6. The central meaning of this comment is that pollution problems shown in the photograph are rooted in the collective attitudes and behaviour of our society. It would appear that other short-term priorities, such as the convenience of disposable items, an insistence on excessive packaging, and an unending need to buy more consumer products, takes priority over the long-term priority of caring for the environment.

Chapter 2: Changing Populations

2.1 Questions, page 475

Knowledge

1. People who attempt to inhabit a rugged landscape are often called pioneers. These people had to be quite hardy to survive the challenging conditions of their new environment, just like the first organisms to grow in a new environment. The human pioneers also changed the environment by their activity.

2. Many pioneering people came to North America to escape overcrowding and a lack of resources in their home countries. Like human pioneers, pioneer species benefit by having fewer organisms to compete with for resources.

3. The following stages in the correct order in which they would be observed during primary succession are the following: bare rock, lichens, mosses, thin soil, grasses, deep humus-rich soil, shrubs, deciduous trees, and coniferous trees.

Applying Concepts

4. a. Soil may have been removed by the process of glaciation, avalanches, rock slides, or strip-mining. However, the answer could be any plausible event that would result in the removal of soil from the habitat.

b. There are several stages of succession to be observed in Figure D2.8. You can make reference to Figure D2.5. The stages of succession are more advanced as viewers move from the foreground to the background. In the foreground, rocks speckled with lichens are surrounded by mosses and grasses. In the background, flowering shrubs eventually lead to a climax community of coniferous trees.

c. The cracks would collect more of the soil and humus to allow for later succession species—such as grasses—to grow sooner.

d. Trees in the background—members of the climax community—have the greatest biomass and, therefore, are the most productive. They collect the solar radiation at the canopy layer above the surface where grasses and other plants are located.

Practice, page 478

1. The aerial photo of the Banff area in Figure D2.14 shows a golf course on the right side. If there are no natural meadows for grazing, the golf course would become a much more attractive grazing ground that would bring elk and deer into close contact with humans at the risk of both species.

2. The thick climax forest pushes right up to the town's border. This would put the town in great jeopardy because there is no fire buffer.

Practice, page 480

3. This question is designed to help you approach the issue of clearcutting from all sides by imagining the viewpoints of several interested parties. Responses will vary, depending on how you view or interpret the interests of each group.

Some examples of viewpoints are noted.

a. A logging company truck driver would most likely view the resource from a mainly economic standpoint and agree with clearcutting as an efficient means of log removal. However, the driver would also be interested in job security so would want to ensure that the resource lasts to ensure employment.

b. An environmental protection group would most likely want to limit or completely ban the practice of clearcutting because of issues with soil erosion, river siltation, habitat loss, and making wildlife more vulnerable to hunters on ATVs.

c. A pulp and paper mill owner may have economic gains to be made from clearcutting as his or her prime focus. However, other considerations include the public perception of the company as being a good corporate citizen.

d. A First Peoples community that hunts traditionally in the area might view **some** clearcutting as a positive thing because it encourages large herbivores into the area for hunting. However, extensive clearcutting would destroy the beauty of the area, reduce the numbers of prey, and the ability to hunt traditionally.

e. The effects on the deer population would include the fact that clearcutting could actually stimulate secondary succession and create more grazing habitat. However, logging and the roads that go with it would open areas up to hunters, ATVs, and snowmobiles. This could lead to overhunting and more roadkill.

4. You should be encouraged to ensure that your results are obtained from the most current sources. Three good sites for starting research include the following:

- You can check Alberta Sustainable Resource Development at **http://www3.gov.ab.ca/srd/forests/index.html**
- A simulation of regeneration after clearcutting can be found at **http://www.sciencemag.org/feature/data/deutschman/cut.htm**
- Alberta Forest Products Association has all kinds of consumer information at **http://www.albertaforestproducts.ca/home**

a. The climax community in Alberta's boreal forests may be coniferous trees, such as spruce and pine used for lumber, or deciduous trees harvested for pulp and paper products.

b. The volume harvested is approximately 50% of the volume of annual growth. The annual growth of Alberta forests is about 44.5 million cubic metres, and the allowed harvest per year is 23.1 million cubic metres.

