AP® BIOLOGY
2010 SCORING GUIDELINES (Form B)

Question 3

Bacteria play central biological roles.

(a) Bacteria may act as
- producers
- parasites
- mutualistic symbionts
- decomposers

Select THREE of the ecological roles above. For each one you choose, **describe** how bacteria carry out the role and **discuss** its ecological importance. **(3 points maximum for each ecological niche; 9 points maximum)**

	1 point each	**1 point each**	**1 point each**
	Defines ecological role (this may be included in example).	Case, example or specific description.	Details, mechanism, elaboration.
Producer	• Primary source of energy for food chain/ecosystem. • Fixes carbon/primary source of organic molecules/produces oxygen.	• Cyanobacteria. • Chemoautotrophs (deep-sea vents). • Photoautotrophs (purple bacteria and green bacteria).	• Role of photosynthesis, light as energy source. OR • Conversion of energy from organic or inorganic sources.
Parasite	• +/- interactions. • Limiting factor in host population size. • Selective agent on host species.	• *Streptococcus*, *Pneumococcus*, etc. (identifies organism). OR • Pathogen causing disease, e.g., cholera, tuberculosis (identifies disease).	• How disease is induced and/or maintained. • Population control (balance in ecosystems).
Mutualistic symbiont	• +/+ interaction. • Expands niche. • Enhances competitive fitness (may confer resistance).	• *Rhizobium* in legumes. • *E. coli* in human digestive Tract. • *Staphylococcus epidermis* on skin. • Cellulose digesters in ruminants. • Etc.	• Implications of specific symbiosis (e.g., availability of nitrogen). • Maintains normal flora and its benefits. • Early exposure induces antibody formation.
Decomposer	• Recycles nutrients. • May also be a mutualistic symbiont. • Removes waste and harmful products (pesticides, oil spills).	• Nitrifying bacteria, denitrifying bacteria. • Nitrogen cycle. • Others (yield phosphate, sulfate).	• Dead organisms and waste as a source of nutrients. • Steps in nitrogen cycle (details, not duplication).

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Question 3 (continued)

(b) **Explain** how bacteria can be altered to make genetically engineered products. **(3 points maximum)**

1 point each for explaining concept fully and/or for describing the lab method.

- Isolating donor DNA/gene; using restriction enzyme; making cDNA, etc.
- Preparing recombinant vector: cutting vector using restriction enzyme; splicing sticky ends (with ligase).
- Delivering vector: transformation with recombinant plasmid, heat shock, virus/retrovirus, etc.
- Testing product or selecting for strain.
- Proliferation of reproducing cells protein purification.
- Examples of products of modified bacteria are insulin, growth hormone, gene amplification, waste decomposition enzymes, etc.

3. Bacteria play central biological roles.

(a) Bacteria may act as

- producers
- parasites
- mutualistic symbionts
- decomposers

3A,

Select THREE of the ecological roles above. For each one you choose, **describe** how bacteria carry out the role and **discuss** its ecological importance.

(b) **Explain** how bacteria can be altered to make genetically engineered products.

a) i) Bacteria, as producers, are autotrophs that make their own energy (usually from light from the sun i ~~sometimes fr.~~), as opposed to obtaining energy through eating/consuming other organisms. Produ-cer bacteria's ecological significance is that it serves to produce atmo-spheric oxygen (as in the case of cyanobacteria that are thought to have introduced oxygen to the earth's atmosphere for the first time). Oxygen is the waste product of photosynthesis.

ii) Bacteria as parasites are heterotrophs that obtain nutrients from other organisms. By the definition of a parasite, parasitic bacteria dwell (usually) on the inside of an organism (the host) and obtain nutrients from the host. Parasitic bacteria negatively impacts their host because the rob nutrients from the host. Parasitic bacteria

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3A2

contribute to (on an ecological level) "controlling" the size of populations of their host organisms. ~~Parasites~~ in that parasites can cause diseases in and/or kill their hosts. It is important that populations don't grow too large due to limited resources.

iii) Bacteria as decomposers ~~dis~~ break down dead bodies of animals, plants, and other organic material. By doing this, ~~the~~ bacteria contributes to the cycle of nutrients that is essential on an ecolo-gical level. For example, bacteria can decompose a dead deer's body to add more nitrogens in the soil, which are then taken up by plants.

