AP BIOLOGY SUMMER ASSIGNMENT

AP BIOLOGY includes topics in a college course for biology. One topic, Ecology, is usually very briefly mentioned in lecture in the year course. There are so many topics to cover! Since emphasis is placed on understanding concepts, not plain memorizing of facts, you can read the chapters on Ecology as a summer assignment. Ecology is the scientific study of the interactions between organisms and the environment. Because of its great scope, ecology is an enormously complex and also an exciting area of Biology. To gain a basic understanding of the richness of the biosphere so we can conserve and sustain that richness, read chapters 52-55 and the essays that accompany each chapter. This will allow us to concentrate on many of the remaining major topics.

For each chapter you have essays that contain relevant ideas or data on the chapter content. Read the essays that pertain to the chapter, then read the chapter and answer the questions. You might reread the essays for a better understanding of the content in the chapter. Questions under each chapter should be answered after you read the article and the chapter. There are questions that pertain to the articles.

These answers are due the first day of school! Hope you enjoy these articles and chapters.

Follow the chapters in order and answer the following questions. You should acquire a better understanding of the topics covered in each section.

Chapter 52: Population Ecology
Essay – Population Ecology, Tales of Nightmare Numbers

1. Draw type I, II, and III survivorship curves on a graph with labeled axes. Explain why the growth rate of species with a type I survivorship curve depends primarily on fertility rates. Explain why the growth rate of species with a type III survivorship curve is extremely sensitive to changes in adult survivorship.
2. Make a rough sketch of the age distribution in developing versus developed countries, and explain the significance of the differences.
3. Consider 2 rivers: One is spring fed and is constant in water volume and temperature year-round; the other drains a desert landscape and floods and dries out at unpredictable intervals. Which is more likely to support many species of iteroparous animals? Why?
4. Explain why a constant rate of increase (r_{max}) for a population produces a growth graph that is J-shaped rather than a straight line.
5. Offer a hypothesis to explain why humans have undergone near-exponential growth for over 500 years. Why can't exponential growth continue indefinitely? Give 2 examples of density-dependent factors that influence population growth in natural populations.
6. Where is exponential growth by a plant population more likely- on a newly formed volcanic island or in a mature, undisturbed rain forest? Why?
7. How does the prediction of the exponential model of population growth differ from that of the logistic model?
8. What is carrying capacity? Is it a property of a habitat or of a population?
9. What is time lag?
10. How have humans sidestepped the controls that regulate populations of other organisms?
11. How does the age structure of a population influence its future population growth?
12. Explain why a population that fits the logistic growth model increases more rapidly at intermediate size than at relatively small or large sizes.
13. Identify three density-dependent factors that limit population size, and explain how each exerts negative feedback.

Chapter 53: Community Ecology
Essay – Community Interactions: No Pigeon is an Island

Read this chapter and learn the meaning of the following terms: interspecific competition, exclusion principle, niche, predation, aposematic coloration, Batesian mimicry, Mullerian mimicry, herbivores, parasites, mutualism, commensalisms.
Read the examples of food webs and food chains on pages 1166 and 1167 and be able to construct a food web.
Answer the following questions after reading the chapter.

1. Why are there limits on the food chain length? (page 1167)
2. Compare a dominant species with a keystone species – give an example of each.
3. How do keystone species influence species richness in communities?
4. What are the differences between cryptic coloration, aposematic coloration, and mimicry? Explain the differences.
5. Compare bottom-up and top-down controls on biological communities and their organization.
6. What is disturbance and give an example?
7. To investigate the structure and function of ecosystems, ecologists may construct a microcosm using organisms and materials from the ecosystem. Properly constructed, these model systems should be self-sustaining. If you remove the primary producers from the microcosm, would you predict that your model would continue to be self-sustaining? Explain.
8. If you remove the decomposers and detritivores, would the microcosm be self-sustaining? Explain.
9. Species interactions affect the distribution and abundance of populations. Summarize experimental evidence that population size for snowshoe hares depends on both predation rates by lynx and competition for food among hares.
10. Using your knowledge of ecosystem structure and function, compare the trophic structure of a desert to that of a temperate hardwood forest. Include the relative number (not exact) of organisms and energy availability for the different trophic levels.
11. What is the difference between primary succession and secondary succession?
12. How does the essay, No Pigeon Is An Island, explain the information about community interactions in this chapter?

