KEY!

CHAPTER 16

THE MOLECULAR BASIS OF INHERITANCE

INTERACTIVE QUESTION 16.1

Hershey and Chase devised an experiment using radioactive isotopes to determine whether the phage's DNA or protein was transferred to the bacteria.

a. How did they label phage protein?

The phage DNA was labeled w/ radioactive Phosphorus + the protein coat was labeled w/ radioactive sulfur.

b. How did they label phage DNA?

* DNA contains P but no S and proteins contain S but never P.

Separate samples of *E. coli* were infected with the differently labeled T2 cells, then blended and centrifuged to isote the bacterial cells from the lighter viral particles.

c. Where was the radioactivity found in the samples with labeled phage protein?

In the Supernatant

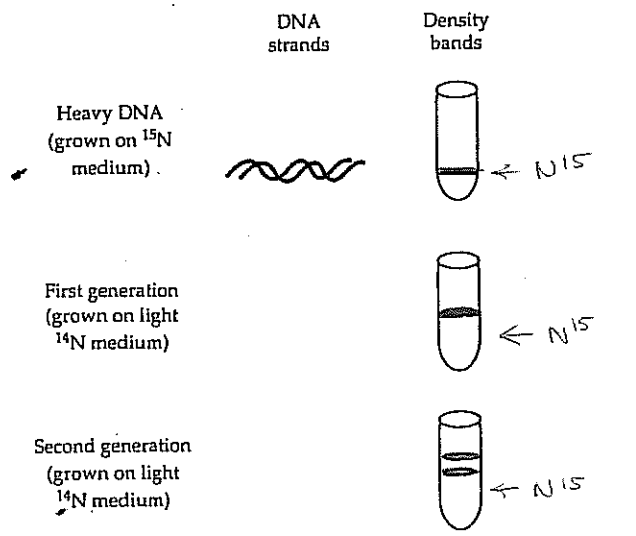
d. In the samples with labeled phage DNA?

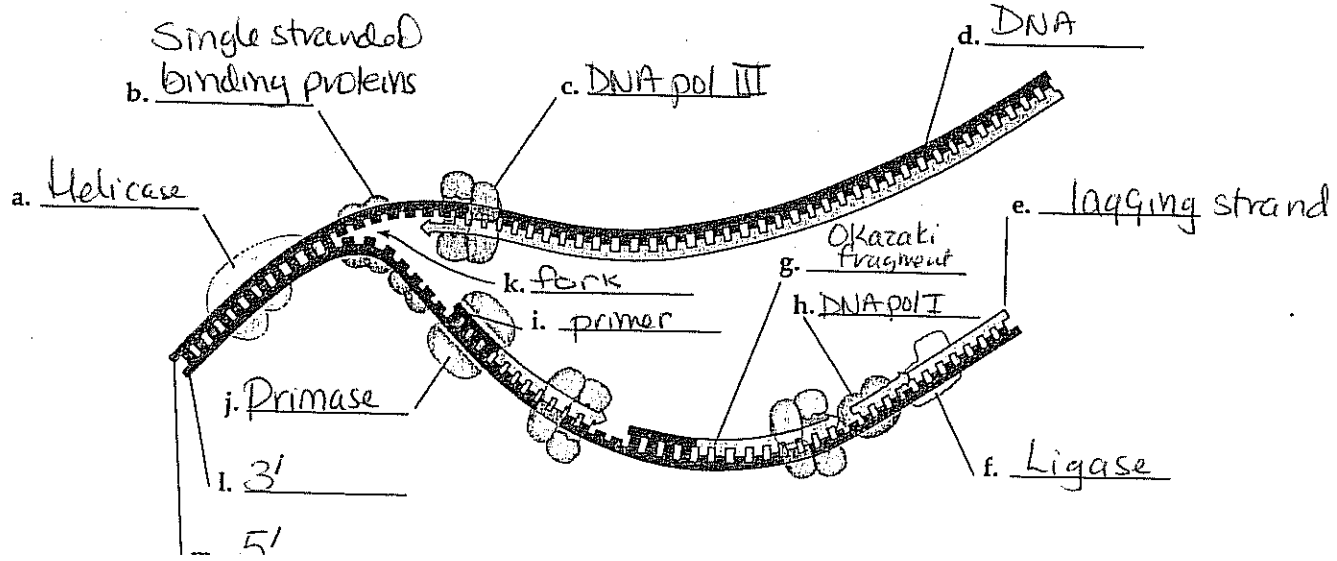
In the pellet - therefore only the DNA entered the bacteria.

e. What did Hershey and Chase conclude from these results? That the viral genes which must enter the bacteria were composed of only DNA.

