Lecture # 11

Gene Expression

Gene Regulation

Exam Review

Grading and the exam

Class mean = 79 points, good job!

Totals so far = ~355 points available.

Class average total = 265 points (~74%)

Some of you should talk to me at the end of class or during break.

Gene Expression & Regulation

Given what we know about DNA replication, DNA is an obvious way to pass genetic information on to the next generation (of cells or individuals).

How do we turn information in DNA into observable phenotypes??

How do cells respond to different environmental,physiological, or developmental conditions?

Beadle and Tatum

One Gene, One Enzyme Hypothesis

Neurospora - a mold

Mostly haploid during its life cycle, so all genes are expressed (no dominance/incomplete dominance etc)

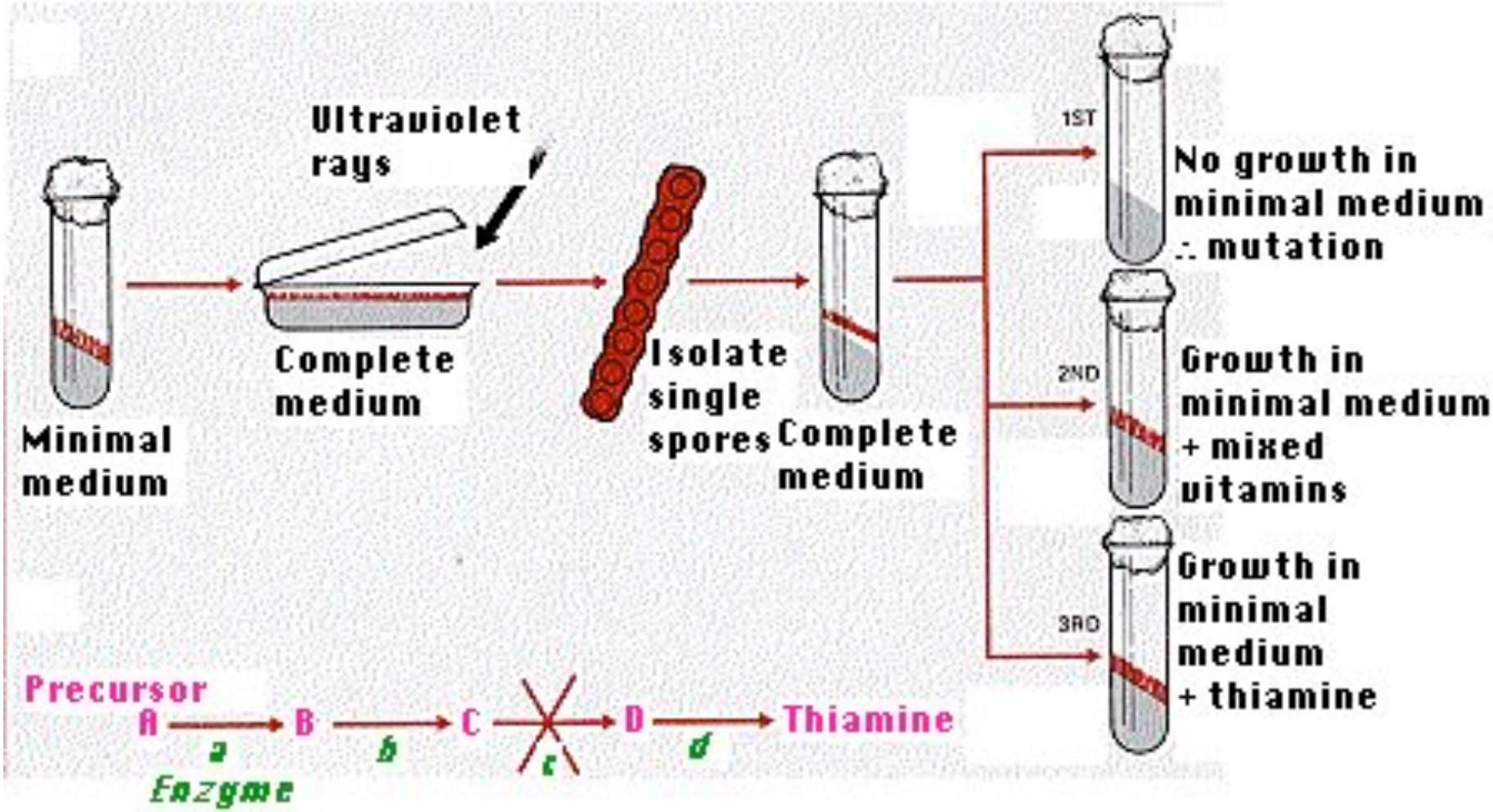
Normal *Neurospora* can make almost all the amino acids, vitamins it needs when grown on sugar, salt and biotin.

Experimental Design

Step 1 - irradiate *Neurospora* spores (U.V. or Xrays cause mutations in DNA)

Step 2 - grow spores on *complete* media (supplemented with all necessary amino acids, vitamins etc)

Step 3 - grow spores derived from 2 on incomplete media (leaves out various combinaitons of vitamins, amino acids)



http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/N/Neurospora.html

We do not believe in the strict form of the One Gene One Enzyme Hypothesis anymore, Why?

Structural proteins are affected

Some enzymes are made up of multiple polypeptides

Gene regulation

The Central Dogma

(another idea that isn't *quite* true)

DNA makes RNA,
RNA makes Protein

Major Players in Protein Synthesis (nouns)

DNA

RNA

mRNA (transcript)

tRNA

Amino Acids

Codons/Anticodons

RNA polymerase

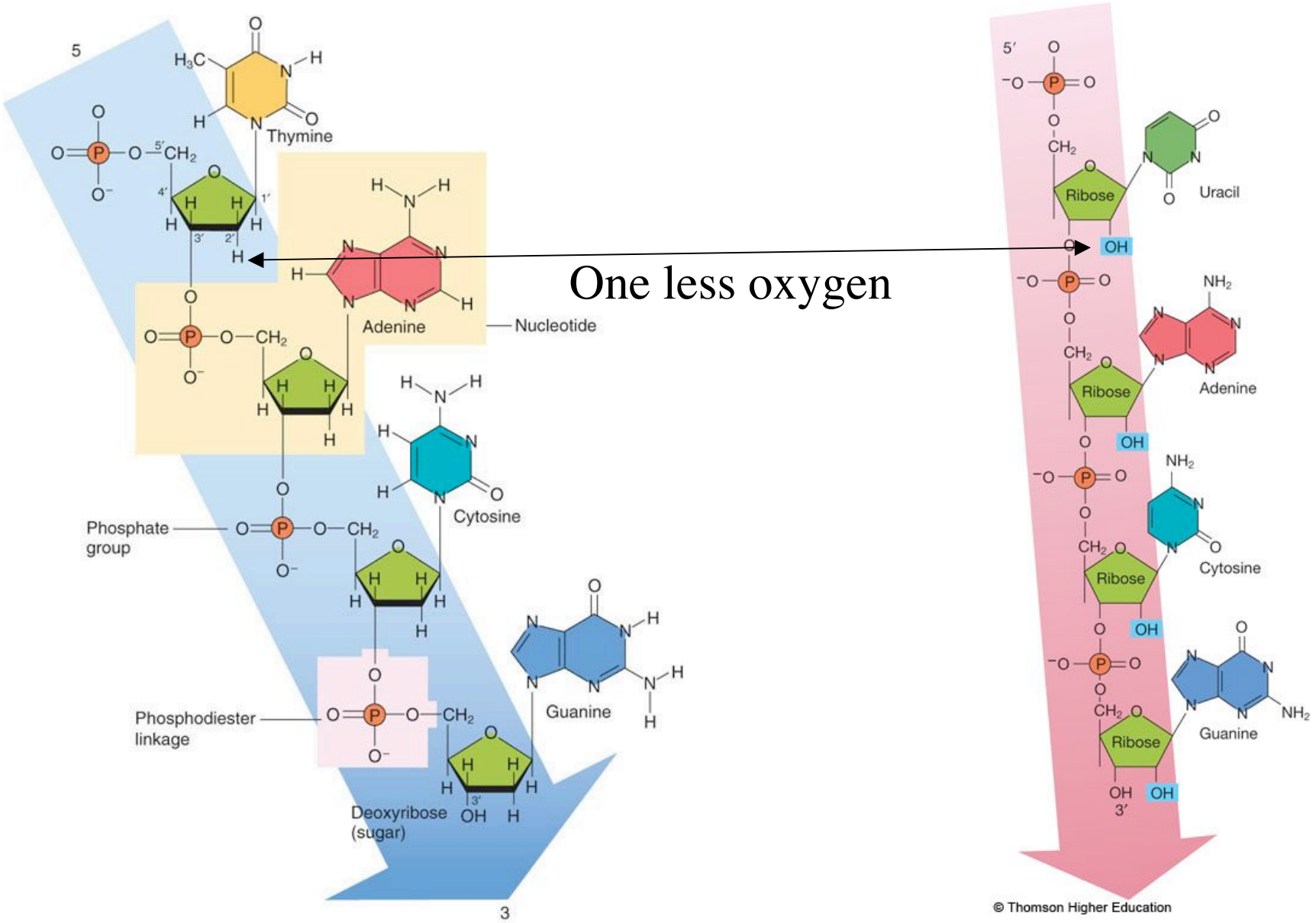
Ribosomes

The Genetic Code

Major Processes in Protein Synthesis (verbs)

