Chapter 18 Review Questions

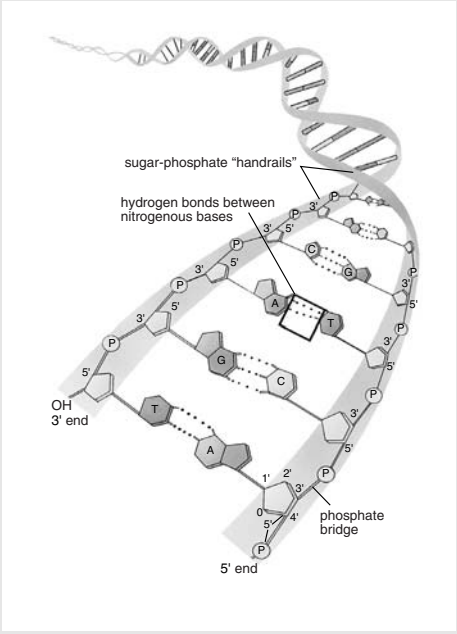
Student Textbook pages 664–665

Answers to Understanding Concepts Questions

1. Alfred Hershey and Martha Chase used radioactive labelling to determine whether viral protein or viral DNA was responsible for taking over the genetic machinery of the host cell. Hershey and Chase produced two batches of the virus. In one batch, they labelled the protein coat using radioactive sulpfur. In the other batch, they labelled the DNA with radioactive phosphorus. The labelled viruses were allowed to infect bacterial cells. The cells were then agitated in a blender to separate the viral coats from the bacterial cells. Each medium was tested for radioactivity. The results demonstrated that viral DNA, not viral protein, enters the bacterial cell, and that DNA is the hereditary molecule.

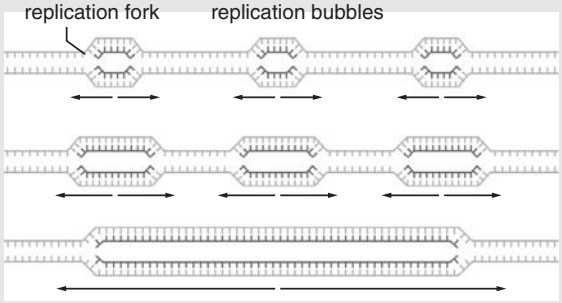
2. Chargaff's rule states that in the DNA nucleotides, the amount of adenine will be more or less equal to the amount of thymine, and the amount of guanine will be equal to the amount of cytosine. The number of A-T nucleotides will not necessarily equal the number of C-G nucleotides. This overturned Levene's earlier hypothesis that the nucleotides occurred in equal amounts and were present in a constant and repeated sequence, such as ACTGACTGACTGACTG.

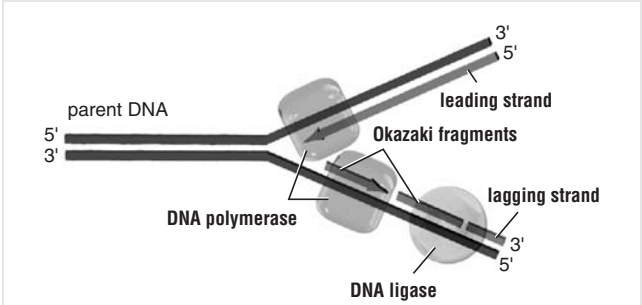
3. Students' illustrations may resemble Figure 18.6 (shown below) in the student textbook, and should include appropriate labels, as given in that figure.



4. The DNA strand that is complementary to the sequence TTCGAATCGA is AAGCTTAGCT.

5. Students' illustrations may resemble Figure 18.9 and 18.10 (shown below) in the student textbook, and should include appropriate labels, as given in those figures.





6. Helicases cleave DNA. Primase synthesizes a new RNA strand. DNA polymerase adds nucleotides to a fragment of DNA. Ligase binds nucleotides together.

7. After each nucleotide is added to a new DNA strand, DNA polymerase recognizes whether or not hydrogen

bonding is taking place between the new nitrogen base and its complement on the original strand. The absence of hydrogen bonding indicates a mismatch between the bases.

8. The genetic code has three important characteristics.

- The genetic code is *redundant*—that is, more than one codon can code for the same amino acid. Only three codons do not code for any amino acid. These codons serve as "stop" signals to end protein synthesis. If a mistake occurs when the genetic code is replicated or transcribed, redundancy reduces the chance that a different amino acid results during translation.
- The genetic code is *continuous*. That is, the genetic code reads as a series of three-letter codons without spaces, punctuation, or overlap. Where to start and stop translation is essential. A shift of one or two nucleotides will alter the codon groupings and result in an incorrect amino acid sequence.
- The genetic code is nearly *universal*. Almost all organisms have the same genetic code. This has important implications for gene technology, since a gene that is taken from one species and inserted into another species will produce the same protein.

