



AP[®] Biology 2003 Sample Student Responses

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4. Death is a natural and necessary part of life cycles at all levels of organization.

- (a) Discuss TWO examples of how cell death affects the development and functioning of a multicellular organism.
- (b) Discuss ONE example of how substances are degraded and reused in cells.
- (c) Discuss the evolutionary significance of death.

(a) Cell death is a necessary part of keeping individuals healthy. As cells get older, their efficiency decreases or their parts might be damaged. This affects the productivity of the individual's body systems. To keep tissues efficient, cells must be replaced periodically. This is true in the skin. Cells of the epidermis are used for protection. As the cells are worn down they are replaced. In some people, their epidermis replaces itself every week. Cell death is also important in preventing cancer or harmful mutations. During DNA replication a cell might receive a ~~mutate~~ mutation or change in DNA. Radiation or chemicals are mutagens that cause mutations. If the mutation affects certain genes, the cell may divide uncontrollably, creating tumors that invade other body tissues and metastasis occurs when it affects the bloodstream. It is best that these cells be destroyed before they can multiply through mitosis.

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(B) Cellular respiration is the metabolic process that breaks down glucose using oxygen and creates ATP while releasing water and CO₂. ATP is used for cellular work. Cellular respiration takes place in the organelles called mitochondria. In glycolysis, sugar is broken down through enzymes. NAD⁺ accepts electrons becoming NAD + H⁺ and ATP is produced. CO₂ is given off then it enters the mitochondria & ~~acetyl~~ Coenzyme A is added. Then acetyl CoA is incorporated into the citric cycle that has intermediates as energy is released in the form of NAD + H⁺ and ATP through substrate-level phosphorylation. Through degrading and reusing substances, the citric cycle or Krebs cycle is possible. Lipids and proteins can be used to substitute molecules that are intermediates in the cycle. These intermediates can be created through other compounds that are broken down, & when released from the cycle, they can be used elsewhere. Other lipids, proteins & carbohydrates can be broken down & added to the cycle at any stage.

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(c) Evolution is the gradual change of organisms over time. Charles Darwin proposed evolution and natural selection as the mechanism of evolution.

Natural selection favors some animals over others in the environment. If a bird has a beak that makes it better able to crush seeds to obtain food, that bird will live longer and leave behind more offspring. The offspring will receive the adaptive trait, making them more successful in life. ~~Over~~ The change or adaptation will eventually be possessed by a large number of individuals and if these individuals have enough differences, speciation will result. Speciation is the creation of new species.

For evolution, some organisms had to be less adaptive or suited to their environment and they would die. Dying favors the survival of traits best suited to an environment & causes evolution.

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4. Death is a natural and necessary part of life cycles at all levels of organization.
- Discuss TWO examples of how cell death affects the development and functioning of a multicellular organism.
 - Discuss ONE example of how substances are degraded and reused in cells.
 - Discuss the evolutionary significance of death.

a) Cell death is particularly important in an organism's immune system. T cells and B cells, produced in the bone marrow (T cells go on to the thymus to mature), combat foreign particles. Macrophages engulf foreign matter. When foreign particles are engulfed, they must be disposed of. T cells, through cell-mediated immunity attack intracellular parasites. After macrophages engulf the foreign particle, the cytotoxic T cell binds to the macrophage with the help of CD8. Antigen receptors make identifying possible. The T_c cell releases perforin, which creates pores in the macrophage. The infected cell lyses and is no more. This attack allows the body to rid itself of dangerous viruses, bacteria, or fungi.

Another example of cell death can be seen specifically in the plant. ~~The~~ xylem consists of ~~a~~ purely dead cells. The xylem is the water conducting vessel in the plant. It is through these existing yet dead cells can the plant transport water throughout the roots, stems, and leaves. ~~¶~~ Dead xylem is also compacted to form the "wood" of the tree. Useless dead phloem, on the other hand becomes bark, even though phloem is living when transporting sugars from the leaves to the rest of the plant.

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b) ATP is used constantly in cells. ~~It~~ It is made by cellular ~~metabolism~~ respiration. A glucose molecule will go through glycolysis. There are two phases in glycolysis: one uses 2 ATP molecules while the second ~~makes~~ makes 4 ATP molecules. ~~In~~ In Krebs cycle, ATP is produced as well, but the largest contributor to ATP production is ~~the~~ oxidative phosphorylation in the electron transport chain. This occurs in the inner mitochondrial membrane. The final electron acceptor is oxygen. Using a chemiosmotic gradient, H^+ diffuses through the membrane via the ATP synthase, which allows the making of an ATP molecule.