Transcription
Translation
Initiation
Elongation
Termination

DNA vs RNA


One less oxygen
5
Thymine
Adenine
Nucleotide
Cytosine
Phosphate group
Guanine
Phosphodiester linkage
Deoxyribose (sugar)
3
5′
Uracil
Ribose
OH
Adenine
Cytosine
Guanine
3′
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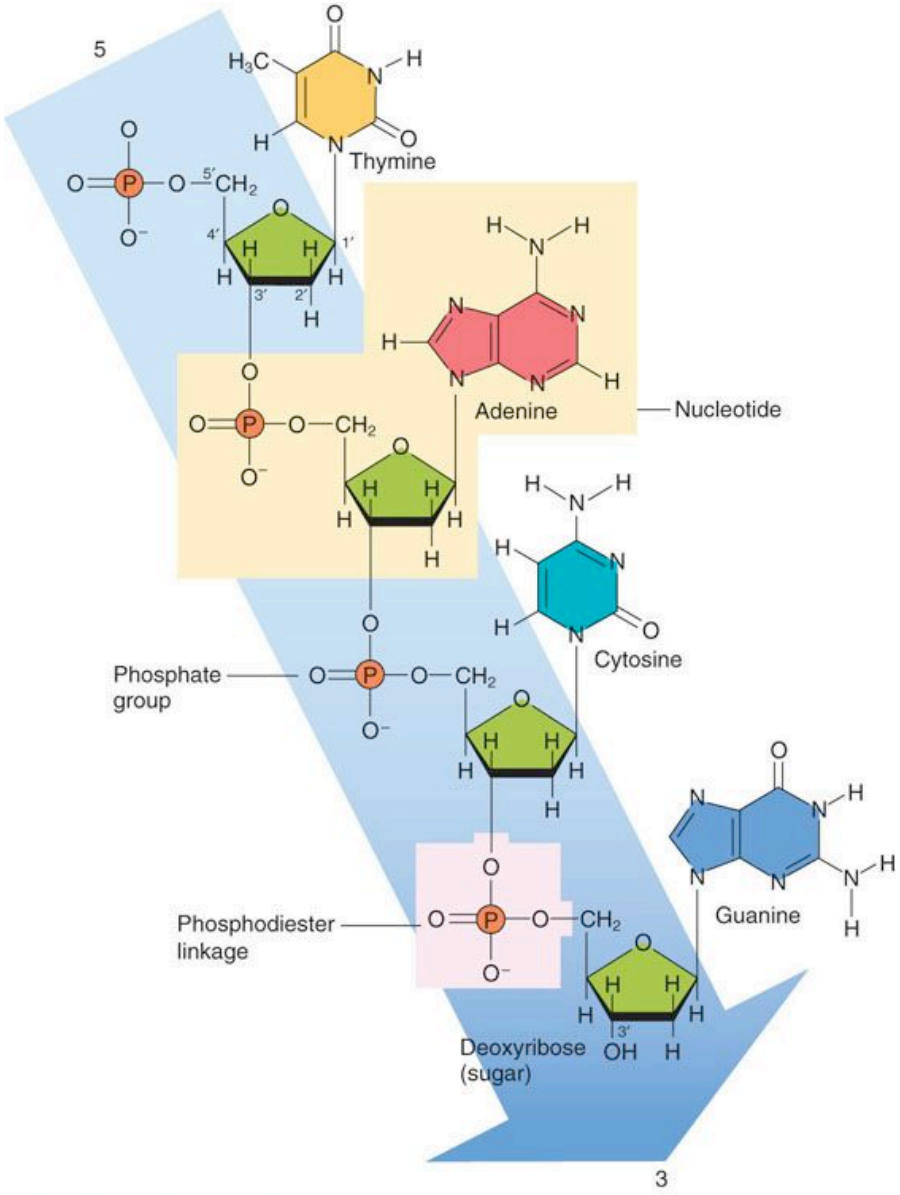
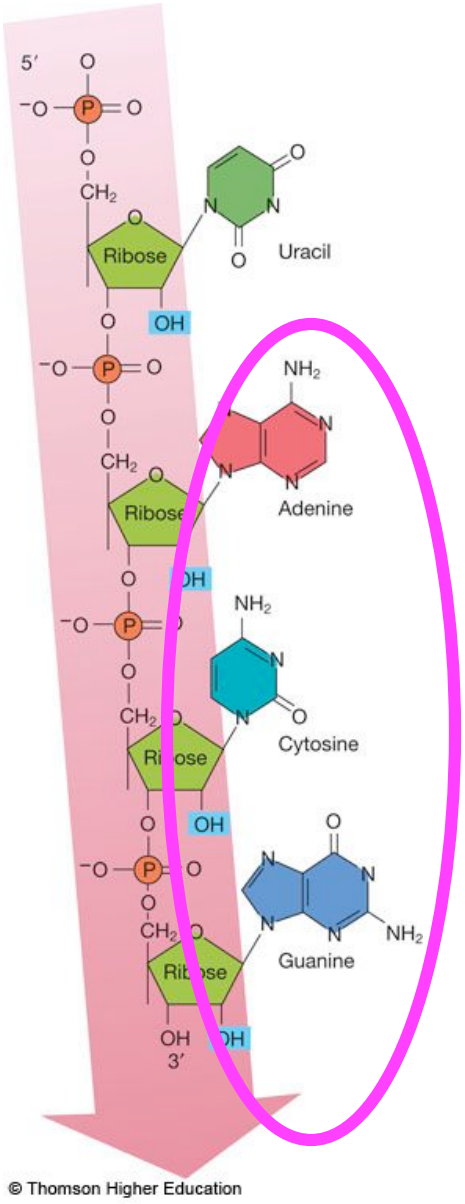
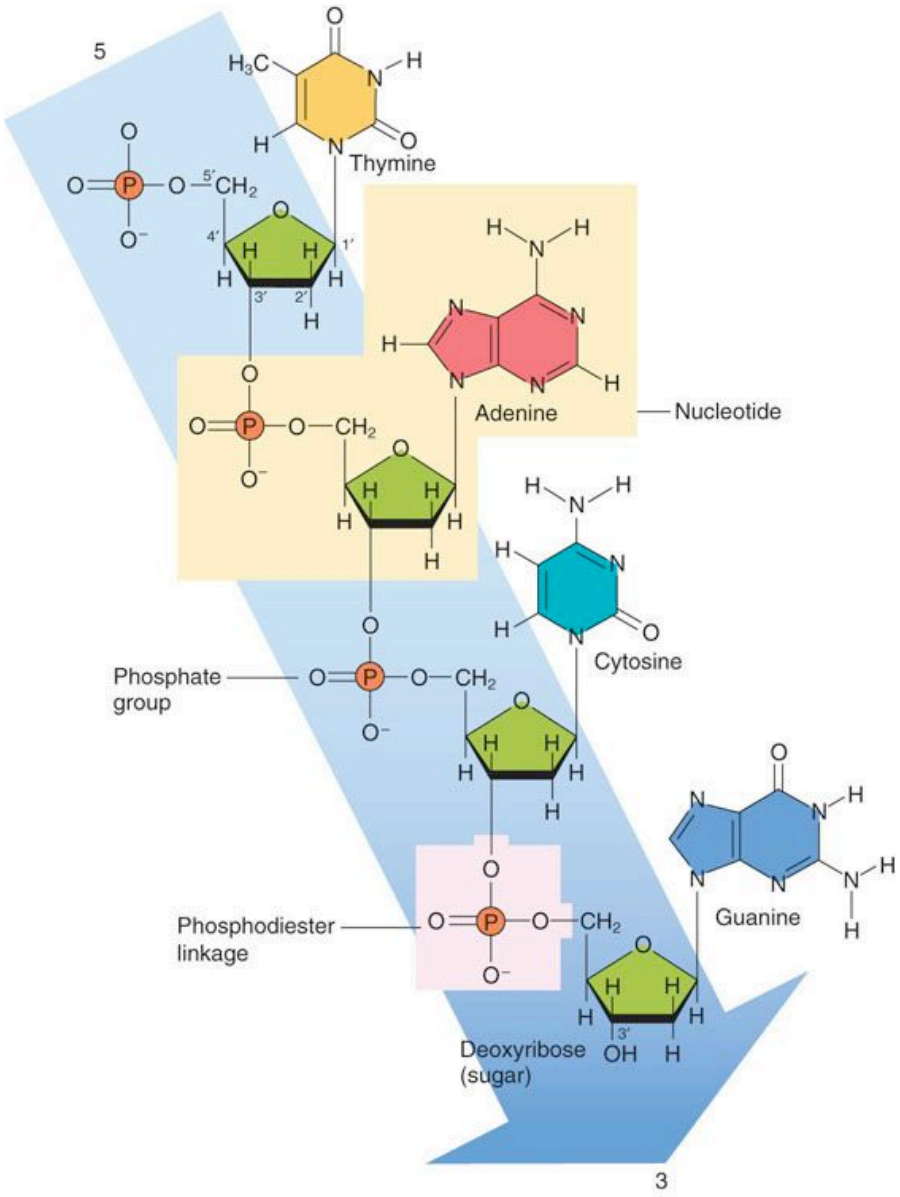
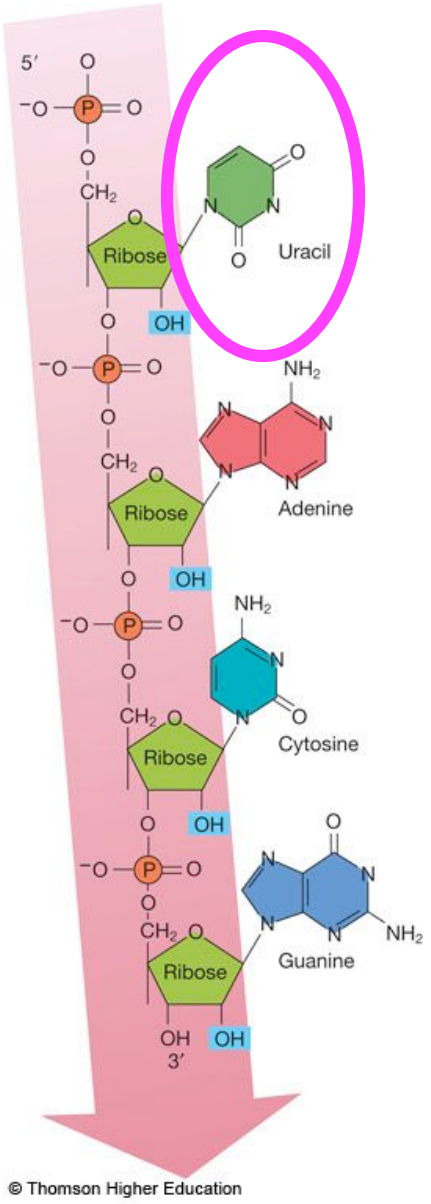
DNA vs RNA





DNA vs RNA





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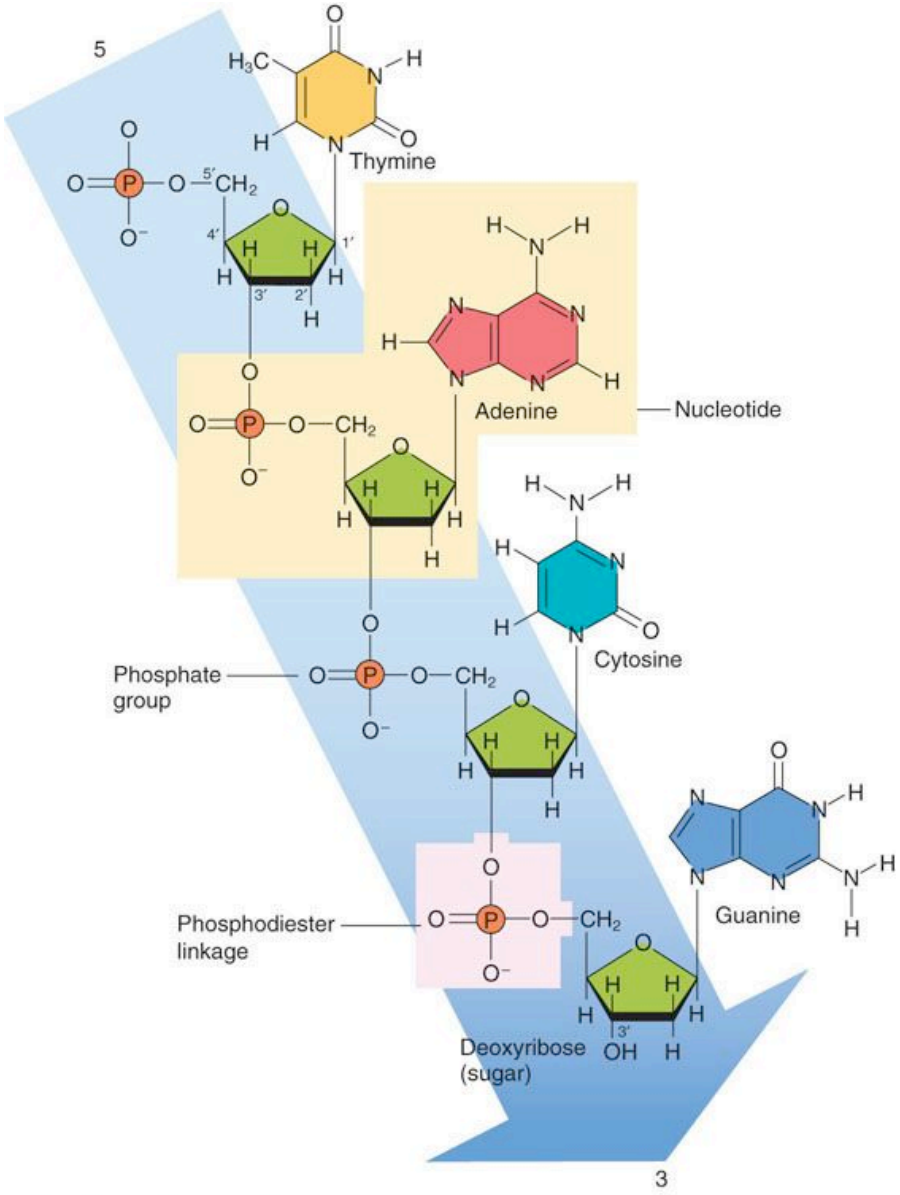
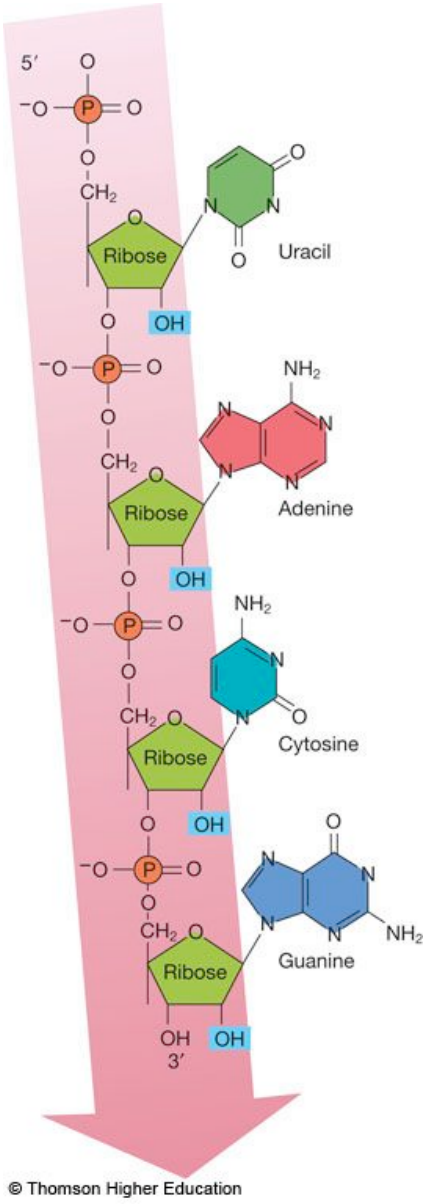
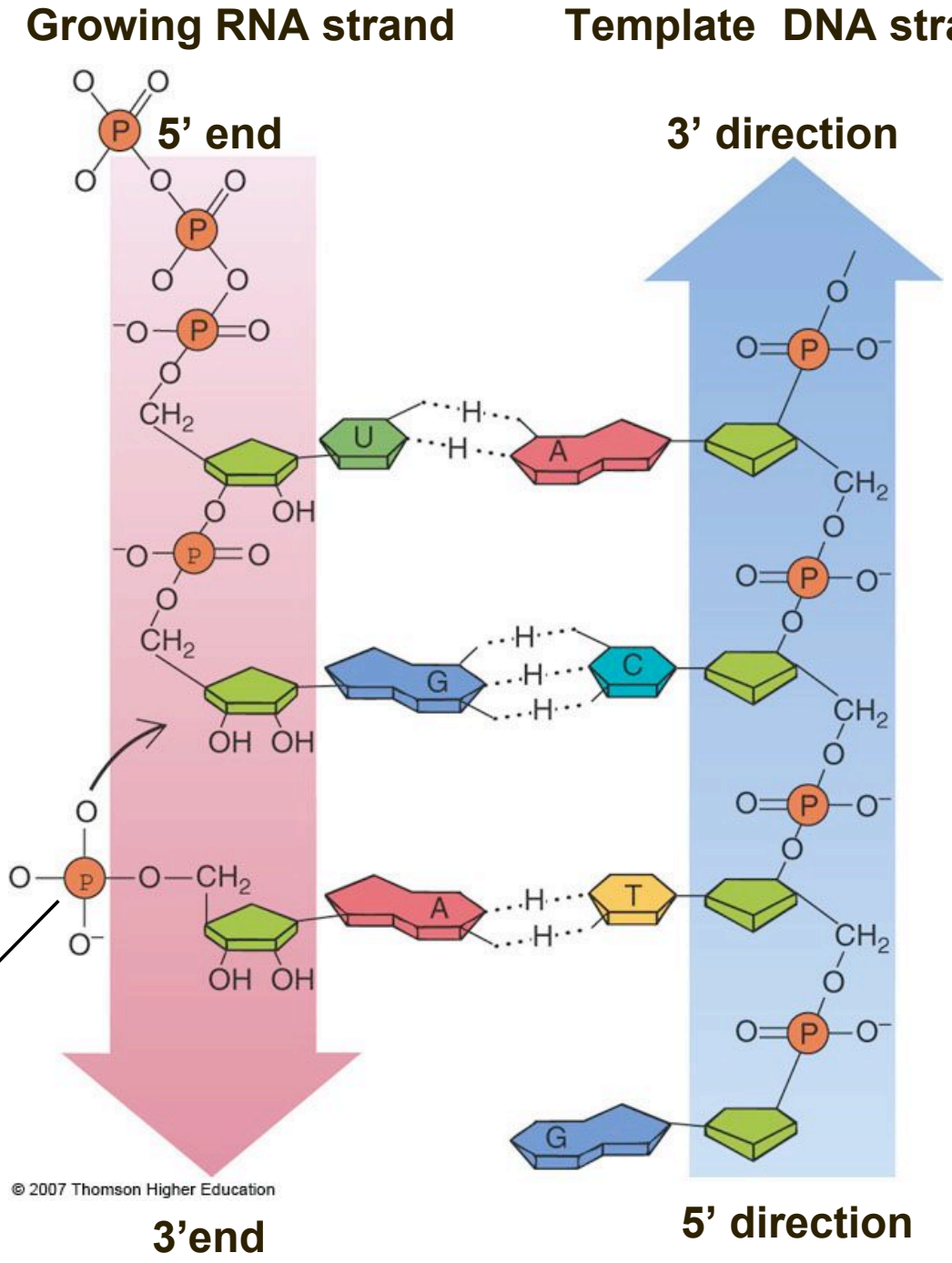