9. (a) A codon is a specific sequence of three mRNA nucleotides, the nitrogen bases of which code for an amino acid. The mRNA "reads" the genetic information of the DNA, and transfers that information to ribosomes in the cytoplasm, where a corresponding polypeptide is synthesized.

(b) An anticodon is a specific sequence of three tRNA nucleotides, the nitrogen bases of which complement those on the mRNA. The tRNA carries a specific amino acid to the ribosome and attaches the amino acid to the growing polypeptide chain according to the complementary mRNA codon.

(c) The ribosome is the site of protein synthesis, and moves along the mRNA chain as each codon is read by a tRNA that carries a specific amino acid to the polypeptide chain.

10.

Type of RNA	Functions of RNA in gene expression in eukaryotic cells
mRNA	Messenger RNA "reads" the genetic information on the DNA. mRNA is processed before it moves to the cytoplasm for translation.
rRNA	Ribosomal RNA is in the ribosomes that move along an mRNA chain as each codon of mRNA is "read" by a tRNA anticodon.
tRNA	Transfer RNA picks up and carries a specific amino acid to the mRNA chain on the ribosome, according to the complementary triplet codon/anticodon of nitrogen bases.

11. A physical mutagen damages DNA by changing its physical structure; for example, X-rays may cause the loss of large portions of chromosomes and ultraviolet radiation may cause distortions in the DNA molecule, which can interfere with replication. A chemical mutagen damages DNA by reacting chemically with the DNA molecule; for example, cancer-causing chemicals cause changes to nucleotide sequences and these incorrect sequences are incorporated into replicated DNA.

12. A restriction endonuclease is an enzyme that "recognizes" a short sequence of DNA nucleotides (called the target sequence) on a strand of DNA. The restriction endonuclease cuts the strand at a particular point within the nucleotide sequence, known as a restriction site. Two characteristics of restriction endonucleases that make them useful to genetic researchers are specificity and staggered cuts. Specificity refers to the cuts made by an endonuclease in the target sequence of DNA, and the resulting nucleotides are specific and predictable. 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 a complementary sequence.

13. No, endonucleases would cut DNA segments, but without the DNA ligase enzyme, the sticky ends of the DNA would not be spliced together to form a stable recombinant DNA molecule.

14. (a) One sheep was the egg cell donor, from which the nuclei of several egg cells were removed and discarded. Another sheep was an udder cell donor, from which the nuclei from several cells were removed and transplanted into the enucleated egg cells. These new egg cells with the udder cell nuclei were electrically stimulated to undergo cell division, and then the resulting embryonic mass of cells was inserted into the uterus of a surrogate mother sheep.

(b) Dolly's clone was the sheep who donated the udder cell nuclei since these nuclei contain the genetic information.

15. (a) An ultrasound image may show physical abnormalities of the fetus.

(b) A fetoscopy uses a miniature camera inserted into the uterus to show more external detail of the fetus than an ultrasound image.

(c) Chorionic villi sampling removes a sample of fluid and cells from the chorionic villi (part of the fetal placenta, which can be tested for various genetic disorders). A karyotype of the chromosomes is prepared to determine larger chromosomal abnormalities.

(d) Amniocentesis removes a sample of amniotic fluid and fetal cells that are cultured and tested for various genetic disorders. A karyotype of the chromosomes is

prepared to determine larger chromosomal abnormalities.

Answers to Applying Concepts Questions

16. It is likely that the virus has RNA, because uracil that is found in RNA is present, and thymine that is found in DNA is absent.

17. (a) Translation is occurring as the ribosomes are reading the mRNA, and the tRNAs are assembling amino acids to the growing polypeptide chain.

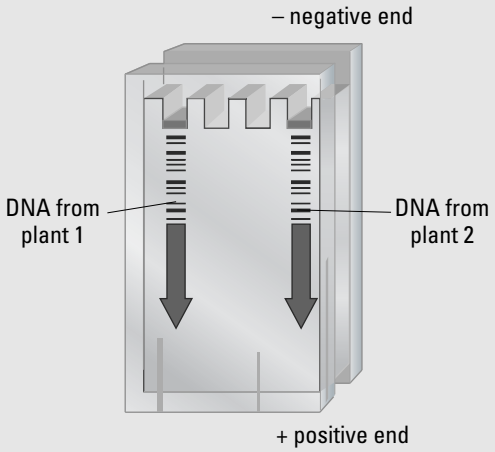
(b) These processes are occurring in a prokaryotic cell because ribosomes and DNA are not found together in the cytoplasm of eukaryotic cells. Instead, DNA remains in the nucleus.

