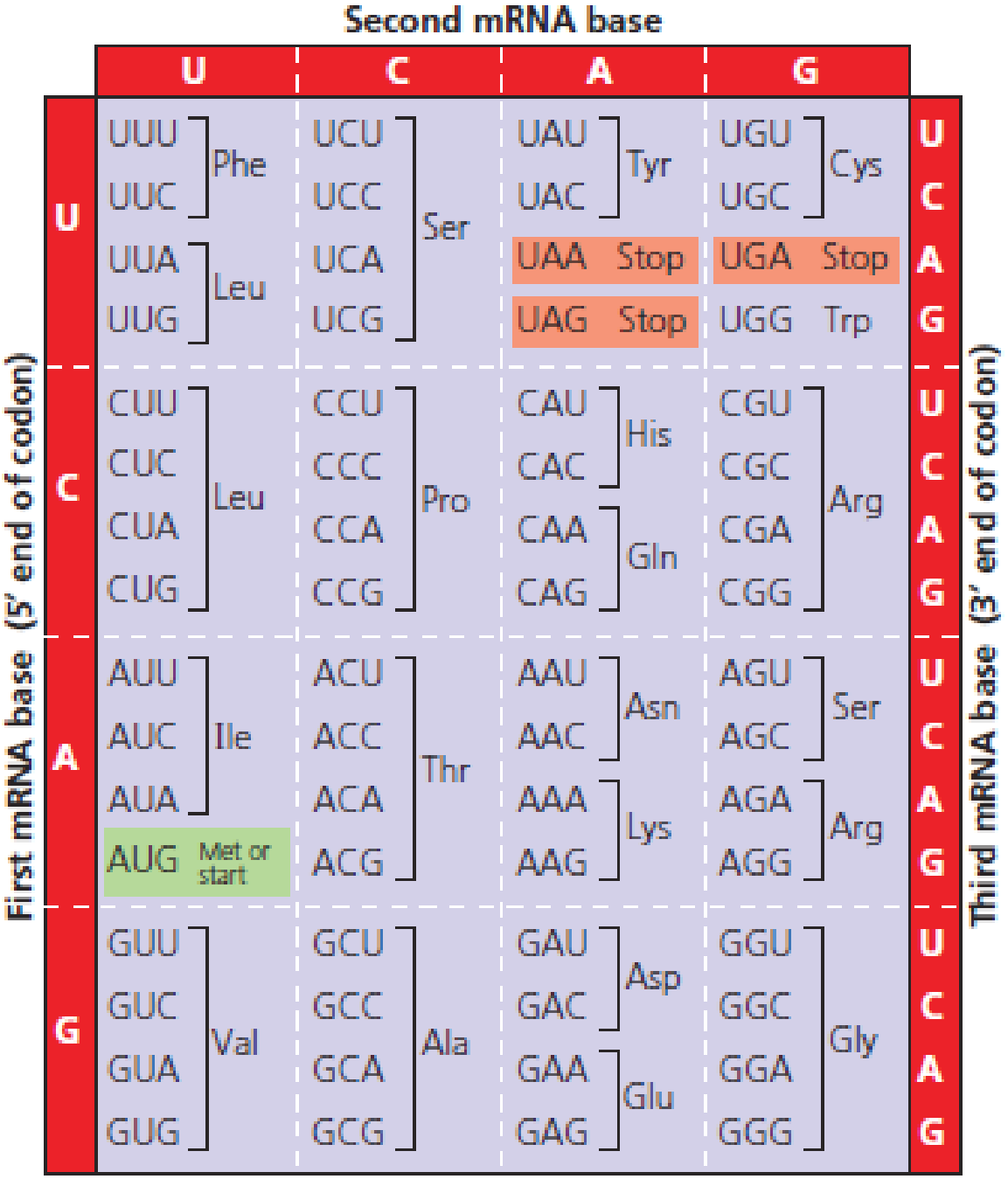
