PEARSON NEW INTERNATIONAL EDITION

Study Guide for Campbell Biology: Concepts & Connections

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Seventh Edition

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13. Which of the following is a known or likely carcinogen?
    a. ultraviolet light
    b. chemicals in cigarette smoke
    c. alcohol
    d. X-rays
    e. all of the above
14. Which of the following is the first thing that happens when a signal molecule acts on a target cell?
    a. A transcription factor acts on the DNA.
    b. The signal molecule binds to the DNA.
    c. A new protein is made in the target cell.
    d. A specific gene is transcribed.
    e. The signal molecule binds to a receptor.
15. Researchers want to test whether a particular combination of 56 suspected genes are active in cancer cells. They might find out by using
    a. reverse transcriptase.
    b. a signal transduction pathway.
    c. a DNA microarray.
    d. therapeutic cloning.
    e. nuclear transplantation.

Essay

1. In the proper growth medium, a single cell from a Boston fern can be stimulated to grow into an entire plant. (This is how nurseries propagate many houseplants.) What does this signify with regard to cellular differentiation in plants?
2. What are introns and exons? Discuss three possible biological functions of introns.
3. What is a homeotic gene? Why does a mutation in a homeotic gene have a much more drastic effect on the organism than a mutation in other genes?
4. Briefly explain how genes control development of the head-to-tail axis of a fruit-fly embryo.
5. Describe the changes in a cell that can make the cell become cancerous.
6. What is the difference between reproductive and therapeutic cloning?
7. Compare the relative advantages and disadvantages of using embryonic stem cells versus adult stem cells for therapeutic cloning.
8. If a person wishes to avoid cancer, what factors in the environment should he or she try to avoid? What dietary and health habits would you recommend?

Apply the Concepts

Multiple Choice

1. When a certain bacterium encounters the antibiotic tetracycline, the antibiotic molecule enters the cell and attaches to a repressor protein. This keeps the repressor from binding to the bacterial chromosome, allowing a set of genes to be transcribed. These genes code for enzymes that break down the antibiotic. This set of genes is best described as
    a. an exon.
    b. a signal transduction pathway.
    c. an operon.
    d. a homeotic gene.
    e. a nucleosome.
2. A genetic defect in humans results in the absence of sweat glands in the skin. Some men have this defect all over their bodies, but in women it is usually expressed in a peculiar way. A woman with the defect typically has small patches of skin with sweat glands and other patches where sweat glands are lacking. This pattern suggests the phenotypic effect of
    a. a mutation.
    b. chromosome inactivation.
    c. RNA splicing.
    d. an operon.
    e. miRNAs.
3. A bacterium either makes the amino acid glycine or absorbs it from its surroundings. A biochemist found that glycine binds to a repressor protein and causes the repressor to bind to the bacterial chromosome, "turning off" an operon. If this is like other operons, the genes of this operon probably code for enzymes that
    a. control bacterial cell division.
    b. break down glycine.
    c. produce glycine.
    d. cause the bacterium to differentiate.
    e. manufacture the repressor protein.
4. In humans, the hormone testosterone enters cells and binds to specific proteins, which in turn bind to specific sites on the cells' DNA. These proteins probably act to
    a. help RNA polymerase transcribe certain genes.
    b. alter the pattern of DNA splicing.
    c. stimulate protein synthesis.
    d. unwind the DNA so that its genes can be transcribed.
    e. cause mutations in the DNA.

5. It is possible for a cell to make proteins that last for months; hemoglobin in red blood cells is a good example. However, many proteins are not this long-lasting. They may be degraded in days or even hours. Why do you think cells make proteins with such short lifetimes if it is possible to make them last longer?
   a. Most proteins are used only once.
   b. Most cells in the body live only a few days.
   c. Cells lack the raw materials to make most of the proteins they need.
   d. Only cancer cells, which can keep dividing, contain long-lasting proteins.
   e. This enables cells to control the amount of protein present.

6. Dioxin, produced as a by-product of various industrial chemical processes, is suspected of causing cancer and birth defects in animals and humans. It apparently acts by entering cells and binding to proteins, altering the pattern of gene expression. The proteins affected by dioxin are probably
   a. enzymes.
   b. DNA polymerases.
   c. transcription factors.
   d. enhancers.
   e. nucleosomes.

7. Researchers studying medical records in a Swedish village found that a famine at a critical time in the lives of grandparents affected the life expectancy of their grandchildren. This appears to be an instance of
   a. differentiation.
   b. epigenetic inheritance.
   c. alternative RNA splicing.
   d. regeneration.
   e. X chromosome inactivation.

