Molecular Biology of the Gene

257 total

10

Exercise 1 (Modules 10.1 – 10.3)

10A *DNA and RNA structure are summarized on the Interactive Study Partner CD-ROM.*

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Review the discovery that DNA is the genetic material and the structures of DNA and RNA. Then match each phrase on the right with the correct term(s) on the left. Note that some answers are used more than once, and some questions have multiple answers.

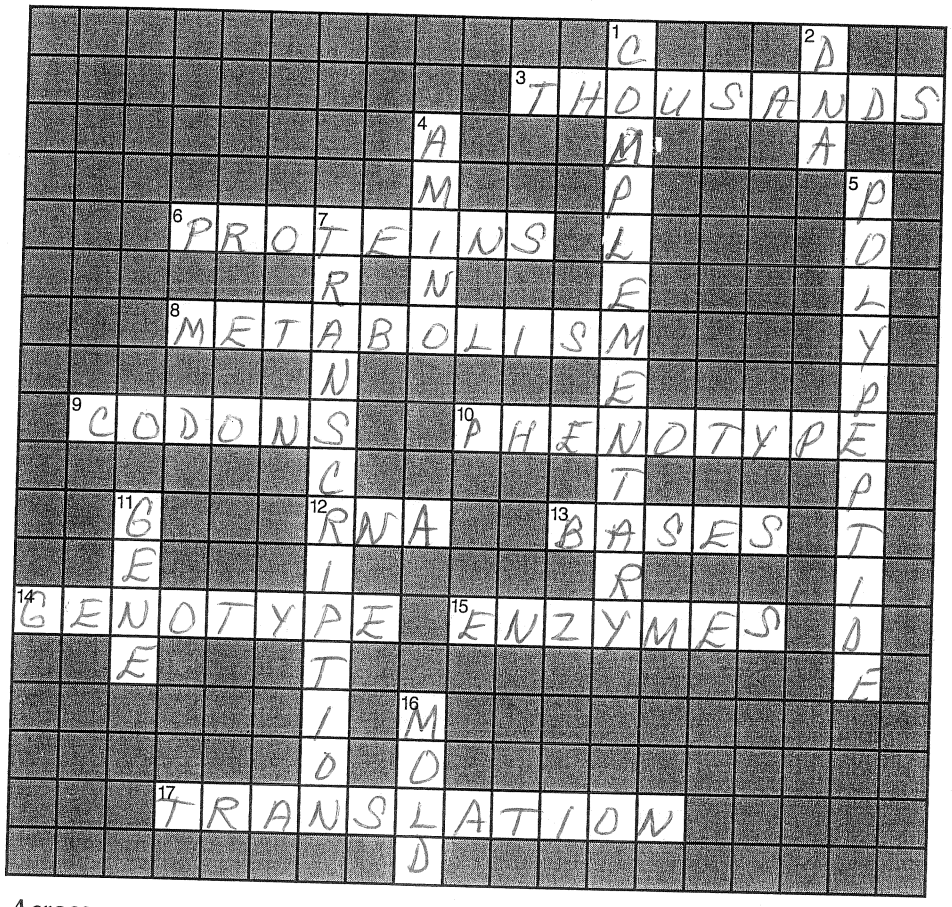
A. Adenine (A)
B. Base
C. Cytosine (C)
D. DNA
E. *E. coli*
F. Double helix
G. Guanine (G)
H. Hydrogen bond
I. Radioactive isotope
J. Covalent bond
K. Bacteriophage
L. Protein
M. Nucleic acid
N. Nucleotide
O. Centrifuge
P. Phosphate
Q. Polynucleotide
R. RNA
S. Sugar
T. Thymine (T)
U. Uracil (U)

N 1. The basic chemical unit of a nucleic acid
D 2. The "transforming factor" that alters pneumonia bacteria
D, R 3. The two kinds of nucleic acids
S, P, B 4. The three parts of every nucleotide
B 5. A pair of these forms a "rung" in the DNA ladder
I 6. Used to "label" DNA and protein in experiments
D 7. The component of a bacteriophage that enters the host cell
S, P 8. Two alternating parts that form the nucleic acid "backbone"
A, C, G, T 9. The four bases in DNA
A 10. The DNA base complementary to T
K 11. A virus that attacks bacteria
L 12. The substance a phage leaves outside its host cell
S 13. Ribose in RNA and deoxyribose in DNA
D 14. Watson and Crick deduced the structure of this molecule
A, C, G, U 15. The four bases in RNA
C 16. The DNA base complementary to G
E 17. A bacterium attacked by T2 and T4 phages
B, N 18. The sequence of these encodes DNA information
L 19. Eukaryotic chromosomes consist of this and DNA
F 20. The overall shape of a DNA molecule
J 21. Links adjacent nucleotides in a polynucleotide chain
O 22. Machine used to separate particles of different weights
H 23. Links a complementary pair of bases together
Q, D, R 24. A polymer of nucleotides
U 25. RNA base that is not in DNA

Exercise 5 (Modules 10.6 – 10.7)

10C *See the CD-ROM to review the flow of genetic information from DNA to RNA to protein.*

In a cell, the genotype—genetic information in DNA—is expressed as phenotype in the form of proteins—structural proteins that shape the organism and enzymes that carry out metabolism. Review the relationship between genotype and phenotype by completing this crossword puzzle.



Across

3. A gene consists of hundreds or ____ of nucleotide bases.
6. The information in DNA specifies the synthesis of ____.
8. Garrod noted the gene-protein link in "inborn errors of ____."
9. Genetic instructions are written in 3-base "words" called ____.
10. An organism's expressed traits (what it looks like) make up its ____.
12. To make a protein, DNA information is first transcribed into ____.
13. The DNA language consists of a linear sequence of nucleotide ____.
14. The ____ is an organism's genetic makeup.
15. Phenotype is expressed via structural proteins and ____.
17. Making a polypeptide according to an RNA message is called ____.

