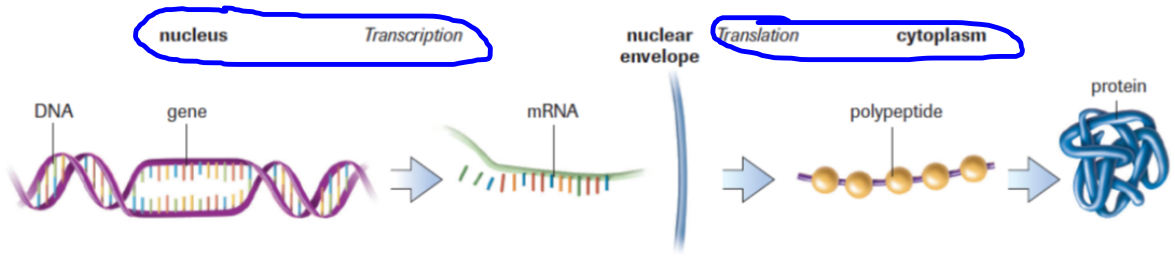
Topic 4 – Gene Expression – Part 1 - Transcription

- Genes make proteins
    - One gene makes one **protein** (no more no less)

- Proteins in our body are made of **20** different **amino acids**

- Proteins are important
- Make up the structure of cells
- Make up muscle filaments that allow us to move
- Hair, nails , hair color, eye color all produced by proteins
- Enzymes that speed up chemical reactions in our body
- Antibodies
- Hormones

- Protein Synthesis involves two processes:
    - **Transcription** – DNA is read and copied onto the mRNA molecule
    - **Translation** – proteins are produced using the DNA instructions encoded in the mRNA



In the process of **transcription**, a gene is copied and the information is taken out of the nucleus so that the cell can make a protein out of the information obtained from the DNA in the gene

- Every 3 nitrogen bases in the DNA that makes up a gene is called a **codon**, and codes for a specific amino acid

- DNA does not leave the nucleus so a carrier molecule called **messanger RNA (mRNA)** is used
    - mRNA carries the genetic message to the ribosomes

- RNA is different than DNA in a few ways
    - RNA contains **ribose** sugar, not deoxyribose

- RNA has no **thymine base (T)**, instead has **uracil (U)** - complementary to adenine

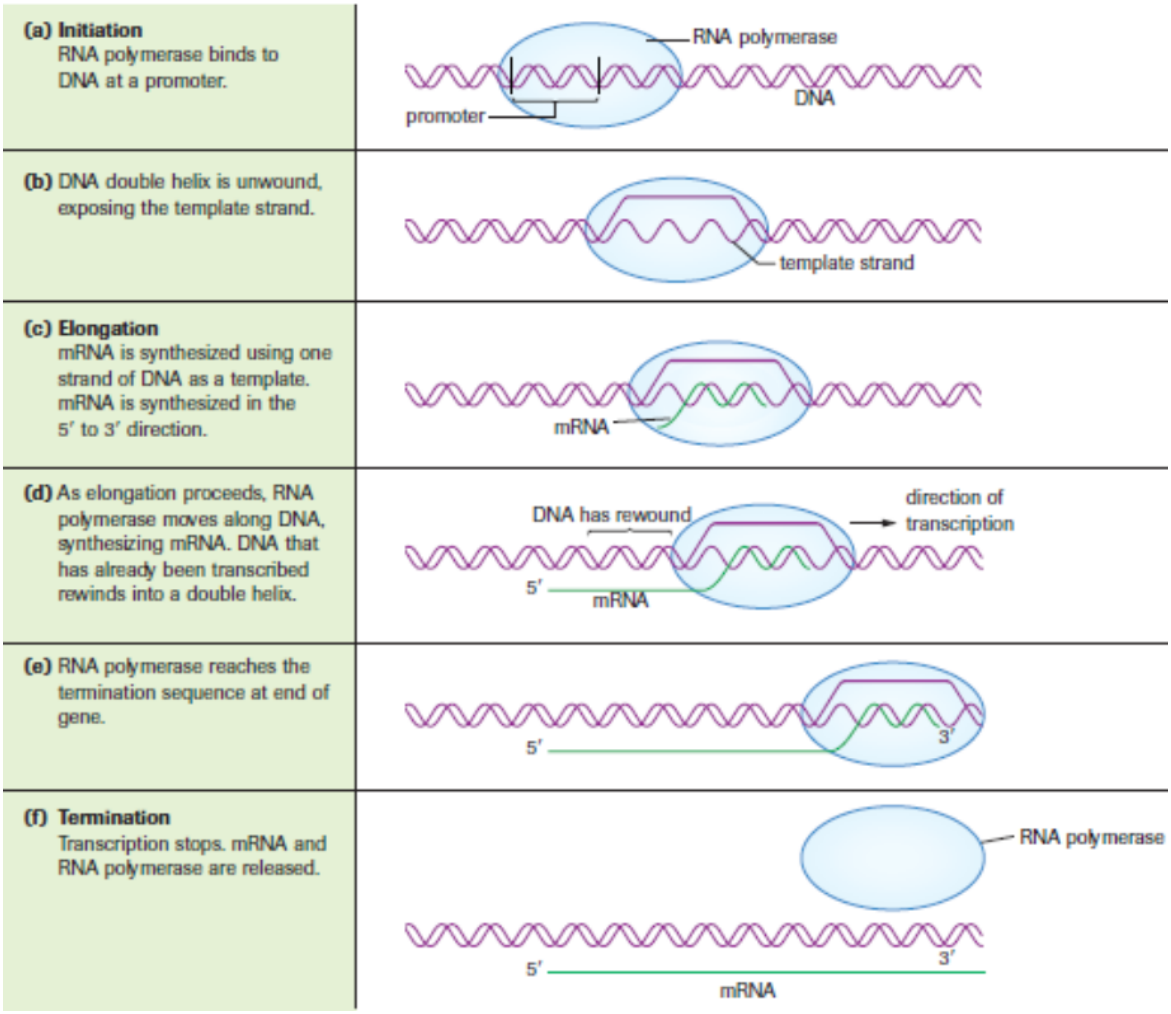
- RNA is **single** stranded, not double stranded like DNA

