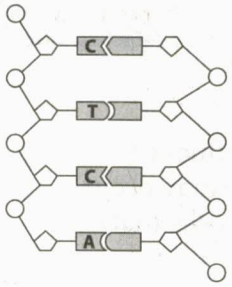
27. Overexposure of animals to X-rays is dangerous because X-rays are known to damage DNA. A direct result of this damage is cells with

(1) unusually thick cell walls
(2) no organelles located in the cytoplasm
(3) abnormally large chloroplasts
(4) changes in chromosome structure

28. The diagram below shows a portion of a DNA molecule. The base sequence of the unlabeled strand shown in the diagram is *most* likely

(1) G-A-G-T
(2) C-U-C-A
(3) T-C-T-G
(4) G-A-G-U



29. The individuality of an organism is determined by the

(1) sequence of bases in DNA
(2) number of amino acids in a cell
(3) position of ribosomes in the cytoplasm
(4) number of bases in the mitochondria

30. In which situation could a mutation be passed on to the offspring of one of the organisms listed in the data table below?

Data Table

Name of Organism	Number of Chromosomes in a Body Cell
Human	46
Fruit fly	8

(1) Ultraviolet radiation causes fruit-fly wing cells to undergo uncontrolled division, resulting in cells with 9 chromosomes.
(2) A cell in the wall of the human uterus undergoes a change, resulting in cells with 47 chromosomes.
(3) A primary sex cell in a human forms a sperm that contains 23 chromosomes.
(4) A cell in the ovary of the fruit fly undergoes a chromosomal change that results in 5 chromosomes per egg cell.

31. A change in the sequence of bases in a DNA molecule is most accurately referred to as

(1) an insertion, deletion, or substitution
(2) a chromosomal replication
(3) carbohydrate molecule synthesis
(4) selective breeding

Genetic Engineering

Genetic engineering is a new technology that humans use to alter the genetic instructions in organisms. The idea of altering organisms to have more desirable traits, however, is not new. In fact, **biotechnology**—the application of technology to biological science—has been producing useful products for thousands of years. Cheese and bread are just two examples of "biotech" products made with the use of microbes.

Throughout recorded history, humans have also used **selective breeding**—a process that produces domestic animals and new varieties of plants with traits that are particularly desirable. Many meat products, for example, come from animals that have been bred to contain less fat. In addition, many of the fruits and vegetables we consume have been selectively bred to be larger, sweeter, hardier, or even juicier.

To breed a better plant, farmers might select a bean plant that produces many pods and then crossbreed it with a bean plant that resists fungus infections. The farmers would expect to get seeds that would grow into bean plants with both features.

Gene Manipulation

In recent years, plants and animals have been genetically engineered by manipulating their DNA instructions. The result of this genetic

manipulation is new characteristics and new varieties of organisms. Consequently, we have been able to produce plants with many beneficial traits. In one instance, plants can now contain genes with the instructions for making chemicals that kill the insects that feed on them. Scientists have also engineered bacteria that can be used to clean up oil spills or that produce human growth hormone.

The basic method that alters genes in organisms uses special enzymes. These enzymes cut DNA segments in a way that allows the segments to be spliced, or moved and attached, to the DNA of a new organism. Once in the new organism, the transferred genes direct the new organism's cells to make the same protein product as the original organism. For example, when we move a human insulin-producing gene into a bacterial cell, the bacterium—and all its offspring—will produce human insulin. This provides a way to produce large quantities of a hormone at low cost. Genes for other human proteins have also been inserted into bacterial cells, as illustrated in Figure 3-9.

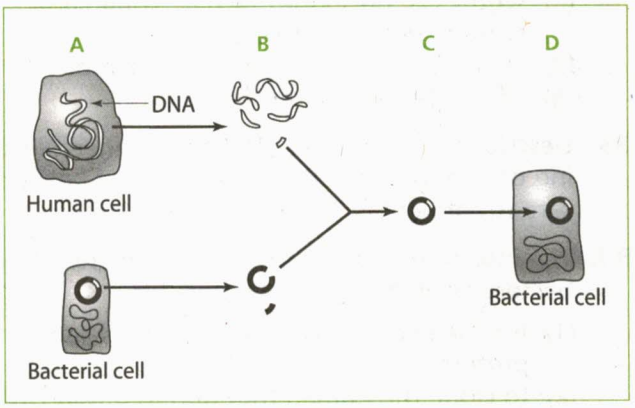


Figure 3-9. Genetic engineering using bacteria: On the left (area A), a special enzyme is used to cut a segment of DNA from a human cell and to also cut open a circular piece of DNA from a bacterial cell. When the piece of human DNA is mixed with the open loop of bacterial DNA (area B), they join to form a closed loop (area C). That loop is then taken up by another bacterial cell (area D). The transformed bacterial cell will produce the protein product of the human DNA segment and that DNA loop will be duplicated and passed to all future offspring.