Down

1. The base sequence of RNA is ____ to the DNA from which it is transcribed.
2. Genotype is the inheritable information encoded in ____.
4. Each codon in DNA and RNA specifies a certain ____ acid in a polypeptide.
5. Translation is conversion of an RNA message into a ____.
7. Transfer of information from DNA into an RNA molecule is called ____.
11. One ____ specifies how to build one polypeptide.
16. Using bread ____, Beadle and Tatum showed that a gene codes for an enzyme.

Exercise 8 (Modules 10.8 and 10.16)

These modules describe the genetic code, how biologists cracked the code, and how mutations change the meaning of the coded genetic message. Use the genetic code chart (Figure 10.8A in the textbook) to translate the following mRNAs into amino acid sequences and answer the questions.

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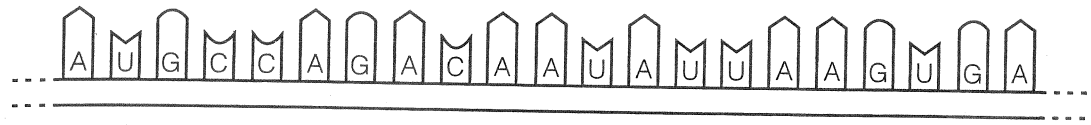
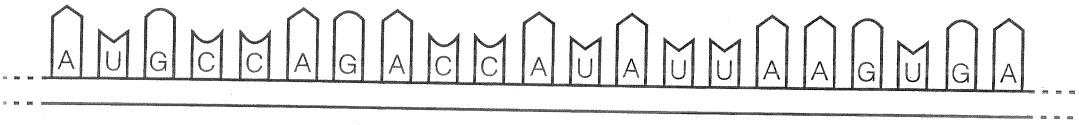
mRNA nucleotide sequence:
(mRNA 1)



1. Amino acid sequence: Met-Pro-Asp-Asn-Ile-Lys

Mutation in mRNA:
mRNA 2)



2. Amino acid sequence: Met-Pro-Asp-His-Ile-Lys
3. Number of bases changed in mRNA: 1
4. Type of mutation: substitution
5. Number of amino acids changed: 1

Mutation in mRNA:
mRNA 3; compare to 1)

6. Amino acid sequence: Met-Pro-Asp-Glu-Tyr
7. Number of bases changed in mRNA (look carefully!): 1 (inserted)
8. Type of mutation: Insertion
9. Number of amino acids changed (compared to mRNA 1): 2 + 1 less a.a.
10. Which mutation had the greatest effect and why? mRNA 3. Frame-shift changed all codons

Exercise 9 (Modules 10.17 – 10.22)

10F–H *See the CD-ROM for animated reviews of the structure and life cycles of viruses.*

These modules describe the structures and life cycles of viruses. Match each phrase on the right with a term from the left. Some answers are used more than once.

A. RNA viruses
B. Prophage
C. AIDS
D. Glycoprotein spikes
E. Virus
F. DNA
G. Lytic cycle
H. Vaccine
I. Nucleus
J. Membranous envelope
K. Bacteriophage
L. Provirus
M. HIV
N. Reverse transcriptase
O. Lysogenic cycle
P. Retrovirus
Q. White blood cell
R. Prophage genes
S. Tobacco mosaic
T. Plasma membrane
U. RNA
V. Cytoplasm
W. Hantavirus
X. Ebola virus

E 1. Consists of nucleic acid packaged in protein
G 2. Leads quickly to breaking open of host cell
B 3. Phage DNA inserted into bacterial chromosome
O 4. When virus "hides" as part of bacterial chromosome
R 5. Responsible for toxins of diphtheria, botulism
S 6. Rod-shaped plant virus
U 7. This or DNA may be virus genetic material
A 8. Cause of flu, colds, polio, mumps, AIDS
J 9. Helps flu or mumps virus enter and leave host cell
D 10. Used by mumps virus or HIV to attach to host receptors
V 11. Mumps virus reproduces here
U 12. Mumps virus makes this and protein from RNA template
T 13. Mumps virus gets envelope from this part of host cell
I 14. Herpesvirus reproduces here
F 15. Genetic material of herpesvirus
L 16. DNA of herpesvirus inserted into host cell DNA
H 17. Can be used to prevent a viral disease
M 18. Virus that causes AIDS
U 19. Genetic material of HIV
P 20. RNA virus that reproduces by means of DNA
N 21. Enzyme that can make DNA from RNA template
L 22. Form in which HIV "hides" in host cell
C 23. Acquired immune deficiency syndrome
Q 24. Kind of cell infected by HIV
X 25. Causes an African sickness
K 26. Viruses like T2 and T4 that infect bacteria
W 27. An RNA virus carried by rodents

Testing Your Knowledge

Multiple Choice

1. In an important experiment, bacteriophages were allowed to infect bacteria. In the first trial, the phages used contained radioactive DNA, and radioactivity was detected in the bacteria. Next, other phages containing radioactive protein were allowed to infect bacteria, and no radioactivity was detected in the bacteria. When the experimenters compared the results of these two trials, they concluded that
   a. genes are made of DNA.
   b. bacteriophages can infect bacteria.
   c. DNA is made of nucleotides.
   d. genes carry information for making proteins.
   e. genes are on chromosomes.

2. An RNA or DNA molecule is a polymer made of subunits called
   a. bases.
   b. amino acids.
   c. nucleotides.
   d. nucleic acids.
   e. pyrimidines.

3. The information carried by a DNA molecule is in
   a. its amino acid sequence.
   b. the sugars and phosphates forming its backbone.
   c. the order of the bases in the molecule.
   d. the total number of nucleotides it contains.
   e. the RNA units that make up the molecule.

