A summary of the flow of genetic information in protein synthesis is useful as an overview. Identify the indicated parts of the illustration on the next page by filling in the blanks with the names of the appropriate structures or functions. Choose from the following: DNA, mRNA, tRNA, polypeptide, rRNA subunits, intron, exon, mature mRNA transcript, new mRNA transcript, anticodon, amino acids, ribosome-mRNA complex. Complete the exercise by matching and entering the letter of the description in the parentheses following each label.

18. DNA (H) [pp. 236-237]
19. Transcription (G) [pp. 236-237] (process)
20. Intron (E) [pp. 236-237]
21. Exon (A) [pp. 236-237]
22. Mature mRNA transcript (L)
23. tRNA (C) [pp. 236-237]
24. rRNA subunit (G) [pp. 236-237]
25. mRNA (B) [pp. 236-237]
26. Anticodon (K) [pp. 236-237]
27. Amino acids (D) [pp. 236-237]
28. tRNA (F) [pp. 236-237]
29. Ribosome-mRNA complex (I) [pp. 236-237]
30. Protein (M) [pp. 236-237]

A. Coding portion of mRNA that will translate into proteins
B. Carries a modified form of the genetic code from DNA in the nucleus to the cytoplasm
C. Transports amino acids to the ribosome and mRNA
D. The building blocks of polypeptides
E. Non-coding portions of newly transcribed mRNA
F. tRNA after delivering its amino acid to the ribosome-mRNA complex
G. Join when translation is initiated
H. Holds the genetic code for protein production
I. Place where translation occurs
J. DNA template creates new RNA transcript
K. A sequence of three bases that can pair with a specific mRNA codon
L. Snipping out of introns, only exons remaining
M. May serve as a functional protein (enzyme) or a structural protein
Complete the Table

Three types of RNA are transcribed from DNA in the nucleus (from genes that code only for RNA). Complete the following table, which summarizes information about these molecules.

<table>
<thead>
<tr>
<th>RNA Molecule</th>
<th>Abbreviation</th>
<th>Description/Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Ribosomal RNA</td>
<td>rRNA</td>
<td>- controls ribosome</td>
</tr>
<tr>
<td>b. Messenger RNA</td>
<td>mRNA</td>
<td>- carries DNA message</td>
</tr>
<tr>
<td>c. Transfer RNA</td>
<td>tRNA</td>
<td>- carries A.A.</td>
</tr>
</tbody>
</table>

Short Answer

17. List three ways in which a molecule of RNA differs structurally from a molecule of DNA. [p.228]
   - short segment
   - uracil instead of thymine
   - single stranded

18. Cite two similarities in DNA replication and transcription. [p.228]
   1. occurs in the nucleus
   2. involves enzymes
   3. same first two steps.

19. What are the three key ways in which transcription differs from DNA replication? [p.228]
   1. mRNA instead of DNA strands
   2. products of transcription leave nucleus

Sequence

Arrange the steps of transcription in correct chronological sequence. Write the letter of the first step next to 20, the letter of the second step next to 21, and so on.

20. A. The RNA strand grows along exposed bases until RNA polymerase meets a DNA base sequence that signals "stop." [p.230]

21. B. RNA polymerase binds with the DNA promoter region to open up a local region of the DNA double helix. [p.229]

22. C. An RNA polymerase enzyme locates the DNA bases of the promoter region of one DNA strand by recognizing DNA-associated proteins near a promoter. [p.229]

23. D. RNA is released from the DNA template as a free, single-stranded transcript. [p.229]

24. E. RNA polymerase moves stepwise along exposed nucleotides of one DNA strand; as it moves, the DNA double helix keeps unwinding. [p.229]
Fill-in-the-Blanks

The pattern of which base follows the next in a strand of DNA is referred to as the base (1) pairing. A region of DNA that calls for the assembly of specific amino acids into a polypeptide chain is a(n) (2) gene. The two steps from genes to proteins are called (3) transcription and (4) translation. In (5) transcription, single-stranded molecules of RNA are assembled on DNA templates in the nucleus. In (6) translation, the RNA molecules are shipped from the nucleus into the cytoplasm, where they are used as templates for assembling (7) polypeptide chains. Following translation, one or more chains become (8) folded into the three-dimensional shape of protein molecules. Proteins have (9) structural and (10) enzymatic roles in cells, including control of DNA. Garrod hypothesized that an enzyme that operated at the next step of a (11) pathway was (12) ________ and could explain why the molecules of a particular substance were accumulating in excess amounts in the body fluids of affected individuals. Experimenting with red bread mold, Beadle and Tatum found that each inherited (13) ________ corresponded to a defective (14) ________. A more precise hypothesis regarding the relationship of genes with proteins emerged from Ingram’s work with hemoglobin: the amino acids of polypeptide chains—the structural units of proteins—are encoded in (15) ________. 