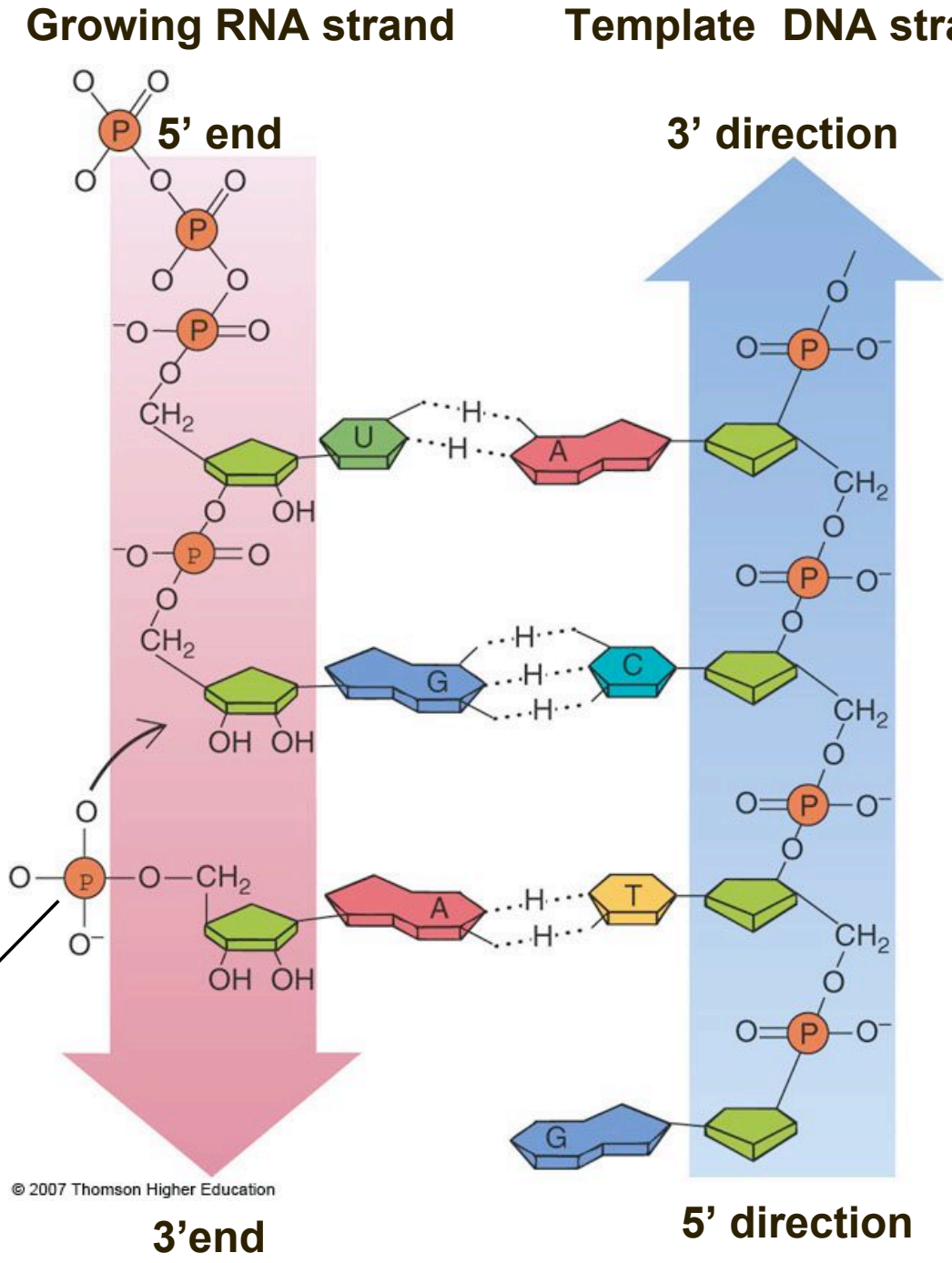


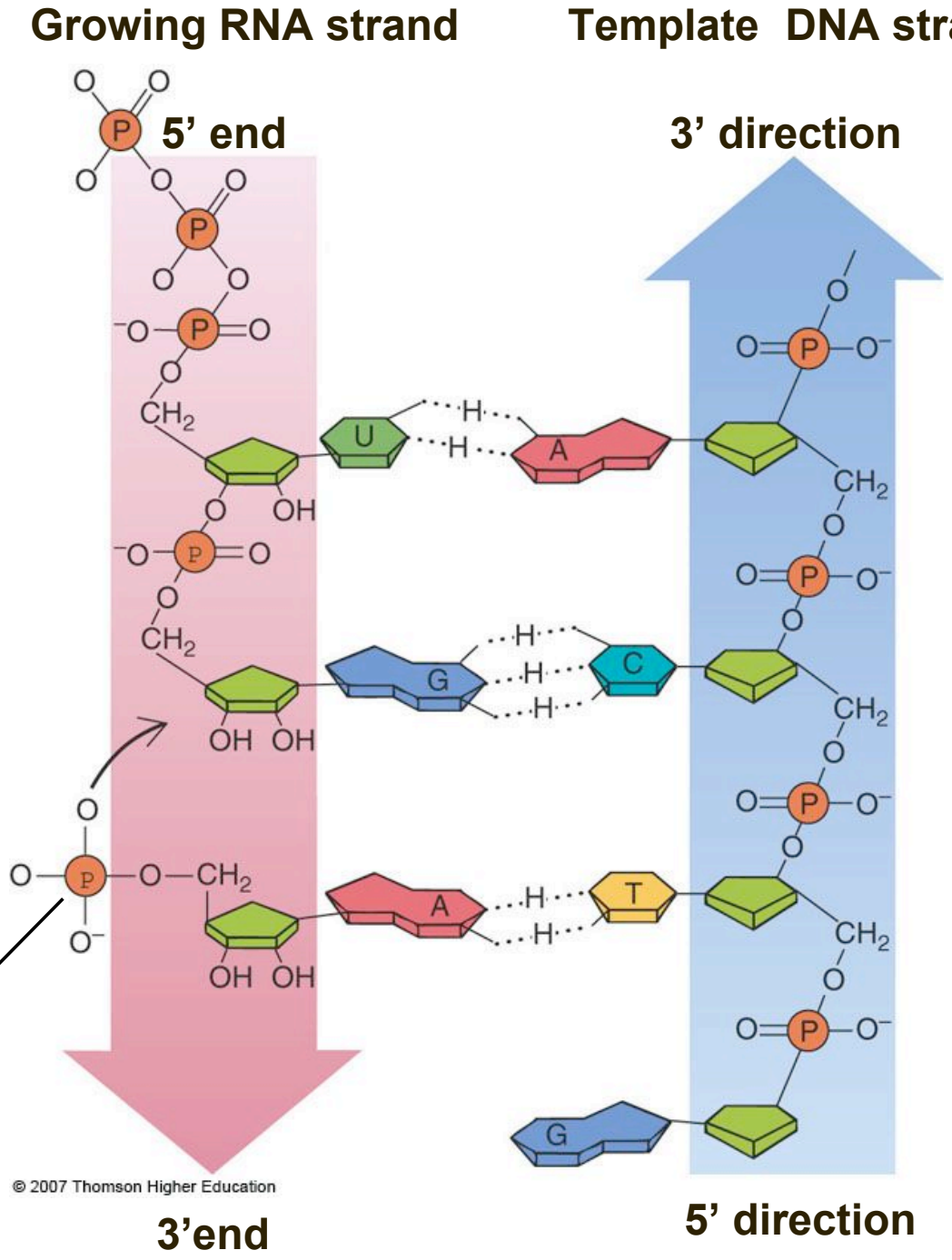
DNA can serve as a template for RNA synthesis



DNA can serve as a template for RNA synthesis

(= Transcripton!!)

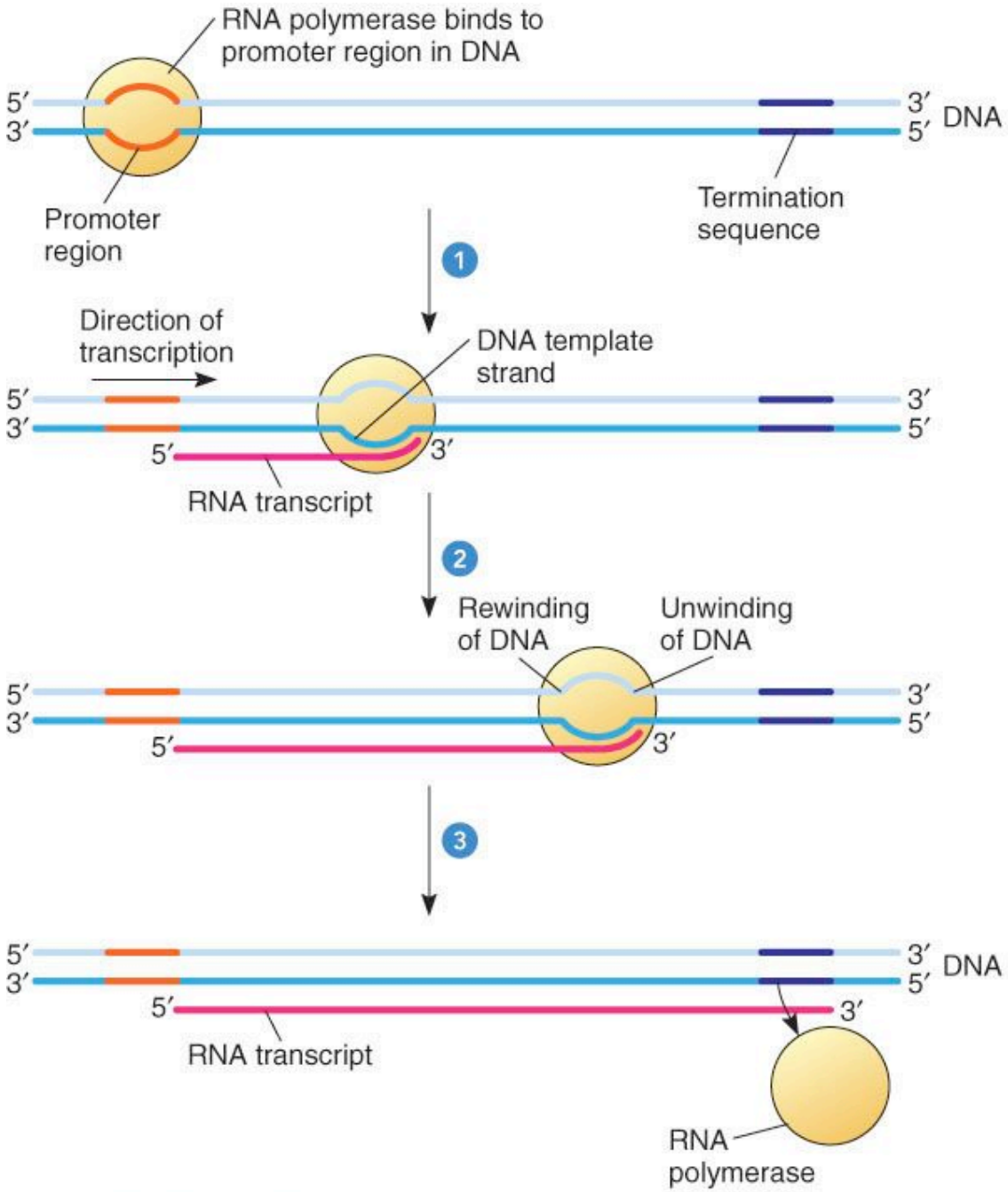




U-A

G-C

Fig. 13-7, p. 286



1 **Initiation.** RNA polymerase unwinds DNA double helix and initiates RNA synthesis.