8. Which of the following would be most likely to lead to cancer?
   a. multiplication of a proto-oncogene and inactivation of a tumor-suppressor gene
   b. hyperactivity of a proto-oncogene and activation of a tumor-suppressor gene
   c. inactivation of a proto-oncogene and multiplication of a tumor-suppressor gene
   d. inactivation of both a proto-oncogene and a tumor-suppressor gene
   e. hyperactivity of both a proto-oncogene and a tumor-suppressor gene

9. A cell biologist found that two different proteins with largely different structures were translated from two different mRNAs. These mRNAs, however, were transcribed from the same gene in the cell nucleus. What mechanism that follows could best account for this?
   a. Different systems of DNA unpacking could result in two different mRNAs.
   b. A mutation might have altered the gene.
   c. Exons from the same gene could be spliced in different ways to make different mRNAs.
   d. The two mRNAs could be transcribed from different chromosomes.
   e. Different chemicals activated different operons.

10. Researchers have found homeotic genes in humans, but they are not yet certain how these genes shape the human phenotype. Considering the functions of homeotic genes in other animals, which of the following is most likely to be their function in humans?
    a. determining skin and hair color
    b. regulating cellular metabolic rate
    c. determining head and tail, back and front
    d. determining whether an individual is male or female
    e. regulating the rate and timing of cell division

11. Look at the signal transduction pathway in Figure 18A. Which of the following changes might cause a speed-up in cell division? A mutation that
    a. alters the middle relay protein so that it does not respond to the first relay protein.
    b. alters the receptor protein so that it overreacts to growth factor.
    c. alters the receptor protein so that growth factor does not fit.
    d. alters the transcription factor so that it does not attach to the DNA.
    e. alters growth factor molecules so they do not fit the receptor.

12. A researcher has modified a virus so that it can "infect" cells with a known nucleic acid sequence that turns off expression of a selected gene. It appears that this technique exploits the phenomenon of
    a. tumor suppression.
    b. RNA interference.
    c. epigenetic inheritance.
    d. DNA methylation.
    e. signal transduction.

Essay

1. Mutations sometimes affect operons. Imagine a mutation in the regulatory gene that produces the repressor of the *lac* operon in E. coli. The altered repressor is no longer able to bind to the operator. What effect will this have on the bacterium?
2. Describe how three different types of cells in your body are specialized for different functions. How do their differences reflect differences in gene expression? Suggest a gene that might be active in each of the cells but none of the others. Suggest a gene that might be active in all the cells. Suggest a gene that is probably not active in any of the cells.
3. A biochemist was studying a membrane-transport protein consisting of 258 amino acids. She found that the gene coding for the transport protein consisted of 3,561 nucleotides. The mRNA molecule from which the transport protein was transcribed contained 1,455 nucleotides. What is the minimum number of nucleotides needed to code for the protein? How can the protein be transcribed from an mRNA that is larger than necessary? How can this mRNA be made from a gene that is so much larger?
4. Explain how, in a eukaryotic cell, a gene on one chromosome might affect the expression of a gene on a different chromosome. How might a gene in a certain cell affect expression of a gene in a different cell?
5. A certain kind of leukemia can be caused by a virus, a chemical, or radiation. Explain how these different factors can all trigger identical forms of cancer in the same kind of tissue.
6. Researchers have suggested that it might be possible to clone an extinct woolly mammoth (an ice age elephant) from a tissue sample obtained from a mammoth frozen in a glacier. Describe how this might be done.

Put Words to Work

Correctly use as many of the following words as possible when reading, talking, and writing about biology:

activator, adult stem cell, alternative RNA splicing, Barr body, cancer, carcinogen, clone, differentiation, DNA packing, DNA microarray, mutagen, embryonic stem cell (ES cell), enhancer, epigenetic inheritance, exon, gene expression, gene regulation, histone, homeotic gene, intron, methylation, microRNA (MiRNA) nuclear transplantation, nucleosome, oncogene, operator, operon, promoter, proto-oncogene, regeneration, regulatory gene, relay protein, repressor, reproductive cloning, RNA interference (RNAi), signal transduction pathway, silencer, therapeutic cloning, transcription factor, tumor-suppressor gene, X chromosome inactivation

