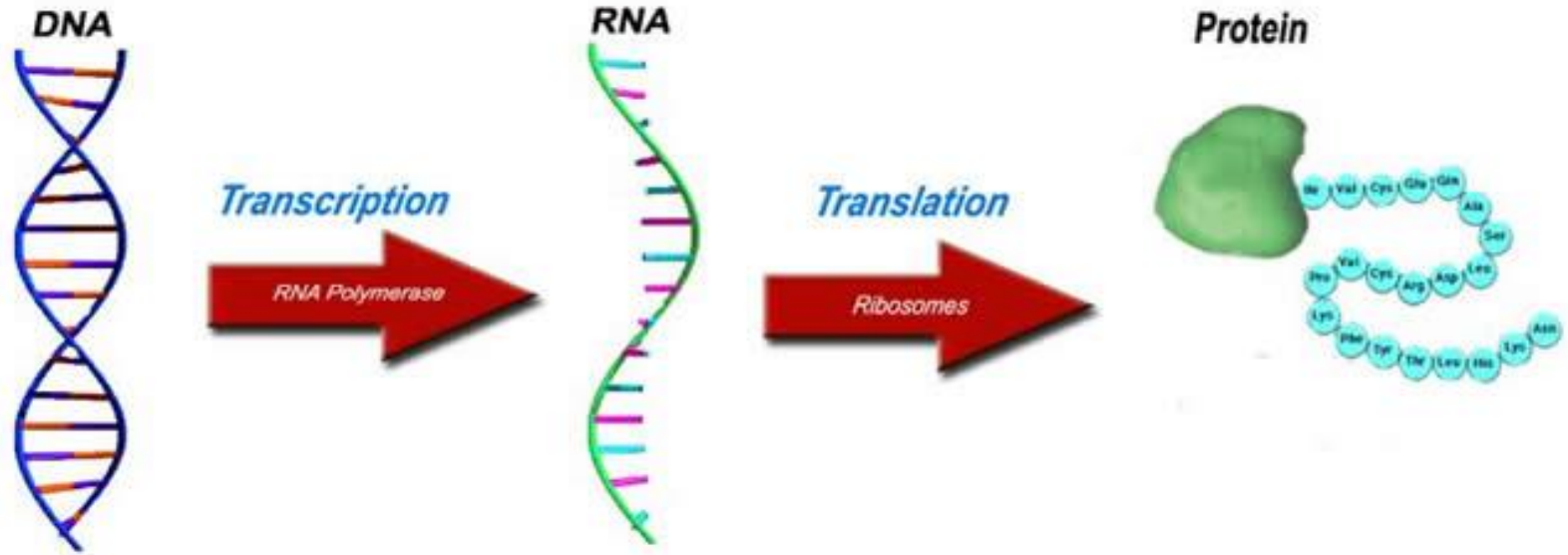
**Gene expression**, the process by which DNA directs protein synthesis, includes two stages: transcription and translation

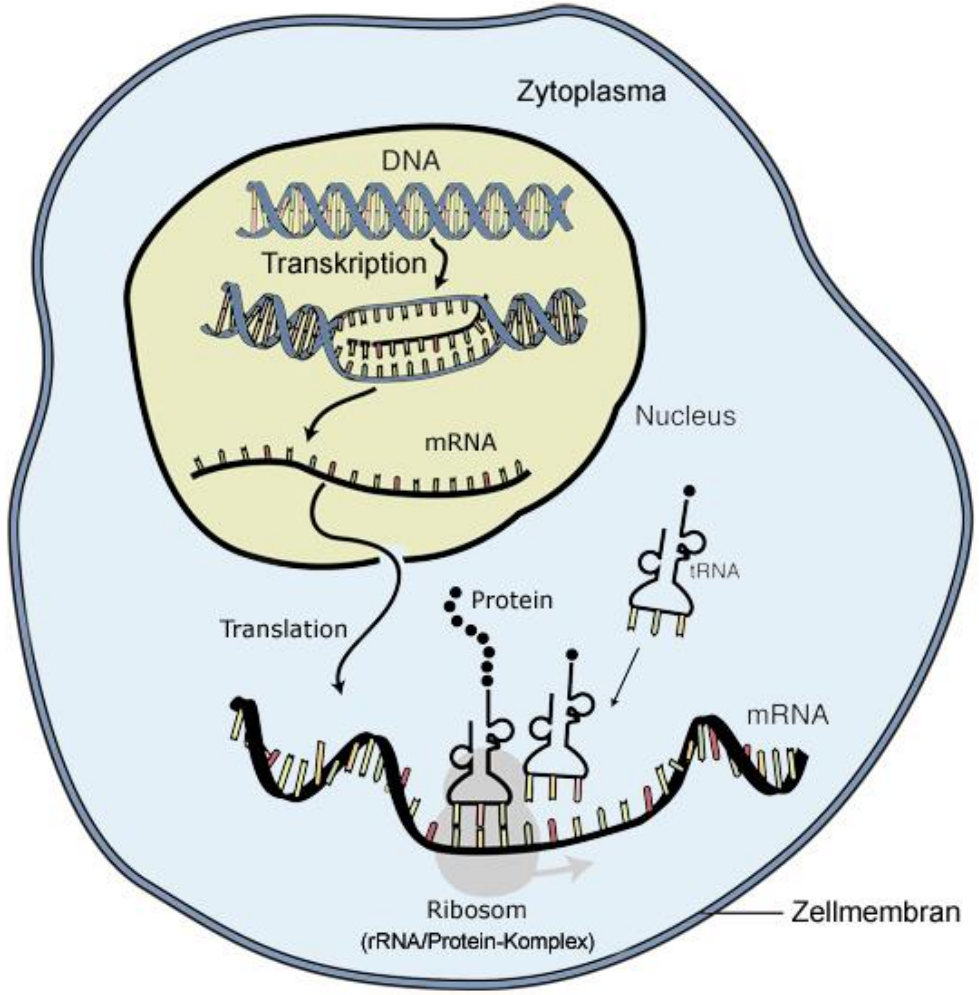
(in other words:  this is a big deal)