b) Bacteria's DNA consists of a single plasmid - a circular band of DNA. ~~A~~ Bacteria can be genetically engineered by ~~cutting~~ inserting a ~~fragment~~ section of foreign DNA that codes for a protein that produces desired effects. The process of doing this are as follows: Cut the ~~p~~ bacterial plasmid AND the section of foreign DNA with the information that codes

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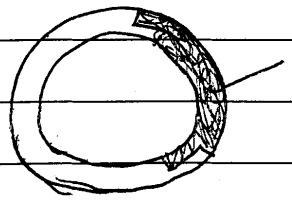
for the desired protein with the same restriction enzyme.* This will leave the sticky ends of DNA fragments (of the plasmid and the foreign DNA) ready to be "glued" together. The "glue" used for the ends is DNA ligase. Once

* Restriction enzymes cut DNA's and/or RNA's at specific sites called restriction sites. Each restriction site cuts the DNA at specific sequences / restriction site.

DNA ligase sticks together the sticky ends of the plasmid and the foreign DNA a recombinant DNA is produced.



This recombinant DNA must be placed back inside bacteria. This can be done by applying heat shock to bacteria and then cooling the bacteria subsequently — this produces pores in

3A4

the membrane of the bacteria through which plasmids can be inserted. Once the plasmid is inserted the bacteria will make proteins according to its new plasmid, meaning the desired protein that comes from the information of foreign DNA ~~is~~ will be produced by the bacteria.

3. Bacteria play central biological roles.

(a) Bacteria may act as

- producers
- parasites
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- decomposers

3B1

Select THREE of the ecological roles above. For each one you choose, **describe** how bacteria carry out the role and **discuss** its ecological importance.

(b) **Explain** how bacteria can be altered to make genetically engineered products.

a) Bacteria as parasites: Some bacteria are present on the surface of food source for particular species of animals, and are hence ingested together. Once these bacteria enters the digestive tract of the consumer, such as mammals, they are able to survive the acidity of the stomach and pass through into the small intestine where they reside and feed on the broken down nutrients in the host's intestine and reproduce. Some bacteria are able to reside in the host's stomach and feed on the host's stomach lining, causing stomach ulcers after a period of time. As such parasitic relations between the bacteria and the host depletes nutrients from the host and also harm the host's health in some cases, this weakens the host, and limits the size of the host population, thus preventing certain population from expanding out of control, as such cases often topple the ecological balance and the prey threaten to eliminate the prey populations.

Bacteria as mutualistic symbionts: Some bacteria reside in the intestines of primary consumers such as cows and sheeps. These bacteria are able to break down cellulose into usable forms of nutrients that can be absorbed by the herbivores, which lack the ability to digest cellulose as a food source. On the other hand, these bacteria survives by feeding on the nutrients in the host's intestines, and reproduce from these. Nitrogen fixation bacteria feeds on the nutrients in plant's roots, and in return it changes atmospheric N_2 into nitrate, which is the usable form of nitrogen crucial for plant growth. Hence bacteria indirectly increases the biomass and net primary productivity in a community, enabling species diversity, benefitting species of the entire food chain.

As decomposers, bacteria breaks down dead matter such as leave litters and dead animals as a source of food, and returning the nutrients to the soil to be absorbed by the plants.

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3B2

Without these bacteria, nutrients in an ecosystem will not be recycled fast enough, which will result in nutrients depletion and hence the collapse of the entire ecosystem.

b) By using genetically engineered bacteriophages through conduction, plasmids can be inserted to be incorporated as genetic material in the bacteria. Since nucleotide sequences are universal, many protein and hormone products can be synthesised by bacteria, and harvested to be used in biomedical fields.

3C,

3. Bacteria play central biological roles.

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Select THREE of the ecological roles above. For each one you choose, **describe** how bacteria carry out the role and **discuss** its ecological importance.

(b) **Explain** how bacteria can be altered to make genetically engineered products.

Bacteria play central biological roles as producers, mutualistic symbionts, and decomposers. Bacteria is essential for other organisms to survive. Many depend on bacteria as a source of substances they need to acquire in order to function properly.

Bacteria are producers. They carry out chemosynthesis. They use chemicals to produce food for other organisms. They convert nitrogen into food other organisms can obtain. This role is essential in where there is no sunlight or few plants for photosynthesis. In a marine ecosystem, because of its depth, light cannot penetrate through the littoral zone. Instead bacteria live there to generate food for bottom-dwelling and other organisms. Bacteria can also survive in places where plants may not. They survive in extreme environments such as acid, hot & salty environment. In those environments, bacteria also work as a primary producers to maintain the ecosystem.

