphenocephala***)**

   - Populations of southern leopard frog in Florida have been given their own subspecies classification; these species cannot be easily distinguished from other species of southern leopard frog.

   Rio Grande (*Rana berlandieri***)**

   - Medium-sized frog reaching lengths in excess of 100 mm; looks similar to the plains and southern leopard frogs, except duller in colour of background and spots; medial inset dorsolateral folds.

   Plains (*Rana blairi***)**

   - Length varies from 51 to 95 mm; stockier than the northern leopard frog, has a shorter head, and a light line running along the upper jaw; broken dorsolateral folds; brownish in colour; small light spot on each tympanum; breeding occurs all year long.

   Ramsey Canyon (*Rana subaquavocalis***)**

   - Up to 150 mm in length, found only in Arizona; green and olive brown in colour; rough skin; broken dorsal lateral folds; morphologically indistinguishable from the Chiricahua leopard frog.

   Lowland (*Rana yavapaiensis***)**

   - 46 – 86 mm in length; colour ranges from tan, brown, light green to bright green; large dorsal spots with no light halos; no spots on head in front of eyes; dorsolateral folds are broken; faint light stripe on upper lip; breeds January–April;

Assessment Options

- Assess answers to Analysis questions .
- Use Assessment Checklist 7: Independent Research (see Appendix A).

Answer to Question for Comprehension

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Q17. The rise and fall of a lake over many thousands of years will create many isolated pockets of water. These will have different environments, within which individuals will have to successfully adapt. Because of the differences in selection, new species can arise because of the geographical isolations. Different selective pressures will eventually create different species.

Section 4.3: Review Answers

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1. For speciation to occur, two populations must be prevented from interbreeding. This means that the populations must become isolated from one another through geographical or biological barriers. If the populations remain isolated long enough, speciation will eventually occur because of changes accumulated in the population due to natural selection. When this happens, individuals in one population are no longer able to reproduce successfully with the other population. Geographical barriers, such as mountain ranges and rivers, prevent interbreeding and result in speciation because they keep populations physically separated.
2. Student drawings should show two pathways. One should illustrate that speciation is the result of accumulated changes over a long period. A new species develops, while the old species is gradually replaced (eg., Mammoth: the ancestral mammoth → steppe mammoth → woolly mammoth.

   The second pathway should show biological diversity increasing because one or more species arise from the same parent species. For example, the *Hyracotherium* that lived about 50 million years ago is thought to be the ancestor for horses, tapirs, and rhinoceroses.
3. A geographical barrier prevents populations from interbreeding. This is quite different from habitat isolation, in which two species can occupy the same geographic range but will occupy different habitats and niches within it.

4. The species that are found within an area such as Hawaii are a result of the available ecological niches, selective pressures, and adaptations that this unique environment has created, as well as the island's isolation.
5. Criteria include physiological and anatomical analysis differences, a molecular biology analysis to look at the amino acid sequence, and an examination of the gametes and genetics of the birds. If it was proven that these birds could still interbreed and produce viable offspring, then these birds are still of the same species, though with differences.
6. The following chart summarizes the models of gradualism and punctuated equilibrium

Gradualism	Punctuated Equilibrium
■ changes occur gradually and in a linear fashion	■ there are periods of rapid change (i.e., rapid speciation after mass extinctions)
■ big changes (such as the evolution of a new species) occur as a result of many small changes	■ long periods of equilibrium "punctuated" or interrupted by periods of speciation
■ not supported by the fossil record but should be noted that not all species leave a fossil record	■ most species undergo most of their morphological changes when they first diverge from the parent species ■ after undergoing morphological changes, the species changes relatively little even as they evolve into a new species

7. The volcanic (Red) island will support a smaller number of species and will have fewer endemic species, since it is populated with organisms that were able to colonize by dispersal, and it is a very young island. In contrast, Blue Island will have more species and more endemic species, since it already had organisms on it when it separated from the mainland and there has been 80 million years for natural selection to occur.
8. The four species in Puerto Rico have each developed traits (adapted) to suit their particular niche—be it grass, tree bases, tree branches, or the canopy. The DNA indicates that these species are closely related, which means they have diversified from a common ancestral species that arrived on the island.

