Answers to Questions for Comprehension

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Q1. Miescher's contribution to the study of hereditary materials was the isolation of a weakly acidic phosphorous-containing substance from the nuclei of white blood cells, which he termed "nucleic acid."

Q2. Avery, MacLeod, and McCarty conducted a series of experiments and discovered the following:

- When they heat-killed pathogenic bacteria with a protein-destroying enzyme, transformation still occurred.
- When they treated heat-killed pathogenic bacteria with a DNA-destroying enzyme, transformation did not occur.

These results provided strong evidence for DNA's role in transformation.

Q3. Hershey and Chase concluded that genes are made of DNA.

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Q4. (a) Chargaff found that the amount of adenine in any sample of DNA is approximately equal to the amount of thymine, and the amount of cytosine is always approximately equal to the amount of guanine.

(b) Franklin used X-ray photography to analyze the structure of DNA. Her observations provided evidence that DNA has a helical structure with two regularly repeating patterns. She also concluded that the nitrogenous bases were located on the inside of the helical structure, and the sugar-phosphate backbone was located on the outside, facing toward the watery nucleus of the cell.

(c) Watson and Crick were the first to produce a structural model of DNA that could account for all of the experimental evidence gathered to that point in time.

Q5. The nitrogenous bases are different sizes. Adenine and guanine have a double-ring structure while thymine and cytosine have as single-ring structure. The A-T and C-G pairs are called "complementary base pairs" and maintain a constant width of 3 three rings in the DNA molecule.

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Q6. A gene is defined as a functional sub-unit of DNA that directs the production of one or more polypeptides (protein molecules). The genome of an organism is the sum of all of the DNA that is carried in each cell of the organism.

strand is synthesized in short fragments called Okazaki fragments.

Q10. The replication machine consists of the complex of polypeptides and DNA that interact at the replication fork. These polypeptides include DNA polymerase, an enzyme that joins nucleotides together to create a complementary strand of DNA (elongation); DNA ligase, an enzyme that splices together Okazaki fragments; primase, an enzyme that constructs the RNA primer needed for replication to begin; and helicases, a group of enzymes that cleave and unravel a segment of the double helix to enable replication. Several other proteins and enzymes are also part of the replication machine.

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Q7. Semi-conservative replication of DNA means that each strand of DNA serves as a template for a new, complementary strand, resulting in two new DNA molecules that each contain the original parent DNA and one new strand. Each new DNA molecule thus conserves half of the original molecule.

Q8. Replication takes place in a slightly different way on each DNA strand because DNA polymerase can only catalyze elongation in the 5′ to 3′ direction. In order for both strands of DNA to be synthesized simultaneously, the method of replication must differ.

Q9. During DNA synthesis, the overall direction of elongation is the same along both strands, but elongation occurs differently. On the leading strand, DNA synthesis takes place along the DNA molecule in the same direction as the movement of the replication fork. On the lagging strand, DNA synthesis proceeds in the opposite direction to the movement of the replication fork: The lagging

acids are strung together and how the proteins are made. In other words, the order of the nucleotides in the gene provides the information—written in genetic code—that is necessary to build a protein.

Q12. The two basic steps in gene expression are:

Step 1: The DNA is copied onto an RNA molecule in a process called transcription. In a eukaryotic cell, transcription takes place in the nucleus.

Step 2: The RNA molecule then moves to the cytoplasm of the cell, where the RNA nucleotide sequence directs the synthesis of a protein. This process is called translation.

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Q13. Three bases make up each mRNA codon.

Q14. The characteristics of the genetic code:

(a) A redundant genetic code means that more than one codon can code for the same amino acid.

(b) A continuous genetic code means that the code reads as a continuous series of three-letter codons without spaces, punctuation, or overlap.

(c) A universal genetic code means that almost all living things use the same genetic code to build proteins.

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Q11. The structure of a protein is determined by the structure of the DNA molecule. The order of the base pairs in a DNA molecule makes up the genetic code of an organism. The genetic code determines how the amino

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Q15. The RNA polymerase complex catalyzes the synthesis of mRNA during transcription. The RNA polymerase complex recognizes the promoter region (specific nucleotide sequence) on the DNA molecule and binds to the sense strand of the DNA. It then opens a section of the double helix and synthesizes a strand of mRNA that is complementary to the sense strand of DNA, replacing the base thymine with uracil as it does so. Synthesis of the new mRNA strand is always in the 5′ to 3′ direction, adding each new nucleotide to the 3′-OH group of the previous nucleotide. When the RNA

physical mutagen. A chemical mutagen is a molecule that can enter the nucleus of a cell and induce mutations by reacting chemically with the DNA. Examples of chemical mutagens include nitrites, gasoline fumes, and various compounds in cigarette smoke.

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Q17. The redundancy of the genetic code protects a cell from the effects of substitution mutations. A change in the coding sequence of a gene does not always result in a change to the polypeptide product of a gene.

Q18. The insertion or deletion of one or two nucleotides results in a frameshift mutation. A frameshift mutation causes the entire reading frame of the gene to be altered. A shift in the reading frame usually results in a nonsense mutation.

Q19. A frameshift mutation is more likely to have serious consequences for a cell than a substitution mutation because the frameshift mutation causes the entire reading frame of the gene to be altered.