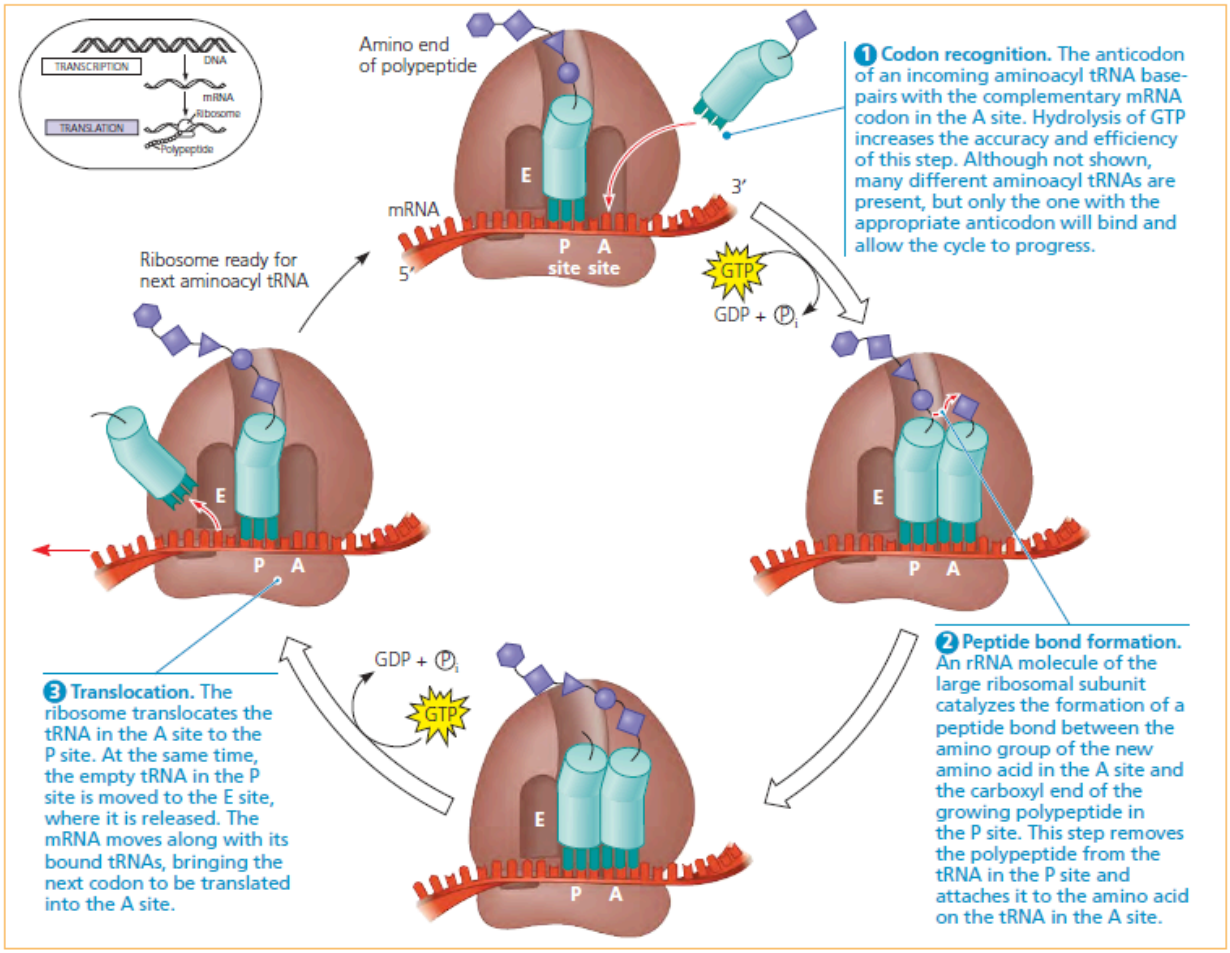

