



AP Biology 1999 Sample Student Responses

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Essay 1 (10 points)

DNA replicates itself using semiconservative replication. This means that each parent strand of DNA will serve as the template for forming a new DNA molecule, resulting in daughter molecules that are $\frac{1}{2}$ old DNA and $\frac{1}{2}$ new. The DNA molecule is split down the middle by helicase, which breaks the bonds holding the complementary nucleotides together. Helicase functions in a 3' to 5' direction, while the next step, synthesis, occurs in a 5' to 3' direction, with 3' and 5' denoting the ends of the DNA molecule. A new strand is synthesized by DNA polymerase, which catalyzes the adding of new nucleotides to each half of the DNA molecule. Thus, each daughter DNA molecule is identical to its parent, ~~because of the process of transcription~~.

The DNA molecule is held together in the middle by hydrogen bonds between the 2 strands, and nucleotides are attached to one another lengthwise down the molecule by phosphodiester bonds. Both of these bonds, plus the coiling of the molecule, contribute to its stability. However, variation is possible due to mutations in the DNA. Mutation may be caused by a number of sources, but they all include the changing of the sequence of nucleotides. ~~Not~~ Nucleotides may be inserted into the chain, deleted, or translocated. Each of these mutations corresponds to a change in the structure of the protein that the gene codes for, which may or may not have serious effects.

DNA consists of 4 nucleotides - adenine, guanine, cytosine, + thymine. Adenine + guanine are purines, and have complementary structures to cytosine + thymine, which are pyrimidines (A pairs with T, + C pairs with G) These four nucleotides, arranged in various sequences along a molecule of DNA are responsible for the incredible diversity of proteins that may be produced. Nucleotides code for proteins in triplets, or codons. Each amino acid corresponds to several

different codons. (64 codons are possible, and 20 amino acids exist, with 2 codons signalling for "stop") The phenotype of an organism is a result of the variations in the proteins produced in this way.

Messelson & Stahl performed an experiment to prove Watson & Crick's theory of semiconservative replication of the DNA molecules. They used a centrifuge to separate DNA from bacteria. The DNA formed a band visible in the tube. When the bacteria were grown in a medium containing heavy nitrogen isotope (^{15}N), the band was in a different place. When they allowed the bacteria to grow in the medium long enough for 1 generation of replication, the band formed was between the 2 light & heavy bands, suggesting that it consisted of $\frac{1}{2}$ light & $\frac{1}{2}$ heavy DNA. One more replication ^{in a ^{14}N medium} would result in only light & medium bands, showing that half of the strands were all new DNA, while the other half were hybrid light & heavy. This proved that each time, half of the DNA served as a template for replication of a new half of the molecule.

Essay 2 (8 points)

DNA, a double helix shaped molecule composed of alternating base pair sequences, nucleotides consisting of a base, phosphate backbone, and simple sugar, and linked in the middle by hydrogen bonds (as proposed by Watson and Crick), can easily copy itself, is fairly stable, and very complex. By first ~~unzipping~~ unzipping itself with the aid of DNA polymerase, DNA is able to replicate having the complementary base pairs of adenine, guanine, thymine and cytosine detach and being joined by other loose DNA strands on the leading 3' and lagging 5' ends. This semi-conservative replication is efficient, quick, and easy. DNA ligase, polymerase, and helicase enzymes all aid in the unzipping, re-binding, and finishing of the replicated strands.

DNA is stable, having all the base pairs bound by the hydrogen bonds and phosphate backbone. It is neither acidic nor basic, isn't radioactive, can be combined with other DNA strands from other sources (such as mixing human DNA with bacteria strands during recombination). However, it is susceptible to change as the genetic ^{information} ~~sequence~~ housed in the base pairs can be changed as mutations change the sequence of the bases. Deletions can remove a base from a replicating strand, insertions may add an extra base, inversions will reverse a sequence, point mutations, ^{frame shifts} will change the sequence, and many more. These may have no effect, but most often do as the change in bases causes a change in what amino acid, enzyme, or

otherwise, is produced. Thus, it is stable but can be changed.

Finally, it is very complex as each facet of an organism's genotype is within the system of bases of the DNA. These bases are then specifically assorted in ways numbering billions upon billions which, depending on that assortment, codes for every aspect of the phenotype (physical expression of the genotype - genetic makeup of an organism). A simple shift, addition, deletion or change of one or more of these bases causes a change in the genotype, and thus, a change in the phenotype.

The complex system of bases and their bonding and harboring of information was determined by Watson and Crick whose theories and postulations on the double helix shape of the DNA molecule deduced such information. And, the experiments of Meselson and Stahl deduced the semi-conservative reproductive replicative nature of DNA when they observed a replicating DNA in a liquid medium and studied the effects.

Essay 3 (6 points)

DNA meets each of the criteria because it can copy itself through the process of DNA replication in which each half of the DNA strand serves as a template for a new complementary strand (semiconservative). It also includes structures such as DNA ligase and helicase which check and fix DNA errors (along with DNA polymerase). The arrangement of hydrogen bonds, phosphates, and nitrogenous bases contribute to its stability. And the varying sequences of the bases allow DNA to be complex enough to determine an organism's phenotype. The order of the bases dictate which amino-acids are produced therefore determining which phenotype is expressed.

To determine that DNA was in fact the hereditary material used to determine the organism's phenotype, a few scientists used bacteriophages incorporated with ^{32}P and ^{35}S . Mixing a bacteria culture with the bacteriophages, the scientists were able to determine whether DNA was the hereditary material by tracing the movement of of the isotopes (^{32}P and ^{35}S). The ^{32}P was ~~at~~ incorporated into the bacteriophage's DNA while the ^{35}S combined with another cellular organelle. From the new colonies, produced by the infected bacteria, only ^{32}P was present indicating that the DNA from the "parent" bacteria colony was replicated and produced in the "daughter" bacteria colony. Therefore, DNA had to be the genetic material.