Use the Web

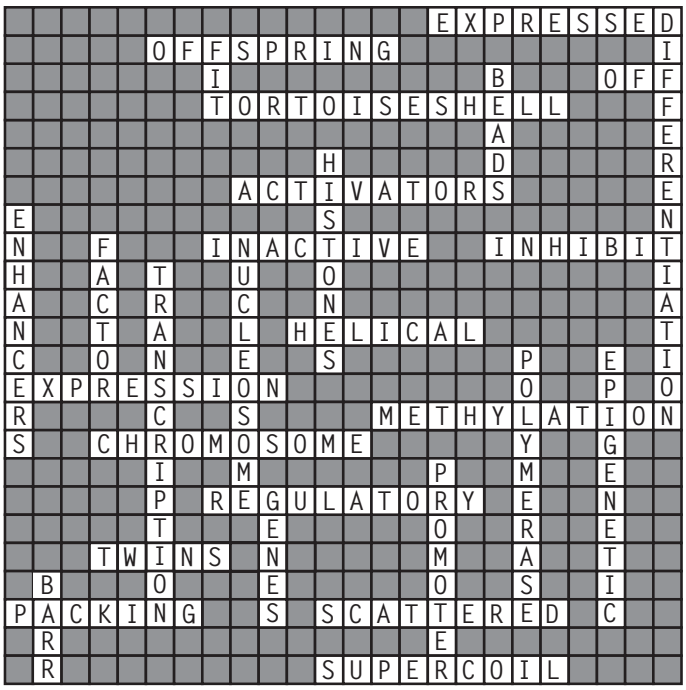
For further review of gene control, be sure to access the exercises and questions at www.masteringbiology.com.

Answers

Review the Concepts

Exercise 1: *lac* operon: 1. E 2. G 3. A 4. B 5. F 6. C 7. H 8. D; *trp* operon: 1. E 2. A 3. G 4. B 5. F 6. C 7. H 8. D

Exercise 2:



Exercise 3: 1. E 2. F 3. D 4. H 5. B 6. C 7. A 8. G

Exercise 4: 1. DNA unpacking and changes 2. transcription 3. addition of cap and tail 4. splicing 5. flow through nuclear envelope 6. mRNA breakdown 7. translation 8. cleavage/ modification/ activation 9. protein breakdown

Exercise 5: 1. head 2. tail 3. genes 4. receptor 5. transcription 6. translated 7. activates 8. mRNA 9. head 10. tail 11. mitoses (cell divisions) 12. proteins 13. segments 14. genes 15. homeotic 16. antennae 17. wings 18. mutant 19. microarray 20. single 21. reverse 22. cDNAs 23. complementary 24. transcribed 25. leukemia

Exercise 6: 1. H, R 2. D,W 3. B,S 4. E,V 5. C,Q 6. A,U 7. F,P 8. G,T

Exercise 7: 1. F 2. A 3. J 4. D 5. G 6. C 7. E 8. I 9. H (or J) 10. B

Exercise 8: 1. control 2. division 3. mutations 4. stimulate 5. inhibit 6. carcinogens 7. mutagens 8. oncogenes 9. proto-oncogenes 10. growth 11. division 12. mutation 13. excess 14. tumor-suppressor 15. repair 16. one 17. several 18. age 19. signal 20. protein 21. growth 22. cell division 23. absence 24. transcription 25. increased 26. exams 27. smoking 28. sun 29. high 30. fat

Exercise 9: 1. C 2. F 3. D 4. B 5. C 6. C 7. G 8. A 9. E 10. D

Test Your Knowledge

Multiple Choice: 1. d 2. a 3. c 4. a 5. e 6. e 7. d 8. a 9. b 10. e 11. e 12. b 13. e 14. e 15. c

Essay: 1. Differentiated fern cells can be made to dedifferentiate and regrow the entire organism. Every plant cell contains the entire genome, and differentiation apparently does not irreversibly change the DNA.

2. Most genes in plants and animals consist of regions that code for polypeptides, called exons, interrupted by long noncoding segments, called introns. Both introns and exons are transcribed from DNA into RNA, then the introns are removed and the remaining exons linked together—a process called RNA splicing. Introns may contain nucleotide sequences that regulate gene activity. The splicing process may help control flow of mRNA from nucleus to cytoplasm. In some cases splicing can occur in more than one way, producing different mRNA molecules from the same transcript.

3. A homeotic gene is a master control gene that functions during development. It regulates a battery of other genes, switching them on or off and thus shaping large-scale aspects of body plan such as development of appendages.