2 **Elongation.** Additional nucleotides are added to the 3′ end of RNA molecule. DNA double helix re-forms following transcription.

3 **Termination.** RNA polymerase recognizes termination sequence. RNA transcript and RNA polymerase are released.

Fig. 13-8, p. 287

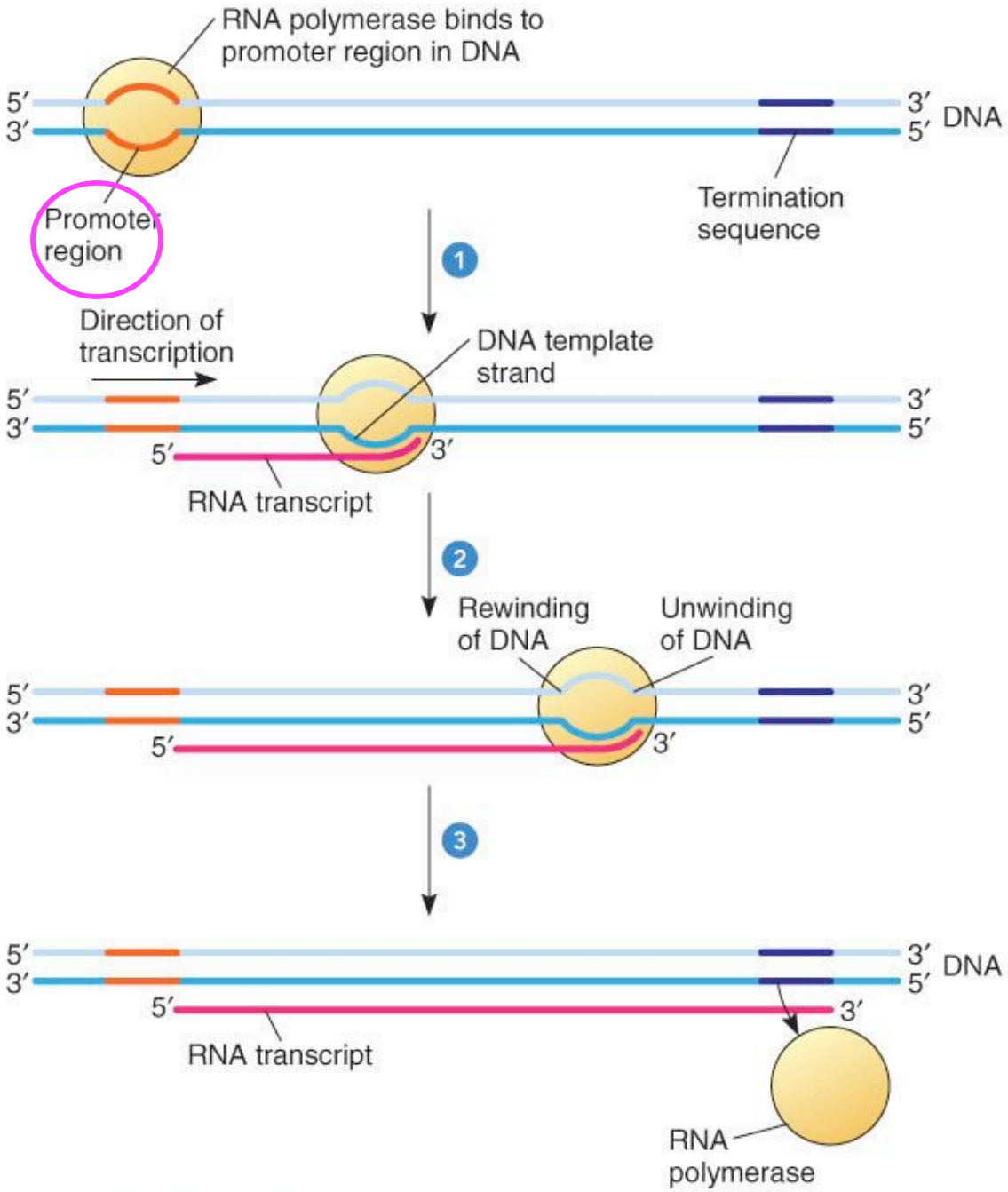


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Fig. 13-8, p. 287

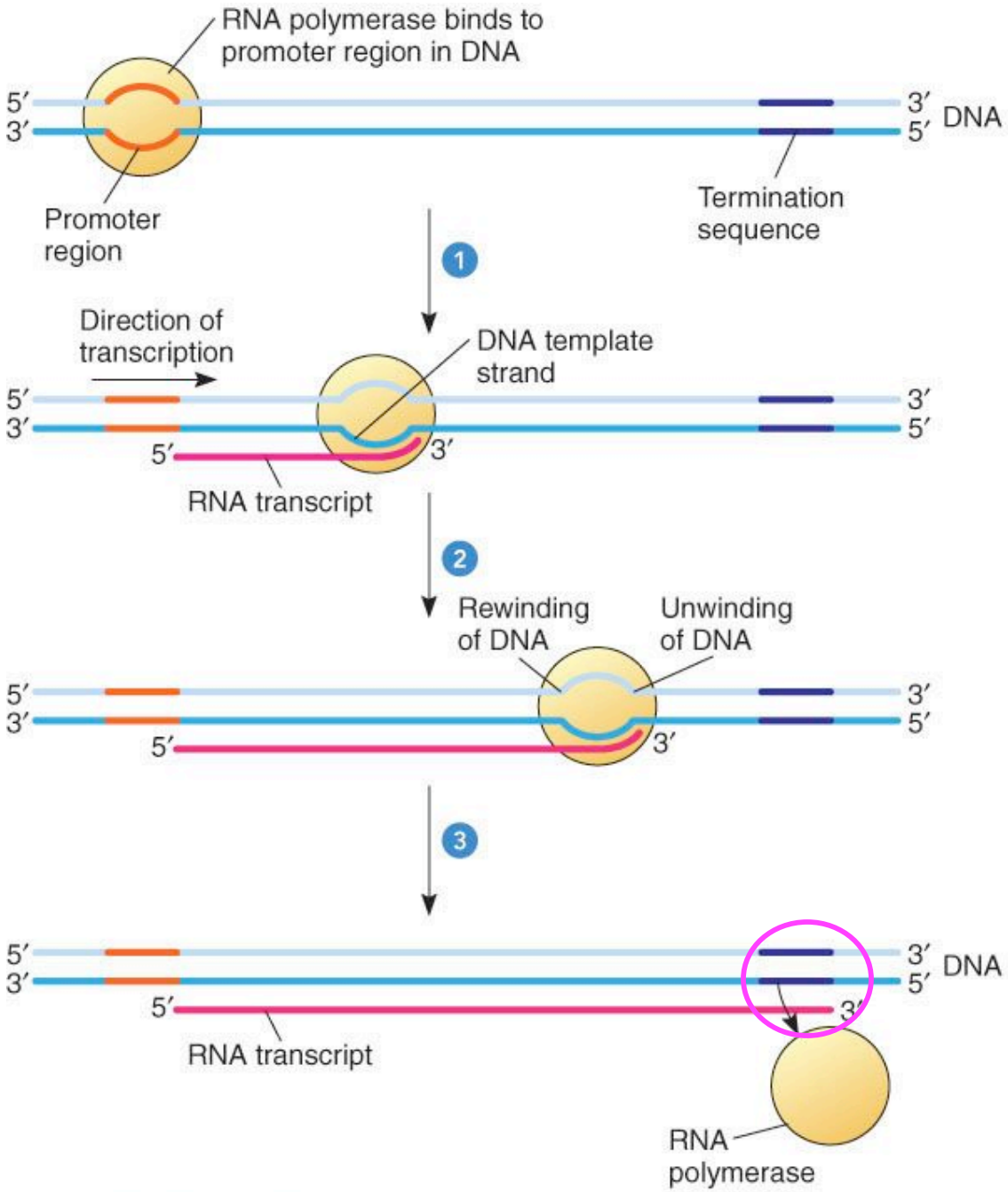

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Fig. 13-8, p. 287

Transcripton

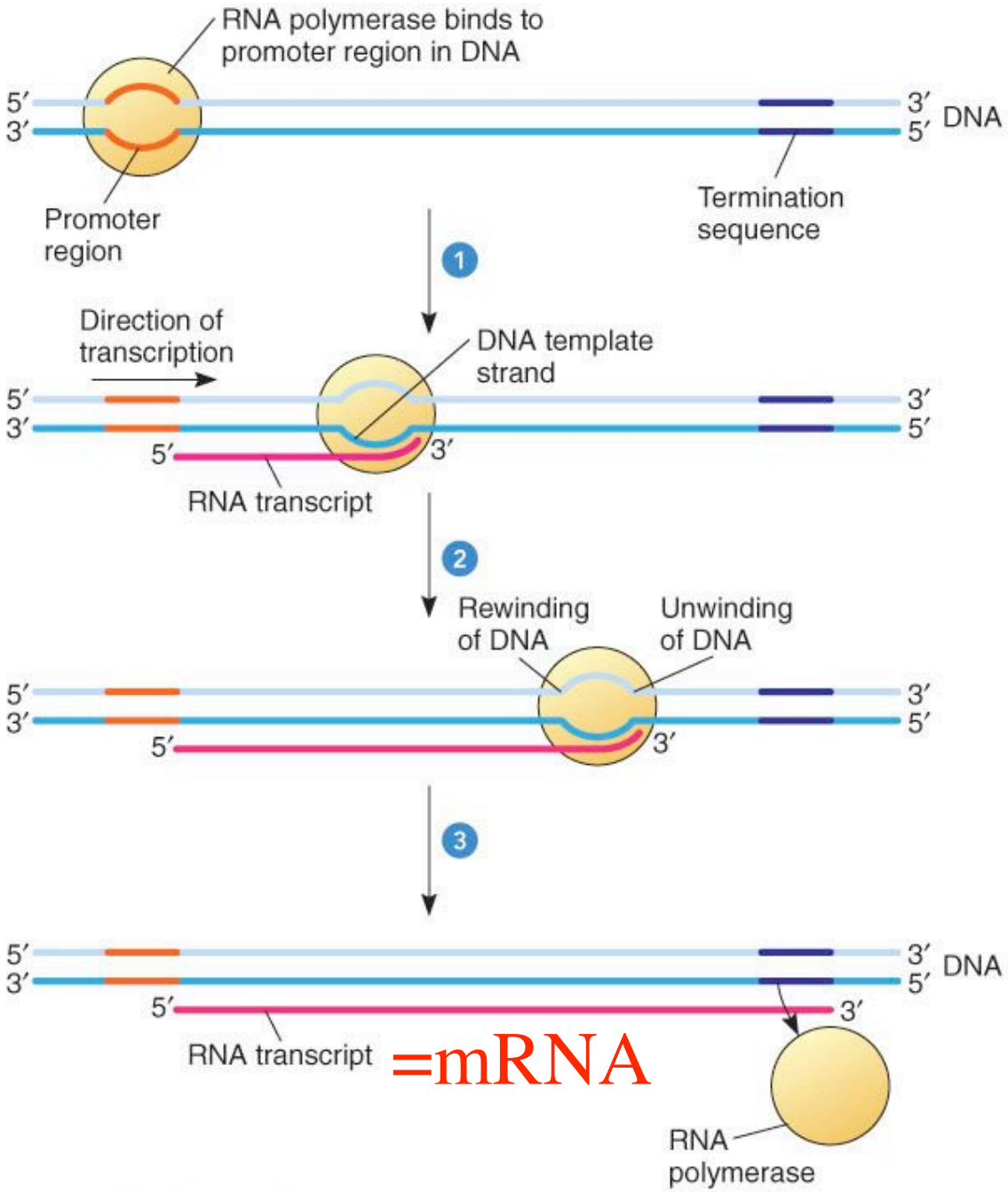

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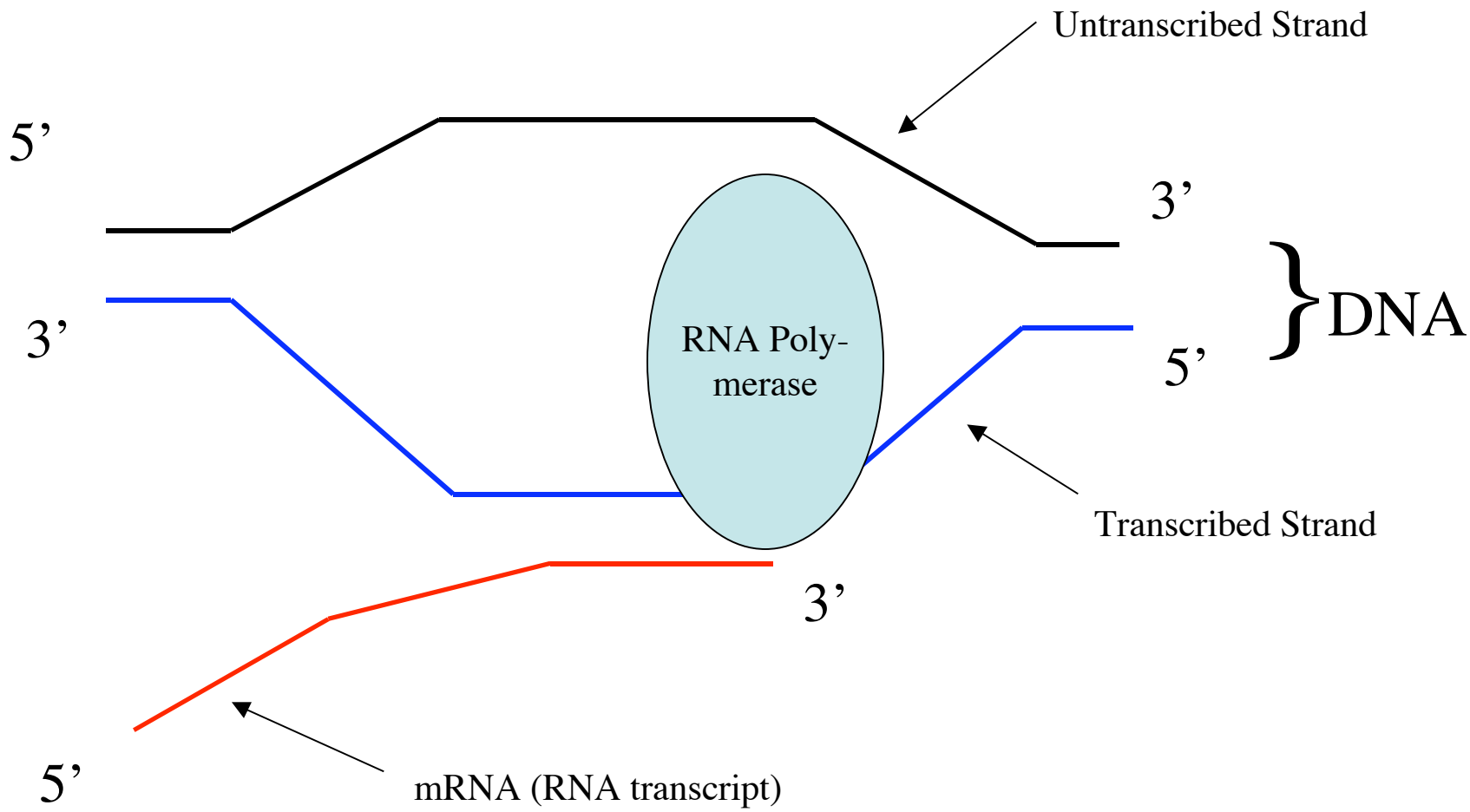
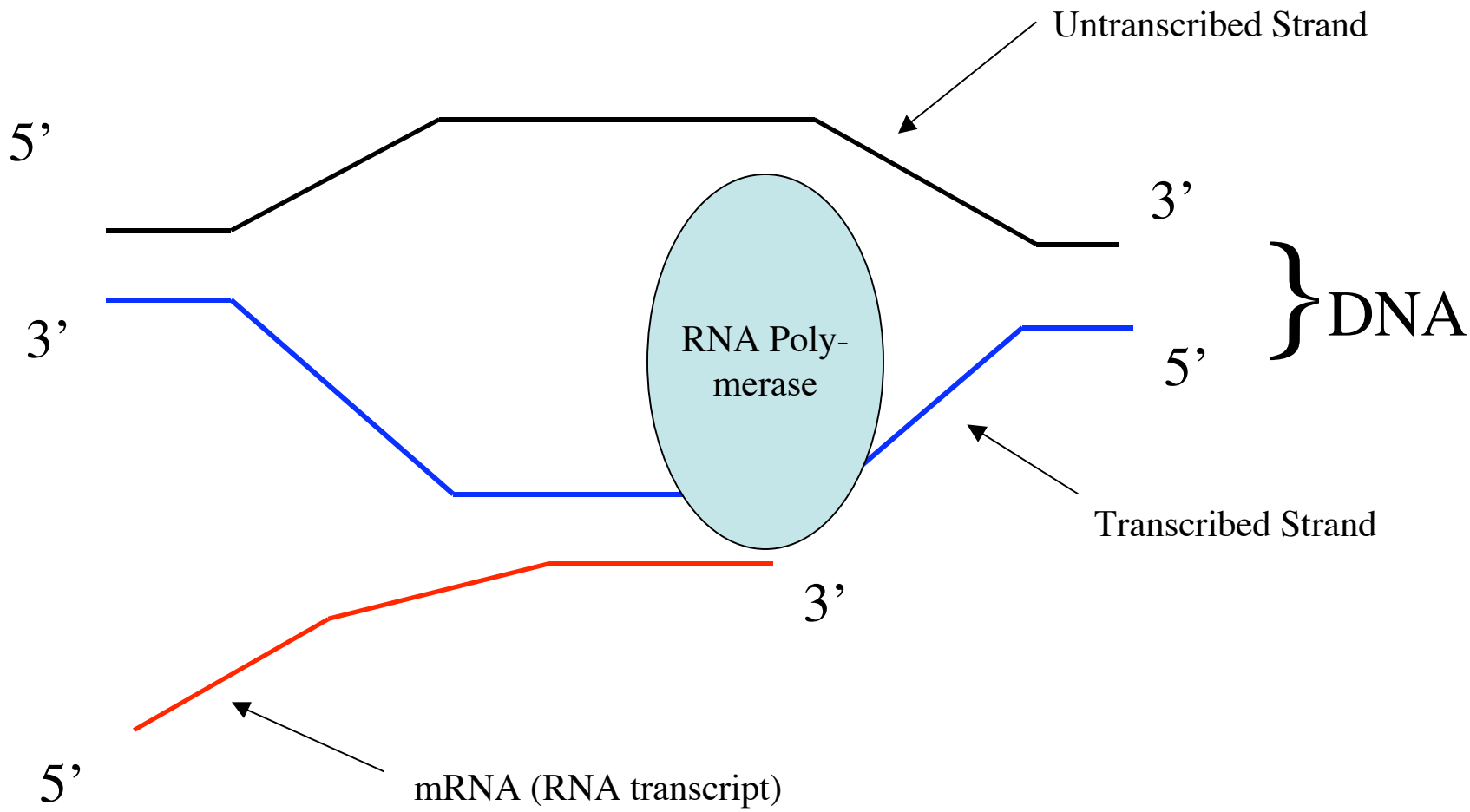
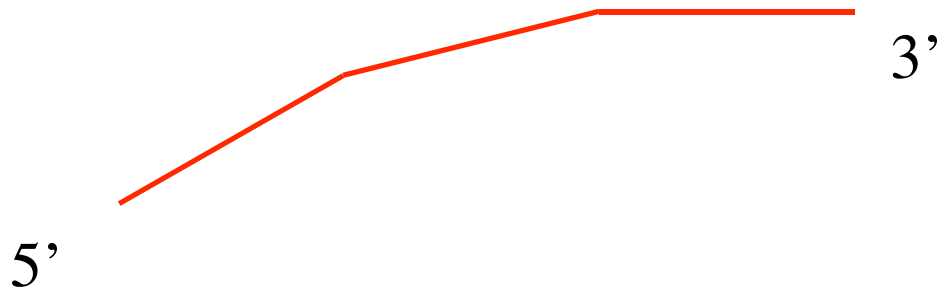
Fig. 13-8, p. 287