Lots of organisms including plants and humans will end up dying without bacteria's mutualistic role. For plants, some bacteria fixes nitrogen from the atmosphere to a different form so that the plants' roots

(NH) nitric acid

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ADDITIONAL PAGE FOR ANSWERING QUESTION 3

can absorb it. Therefore many nitrogen-fixing bacteria live near or on plants' roots. Bacteria also absorb other substances from plants without hurting the plant itself. Bacteria is also beneficial to human and other animals. Bacteria live on the body of animals. Millions of it live on the body, and they protect the animals from diseases that may severly cause an impact. Bacteria prevents harmful substances that may go into the bodies.

Bacteria are decomposers essential to carry out carbon, nitrogen, phosphorus cycle. They decompose dead body and return the nutrients to soil and carbon/nitrogen back to the atmosphere. Because of bacteria, other organisms can reobtain those substances from the atmosphere. As decomposers, bacteria can survive and gain food through the dead bodies of organisms.

Through technology, bacteria can be altered to make genetically engineered products. Using a vector, necessary gene of bacteria can be cut out to form a recombinant DNA that can be injected into different organisms. These genetically engineered products can extract beneficial traits of bacteria and use it to create a more efficient organisms.

AP® BIOLOGY
2010 SCORING COMMENTARY (Form B)

Question 3

Sample: 3A
Score: 10

This well-organized response could have earned more than the maximum 10 points. The description of producers in part (a) earned 3 points: 1 point for recognition of autotrophs capturing energy as sunlight; 1 point for defining a role of producers as generating oxygen; and 1 point for listing cyanobacteria as producer bacteria.

Also in part (a) the discussion of parasitism earned 3 points. The first point was for recognition that this is a +/- interaction. The second point was earned for description of the role of parasites as a limiting factor on host population size. The third point was earned for indicating that ecosystem balance is maintained by preventing populations from growing too large in the face of resource limits.

The decomposer role earned 2 points in part (a). The first point was for noting the breakdown of organic material as contributing to nutrient cycles. The second point was earned for the specific example of nitrogen as a soil nutrient released through decomposition.

In part (b) the discussion of genetic engineering of bacteria earned 1 point for the mention of cutting foreign DNA and plasmid DNA with a restriction enzyme and 1 point for noting the production of recombinant DNA by using ligase to "glue" the plasmid and foreign DNA together. This section includes a simple diagram to illustrate the product described and clarify the point being made. Additional valid information is provided in the rest of the response, but the maximum 10 points for the question had already been reached so no additional points were awarded.

Sample: 3B
Score: 8

In part (a) the three required roles are clearly identified with headings and pertinent information limited to the text following each. This portion earned 7 points. The first point of the possible 3 points under parasitism was earned for the example of stomach residents causing ulcers. A second point came from description of the bacterium feeding on the host's tissues and harming the host's health, a +/- interaction. The third point came from the elaboration that a parasite can serve to keep a population size under control, maintaining a balanced, stable ecosystem. One point could have been awarded for parasites limiting the host population size if one had not already been earned for the nature of the interaction.

Also in part (a), the discussion of mutualistic symbiosis earned 1 point for the example of cellulose digesting bacteria in herbivores. A second point was awarded for identification of this as a benefit to both the bacteria and the host, a +/+ interaction. The nitrogen-fixing bacteria are provided as a second example, but points were awarded only for the first example.

The role of decomposers earned 2 points in part (a) as well. One point was earned for indicating that the breakdown of dead matter returns nutrients to the soil, and 1 point was earned for mention of this contribution to the recycling of nutrients in ecosystems.

The genetic engineering portion of the response, part (b), earned 1 point for noting the use of vectors such as a genetically engineered bacteriophage or plasmid to introduce genetic material into bacteria.

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Question 3 (continued)

Sample: 3C
Score: 5

In this response the four parts of the question are clearly delineated. The introductory paragraph is not necessary and provides no valuable information.

In part (a) the first point came from the explanation that bacterial producers "carry out chemosynthesis" when sunlight is not available. One point was earned for stating that bacteria serve as primary producers in the deep ocean ecosystem. The third point was earned through the mutualistic symbiosis discussion for the association between nitrogen-fixing bacteria and plant roots. Two final points were earned under decomposers for mention of their involvement in the cycling of carbon, nitrogen and phosphorus and returning nutrients to the soil as they break down dead organisms.

In part (b) the discussion of genetic modification was too superficial to earn any points.