Chapter 54: Ecosystems
Essay: Phosphate Pollution, Acid Rain, and The Ozone Hole: Hope for the Ecosystem Recovery?

1. Why is the transfer of energy in an ecosystem referred to as energy flow, not energy cycling?
2. How are detritivores essential to sustaining ecosystems?
3. Why is only a small portion of the solar energy that strikes Earth's atmosphere stored by primary producers?
4. What is the difference between gross primary productivity and net primary productivity?
5. What environmental factors influence rates of primary productivity in terrestrial and aquatic ecosystems?
6. Why is an ecosystem's net primary production lower than its gross primary production?
7. On a global scale, herbivores consume only about 17% of net primary production be terrestrial plants, yet most plant biomass is eventually consumed. Explain.
8. Why is energy lost from a ecosystem at every transfer from one trophic level to the trophic level above it?
9. Marguerite has a vegetable garden in Maine. Eduardo has one in Florida. What are some of the variables that influence primary production in each place?
10. Look around you and name all of the objects, natural or manufactured, that might be contributing to amplification of the greenhouse effect.
11. Why does deforestation of a watershed increase the concentration of nitrates in streams draining the watershed?
12. Draw a SIMPLE diagram that shows one possible path for an atom or molecule of that chemical from abiotic to biotic reservoirs and back for each of the 4 biogeochemical cycles.
13. How can the addition of excess nutrients to a lake threaten its fish population?
14. In the face of biological magnification of toxins, is it healthier to feed at a lower or higher trophic level? Explain
15. Suppose that herbivores were removed from a temperate deciduous forest ecosystem. Predict what would happen to the rate of nitrogen cycling. Explain the logic behind your prediction.
16. What is Earth's main reservoir for phosphorus, and why is it recycled at such a slow rate from that reservoir?
17. In 1997, nonnative and invasive Asian swamp eels were collected in Florida for the first time at two sites near Tampa and Miami. These fish are extremely adaptable to a wide range of freshwater habitats, from wetlands to streams and ponds. They are predators that feed on worms, insects, crayfish, frogs, and other fishes, including bluegill and bass. Swamp eels have the ability to gulp air, which allows them to survive in only a few inches of water and to move over land to a nearby body of water. Scientists are tracking their movements and increasing numbers in the Southeast. In one pond, several species of fish have been completely eliminated.

Based on your understanding of the pond ecosystem, predict the effect of introducing swamp eels on the following components of the pond.

Bluegill:

Bass:

Pond Life:

18. Using your knowledge of ecosystem structure and function, propose a plan of action for eliminating the swamp eels (question 17) from the pond before they eliminate the other organisms. You cannot use toxins, since the local anglers fish in this pond.

Chapter 55: Conservation Biology and Restoration Ecology
ESSAY – EXOTIC AND ENDANGERED SPECIES

1. In what ways would humans benefit by preserving biodiversity?
2. Describe the 4 main threats to biodiversity and how each one damages diversity.
3. Why does the reduced genetic diversity of small populations make them more vulnerable to extinction?
4. How do naturally occurring organisms provide humans with ecosystem services?
5. What are the consequences of the overexploitation of fish populations?
6. How do extinction rates today compare with the background extinction rate evident in the fossil record?
7. Would a single large nature preserve or several small preserves experience greater edge effects?
8. Why is a population's effective size (Ne) almost always smaller than its total size (N)?
9. What are the goals of restoration ecology?
10. How do bioremediation and biological augmentation differ?
11. What is meant by the term sustainable development?
12. What are the lessons that can be learned from the essays – use information from the chapter to explain your answer.