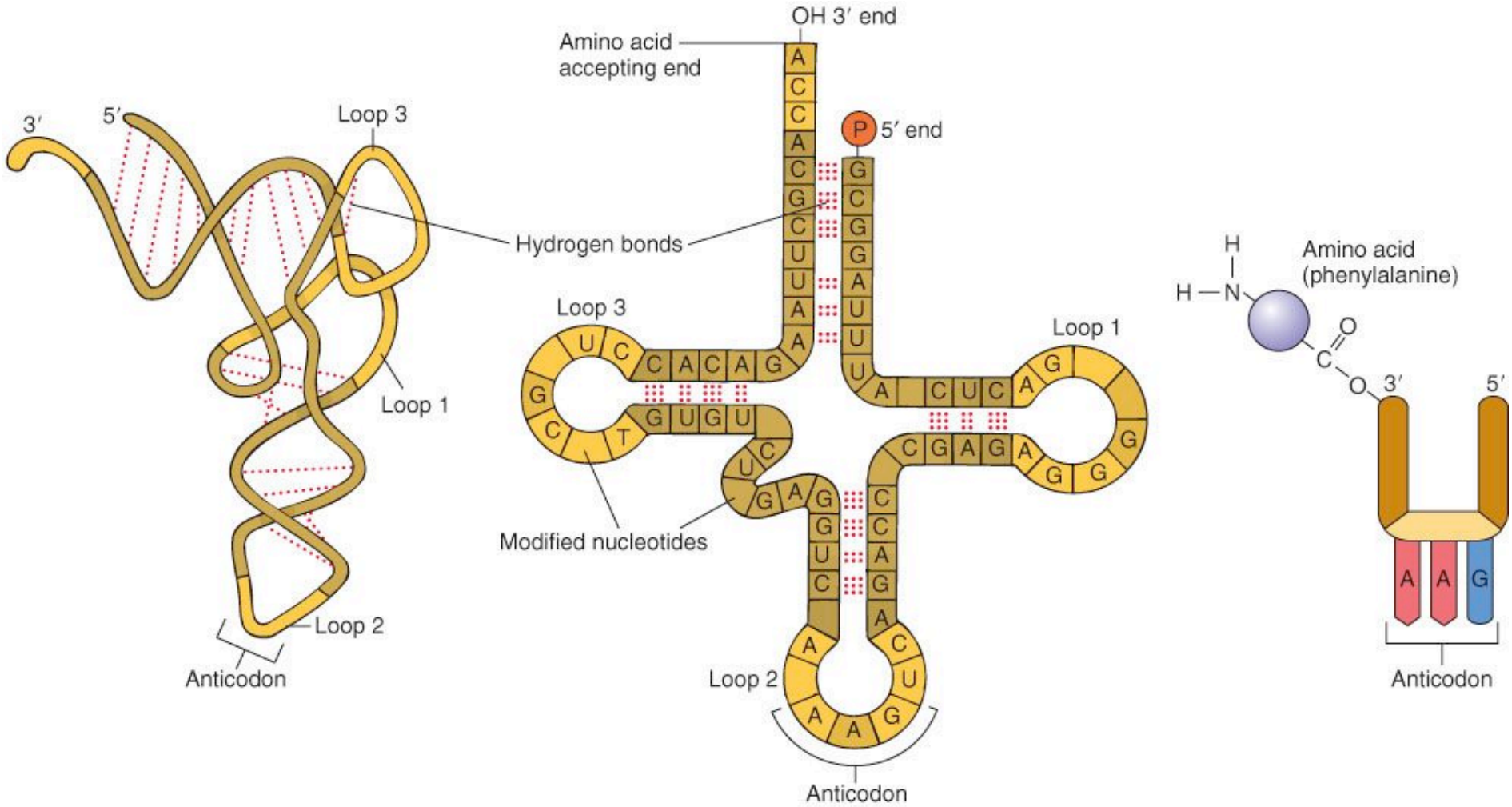

Untranscribed Strand
5’
3’
3’
RNA Poly-
merase
}DNA
5’
Transcribed Strand
3’
5’
mRNA (RNA transcript)



All of this happens in the Nucleus (eukaryotes)

The mRNA passes out of the nucleus and interacts with tRNA and rRNA and various enzymes





(a) The 3-D shape of a tRNA molecule is determined by hydrogen bonds formed between complementary bases.

(b) One loop contains the anticodon; these unpaired bases pair with a complementary mRNA codon. The amino acid attaches to the terminal nucleotide at the hydroxyl (OH) 3′ end.

(c) This stylized diagram of an aminoacyl-tRNA shows that the amino acid attaches to tRNA by its carboxyl group, leaving its amino group exposed for peptide bond formation.