c. Clearcutting is seen as the best method to use when the stand of trees are all the same age. Clearcutting is also seen as being advantageous when the reforested trees cannot grow in shade and, therefore, clearcutting creates wide-open spaces with lots of light exposure for the seedlings.

d. Approximately 60 000 jobs in Alberta depend on the forest industry.

e. The practice of replanting trees into clearcutting areas reduces species diversity. It is costly and can leave the monocultures more susceptible to disease. However, replanting helps ensure that the product will be available for reharvesting in a few decades. About 75 million seedlings are planted each year in Alberta.

f. Environmental effects of clearcutting include the removal of habitat for wildlife, the removal of nutrients and biomass from the ecosystem, landslides, the siltation of waterways due to increased erosion, and increased hunting.

Practice, page 481

5. The idea of certification allows issues from the ecological system, such as habitat destruction and loss of biodiversity, to become key considerations in the economic system. The idea is that if companies do not embrace the principles of sustainable development recognized by certification, then they will lose business to their competitors who embrace these practices.

6. a. The purpose of this question is to act as a springboard for discussion. It would be interesting to see where sustainable development, in the context of this question, ranks within the personal value system for each student.

b. This question makes links to the collective power of lifestyle choices introduced in Chapter 1. If FSC certification became a desirable factor in the minds of consumers, then the industry would have to respond. Companies that responded by embracing certification would have a competitive advantage over companies that did not welcome certification. It is conceivable that eventually all companies would have to face the reality of either embracing sustainable development practices, as defined by FSC certification, or going out of business. However, all of this is dependent upon a significant number of consumers insisting upon some form of certification.

2.2 Questions, page 481

Knowledge

1. Secondary succession occurs much more rapidly than primary succession because nutrient-rich soil is already present. In primary succession, this soil must be produced over many years by lichens and mosses.

2. Disturbances that could cause secondary succession to begin include tilling the land for farming, avalanches, floods, excavating for building, severe storms that remove or blow down trees, the creation of cutlines for surveying and seismic research, the building of roads, or any other plausible answer.

Applying Concepts

3. This would be an advantage to the pines because after the fire there would be less competition for space and resources, so more seeds would have an opportunity to grow from seedlings into trees. More seeds are needed to re-establish the community after the fire, and it is an advantage to have a surplus of seeds in the event of fire. Releasing all the seeds every year would be wasteful as few would become full-grown trees due to over-competition.

4. This practice does not encourage diversity because the planting of monocultures skips several stages of succession and attempts to force a change from bare soil directly to a climax community. The missing stages of succession mean that the species that would have lived best in those stages will be missing from the ecosystem.

5. The gasoline removed the conditions that were ideal for grass to grow. More hardy species like the dandelion and clover needed to re-establish the conditions and help absorb the toxins before the grasses could return. Since soil is present, this is still an example of secondary succession.

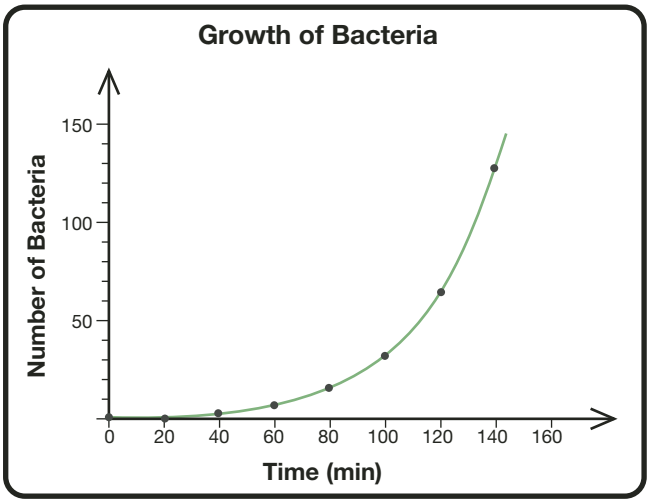
6. If most of the topsoil is removed, primary succession will take from hundreds to thousands of years to replace the climax community before it can be harvested/utilized again. In the boreal forest, topsoil is usually preserved with clearcutting because of lower precipitation levels. As a result, succession takes much less time than it does in the Amazon rain forest.