Succession:

Read the section on succession and answer the following questions:

1. Discuss the expected changes in biodiversity as the stages of succession progress from annual plants, perennial plants and grasses to shrubs, pine trees, and hardwood forests.
2. Describe and explain 3 changes in abiotic conditions over time that lead to the succession.
3. For each of the following disturbances, discuss the immediate and long-term effects on ecosystem succession.
    a. A volcano erupts, covering a 10-square-kilometer portion of a mature forest with lava.
    b. A 10-square-kio\lometer portion of a mature forest is clear-cut.

ESSAY: PHOSPHATE POLLUTION, ACID RAIN, AND THE OZONE HOLE: HOPE FOR THE ECOSYSTEM RECOVERY?

A central message of chapter 54 is that energy flows and nutrient cycling are undergoing extraordinary changes in ecosystems throughout the world. Although the outcome of these changes is uncertain, it is important to recognize that humans have already identified and acted on several recent changes in the abiotic environment that clearly had negative consequences. The events and responses took place at the local, regional, and global levels.

The first example of an effective response to an abiotic change took place at a local level and involved a global nutrient cycle. Like many other elements and molecules, phosphorus cycles through ecosystems. The use of phosphate-based detergents in the industrialized countries led to a large increase in the concentrations of phosphate in lakes and streams, triggering rapid and widespread eutrophication – particularly in shallow lakes that received out-flow from municipal sewage systems. In response, governments in North America and Western Europe encouraged or required the use of phosphate-free detergents, and sewage plants were upgraded to remove more phosphate during treatment. Although phosphate pollution from farm fertilizers remains a serious problem, the crisis conditions of the 1960's and 1970's have largely been alleviated.

The second example involves changes in the pH of rainwater at a regional level. The problem began with sulfur oxides and nitrogen oxides that are pumped into the atmosphere by coal-burning electrical power plants and vehicles that lack catalytic converters. When exposed to sunlight and water vapor, the molecules react to form sulfuric acid (H_2SO_4) and nitric acid (HNO_3). Normal rainwater has a slightly acidic pH, about 5.6. But in areas affected by acid rain, precipitation can have a pH as low as 4.2 or 4.4. During the 1980's and the 1990's, biologists documented that forests and lakes in eastern North America and northern Europe were being affected by acid rain. Tree growth slowed in response to the acidification of soils, and lakes became less productive and less diverse. Once biologists had documented the problem, governments instituted stricter controls on the amounts of sulfur oxides and nitrogen oxides that could be emitted from power plants, cars, and trucks. Over the past decade, the intensity of acid rain has diminished and some of the ecosystems that were being affected have begun to recover.

A third example involves changes in atmospheric chemistry that were global in scale. Widespread use of the compounds called *chlorofluorocarbons* (CFCs) in refrigeration and aerosol products resulted in the release of thousands of tons of CFCs into the atmosphere. When CFCs accumulated in the upper atmosphere, they participated in chemical reactions that released chlorine atoms. These chlorine atoms subsequently reacted with ozone (O_3) molecules, which also accumulate in the upper atmosphere. In some years, the loss of ozone due to these reactions was so severe that an **ozone hole** opened over Antarctica. This issue concerned scientists from around the world, because ozone absorbs large amounts of ultraviolet (UV) radiation. When the ozone layer that surrounds Earth thins or is wiped out, an excess of UV radiation can reach Earth's surface and act as a mutagen and carcinogen. Fortunately, soon after the problem was documented in the early 1990's, international treaties scheduled and enforced the rapid phasing out of CFC productions and use. Scientists have recently been able to document the first signs that the size and duration of the ozone hole may be moderating.

The message of these examples is clear: Effective responses have occurred at the local, regional, and global levels when biologists documented serious problems in ecosystem ecology. It remains to be seen whether the same success can be achieved in response to global warming, nitrate pollution, and other current problems in the abiotic environment.

ESSAY – POPULATION ECOLOGY – CHAPTER 52

Tales of Nightmare Numbers

Across from Sausalito, California, the steep flanks of Angel Island rise form the waters of San Francisco Bay. The island, set aside as a game reserve, escaped urban development. It did not escape from the descendants of a few deer that well-meaning nature lovers shipped over in the early 1900s. With no natural predators to keep them in check, the few deer became many-far too many for the limited food supply of their isolated habitat. Yet the island attracted a steady stream of picnickers from the mainland. They felt sorry for the malnourished animals and made sure to load the picnic baskets with extra food for them.

