

Biology 1305
Modern Concepts in Bioscience (ICB Textbook)

Hello and welcome to the weekly resources for BIO-1305 - Biology 1

This week is Week 4 of class, and typically in this week of the semester, your professors are covering the topics below. If you do not see the topics your particular section of class is learning this week, please take a look at other weekly resources listed on our website for additional topics throughout the semester.

We also invite you **to look at the group tutoring chart on our website to see if this course has a group tutoring session offered this semester.**

If you have any questions about these study guides, group tutoring sessions, private 30 minute tutoring appointments, the Baylor Tutoring YouTube channel, or any tutoring services we offer, please visit our website www.baylor.edu/tutoring or call our drop in center during open business hours (M-Th 9am-8pm on class days at 254-710-4135).

KEYWORDS: **Transcription, Translation, Central Dogma, Gene Induction**

TOPIC OF THE WEEK

Transcription and Translation

Transcription: the process of converting DNA to RNA by the enzyme RNA polymerase.

Translation: the process of converting RNA to amino acids (proteins) by ribosomes.

In transcription, a strand of DNA is used to make a strand of RNA, similar to what happens in DNA replication, but instead of adding **Thymine**, RNA is assembled with **Uracil**.

There are three different forms of RNA that we will need to know!

Messenger RNA (mRNA): This is the type of RNA that is used as the template to make proteins

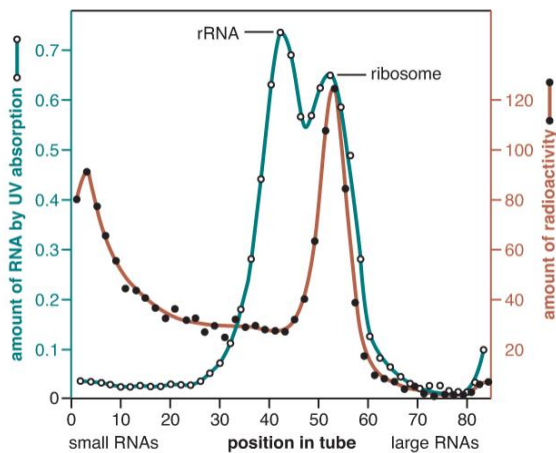
Transfer RNA (tRNA): This RNA is responsible for transferring amino acids to the growing polypeptide chain during the polymerization of proteins

Ribosomal RNA (rRNA): This is the most abundant form in the cell and is closely attached to ribosomes during translation

All diagrams, tables, and external information are property of Integrating Concepts in Biology by Campbell, Heyer and Paradise, unless otherwise specified.

Brenner, Jacob, and Meselson wanted to observe the different types of RNA involved in transcription and translation. In order to do this, they grew bacteria in the presence of **radioactive uracil**, a nitrogenous base which is only found in RNA nucleotides. They infected these bacteria with viruses at the same time they added the radioactive uracil, and then isolated and centrifuged the RNA so that it reached its **density dependent** location in the centrifuge (Think back to Meselson and Stahl!!). Essentially, they separated the RNA molecules by molecular weight, or size. They used UV light absorption to locate the radioactive RNA.

(Remember: the radioactivity of the RNA was a result of the radioactive Uracil which they initially grew the bacteria in, which has now become incorporated into the RNA)



The graph displays their results:

X Axis: Position of RNA in tube (because there was a density gradient, the location of the RNA molecule correlates to their size)

Y Axis: The left (blue curve) displays the amount of RNA present based on UV absorption, and the right (red curve) displays the amount of total radioactivity along the length of the centrifuge tube, which they measured separately

NOTE: The radioactive uracil will only be found in **NEWLY TRANSCRIBED RNA** (because it was transcribed after the Uracil was added)---This means that they were transcribed from **viral DNA** (**Think:** How do we know this based on the experimental design?)

The two large blue peaks are **ribosomes** (organelles made up of protein and RNA, they are the sites of translation, where proteins are synthesized)

This graph shows that there are many small radioactive RNA molecules which vary in size, and which associate with the ribosomes in the cell, but not with individual rRNA molecules. Because they are radioactive, they were transcribed from viral DNA, and not by the host cell. This data showed that an **RNA intermediate was being used to encode viral protein production**. The scientists called it **"messenger RNA"** because it brings DNA information from the nucleus to the ribosomes in the cytoplasm so that it can be used to make proteins.

The following videos provide a good overview of the processes of transcription and translation:

Transcription: <https://youtu.be/yEJ0OSK5nE0>

Translation:

https://www.youtube.com/watch?v=l3ayESyldd0&list=PLYjFOc4FIyikoVfco6zaxMx5_CDDHj2m&index=75

HIGHLIGHT #1: Central Dogma

The **Central Dogma** describes the flow of genetic information. It is the process by which the information in DNA is passed on through RNA (**transcription**), which is then used to create a functional protein product (**translation**).

DNA-----> RNA----->PROTEIN

Although these processes vary between eukaryotes and prokaryotes, this central dogma is shared by all life. Although the processes of transcription or translation can be very complex, it is important to remember that this Central Dogma is the big picture, and the ultimate goal is to use the information that is stored in DNA to make proteins.

HIGHLIGHT #2: Gene Induction

Gene Induction is the activation of an inactive gene so that it can be transcribed. This is a form of transcriptional regulation.