INTERACTIVE QUESTION 16.3

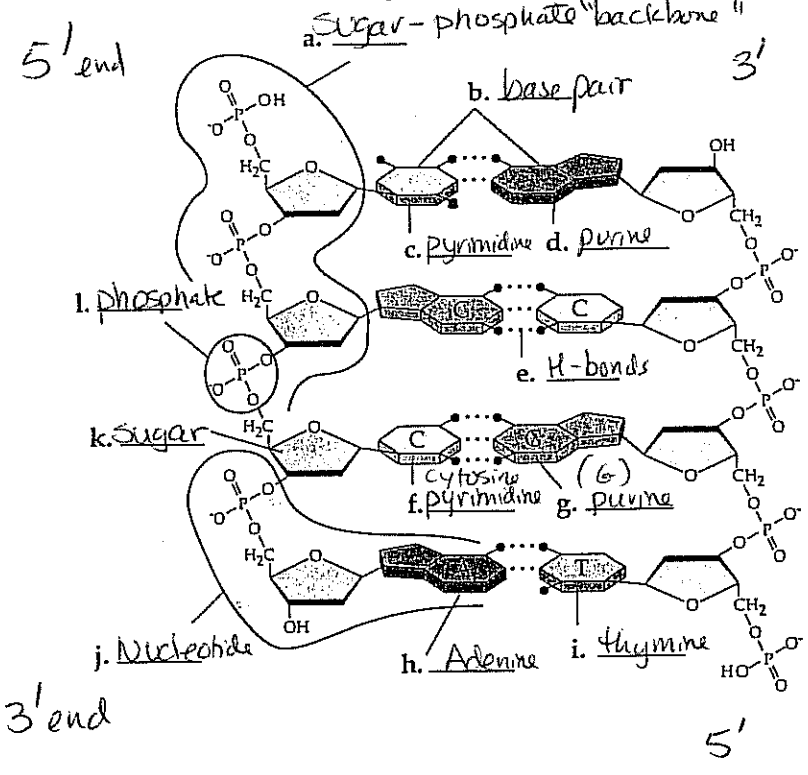
Using different colors for heavy (parental) and light (new) strands of DNA, sketch the results of two replication cycles when *E. coli* were moved from medium with ^{15}N to ^{14}N medium. Show the resulting density bands in the centrifuge tubes.

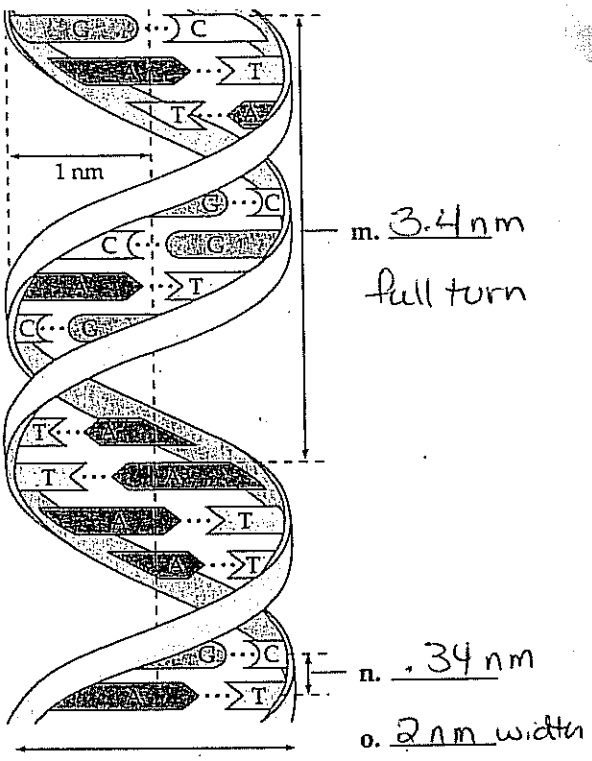




■ INTERACTIVE QUESTION 16.2

Review the structure of DNA by labeling the following diagrams.