Fig. 13-6, p. 285

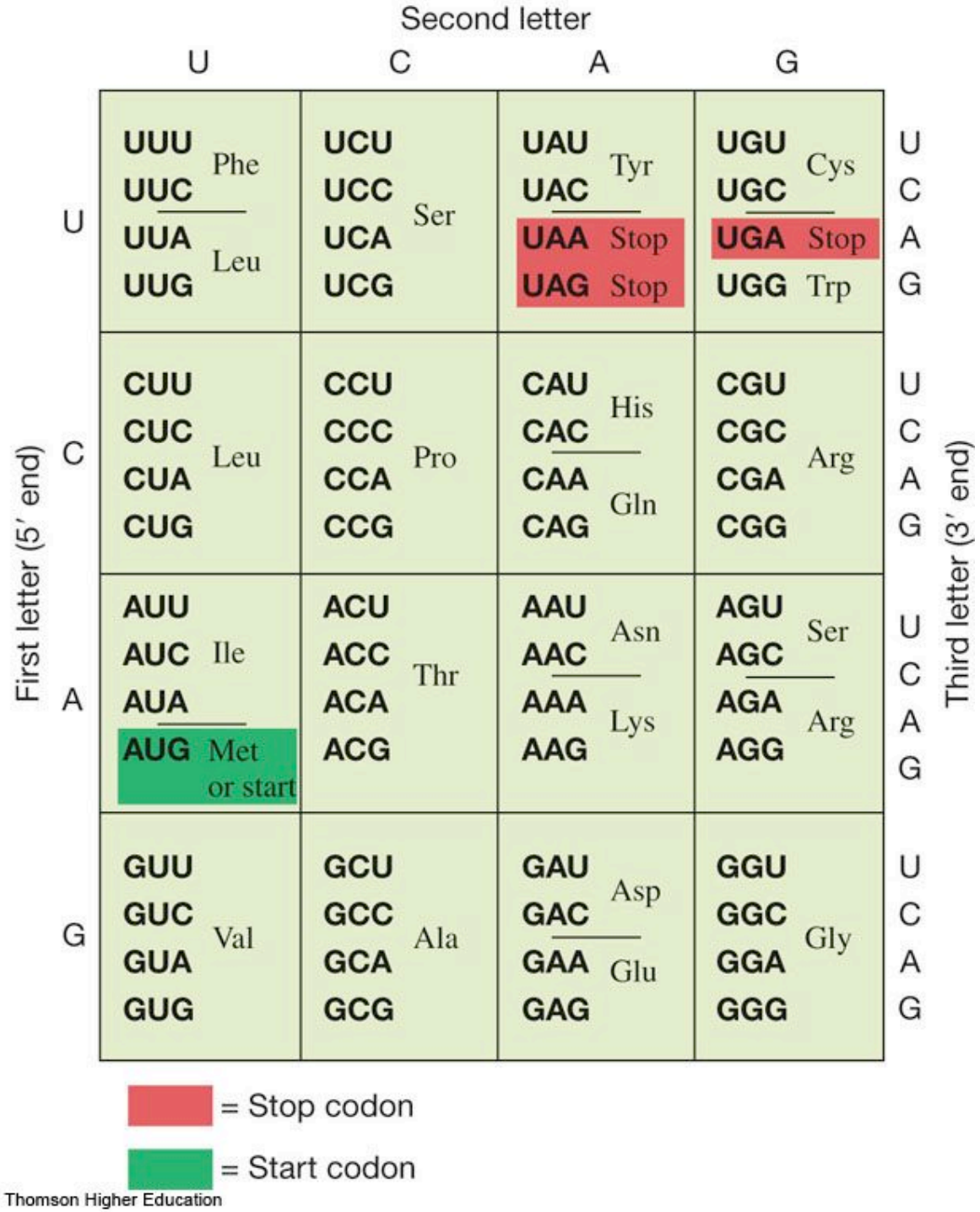


Fig. 13-5, p. 284

Ribosomes - A complex of protein and rRNA - found along the rough endoplasimic reticulum in eukaryotes

Responsible for taking the information in mRNA and turning it into amino acid (protein) sequences

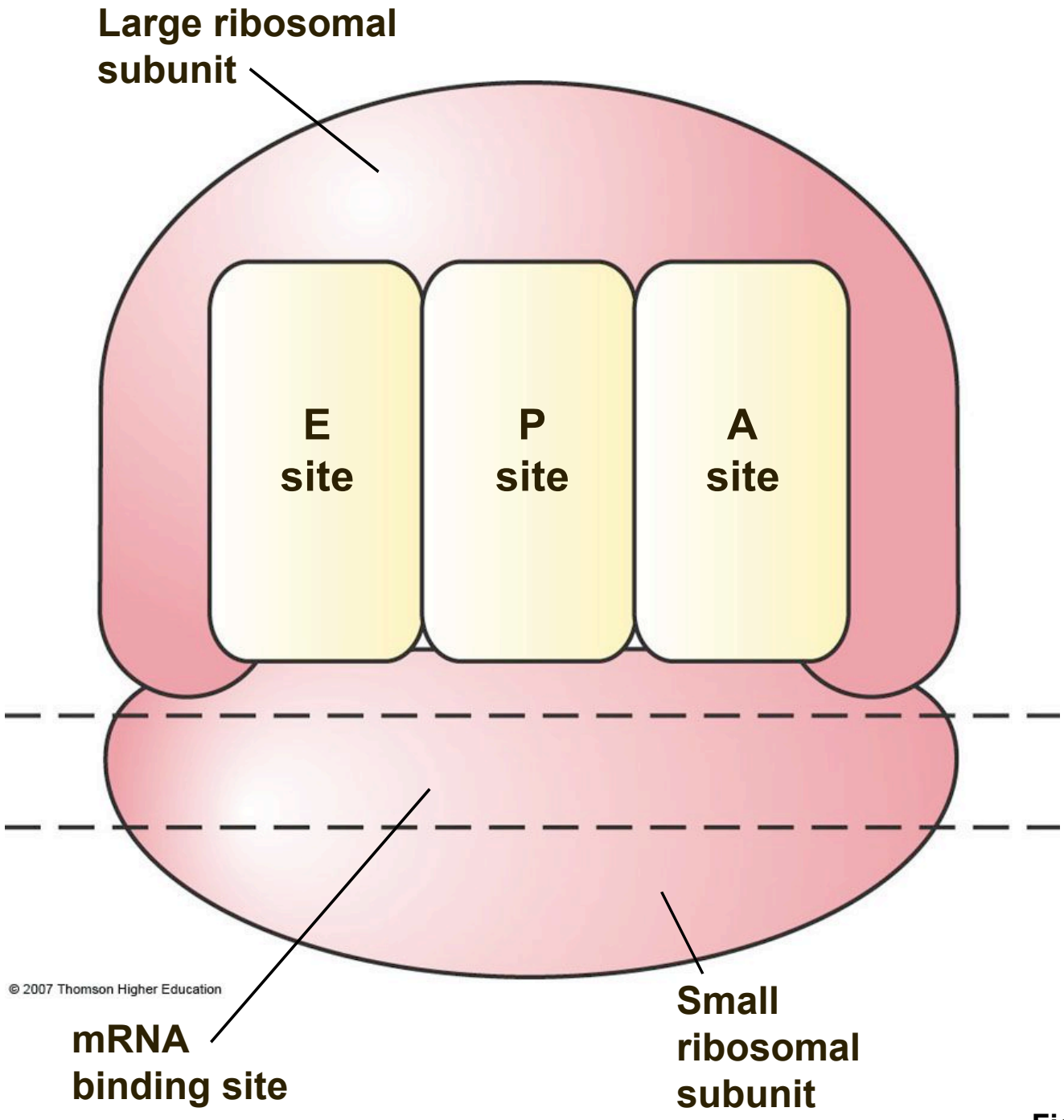
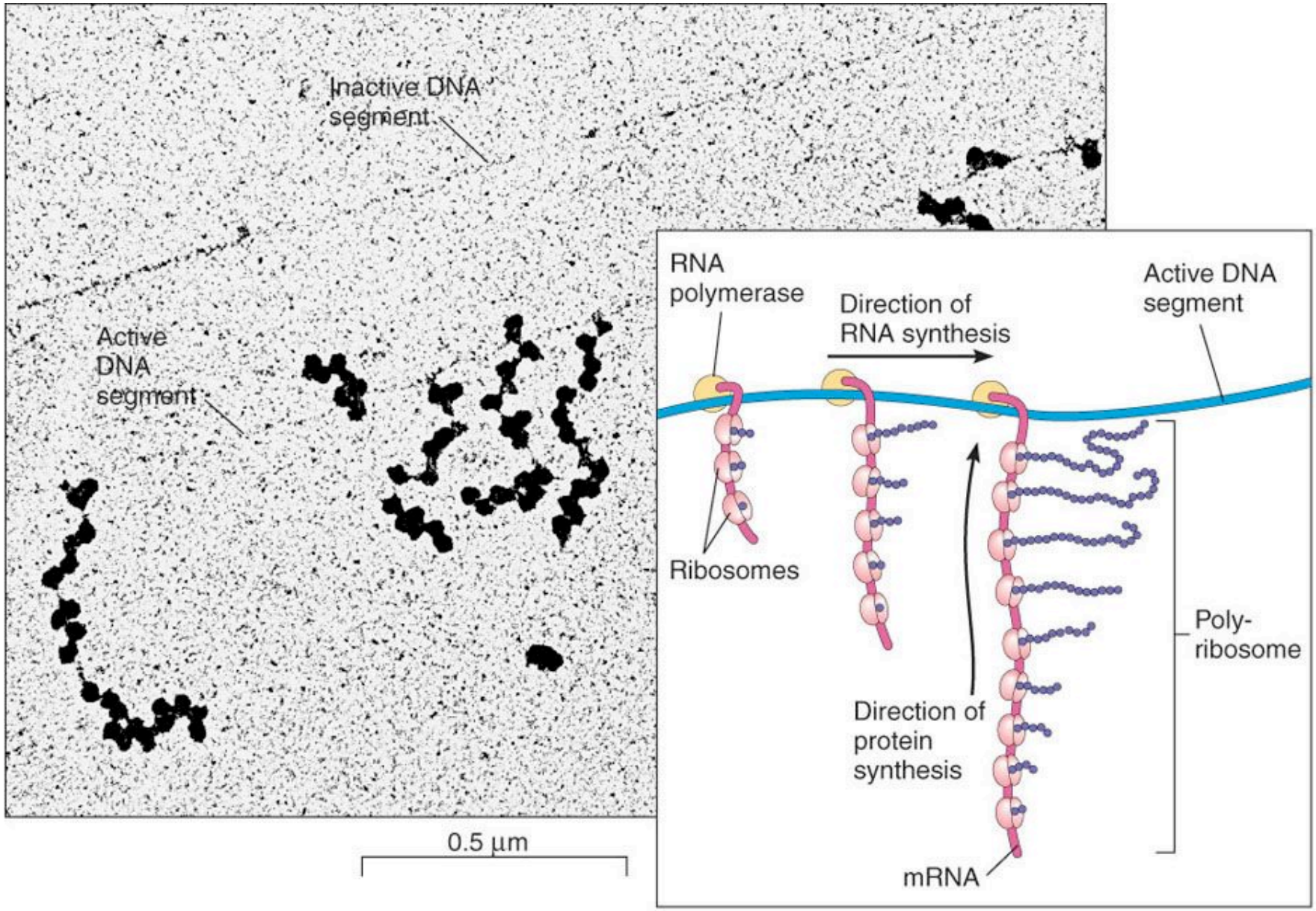


Fig. 13-12b, p. 290



(a) This TEM shows two strands of *E. coli* DNA, one inactive and the other actively producing mRNA. Protein synthesis begins while the mRNA is being completed.

(b) A sequence (*left to right*) of coupled transcription and translation. Note that several ribosomes translate each mRNA molecule simultaneously.

Fig. 13-16, p. 294

Summary -

RNA polymerase makes an RNA transcript
of a specific gene

The transcript enters the cytoplasm (RER)

Ribosomes attach, tRNA's grab amino acids and bring them to the ribosomal complex, where they are strung together.

Class Exercise,

then….

Mutations….