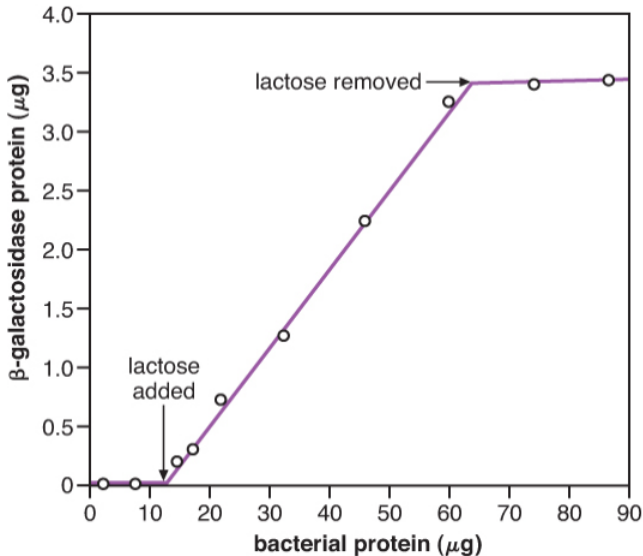
Transcriptional Regulation of Gene Expression: The variety of mechanisms by which a cell regulates transcription in order to increase or decrease the formation of specific gene products

This video provides a good overview of this process:

Regulation of Transcription: <https://www.youtube.com/watch?v=ypH-hDKpCY0>

Let's look at an example of gene induction:

Lactase and beta-galactosidase are two enzymes which play a role in the bacteria *E. coli*'s ability to consume lactose. We will look at the induction of beta-galactosidase after exposure to lactose, shown by the graph.



REMEMBER to always understand your X and Y axes before getting into what the graph shows.

Here we have a relationship between the amount of bacterial protein (x-axis) and the amount of beta-galactosidase produced (y-axis) as a function of the bacterial protein. The importance of this figure is to

understand the indirect function of time; in other words, how bacterial growth, shown by the amount of bacterial protein, was used to indirectly measure the time to produce beta-galactoside.

However, it is important to realize that the tick marks on the horizontal axis do NOT represent equal increments of time. In other words, the horizontal scale of this graph is not linear in time. To understand why, you need to know that *E. coli* divides approximately every 20 minutes, so the total protein mass in an aliquot would also double every 20 minutes. If time zero corresponds to the first measurement of 2 mg total protein mass, then 20 minutes have passed when the total mass is 4 mg, 40 minutes have passed when the total mass is 8 mg, and so on. This is how we can measure the strength and speed of gene induction.

This graph shows that the presence of lactose induces the beta-galactosidase gene, which caused beta-galactosidase to accumulate rapidly when lactose was introduced.

HIGHLIGHT #3: Codons

How is the RNA code translated into protein?

Recall that a protein is made up of many amino acids. In order for the nucleotides in RNA to be translated into amino acids, each of the 20 amino acids needs to have a unique corresponding

nucleotide sequence. Because of this, scientists realized that the genetic code is made up of three nucleotides; three RNA nucleotides correspond to one amino acid.

How did they know this?

Because there are 4 nucleotides in total, if RNA sequences of only 2 nucleotides were the genetic code, there would only be 4^2 , or 16, total combinations, which isn't enough to account for all 20 amino acids. 4^3 , on the other hand, is 64, which allows for more than enough combinations to account for each amino acid.

These 3-nucleotide sequences are called **codons**.

CHECK YOUR LEARNING

(Answers below)

- 1) Where does transcription take place in the cell? And Translation?
 - 2) In Brenner, Jacob, and Meselson's experiment, how did they know that all of the radioactive RNA was made from viral DNA?
 - 3) Why do you think beta-galactosidase is inactive in the absence of lactose and active in the presence of lactose?
 - 4) What do we mean when we say that the genetic code is redundant but not ambiguous?
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THINGS YOU MAY STRUGGLE WITH

- It is easy to mix up details of transcription and translation. Make sure you double check the locations, organelles, enzymes used, and overall processes of both!
- Remember that tRNA is involved in translation and brings amino acids to be added to the polypeptide chain, rRNA helps make up the ribosome and facilitates translation in the ribosome, and mRNA carries the information in DNA from the nucleus to the cytoplasm
- Remember that the gene induction study we looked at is only one example of transcriptional control, and not all examples of transcriptional control will look the same. There are many different mechanisms of transcriptional control, and gene product production can be increased and decreased through various means.

ANSWERS

- 1) Transcription takes place in the nucleus. Translation takes place in the cytoplasm.
- 2) Because they infected the bacteria with the virus at the same time that they added the radioactive uracil
- 3) Beta-galactosidase is needed for lactose digestion, so it is produced when there is lactose present. It is inactive when there is no lactose because it would be a waste of resources for the cell for the gene to be transcribed when there is no use for the enzyme.
- 4) The genetic code is redundant because multiple codons correspond to one amino acid. However, it is not ambiguous because each codon does NOT correspond to multiple amino acids. One codon can only designate one amino acid.

Thanks for checking out these weekly resources! Don't forget to check out our website for group tutoring times, video tutorials and lots of other resources: www.baylor.edu/tutoring! Answers to Check your Learning questions are below!