# The Central Dogma



# Basic Principles of Transcription and Translation

- RNA is the intermediate between genes and the proteins for which they code
- **Transcription** is the synthesis of RNA under the direction of DNA
- Transcription produces **messenger RNA (mRNA)**
- **Translation** is the synthesis of a polypeptide, which occurs under the direction of mRNA
- **Ribosomes** are the sites of translation



- *One gene–one enzyme hypothesis*, which states that each gene dictates production of a specific enzyme
- Some proteins aren't enzymes, so researchers later revised the hypothesis: *one gene–one protein*
- Many proteins are composed of several polypeptides, each of which has its own gene
- Therefore, Beadle and Tatum's hypothesis is now restated as the *one gene–one polypeptide hypothesis*
- Note that it is common to refer to gene products as proteins rather than polypeptides

# RNA – how the genetic code is expressed as proteins

- **Genetic information is first passed to an intermediate molecule – RNA**
- **Proteins called transcription factors control the transfer of genetic information of DNA to RNA by binding specific DNA sequences.**

**DNA** ---(transcription, in the nucleus)---> **RNA** ---(translation, in the cytoplasm)---> **Proteins**

# RNA – 3 differences from DNA

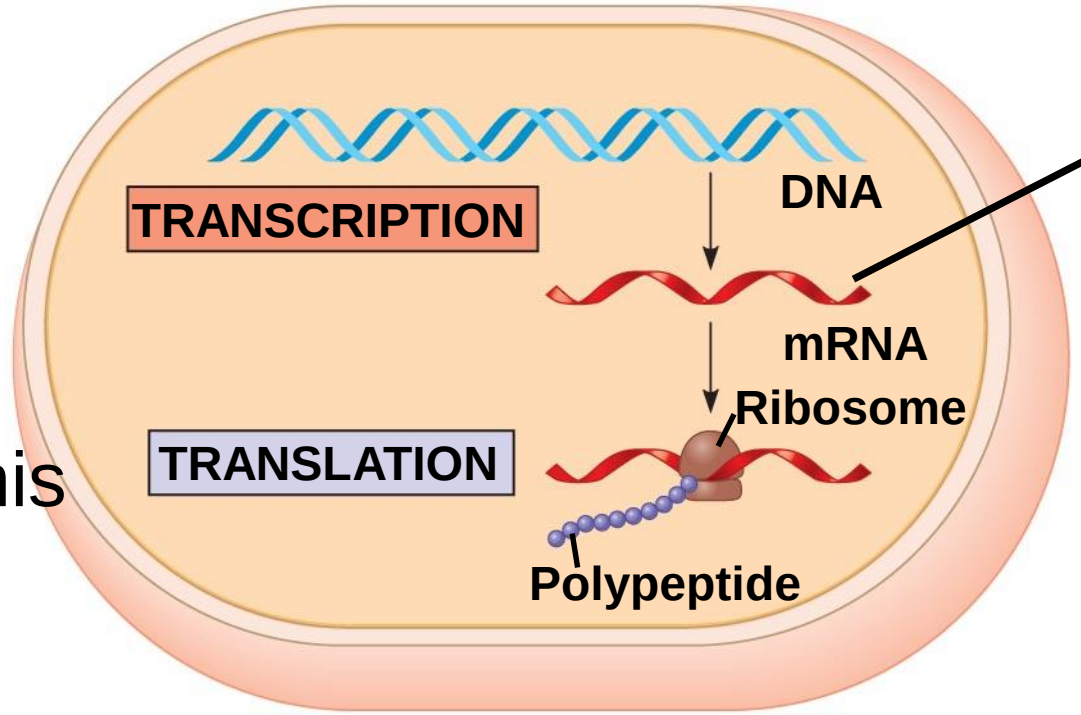
1. **RNA is single-stranded, not double stranded**
2. **The five-carbon sugar is ribose instead of deoxyribose**
3. **The nitrogenous bases are adenine, guanine, cytosine, and a different base called uracil**

# RNA – 3 types of RNA

1. **Messenger RNA (mRNA)**
   - **copies the info stored in the strand of DNA**
2. **Ribosomal RNA (rRNA)**
   - **produced in nucleus**
   - **make up part of the ribosome**
3. **Transfer RNA (tRNA)**
   - **shuttles amino acids to the ribosomes**
   - **responsible for bringing the appropriate amino acids into place at the appropriate time**