Practice, page 484

7. a. The following table includes all of the missing values.

Time (min)	0	20	40	60	80	100	120	140
Number of Bacteria	1	2	4	8	16	32	64	128

b. and c. The results should look similar to the graph that follows.



d. This curve looks like the letter *J*.

8. The number of bacteria doubles every 20 minutes.

9. A variety of methods can be used to arrive at the answer of 6.9×10^{10} bacteria. One method is to extend the chart until a time of 720 minutes is reached. This approach is quite time-consuming. Another approach is to notice that since the doubling time is 20 minutes, there will be three doublings every hour and, therefore, 36 doublings in 12 hours. Instead of multiplying 2 by itself 36 times, you could enter 2^{36} into a scientific calculator or a graphing calculator to determine the result of 6.9×10^{10}.

10. Bacteria like dark, warm, and moist environments with an ample supply of nutrients. If these needs could be met, the main factor that would encourage the bacteria's exponential growth would be either to increase the size of the test tube or to split the population into several test tubes. More nutrients could be added so that there was less competition, and growth could continue.

11. Some factors that may prevent or limit the bacteria's exponential growth would be a lack of nutrients, a lack of space for growth, a change in temperature out of the optimum range, a change in light conditions, or a lack of moisture. A disease or an entry of another type of micro-organism could directly harm the population or cause greater competition for resources. As the population increases, the competition for resources between bacteria would lower the growth rate.

Practice, pages 484 and 485

12. **a.** If the number of births and the number of immigrants into an area are greater than the number of deaths and the number of emigrants out of an area, then the population should increase.

b. If the number of deaths and the number of emigrants out of an area are greater than the number of births and the number of immigrants into an area, then the population should decrease.

c. If the number of births and the number of immigrants are equal to the number of deaths and the number of emigrants, then the population should not change.

13. This is an open population because there is both immigration and emigration.

14. The population change for the year 2000 is an increase of five individuals.

15. **a.** Since the population increases from 100 individuals to 115 individuals, the population has increased by 15 individuals over the three years.

b. The average population change per year is determined by dividing 15 by 3 to get five additional individuals each year.

16. Assuming the average annual population change remains constant, the predicted size of the population in 2010 would be **150** organisms. The reason is that if an average of five individuals are added each year for 10 years, an additional 50 would be added to the original 100.

17. The growth rate described involves adding an average of five more individuals each year. If this was graphed, it would produce a straight-line graph and not the characteristic J-curve of exponential growth. Therefore, this is not an example of exponential growth.

Practice, page 485

18. An invasive species is the proper name for a species that does not normally live in an area, but is introduced by human action and then expands to become a threat to an area's biodiversity.

19. People might have introduced rabbits into Australia as pets, as a food source, or for sport hunting.

20. Australia is a continent-sized island, and it would be much more difficult for the rabbits to overeat all the food in such a large habitat.

21. Australians may be concerned because the rabbits may cause the extinction of the native marsupials. In addition, six rabbits can eat as much vegetation in a day as one sheep. Rabbits are competing with livestock whose wool and meat are meant to be sold.

22. Answers will depend on a justified opinion. Historically, the introduction of a species to control another introduced species has not been very successful. It is difficult to predict what effect the introduction of a species will have. For example, lynxes may find the marsupials to be easier prey than the rabbits they are intended to hunt.

23. Australians have tried rabbit-proof fences to control the spread of the rabbit population, poisoning the rabbits, injecting carbon monoxide foam down warrens (rabbit holes), and creating a bounty for rabbit hunters. All of these techniques have proved to be expensive, labour-intensive, time-consuming, and largely ineffective. There are even cases of rabbit hunters aiding the growth of the rabbit population to ensure steady work for themselves.