Different classes of mutations…

- Base substitutions
  - missense
  - nonsense
- Frame-shift mutations
  - nonsense
  - altered amino acid sequence

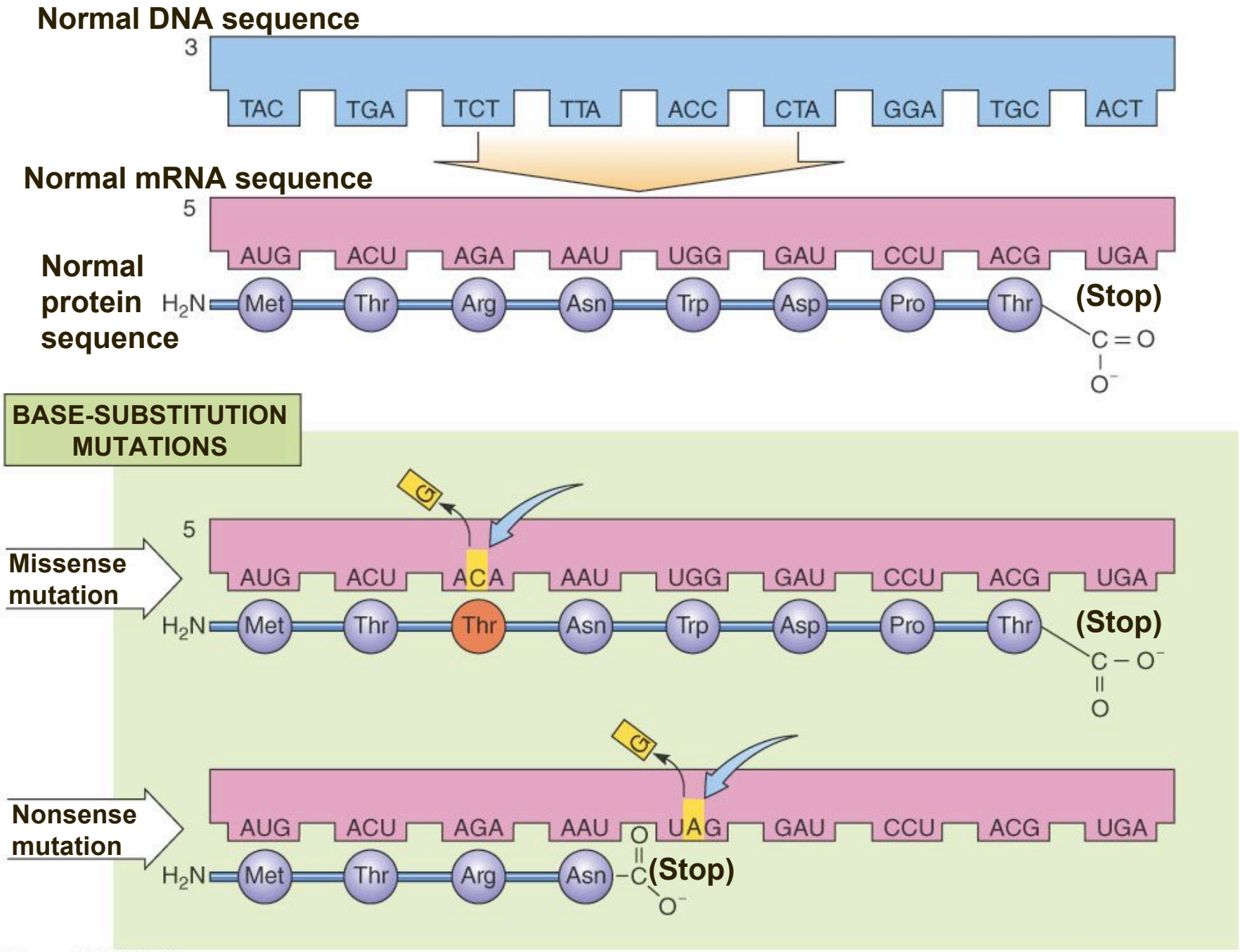


Fig. 13-20a, p. 299

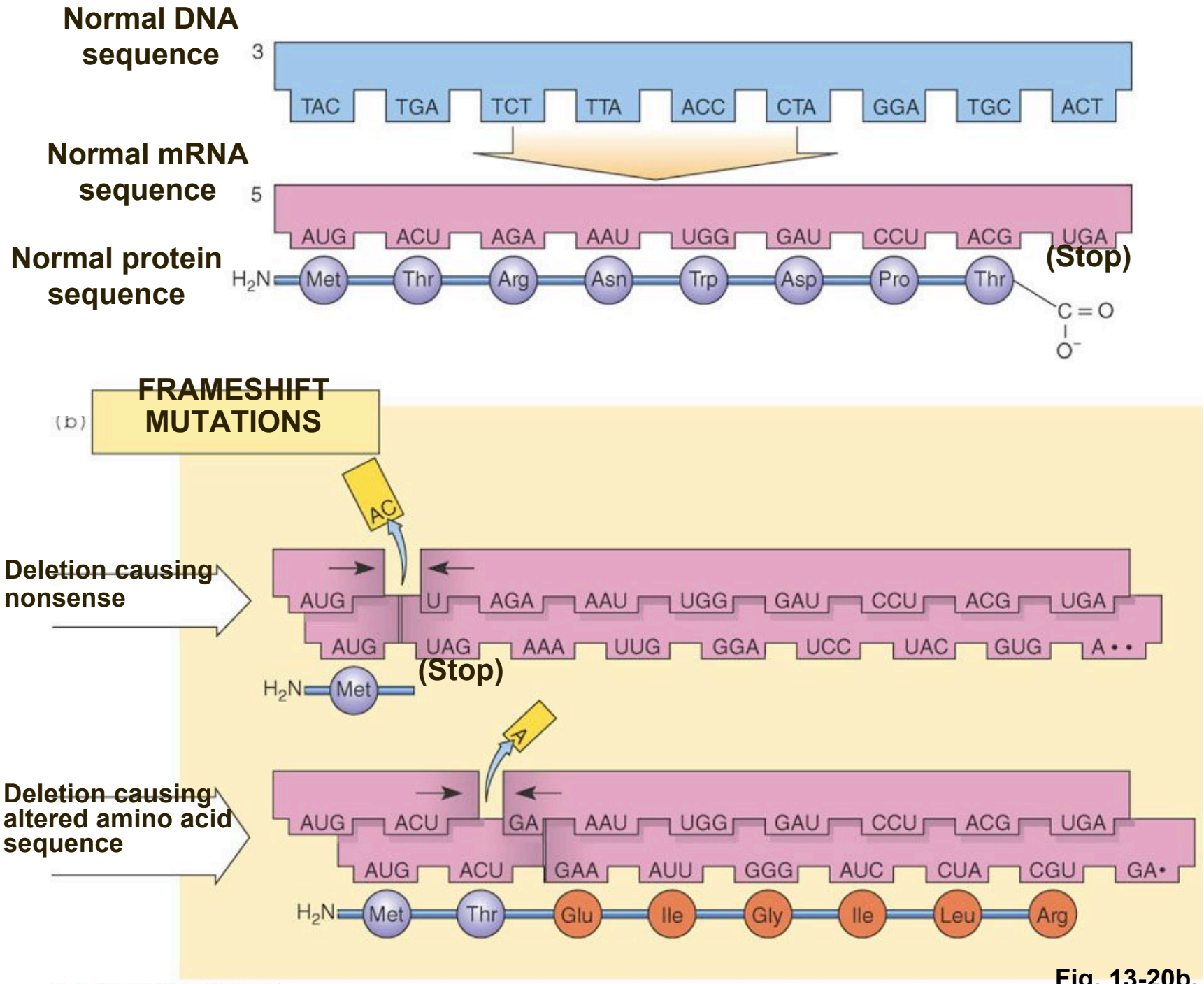


Fig. 13-20b, p. 299

Gene Regulation

Transcriptional Control (make more, or less mRNA)

- inducible genes
- repressible genes

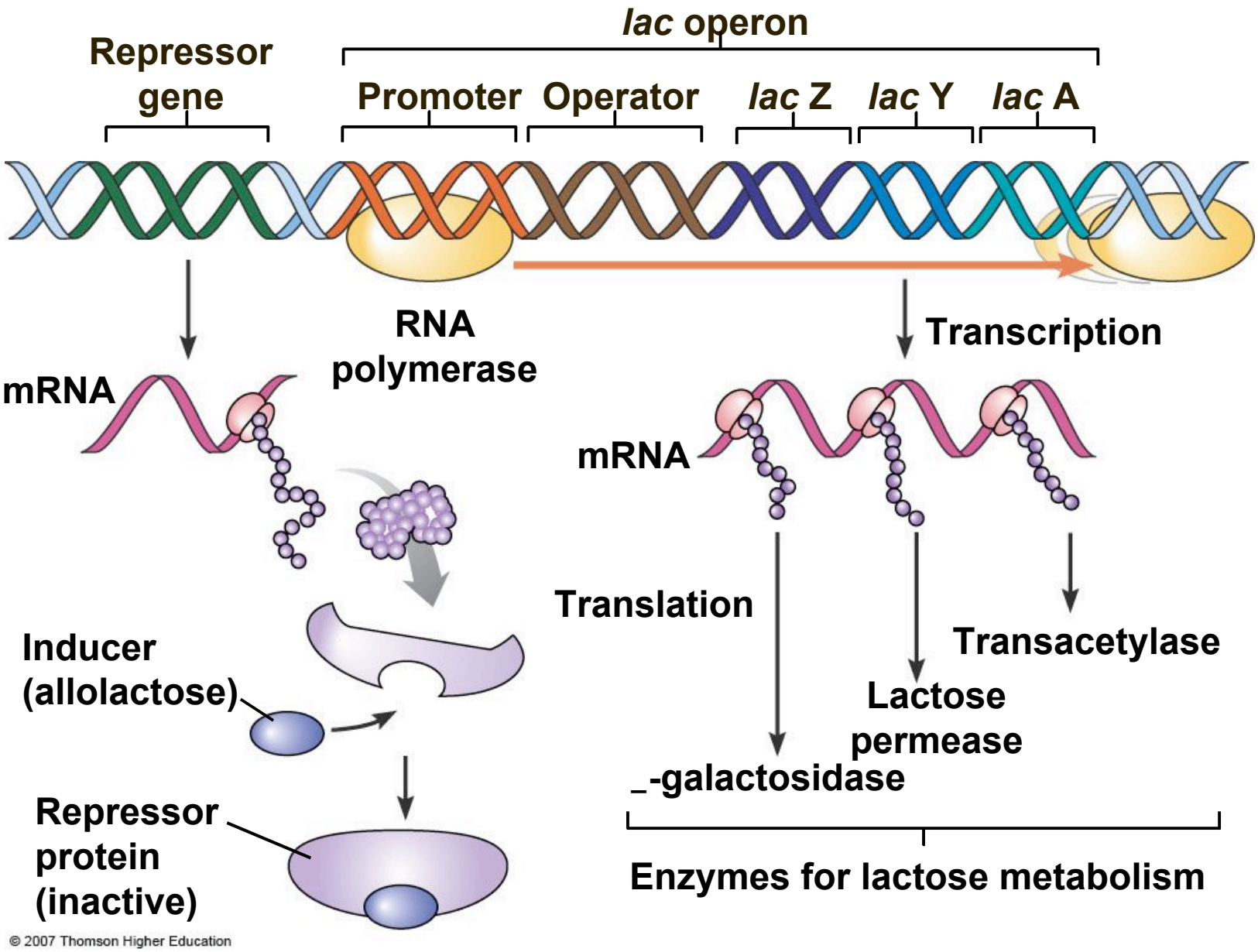
Post transcriptional Control (eg. Modify mRNA)

- splicing

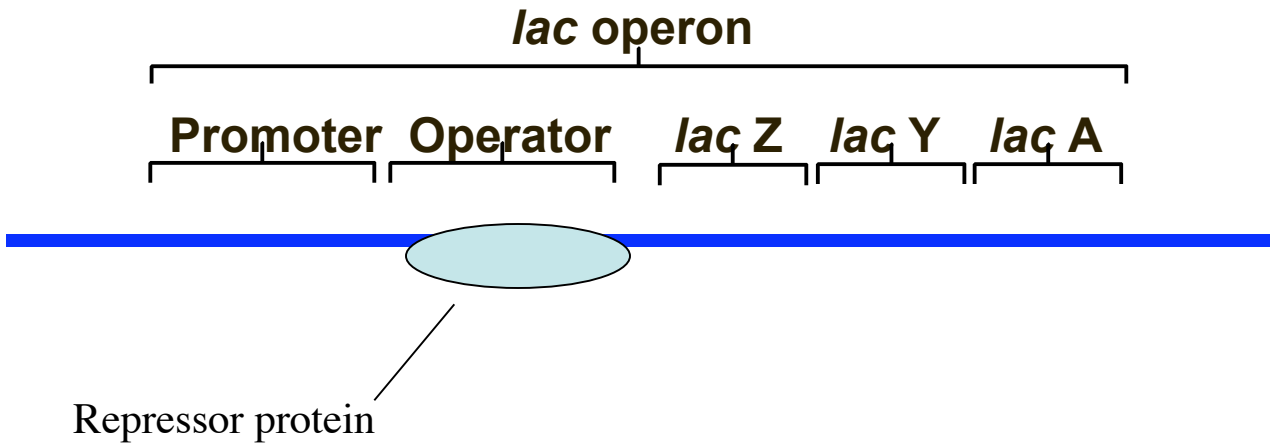
Gene Regulation

The *lac* operon is an example of an inducible gene in a Eukaryote (*E. coli*)

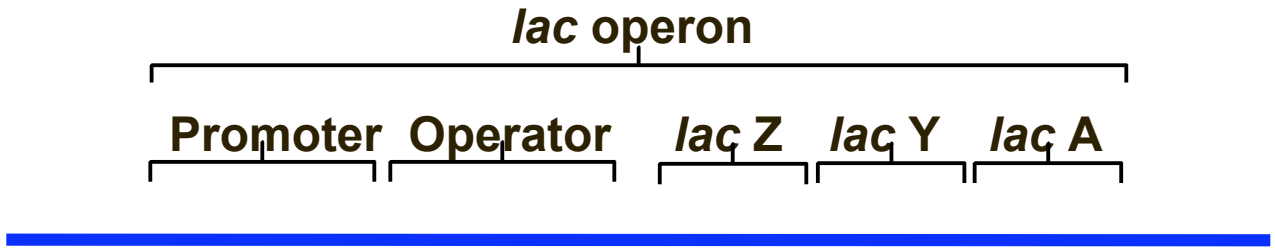
E. coli growing need a special set of enzymes to use the sugar lactose. These enzymes aren't needed when the cells are growing on glucose.