TEST YOUR KNOWLEDGE

MULTIPLE CHOICE: *Choose the one best answer.*

1. One of the reasons most scientists believed proteins were the carriers of genetic information was that
   a. proteins were more heat stable than nucleic acids.
   b. the protein content of duplicating cells always doubled prior to division.
   c. proteins were much more complex and heterogeneous molecules than nucleic acids.
   d. early experimental evidence pointed to proteins as the hereditary material.
   e. proteins were found in DNA.

2. Transformation involves (Griffith)
   a. the uptake of external genetic material, often from one bacterial strain to another.
   b. the creation of a strand of RNA from a DNA molecule.
   c. the infection of bacterial cells by phage.
   d. the type of semiconservative replication sh by DNA.
   e. the replication of DNA along the lagging stran

3. The DNA of an organism has thymine as 20% of its bases. What percentage of its bases would be guanine?
   a. 20% c. 40% e. 80%

T = 20
A = 20
C = 30
G = 30

4. In his work with pneumonia-causing bacteria, Griffith found that
   a. DNA was the transforming agent. (Avery)
   b. the pathogenic and harmless strains mated.
   c. heat-killed harmless cells could cause pneumonia when mixed with heat-killed pathogenic cells.
   d. some heat-stable chemical was transferred to harmless cells to transform them into pathogenic cells.
   e. a T2 phage transformed harmless cells to pathogenic cells.

5. When T2 phages are grown with radioactive sulfur,
   a. their DNA is tagged. Hershey + Chase
   b. their proteins are tagged.
   c. their DNA is found to be of medium density in a centrifuge tube.
   d. they transfer their radioactivity to *E. coli* chromosomes when they infect the bacteria.
   e. their excision enzymes repair the damage caused by the radiation.

6. Meselson and Stahl
   a. provided evidence for the semiconservative model of DNA replication.
   b. were able to separate phage protein coats from *E. coli* by using a blender. Hershey / Chase
   c. found that DNA labeled with ^{15}N was of intermediate density. false
   d. grew *E. coli* on labeled phosphorus and sulfur. false
   e. found that DNA composition was species specific. Chargaff

7. Watson and Crick concluded that each base could not pair with itself because
   a. there would not be room for the helix to make a full turn every 3.4 nm.
   b. the uniform width of 2 nm would not permit two purines or two pyrimidines to pair together.
   c. the bases could not be stacked 0.34 nm apart.
   d. identical bases could not hydrogen-bond together.
   e. they would be on antiparallel strands.

8. The joining of nucleotides in the polymerization of DNA requires energy from
   a. DNA polymerase.
   b. the hydrolysis of the terminal phosphate group of ATP.
   c. RNA nucleotides.
   d. the hydrolysis of GTP. → (2 last phosphates)
   e. the hydrolysis of the pyrophosphates removed from nucleoside triphosphates.

9. Continuous elongation of a new DNA molecule along one strand of DNA
   a. requires the action of DNA ligase as well as polymerase.
   b. occurs because DNA ligase can only elongate in the 5′ → 3′ direction.
   c. occurs on the leading strand.
   d. occurs on the lagging strand.
   e. a, b, and c are correct.

10. Which of the following statements about DNA polymerase is *incorrect*? DNA pol. creates bonds between sugar + phosphate the bases H-bond by themselves
    a. It joins complementary base pairs to each other.
    b. It is able to proofread and correct for errors in base pairing.
    c. It is unable to initiate synthesis; it requires an RNA primer.
    d. It only works in the 5′ → 3′ direction.
    e. It is found in eukaryotes and prokaryotes.