[Page 228] messenger RNA, mRNA transfers DNA message from nucleus to ribosomes.

[Page 228] ribosomal RNA, rRNA controls functions of the ribosome.

[Page 228] transfer RNA, tRNA carries amino acids to the mRNA.

[Page 228] uracil nucleotide found in RNA, not DNA.

[Page 228] RNA polymerase adds nucleotides to growing mRNA strand.

[Page 229] promoter N/A.

[Page 229] introns are removed before translation.

[Page 229] exons are expressed in translation.
Completion

10. Given the following DNA sequence, deduce the composition of the mRNA transcript:

TAC AAG ATA ACA TTA TTT CCT ACC GTC ATC

(mRNA transcript)

11. Deduce the composition of the tRNA anticodons that would pair with the specific mRNA-codons, from question 10, as these tRNAs deliver the amino acids (identified below) to the P and A binding sites of the small ribosomal subunit.

<table>
<thead>
<tr>
<th>mRNA transcript</th>
<th>tRNA anticodons</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAC AAG ATA ACA TTA TTT CCT ACC GTC ATC</td>
<td>UUA UUA UUA UUA UUA UUA UUA UUA UUA UUA</td>
</tr>
</tbody>
</table>

(tRNA anticodons)

12. From the mRNA transcript in question 10, use Figure 14.11 of the text to deduce the composition of the amino acids of the polypeptide sequence.

Met Pro Tyr Gln Pro Leu Glu Try Glu Stop

(amino acids)

Fill-in-the-Blanks

The order of (13) amino acids in a protein is specified by a sequence of nucleotide bases. The genetic code is read in units of (14) 3 nucleotides; each unit of three codes for (15) one amino acid(s). In the table that showed which triplet specified a particular amino acid, the triplet code was incorporated in (16) mRNA molecules. Each of these triplets is referred to as a(n) (17) codon. (18) mRNA alone carries the instructions for assembling a particular sequence of amino acids from the DNA to the ribosomes in the cytoplasm, where (19) synthesis of the polypeptide occurs. (20) Translation (pp.230–231) RNA acts as a shuttle molecule as each type brings its particular (21) amino acid to the ribosome where it is to be incorporated into the growing (22) protein. A(n) (23) codon is a triplet on mRNA that forms hydrogen bonds with a(n) (24) anticodon on tRNA. During the stage of translation called (25) initiation, a particular tRNA that can start transcription and an mRNA transcript are both loaded onto a ribosome. In the (26) elongation stage of translation, a polypeptide chain is assembled as the mRNA passes between two ribosomal subunits, like a thread being moved through the eye of a needle. During the last stage of translation, (27) termination, a STOP codon in the mRNA moves onto the platform, and no tRNA has a corresponding anticodon. Now proteins called (28) release factors bind to the ribosome. They trigger (29) enzyme activity that detaches the mRNA and the chain from the ribosome.
Labeling

1. The term *semiconservative replication* refers to the fact that each new DNA molecule resulting from the replication process is “half old, half new.” In the following illustration, complete the replication required in the middle of the molecule by adding the required letters representing the missing nucleotide bases. Recall that ATP energy and the appropriate enzymes are actually required in order to complete this process. [p.220]

<table>
<thead>
<tr>
<th>Old</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>A</td>
</tr>
<tr>
<td>G</td>
<td>C</td>
</tr>
<tr>
<td>A</td>
<td>T</td>
</tr>
<tr>
<td>C</td>
<td>G</td>
</tr>
<tr>
<td>C</td>
<td>G</td>
</tr>
</tbody>
</table>

True–False

If a statement below is true, write T in the blank. If false, explain why by changing one or more of the underlined words.

2. The hydrogen bonding of adenine to thymine is an example of complementary base pairing. [p.220]

3. The replication of DNA is considered a *conservative* process because each new molecule is really half new and half old. [pp.220–221]

4. Each parent strand remains intact during replication, and a new companion strand is assembled on each of those parent strands. [p.220]

5. DNA ligases govern the assembly of nucleotides on a parent strand. [p.221]

6. DNA polymerases, DNA ligases, and other enzymes also engage in DNA replication. [p.221]

Boldfaced, Page-Referenced Terms

- [p.254] gene therapy
- [p.255] recombinant DNA technology
- [p.255] genetic engineering
- [p.256] restriction enzyme
Fill-in-the-Blanks