4. A gene is
   a. the same thing as a chromosome.
   b. the information for making a polypeptide.
   c. made of RNA.
   d. made by a ribosome.
   e. made of protein.

5. DNA replication occurs
   a. whenever a cell makes protein.
   b. to repair gene damage caused by mutation.
   c. before a cell divides.
   d. whenever a cell needs RNA.
   e. in the cytoplasm of a eukaryotic cell.

6. The flow of information in a cell proceeds
   a. from RNA to DNA to protein.
   b. from protein to RNA to DNA.
   c. from DNA to protein to RNA.
   d. from RNA to protein to DNA.
   e. from DNA to RNA to protein.

7. Which of the following is *not* needed for DNA replication?
   a. ribosomes
   b. DNA
   c. nucleotides
   d. enzymes
   e. All of the above are needed.

8. Which of the following processes occur(s) in the cytoplasm of a eukaryotic cell?
   a. DNA replication
   b. translation
   c. transcription
   d. DNA replication and translation
   e. translation and transcription

9. Beadle and Tatum showed that each kind of mutant bread mold lacked a specific enzyme. This experiment demonstrated that
   a. genes carry information for making proteins.
   b. mutations are changes in genetic information.
   c. genes are made of DNA.
   d. enzymes are required to repair damaged DNA information.
   e. cells need specific enzymes in order to function.

10. During the process of translation (polypeptide synthesis), ____ matches a nucleic acid codon with the proper amino acid.
    a. a ribosome
    b. DNA polymerase
    c. ATP
    d. transfer RNA
    e. messenger RNA

11. How does RNA polymerase "know" where to start transcribing a gene into mRNA?
    a. It starts at one end of the chromosome.
    b. Transfer RNA acts to translate the message to RNA polymerase.
    c. It starts at a certain nucleotide sequence called a promoter.
    d. The ribosome directs it to the correct portion of the DNA molecule.
    e. It looks for the AUG start codon.

12. When RNA is being made, the RNA base ___ always pairs with the base ___ in DNA.
    a. U . . . T
    b. T . . . G
    c. U . . . A
    d. A . . . U
    e. T . . . A

13. A mutagen is
    a. a gene that has been altered by a mutation.
    b. something that causes a mutation.
    c. an organism that has been changed by a mutation.
    d. the portion of a chromosome altered by a mutation.
    e. any change in the nucleotide sequence of DNA.

14. How do retroviruses, such as HIV, differ from other viruses?
    a. They are much simpler than other viruses.
    b. They contain DNA that is used as a template to make RNA.
    c. They can reproduce only inside of living cells.
    d. They contain nucleic acids that code for the making of proteins.
    e. They contain RNA that is used as a template to make DNA.

Applying Your Knowledge

10

Multiple Choice

1. Which of the following are arranged in the correct order by size, from largest to smallest?
    a. chromosome-gene-codon-nucleotide
    b. nucleotide-chromosome-gene-codon
    c. codon-chromosome-gene-nucleotide
    d. gene-chromosome-codon-nucleotide
    e. chromosome-gene-nucleotide-codon

2. A geneticist raised a crop of T2 bacteriophages in a medium containing radioactive phosphorus, so that the DNA of the bacteriophages was labeled with radioactivity. The labeled phages were then allowed to infect nonradioactive bacteria. In a few hours, these bacteria burst open, releasing many bacteriophages. Some of these phages contained labeled
    a. DNA.
    b. RNA.
    c. protein.
    d. all of the above.
    e. DNA and protein only.

3. A messenger RNA molecule for making a protein is made in the nucleus and sent out to a ribosome. The ribosome reads the mRNA message and makes a protein containing 120 amino acids. The mRNA consisted of at least how many codons?
    a. 30
    b. 40
    c. 120
    d. 360
    e. 480

4. The nucleotide sequence of a DNA codon is ACT. A messenger RNA molecule with a complementary codon is transcribed from the DNA. In the process of protein synthesis, a transfer RNA pairs with the mRNA codon. What is the nucleotide sequence of the tRNA anticodon? (Careful—this one is harder than it appears.)
    a. TGA
    b. UGA
    c. ACT
    d. TGU
    e. ACU

5. Imagine an error occurring during DNA replication in a cell, so that where there is supposed to be a T in one of the genes there is instead a G. What effect will this probably have on the cell?
    a. Each of its kinds of proteins will contain an incorrect amino acid.
    b. An amino acid will be missing from each of its kinds of proteins.
    c. One of its kinds of proteins might contain an incorrect amino acid.
    d. An amino acid will be missing from one of its kinds of proteins.
    e. The amino acid sequence of one of its kinds of proteins will be completely changed.

6. A cell is grown in a solution containing radioactive nucleotides, so that its DNA is labeled with radioactivity. It is removed from the radioactive solution and grown in a normal medium, so that any new DNA strands it makes will not be radioactive. In the normal medium, the cell replicates its DNA and divides. The two daughter cells also replicate their DNA and divide, producing a total of four cells. If a dotted line represents a radioactive DNA strand and a solid line represents a nonradioactive DNA strand, which of the following depicts the DNA of the four cells?

    a. 

    b. 

    c. 

    d. 

    e. 

7. A particular ____ carry the information for making a particular polypeptide, but ____ can be used to make any polypeptide.
   a. gene and ribosome . . . a tRNA and an mRNA
   b. gene and mRNA . . . a ribosome and a tRNA
   c. ribosome and mRNA . . . a gene and a tRNA
   d. gene and tRNA . . . a ribosome and an mRNA
   e. tRNA and ribosome . . . a gene and an mRNA

8. A sequence of pictures of polypeptide synthesis shows a ribosome holding two transfer RNAs. One tRNA has a polypeptide chain attached to it; the other tRNA has a single amino acid attached to it. What does the next picture show?
   a. The polypeptide chain moves over and bonds to the single amino acid.
   b. The tRNA with the amino acid leaves the ribosome.
   c. The amino acid moves over and bonds to the polypeptide chain.
   d. The tRNA with the polypeptide chain leaves the ribosome.
   e. A third tRNA with an amino acid joins the pair on the ribosome.