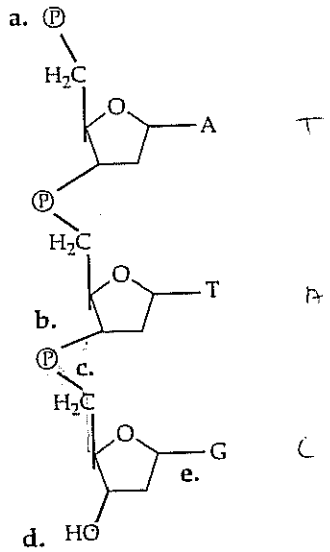
11. Thymine dimers, covalent links between adjacent thymine bases in DNA, may be induced by UV light. When they occur, they are repaired by
    a. excision enzymes (nucleases).
    b. DNA polymerase.
    c. ligase.
    d. primase.
    e. a, b, and c are all needed.

12. How does DNA synthesis along the lagging strand differ from that on the leading strand?
    a. Nucleotides are added to the 5′ end instead of the 3′ end.
    b. Ligase is the enzyme that polymerizes DNA on the lagging strand.
    c. An RNA primer is needed on the lagging strand but not on the leading strand.
    d. Okazaki fragments, which each grow 5′ → 3′, must be joined along the lagging strand.
    e. Helicase synthesizes Okazaki fragments, which are then joined by ligase.

13. Which of the following enzymes or proteins is paired with an incorrect or inaccurate function?
    a. Helicase—unwind and separate parental double helix
    b Telomerase—add telomere repetitions to end of chromosomes
    c. Single-strand binding protein—hold strands of unwound DNA apart and straight
    d. Nuclease—cut out (excise) damaged DNA strand
    e. Primase—form DNA primer to start replication

↓ RNA primer, not DNA

Use the following diagram to answer Questions 14 through 17.



14. Which letter indicates the 5′ end of this single DNA strand?
a. b. c. d. e.

15. At which letter would the next nucleotide be added?
a. b. c. d. e.

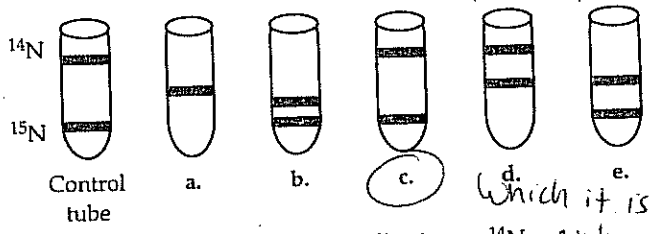
16. Which letter indicates a phosphodiester bond formed by DNA polymerase?
a. b. c. d. e.

17. The base sequence of the DNA strand made from this template would be (from top to bottom)
a. A T C.
b. C G A.
c. T A C.
d. U A C.
e. A T G.

18. T2 phage is grown with radioactive phosphorus and then allowed to infect *E. coli*. The culture is blended to separate the viral coats from the bacterial cells and centrifuged. Which of the following best describes the expected results of such an experiment?
a. Both viral and bacterial DNA are labeled; radioactivity is found in the supernatant.
b. Both viral and bacterial proteins are labeled; radioactivity is present in both the supernatant and the pellet.
c. Viral proteins are labeled; radioactivity is found in the supernatant but not in the pellet.
d. Viral DNA is labeled; radioactivity is found in the pellet.
e. The virus destroyed the bacteria; no pellet is formed.

19. What are telomeres and what do they do?
a. ever-shortening tips of chromosomes that may signal cells to stop dividing at maturity
b. highly repetitive sequences at tips of chromosomes that protect the lagging strand during replication
c. repetitive sequences of nucleotides at the centromere region of a chromosome
d. enzymes that are present in germ-line cells that allow these cells to undergo repeated divisions
e. Both a and b are correct.

20. You are trying to ~~support~~ your hypothesis that DNA replication is *conservative*; i.e., parental strands separate; complementary strands are made, but these new strands join together to make a new DNA molecule and the parental strands rejoin. You take *E. coli* that had grown in a medium containing only heavy nitrogen (^{15}N) and transfer a sample to a medium containing light nitrogen (^{14}N). After allowing time for only one DNA replication, you centrifuge a sample and compare the density band(s) formed with control bands for bacteria grown on either normal ^{14}N or ^{15}N medium. Which band location would support your hypothesis of *conservative* DNA replication?



