Chapter 14: From DNA to Protein
Steps from DNA to Proteins

Same two steps produce all proteins:

1) DNA is transcribed to form RNA
   - Occurs in the nucleus
   - RNA moves into cytoplasm

2) RNA is translated in ribosomes to form polypeptide chains, which fold to form proteins
Three Classes of RNAs

- **Messenger RNA (mRNA)**
  - Carries protein-building instruction

- **Ribosomal RNA (rRNA)**
  - Major component of ribosomes

- **Transfer RNA (tRNA)**
  - Delivers amino acids to ribosomes
A Nucleotide Subunit of RNA

Fig. 14-2, p. 220
Fig. 14-2a, p.220
Fig. 14-2b, p.220

phosphate group

base (thymine)

sugar (deoxyribose)
Base Pairing during Transcription

DNA

A C T C

RNA

U G A G

base pairing during transcription

DNA

A C T C

DNA

T G A G

base pairing during DNA replication
Transcription & DNA Replication

• Like DNA replication
  – Nucleotides added in 5’ to 3’ direction

• Unlike DNA replication
  – Only small stretch is template
  – Product is a single strand of RNA
  – RNA polymerase catalyzes nucleotide addition
Promoter

- A base sequence in the DNA that signals the start of a gene
- For transcription to occur, RNA polymerase must first bind to a promoter
a RNA polymerase initiates transcription at a promoter region in DNA. It recognizes a base sequence located next to the promoter as a template. It will link the nucleotides adenine, cytosine, guanine, and uracil into a strand of RNA, in the order specified by DNA.

**Promoter**

RNA polymerase, the enzyme that catalyzes transcription
b All through transcription, the DNA double helix becomes unwound in front of the RNA polymerase. Short lengths of the newly forming RNA strand briefly wind up with its DNA template strand. New stretches of RNA unwind from the template (and the two DNA strands wind up again).
c What happened at the assembly site? RNA polymerase catalyzed the assembly of ribonucleotides, one after another, into an RNA strand, using exposed bases on the DNA as a template. Many other proteins assist this process.
d At the end of the gene region, the last stretch of the new transcript is unwound and released from the DNA template. Shown below is a model for a transcribed strand of RNA.
Transcript Modification

unit of transcription in a DNA strand

- exon
- intron
- exon
- intron
- exon

transcription into pre-mRNA

- cap
- snipped out
- snipped out
- poly-A tail

mature mRNA transcript
Genetic Code

- Set of 64 base triplets
- Codons
- 61 specify amino acids
- 3 stop translation

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Fig. 14-6, p.222
Genetic Code

DNA

mRNA
codons

mRNA

threonine
proline
glutamate
lysine

amino acids

Fig. 14-5, p.222
tRNA Structure

codon in mRNA

anticodon

amino-acid attachment site

amino acid

OH

Figure 14.7
Page 223
tRNA Structure

- codon in mRNA
- anticodon in tRNA
- amino acid

Fig. 14-7, p.223
Ribosomes

small ribosomal subunit + large ribosomal subunit → intact ribosome

Fig. 14-8, p.223
Three Stages of Translation

Initiation

Elongation

Termination
Initiation

- Initiator tRNA binds to small ribosomal subunit
- Small subunit/tRNA complex attaches to mRNA and moves along it to an AUG “start” codon
- Large ribosomal subunit joins complex
Binding Sites

binding site for mRNA

$P$ (first binding site for tRNA)

$A$ (second binding site for tRNA)
Elongation

- mRNA passes through ribosomal subunits
- tRNAs deliver amino acids to the ribosomal binding site in the order specified by the mRNA
- Peptide bonds form between the amino acids and the polypeptide chain grows
Elongation
Termination

• Stop codon into place
• No tRNA with anticodon
• Release factors bind to the ribosome
• mRNA and polypeptide are released
What Happens to the New Polypeptides?

• Some just enter the cytoplasm

• Many enter the endoplasmic reticulum
Overview

Transcription
- mRNA
- rRNA
- tRNA

Translation
- Mature mRNA transcripts
- Ribosomal subunits
- Mature tRNA

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a A mature mRNA transcript leaves the nucleus through a pore in the nuclear envelope.

b Initiation, the first stage of translating mRNA, will start when an initiator tRNA binds to a small ribosomal subunit.

c Initiation ends when a large and small ribosomal subunit converge and bind together.

d The initiator tRNA binds to the ribosome.

e One of the rRNA molecules

Fig. 14-9a-e, p.224
f The first tRNA is released.
g A third tRNA binds with the next codon.
h Steps f and g are repeated.

Termination:
i A STOP codon moves into the area where the chain is being built.
j The new polypeptide chain is released from the ribosome.
k The two ribosomal subunits now separate, also.
http://www.stolaf.edu/people/giannini/flashanimat/molgenetics/translation.swf

http://www.youtube.com/watch?v=5bLEDd-PSTQ

http://learn.genetics.utah.edu/content/begin/dna/transcribe/
Gene Mutations

Base-Pair Substitutions

Insertions

Deletions
Frameshift Mutations

• Insertion
  – Extra base added into gene region

• Deletion
  – Base removed from gene region

• Both shift the reading frame

• Result in many wrong amino acids
Base-Pair Substitution

During replication, proofreading enzymes make a substitution within the triplet (red).

Possible outcomes:

- Original, unmutated sequence
- A gene mutation
Frameshift Mutation

Part of DNA template

mRNA transcribed from DNA

Resulting amino acid sequence

Base substitution in DNA

Altered mRNA

Altered amino acid sequence

Deletion in DNA

Altered mRNA

Altered amino acid sequence

Fig. 14-10, p.226
Mutagens

• Ionizing radiation (X rays)

• Nonionizing radiation (UV)

• Natural and synthetic chemicals
Ionizing Radiation

Fig. 14-12, p.227
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