9. A microbiologist analyzed chemicals obtained from an enveloped RNA virus (similar to a mumps virus) that infects monkeys. He found that the virus envelope contained a protein characteristic of monkey cells. Which of the following is the most likely explanation for this?
   a. The virus gets its envelope when it leaves its host cell.
   b. The virus forced the monkey cell to make proteins for its envelope.
   c. The virus has a lysogenic life cycle.
   d. The virus gets its envelope when it enters its host cell.
   e. The virus fools its host cell by mimicking its proteins.

10. At one point as a cell carried out its day-to-day activities, the nucleotides G A T were paired with the nucleotides C U A. This pairing occurred
   a. in a double-stranded DNA molecule.
   b. during translation.
   c. during transcription.
   d. when an RNA codon paired with a tRNA anticodon.
   e. It is impossible to say, given this information.

The Control of Gene Expression

11

Exercise 1 (Module 11.1)

A prokaryote can respond to changes in its environment by turning genes on and off. In bacteria, genes are grouped, with control sequences called operators and promoters, into clusters called operons. The *lac* and *trp* operons are two such gene clusters in the bacterium *E. coli*. Study the diagrams in Module 11.1, and then match each of the components of the *lac* and *trp* operon systems with its function.

lac operon:

E 1. Regulatory gene
G 2. Repressor protein + lactose
A 3. Repressor protein without lactose
B 4. RNA polymerase
F 5. Promoter
C 6. Operator
H 7. Operon genes
D 8. Enzymes

16

A. Keeps RNA polymerase from attaching to promoter and transcribing genes
B. Transcribes genes into RNA for protein synthesis
C. Repressor protein attaches here
D. Use lactose
E. Information for making repressor protein
F. Where RNA polymerase starts transcribing genes
G. Allows RNA polymerase to transcribe genes
H. Information for making enzymes that use lactose

trp operon:

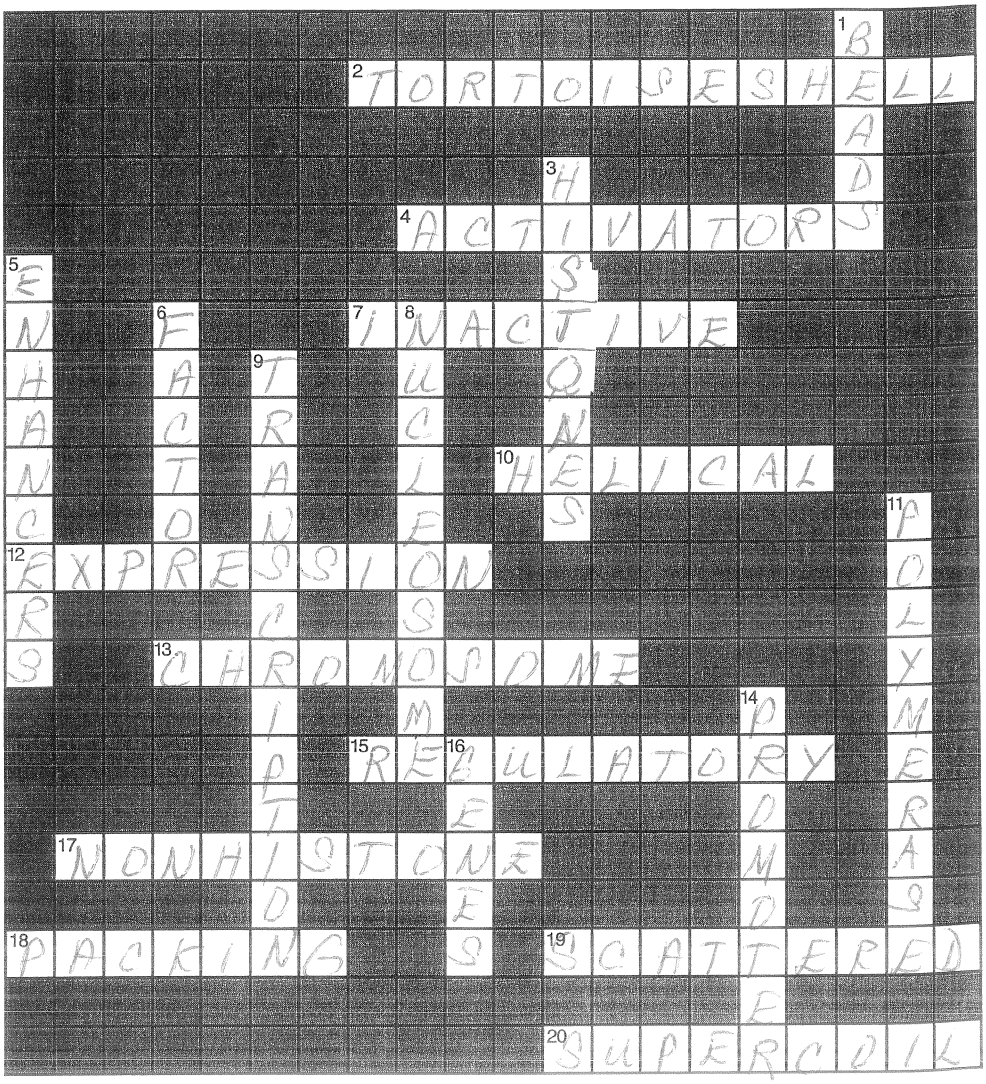
E 1. Regulatory gene
A 2. Repressor protein + tryptophan
G 3. Repressor protein without tryptophan
B 4. RNA polymerase
F 5. Promoter
C 6. Operator
H 7. Operon genes
D 8. Enzymes

A. Keeps RNA polymerase from attaching to promoter and transcribing genes
B. Transcribes genes into RNA for protein synthesis
C. Repressor protein attaches here
D. Make tryptophan
E. Information for making repressor protein
F. Where RNA polymerase starts transcribing genes
G. Allows RNA polymerase to transcribe genes
H. Information for making enzymes that make tryptophan

Exercise 3 (Modules 11.5 – 11.6)

11A *Review control of gene expression in eukaryotes on the Interactive Study Partner CD-ROM.*

Complete this crossword puzzle to review the roles of DNA packing and protein activators in gene expression.



