AP® Biology
2002 Sample Student Responses

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Q1R1

BIOLOGY
SECTION II
Time—1 hour and 30 minutes

Directions: Answer all questions.

Answers must be in essay form. Outline form is not acceptable. Labeled diagrams may be used to supplement discussion, but in no case will a diagram alone suffice. It is important that you read each question completely before you begin to write. Write all your answers on the pages following the questions in this booklet.

1. The human genome illustrates both continuity and change.

   (a) **Describe** the essential features of **two** of the procedures/techniques below. For **each** of the procedures/techniques you describe, **explain** how its application contributes to understanding genetics.

   - The use of a bacterial plasmid to clone and sequence a human gene
   - Polymerase chain reaction (PCR)
   - Restriction fragment length polymorphism (RFLP) analysis

   (b) All humans are nearly identical genetically in coding sequences and have many proteins that are identical in structure and function. Nevertheless, each human has a unique DNA fingerprint. **Explain** this apparent contradiction.

The Human Genome is an exciting undertaking that provides us with many opportunities for the future. The human genome project uses many techniques to decode human DNA. Some of those processes that are helping us further understand genetics are the use of bacterial plasmids to clone a human gene, and Restriction Fragment Length Polymorphism or RFLP analysis.

The use of bacteria to clone a human gene is very important to our understanding genetics. In this procedure, scientists inject part of a human gene into a bacterial cell. This DNA attaches itself to the bacteria's, which enables it to divide with the cell. After this is accomplished the bacteria is stimulated to divide, which

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

results in many bacterial cells with the human gene. This is very important to our understanding of genetics, for it allows scientists to be able to concentrate on one gene. This kind of study could prove vital to finding cures for genetic defects such as sickle cell anemia.

RFLP analysis is another important part of genetics. In this procedure, scientists use restriction enzymes to "break" DNA when certain patterns appear. The broken fragments then goes through electrophoresis, which seperates them according to length. By using certain enzymes, scientists are able to figure out the order of bases in DNA. This is important to genetics because it will allow mutations in the genome to be detected by something as simple as an amniocentesis.

The person who's DNA is being studied is a Middle-Aged Man from the US. This is possible because the DNA sequence of all humans is almost identical. This brings up the question however of how people have unique DNA fingerprints. This is because at those rare differences the bases are different. By using the restriction enzymes mentioned before the differences can be picked up during electrophoresis, thus producing the person's "unique" fingerprint.

The human genome is an exciting

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project that illustrates continuity and change. This project may lead to potatal cures and more accurat DNA fingerprinting. To do this however it needs techniques such as bacterial cloning of a human gene, and RFLP analysis

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BIOLOGY

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Bacterial plasmids are used as a means for cloning and sequencing human genes. This process begins when both the bacterial plasmid and the desired human gene are both cut with the same restriction enzyme, such as HindIII or EcoRI, to produce "sticky ends". The cut plasmids and DNA are then mixed together along with DNA ligase in order for the DNA to become part of the bacterial plasmid. Once this is accomplished a vector is used to return the plasmid to the bacteria. This is called transduction. Vectors include gene guns or using micropipettes. If this procedure is successful, the bacteria will follow the directions on the foreign DNA; thus producing whichever product it codes for. An example of this technique used for medical purposes is its use to produce human insulin. By using different restriction enzymes, different lengths of the gene will result because of the different restriction

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sites. These varying lengths of DNA allow scientists to sequence the gene.

The Polymerase Chain reaction combines the desired sequence of DNA, DNA nucleotides, and transcription enzymes such as DNA polymerase to produce large amounts of a particular DNA sequence. The fragments that are mass produced in the PCR can then be used for transduction into bacterium or for DNA analysis using gel electrophoresis.

Although all humans are nearly identical genetically, there are unique differences in each person's genome. Different alleles of genes are each slightly different, coding for different proteins that allow for the different phenotypes. Although most human genes code for the same protein in each person, there is enough genetic diversity derived from genes that differ from person to person to allow for different and unique DNA fingerprints. Differing DNA sequences eliminate or create restriction sites for restriction enzymes. Since no two people have the exact same DNA sequence (except identical twins), no two people will have same RFLPs produced by restriction enzymes. Also, several sequences can sometimes code for the same amino acid - allowing for even more different restriction sites.

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Bacterial plasmids can be used to clone and sequence specific human genes in the laboratory. An example of this is the procedure used to amplify genes for study. An enzyme such as EcoRI (a restriction enzyme) is added to a sample of DNA, where it selects and removes a segment from the strand. Another restriction enzyme is exposed to the bacterial plasmid, and cuts out a corresponding section. DNA ligase is used to make the fragment of human DNA "stick" to the open section in the bacterial plasmid. Once this has happened, the bacteria is allowed to clone itself and make copies of the human gene which has been placed in it. The use of the gene by the bacteria (as for example, the use of formerly unusable materials in the production of human proteins formerly unproduceable) can serve to clarify what that gene does inside of its normal owner. Understanding this adds to the knowledge of genetics.

The analysis of RFLPs serves to let scientists see similarities and differences between DNA samples, giving them an idea of how closely related in family, species, genus, etc the donors of these samples are. In RFLP analysis, several kinds of restriction enzymes are added to isolated DNA samples, producing fragments

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which are placed in wells in a gel agarose. This procedure is called electrophoresis. After the fragments are placed in the wells ~~[illegible]~~ electrical current is hooked to the container and run through the gel. This drives the nucleotide fragments different lengths down the gel depending on how long the fragment is. The gel is then dyed and the samples are compared. Several restriction enzymes are used so that the genetic sequence can be seen ~~from~~ more clearly and similarities be verified as not coincidental.

Much of the DNA contained in a strand is not used for protein production. Therefore, although humans ~~are~~ produce mostly similar proteins, there is a lot of room for difference, because this "junk DNA" has a higher rate of mutations. Also some proteins ~~can~~ are produced by more than one codon (segment of 3 nucleotide pairs in RNA), allowing for more genetic diversity. These two things combine to give each human a genetic fingerprint which is unlikely to be randomly reproduced in another.