Fig. 14-3a-2

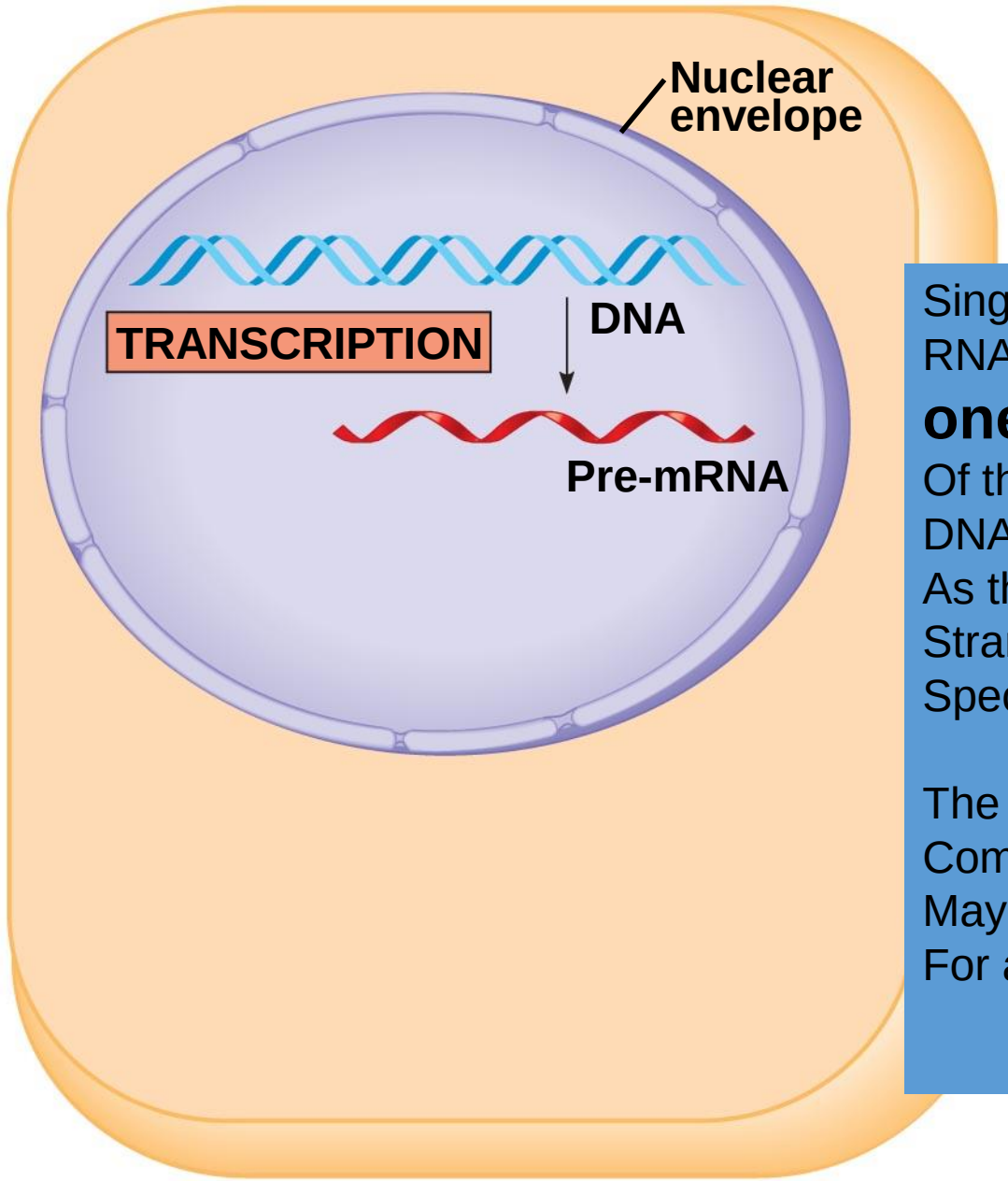
REMEMBER:
Bacterial
DNA is
Circular
It doesn't
really
Look like this




