AP® Biology
2001 Sample Student Responses

These materials were produced by Educational Testing Service (ETS), which develops and administers the examinations of the Advanced Placement Program for the College Board. The College Board and Educational Testing Service (ETS) are dedicated to the principle of equal opportunity, and their programs, services, and employment policies are guided by that principle.

The College Board is a national nonprofit membership association dedicated to preparing, inspiring, and connecting students to college and opportunity. Founded in 1900, the association is composed of more than 3,900 schools, colleges, universities, and other educational organizations. Each year, the College Board serves over three million students and their parents, 22,000 high schools, and 3,500 colleges, through major programs and services in college admission, guidance, assessment, financial aid, enrollment, and teaching and learning. Among its best-known programs are the SAT®, the PSAT/NMSQT™, the Advanced Placement Program® (AP®), and Pacesetter®. The College Board is committed to the principles of equity and excellence, and that commitment is embodied in all of its programs, services, activities, and concerns.

2. Charles Darwin proposed that evolution by natural selection was the basis for the differences that he saw in similar organisms as he traveled and collected specimens in South America and on the Galapagos Islands.

(a) **Explain** the theory of evolution by natural selection as presented by Darwin.

(b) Each of the following relates to an aspect of evolution by natural selection. **Explain** three of the following.

(i) Convergent evolution and the similarities among species (ecological equivalents) in a particular biome (e.g., tundra, taiga, etc.)

(ii) Natural selection and the formation of insecticide-resistant insects or antibiotic-resistant bacteria

(iii) Speciation and isolation

(iv) Natural selection and behavior such as kinesis, fixed-action-pattern, dominance hierarchy, etc.

(v) Natural selection and heterozygote advantage

Darwin's theory of evolution by natural selection first states that acquired characteristics are not inheritable. Therefore, Darwin's theory makes clear that only by genetic changes may a species evolve.

Natural selection states that organisms with desirable and more functional characteristics for their particular environment will have more success. More success, especially reproductive, leads to greater numbers of organisms with the desired traits. The organisms with less desirable characteristics will thus be less successful in reproduction as well as life, and their numbers will dwindle. After much time, a new species may form due to small genetic changes accumulating over that period of time. To better illustrate this, take, for example, a species of bird living in tropical conditions. The bird species eats berries off of trees and requires a sharp, curved beak to pick the berries. Suppose a bird is born with a longer, more curved beak. This bird is able to get more berries from the trees which sustains its life better than the other birds. Its success draws birds toward it in mating, and the gene is passed on. More birds with longer, more curved beaks evolve and compete with the original birds. Soon, the number of birds with better adapted beaks

soars above the numbers of the original birds. Given enough time, the better suited birds win the evolutionary battle and become a new species.

This same concept applies to the formation of insecticide-resistant insects and ~~to~~ antibiotic-resistant bacteria. If an orchardist constantly sprays a certain strength of insecticide, most of the insects will die. However, insects reproduce very rapidly + in great number; so a few insects with a slightly different gene are left living because the gene gives them resistance to the insecticide. These insects then multiply, and do not die when the orchardist sprays the trees. The same is true for bacteria. Since bacteria are so proliferous, the chance and occurrence of mutation in the genes is high. Therefore, a colony of bacteria may be exposed to an antibiotic which kills most of the bacteria. However, a few survive because their genes give them resistance to the drug. This group then multiplies and gives rise to many bacteria which can resist the drug. The chain continues as antibiotics are changed.

Speciation, as far as natural selection is concerned, can occur under many circumstances, one of which is isolation. If a ~~species~~ population of ~~organism~~ a species some how becomes isolated from another population the same species (let's say due to a geographic barrier like a newly formed mountain range), the two populations will, given enough time, become seperate species. Different environments will require ~~the~~ different characteristics and traits to succeed. One side of the range may be cooler than the other side and may have more rainfall. The organisms on the cooler side would likely

develop bodies better suited to the temperature as well as to the rain. On the other side, the other population would have to adapt to warmer temperatures and decreased food supply (due to a lack of rain). After enough time, the two populations would have changed enough to not allow cross-breeding. This would mean that the two populations had evolved into different species.

Lastly, natural selection is also influenced by a phenomenon known as heterozygote advantage. Take, for example, a population of humans with genes for sickle cell anemia (h) and genes for malaria resistance (M). Individuals who are homozygous (HH) for malaria resistance will most likely not get the disease, but are more susceptible to sickle-cell anemia. Individuals who are homozygous for sickle-cell anemia (hh) will have the disease to a great extent and will also be very susceptible to malaria. However, individuals who are heterozygous (Hh) will be somewhat resistent to malaria, and will only have mild sickle-cell anemia. Natural selection would prefer the heterozygotes because they would be able to survive better amidst both conditions than any homozygotes. Therefore more heterozygotes would be produced due to their greater success.

2. Charles Darwin proposed that evolution by natural selection was the basis for the differences that he saw in similar organisms as he traveled and collected specimens in South America and on the Galapagos Islands.

(a) **Explain** the theory of evolution by natural selection as presented by Darwin.

(b) Each of the following relates to an aspect of evolution by natural selection. **Explain** three of the following.

(i) Convergent evolution and the similarities among species (ecological equivalents) in a particular biome (e.g., tundra, taiga, etc.)