Practice, page 486

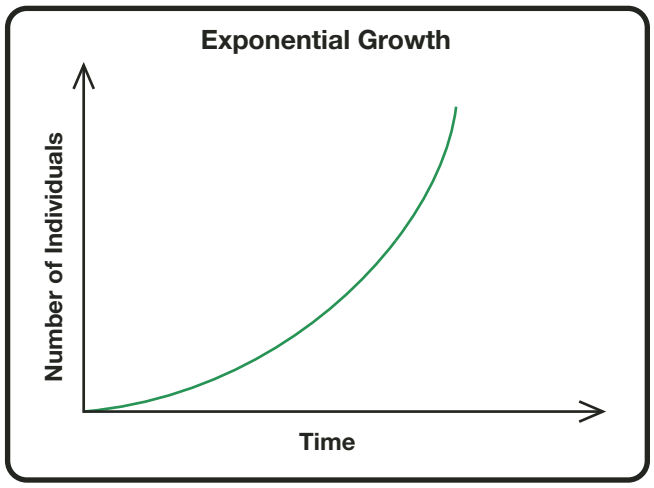
24. In the first cartoon, entitled "Human Population Growth Chart," the artist is illustrating a fear that the supply of food will not be able to meet the growth of the human population. The artist is comparing the difficulty of meeting demands of a growing population with the reference and image of the "Little Engine That Could." The supply train is literally climbing the steep curve of exponential growth. The reader should extrapolate that, as the curve gets even steeper, it will be impossible to continue climbing. The train is even expressing its own doubts about reaching the goal.

In the second cartoon, entitled "World Population," the artist is illustrating a perception that the world is already overcrowded. However, people still keep having more and more babies. This is evidenced by the nurse who is shouting ". . . and another million boys (girls)!" People are dropping off the Earth as they get pushed off by overcrowding.

2.3 Questions, page 487

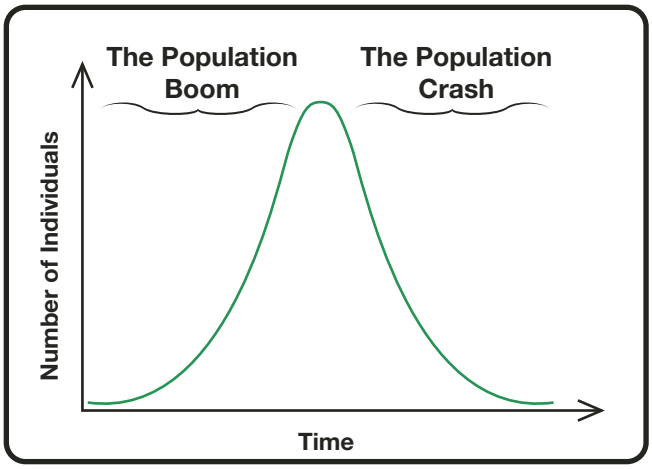
Knowledge

1. The essential features of exponential growth are noted in this graph.



2. In a closed population system, emigration and immigration are not possible. This is the case with fish in an aquarium, with terrestrial animals on an island far from land, and for large game animals like elk that are fenced in within a game farm. In an open population system, emigration and immigration are both possible. This would apply to ducks nesting by a pond, fish swimming into a fjord from the deep ocean, and sparrows visiting a bird feeder.

3. This graph shows a population boom followed by a population crash.



Applying Concepts

4. Although specifics of the answers will vary from one location to another, the problems of habitat destruction and habitat fragmentation will likely be common elements.

5. **a.** This is a closed population because no new sea monkeys will immigrate, and they are not able to emigrate.

b. The carrying capacity is approximately ten adult sea monkeys.

c. Space in the tank and the amount of food available are two limiting factors.

d. To increase the carrying capacity of the sea monkey population, move the sea monkeys into a bigger tank or increase the food supply.

6. **a.** In ecological systems, the factors that affect population growth—the number of births and immigration—are balanced by the factors that cause populations to decline—the number of deaths and emigration. This balance often takes the form of a cycle in which years of growth are counteracted by years of decline. The carrying capacity reflects the number of individuals that can be sustained over an indefinite period of time in a given environment. This stands in sharp contrast to the ideal of perpetual growth in economic systems.

b. Populations that experience a population boom must either eventually reach the carrying capacity or experience a population crash.

c. Many ecologists suggest that because economic systems put demands on the ecological system for raw materials and for waste storage, the ecological system will eventually no longer be able to sustain the constant growth model of the economic system.