RNA
Is
Single
stranded

**(a) Bacterial cell**

Fig. 14-3b-1

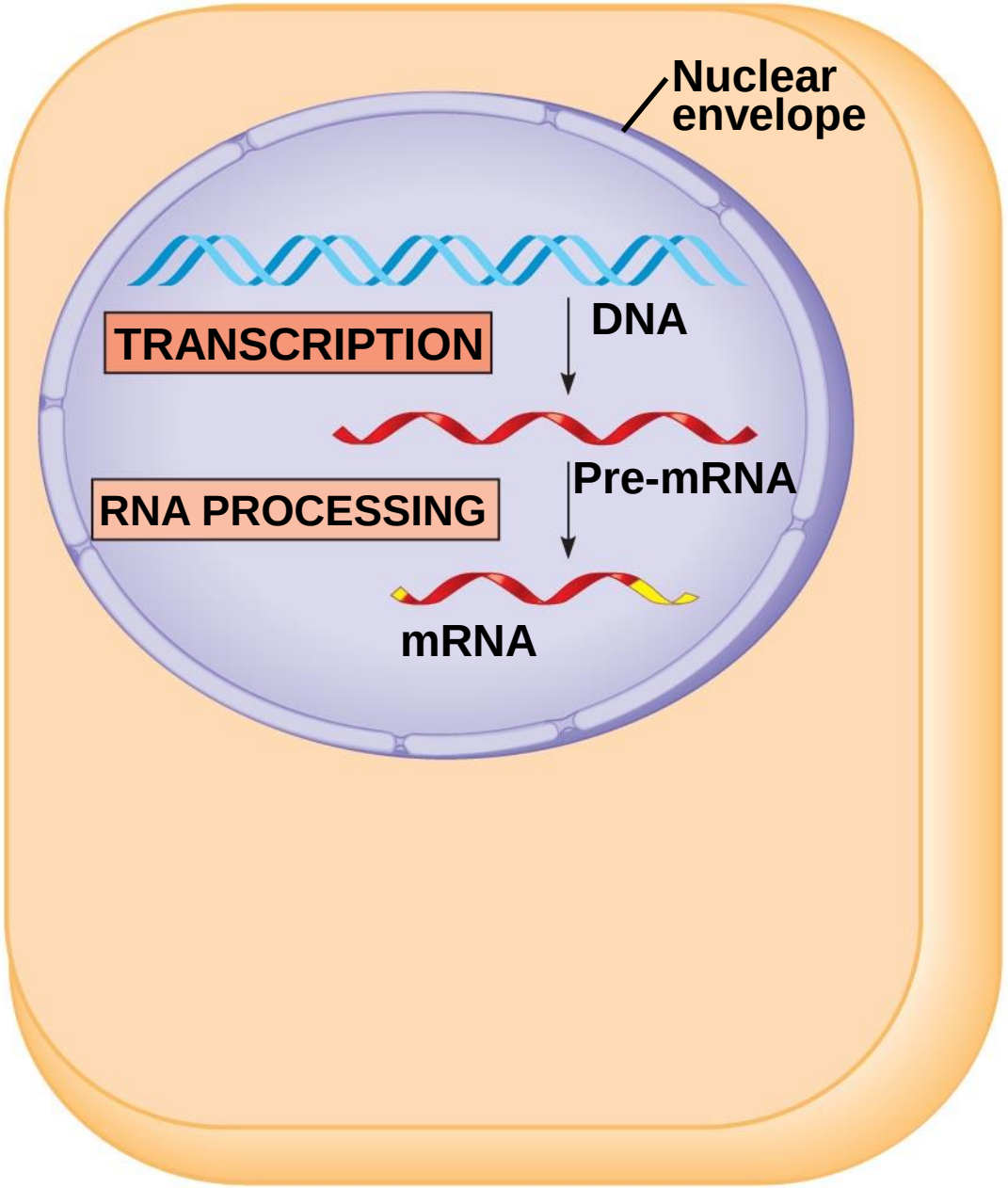



(b) Eukaryotic cell

Single stranded
RNA,
**one** strand
Of the original
DNA will be used
As the template
Strand for a
Specific gene,

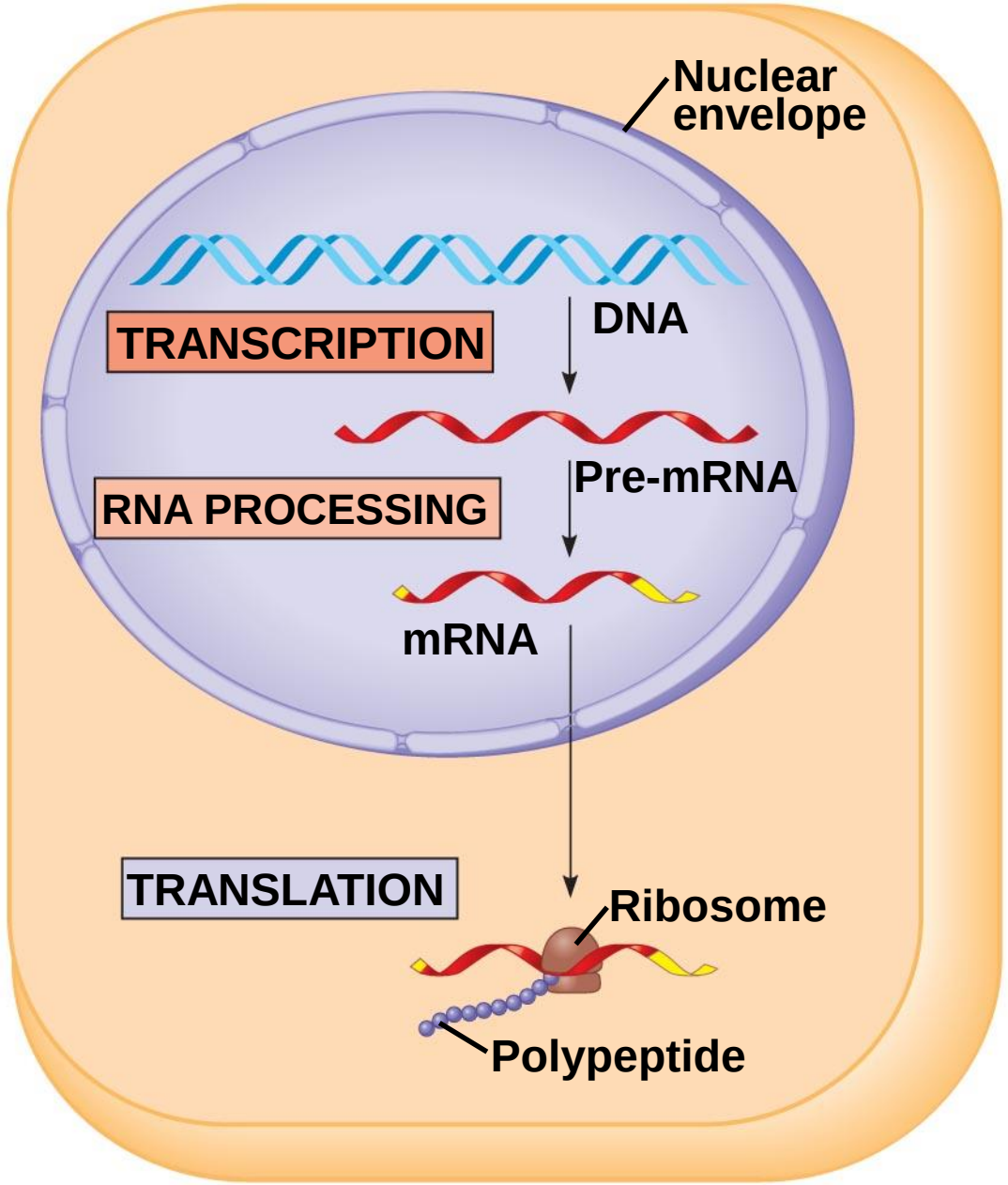
The Other strand (the
Complement) of DNA
May serve as a template
For another gene