Chapter 4: Review Answers

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Answers to Understanding Concepts Questions

1. The theory of evolution by natural selection is based on the observation that individuals with physical, behavioural, or other traits that helped them survive in their local environment were more likely to have offspring and pass those traits on to the next generation. The environmental conditions that favour those traits over others are said to exert "selective pressure" on the population by those favouring individuals with certain traits, which become predominant over time if the environmental conditions continue.
2. The more visible a field mouse is within its environment, the more likely it is to be preyed upon. The field mice that have been selected for phenotypes that allow them to camouflage successfully will increase in frequency because of their adaptive success.
3. If a mutation becomes heritable (passed through the gametes of sexually reproducing organisms), it could lead to a positive mutation. The new, mutated DNA sequences could code for the protein synthesis needed for a better adapted trait that gives the new individual better competing success.
4. Individuals within a population will exhibit many variations of their physical characteristics. These variations are heritable and are passed from generation to generation. The variations that are the most successful in a particular environment will help the population become better adapted. These variations will make each subsequent population more successfully adapted over time, though this process is slow. This process of variations becoming successful adaptations over time is known as natural selection.
5. Darwin noted that the flora and fauna that he was accustomed to in England and the rest of Europe was very different from the regions the *Beagle* visited. For example, the rodents of South America were very similar to each other on that continent but very different from the rodents of Europe. The finches and tortoises that he observed on the Galapagos Islands looked very similar at first, but as he made more careful observations, he was able to see, for example, that each type of finch fed upon different food. He began to surmise that these may be different species of finches that had arisen from a common ancestral form.
6. Darwin used this terminology because of the influence of geologists and paleontologists Hutton, Lyell, Smith, and Malthus. He adopted some of their ideas and streams of research and the terminology of the times.
7. Lamarck would have used the proposal of acquired characteristics. If the Ord's kangaroo rat needed to jump to 2m in the air to hop away from predators, successful

leapers would pass the trait on to their offspring. Darwin would account for the origin of the long hind legs of the Ord's kangaroo rat by explaining that phenotypic and genotypic variations within the individuals would allow for different adaptive and survival traits to be tested. If the kangaroo rats that were able to jump 2m in the air were more successful in avoiding predators, this selective advantage would have allowed them to reproduce more, and thus more individuals in the next generations would inherit this adaptive variation.

8. A bird wing and an insect wing are not homologous structures. Birds and insects do not share a common ancestor. Bird wings have internal skeletons, while insect wings are made of chitin.

9. When 2 species are very similar in regards to their anatomy, it suggests that they arose from a common ancestor and that they are close on the phylogenetic tree.

10. These similarities point to a common ancestral origin. All vertebrate embryos have paired pharyngeal pouches and a tail. In fish, these develop into gills, whereas in humans, they become parts of the ears and throat. The shared features in the embryo suggest evolution from a distant, but common, ancestor.

11. Rapid shifts in the abiotic and biotic conditions of the environment will promote more rapid speciation. For example, rapid changes in the environment can promote extinction, as well as speciation. The new environments that are created will select for new adaptive traits, and if populations are kept apart by geographical, reproductive, or behavioural barriers, new species can arise from common origins.

Answers to Applying Concepts Questions

12. Through the use of artificial selection, an individual could continually select the best milk producers. These new cows could be interbred to continue producing better milk producers. This would not produce a new species, as the cows that were artificially selected for would still be able to interbreed with the original populations.

13. The two populations have access to each other through the connecting tube so they are not geographically isolated. However, because they are genetically very different, they may develop as separate species as a result of biological barriers. Biological barriers include different courtship and/or mating rituals that would prevent mating. If individuals of the two populations mated, the resulting eggs might not be viable. In either case, the exchange of genetic information cannot take place between the two populations and they develop as separate species.