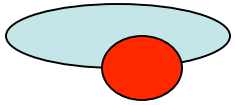


No lactose present….



Lactose present….

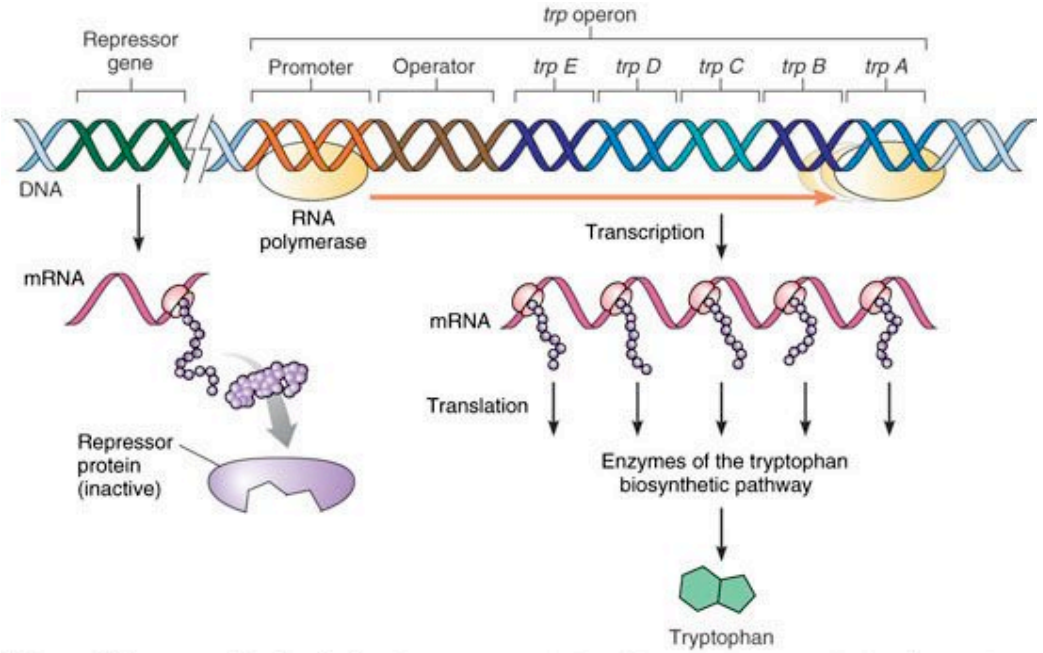




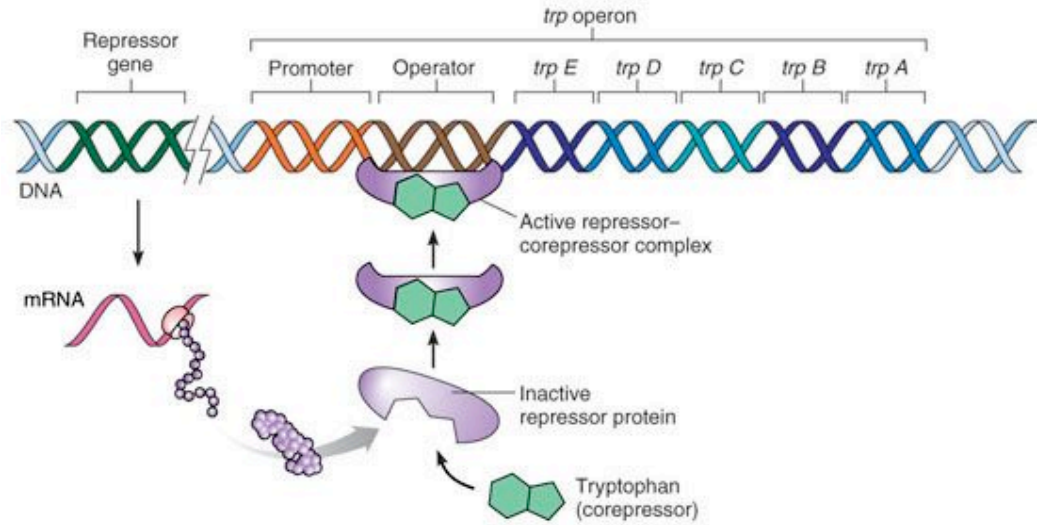
Repressor protein + lactose - doesn't stick to operator region, Transcription Can Occur

Contrasts with a Repressible Gene

In this case, the cell needs to make Tryptophan, unless it has enough

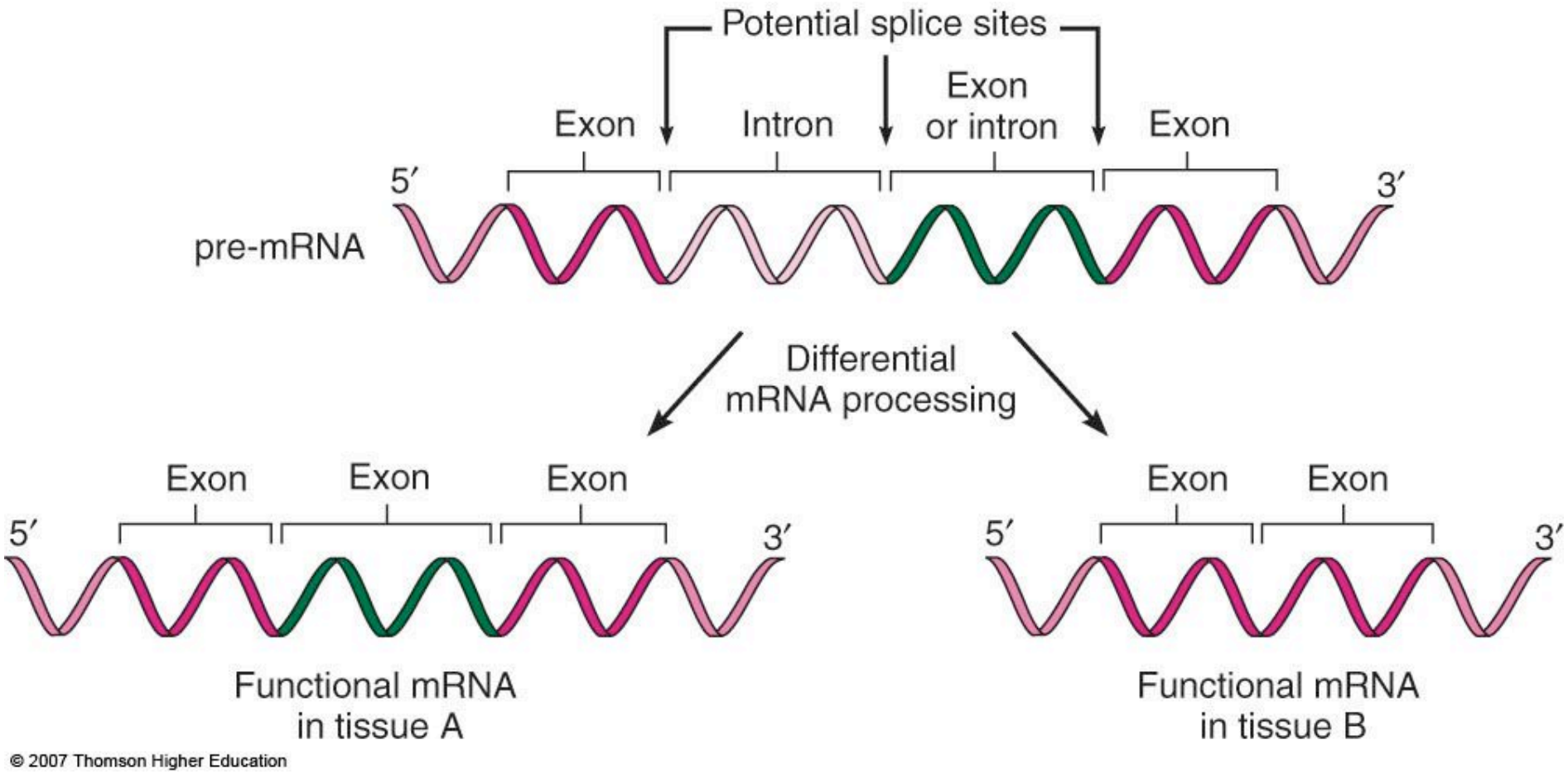


(a) Intracellular tryptophan levels low. Repressor protein is unable to prevent transcription because it cannot bind to the operator.



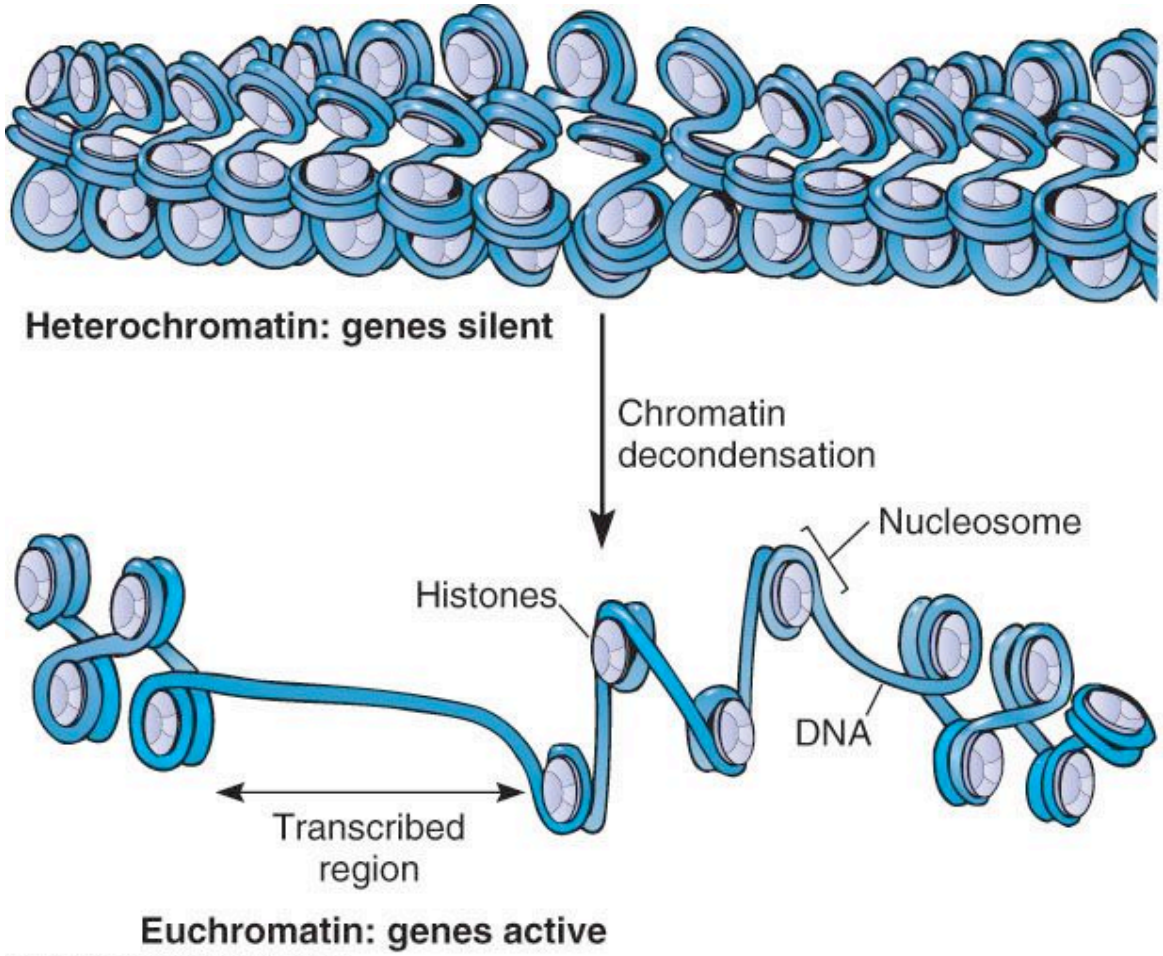
(b) Intracellular tryptophan levels high. The amino acid tryptophan binds to an allosteric site on the repressor protein, changing its conformation. The resulting active form of the repressor binds to the operator region, blocking transcription of the operon until tryptophan is again required by the cell.

RNA splicing (eukaryotes)



Introns - 'extra', non coding sequences. Exons = coding sequences.

Fig. 14-12, p. 318



(a) An inactive region of DNA; heterochromatin is organized into tightly associated nucleosomes.

(b) Active genes are found in decondensed chromatin called euchromatin. Euchromatin increases the accessibility to RNA polymerase required for transcription. The histones are physically removed from the DNA in the region where transcription occurs.