Fig. 14-3b-2




(b) Eukaryotic cell

Fig. 14-3b-3



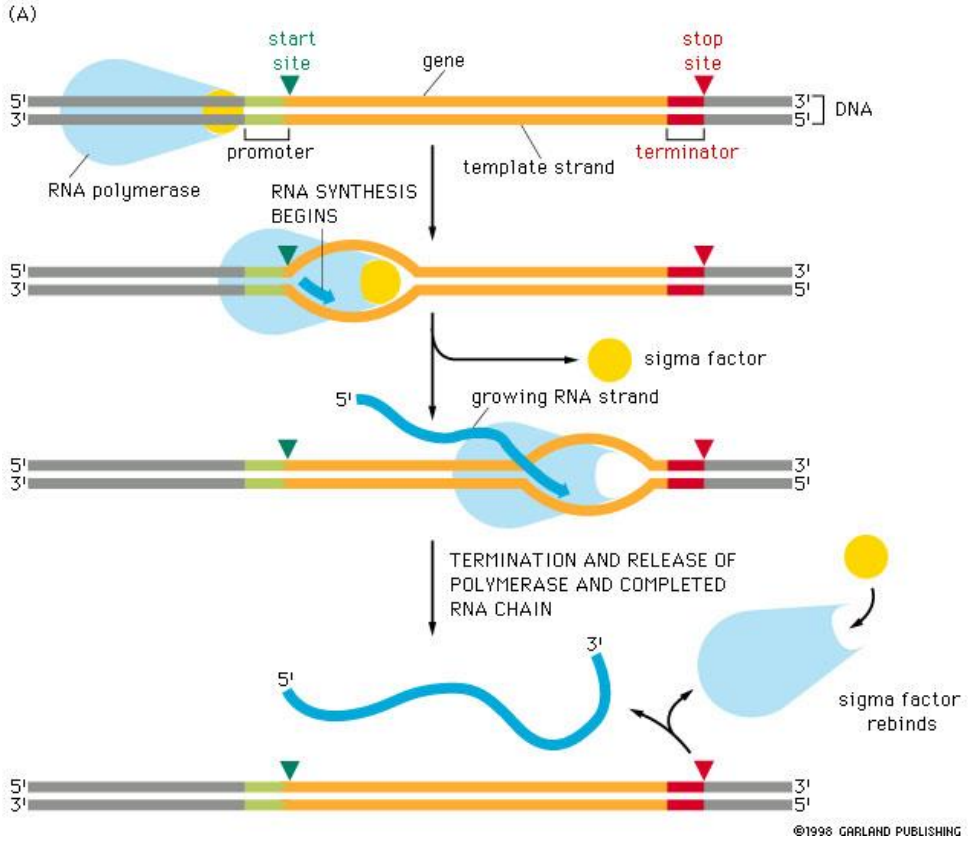

(b) Eukaryotic cell

# Protein Synthesis – 3 basic steps

transcription → RNA processing → translation

## 1. Transcription – copying the genetic code directly from DNA

- **Initiation – unwinds DNA strands using helicase**
  - **Begins at a sequence called the promoters**
  - **Only copies one side of the DNA, the sense strand, because RNA is a single strand, the other side of the DNA is the antisense strand**
- **Elongation – RNA nucleotides are lined up along the DNA to form mRNA using RNA polymerase**
  - **C lines up with G of the DNA**
  - **G lines up with C of the DNA**
  - **A lines up with T of the DNA**
  - **U lines up with A of the DNA**
- **Termination – at the end of the gene is a termination point which stops the addition of RNA nucleotides**
  - **The mRNA detaches from the DNA**




DNA Learning Center (2:00)
https://www.dnalc.org/resources/3d/13-transcription-advanced.html

# Molecular Components of Transcription

- RNA synthesis is catalyzed by **RNA polymerase**, which pries the DNA strands apart and hooks together the RNA nucleotides
- RNA synthesis follows the same base-pairing rules as DNA, except uracil substitutes for thymine
- The DNA sequence where RNA polymerase attaches is called the **promoter**; in bacteria, the sequence signaling the end of transcription is called the **terminator**
- The stretch of DNA that is transcribed is called a **transcription unit**
- **http://www.youtube.com/watch?v=41_Ne5mS2ls**