Practice, page 489

25. The snails at each thermal spring form a closed population.

26. The snails are so small that a person could easily crush them by walking around the thermal springs or merely by entering the water. Swimming in the water could introduce chemicals from insect repellant, deodorant, and perfume into the snail's habitat. Waves created by swimming could dislodge the snails or their eggs from the water's edge.

Practice, page 493

27. 100 new snails every month × 24 months = 2400 new snails

The total number of snail offspring created would be 2400.

28. **a.** 100 hatchlings = 50 pairs of mating snails
50 pairs of mating snails × 100 new snails per pair = 5000 snails

There could be 5000 snails created in the 25th month.

b. In the 26th month, the second set of hatchlings can now reproduce as well.

c. This type of calculation assumes that no snails die and that the same nutrients, space, and other essentials are always available. In nature, only a fraction of the snail hatchlings survive because most become food for predators or other snails. Limits are also imposed by the availability of nutrients and suitable habitat.

Practice, page 494

29. **a.** The unbanded snail is the one most likely to survive because it is more difficult to spot by predators in this environment.

b. The banded snail would likely have an advantage in the grassland environment because its stripes would blend with the grasses and with the shadows left by the vegetation.

30. The most common snail shell pattern found in this environment is one in which snails have two bands.

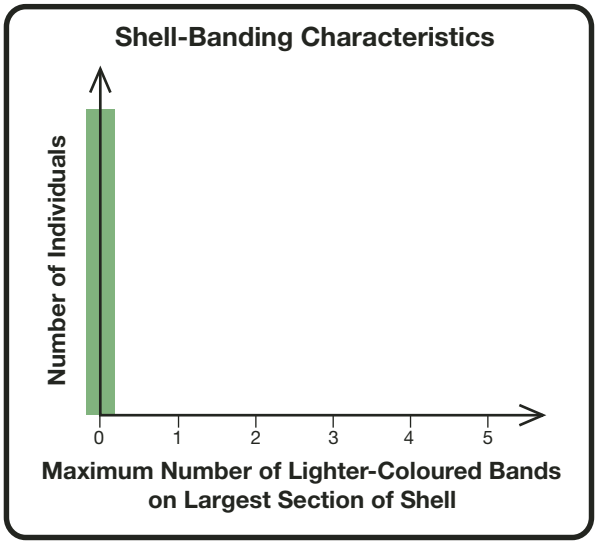
31. **a.** The absence of shrubs and small trees would mean unbanded snails would no longer have an advantage in the darker areas under this vegetation. If the area became grassland, then the banded snails would blend better with the patterns of grasses and shadows left by the grasses.

b. If more banded snails survive predators, then more banded snails will be able to reproduce. The offspring of these banded snails will inherit the genes for being banded. Over time, a greater percentage of snails will become banded, and the percentage of unbanded snails will decrease.

c. If there was no variation in the population and all the snails were unbanded, then the predators could become so successful that no snails would survive. In this case, the snails could become extirpated from this area.

d. This mutation would likely be at a disadvantage in the tall-grass environment.

32. a. Note that zero lighter-coloured bands means that the snails are unbanded and have a solid colour.



b. The environment made it difficult for banded snails to survive and leave offspring, while the unbanded snails would be more likely to survive and reproduce. This means that future generations would be more likely to have the genetic characteristics of unbanded snails. As this process is repeated through successive generations, the genes for light-coloured bands might disappear completely from the population. In this case, the successive generations of snails that survive the change to a darker forest-floor environment could eventually become completely unbanded.

c. If there was no variation in the population and all the snails in the original population had many light-coloured bands, then very few snails would survive because they would be so easy to spot by predators. This could lead to an extirpation of snails in this area.

d. Snails that were a solid dark-brown colour with no banding, due to a mutation, would have an advantage in the dense forest environment because they would be the most difficult snails to spot by predators.