Across

2. The color pattern of a ____ cat reflects the influence of chromosome inactivation.
4. Scientists think most eukaryotic regulatory proteins act as ____.
7. One X chromosome in each of a woman's cells is ____.
10. The DNA-histone beaded fiber is further wrapped into a tight ___ fiber.
12. Nucleosomes may control gene ____ by limiting access to DNA.
13. The DNA supercoil is further wrapped and folded into a ____.
15. In eukaryotes, many ____ proteins interact with DNA and one another to turn genes on and off.
17. ____ chromosomal proteins control how tightly the histones bind the DNA.
18. DNA fits into a cell because of a system of folding, or ____.
19. In eukaryotes, structural and regulatory genes are ____.
20. The twisted DNA further coils into a ____ with a diameter of 200 nm.

Down

1. The DNA-histone complex looks like "____ on a string."
3. DNA is wound around small proteins called ____.
5. The first step in initiating gene transcription is binding of activators to sites called ____.
6. A transcription ____ may be involved in turning on a eukaryotic gene.
8. A ____ is a complex of DNA wrapped around eight histone molecules.
9. DNA packing seems to control gene expression at the ____ stage.
11. Activators trigger RNA ____ to begin transcription.
14. An activator may help position RNA polymerase on a gene's ____.
16. In most eukaryotic cells, most ____ are not expressed.

Exercise 4 (Modules 11.7 – 11.8)

In eukaryotes, gene expression is also regulated after transcription of genes into mRNA and during and after translation of mRNA into protein. Review these processes by matching each of the processes on the right (listed in order of occurrence) with a description on the left.

A. Altering a protein to form an active final product
B. Retaining or breaking down mRNA molecules, controlling the amount to which they are translated
C. Action of inhibitors that may block synthesis of protein from mRNA message
D. Addition of nucleotides to beginning and end of mRNA; may protect mRNA and enhance translation
E. Removal of noncoding introns from mRNA and joining of exons that will be expressed
F. Retaining or breaking down proteins, depending on cell's needs

E 1. RNA splicing
D 2. Addition of cap and tail to RNA
B 3. Selective breakdown of mRNA
C 4. Inhibition of translation
A 5. Activation of finished protein
F 6. Selective breakdown of proteins

Exercise 8 (Module 11.17)

After reading this module, match each of the following human cancers with the carcinogen(s) implicated as its major cause. (Answers may be used more than once or not at all.)

A. Ultraviolet light
B. Testosterone; possibly dietary fat
C. Cigarette smoke
D. Estrogen; possibly dietary fat
E. Alcohol; hepatitis viruses
F. High dietary fat; low dietary fiber
G. X-rays

C 1. Lung
F 2. Colon and rectum
D 3. Breast
B 4. Prostate
C 5. Bladder
C 6. Kidney
C 7. Pancreas
A 8. Melanoma (skin)
E 9. Liver

Testing Your Knowledge

Multiple Choice

1. Your muscle and bone cells are different because
   a. they contain different sets of genes.
   b. they are differentiated.
   c. they contain different operons.
   d. different genes are switched on and off in each.
   e. they contain different histones.

2. Operons enable bacteria to
   a. function in frequently changing environments.
   b. resist attack by predators.
   c. correct mutations that might interfere with their genetic instructions.
   d. differentiate.
   e. mutate and evolve more rapidly.

3. If the nucleus of a frog egg is destroyed and replaced with the nucleus of an intestine cell from a tadpole, the egg can develop into a normal tadpole. This demonstrates that
   a. intestine cells are fully differentiated.
   b. there is little difference between an egg cell and an intestine cell.
   c. an intestine cell possesses a full set of genes.
   d. intestine cells are not differentiated.
   e. frogs can regenerate lost parts.

4. DNA packing—the way DNA is folded into chromosomes—affects gene expression by
   a. controlling access to DNA.
   b. positioning related genes near each other.
   c. protecting DNA from mutations.
   d. enhancing recombination of genes.
   e. allowing "unpacked" genes to be eliminated from the genome.

5. The genes that malfunction in cancer normally
   a. control RNA transcription.
   b. are responsible for organizing DNA packing.
   c. code for enzymes that transcribe DNA.
   d. are not present in most body cells unless inserted by a virus.
   e. regulate cell division.

6. In most eukaryotic cells most genes are not expressed. This suggests that most eukaryotic regulatory proteins act as
   a. exons.
   b. repressors.
   c. introns.
   d. enhancers.
   e. activators.

7. After an mRNA molecule is transcribed from a eukaryotic gene, portions called ____ are removed and the remaining ____ are spliced together to produce an mRNA molecule with a continuous coding sequence.
   a. operators . . . promoters
   b. exons . . . introns
   c. silencers . . . enhancers
   d. introns . . . exons
   e. promoters . . . operators

8. Which of the following mechanisms of gene regulation operates after mRNA transcription but before translation of mRNA into protein?
   a. mRNA splicing
   b. DNA packing
   c. repressors and activators
   d. protein degradation
   e. all of the above

9. Homeobox polypeptide segments
   a. serve as histones, facilitating DNA packing.
   b. bind to DNA and activate or repress gene transcription.
   c. are vastly different in different organisms.
   d. act as enzymes, carrying out important chemical reactions.
   e. carry out mRNA splicing in the cell nucleus.