Fig. 14-7

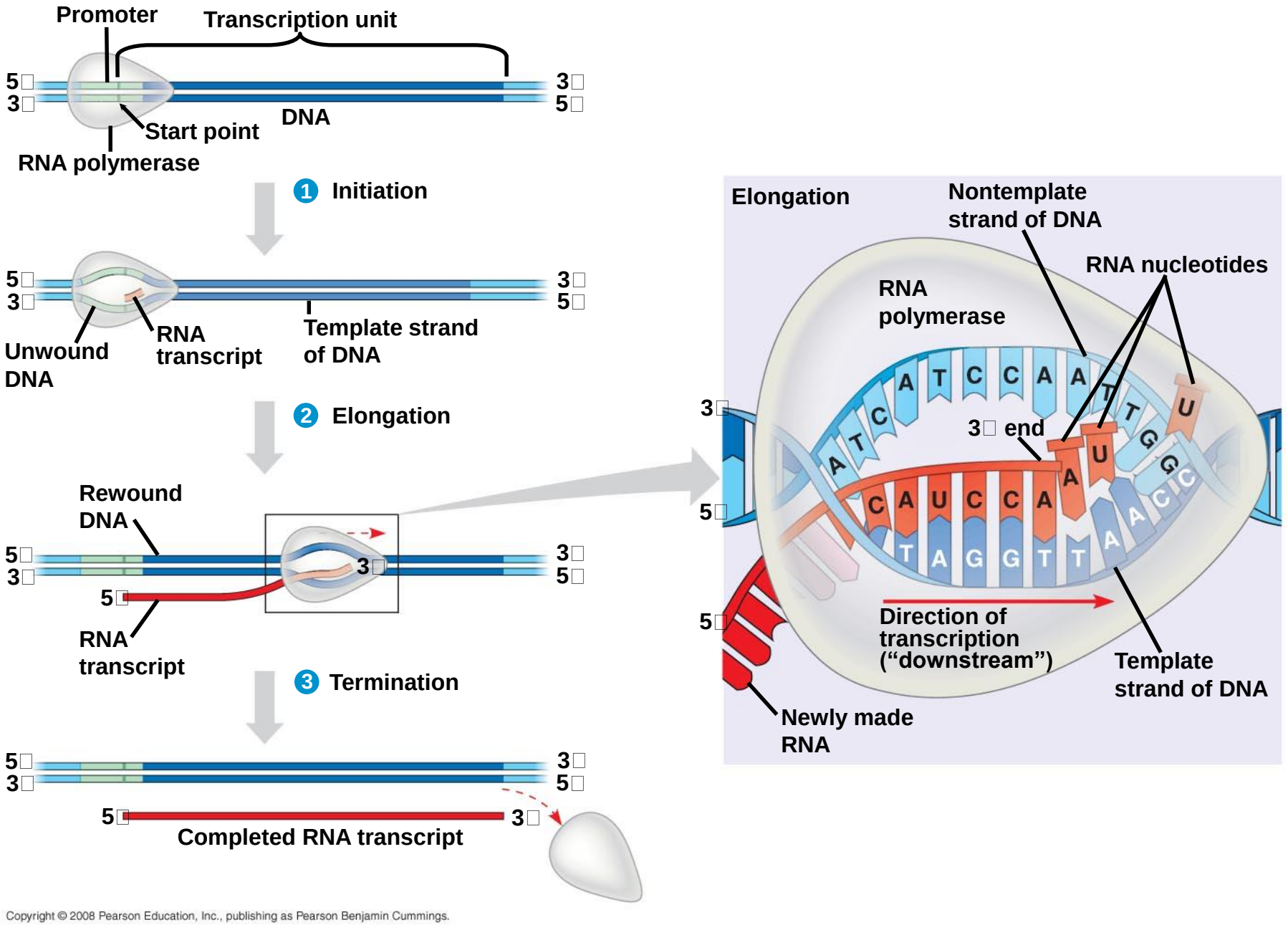
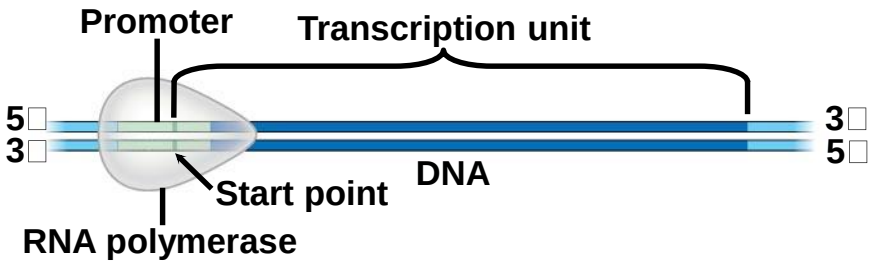


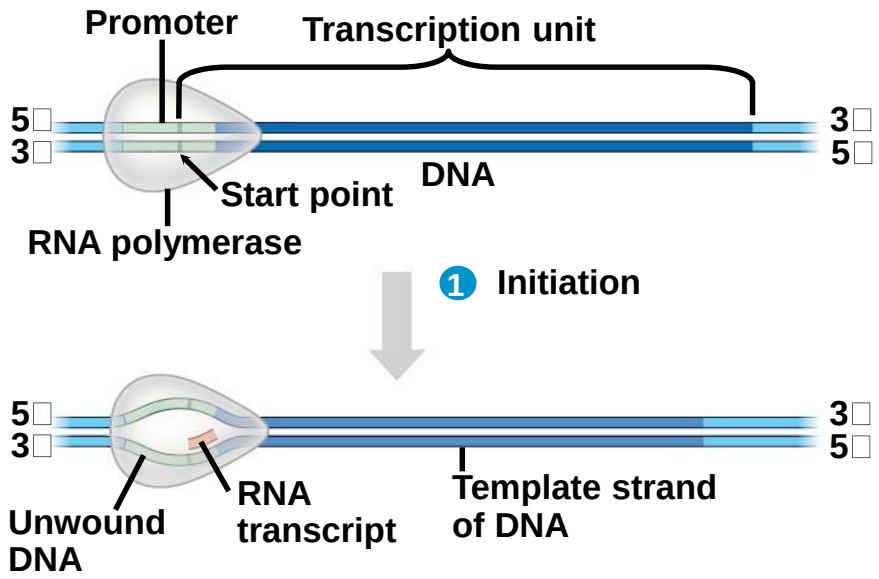
Fig. 14-7a-1




There are transcription factors that bind to the Transcription origin site and they allow the RNA polymerase to bind (it binds to the transcription Factors) to start transcription