Transcription

- During transcription, the DNA sequence of a gene is copied (transcribed) into the sequence of a single strand mRNA molecule

- Divided into three processes
  - Initiation
    - **RNA polymerase** binds to the DNA at a promoter site
      - usually a sequence of T and A bases called a TATA box
      - DNA helix unwinds and separates exposing a template strand
  - Elongation
    - mRNA is synthesized using one strand of DNA as a template
    - mRNA is synthesized in the **5' to 3'** direction
    - mRNA that is synthesized detaches from the template strand
    - DNA that has already been transcribed rewinds into the helix
  - Termination
    - RNA polymerase will reach a stop signal called a termination sequence at the end of the gene
    - mRNA detaches from the DNA strand

http://www.stolaf.edu/people/giannini/flashanimat/molgenetics/transcription.swf



Topic 4 – Part 1 – Transcription
Review Sheet

DNA is structurally different from RNA in that DNA

A. contains uracil and is composed of double strands
B. contains adenine and is composed of single strands
C. contains guanine and is composed of single strands
D. contains thymine and is composed of double strands

Use the following information to answer the next question.

A section of template DNA contains the following proportions of bases:

adenine—20% thymine—30% cytosine—10% guanine—40%

~ RNA U-20% A-30% G-10% C-40%

The proportions of three of the mRNA nucleotides produced from this DNA are

A. 20% adenine, 30% uracil, and 10% cytosine
B. 40% cytosine, 20% adenine, and 30% uracil
C. 20% uracil, 40% cytosine, and 10% guanine
D. 20% thymine, 30% adenine, and 10% guanine

1. A short fragment of a particular gene includes the following sequence of nucleotides:

TACTACGGT

Write out the corresponding mRNA transcript.

AUGAUGCCA

2. A short fragment of another gene includes the following sequence of nucleotides:

ACCATAATATTACCGACCT TCG

(a) Explain the purpose of the promoter region in transcription.
(b) Circle the promoter region. Explain the rationale for your selection.