14. (a) The seed's large size ensures it has more of its needed start-up nutrients for survival. It gives the plant an edge in competing for the needed abiotic factors, such as sunlight and water.

(b) Larger seeds would be more visible to birds or rodents, and thus would be eaten before they could grow and reproduce. Smaller seeds may be better able to withstand freezing temperatures during the winter, or less vulnerable to mold and fungi.

(c) The gardener could remove the smaller seeds prior to germination, which would ensure the larger seeds had a selective advantage. Another strategy the gardener could use would be to harvest only the larger seeds each year. By using only larger seeds in subsequent years, the gardener would be applying selective pressure favouring plants that produce larger seeds.

15. (a) Baboon: 5 different amino acids—33% difference in amino acid sequence.

Chimpanzee: 0 different amino acids —0% difference in amino acids sequence.

Lemur: 7 different amino acids—47% difference in amino acid sequence.

(b) The chimpanzee and the human have the identical amino acid sequence for this specific protein. Based on this information, one could infer that the mammal most closely related to the human is the chimpanzee. The lemur and the human have the greatest variation in the sequence of amino acids; this suggests that the lemur and human are not closely related.

(c) No. An evolutionary biologist would look at many other characteristics before drawing any conclusions on the relatedness of these mammals.

16. These two garter snakes are likely to remain separate species because they are biologically isolated. Even though these snakes live in the same general area, they use different habitats, and therefore encounter each other rarely, if at all. This is different from a geographic barrier because there is no physical impediment keeping the populations apart.

Answers to Making Connections Questions

17. Students could use the fossil evidence for the development of the modern toothed whale (Figure 4.11 page 129). An example that students could look up would be the Cenozoic horses. These horses demonstrate sequential evolution quite clearly.

18. Students need to understand that when a population of bacteria is exposed to an antibiotic, only the resistant bacteria can survive. Lists should include finishing all the course of treatment, taking the correct dosage, and not using antibiotics to treat viral diseases.

19. Student memos should mention that a biologist needs to know exactly where a species was found, so that its environmental niche and range can be established. The unique characteristics of the species can only be linked to the biotic and abiotic elements in their environment if the environment is noted in detail. The time of year the plant was found is also needed in order to see traits such as breeding cycles (annual or perennial, flowering season) and different stages in its life cycle.

Unit 2 Career Focus: Ask a Paleontologist

Student Textbook pages 146–147

Teaching Strategies

- Contact a local museum or university to ask a paleontologist to visit the class for a discussion of the latest findings.
- The Royal Tyrrell Museum may be able to put you in touch with a local volunteer who has visited and worked on the site. Staff may also be able to put you in touch with someone in a related field who would be able to visit the class.

Answers to Go Further Questions

1. To help study the evolutionary relationships between dinosaurs and birds, scientists have a number of avenues available:

   –fossil record

   –animal distribution

   –comparative anatomy

   –molecular biology

   –and observations within the laboratory

   An excellent site to direct the students to for beginning this project is: **http://ca.encarta.msn.com/encyclopedia_761554675_5/Evolution.html.**
2. Geneticists can do comparative chromosome analysis between different species. As they analyze the chromosomes and the genes upon them, they can compare the similarities and determine how closely related different species are. They can also compare many species to determine which are more closely related, which probably came from a common ancestor, and where they branched off from each other on the phylogenetic tree. This may eventually allow scientists to understand where each species got its unique combination of genes and what inherent mutations within its own DNA allowed the species to develop.
3. Human activities are causing extinction of species at a rate that has never been seen before in the fossil records. We truly do not understand the ramifications of the elimination of these species from their ecosystems and the loss of their gene pool. We can use the study of evolution and how it accounts for change over time to help us predict the effects of our actions. As some species disappear, new ones appear to fill the empty ecological niche within the environment. Evolution, however, is most often a slow process and these open niches within nature may take a long time to fill. Habitat destruction is the greatest cause of extinction.