The visitors imported so much food that scrawny deer kept on living and reproducing. In time, the herd nibbled away the native grasses, the roots of which had helped slow soil erosion on the steep hillsides. Hungry deer chewed off all the new leaves of seedlings; they killed small trees by stripping the bark and its phloem. The herd was destroying the environment.

In desperation, game managers proposed using a few skilled hunters to thin the herd. They were strongly denounced as being cruel. They proposed importing a few coyotes to the island to thin the herd naturally. Animal rights advocates opposed that solution, also.

As a compromise, about 200 of the 300+ deer were captured, loaded onto a boat, and shipped to suitable mainland habitats. A number of them received collars with radio transmitters so that game managers could track them after the release. In less than 60 days, dogs, coyotes, bobcats, hunters, and speeding cars and trucks had killed off most of them. In the end, relocating each surviving deer had cost taxpayers almost 3,000 dollars. The State of California refused to do it again. And no one else, anywhere, volunteered to pick up future tabs.

It is not difficult to define the boundaries of Angel Island or track its inhabitants, so it is easy to draw a lesson from this tale: *A population's growth depends on the resources of its environment. And attempts to "beat nature" by altering the sometimes cruel outcome of limited resources only postpone the inevitable.* Does the same lesson apply to other populations, in other places? Yes, it does, as the next tale makes clear.

When 1999 drew to a close, there were over 6 billion people on Earth. About 2 billion already live in poverty. Each year 40 million more join the ranks of the starving. Next to China, India is the most populous country, with more than a billion inhabitants. By 2010 there may be 182 million more. Forty percent of those people live in rat-infested shantytowns, without enough food or fresh water. They are forced to wash clothes and dishes in open sewers. Land available to raise their food shrinks by 365 acres a day, on average. Why? Irrigated soil becomes too salty when it drains poorly, and there is not enough water to flush away the salts.

Can wealthier, less densely populated nations help? After all, they use most of the world's resources. Maybe they should learn to get by more efficiently, on less. For example, people might limit their meals to cereal grains and water; give up their private cars, living quarters, air conditioners, televisions, and dishwashers; stop taking vacations, and stop laundering so much; close all the malls, restaurants, and theatres at night; and so on.

Maybe wealthier nations also should donate more surplus food than they already donate to less fortunate ones. Then again, would huge donations help, or would they encourage dependency and spur more increases in population size? And what if surpluses run out?

In is a monumental dilemma. At one extreme, the redistribution of resources on a global scale would allow the greatest number of people to survive, but at the lowest comfort level. At the other extreme, foreign aid rationed only to nations that restrict population growth would allow fewer individuals to be born, but the quality of life would be greater.

Currently, the foreign aid program of the United States is based on two premises: (1) that individuals of every nation have an irrevocable right to bear children, even if unrestricted reproduction ruins the environment that must sustain them; and (2) that because human life is precious above all else, the wealthiest nations have an absolute moral obligation to save lives everywhere.

Regardless of the positions that nations take on this issue, ultimately they must come to terms with this fact: *Certain principles govern the growth and sustainability of populations over time.* These principles are the bedrock of **ecology** – the systematic study of how organisms interact with one another and with their physical and chemical environment. Ecological interactions start within and between populations, and they extend on through communities, ecosystems, and the biosphere. They are the focus on this next chapter of the book.

Read this chapter and look at the relationships that influence the size, structure, and distribution of populations. Later, apply the basic principles of population growth to the past, present, and future of the human species.

EXOTIC AND ENDANGERED SPECIES

When you hear someone bubbling enthusiastically about an **exotic species**, you can safely bet the speaker is not an ecologist. This is a name for a resident of an established community that has moved from its home range and successfully taken up residence elsewhere. It makes no difference whether the importation was deliberate or accidental. Unlike most imports, which cannot take hold outside their home range, an exotic species insinuates itself into the new community.