2.4 Questions, page 496

Knowledge

1. a. A fossil is the evidence or remains of ancient life preserved in Earth's crust.

b. Gradualism is the theory that changes to the organisms in a population occur slowly and gradually over time.

c. Punctuated equilibrium is the theory that spurts of rapid change to the organisms in a population are followed by long periods of little change.

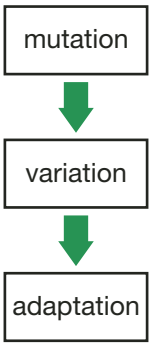
d. A gene is the basic unit of inheritance passed down from parent to offspring.

e. A mutation is a change in genetic information contained in a DNA molecule.

f. An adaptation is any structural trait or behavioural trait that improves an organism's success at reproducing and surviving in a particular environment.

Applying Concepts

2. **a.** A flowchart shows how the processes of adaptation, mutation, and variation occur.



b. Mutations are the source of variation within members of a population. The variation may be behavioural, biochemical, or in the form of a physical trait.

Some of the variations may reduce an individual's chance of survival. Individuals with this inherited trait are less likely to survive and produce offspring. Some of the variations may improve an individual's chance of survival. Individuals with this inherited trait are more likely to survive and produce offspring.

Over time, the environment will select the individuals with the favourable inherited trait, and this trait is called an adaptation.

3. The variation seen in the colour and banding of shells is due to mutations.

4. Snails that blend with their surroundings have a good chance of avoiding predators.

5. Yellow and banded snails have a good chance of avoiding predators because they readily blend in with their grassland habitat.

6. **a.** The darker colour is an advantage for these snails because they can stay warm by climbing higher on the vegetation to be in direct sunlight.

b. By climbing higher on the vegetation, the dark-coloured snails become more vulnerable to predators than they would be if they stayed lower to the ground in dark places.

c. The previous two parts to question 6 illustrate that a trait is not always a clear advantage or disadvantage. In the case of the dark-coloured snails, the darker colour was an advantage for staying warm. However, exploiting the warming capabilities of a darker colour made them more available to predators.

Practice, page 498

33. The most likely cause for the variations in beak characteristics is mutations.

34. **a.** On an island with an abundance of insects as a food source, the finches most likely to survive would be the ones with smaller, narrow beaks.

b. The lack of range of food sources would have the effect of reducing the population size because there would be competition for a limited resource.

c. After many generations of finches with smaller, narrow beaks surviving and reproducing, a larger percentage of the finches on this island would have inherited the genes for small, narrow beaks.

d. An adaptation is the proper term for a structure like a small, narrow beak that improves a finch's chances of reproducing and surviving on this particular island.

Practice, page 500

35. Earlier in Chapter 2, you studied the effects on the population of different patterns of light-coloured banding on snail shells. The pattern of banding on the shell is a genetic trait passed from parents to the snail offspring. The variations in this trait create differences in the ability of snails to be hidden from predators. Snails that have a superior ability to remain hidden will be more likely to survive to maturity, and reproduce. This means that a greater percentage of snails in future generations will have the genes for the banding pattern that enables them to survive in their particular environment. In this sense, the environment has selected the banding pattern for the population of snails.

36. The left graph shows the distribution of beak widths for the original population of finches prior to the drought. The wider shape of the bell curve on this graph represents the fact that from narrow to wide beak widths are represented. The peak of this graph is centred on a beak width of 8 mm.

After several years of drought, a greater percentage of finches in the population would have wider beaks. They inherited this trait from the increasing numbers of finches with wide beaks that survived the previous years of drought. A lower percentage of birds have narrow beaks because of the stress created by the years of drought. These dry years reduced the abundance of caterpillars, which are the main food source for the narrow-beaked finches. This process is represented by the arrow and is called natural selection. The end result of natural selection is shown on the right graph—this shows a larger number of finches with wider beaks and a lower percentage of birds with narrow beaks.

Practice, page 501

37. Darwin would explain the giraffe's long neck by stating that most giraffes originally had short necks. Because of variation, some had longer necks. The giraffes with the longer necks were more successful at getting food from tall trees and, therefore, were better able to survive and reproduce. Over time, only the long-necked giraffes survived because the short-necked giraffes starved due to a lack of food.