Unit 2 Review Answers

Student Textbook pages 148–151

Answers to Understanding Concepts Questions

1. A population is a group of individuals from the same species, occupying a defined area, and sharing a common gene pool.
2. Ecology is the study of the interactions of organisms amongst themselves, and with other species. It is also a study that observes how different organisms interact with their physical environments. It is a study of the interdependence and interconnectedness of both the abiotic and biotic factors within ecosystems.
3. If all of the predators were eliminated from an ecosystem, this would cause a population explosion among the prey species until the prey species reached or exceeded the carrying capacities for their environment. Then their reproductive rates would slow down to a sustainable level: or, if they had exceeded the carrying capacity, they would suffer a population crash.
4. Organisms are not randomly or evenly distributed across the planet because for an organism to survive, the biotic and abiotic factors must be present to support its existence. The right combinations of abiotic and biotic factors for different species are isolated in different geographical ranges across the planet. Different regions will support different species because of the differences in abiotic and biotic factors.
5.

Abiotic Factors	Effects on the Pond Ecosystem
Temperature	The deeper regions of the pond will be cooler and will support different plant and animal species than the shallower regions.
Light	Plants will be able to exist within the shallower waters, but as the water becomes deeper, the amount of available light for the plants becomes less and less. This would limit the amount of photosynthesis.
Precipitation	Depending on how the water flows as it enters the pond, some areas may flood over, and others may become silty from the eroded soil entering the water. Not all animals or plants would be able to occupy these areas. This could also change the vertical stratification of the pond water.

Abiotic Factors	Effects on the Pond Ecosystem
Nitrogen and Phosphorous	These elements, when limited in amounts, control the amount of plant growth possible.

6. A scavenger is an animal that feeds upon dead animals or garbage. Biotic factors that would limit the scavenger's population size include prey density for predators and the success of the predators in killing their prey. Another biotic limiting factor would be the number of scavengers competing for the dead organisms within the environment. Too much competition will limit their population sizes. As well, abiotic factors such as drought, floods, and natural disasters could rapidly change the number of dead organisms to be fed upon. The scavengers' populations may crash over time, as the number of animals occupying the ecosystem has rapidly dropped.
7. An example of (a) a biome is the northern boreal forest (taiga). (b) One ecosystem within this biome is a tract of coniferous forest. (c) Within this forest ecosystem, the community includes such animals as deer, bears, elk, wolves, spruce trees, shrubs and many other species.
8. Order is higher on the hierarchy of classification. The lower levels branch out from the higher levels, so two species of the same *family* must also be in the same *order*.
9. **(a)** An example of an abiotic factor that limits population growth is the availability of sunlight for plants. As the plant density increases within an ecosystem, competition emerges for sunlight, and eventually the ones that cannot compete for their needed amounts of sunlight will die off.