Second mRNA base
U
C
A
G
First mRNA base (5′ end of codon)
Third mRNA base (3′ end of codon)
UUU Phe
UUC
UUA Leu
UUG
UCU Ser
UCC
UCA
UCG
UAU Tyr
UAC
UAA Stop
UAG Stop
UGU Cys
UGC
UGA Stop
UGG Trp
CUU Leu
CUC
CUA
CUG
CCU Pro
CCC
CCA
CCG
CAU His
CAC
CAA Gln
CAG
CGU Arg
CGC
CGA
CGG
AUU Ile
AUC
AUA
AUG Met or start
ACU Thr
ACC
ACA
ACG
AAU Asn
AAC
AAA Lys
AAG
AGU Ser
AGC
AGA Arg
AGG
GUU Val
GUC
GUA
GUG
GCU Ala
GCC
GCA
GCG
GAU Asp
GAC
GAA Glu
GAG
GGU Gly
GGC
GGA
GGG


TRANSCRIPTION
DNA
mRNA
TRANSLATION
Ribosome
Polypeptide
Amino end of polypeptide
mRNA
5′
3′
E
P site
A site
Ribosome ready for next aminoacyl tRNA
GTP
GDP + Pi
1 Codon recognition. The anticodon of an incoming aminoacyl tRNA base-pairs with the complementary mRNA codon in the A site. Hydrolysis of GTP increases the accuracy and efficiency of this step. Although not shown, many different aminoacyl tRNAs are present, but only the one with the appropriate anticodon will bind and allow the cycle to progress.
2 Peptide bond formation. An rRNA molecule of the large ribosomal subunit catalyzes the formation of a peptide bond between the amino group of the new amino acid in the A site and the carboxyl end of the growing polypeptide in the P site. This step removes the polypeptide from the tRNA in the P site and attaches it to the amino acid on the tRNA in the A site.
3 Translocation. The ribosome translocates the tRNA in the A site to the P site. At the same time, the empty tRNA in the P site is moved to the E site, where it is released. The mRNA moves along with its bound tRNAs, bringing the next codon to be translated into the A site.

Chapter 17 Questions

1. **What is gene expression?**
2. **What is alkaptonuria?**
3. **The does the one gene-one enzyme hypothesis?**
4. **What is *Neurospora crassa?***
5. **What is the difference between a minimal medium and a complete medium?**
6. **What are the two intermediates in arginine synthesis?**
7. **The lack of what causes albinism in donkeys?**
8. **What is the one gene-one polypeptide hypothesis?**
9. **What are the two steps of protein synthesis?**
10. **What is the difference between bacterial and eukaryotic protein synthesis?**
11. **What is the initial RNA transcript from any gene called?**
12. **What is the information flow of DNA to RNA to proteins called ?**
13. **What is the flow of information from gene to protein based on?**
14. **What is the DNA strand that is transcribed called?**
15. **What are mRNA nucleotide triplets and nontemplate DNA strand triplets called?**
16. **What is another name for the nontemplate DNA strand?**
17. **What are the start and stop codons?**
18. **Name the codons for each of the 20 amino acids.**
19. **What is the reading frame?**
20. **What is RNA polymerase?**
21. **What is the DNA sequence where RNA polymerase initiates transcription called?**
22. **In bacteria, what is the sequence that signals the end of transcription called?**
23. **What do upstream and downstream mean?**
24. **How many RNA polymerases do bacteria and humans have?**
25. **Name the three stages of transcription.**
26. **Describe the promoter.**
27. **How do transcription factors work?**
28. **What is the TATA box?**
29. **About how many DNA nucleotides are exposed at a time by RNA polymerase?**
30. **What is the transcription rate in eukaryotes?**
31. **How does termination differ in bacteria and eukaryotes?**
32. **What occurs during RNA processing?**
33. **What is a 5' cap?**
34. **What is a poly-A tail?**
35. **What are the function of the 5' cap and the poly-A tail?**
36. **What are UTRs?**
37. **What is RNA splicing?**
38. **What are the average lengths of primary RNA transcript and proteins?**
39. **What are introns?**
40. **What is the term for regions that are not introns?**

41. **What carries out pre-mRNA splicing?**
42. **What are ribozymes?**
43. **What is *Tetrahymena*?**
44. **What is alternative RNA splicing?**
45. **What are domains?**
46. **What is exon shuffling?**
47. **What is the function and structure of tRNA?**
48. **What correctly matches tRNA and amino acids?**
49. **What is wobble?**
50. **How are ribosomes manufactured?**
51. **What are tetracycline and streptomycin?**
52. **What are the 3 binding sites for mRNA?**
53. **What is the exit tunnel?**
54. **What is the first step of translation?**
55. **What is the second step of translation?**
56. **In what direction are proteins synthesized?**
57. **Describe the three stages of the elongation stage of translation.**
58. **How long does each elongation cycle take?**
59. **What occurs in termination?**
60. **What may be required after termination?**
61. **What determines whether a ribosome is free or bound?**
62. **What is the difference between polypeptides targeted to endomembrane organelles and those that are not?**
63. **What are polyribosomes (polysomes)?**
64. **What are mutations?**
65. **What are point mutations?**
66. **What is familial cardiomyopathy?**
67. **What is a nucleotide-pair substitution?**
68. **What is a mutation that has no observable effect on the phenotype called?**
69. **What are missense mutations?**
70. **What are nonsense mutations?**
71. **What are frameshift mutations?**
72. **What are spontaneous mutations?**
73. **What are agents that cause mutations called?**
74. **What are cancer-causing chemicals called?**