4. A gene in the egg cell codes for a protein that signals surrounding follicle cells. The protein binds to the membrane of a follicle cell and through a series of relay proteins activates transcription factors in the target cell. This triggers transcription and translation of specific genes into proteins. These follicle cell proteins in turn act on the egg cell, causing it to

localize a kind of mRNA at the end of the egg that will later become the head. After fertilization, the "head" mRNA is translated into a regulatory protein that acts on other genes, which trigger the pattern of gene expression that divides the embryo into segments from head to tail.

5. Cancer cells escape from normal controls that regulate division and growth, and multiply excessively. This is usually triggered by several mutations. A proto-oncogene is a gene that normally makes a protein that helps trigger cell division. A mutation can change this gene into an oncogene that codes for a hyperactive protein or an excess of protein, stimulating cell division more than normal. A second kind of mutation occurs in a tumor-suppressor gene. This mutation keeps a protein that normally blocks cell division from being made. The combined effect of these mutations is the uncontrolled cell division characteristic of cancer.

6. Animal cloning is achieved by replacing the nucleus of an egg or zygote with the nucleus of a somatic cell. The cell formed then divides repeatedly, forming a ball of cells called a blastocyst. In the right environment (i.e., the uterus of a surrogate mother), this blastocyst may grow into a new individual, genetically identical to the nuclear donor. This is called reproductive cloning. Alternatively, embryonic stem cells can be harvested from the blastocyst. These cells can be grown indefinitely in the laboratory, and they have the potential for differentiating into virtually any kind of somatic cell. Such embryonic stem cells may be used to repair or replace injured or diseased organs—a procedure called therapeutic cloning.

7. Embryonic stem cells are capable of developing into a wider variety of cell types than adult stem cells, but there are ethical concerns about obtaining cells from embryos. Adult stem cells are easier to obtain, but their developmental potential is limited to fewer cell types.

8. To avoid cancer a person should avoid carcinogens—UV radiation, unnecessary X rays, tobacco, alcohol, and so on. A high-fiber, low-fat diet, with foods high in vitamin C, vitamin E, substances related to vitamin A, and other plant substances also reduces the risk of cancer.

Apply the Concepts

Multiple Choice: 1. c 2. b 3. c 4. a 5. e 6. c 7. b 8. a 9. c 10. c 11. b 12. b

Essay: 1. Normally, when lactose is absent, the repressor binds to the operator site, blocking gene transcription, and no enzymes for using lactose are made. When lactose is present, it binds to the repressor and changes the shape of the repressor in such a way that it can no longer bind to the operator. Genes are then transcribed and enzymes for using lactose are made. If the mutation altered the repressor in such a way that it could no longer bind to the operator, the genes would be transcribed and enzymes for using lactose would be made all the time, whether or not lactose was present.

2. Many answers are possible, but the following is an example: Liver cells are small and metabolically active, making and breaking down many substances. They also make fibrinogen, a blood-clotting protein. Muscle cells are long and thin and have the ability to contract or shorten. Salivary gland cells form saclike clusters and secrete saliva. Genes for making fibrinogen would be active in liver cells but not in the other cells. The genes for building contractile proteins would be active in muscle cells, and the gene for making amylase, a digestive enzyme, would be active in salivary gland cells. All the cells perform glycolysis, the first process in breaking down sugar, so genes that code for glycolysis enzymes would be active in all the cells. The gene that codes for the blood protein hemoglobin would not be active in any of the cells.

3. The minimum number of nucleotides needed to code for the protein is $258 \times 3 = 774$ (or 777, if you wish to include the 3 nucleotides of the stop codon). There are numerous nucleotides upstream from the AUG start codon and downstream from the stop codon. Only the 777 nucleotides from start to stop actually code for the protein. The mRNA is much shorter than the gene because noncoding introns in the gene are cut out, and the remaining exons are joined together to form the final mRNA in the RNA splicing process that occurs in the nucleus.

4. A gene might code for a silencer or activator protein that binds to the DNA of other chromosomes and turns off or enhances transcription of genes at those sites. A gene may code for production of a signal molecule that travels through the bloodstream to a distant site, attaches to a receptor and activates a signal transduction pathway that similarly affects gene transcription.

5. Different carcinogens can cause the same kind of cancer because they all might cause mutations in bone marrow cells that change proto-oncogenes into oncogenes and/or inactivating tumor-suppressor genes. The oncogenes and damaged tumor-suppressor genes, no matter what changes them, have the same effect—to stimulate the uncontrolled cell division characteristic of this kind of cancer.