   (b) An example of a biotic factor that can limit population growth is a predator/prey relationship. As the number of predators increases within an area, there is a subsequent decrease in the prey population. As the prey population begins to decrease, so does the population of predators.
10. Regular population cycles of mice and squirrels are dependent on both abiotic and biotic factors. Their population cycles could be regulated by biotic factors such as intraspecific and interspecific competition, predation, or parasitism. Abiotic factors that could impact on the population cycles of these animals could be the amount of precipitation, drastic temperature changes, or natural disasters such as a forest fire in the area.
11. The range of a species can be described as the city it lives in. The range is the habitat that the species is able to live in successfully.
12. An example is the Grizzly Bear. Its population growth can be limited by many factors such as the availability of mates, territory, and food. Human activities such as hunting, collisions with vehicles and trains, and continued community development within the bear's natural habitat can also limit the growth the of bear population.
13. Possible student answers include the following: A population of a species in a field could compete for things such as: territory for habitat and mating; access to limited food supplies; limited access to mates; access to water and other abiotic limiting factors such as sunlight and suitable temperature environments.
14. For evolution to occur, both physical diversity (including adaptive traits) and genetic diversity are necessary. As changes occur in the environment, some individuals will have a selective advantage within a population as compared to the others; this advantage will allow them to reproduce more successfully and allow for the more "fit" adaptations and their supporting genes to be passed on. Without diversity, the population would only be able to survive if it was a static environment.
15. - Structural adaptations are an organism's physical features, for example, the bills of varying lengths and design on birds or hair on mammals such as bears.
    - Physiological adaptations are adaptations of the metabolic processes of an organism. For example, a warm-blooded organism can survive in different environments than a cold-blooded one.
    - Behavioural adaptations are behaviours that an organism uses to survive. This could include hibernation or migration.
16. The bat wing and butterfly wing are considered to be analogous structures. They both serve a very similar function but were derived by similar needs in an environment, not from a common ancestor.
17. Individuals in a population cannot change their genetic makeup and do not change even if local environmental conditions change. However, it is unlikely that all of the individuals in a population will be killed or adversely affected by this environmental change. These individuals will pass on the traits (genes) that enabled them to survive the changing conditions, resulting in the population changing over time. An abiotic environmental condition can be said to select for certain characteristics in some individuals and select against different characteristics in other individuals. In this way, the environment exerts selective pressure on a population.
18. A fact is a statement based on collected data. A theory is a collection of ideas and thoughts that explain the collected facts (data) of the world. For example, it is a fact that change over time among species occurs; however, natural selection is a theory that explains the observed facts, such as fossil and biochemical evidence.
19. If two species have similarities within their DNA sequences and patterns, it indicates that these sequences were most likely inherited from a common ancestor. For example, comparing 1 human to another, there would be a 100 percent match of genes (some in different orders),

but comparing human DNA to that of a chimpanzee gives a 98 percent match, suggesting common ancestry.

20. (a) Darwin's experiences on the *Beagle* allowed him to explore the coast and coastal islands of South America, observing the natural history and geographical location of each stop. He noted that the flora and fauna of the regions were very different from those found in Europe.

(b) Lyell was a good friend of Charles Darwin, and his writings and support for the idea of continuous, gradual changes were integral to helping Charles Darwin find the support he needed for his theories of natural selection and evolution occurring over time.

(c) Malthus's essay, "On the Principles of Populations" proposed the idea that populations produced more offspring than could actually survive. This competition would weed out the weaker individuals who did not have adaptive advantages, and this would ensure the strongest and most fit individuals would continue breeding in environments where limited resources promoted competition.

21. (a) Many mutations happen during our lifetimes, and as written in the student's text, about 175 mutational changes occur prior to the birth of a human offspring. Mutations are most often neither beneficial nor harmful. In instances where mutations have a negatively selected influence, the fetus may be aborted, be born sterile, or have adaptive traits that make others within the population not mate with individuals possessing these disadvantaged adaptations.

(b) If a mutation provides a selective advantage, its gene frequency will increase rapidly over successive generations. As it is being selected for, more and more individuals within the population will exhibit this selective advantage.

22. (a) A geographical barrier can be a mountain range or a body of water. A biological barrier can be behaviours such as mating rituals or genetic differences between two populations.

(b) A geographical barrier keeps populations of individuals physically separate. Species separated by a biological barrier can co-exist with overlapping habitats and ranges, but because of behavioural patterns for mating, different courtship songs, and even different attractive pheromones, they will never mate.

23. Evolution explains the gradual changes in organisms as each species cultivates (selects for) traits that improve chances of survival in a wide variety of abiotic conditions. Despite the wide variety of environments on Earth, however, there are still some common elements shared by most environments that relate to oxygen, water, and nutrients. This results in species developing analogous traits to cope with those common elements. Students may also suggest that the commonality of life forms at the cellular level indicates that life originated from a very small number of organisms.

24. A transitional fossil is defined as a fossil that combines features of two taxonomical divisions. It is an intermediate stage that has links to both the prior ancestor and to what the species is becoming. The example of a whale-like aquatic animal with tiny legs is a transitional fossil, as it could show the evolution of an aquatic species to a new terrestrial species.