10. In a eukaryote, a repressor protein may block gene expression by binding to a DNA site called
    a. an operon.
    b. a histone.
    c. an enhancer.
    d. a promoter.
    e. a silencer.

11. Gene expression in animal development seems to be regulated largely by
    a. controlling gene packing and unpacking.
    b. controlling the transcription of genes into mRNAs.
    c. controlling the translation of mRNAs into protein.
    d. selectively eliminating certain genes from the genome.
    e. selectively breaking down certain proteins so they cannot function.

12. Which of the following is a known or likely carcinogen?
    a. ultraviolet light
    b. cigarette smoke
    c. hormones
    d. X-rays
    e. all of the above

13. 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.

Applying Your Knowledge

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. regulatory genes.
   c. an operon.
   d. a homeobox.
   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. the homeobox.

3. A bacterium 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 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. 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

8. 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 below 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 chromosome puffs.
   e. Different chemicals activated different operons.

9. 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

DNA Technology and the Human Genome 12

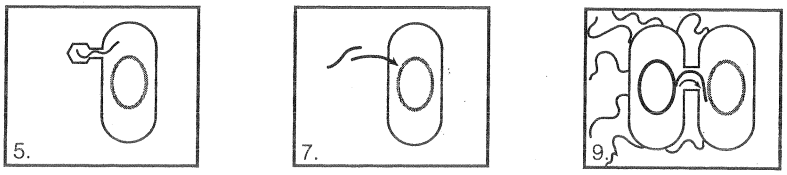
Exercise 1 (Modules 12.1 – 12.2)

Bacteria can transfer DNA via conjugation, transformation, and transduction. Match the following statements with one of the methods of bacterial DNA transfer. (Some statements are true of all methods of DNA transfer.)

A. Conjugation
B. Transformation
C. Transduction
D. All three of the above

13

B 1. What happened in Griffith's experiment with pneumonia bacteria
D 2. DNA may be integrated into chromosome of recipient
B 3. Taking up of DNA from the fluid surrounding a cell
D 4. Alters genetic makeup of recipient cell
C 5. Figure 5 below
A 6. Male and female cells joined by sex pili
B 7. Figure 7 below
A 8. Bacterial "mating"
A 9. Figure 9 below
D 10. Creates a recombinant cell
C 11. Transfer of genes by a bacteriophage
A 12. May involve transfer of genes by a plasmid
A 13. Usually controlled by a piece of DNA called an F factor



Exercise 4 (Modules 12.10 – 12.12)

15

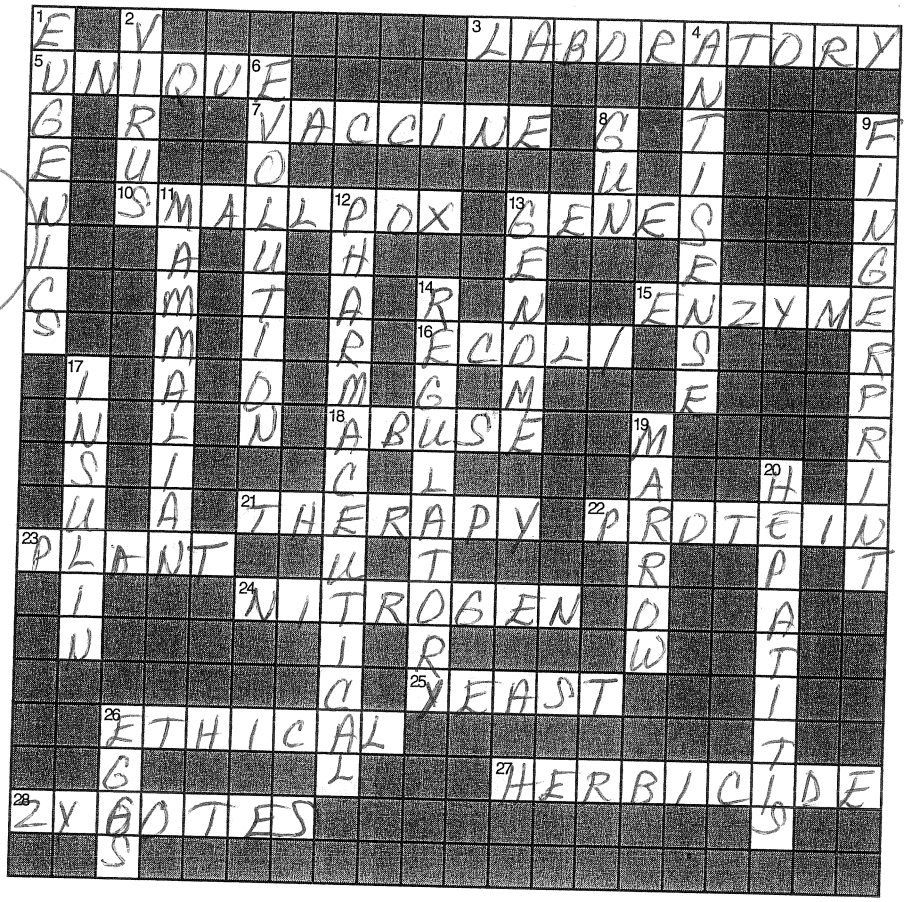
Powerful molecular biology techniques now allow us to amplify, analyze, and compare genes. Review these methods by matching each phrase on the right with a term on the left.