Chapter 17 Answers

1. Process by which DNA directs synthesis of proteins
2. Disease that causes black urine because it contains chemical called alkapton (darkens upon exposure to air). Most people have enzyme to break it down.
3. Gene dictates production of specific enzyme
4. Haploid bread mold species
5. Medium with just enough nutrients for growth, medium with all nutrients needed for growth
6. Ornithine, Citrulline
7. tyrosinase, enzyme that produces melanin (dark pigment)
8. Every gene codes for a polypeptide
9. Transcription - synthesis of RNA using info in DNA.(messenger RNA, mRNA)
   Translation - synthesis of polypeptide using info in mRNA, occurs at ribosomes
10. Bacteria, no nucleus so transcription and translation can occur simultaneously
    Eukaryotic, pre-mRNA must be modified to make mRNA, then transported to cytoplasm
11. Primary transcript
12. Central dogma
13. Triplet code
14. template strand, same always used
15. Codons
16. Coding strand
17. AUG; UAA, UAG, UGA
18. See picture
19. It is how symbols (nucleotides) are grouped
20. Enzyme that pries two strands of DNA apart and joins together RNA nucleotides complementary to DNA template strand, can assemble only in 5'→3' direction, don't need pre-existing primer
21. promoter
22. terminator, diff in eukaryotes
23. Upstream = towards 5' , downstream = towards 3' (direction of transcription)
24. Bacteria have single, eukaryotes have at least 3 in nuclei (RNA pol II used for pre-mRNA synthesis, others transcribe RNA molecules not translated into protein)
25. Initiation, elongation, termination
26. Contains start point (nucleotide where RNA pol begins synthesis), extends several dozen nucleotides upstream of start point, RNA pol binds in precise location and orientation on promoter
27. proteins that mediate binding of RNA pol and initiation of transcription, attach to promoter to allow pol II to bind. Transcription factors + RNA polymerase + promoter = transcription initiation complex
28. Nucleotide sequence containing TATA about 25 nucleotides upstream from start point, transcription factors recognize box and bind to DNA

29. 10-20
30. 40 nucleotides per second
31. Bacteria: Transcribed terminator functions as termination signal, causes polymerase to detach and release transcript (requires no further modification before translation) Eukaryotes: RNA pol II transcribed sequence on DNA called polyadenylation signal sequence, specifies polyadenylation signal (AAUAAA) in pre-mRNA, bound by proteins in nucleus immediately after it appears, at point 10-35 nucleotides downstream from AAUAAA, the proteins cut RNA transcript free from polymerase. Pre-mRNA undergoes processing. RNA pol II continues to transcribe, enzymes degrade RNA at exposed 5' end until reach polymerase and cause it to dissociate from DNA
32. both ends of primary transcript are altered, certain interior sections of RNA molecule are cut out and remaining parts are spliced together
33. Modified form of guanine (G) nucleotide added on to 5' end after transcription of first 20-40 nucleotides
34. Sequence of 50-250 more adenine (A) nucleotides at 3' end
35. Facilitate export of mature mRNA from nucleus, protect mRNA from degradation by hydrolytic enzymes, help ribosomes attach to 5' end of mRNA once the mRNA reaches cytoplasm
36. untranslated regions at 5' and 3' ends of mRNA (5' UTR and 3' UTR, parts of mRNA that will not be translated into protein)
37. Large portions of RNA molecules are removed and remaining portions are reconnected.
38. 27,000 nucleotides, 400 amino acids
39. Intervening sequences, noncoding sequences that are between coding sequences
40. exons, sequences of RNA that leave nucleus (and DNA counterparts)
41. Large complex made of proteins and small RNAs called spliceosome, binds to short nucleotide sequences along intron (which is then released and rapidly degraded) and splices together the exons that flanked introns
42. RNA molecules that function as enzymes, in some organisms, intron RNA catalyzes its own excision
43. Ciliate protist where self-splicing occurs
44. Genes giving rise to different polypeptides depending on what are considered exons
45. Discrete structural and functional regions of proteins
46. Introns increase probability of crossing over between the exons of alleles of gene
47. Transfer amino acid to growing polypeptide of ribosome, 4 base-paired regions and 3 loops (looks like clover), base sequence of amino acid attachment site at 3' end, single RNA strand about 80 nucleotides long, loop extending from other end of L called anticodon (written 3'→5', codons 5'→3')
48. family of enzymes called aminoacyl-tRNA synthetases, active site fits only specific combination of amino acid and tRNA, 20 types, catalyzes covalent attachment of amino acid to tRNA in process driven by ATP hydrolysis (results in aminoacyl tRNA, aka charged tRNA). Charged tRNA released from enzyme
49. Flexible base pairing at third codon position (3' end on mRNA)