Answers to Applying Concepts Questions

25. (a) Organism A is a damsel fly. Organism B is a dragonfly because wing structure matches 1b.

(b) It can be inferred that dragonflies and damselflies evolved from a common ancestor because both have homologous structures, both are of the class *Insecta*, from the same family (*Odonata*), and have similar life cycles. Note, students do not have to include the Latin names in their answer.

26. (a) Domain – Eukarya

Kingdom – Animalia

Phylum – Chordata

Class – Mammalia

Order – Carnivora

Family – Canidae

Genus – *Canis*

Species – *lupus*

(b) The scientific name of the grey wolf is *Canis lupus*.

27. (a) Grizzly bears will be more likely to become endangered than black bears as the two species come under increased levels of stress (due to habitat loss for example) and as population levels decline. This is due to differences in their habitat requirements and reproductive behaviours. Grizzlies have a more restricted range, niche, and diet than black bears.

(b) Since black bears cannot mate successfully with either grizzly or polar bears, it can be said that black bears are further removed from these other two species of bear. Since grizzly and polar bears can reproduce and have viable offspring, this confirms that they are very close relatives and have a common ancestor more recently in history than that of the common ancestor of the black bear.

28. (a) These data might indicate that leaves in British Columbia and Nova Scotia release more water than leaves in Ontario or Alberta.

(b) The rainfall is higher in provinces whose leaves have more stomata (British Columbia and Nova Scotia).

29. (a) D_p (population density) = $\frac{N}{A}$ where N represents number of organisms and A represents the area where they live.

The mean number of oak tress from the transect data is: $\frac{18.6 \text{ oak trees}}{500 \text{ m}^2}$.

(b) We are now asking the students to convert this to hectares. The conversion is: 1 hectare = 10 000 square metres.

Therefore, 500 square metres / 10 000 square metres = .05 ha (1/20 ha).

Multiply .20 × 18.6 to determine the approximate number of oak trees in one hectare. This results in 372 oak trees.

Multiply this number by 100 (for the total number of hectares) and we get 37 200 oak trees in 100 ha area.

(c) The forester could have used quadrats to obtain similar data.

30. Included within the student response should be a hypothesis that variations will exist within specific traits identified within a population. The procedure needs to offer an effective way to collect, record, and display this information (i.e., measuring the length of the corn cobs, or the average number of kernels per cob).

31. Within a population's gene pool, mutations will introduce new variations in individuals' gene sequences. These new variations can result in new adaptations being produced among individuals within the population. The adaptation will be selected for if it helps the organism to survive and reproduce. As a result, the frequency of the selected gene will increase in the population. As changes occur and new adaptations are selected for, reflecting the principles behind natural selection, the most fit individuals pass on their genes to the next generation to ensure the best adaptive traits for continued existence in that particular environment.

32. This statement accurately describes evolution if we accept the theory of natural selection. Environments continually change over time, just like a continually running motor. For the motor to keep running, it needs to adjust to the changes occurring around it. Evolution is just like tweaking the performance of a machine while it is running to ensure it runs at its best. To ensure that a biosphere works at its best, new adaptations and the adjustments that work (successful adaptations) will be kept (selected for).

33. (a) The first of the pathways comes about as changes accumulate over time. The second pathway occurs when one or more new species arise from a common parent species, and the parent species continues to exist.

(b) An increase in biodiversity will come about through the second pathway, in which one or more new species forms from the original parent species.

34. (a) The distinctive patterns of flashes are like the mating songs of birds—slight changes in the flashes help the different species of fireflies identify their prospective mates and keep them from mating with a different species.

(b) This reproductive barrier ensures no cross-fertilization between the two species of grass. This ensures that they will continue their own species line and not create a new "hybrid" species between the two.

