DNA-RNA-Protein

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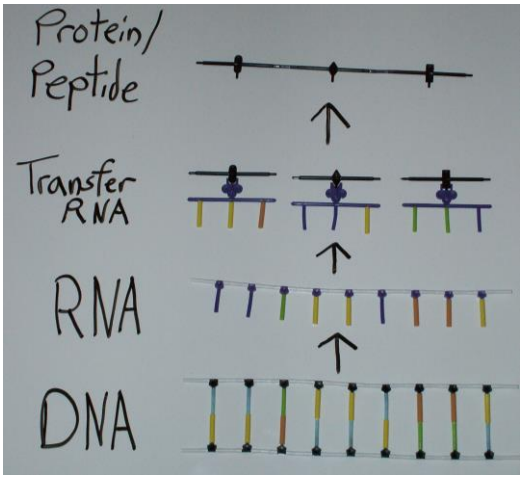
This lecture should be given after the Orbitals and Bonds lecture

Materials:

Advance Handouts: Picture of real blood cells showing white blood cells with nucleus and red blood cells
Hemoglobin handout illustrating that it as a chain of different amino acids
Globin amino acid sequence with amino acid code

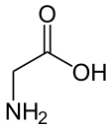
White board or other writing surface
Molecular modeling kit
DNA-RNA-Protein model kit (Commercial kit recommended (e.g. from Lab Aids, Catalog# 72-8)
Table of Elements (enough handouts for students to share in small groups)

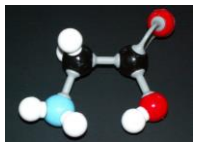


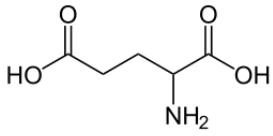
Preparation before the lesson:
Put together a double stranded DNA, single stranded RNA backbone and three transfer RNAs with attached amino acids, ready for giving an overview of transcription (DNA to RNA) and translation (RNA to Protein) below. Kits other than the one indicated above can be used. Also, put together molecular models of Glycine and Glutamate (see structure below)

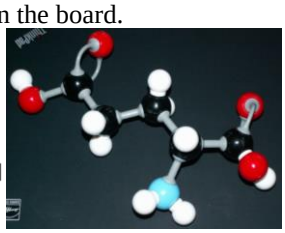
Key Words for use by students in discussion:
DNA, RNA, protein, amino acid

1) Before lesson, draw the stick atomic structure models of glycine and glutamate on the board.

Glycine 



Glutamate 



2) Tell the students to imagine you took blood from your hand and put it on some glass and stained it with a coloring dye. Discuss how the blood might look in a microscope. Distribute the handouts and note the picture of blood cells that shows red blood cells and white blood cells. Briefly discuss the function and importance of red blood cells, focusing on the importance of oxygen for providing energy to the body, and the need to move oxygen from our lungs to all of our cells, utilizing red blood cells to carry the oxygen.
3) Distribute Table of Elements for students to share and review Oxygen: Refer the students to the Neutelpro trading card. Determine the number of protons in the oxygen nucleus and the number of electrons spinning around the nucleus. Next indicate that Oxygen atoms like to travel around in pairs in a molecule referred to as O_2. Mention the Peewee trading card and ask the students how these 2 oxygen atoms stick together. After discussion, conclude that they must be sharing electrons to form a bond.
4) Ask the students how the red blood cells carry oxygen around the body, noting that other cells cannot do this. Initiate some thoughts by suggesting that there must be something in the red blood cells but not other cells that allows them to do this.
5) Refer the students to the handout picture of the protein hemoglobin and tell the students that this protein is made by putting together four separate proteins called globins and an iron containing molecule called Heme that binds oxygen very tightly. Refer to the handout and note that a lot of hemoglobin is found in red blood cells but not in other cells

6) Ask the students, "What is a protein like hemoglobin made of?" Guide them to conclude that it is made up of elements or atoms put together in some design. Tell them that if we break up hemoglobin or other proteins we will find little pieces called amino acids. Show models of glycine and glutamate amino acids using a molecular modeling kit, and refer to the illustrations on the board. Refer to the Neutelpro trading card and mention/discuss the atoms that are present in the amino acid models. Have select students describe the amino acids atoms and bonds in the models.

7) Note that all amino acids have at least one nitrogen group and one group containing two oxygen atoms attached to a carbon. But they are different in the remaining group. Demonstrate to the students that the two amino acids can be connected to start a chain by having the NH_2 of glutamate kick out the OH of glycine. Indicate you are starting to build a protein which is a chain of amino acids.