Sometimes the additions are harmless and even have beneficial effects. More often, they make native species **endangered species**, which by definition are extremely vulnerable to extinction. Of all species that are now on rare or endangered lists or have already become extinct, *close to 70 percent owe their precarious existence or demise to displacement by exotic species.*

HELLO VICTORIA, GOOD-BYE CICHLIDS Finding better ways to manage our food supplies is essential, given the astounding growth rate of the human population. Such efforts are well intentioned, but they can have disastrous consequences when ecological principles are not taken into account. For example, several years ago, someone thought it would be a great idea to introduce the Nile perch into Lake Victoria in East Africa. People had been using simple, traditional methods of fishing there for thousands of years. Now they were taking too many fish. Soon there would be too few fish to feed local populations and no excess catches to sell for profit. But Lake Victoria is a very big lake, and the Nile perch is a very big fish (more than two meters long). A big fish in a big lake seemed like an ideal combination to attract commercial fishermen with big, elaborate nets from the outside world – right? Wrong.

Native fishermen had been harvesting native fishes called cichlids, which eat mostly detritus and aquatic plants. The Nile perch eats other fish – including cichlids. Having had no prior evolutionary experience with the new predator, the 200 coexisting species of cichlids that were native to Lake Victoria had no defenses against it.

And so the Nile perch ate its way through the cichlid populations and destroyed the lake's biodiversity. Dozens of cichlid species found nowhere else are extinct. Without the cichlids to clean up the lake bottom, levels of dissolved oxygen plummeted and contributed to frequent fish kills. By 1990, fishermen were catching mostly Nile perch. Now there are signs that the Nile perch population is about to crash. By destroying its food source, the Nile perch has undercut its own population growth. It has ceased to be a potentially large, exploitable food source for the people who live around the lake.

As if that weren't enough, the Nile perch is an oily fish. Unlike cichlids, which can be sun dried, the Nile perch must be preserved by smoking – and smoking requires firewood. Local people started cutting down more trees in the local forests, and trees are not rapidly renewable resources. To add insult to injury, the people living near Lake Victoria never liked to eat Nile perch anyway. They prefer the flavor and texture of cichlids.

What is the lesson? A little knowledge and some simple experiments in a contained setting could have prevented the whole mess at Lake Victoria.

THE RABBITS THAT ATE AUSTRALIA During the 1800's, British settlers in Australia just couldn't bond with koalas and kangaroos, so they started to import familiar animals from their homeland. In 1859, in what would be the start of a wholesale disaster, a landowner in northern Australia imported and released two dozen wild European rabbits. Good food and good sport hunting, was the idea. An ideal rabbit habitat with no natural predators – that was the reality.

Six years later, the landowner had killed 20,000 rabbits and was besieged by 20,000 more. The rabbits displaced livestock, even kangaroos. Now Australia has 200 to 300 million hippityhopping through the southern half of the country. They overgraze perennial grasses in good times and strip bark from shrubs and trees during droughts. You know where they've been; they transform grasslands and shrublands into eroded deserts. They have been shot and poisoned. Their warrens have been plowed under, fumigated, and dynamited. Even when all-out assaults reduced their population size by 70 percent, the rapidly reproducing imports made a comeback in less than a year. Did the construction of a 2,000-mile-long fence protect western Australia? No. Rabbits made it to the other side before workers completed the fence.

In 1951, government researchers introduced myxoma virus by way of mildly infected South American rabbits, its normal hosts. This virus causes *myxomatosis*. The disease has mild effects on the South American rabbits that coevolved with the virus but nearly always had lethal effects on the European rabbits. Biting insects, mainly mosquitoes and fleas, quickly transmit the virus from host to host. Having no coevolved defenses against the novel virus, the European rabbits died in droves. As you might expect, natural selection has since favored rapid growth of populations of the European rabbits that are resistant to the virus.

