Exercise 3 (Modules 1.3 – 1.4)

All living things are built from complex systems called cells. Cells are the smallest units that display the properties of life. All cells are controlled by the genetic information in DNA molecules. These two modules briefly discuss the structure and function of cells and DNA and other features shared by all living things. Write a paragraph describing how an organism familiar to you—a college student—displays these features of life.

Exercise 4 (Module 1.5)

Review the three domains of life by matching each statement on the right with the correct domain. Write your answer in the first column. In addition, name the kingdom for each of the organisms in Domain Eukarya, and write your answer in the second column. Choose from:

Domain Bacteria
Domain Archaea
Domain Eukarya
- protists (several kingdoms)
- Kingdom Plantae
- Kingdom Fungi
- Kingdom Animalia

Domain	*Kingdom*	
________	________	1. Tree and fern
________	________	2. Prokaryotes
________	________	3. Another domain of prokaryotes
________	________	4. Multicellular eukaryotes that ingest (eat) other organisms
________	________	5. Molds, yeasts, and mushrooms
________	________	6. Algae and protozoa
________	________	7. Organisms whose cells lack a nucleus
________	________	8. Brown pelican, sloth, and spider
________	________	9. Multicellular photosynthetic organisms with rigid cellulose cell walls
________	________	10. Single-celled eukaryotes such as an amoeba

Exercise 5 (Module 1.6)

Evolution is biology's core theme. It explains the diversity of life, the relatedness of all living things, and the adaptation of living things to their environments. Fill in the blanks in the following story to review the concepts of evolution.

While investigating the insect life of the rainforest canopy, a zoologist captured several specimens of a previously unknown species of butterfly. The butterfly was mostly black but had conspicuous red and yellow stripes on its wings. It rested on bare tree limbs in plain view; the zoologist was surprised she had not seen it before. The butterfly was very similar in structure to that of a much less conspicuous all-black species found in the same general area, so the zoologist figured that the two species were closely 1________________ members of the same family.

Biologists have long marveled at the diversity of insect life in the tropics. 2________________, the English biologist who wrote *The Origin of Species*, was surprised by the large number of insect species he encountered in the rain forests of South America. In fact, biologists estimate that most species of living things are rain forest insects.

Like Darwin, the zoologist concluded that the black butterfly and the new species looked alike because they were both descended from a common 3________________ species. But why the difference in color pattern? When she first encountered the striped butterflies, she speculated that the red and yellow stripes were an evolutionary adaptation, a beneficial feature that evolved by means of natural selection. But how could a bright color pattern be of any possible benefit? Wouldn't brightly colored butterflies be attacked by predators?

Her suspicions intensified when the zoologist saw the red and yellow winged butterfly resting on a tree limb. A predatory bird landed nearby and peered at the butterfly. The butterfly responded by rapidly flapping its wings, displaying their striped pattern, and the bird flew off.

This is what first caused the zoologist to suspect that the bright wing pattern was an example of "warning coloration," often seen in harmful or bad-tasting animals—for example, the conspicuous yellow and black stripes of bees and wasps. How could such a color pattern have evolved in this species of butterfly? The zoologist speculated that at one time a 4________________ of black butterflies existed in this area, breeding among themselves but not with other members of their species. These butterflies exhibited 5________________ traits—slightly different wing shapes, sizes, behaviors, and so on. They also may have tasted different. Perhaps some were able to make a bad-tasting substance or store a bad-tasting substance obtained from food plants. Just as Darwin reasoned, the zoologist realized that 6________________ variation must be present in the population for natural selection to operate. Also like Darwin, she realized that there is great overproduction of offspring—many more butterflies are produced each year than can possibly survive. In this population, it appeared that among this abundance of butterfly prey, the good-tasting butterflies were more likely to be eaten by 7________________ than bad-tasting ones. The surviving bad-tasting butterflies were more likely to survive to 8________________, and they passed their ability to make the bad-tasting chemical on to their 9________________. Over time, this

10 ________________ trait accumulated in the population—the bad-tasting butterflies became more numerous.

What about the difference in color pattern? The zoologist speculated that among the bad-tasting butterflies, there may have been variation in wing coloration. Butterflies with bright colors on their wings were easier for predators to remember and avoid. The colorful butterflies had more offspring than less-conspicuous individuals—they had 11 ________________ reproductive success. Eventually bright-colored, bad-tasting butterflies became the norm in the population. In this situation, as in others explained by Charles Darwin, 12 ________________ occurs as heritable 13 ________________ are exposed to 14 ________________ factors that favor the 15 ________________ success of some individuals over others.