Other enzymes have been found that can be used to make many copies of segments of DNA. These can be used to increase the amount of DNA available from a tiny sample. This procedure is helpful even when only a drop of blood or saliva is found at a crime scene. By copying and re-copying the DNA in the sample, criminal investigators can produce a sample that is large enough to test. The test results may identify or clear suspects.

Applications of Biotechnology

The health care field has much to gain through our increasing knowledge of genetics and biotechnology. New methods enable us to locate and decode genes that cause diseases. Once we have a better understanding of the gene's specific defect, we may be able to develop ways to treat the disease. In some cases, we may be able to alter the DNA in affected cells and cure the person.

Due to mutations in their genes, people with genetic diseases are sometimes unable to produce certain hormones, enzymes, or other body chemicals. At times, we can extract these chemicals from animals, such as sheep and cattle. These extractions, however, can be expensive, and the chemicals may contain contaminants that cause side effects. If scientists can produce the chemicals using genetically engineered organisms, we may be able to economically provide the missing chemicals in a pure enough form to avoid the side effects associated with chemicals obtained from animal sources.

32. Genetic engineering is used in the biotechnology industry to

(1) eliminate all infections in livestock
(2) synthesize hormones such as insulin and human growth hormone
(3) increase the frequency of fertilization
(4) eliminate asexual reproduction

33. Describe two examples of how an understanding of genetics is making new fields of health care (treatment or diagnosis) possible. [1]

34. The insertion of a human DNA fragment into a bacterial cell might make it possible

(1) for the bacterial cell to produce a human protein
(2) to clone the human that donated that DNA fragment
(3) for humans to become immune to an infection by this type of bacteria
(4) to clone this type of bacteria

35. Assume that a section of double-stranded DNA contains 100 base pairs. If 40 of the pairs contain base C, how many of the pairs would contain base A?

Base your answers to questions 36 through 40 on the passage below and on your knowledge of biology.

Advances with Cells and Genes

Recent advances in cell technology and gene transplanting have allowed scientists to perform some interesting experiments, including splicing human DNA into the chromosomes of bacteria. The altered bacteria express the added genes.

Bacteria reproduce rapidly under certain conditions. This means that bacteria with the gene for human insulin could multiply rapidly, resulting in a huge bacterial population capable of producing large quantities of human insulin.

The traditional source of insulin has been the pancreases of slaughtered animals. Continued use of this insulin can trigger allergic reactions in some humans. The new bacteria-produced insulin is actually human insulin. As a result, it does not produce many side effects.

The bacteria used for these experiments are *E. coli*, which are found in the digestive system of humans and many other animals. Some scientists question these experiments and are concerned that the altered *E. coli* may accidentally get into water supplies.

For each of the statements below, write the number 1 if the statement is true according to the passage, the number 2 if the statement is false according to the passage, or the number 3 if not enough information is given in the passage.

36. Transplanting genetic material into bacteria is a simple task. [1]

37. Under certain conditions, bacteria reproduce at a rapid rate. [1]

38. The continued use of insulin from animals may cause harmful side effects in some people. [1]

39. The bacteria used in these experiments are normally found only in the nerve tissue of humans. [1]

40. Bacteria other than *E. coli* are unable to produce insulin. [1]

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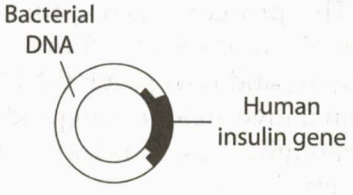
41. A product of genetic engineering technology is represented below.



Which substance was needed to join the insulin gene to the bacterial DNA as shown?

(1) a specific carbohydrate
(2) a specific enzyme
(3) hormones
(4) antibodies

42. Explain the following: An individual has a nutrient deficiency due to a poor diet and is missing a specific amino acid. How would this affect the ability of

- the individual's DNA code to replicate itself? [1]
- the cell to synthesize particular proteins? [1]

43. In recent research, the DNA that codes for a different key enzyme was removed from each of three different species of soil bacteria. A new bacterium, containing DNA for all three key enzymes, could be produced by

(1) selection breeding
(2) screening for mutations
(3) genetic engineering
(4) random alteration