(ii) Natural selection and the formation of insecticide-resistant insects or antibiotic-resistant bacteria

(iii) Speciation and isolation

(iv) Natural selection and behavior such as kinesis, fixed-action-pattern, dominance hierarchy, etc.

(v) Natural selection and heterozygote advantage

a) Charles Darwin's theory of evolution states that mutations will occour and whichever ~~thing~~ individual with the best characteristics will survive. When a mutaton occurs in a species which benefits the species, ~~the mutation~~ the individuals with that mutation will have an advantage over those with less adventageous traits, and these "better" or more fit individuals will survive to reproduce in greater numbers than those without the mutation. In this way, new species are formed.

b) i) Convergent evolution occurs when two non-related species evolve similar characteristics to deal with their environment. These similar charactics may begin as mutations in these two species, however, the mutation was advantageous in this particular biome, so it became a trait of the two species. This is shown in the evolution of dolphins and sharks - one is a mammal & one an amphibian but they resemble eachother.

ii) Natural selection is shown in the development

of antibiotic resistant bacteria. Antibiotic resistance begins as a plasmid (a circular, extrachromosomal, self-replicating piece of DNA) which has DNA to form the gene for antibiotic resistance. When one bacterium recieves ~~this~~ or develops this plasmid, it can no longer be distroyed by antibiotics and survives to pass the plasmid to other bacterial cells for conjugation. Soon, ~~the~~ bacterial cells with the plasmid will be the majority, and the "fittest" survive (the ones with a plasmid).

iii) The definition of a species is a group of organisms who can reproduce to produce viable offspring. Through evolution, millions of new "species" have formed, many due to isolation. Allopatric isolation is geographic isolation. This could be an island, mountains, or a river. When ~~species~~ two groups of the same species are isolated allopatrically, through natural selection they will develop different mutations from the another, and, with sufficient mutations, will no longer be able to mate & produce viable offspring — thus creating a new species.

2. Charles Darwin proposed that evolution by natural selection was the basis for the differences that he saw in similar organisms as he traveled and collected specimens in South America and on the Galapagos Islands.

(a) **Explain** the theory of evolution by natural selection as presented by Darwin.

(b) Each of the following relates to an aspect of evolution by natural selection. **Explain** three of the following.

(i) Convergent evolution and the similarities among species (ecological equivalents) in a particular biome (e.g., tundra, taiga, etc.)

(ii) Natural selection and the formation of insecticide-resistant insects or antibiotic-resistant bacteria

(iii) Speciation and isolation

(iv) Natural selection and behavior such as kinesis, fixed-action-pattern, dominance hierarchy, etc.

(v) Natural selection and heterozygote advantage

---

a. Darwins theory of natural selection was that some organisms have traits which permit them to be more successful in reproducing. Organisms which Reproduce more are more successful because they are furthering themselves through offspring.

Also, from the variety of Finches in the Galapagos, Darwin theorized that gradual changes can occur in a population, but if the population is small, then the chances that the mutated trait will be displayed is greater. The finches showed that due to environmental factors, some traits succeed where others fail, and so the best reproduces and gradually changes accumulate, causing micro-evolution.

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

b. i. Convergent evolution is when 2 different species show similar traits, but not because of a common ancestor. Rather, convergent evolution comes about when 2 organisms experience similar environmental pressures + factors, and so the same random mutations succeed in both groups. In one particular biome, all species might have one similar trait because all organisms in that biome are under the same environmental pressures. Ex. a snowy white owl and a show-shoe hare are 2 very different animals w/o a common recent ancestor, but they have both evolved to have white outer covering because in their same habitat that is an advantage! Living in a snowy environment, protection comes from being white colored, so 2 species have convergent evolution.

ii. With many very old strains of bacteria, it is becoming more common to see antibiotic resistance. Random mutations occur which allow the bacteria to be resistant, but in pre-human times, the mutation didn't give the bacteria any special advantage over the non-mutated bacteria, so the mutation ended (when the mutated bacteria died) or stayed hidden from diploidy. But now that humans are using anti-biotic medicines to kill bacteria, the mutations that once were not-helpful, suddenly become very helpful. The mutated bacteria now have

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

a huge advantage over the normal bacteria, so they replicate like mad. They will eventually take over because their genes, (the mutation occurs in the DNA of the organism) have allowed them to be more sucessful. The mutation leads to microevolution, the evolution through trait changes, of a population. These resistant bacteria displayed natural selection because their mutated genes allowed them to be more successful.

V. Heterozygote advantage.

Organisms which reproduce sexually have recombinant DNA. The offspring of 2 parents has a version of the same gene from each parent. When the two versions of this gene are different, the offspring is heterozygous for that gene. Heterozygotes have an advantage over homozygotes (organisms with 2 copies of the same variation) because often homozygous genes are flawed or fatal. A bad variation in a gene is bad once, but much worse twice. Most genetic disease are homozygous recessive, meaning if you have one copy of the bad gene you are just a carrier, but if you have 2 copies, then

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

you have the disease. Heterozygotes have the ability to mask mutations or bad traits because they have a stronger trait, the dominant gene, to over be displayed.

Heterozygotes have more genetic variability because they have two copies of the same gene. They can have natural selection because their offspring can have the chance to be homozygous if the mutation was positive, but they also won't die due to homozygous recessive diseases.

Sometimes, because of codominance, where both genes are expressed, the new phenotypic expression is an advantage which can make them more evolutionarily successful as explained earlier