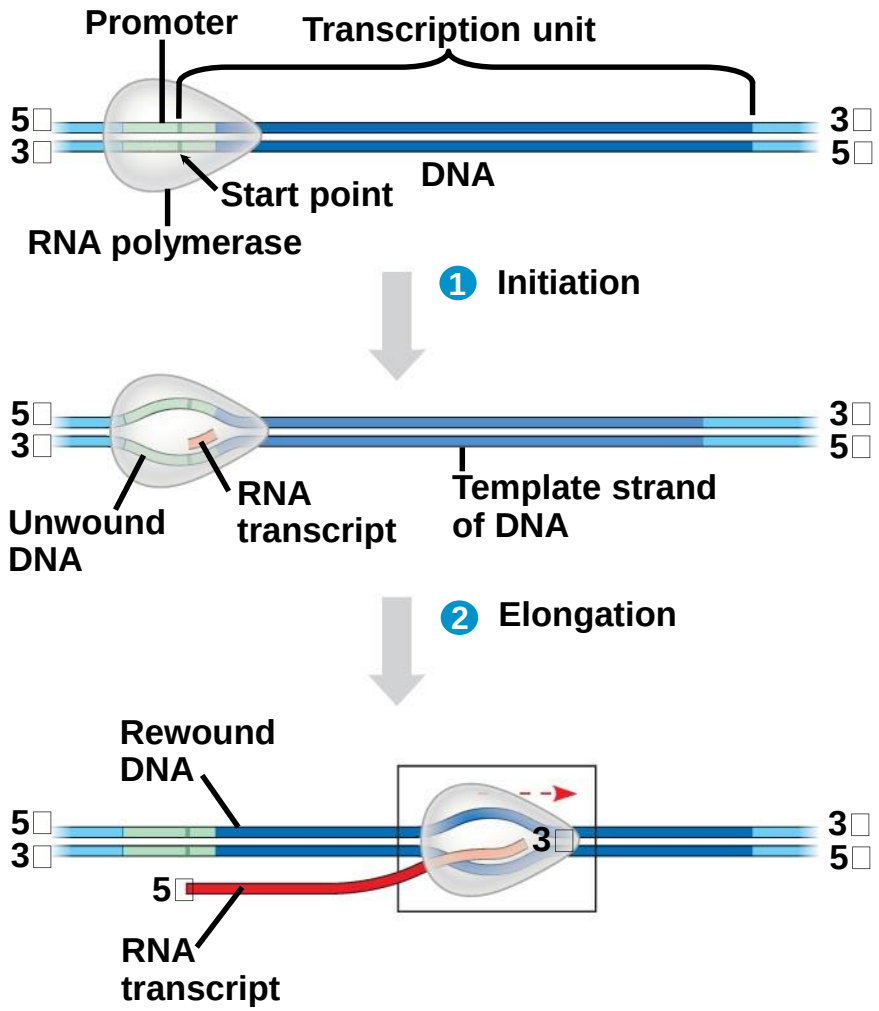
The template DNA is read 3’ to 5’ while the mRNA is Made 5’ to 3’

Fig. 14-7a-2



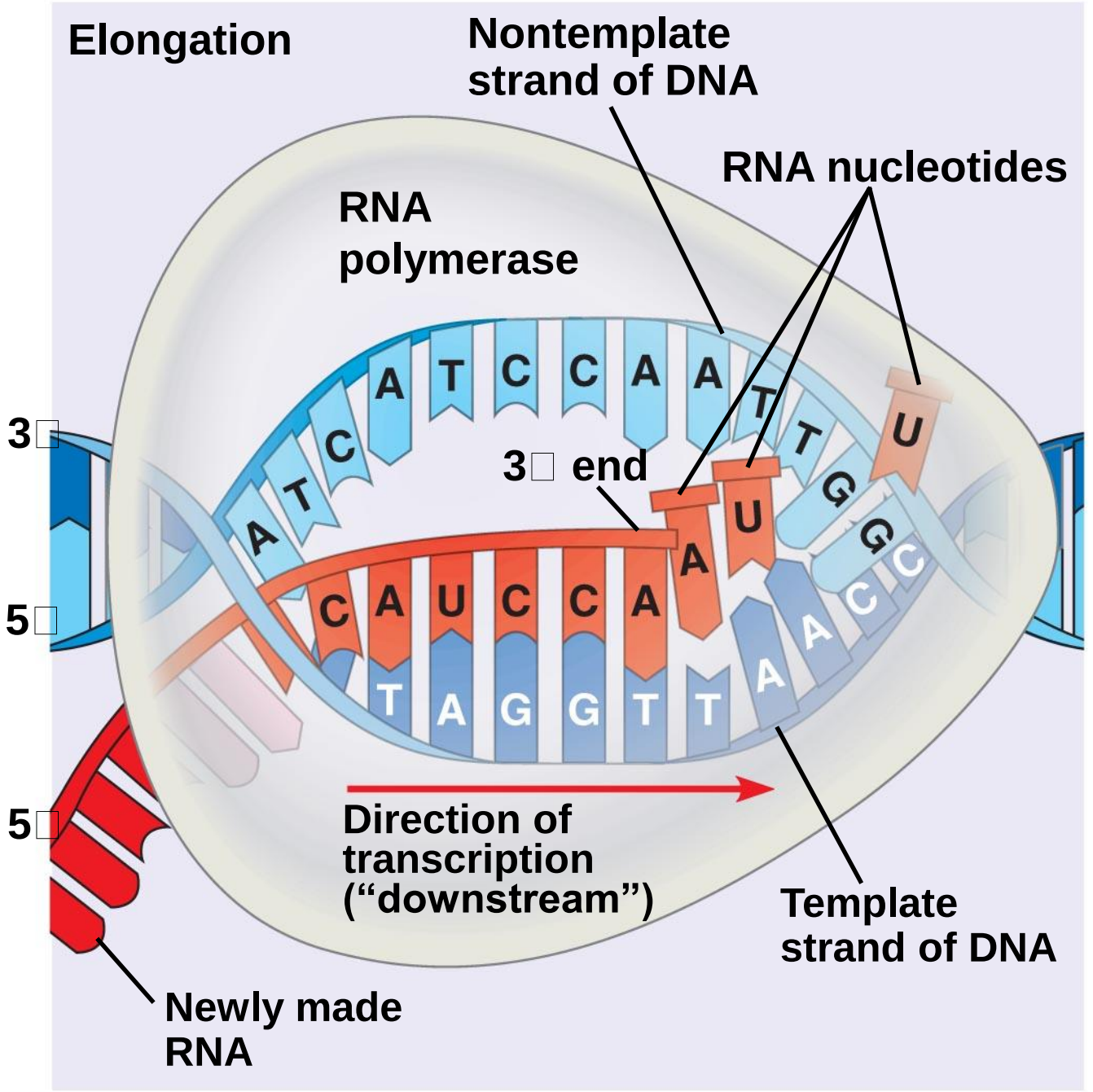

The promoter initiates transcription at a specific Spot and serves as a binding site for the RNA polymerase; it also determines which strand Of DNA will be the template for the particular Gene; usually the other strand is a template for a Different gene