In 1991, on an uninhabited island in Spencer Gulf, Australian researches released a population of rabbits that they had injected with a calicivirus. The rabbits died quickly and relatively painlessly from blood clots in their lungs, heart, and kidneys. In 1995, the test virus escaped from the island, possibly on insect vectors. It has been killin 80 to 95 percent of the adult rabbits in Australian regions. At this time, researchers are now questioning whether the calicivirus should be used on a widespread scale, whether it can jump boundaries and infect animals other than rabbits (such as humans), and what the long-term consequences will be.

THE PLANTS THAT ATE GEORGIA A vine called kudzu (Pueraria lobata) was deliberately imported from Japan to the United States, where it faces no serious threats from herbivores, pathogens, or competitor plants. In temperate parts of Asia, kudzu is a well-behaved legume with a well-developed root system. It *seemed* like a good idea to import it for erosion control on hills and near highways in the southeastern United States. However, with nothing to stop it, kudzu's shoots can grow one-third of a meter per day. Vines now blanket streambanks, trees, telephone poles, houses, hills, and almost everything else in their path. Attempts to dig them up or burn them are futile. Grazing goats and herbicides help, but goats are indiscriminate eaters and herbicides contaminate water supplies. If the global temperature continues to rise, kudzu could reach the Great Lakes by the year 2040.

On the bright side, a Japanese firm is constructing a kudzu farm and processing plant in Alabama. Asians use a starch extract from kudzu in beverages, candy, and herbal medicines. The idea is to export the starch to Asia, where the demand currently exceeds supply. Also, kudzu might eventually help reduce the extent of logging operations. At the Georgia Institute of Technology, researches have reported that kudzu may be used as an alternative source of paper.

ESSAY – COMMUNITY INTERACTIONS

NO PIGEON IS AN ISLAND

Flying through the rain forests of New Guinea is an extraordinary pigeon with cobalt blue feathers and lacy plumes on its head. It is about as big as a turkey, and it flaps so slowly and noisily that its flight sounds like an idling truck. As is true of eight species of smaller pigeons living in the same forest, it perches on branches to eat fruit. How is it possible that nine species of large and small fruit-eating pigeons live in the space of the same forest? Wouldn't you think that competition for food would leave one the winner? In fact, in that rain forest, every species lives, grows, and reproduces in a characteristic way, as defined by its relationships with other organisms and with the surroundings.

Big pigeons perch on the sturdiest branches when they feed, and they eat big fruit. Smaller pigeons, with their smaller bills, cannot open big fruit. They eat small fruit hanging from slender branches that are not sturdy enough to support the weight of a turkey-sized pigeon. The species of trees in the forest differ with respect to the diameter of their fruit-bearing branches and the size of their fruit. So they attract different pigeons with different characteristics. Is such ways, the nine species of pigeons *partition* the fruit supply.

And how do individual trees benefit from enticing the pigeons to dine? The seeds inside their fruits have tough coats, which can resist the action of digestive enzymes inside the pigeon gut. During the time it takes for ingested seeds to travel through the gut, the pigeons fly about, so they dispense seed-containing droppings in more than one place. In this way, the pigeons tend to disperse seeds some distance from the parent plants. Later, when seedlings grow, the odds are better that at least some will not have to compete with their parents for sunlight, water, and nutrients. Seeds that drop close to home cannot compete in and significant way with the resource-gathering capacity of the mature trees, which already have extensive, well-developed roots and leafy crowns.

Within the same forest, leaf-eating, fruit-munching, and bud-nipping insects interact with other organisms and their surroundings in certain ways. So do nectar-drinking, flower-pollinating bats, birds, and insects. And so do great numbers of beetles, worms, and other invertebrates that busily extract energy from remains and wastes of other organisms on the forest floor. By their activities, they cycle nutrients back to the trees.

Like humans, then, no pigeon is an island, isolated from the rest of the living world. The nine species of New Guinea pigeons eat fruit of different sizes. They disperse seeds from different sorts of trees. Dispersal influences where new trees will grow and where the decomposers will flourish. Ultimately, tree distribution and decomposition activities influence how the entire forest community is organized.

Directly or indirectly, interactions among coexisting populations organize the community to which they belong. With this chapter, we turn to community interactions that influence all populations over time and in the space of their environment.