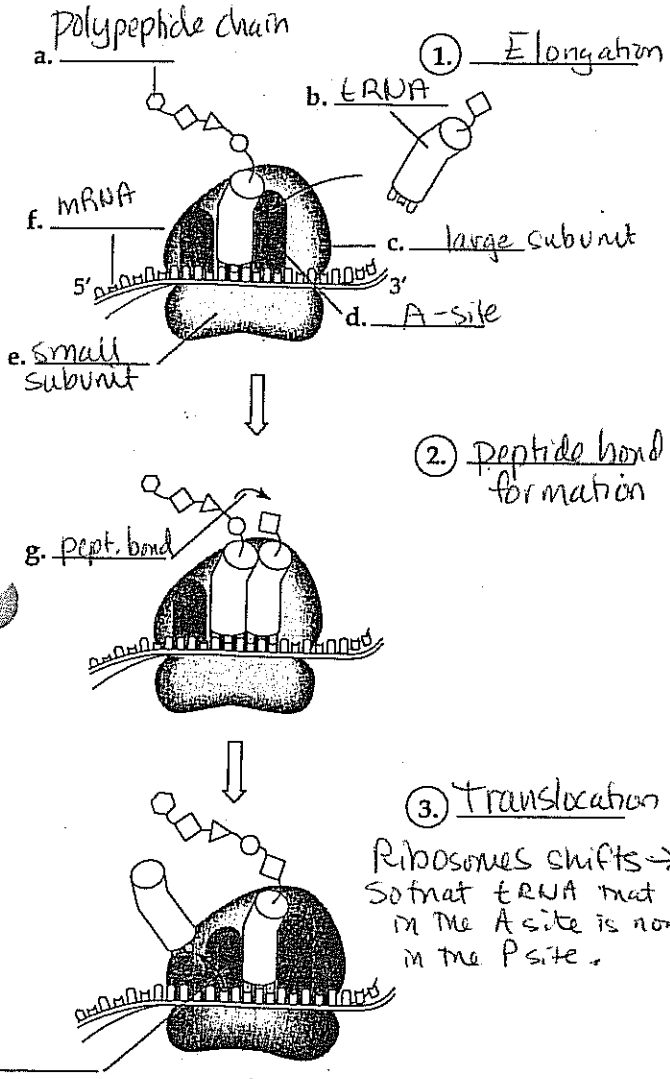
Bands after one replication on ^{14}N

21. Using the experiment explained in question 20, which centrifuge tube would represent the band distribution obtained after one replication showing that DNA replication is *semiconservative*?

FROM GENE TO PROTEIN

INTERACTIVE QUESTION 17.6

In the following diagrams of polypeptide synthesis, name the stages (1–4), identify the components (a–l), and then briefly describe what happens in each stage.



INTERACTIVE QUESTION 17.7

What determines if a ribosome becomes bound to the ER?

Depends on the polypeptide being made - if it has a signal sequence at the start it will be dragged to a receptor on the ER by the SRP (signal recognition particle)

INTERACTIVE QUESTION 17.5

Using some of the codons and the amino acids you identified in Interactive Question 17.2, fill in the following table.

DNA Triplet 3′ → 5′	mRNA Codon 5′ → 3′	Anticodon 3′ → 5′	Amino Acid
			methionine
		GGA	
TTC			
	UAG		

INTERACTIVE QUESTION 17.8

Fill in the functions for the following types of RNA molecules.

a. mRNA ~~Copies~~ a copy of a DNA Gene

b. tRNA carries amino acids to the ribosome.

c. rRNA together w/ proteins, composes a ribosome. Forms ribosome in the nucleolus.

d. snRNA forms spliceosomes which cut out introns.

e. SRP RNA help guide polypeptide to ER.

■ INTERACTIVE QUESTION 17.9

Define the following, and explain what type of point mutation could cause each of these mutations.

a. silent mutation if base change results in codon that codes for same amino acid.

b. missense mutation base change that results in codon for different amino acid.

c. nonsense mutation base change that results in codon stop.

d. frameshift mutation addition or deletion of a base that shifts the entire reading frame.

