

Name _____ Period _____

Chapter 20: Biotechnology

The AP Biology exam has reached into this chapter for essay questions on a regular basis over the past 15 years. Student responses show that biotechnology is a difficult topic. This chapter requires a strong conceptual understanding of the technological processes and the underlying biology that guides the procedure. With a little careful work, this chapter will give you insights into the incredible advancements already made and a basis for understanding the new marvels yet to be discovered in biotechnology.

Overview

1. It is important to understand the meaning of the three terms in bold to start this chapter.

recombinant DNA

biotechnology

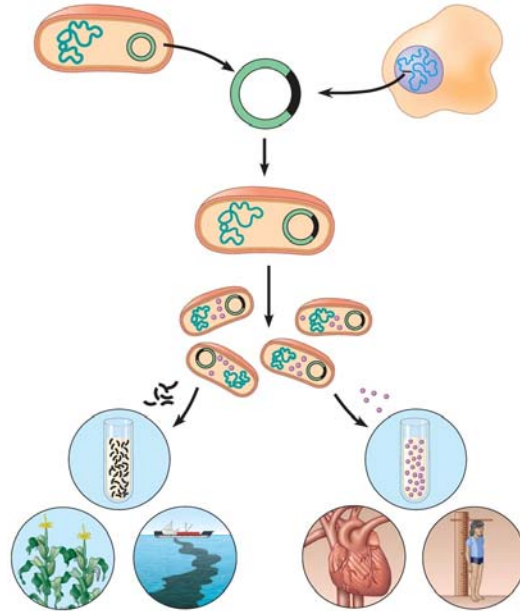
genetic engineering

Concept 20.1 DNA cloning yields multiple copies of a gene or other DNA segment

2. Plasmids are important in biotechnology. Give a full and complete definition of *plasmid*.

3. The production of multiple copies of a single gene is called _____.

4. Using Figure 20.2, label and explain the four steps in this preview of *gene cloning*.



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5. Read the description of *restriction enzymes* on page 398 carefully. Then draw and explain each step of Figure 20.3. When you finish, you should have recreated Figure 20.3 in the space below.

6. What is a *cloning vector*?

7. Figure 20.4 is a more detailed discussion of the gene cloning procedure shown in Figure 20.2. Explain the following key points.
 - a) Explain why the plasmid is engineered with *amp^R* and *lacZ*.

 - b) After transformation has occurred, why are some colonies blue?

 - c) Why are some colonies white? Why is this important?

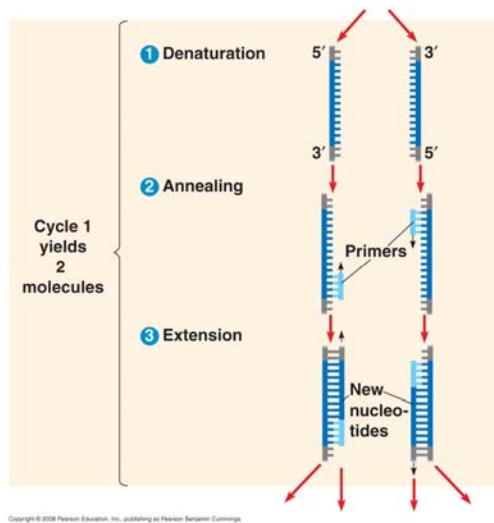
8. The cloning procedure described in question 7 and Figure 20.4 will produce many different fragments of hummingbird DNA. These fragments may be stored in a *genomic library*.
 - a) What is the purpose of a *genomic library*?

 - b) Explain how a *bacterial artificial library (BAC)* and a *cDNA library* are formed.

9. Once the hummingbird DNA is cloned, we have the problem of finding the piece of DNA that holds our gene of interest. Explain how *nucleic acid hybridization* will accomplish this task.

10. Describe how a radioactively labeled *nucleic acid probe* can locate the gene of interest on a multiwell plate. (Use Figure 20.7 to guide your response.)

11. What are two problems with bacterial gene expression systems?
12. The *polymerase chain reaction (PCR)* is a Nobel Prize–winning idea that is used by scientists to amplify DNA, particularly when the quantity of DNA is very small or contaminated. Explain the three initial steps that occur in cycle 1 of PCR.



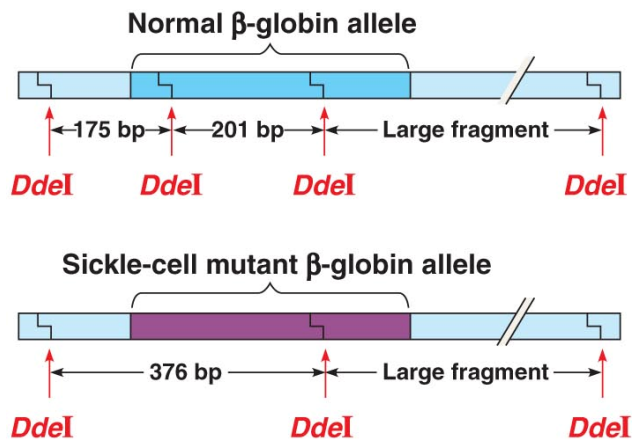
13. How many molecules will be produced by four PCR cycles?