In turn, ATP is broken down by the cellular activities of an organism to produce energy. ATP is reduced to ADP and a phosphate is lost from ATP. This powers many activities of a cell. ATP is the source of energy for active transport of particles across the cell membrane.

c.) death is significant not only on a cellular or tissue level. ~~It~~ It also affects evolution

Darwin's theory of natural selection comes into play. Organisms with certain characteristics are more adapted to the environment. Thus, they will survive at a greater rate compared to organisms without the characteristic. The surviving individual will reproduce and pass on its genes to its offspring. ~~As~~ As time passes the number of organisms with the certain characteristic, are more popular, because they can survive. Survival of the

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fittest plays a key role in evolution. Death "weeds" out the weak individuals whose genotype produces a phenotype vulnerable to environmental conditions. Some species may even become extinct.

Evolution has caused great changes in plants and animals. For instance, plants evolved well with their environment. A watery environment facilitated fertilization; hence bryophytes. Then came the seedless vascular plants, then gymnosperm (naked seed plants) and angiosperm. The dominant gametophyte generation in the bryophyte changed to dominant sporophyte generation. The changes in the plants are marked by specific periods and eras, where environmental changes forced the plants to adapt to their advantage.

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4. Death is a natural and necessary part of life cycles at all levels of organization.

- Discuss **TWO** examples of how cell death affects the development and functioning of a multicellular organism.
- Discuss **ONE** example of how substances are degraded and reused in cells.
- Discuss the evolutionary significance of death.

Death is seen by scientists as paradoxically necessary for life. One example would be apoptosis, programmed cell death. In ~~embryos~~ embryos and fetuses certain features that form while in development will not be in the final ~~birth~~ form and must be eliminated before birth. Some examples are pharyngeal gill slits found in most ~~higher~~ embryos of higher forms of life. The cells in these slits are programmed to die ~~before birth~~ and ~~are~~ are resorbed into the tissue before birth in mammals, ~~and~~ birds, and reptiles. In human fetuses have hands in which all the fingers are connected by a thin webbing. The cells in this webbing all undergo apoptosis and the fingers are separated before the baby is full term and born.

Cell death is also very important in preventing cancer. Scientists have recently found that the p53 gene is vital in programming apoptosis. In studies in which rats ~~were given high~~ ~~do~~ had high levels of p53 and were given carcinogens, there was a far lower occurrence of cancer than in normal rats without elevated p53 levels and same amount of carcinogens. One curious side-effect was that p53 seems to stimulate aging in the rats.

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Those rats with high levels of p53 exhibited symptoms of aging like decreased sight, smell, and osteoporosis. The p53 gene works by ~~regulating~~ ^{assisting in the} monitoring of cellular DNA. In normal cells, any mutations ^{DNA} prompts p53 to ~~kill~~ kill the cell. Since cancer is caused by mutations of DNA p53 is ^{thought to be} a regulator of cancer. Most malignant tumors are found with mutations in the p53 gene, ^{thus} supporting ^{the} theory. It is ironic that p53, the gene that kills cancer cells before they can manifest itself, also seems to be what makes us age. It appears that cells must die so that the organism might live.

Substances like proteins are used by the cell to carry out metabolism and other important functions. Proteins are made when transcribed mRNA comes to a Ribosome where the message is translated and tRNA help to form the polypeptide chain. The protein then goes off and completes its function. When it is no longer needed the cell usually breaks it down into its component pieces ^{once} again. This is done in ^{special} lysosomes, where enzymes are kept that break the proteins into its component amino acids. The amino acids are then put back into the cytosol where the ribosomes and tRNA can ~~use~~ readily use them to make new proteins.

Many scientists agree that if there is one useful aspect to death, it is for evolution. As organisms ~~make~~ offspring, some of these offspring will have mutations.

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Those which have beneficial variations caused by these mutations, greater water retention in a desert perhaps, will be better suited for survival. Those offspring with deleterious variations or variations that provide no added benefit will be at more of a disadvantage. Continuing the example of water retention, if the climate of an area gets more and more arid, those animals with ~~good~~ variations that allow for greater water ~~retention~~ retention will survive in greater number than those without such variations. Thus, animals with less retention ~~retention~~ capacity will die out. The ~~species~~ type of natural selection exhibited here is directional selection, in which one ^{extreme} aspect, ^{greater} water retention, is selected for. To put death on evolution in a stark sense; those ~~are~~ with more beneficial variation will survive and adapt, while those organisms without such variations or detrimental ones will die out, as less beneficial variants die out, their genes are removed from the gene pool, thus driving evolution forward in the direction of the genes that survived.

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