(c) Evolution and the limiting factors within the ecosystem will select against the offspring produced by the hybrid. Natural selection will ensure these weaker individuals will not become a new species, as they do not have the adaptive traits needed to compete successfully for the limited resources. As well, the hybrid offspring are infertile and cannot reproduce.

35. Key concepts include: Climate is ultimately determined by average annual temperature and precipitation and is affected by latitude, altitude, and proximity to water bodies. Such abiotic conditions, coupled with parent bedrock material (the geology of an area), will determine soil type. Soils, topography, precipitation, and other abiotic factors will determine the vegetation that an area can support. The types of vegetation will ultimately determine what animals can be supported in that area, as vegetation provides shelter, protection, and food for animals. It is important that in student diagrams, arrows point in both directions, showing an understanding that these relationships are not unidirectional, but rather complex interrelationships. Students should provide examples to show their understanding of this concept.

36. Student answers should include that it is important to respect these restrictions because of the damage these pests cause to ecosystems and the economy. By bringing restricted items into Alberta, people are spreading pests into the area. The affected trees die, resulting in changes to the biotic community as well as the abiotic conditions in the area. For example, areas where trees have died may be more susceptible to soil erosion or to forest fires. In economic terms, infestations of these pests have a direct impact on the forest industry in the province and could also have a detrimental impact on the tourism industry in some locations (tourists are not likely to come into areas with large stands of dead or dying trees).

37. The population remaining constant (2000 for 10 years) showed the carrying capacity for this lake had been reached and maintained. An introduction of the 1000 new fish of the same species will promote intra-specific competition because this large increase will exceed the carrying capacity of the lake's ecosystem for this species. One would expect a population crash as competition increases for the now limited resources. In addition, the new carrying capacity of the lake after the population crash would now exist at a lower level (i.e., 1200 fish) because of the depletion and degradation of the limited resources needed to survive.

38. A forest that has been replanted with a single species (monoculture) has less total species diversity due to the lack of variety of habitats and ecological niches required to support a high biodiversity. On the other hand, a forest that hasn't been logged would have a greater variety of trees which, in turn, results in greater variation of habitats and niches in the area. This variety would allow other species to flourish, resulting in greater biodiversity.

39. The following explains why the examination of proteins in individual organisms can demonstrate relatedness among species.

- In all organisms, the order of amino acids in specific proteins is determined by DNA.
- Since DNA carries genetic information, scientists can determine how closely related two organisms are by comparing their DNA.
- You can infer that if two species have similar proteins, then their DNA must also be similar.
- If two species have similar patterns in portions of their DNA, this similarity indicates that these portions of DNA were most likely inherited from a recent common ancestor.

40. In this situation, the organism's environment is likely changing. Mutations that once were no advantage, or perhaps even a disadvantage, may become favourable in a new environment. In this situation, the mutation provides a selective advantage in the new environment. A mutation that helps individual organisms survive has a good chance of being passed on to subsequent generations. In time, the gene that provided the selective advantage becomes more prevalent in the population.

41. Model "A" supports gradualism, because it visually represents that change occurs within a lineage, slowly and steadily over time. According to this model, big changes (such as the evolution of a new species) occur as a result of many small changes.

Model B shows punctuated equilibrium. This model proposes that evolutionary history consists of long periods of equilibrium where there is little change, "punctuated" or interrupted by periods of speciation. According to the model of punctuated equilibrium, most species undergo most of their morphological changes when they first diverge from the parent species.

42. Students could construct a timeline similar to the one shown below:

300-400 B.C.E.: Aristotle and Plato (life exists in perfect and unchanging form) → 1749: Buffon (*Histoire Naturelle*) → 1790s: Cuvier (*fossil evidence*) → 1809: Lamarck (*inheritance of acquired characteristics*) → 1830: Lyell (*Principles of Geology*) → 1844-1858: Darwin and Wallace (*theory of evolution by natural selection*). A concept map could also be used to display this information.

Answers to Making Connections Questions

43. (a) To help determine if the frogs were of the same species: compare information on the frogs, including mating behaviours, frog calls, time of year that they mate, life cycle stages and lengths, and DNA analysis.