Concept 20.2 DNA technology allows us to study the sequence, expression, and function of a gene

This section begins with a discussion of *gel electrophoresis*, a technique covered in AP Biology Lab 6. It is important to understand the principles of gel electrophoresis.

14. _____ is a technique used to separate nucleic acids or proteins that differ in size or electrical charge.

15. Why is the DNA sample to be separated by gel electrophoresis always loaded at the cathode or negative end of the power source?
16. Explain why shorter DNA molecules travel farther down the gel than larger molecules.
17. To the right of the β -globin alleles, draw a gel showing the different pattern obtained from a normal patient and a sickle-cell patient. For help, examine Figure 20.10.



(a) $DdeI$ restriction sites in normal and sickle-cell alleles of β -globin gene

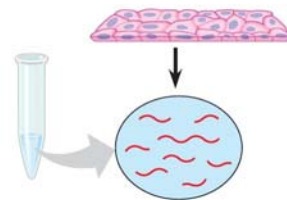
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18. A patient who is a carrier for sickle-cell anemia would have a gel electrophoresis pattern showing four bands. Add this pattern to your gel in number 17 and explain why the gel shows a four-band pattern.

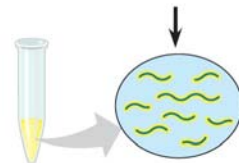
19. What is the purpose of a *Southern blot*?
20. What two techniques discussed earlier in this chapter are used in performing a Southern blot?
21. In working toward the general idea of how DNA sequencing was mechanized, look at Figure 20.12 to answer the following general questions about the *dideoxy chain termination method* for sequencing DNA.
- a) Why does a dideoxynucleotide terminate a growing DNA strand? (You may need to refer to Figure 16.14, as suggested in the text, to answer this question).
 - b) Why are the four nucleotides in DNA each labeled with a different color of fluorescent tag?

Use unlabeled Figure 20.15 to explain the four steps of *DNA microarray assays*.

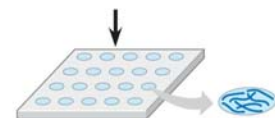
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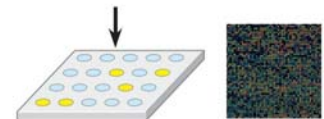
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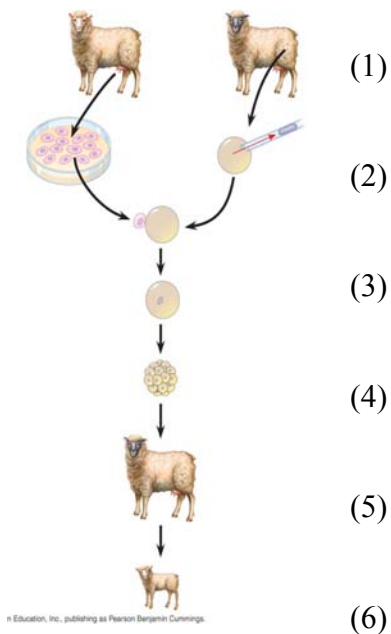
22. Explain how microarrays are used in understanding patterns of gene expression in normal and cancerous tissue.

Concept 20.3 Cloning organisms may lead to production of stem cells for research and other applications

23. What is a *totipotent* cell?

24. How is *nuclear transplantation* performed in animals?

25. Use unlabeled Figure 20.18 to explain the six steps in reproductive cloning for mammals.



26. What are *stem cells*?
27. What is the major difference between *embryonic stem cells (ES)* and *adult stem cells*?
28. How might *induced pluripotent stem cells (iPS)* resolve the debate about using stem cells for medical treatments?

Concept 20.4 The practical applications of DNA technology affect our lives in many ways

29. In question 17, you used two ideas that are featured in the first part of this concept. Explain how *single-nucleotide polymorphisms (SNPs)* and *restriction fragment length polymorphisms (RFLPs)* were demonstrated in analyzing sickle-cell alleles.
30. Explain the idea of *gene therapy*, and discuss the problems with this technique as demonstrated in the treatment of SCID.
31. Explain how *transgenic* “pharm” animals might be able to produce human proteins.

32. Describe how *short tandem repeats* can produce a sensitive *genetic profile*.

33. How does the *Ti plasmid* make genetic engineering in plants a possibility?

34. What are *genetically modified organisms*, and why are they controversial?

Testing Your Knowledge: Self-Quiz Answers

Now you should be ready to test your knowledge. Place your answers here:

1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ 7. _____ 8. _____

9. Use the space below for the drawing.