8) Tell the students that there are 20 different amino acids (refer them to the handout and briefly review) that get put together in different orders to make over 20,000 proteins in our body. Tell them the red blood cell makes hemoglobin by forming four chains of about140 amino acids (refer them to sequence in handout). Ask the students to point out where glycine and glutamate are present in the given sequence for one of the chains.

9) Discuss the repercussions of the red blood cell making mistakes when it made hemoglobin. If some of the amino acids are in the wrong order perhaps hemoglobin will not bind oxygen anymore. Ask, "what would happen to the body?"

10) Discuss ideas about how our cells put the amino acids for proteins in the right order so that they work correctly. Conclude by asking them, "where are the instructions for putting the amino acids in the correct order so the proteins work?"

11) Show the students a double stranded DNA, with two chains of repeating nucleotides, twisted into a helix. Tell them that DNA is used by the cells in our body to make proteins having the correct order of amino acids. Point to the white blood cell nucleus in the handout and note that this is where the DNA is located, in the nucleus of a cell. Have the students look at the DNA and ask for hypotheses/ideas on how DNA might act as the instructions for making proteins in a cell. Discuss the ideas in detail. During the discussion note that the DNA has only four different colors where the nucleotides meet on adjacent chains. For the model referred to above, guide the students to note that orange always seem to bind to green, and yellow to blue.

12) Write "DNA ⇨ RNA ⇨ Protein" on the board. For the kit listed, line up the components as illustrated in the figure above and describe the process as described in the steps below. For other kits, perform a similar exercise.

a) DNA uncoils and unzips and makes a matching RNA that has a different backbone (purple instead of black). Although yellow pairs with blue, blue with yellow, and green with orange, orange in DNA pairs with purple in RNA (uracil instead of thymine).
b) RNA floats away from the DNA, and DNA zips back up and goes into a helix again
c) RNA leaves the nucleus of the cell
d) With the help of a protein called ribosomes, the RNA binds to matching transfer RNA that have certain amino acids attached.
e) When transfer RNAs come close to each other on the DNA, their amino acids bind to each other.
f) The next transfer RNA binds to RNA and its amino acid joins the chain.
g) The amino acid chain keeps getting bigger, then folds into shapes such as ribbons, like in the protein globin (refer to handout).

13) Note that the DNA chain colors are deciding what the RNA chain looks like; and the RNA is deciding what the amino acid chain will be. Have as many students as possible lead the class through lesson step 12) with guidance when necessary.

14) Ask the students if they have ever translated words in one language to another. Tell them that the cells in their body are also translating languages. Point the students towards the handout that includes a code/language for making RNA from DNA and then Protein from RNA.

15) Write DNA sequences on the board utilizing the language in the handout (e.g. 9 base pairs) and have the students take turns using the table to determine the sequence of the amino acid chain that will be produced. Note to the students that each of these different proteins made would serve different functions in the cell.

16) Give the students a challenge question: Red blood cells do not have a nucleus with DNA, so how are proteins like hemoglobin made correctly in red blood cells? Discuss ideas as long as time permits, eventually informing the students that when red blood cells are being formed, the cells have a nucleus with DNA. But in the final step of red blood cell formation a small part of the cell containing the nucleus is pinched off. Thankfully, before the nucleus is pinched off, the cell has already utilized the instructions in the DNA to make hemoglobin.

DNA-RNA-Protein lesson highlights checklist

- ☐ Draw stick model of 2 amino acids on the board
- ☐ Show blood cells and discuss red blood cell function
- ☐ Review oxygen, O_2, utilizing Table of Elements, Neutelpro card, and Peewee card
- ☐ Introduce hemoglobin (globin proteins + hemes) as oxygen carrier
- ☐ Discuss proteins = chain of amino acids
- ☐ Illustrate the start of amino acid chain (protein) formation with 2 amino acids: have nitrogen group of glutamate kick out OH group of glycine
- ☐ Find glutamate and glycine in globin amino acid sequence
- ☐ Discuss consequences of amino acid sequence errors
- ☐ Demonstrate DNA ⇨ RNA ⇨ Protein with kit
- ☐ DNA ⇨ RNA ⇨ Protein demonstration by students
- ☐ DNA ⇨ RNA ⇨ Protein code as language translation
- ☐ Challenge: Determine protein from provided DNA sequence
- ☐ Challenge: How is hemoglobin formed if red blood cells have no nucleus?