18. (a) If the gene for stoat coat colour could be isolated with endonuclease, the DNA could be inserted into a dog egg cell, which could then be artificially fertilized and implanted into the uterus of a dog. If the coat colour gene was coded for, the offspring may show stoat coat colour.

(b) Consideration should be given to the biological characteristics of the transgenic product, compared with the characteristics of the natural variety. Will the dog be healthy and able to breed? Will the dog have adverse behavioural characteristics and how will these be controlled?

19. (a) Restriction enzymes are added to a sample of DNA from each plant. The enzymes cut the DNA into fragments. Small amounts of the DNA sample are placed into gel electrophoresis wells. An electric charge is attached to the gel, and the DNA segments migrate in the gel according to their lengths. The resulting DNA "fingerprints" are analyzed to determine if segments from the two plants match, indicating whether the plants would be clones (genetically identical).

(b) A diagram similar to that shown below would indicate identical DNA segments for each of the two plants.



20. A DNA probe with a nucleic acid sequence CCGTAATAGGC that is complementary to the gene sequence GGCATTATCCG, which is associated with stunted growth, 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 for stunted growth in mice, the probe will bind to the marker sequence, indicating the presence of the gene.

Answers to Making Connections Questions

21. (a) There is no set relationship between the complexity of an organism (number of genes in an organism) and the total size of its genome. An organism may have an enormous number of base pairs in its genome and very few genes if the bulk of its genome consists of non-coding "junk" DNA.

(b) Comparing the genomes of the two organisms would show what genes they have in common, and would indicate their evolutionary relationship—how closely or distantly related they are.

22. The different tissues all develop from the same fertilized egg cell (zygote). While the tissues have the same genes, only those genes necessary for a specific tissue's functions are active.

23. There are some similarities; however, DNA "words" are limited to sequences of amino acids. Each section of code has only "one meaning"—resulting in one specific protein. This does not compare to the arrangement of letters in a language, which results in words that can have a great variety of meanings.

24. Students' answers will depend on their point of view. In support of human cloning, a response might be that cloning can contribute to further understanding of the complexities of gene expression in humans. Against human cloning, a response might be that cloned offspring have a high mortality rate, and also have a high incidence of disease. Many clones show signs of metabolic disorders, such as premature aging.

25. Studying viral genetics could lead to an understanding and treatment of viral diseases in humans that would benefit all society. There may be a greater benefit to society from knowing how to treat viral diseases than from understanding human genetics. The moral and ethical issues that are associated with the study of human genetics are not an issue when studying viral genomes.

26. Eating preserved foods containing nitrites should be done in moderation to limit the exposure to these mutagens. The amount of nitrite preservative added to processed foods is regulated to minimize the exposure from eating any one food product. The risk of exposure to nitrites may be less than that resulting from bacterial toxins in foods that spoil because the nitrite preservatives are absent.

27. (a) The potential advantages of this transgenic fish are that more salmon are produced in a shorter time and a high protein food is produced more quickly.

(b) The potential risks associated with this fish are: The transgenic salmon require more nutrients in a short growth cycle. Transgenic salmon that are grown in crowded conditions have a greater risk of contracting and spreading disease to other fish—both the transgenic and the wild stocks. Transgenic salmon that escape from the holding pens may breed with wild salmon and adversely affect wild salmon stocks.

(c) Commercial fish-farming operations should have measures in place that prevent diseases from being transmitted to other fish. Commercially grown fish should be contained to prevent escape and breeding with wild fish.

28. Ethical dilemmas that arise from our ability to detect genetic disorders before birth include: terminating pregnancy (therapeutic abortion) to prevent the birth of a child with a serious genetic disorder; the risks to the child and mother of treating a fetus in the uterus; determining who should bear the financial burden of expensive treatments; and does society have a responsibility to inform and counsel parents who are at risk of producing a child with a genetic disorder in future pregnancies?

Ethical dilemmas that arise from our ability to detect genetic disorders after birth include: the possible emotional and financial burdens to family and society of raising a child with a genetic disorder; and does society have an obligation to inform parents of the probability of producing a child with the same genetic disorder? If there is a high probability of a genetic disorder in a future child, what responsibility do society, the immediate family, and the parents have in deciding whether a future pregnancy should occur?