TEST YOUR KNOWLEDGE

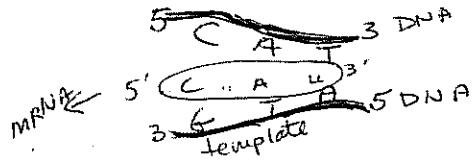
MULTIPLE CHOICE: *Choose the one best answer.*

1. In Beadle and Tatum's study of *Neurospora*, they were able to identify three classes of mutants that needed arginine added to minimal media in order to grow. The production of arginine includes the following steps: precursor → ornithine → citrulline → arginine. What nutrient(s) had to be supplied for the mutants with a defective enzyme for the precursor → ornithine step to grow?
   a. precursor only
   b. ornithine only
   c. citrulline only
   d. ornithine or citrulline
   e. precursor, ornithine, and citrulline

   } we will study this later

2. Transcription involves the transfer of information from
   a. DNA to RNA.
   b. RNA to DNA.
   c. mRNA to an amino acid sequence.
   d. DNA to an amino acid sequence.
   e. the nucleus to the cytoplasm.

3. If the 5′ → 3′ nucleotide sequence on the complementary (noncoding) DNA strand is CAT, what is the corresponding codon on mRNA?
   a. UAC
   b. CAU
   c. GUA
   d. GTA
   e. CAT



4. RNA polymerase
   a. is the protein responsible for the production of ribonucleotides.
   b. is the enzyme that creates hydrogen bonds between nucleotides on the DNA template strand and their complementary RNA nucleotides.
   c. is the enzyme that transcribes exons, but does not transcribe introns. (Spliceosome)
   d. is a ribozyme composed of snRNPs.
   e. begins transcription at a promoter sequence and moves along the template strand of DNA, elongating an RNA molecule in a 5′ → 3′ direction.

	Transcription	Translation
Template	DNA is copied	mRNA is "read"
Location	nucleus	cytoplasm
Molecules involved	RNA polymerase, TF, DNA	Ribosome, mRNA, tRNA, amino acids, various factors
Enzymes involved	RNA polymerase	Aminoacyl tRNA synthetase, enzymes in ribosome
Control—start and stop	promoter, termination sequence	start + stop codons
Product	RNA	polypeptide
Product processing	mRNA has 5′ cap, poly A tail, introns/exons	chaperone proteins help fold polypeptide, other chemical modifications may occur
Energy source	cleaving pyrophosphate (P-P) from nucleoside triphosphate building blocks, mainly GTP	

5. How is the template strand for a particular gene determined?
   a. It is the DNA strand that runs from the 5′ → 3′ direction.
   b. It is the DNA strand that runs from the 3′ → 5′ direction.
   c. It depends on the orientation of RNA polymerase, whose position is determined by particular sequences of nucleotides within the promoter.
   d. It doesn't matter which strand is the template because they are complementary and will produce the same mRNA.
   e. The template strand always contains the TATA box.

6. Which enzyme is responsible for the synthesis of tRNA?
   a. RNA replicase
   b. RNA polymerase
   c. aminoacyl-tRNA synthetase
   d. ribosomal enzymes
   e. ribozymes

7. Which of the following is true of RNA processing?
   a. Exons are excised before the mRNA is translated.
   b. The RNA transcript that leaves the nucleus may be much longer than the original transcript.
   c. Assemblies of protein and snRNPs, called spliceosomes, may catalyze splicing.
   d. Large quantities of rRNA are assembled into ribosomes.
   e. Signal peptides are added to the 5′ end of the transcript.

8. Which of the following is *not* involved in the formation of a eukaryotic transcription initiation complex?
   a. TATA box
   b. transcription factors
   c. snRNA
   d. RNA polymerase II
   e. promoter

9. A prokaryotic gene 600 nucleotides long can code for a polypeptide chain of about how many amino acids?
   a. 100 c. 300 e. 1800
   b. 200 d. 600

10. All of the following are transcribed from DNA *except*
    a. exons.
    b. introns.
    c. tRNA.
    d. rRNA.
    e. promoter.

11. What might introns have to do with the evolution of new proteins?
    a. The excised introns may be transcribed and translated as new proteins by themselves.
    b. Introns are more likely to accumulate mutations than exons, and these mutations may result in the production of novel proteins.
    c. Introns that are self-excising may also function as hydrolytic enzymes for other nuclear processes.
    d. Introns provide more area where crossing over may occur (without interfering with the coding sequences) and thus increase the probability of exon shuffling between alleles.
    e. Introns often correspond to domains in proteins that fold independently and have specific functions. Changing domains between nonallelic genes could produce novel proteins.