As cells age, there is an increase in DNA damage and a decrease in DNA repair processes. The **initial** effect is

A. a decrease in ATP synthesis
B. an increase of cancerous cells
C. the production of altered proteins
D. the production of abnormal mRNA

Topic 4 – Gene Expression – Part 2 - Translation
Pre-Class Reading Assignment

1. Read pages 670-674

2. Define the following terms

a. codon
b. start codon
c. stop codons
d. ribosome
e. transfer RNA
f. anticodon

Topic 4 – Gene Expression – Part 2 - Translation

Translation
- After transcription, the mRNA leaves the nucleus and enters the cytoplasm of the cell to be **translated**

- Translation involves three processes
  - **Initiation**
  - **Elongation**
  - **Termination**

Initiation
- Initiation occurs when a ribosome recognizes a specific sequence on the mRNA and binds to that site

- Ribosome consists of two subunits that join together and clamp the mRNA in between

- Ribosomes move in the **5' to 3'** direction

- Starts at the codon that reads **AUG**
  - This codon also codes for the amino acid methionine

- Therefore, every protein starts with the a.a. methionine

AUG

Messenger RNA Codons and Their Corresponding Amino Acids

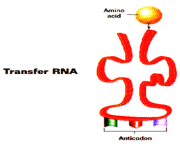
First Base	Second Base				Third Base
	U	C	A	G	
U	UUU phenylalanine	UCU serine	UAU tyrosine	UGU cysteine	U
	UUC phenylalanine	UCC serine	UAC tyrosine	UGC cysteine	C
	UUA leucine	UCA serine	UAA stop**	UGA stop**	A
	UUG leucine	UCG serine	UAG stop**	UGG tryptophan	G
C	CUU leucine	CCU proline	CAU histidine	CGU arginine	U
	CUC leucine	CCC proline	CAC histidine	CGC arginine	C
	CUA leucine	CCA proline	CAA glutamine	CGA arginine	A
	CUG leucine	CCG proline	CAG glutamine	CGG arginine	G
A	AUU isoleucine	ACU threonine	AAU asparagine	AGU serine	U
	AUC isoleucine	ACC threonine	AAC asparagine	AGC serine	C
	AUA isoleucine	ACA threonine	AAA lysine	AGA arginine	A
	AUG methionine*	ACG threonine	AAG lysine	AGG arginine	G
G	GUU valine	GCU alanine	GAU aspartate	GGU glycine	U
	GUC valine	GCC alanine	GAC aspartate	GGC glycine	C
	GUA valine	GCA alanine	GAA glutamate	GGA glycine	A
	GUG valine	GCG alanine	GAG glutamate	GGG glycine	G

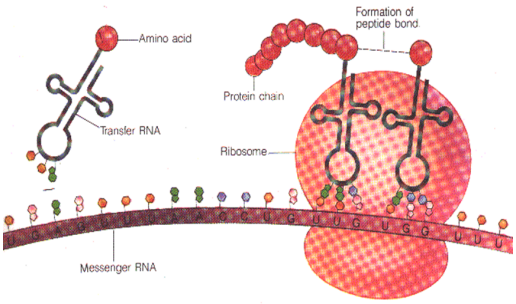
* Note: AUG is an initiator codon and also codes for the amino acid methionine.
** Note: UAA, UAG, and UGA are terminator codons.

Elongation
- A different type of RNA, **transfer** RNA (tRNA) brings the amino acids to the ribosome
    - Each tRNA has an **anticodon** complementary to the codon on the mRNA strand
    - Each tRNA carries an **amino acid**

- The tRNA binds to the ribosome and adds its amino acid to the chain in the correct sequence determined by the mRNA

- Process continues until the **stop** codon is reached

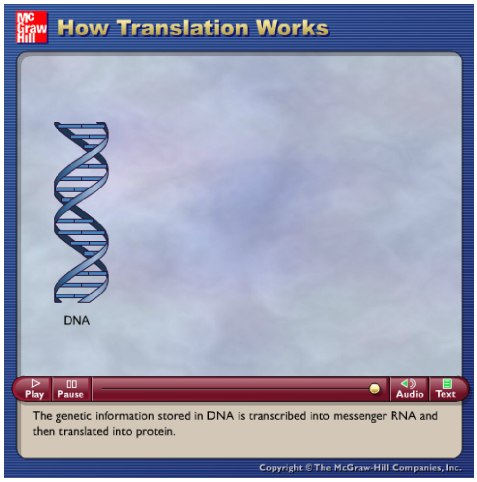




Termination
- Occurs when one of the three stop codons is reached
    - **UGA, UAG, UAA** on mRNA

- The protein that was created detaches from the ribosome and is released into the cell

- http://highered.mcgraw-hill.com/sites/0072507470/student_view0/chapter3/animation__how_translation_works.html
- http://learn.genetics.utah.edu/units/basics/transcribe/