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Q20. (a) A spontaneous mutation is a mutation that is caused by molecular interactions that take place naturally within cells. An induced mutation is caused by agents outside of the cell, such as certain factors in the environment.

(b) Physical mutagens cause changes in the structure of the DNA. High-energy radiation, such as those from x-rays and gamma rays, is the most damaging form of

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Q21. Your mitochondrial DNA is identical to the mitochondrial DNA of your mother, as the father's sperm contributes essentially no cytoplasm, and therefore no cytoplasmic organelles, to its offspring. On the other hand, your mother's egg provided most of the cytoplasm and cytoplasmic organelles, such as the mitochondria. While the DNA in the nuclei of your cells is made up of an equal combination of DNA from your mother and your father, your mtDNA came from the cytoplasm of your mother's ovum.

Q22. DNA allows scientists to study genetic variations among individuals of the same species, as well as the genetic variation among different species. This helps scientists to track the evolution of a species through time.

Comparing the DNA of ancient plants, animals, and even bacteria, with the DNA of their modern counterparts can reveal such varied information as the ancestry of modern organisms, the movement of populations through time, the evolution of particular disease-causing bacteria, and the way that ecosystems respond to climate change.

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Q23. (a) Specificity: The cuts made by an endonuclease are specific and predictable. That is, the same enzyme will cut a particular strand of DNA the same way each time, producing an identical set of small DNA fragments called restriction fragments.

(b) Staggered cuts: Most restriction endonucleases produce a staggered cut that leaves a few unpaired nucleotides on a single strand at each end of the restriction fragment. These short strands, often referred to as "sticky ends," can then form base pairs with other short strands that have complementary strands, creating a recombinant DNA molecule.

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Q24. A DNA microarray experiment allows scientists to analyze the activity of thousands of genes at once. It is generally used to compare gene expression.

Q25. The results of DNA microarray analysis allow scientists to pinpoint the genes that are responsible for particular functions or conditions, to study the interactions among genes, or to gather information about the relationship between environmental conditions and gene expression.

Q26. Studying the human genome, as a whole, offers the potential for developing drugs that are tailored not only to the expression of individual genes associated with particular disorders, but also to the unique genome of the individual. Studying the differences in gene expression among individuals can help medical researchers understand why certain drugs work better in some people than in others, and why certain people experience side effects from medications.

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Q27. The benefits of transgenic organisms include improving human health, cleaning up toxic spills, producing plants with more nutritional value, producing pharmaceutical products, and producing animals that could serve as organ donors for humans.

Examples include (students are only asked to provide one example of each):

- Transgenic bacteria are making pure human insulin, making medicines at lower costs, and are used to clean up oil spills.
- Transgenic plants, such as golden rice, provide higher nutritional value to feed those who are starving.
- Transgenic animals, such as goats, are genetically modified to secrete a human polypeptide or other substances in their milk.

Q28. Social, legal, and moral issues associated with transgenic organisms involve environmental threats, health effects, and social and economic issues. These concerns are summarized below:

- Environmental threats: The use of herbicide-resistant plants could encourage farmers to use higher levels of herbicides. This, in turn, could lead to a build up of herbicide chemicals in water supplies and neighbouring ecosystems. As well, there is evidence that engineered genes can be transferred to wild plants and other organisms, raising concerns about the emergence of "superweeds" and "superbugs." More generally, ecosystems involve complex and delicate balances among many different organisms. The introduction of transgenic bacteria, plants, or animals could upset these balances, with unknown results.
- Health effects: Many consumer groups argue that not enough is known about the long-term effects of consuming transgenic products, including genetically modified foods and medicines. The complex processes of gene regulation are not well understood, so it is difficult to predict potential health risks.
- Social and economic issues: Advocates of genetically modified foods argue that these foods will help to improve human health and alleviate world hunger. Their opponents argue that genetic research absorbs millions of dollars, which would be better spent directly helping people in need. In addition, many people are concerned about the growing influence of private corporations over global food production. The treatment of plants and animals as commodities to be manipulated and patented also raises questions about our relationships with—and responsibilities to—other living organisms.

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Q29. (a) During an ultrasound procedure, sound waves beyond the limit of human hearing are sent through the amniotic fluid. The sound waves bounce off the developing fetus and are used to create a cross-sectional image of the fetus. This image can reveal physical abnormalities, such as a missing limb, malformed heart, or cleft palate. Many other genetic conditions, however, can be identified only by analyzing a tissue sample from the fetus.

(b) In an amniocentesis, a needle is used to withdraw a small sample of amniotic fluid from the uterus. The extracted fluid is placed in a special nutrient-rich medium and the cells are allowed to multiply. When the cell sample is large enough, researchers can prepare a karyotype or another genetic analysis. The karyotype can be used to identify chromosomal disorders, such as Down's syndrome.

(c) A DNA marker can be found using a DNA probe. A DNA probe consists of a molecule of DNA with a nucleic acid sequence that is complementary to the marker sequence, and is "marked" with a radioactive or fluorescent chemical tag. DNA from the tissue sample is placed in a suspension with the DNA probe. If the DNA sample contains the gene of interest, the probe will bind to the marker sequence. Using the tag, researchers can verify the presence of the gene of interest.