A bacteriophage is a kind of (2) ________ [p.216] that can infect (3) ________ [p.216] cells. Enzymes from the (2) take over enough of the host cell's metabolic processes to make substances that are necessary to construct new (4) ________ [p.216]. Some of these substances are (5) ________ [p.217] that can be labeled with a radioisotope of sulfur, $^{35}$S. The genetic material of the bacteriophage used in the experiments by Hershey and Chase was labeled with the radioisotope of phosphorus known as (6) ________ [p.217]. When (7) ________ [p.217] particles were allowed to infect Escherichia coli cells, the (8) ________ [p.217] radioisotope remained outside the bacterial cells; the (9) ________ [p.217] became part of the (10) ________ ________ [p.217] injected into the bacterial cells. Through many experiments, researchers accumulated strong evidence that (11) ________ [p.217], not (12) ________ [p.217], serves as the molecule of inheritance in all living cells.

13.2. DNA STRUCTURE [pp.218-219]

13.3. Focus on Bioethics: ROSALIND'S STORY [p.220]


Boldfaced, Page-Referenced Terms

[p.218] nucleotide

[p.218] adenine, A, purine, pairs w/ T

[p.218] guanine, G, purine, pairs w/ C

[p.218] thymine, T, pyrimidine, pairs w/ A

[p.218] cytosine, C, pyrimidine, pairs w/ G

[p.218] x-ray diffraction images

Short Answer

1. List the three parts of a nucleotide. [p.218] phosphate group, sugar, nitrogen base.
Labeling

Four nucleotides are illustrated below. [All are from text p.218.] In the blank, label each nitrogen-containing base correctly as guanine, thymine, cytosine, or adenine. In the parentheses following each blank, indicate whether that nucleotide base is a purine (pu) or a pyrimidine (py). (See next section for definitions.)

![Nucleotide Diagram]

2. ______ ( )
3. ______ ( )
4. ______ ( )
5. ______ ( )

Labeling and Matching

Identify each indicated part of the following DNA illustration. Choose from these answers: phosphate group, double-ring nitrogen base, single-ring nitrogen base, nucleotide, and deoxyribose. Complete the exercise by matching and entering the letter of the proper structure description in the parentheses following each label.

The following memory devices may be helpful: use pyrCUT to remember that the single-ring nucleotides (pyrimidines) are cytosine, uracil (in RNA), and thymine. Use purAG to remember that the double-ring nucleotides (purines) are adenine and guanine; to help recall the number of hydrogen bonds between the DNA bases, remember that AT = 2 and CG = 3.

6. sugar ( ) [p.219]
7. phosphate group ( ) [p.219]
8. ______-ring nitrogen base ( ) [p.219]
9. ______-ring nitrogen base ( ) [p.219]
10. ______-ring nitrogen base ( ) [p.219]
11. ______-ring nitrogen base ( ) [p.219]
12. A complete ( ) [p.219]

A. The single-ring nitrogen base is thymine, because it has two hydrogen bonds.
B. A five-carbon sugar joined to two phosphate groups in the upright portion of the DNA ladder.
C. The double-ring nitrogen base is guanine, because it has three hydrogen bonds.
D. The single-ring nitrogen base is cytosine, because it has three hydrogen bonds.
E. The double-ring nitrogen base is adenine, because it has two hydrogen bonds.
F. Composed of three smaller molecules: a phosphate group, five-carbon deoxyribose sugar, and a nitrogenous base (in this case, a single-ring nitrogen base).
G. A chemical group that joins two sugars in the upright portion of the DNA ladder.
Matching
Choose the most appropriate answer for each term.
1. **E** codon [p.230]
2. **B** three bases at a time [p.230]
3. **C** sixty-one [p.230]
4. **H** the genetic code [p.230]
5. **L** molecular "hook" [p.230]
6. **A** ribosome [p.231]
7. **E** anticodon [p.230]
8. **D** the "stop" codons [p.230]

A. Composed of two subunits, the small subunit with P and A amino acid binding sites as well as a binding site for mRNA
B. Reading frame of the nucleotide bases in mRNA
C. on tRNA, an attachment site for an amino acid
D. UAA, UAG, UGA
E. A sequence of three nucleotide bases that can pair with a specific mRNA codon
F. Name for each base triplet in mRNA
G. The number of codons that actually specify amino acids
H. Term for how the nucleotide sequences of DNA and then mRNA correspond to the amino acid sequence of a polypeptide chain

Completion
25. Suppose the following line represents the DNA strand that will act as a template for the production of mRNA through the process of transcription. Fill in the blanks below the DNA strand with the sequence of complementary bases that will represent the message carried from DNA by mRNA to the ribosome in the cytoplasm [see text Figure 14.8 on pp.228-229].

(transcribed single-strand mRNA)