The zoologist speculated that, over a long period, the changes in palatability, wing pattern, and other characteristics must have combined, and a whole new 16 ________________ of butterfly came into existence. According to Darwin, the 17 ________________ of new species results from the accumulation of minute changes resulting from natural selection over 18 ________________. This short story is just one illustration of evolution, biology's core 19 ________________. Evolution is an important idea, because it explains both the 20 ________________ of life (descent from a common ancestor) and 21 ________________ of life (modification as species diverged from their ancestors).

Exercise 6 (Modules 1.7 – 1.8)

Review the scientific method by filling in the blanks in the following story. Choose from **factor, hypothesis, question, inductive reasoning, control, prediction, deductive reasoning, discovery, observation, experiment, experimental,** and **scientific method.** Answers may be used more than once.

In Exercise 5, you read how a zoologist identified a previously unknown species of butterfly. This species was mostly black, but had conspicuous red and yellow stripes on its wings. It was very similar in appearance and structure to an all-black species found in the same area. Carefully comparing the two species, the zoologist concluded that they were closely related—members of the same family. Looking at many examples (of butterflies) and deriving a general principle (the characteristics of the butterfly family) employs a kind of logic called 1 ________________. This kind of thinking is often involved when a scientist does 2 ________________ science, which is mostly concerned with describing nature.

A different process is followed when a scientist seeks to develop an explanation for natural events. This second method of inquiry is called 3 ________________-based science. It employs a process of inquiry sometimes called the 4 ________________. Although it is not a single method, its key element is the kind of logic called 5 ________________.

In our example, like many examples of hypothesis-based science, the process started with a simple 6 ________________: The zoologist noticed that predatory birds avoided the brightly colored butterflies even though they rested in tree branches in plain sight. This evoked a 7 ________________: Is there something about the butterflies that the birds don't like? The researcher had a hunch; she suspected that the striped butterflies tasted bad and that their bright colors acted as a sort of "warning" to predators to stay away. This kind of tentative explanation is called a [8] ________________.

The zoologist decided to test this in the laboratory, under conditions that she could manipulate and monitor. Such a test is called a controlled [9] ________________. She captured insect-eating birds native to the area and put them in cages at a nearby research station. Then she netted a number of brightly striped butterflies and their black cousins. For her first experiment, she allowed the birds to choose between a black butterfly and a striped one. The birds invariably chose the black butterflies and avoided the striped ones. This confirmed her field observations.

But did the striped butterflies taste bad? The researcher set up another controlled experiment, designed to compare an [10] ________________ group—striped butterflies with their wings painted black—with a [11] ________________ group of "normal" striped butterflies. (Actually, the "normal" butterflies were also handled and painted with clear paint, so that only one [12] ________________ would differ between the two groups.) Her hypothesis led the zoologist to make a [13] ________________ about how she thought the experiment would turn out: *If* the stripes really acted as a warning, *then* the birds would be fooled and eat the butterflies when the stripes were covered—and that *if* the striped butterflies tasted bad, *then* the birds would spit them out. Such "if-then" thinking is called [14] ________________ and is an important feature of hypothesis-driven science.

Just as the researcher hypothesized, the birds chose the black-painted butterflies in every trial. Also, most of the birds quickly spat out the black-painted butterflies, and those that swallowed the butterflies became ill. Just to cover things, the zoologist performed another experiment in which she painted the wings of the edible black-winged butterflies. The birds ate them with gusto, demonstrating that the paint itself was not distasteful and produced no ill effects.

After repeating the experiments several times, the researcher wrote a paper describing her hypothesis, experiments, results, and conclusions. It was published in the *Journal of Tropical Entomology*. There other scientists could read about the experiments, repeat and expand upon them, even challenge the results—all part of the process of science.

Exercise 7 (Modules 1.9 – 1.10)

After reading these modules, and without referring back to the text, list six ways in which you think the science of biology and its technological applications may affect society in the next decade. Which of these are primarily scientific? Which are technological? Are any of them related to evolution, the core theme of biology? Which do you think will have the most effect on you personally in the coming years?