Bioengineering a Sustainable World
Jigsaw Reading 1: The Central Dogma

ISB Systems Education Experiences

TEACHER KEY

This article has been adapted from a scientific paper in the journal Nature.[1]

The Central Dogma describes the general sequencing and flow of information as found in living organisms. Each living organism, whether it is a single-celled prokaryote, or a complex mammalian eukaryote, must transfer information where it is stored in its DNA to the more usable form of protein. In his paper, Francis Crick proposes a specific sequence of information transfers that make up the central dogma of molecular biology. He supports his argument using previous research from other scientists as well as general logical reasoning.

DNA is a **polymer**, which means that it is a large molecule made of many ("poly") smaller subunit molecules—or, **monomers**. DNA is a **nucleic acid** that is made of monomers called **nucleotides**. Each nucleotide contains a nitrogenous base. There are four types of nitrogenous bases found within the DNA molecule. These four bases can be arranged in an almost infinite number of ways, with some bases repeating over and over. The sequence of these bases on segments of our DNA are called genes. Crick knew that somehow the genes on our DNA were being "read" or translated into our traits.

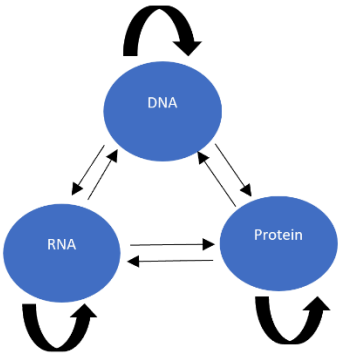


Figure 1 (to the left) shows a proposed transfer pattern between groups of polymers. The arrows point to the molecule receiving information. Answer the following questions based on this diagram:

1. What do you think the bold arrows represent (the ones that are present for each molecule, circling back to themselves!)?

Information transfer within that class of molecules - proteins transferring information to other proteins

2. Which polymer(s) provide direct information for the creation of protein? Do you think this is accurate? Why or why not?

Both DNA and RNA in this diagram.
No, this is inaccurate because only RNA is directly turned into protein sequences.

3. According to Crick, this diagram does not accurately show the central dogma. He says that there is no direct evidence found in research to support a number of the transfers shown in Figure 1. If he knew that this diagram was incorrect, why do you think it was still valuable for him to include it in his research paper?

It's important to see prior thinking in order to develop ideas and move forward.

[1] Crick, Francis. "Central Dogma of Molecular Biology." Nature Vol. 227, August 8, 1970.

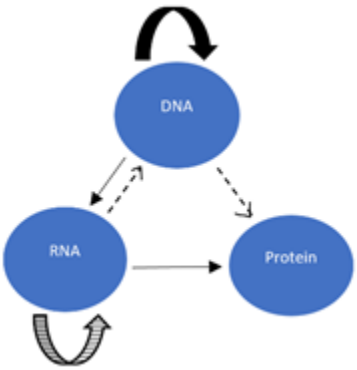


Figure 2 (to the left) shows a modified version of the original central dogma hypothesis. According to Crick, the solid arrows show general transfers; dotted arrows show special transfers; and absent arrows are the undetected transfers.

4. Describe at least 2 ways in which Figure 2 differs from Figure 1.

Some communication is only one way now (DNA → protein, RNA → protein). Not all transfers are of the same type anymore.

5. What do you think it means that protein has no arrows traveling FROM itself TO another polymer? What can we infer about protein?

Protein doesn't transfer any information - it is the end of the chain, the final expression of the information contained in the DNA.

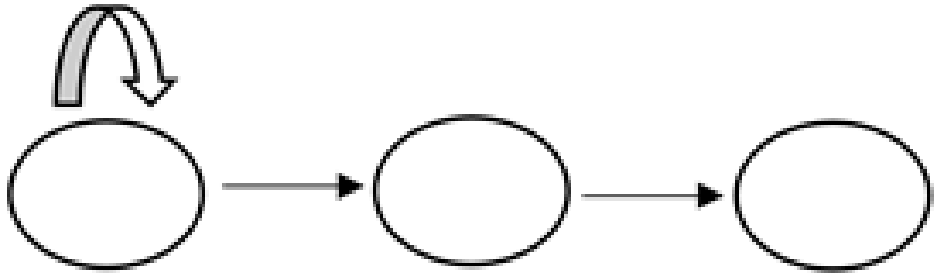
6. Complete the table below based on the key to Figure 2:

General Transfers	DNA → DNA, DNA → RNA, RNA → Protein
Special Transfers	RNA → RNA, __RNA → DNA__, __DNA → Protein__
Unknown Transfers	__Protein → DNA___, __Protein → RNA___, __Protein → Protein___

When creating this model, Crick made sure to highlight a few of the conditions of using this model. His main points have been summarized below:

- *It says nothing about what the machinery of the transfer is made of, and it says nothing about errors. An assumption in the model is that the transfers are accurately made.*
- *It says nothing about the rate at which the process is working.*
- *It only applies to present day organisms (keep in mind this paper was from 1970), and not for organisms of the past or undescribed organisms.*

Presently, a commonly used model of the Central Dogma is linear instead of triangular. Try to complete FIgure 3 below using the previous models as guides. Label each circle and arrow with appropriate terms.



DNA → RNA → Protein

7. Explain how you came up with your model for Figure 3. What key information did you use from the previous models?

I used the "general transfers" from the second model, as well as the fact that the protein is the final stage of the information.

8. Define the Central Dogma in your own words. Then, describe why you think it is so important in understanding various biological phenomena. For example, how a gene you inherited codes for a particular trait.

Information in DNA is turned into RNA which is then used to create proteins. Proteins then give rise to traits (like eye color) and this chain links the source of information for those traits back to DNA and genes.

In your group, decide what some of the key points are regarding the Central Dogma. Imagine you are teaching someone about how our DNA codes for our traits. Here is a direct quote from the end of Crick's paper for inspiration:

"...the discovery of just one type of present day cell which could carry out any of the three unknown transfers* would shake the whole intellectual basis of molecular biology, and it is for this reason that the central dogma is as important today as when it was first proposed."

**see table from question #6.*

List of Key Points:

- Three types of molecules contain information in cells
  - DNA - nucleotides (monomer), nucleic acid (polymer)
  - RNA
  - Protein
- A sequence of nitrogenous bases in DNA is a "gene"
- The original map of information transfer was a triangle with transfers between all elements
- The final map, the Central Dogma, is linear: DNA → RNA → Protein …. → Traits!
  - Therefore: genes give rise to traits!

Together with members from other groups--the algae biofuel group and the gene regulatory networks group, you will complete the Venn Diagram below relating the 3 topics. Try and have at least 1 point for each area of overlap. If writing doesn't fit in the overlap spaces, just number them and include a list below.

SEE PDF for Teacher KEY for Venn Diagram