A. RFLP analysis
B. carrier
C. gel
D. recognition sequence
E. positive pole
F. restriction fragment
G. DNA polymerase
H. RFLP
I. Southern blotting
J. white blood cell
K. band
L. restriction enzyme
M. genetic marker
N. gel electrophoresis
O. polymerase chain reaction (PCR)

I 1. Transferring DNA to paper: named for its discoverer
L 2. Used to cut up DNA for analysis
F 3. Piece of DNA cut up by restriction enzymes
D 4. Place where enzyme cleaves DNA
H 5. Restriction fragment length polymorphism
J 6. Type of cell often used in RFLP analysis
N 7. Separates DNA fragments by size and electrical charge
C 8. Restriction fragments move through this
E 9. Restriction fragments are attracted to this
K 10. Where specific restriction fragment collects in gel
M 11. Chromosomal "landmark" that can be studied
A 12. Comparing restriction fragment patterns
O 13. Method for making many copies of a DNA molecule
G 14. Used to replicate DNA in a test tube for PCR method
B 15. Heterozygote who might possess a harmful allele

Exercise 8 (Modules 12.16 – 12.22)

DNA technology promises great benefits, but is also presents some risks and raises ethical questions. Review some of the tools, uses, and dilemmas of DNA technology by completing this crossword puzzle.



Across

3. Microorganisms used in recombinant DNA experiments are genetically crippled so they cannot live outside the____ .
5. Except in the case of identical twins, the DNA sequence of every individual is ____ .
7. A ____ is a harmless variant or derivative of a harmful bacterium or virus, used to prevent disease.
10. A harmless variant of the____ virus might be able to confer immunity to several diseases at once.
13. There is some concern that transgenic plants may pass their new ____ to wild relatives.
15. In a test of gene therapy, researchers are attempting to correct an immune deficiency caused by lack of an ____ called ADA.
16. Many proteins important in medicine and agriculture are produced in the bacterium ____ .
18. ____of genetic information might take the form of genetic discrimination or invasion of privacy.
21. Gene ____ is alteration of human genes to remedy a genetic disease.
22. Bacteria often are the best organisms to engineer for production of a ____ product.
23. A plasmid from a soil bacterium is used to get genes into ____ cells.
24. Plant researchers are trying to engineer plants that can fix ____.
25. A ____ is often better than a bacterium at producing eukaryotic proteins.
26. There are difficult ____ questions relating to modification of the human genome.
27. A number of transgenic plants have been engineered with genes for ____ resistance.
28. It is easier to modify genes in human germ cells or ____ than in somatic cells.

Down

1. Our society rejects the notion of ____—controlling the genetic makeup of human populations.
2. A ____ can be used as a vector to carry genes for gene therapy.
4. ____ nucleic acid prevents translation of mRNA coding for disease-causing proteins.
6. We might be able to eliminate genetic defects in children and their decendants, but some people wonder whether we should interfere with ____ in this way.
8. A gene ____ can fire pieces of DNA into cells.
9. A DNA ____ is a pattern of bands used to link an individual with evidence.
11. Only ____ cells can correctly manufacture glycoproteins.
12. DNA technology has been used to create many useful ____ products.
13. Results of the Human ____ Project are revolutionizing medicine.
14. Biotechnology is scrutinized for possible risks by government ____ agencies such as the EPA and FDA.
17. Human growth hormone and human ____ were the first pharmaceutical products made using DNA technology.
19. Bone ____ cells are prime targets of gene therapy.
20. Yeast cells have been engineered to make a vaccine against ____ B.
26. Researchers produce transgenic animals by injecting DNA into fertilized ____.

Testing Your Knowledge

Multiple Choice

1. The primary difference between bacterial sex and sexual reproduction in plants and animals is that
   a. bacterial sex involves more than two individuals.
   b. bacterial sex does not involve genetic recombination.
   c. bacteria exchange RNA, not DNA.
   d. bacterial sex does not produce offspring.
   e. eggs and sperm are different, but bacterial gametes are all alike.

2. Sometimes a bacteriophage transfers a gene from one bacterium to another. This process is called
   a. transduction.
   b. conjugation.
   c. cloning.
   d. DNA splicing.
   e. transformation.

3. There are thought to be about ____ genes in a human cell.
   a. 23
   b. 46
   c. 1000
   d. 100, 000
   e. 3 billion

4. The ability of a male *E. coli* to carry out conjugation is usually due to a piece of DNA called
   a. a probe.
   b. an R plasmid.
   c. recombinant DNA.
   d. an F factor.
   e. a Ti plasmid.

5. A genetic marker is
   a. a place where a restriction enzyme cuts DNA.
   b. a chart that traces the family history of a genetic trait.
   c. a nucleotide sequence near a particular gene.
   d. a radioactive probe used to find a gene.
   e. an enzyme used to cut DNA.

6. In recombinant DNA experiments, ____ is used to cut pieces of DNA, and ____ joins these segments to form recombinant DNA.
   a. a restriction enzyme . . . DNA ligase
   b. a transposon . . . a restriction enzyme
   c. a plasmid . . . DNA ligase
   d. DNA ligase . . . a restriction enzyme
   e. a transposon . . . a plasmid

7. A genomic library is
   a. where you look to find out how to make recombinant DNA.
   b. a listing of the known nucleotide sequences for a particular species.
   c. all the genes contained in one kind of cell.
   d. a collection of cloned DNA pieces from an organism's genome.
   e. a place where one can obtain DNA samples from various species.

8. A nucleic acid probe might be used to
   a. insert genes into a host cell.
   b. make DNA for gene cloning.
   c. splice pieces of DNA.
   d. cut pieces of DNA down to manageable size.
   e. find a nucleotide sequence.