38. The bodybuilder is taking a Lamarckian approach. He believes that his children will acquire the traits he has obtained throughout his life. The children may model their behaviour after him, resulting in muscular bodies. Genetically, his children may have the potential to be quite muscular. Without the exertion of physical exercise, though, the bodybuilder's children will not become muscular. This question allows for a discussion of nature versus nurture.

39. Lamarck would predict that since generations of dogs are not using their tails, eventually puppies would be born without tails.

40. **a.** The explanation follows Lamarckian theory, since it implies that the offspring of that original beaver received traits it acquired during its lifetime.

b. Lamarck would probably say that the beaver's tail gradually became flatter through use as it swam through the water, since a flatter tail is more efficient for propulsion through water.

c. Darwin would say that most beavers once had round tails except that, because of variation, a few beavers had flatter tails. The flat tail gave more of a swimming advantage and these flat-tailed beavers were better able to escape from predators. This increased survival meant there was a better chance of flat-tailed beavers having offspring. Eventually, all the beavers had flat tails because the round-tailed animals were easier prey and were killed off.

41. Answers will vary for this activity, depending on the legend that students choose. Most legends follow the Lamarckian theory for the change in species.

Practice, page 503

42. The appearance of the rare black form of the peppered moth was caused by a gene mutation.

43. The variety in coloration allowed the population to survive as the background of their habitat changed. If there was not a variation, the peppered-moth population around Manchester would have been wiped out.

44. A return to the original conditions would reduce the evolutionary trend toward black colour that the population was experiencing. As factories were shut down, air pollution was reduced. This placed less black colouring on the trees and removed the benefit of being black in colour.

45. If predators were removed, there would be no reason for the black colour to be favoured. Black coloration would still appear in the natural population but since the peppered version was already in the majority, it is not expected that there would be an increase in black colour.

46. Yes, this situation supports Darwin's theory of natural selection. These features were genetically based and were, therefore, inherited. Further, these features caused differences in the moth's ability to survive and reproduce. This caused the features shown in the whole population to evolve or change over time. Colour was the selective pressure.

2.5 Questions, page 504

Knowledge

1. a. The theory of natural selection states that inherited differences in the rates of survival and reproduction, which are passed on to the next generations, are due to the interactions of organisms with their environment.

b. Darwinian fitness is the reproductive success of an organism. Darwinian fitness is not a measure of speed, strength, or health, although these factors may influence reproductive success.

2. In order for natural selection to occur, the following two conditions must be satisfied:

- There must be a genetic basis for the variation observed in some trait.
- There must be differences in the rate of survival and reproduction associated with the possession of a certain trait.

Applying Concepts

3. The cheetah population was once full of average-speed runners. A few individuals were much faster. These faster cheetahs were more successful at finding food and escaping predators, so they survived to produce offspring while others died off. Over time, the population was made up of faster and faster individuals.

4. **a.** This horse is not fit at all. Although the horse has traits that are desirable to humans, he is not able to pass them on to his offspring. Even if he was able to breed, the trait of extreme speed might be less desirable in nature.

b. Closely related animals are often bred together. The humans are selecting the same variation (mutation) in two individuals and mating them together. Although selective breeding increases the chances that a desirable trait will appear in the offspring, the chances of a negative trait appearing are also increased.

c. The benefit of using the horse for clones would be that you could have many fast horses to sell. Disadvantages are that they could not be used to breed if the sterility was a genetic mutation, they would be susceptible to the same diseases, and there would be no point in racing them against each other since it is expected they would finish a race in about the same amount of time.

5. No, this is not an example of evolution. An improved diet and vitamins are the cause of the increased activity and size. If their offspring were released into the wild, they would not be larger and more active since they would not be receiving the beneficial vitamins and medicine. The change is environmental and would not be passed on to the offspring.

6. Banana growers are much more concerned about a disease that infects the population of clone bananas because cloned bananas have no variety. Little variety means there is only a small chance that one of them has a mutation for resistance to the disease and will survive the disease to create clone offspring. If one cloned banana is infected and dies, the chances are high that the entire crop of cloned bananas will become infected and die.