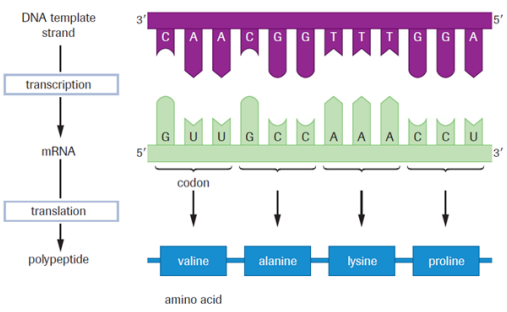


Figure 10
An overview of gene expression

Topic 4 – Gene Expression – Part 2 - Translation
Review Sheet

1. a. Transcribe the following DNA sequence into mRNA
b. Translate the mRNA strand into a string of amino acids (polypeptide)

DNA template: 5' - T A C G C A T T A G C C T A A G G T C A T G C C G T – 3'

mRNA strand:

polypeptide:

2. How many nucleotides are necessary in the DNA to code for the following sequence of amino acids?

Leu-Tyr-Arg-Trp-Ser

3. Identify which step in transcription would be affected and predict what would happen in each situation:
(a) The termination sequence of a gene is removed.

(b) RNA polymerase fails to recognize the promoter.

4. Distinguish between the following terms:
(a) P site and A site

(b) codon and anticodon

(c) start and stop codon

(d) DNA and RNA

5. Identify which of the following selections correctly lists the anticodons for the amino acids threonine, alanine, and proline:
A. ACU GCU CCA
B. ACT GCT CCA
C. TGA CGA GGT
D. UGA CGA GGU

6. Errors are occasionally made during the process of transcription. Explain why these errors do not always result in an incorrect sequence amino acids. Describe at least two examples to illustrate your answer.

Use the following information to answer the next two questions.

Some people have condemned the use of food preservatives because they may cause cancer. A researcher has found contradictory evidence that suggests that two widely used food preservatives actually increase levels of natural cancer-fighting agents in laboratory animals. The preservatives BHA and BHT increase the activity of a gene that controls the production of an enzyme. This enzyme helps destroy cancer-causing substances (carcinogens) before they trigger the development of tumours.

—from *Pearson et al, 1983*

The most **direct** relationship between a gene and an enzyme is that

A. an enzyme causes a gene to destroy carcinogens
B. the sequence of nucleotides in a gene determines the structure of an enzyme
C. each gene contains the code needed to construct many different types of enzymes
D. the sequence of amino acids in an enzyme is unrelated to nucleotide sequence in a gene

Use the following additional information to answer the next question.

Some Events that Occur Following BHA or BHT Exposure

1 The polypeptide folds into an enzyme shape.
2 tRNAs transport amino acids to the ribosomes.
3 A polypeptide is released from the ribosomes.
4 mRNA leaves the nucleus and attaches to ribosomes in the cytoplasm.

erical Response

The sequence of events that results in the production of the cancer-fighting enzyme is _____ , _____ , _____ , and _____.

Use the following information to answer the next question.

Portion of Insulin Protein

Phenylalanine–Valine–Asparagine–Glutamine–Histidine

mRNA
DNA

What is the strand of DNA that would code for this portion of insulin?

A. AAG CAA TTA GTT GTA
B. AAA CAA TTC CAC CTA
C. CAC GAG AAC GTA TTC
D. TTC GTA AAC GAG CAC

The endorphin met-enkephalin is comprised of the amino acids methionine, phenylalanine, glycine, glycine, and tyrosine. Possible mRNA codons for the production of met-enkephalin are

A. ATG TTT GGT GGT TAT
B. ATG TTG GGC GGC TAT
C. AUG UUC GGT GGT UAC
D. AUG UUU GGC GGC UAC

Benign prostatic hyperplasia (BPH), an enlargement of the prostate gland, causes urination problems such as dribbling and pain. BPH is not a precursor to prostate cancer. Prostate cancer is linked to the absence of a protein coded for by the *p27* gene. The absence of this protein leads to uncontrolled cell growth in prostate tissue.

—from *Seppa, 1998*

In normally functioning cells, the protein coded for by the *p27* gene is produced continuously. The process by which the *p27* gene's code is read from the DNA and the name of the molecule formed in the process are identified in row

Row	Process	Molecule
A.	transcription	mRNA
B.	translation	mRNA
C.	transcription	tRNA
D.	translation	tRNA