9. It is sometimes necessary to genetically engineer mammalian cells to produce proteins because they
   a. can produce larger quantities of protein than bacteria.
   b. can read eukaryotic genes, and bacteria cannot.
   c. can add sugars to make glycoproteins, and bacteria cannot.
   d. are easier to grow than bacteria.
   e. can be induced to secrete proteins into their environment.

10. Scientists have produced a smallpox virus that contains genes from several other disease-causing microorganisms. They hope to use the virus
    a. in a vaccine against several diseases.
    b. as a compact genomic library.
    c. to perfect a germ-warfare weapon with no antidote.
    d. as a gene vector for human gene therapy.
    e. as a tool for diagnosing various infectious diseases.

11. So far, genetic engineering of plants has not resulted in significant increases in food production because
    a. new plant diseases have evolved faster than expected.
    b. genetically engineered plants are very expensive.
    c. the vectors used do not work with many food plants.
    d. most crop plants already grow at the maximum theoretical rate.
    e. agricultural scientists have not pursued it seriously.

12. Electrophoresis is used to
    a. separate fragments of DNA.
    b. clone genes.
    c. cut DNA into fragments.
    d. match a gene with its function.
    e. amplify small DNA samples to obtain enough for analysis.

Applying Your Knowledge

Multiple Choice

1. A geneticist found that a particular nucleotide sequence was found on different chromosomes in different mouse skin cells. This suggested that
    a. transformation was occurring in some skin cells.
    b. transposons were moving around.
    c. the cells were engaging in conjugation.
    d. plasmids were transferring genes from cell to cell.
    e. the mice were transgenic animals.

2. A microbiologist analyzed the DNA of *E. coli* before and after conjugation. She found that
    a. both cells lost some genes and gained others.
    b. both cells gained genes but lost none of their original genes.
    c. one cell lost genes, and the other gained genes.
    d. one cell gained genes, and the genes of the other were unchanged.
    e. the genes of both cells remained unchanged.

3. Which of the following do "sticky ends" and molecular probes have in common?
    a. They both are used as gene vectors in genetic engineering.
    b. They both involve complementary base pairing.
    c. They both are parts of RNA molecules.
    d. They both are produced by the action of restriction enzymes.
    e. They both are important aspects of bacterial sex.

4. Because eukaryotic genes contain introns, they cannot be translated by bacteria, which lack RNA splicing machinery. If you want to engineer a bacterium to produce a eukaryotic protein, you can synthesize a gene without introns (if you know the nucleotide sequence) or
    a. alter the bacteria used so that they can splice RNA.
    b. use a molecular probe to find a gene without introns.
    c. work backward from mRNA to a piece of DNA without introns.
    d. use a phage to insert the desired gene into a bacterium.
    e. use a restriction enzyme to remove introns from the gene.

5. When recombinant plasmids are added to *E. coli*, not all the bacteria take them in. This makes it difficult to spot the bacteria that actually contain the plasmids. For this reason, R plasmids are often used as gene vectors in recombinant DNA experiments. Using R plasmids would allow experimenters to find the bacteria with recombinant DNA easily by
    a. using a molecular probe.
    b. killing off the bacteria without the R plasmids.
    c. feeding them a special diet.
    d. exposing the bacteria to restriction enzymes.
    e. watching what happens when the bacteria reproduce.

6. Scientists wished to create an organism capable of breaking down several kinds of toxic wastes, so they combined the genes of several bacteria to create a single "superbacterium." They probably did not need to use which of the following in creating the superbacterium?
    a. nucleic-acid probes
    b. F factors
    c. plasmids
    d. restriction enzymes
    e. DNA ligase

7. A crop scientist spliced genes for disease resistance into Ti plasmids and then treated tomato plants with the plasmids. Some parts of some plants resisted the disease, but most of the plants eventually died. The researcher could increase his chances for success by
   a. treating single cells and cloning whole plants from the cells.
   b. using molecular probes to figure out where to put the genes.
   c. using R plasmids rather than Ti plasmids to introduce the genes.
   d. inserting the genes into the cells of the tomato plants with a needle.
   e. employing bacteriophages as vectors to get the genes into the plants.

8. A molecular biologist used a virus to introduce a gene coding for a certain enzyme into mouse cells. Most of the mouse cells were able to make the enzyme, but most of them lost the ability to make some other protein (different ones in different cells), and many died. Which of the following best explains these results?
   a. The viruses caused the mouse cells to become diseased.
   b. The viruses transferred genes from one mouse cell to another.
   c. The viruses inserted the enzyme gene into mouse cell genes.
   d. The viruses activated transposons, which disrupted other genes.
   e. The enzyme acted as a restriction enzyme, cutting up mouse DNA.

9. DNA fingerprints were used to determine whether Sam could be the father of Becky's baby. Which of the following would show that Sam is not the father? If ____ genetic fingerprint showed some bands not in ____ genetic fingerprint.
   a. Sam's . . . the baby's
   b. Becky's . . . the baby's
   c. the baby's . . . Sam's
   d. the baby's . . . Becky's
   e. the baby's . . . Sam's or Becky's

10. Archaeologists unearthed a human skull with a small dried fragment of the scalp still attached. They extracted a tiny amount of DNA from the scalp tissue. How could they obtain sufficient DNA for an analysis of the ancient man's genes?
   a. subject the DNA to electrophoresis
   b. use a molecular probe
   c. subject the specimen to amniocentesis
   d. use the polymerase chain reaction
   e. subject the DNA to restriction enzymes

11. There is about 1000 times as much DNA in a human cell as in an *E. coli* cell but only about 50 times as many genes. Why?
   a. A human cell has much more noncoding DNA.
   b. The DNA is much more tightly coiled in a human cell.
   c. Most of the genes in a human cell are turned off.
   d. *E. coli* genes are less efficient than human genes.
   e. Human cells are much smaller than *E. coli* cells.