(b) If the two species of frogs were different, you could tell how closely they are related by analyzing their DNA, looking for similarities and difference in terms of gene sequencing. A more practical analysis would involve the comparison of the above-mentioned points—to observe the frogs' geographic area and suggest a time when they may have become geographically isolated, or to conduct an investigation attempting to breed the two frogs to see if they produce viable offspring. If the offspring produced were not viable, then they truly would be new biological species. If a viable hybrid could be formed, then it would suggest that their divergence along the phylogenetic tree was relatively recent.

44. This opinion-based question can be answered either way, as long as the student argues with logical points. For example, if a student says it is as important to be concerned about moss, the answer should include the ecological importance of moss, including its role in the cycling of nutrients; water retention for forests; soil protection; and the importance of other organisms that are supported by the moss and the implications of the loss of the moss. Students might also mention the potential medicinal importance of the moss, or question why the moss is threatened. Finally, suggestions should be made as to how either species can be protected to ensure that it does not become extinct.

45. All living things have general requirements for growth. These factors include nutrient availability, habitat (space), light, water availability, and suitable temperature range. Factors that limit growth of populations will be access to these resources, coupled with competition pressures, predation, and potential parasites.

- The population growth of most food-borne bacteria is limited by access to warm temperatures, moisture, and a food source.
- Tree population growth is limited by access to water, light, and nutrients in the soil.
- Deer populations can be limited by access to food, the size of predator populations in their area, as well as infestations of parasites.

46. Many of the endangered species in the world have very specific, or narrow, ecological niches because they often live in highly diverse areas with other organisms, and as such, need a specialized niche in order to survive. Some species exist only in one geographic area and nowhere else in the world (endemic). Both endemic and threatened species can have very restricted ranges because of either natural geographic barriers (such as islands or mountain tops) or human-engineered barriers (such as habitat fragmentation, destruction, and isolation). Species are further threatened by extinction when they are over-hunted or out-competed by invasive species.

47. Biodiversity needs to be maintained because it keeps the gene pool of many species alive. Within these gene pools, there exist significant differences in genetic adaptations. As the environment continually changes, different adaptations will be selected for as individuals or populations out-compete the other species (inter-specific competition), or their own species (intraspecific competition) for the limited resources.

48. Students may choose to argue that antibiotics should be available without a prescription. However it will be difficult to make a case for this using the principles of natural selection.

Antibiotics work by killing bacteria. However, there will always be some bacteria that may be genetically resistant to the antibiotic due to a mutation that suddenly becomes a selective advantage. While early application of the antibiotic will kill the non-resistant bacteria, it may take a sustained application of the antibiotic to kill the resistant bacteria. If this sustained application does not happen, the resistant bacteria will be able to survive and reproduce, passing the resistant mutation on to their offspring. (This is an example of natural selection for this mutation.) As the numbers of resistant bacteria increase, the antibiotic in question will be less effective and eventually may be unable to have any effect on a population of largely resistant bacteria.

If antibiotics are available by prescription only, it is assumed that a physician will supervise the drug use, ensuring that the whole course of medication is taken in order to kill off all bacteria, and that antibiotics are not used indiscriminately, thus increasing the chances that resistant bacteria will develop.

49. **(a)** Growth was much faster in the first 30 days.

(b) Access to light, nutrients, and water might influence the growth. As more plants grow, they begin to compete with each other for resources, and the rate of growth slows.

(c) Student answers should show a surge in the organisms feeding on the algae in response to the increased plant growth, with numbers tapering off in response to the slower growth.

50. Some (1 percent) of the insects in this population are resistant to the insecticide. The 1 percent of the organisms that lived passed on this adaptive trait to many of the new offspring that were produced. As a result, a larger percent of subsequent generations of insects were resistant to the insecticide. This is one possible explanation why only 50 percent of the insects (instead of 99 percent) were killed by subsequent applications of the same insecticide.