Fig. 14-7a-3




The polymerase moves downstream, unwinding the DNA it elongates the RNA transcript 5’ to 3’; the DNA reforms the double helix

Fig. 14-7b



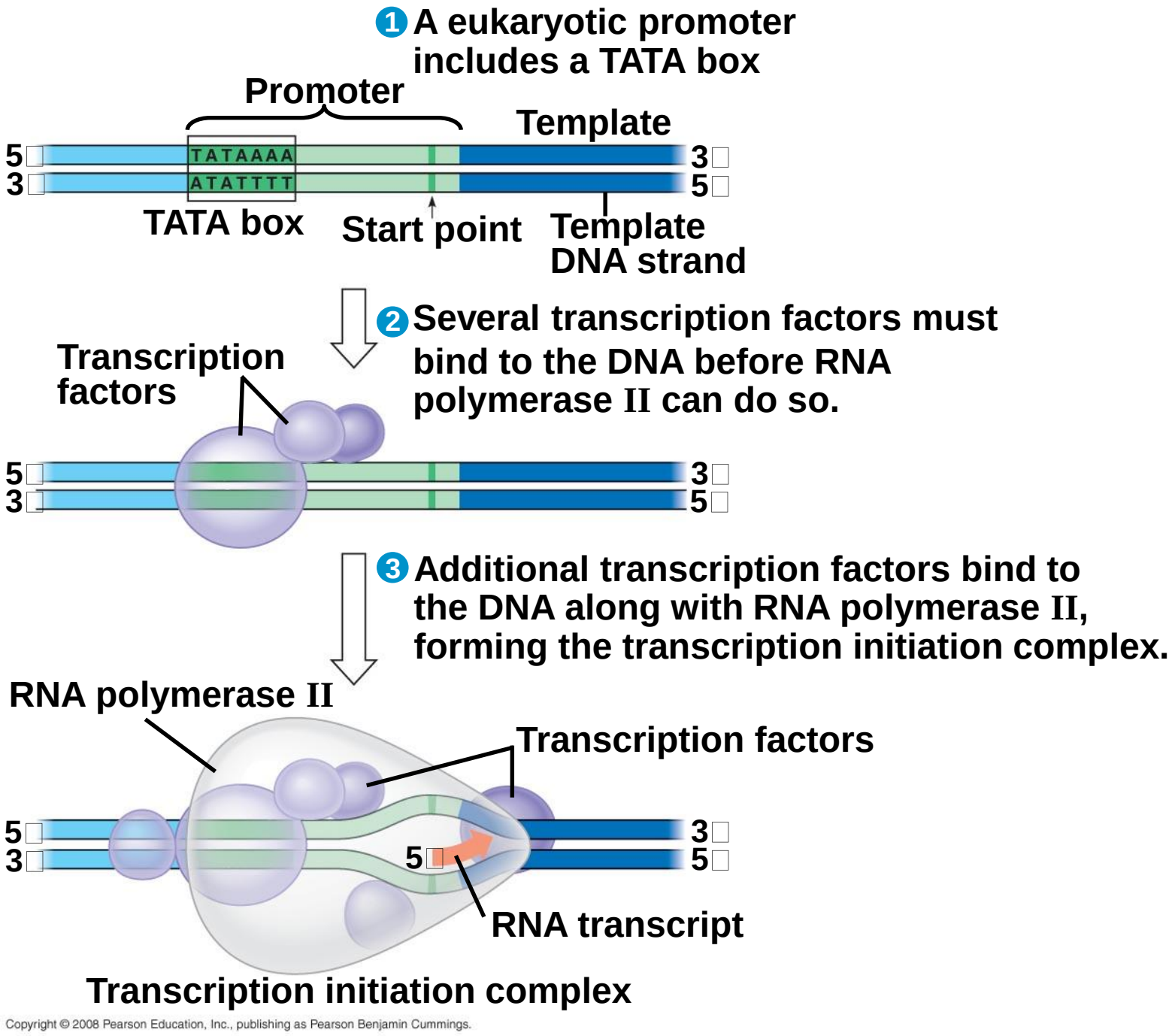
# *RNA Polymerase Binding and Initiation of Transcription*

- Promoters signal the initiation of RNA synthesis
- **Transcription factors** mediate the binding of RNA polymerase and the initiation of transcription
- The completed assembly of transcription factors and RNA polymerase II bound to a promoter is called a **transcription initiation complex**
- A promoter called a **TATA box** is crucial in forming the initiation complex in eukaryotes

# Let’s talk about TATA boxes

- The TATA box has the core DNA sequence  5'-TATAAA-3' or a variant, which is usually followed by three or more adenine bases.
- A TATA box is a DNA sequence that indicates where a genetic sequence can be read and decoded.
- It is a type of promoter sequence, which specifies to other molecules where transcription begins.
- The TATA box is named for its conserved DNA sequence, which is most commonly TATAAA.
- Many eukaryotic genes have a conserved TATA box located 25-35 base pairs **before** (upstream) the transcription start site of a gene (so they are all over the place on the DNA strand).
- The TATA box is able to define the direction of transcription and also indicates the DNA strand to be read.
- Proteins called transcription factors can bind to the TATA box and recruit an enzyme called RNA polymerase, which synthesizes RNA from DNA.

Fig. 14-8



# *Termination of Transcription*

- The mechanisms of termination are different in bacteria and eukaryotes
- In bacteria, the polymerase stops transcription at the end of the terminator sequence (with is an RNA sequence)
- This sequence causes the polymerase to detach from the DNA and release the transcript
- In eukaryotes, the polymerase continues transcription after the pre-mRNA is cleaved from the growing RNA chain; the polymerase eventually falls off the DNA
- There is a sequence on the DNA called the polyadenylation signal sequence (guess what it does)
- Puts a lot of adenines in a string (AAUAAA)
- Which signals the RNA transcript to be cut free the polymerase