12. A ribozyme is
    a. an exception to the one gene–one RNA molecule axiom.
    b. an enzyme that adds the 5′ cap and poly(A) tail to mRNA.
    c. an example of rearrangement of protein domains caused by RNA splicing.
    d. an RNA molecule that functions as an enzyme.
    e. an enzyme that produces both small and large ribosomal subunits.

13. All of the following would be found in a prokaryotic cell *except*
    a. mRNA.
    b. rRNA.
    c. simultaneous transcription and translation.
    d. snRNA.
    e. RNA polymerase.

14. Which of the following is transcribed and then translated to form a protein product?
    a. gene for tRNA
    b. intron
    c. gene for a transcription factor
    d. leader and trailer
    e. gene for rRNA

15. Transfer RNA
    a. forms hydrogen bonds between its codon and the anticodon of an mRNA in the A site of a ribosome.
    b. binds to its specific amino acid in the active site of an aminoacyl-tRNA synthetase.
    c. uses GTP as the energy source to bind its amino acid.
    d. is translated from mRNA.
    e. is formed in the nucleolus.

16. Place the following events in the synthesis of a polypeptide in the proper order.
4 1. A peptide bond forms.
3 2. A tRNA matches its anticodon to the codon in the A site.
5 3. A tRNA translocates from the A to the P site, and an unattached tRNA leaves the ribosome from the E site.
2 4. The large subunit attaches to the small subunit and the initiator tRNA fits in the P site.
1 5. A small subunit binds to an mRNA and an initiator tRNA.

a. 4-5-3-2-1
b. 4-5-2-1-3
c. 5-4-3-2-1
d. 5-4-1-2-3
e. 5-4-2-1-3

17. Translocation involves
a. the hydrolysis of a GTP molecule.
b. the movement of the tRNA in the A site to the P site.
c. the movement of the mRNA strand one triplet length in the A site. or codon
d. the release of the unattached tRNA from the E site.
e. all of the above.

18. Which of the following catalyzes the formation of a peptide bond?
a. RNA polymerase
b. rRNA oops it's actually a ribozyme (RNA enzyme) part of the ribosome.
c. mRNA
d. aminoacyl-tRNA synthetase
e. protein ribosomal enzyme

19. Which of the following is *not* true of an anticodon?
a. It consists of three nucleotides.
b. It lines up in the 5′ → 3′ direction along the 5′ → 3′ mRNA strand. antiparallel
c. It extends from one end of a tRNA molecule.
d. It may pair with more than one codon, especially if it has the base inosine in its third position.
e. Its base uracil base-pairs with adenine.

20. Changes in a polypeptide following translation may involve
a. the addition of sugars or lipids to certain amino acids. such as the changes that happen inside ER + Golgi
b. the action of enzymes to add amino acids at the beginning of the chain.
c. the removal of poly(A) from the end of the chain.
d. the addition of a 5′ cap of a modified guanosine residue. mRNA
e. all of the above.

21. Several proteins may be produced at the same time from a single mRNA by
a. the action of several ribosomes in a string called a polyribosome.
b. several RNA polymerase molecules working sequentially.
c. signal peptides that associate ribosomes with rough ER.
d. containing several promoter regions.
e. the involvement of multiple spliceosomes.

22. A signal peptide
a. is most likely to be found on proteins produced by bacterial cells.
b. directs an mRNA molecule into the cisternal space of the ER.
c. is a sign to help bind the small ribosomal unit at the initiation codon.
d. would be the first 20 or so amino acids of a protein destined for secretion from the cell.
e. is part of the 5′ cap.

23. A base deletion early in the coding sequence of a gene may result in
a. a nonsense mutation.
b. a frameshift mutation.
c. multiple missense mutations.
d. a nonfunctional protein.
e. all of the above.

24. Base-pair substitutions may have little effect on the resulting protein for all of the following reasons *except* which one?
a. The redundancy of the code may result in a silent mutation.
b. The substitution must involve three nucleotide pairs, or else the reading frame will be altered. → still could be very harmful
c. The missense mutation may not occur in a critical part of the protein.
d. The new amino acid may have similar properties to the replaced one.
e. The wobble phenomenon could result in no change in translation.