50. Consists of large/small subunit made up of proteins and one or more rRNAs (ribosomal). Subunits made in nucleolus in eukaryotes. rRNA genes transcribed, RNA processed and assembled with proteins imported from cytoplasm, subunits exported via nuclear pores to cytoplasm (in bacteria/eukaryotes, large and small subunit join to form functional ribosome only when attached to mRNA molecule). ⅓ mass of ribosome is proteins, rest consists of 3 rRNA in bacteria (4 in eukaryotes), rRNA is most abundant RNA
51. Antibiotic drugs that inactivate bacterial ribosomes without affecting eukaryotic ones
52. Peptidyl-tRNA binding site (P site) - holds tRNA carrying growing polypeptide chain
    Aminoacyl-tRNA binding site (A site) - holds tRNA carrying next amino acid
    Exit site (E site) - where discharged tRNAs leave ribosome
    All in large subunit
53. Place where polypeptide leaves large subunit, connected to P site
54. small subunit binds to mRNA and specific initiator tRNA that carries methionine (in bacteria, order doesn't matter, subunit binds mRNA at specific RNA sequence just upstream of AUG codon)(in eukaryotes, small subunit, with initiator tRNA already bound, binds to 5' cap of mRNA and scans downstream until it reaches start codon, which initiator binds to) Initiator starts in P site
55. Large ribosomal subunit attaches to complete translation initiation complex, proteins called initiation factors required to bring all components together. Cell uses hydrolysis of GTP to form initiation complex.
56. At amino end of polypeptide is the initial methionine.
57. See picture
58. 1/10 of a second
59. When stop codon reaches A site, release factor (protein shaped like aminoacyl tRNA binds directly to stop codon in A site, causes addition of water molecule instead of amino acid to polypeptide chain, breaking bond between completed polypeptide and the tRNA in the P site.Translation assembly comes apart in multistep process, requires hydrolysis of two more GTP molecules
60. Post-translational modifications, certain amino acids may be chemically modified or amino acids may be removed from amino end of polypeptide, polypeptide may be cleaved into pieces, multiple polypeptides may come together
61. Bound and free are identical/interchangeable, polypeptide synthesis always begins in cytosol. Polypeptides of proteins destined for endomembrane system/secretion marked by signal peptide (targets protein to ER, sequence of 20 amino acids near N-terminus, recognized by protein-RNA complex called signal-recognition particle, SRP). SRP escorts ribosome to receptor protein in ER membrane and part of multiprotein translocation complex. Polypeptide synthesis continues, polypeptide moves into ER lumen. If to be secreted, enters completely, if to be in membrane, becomes embedded (signal peptide is removed by pore)
62. If targeted to non-endomembrane organelles, completed in cytosol before polypeptide is imported to organelle
63. String of multiple ribosomes simultaneously translating the same mRNA
64. Changes to genetic information of cell

65. small-scale mutations, changes in single nucleotide pair
66. Heart condition caused by point mutation, responsible for sudden death in young athletes
67. Replacement of nucleotide and partner with another pair of nucleotides
68. silent mutation
69. Substitutions that change one amino acid to another one
70. Point mutation that can change codon for amino acid into stop codon, usually lead to nonfunctional proteins
71. Mutations that change the grouping of nucleotides into codons (insertions/deletions)
72. Mutations where nucleotide base is incorrectly paired and not proofread (about 1 in 10^{10} altered)
73. Mutagens; nucleotide analogs (chemical mutagens) are similar to normal nucleotides but pair incorrectly during DNA replication; other chemical muts insert themselves in DNA and distort double helix; others cause changes in bases that change pairing
74. carcinogens