#72 DNA-RNA-Protein Synthesis Model Kit
(Molecular Model of Transcription and Translation)

PART I

Student Worksheet and Guide

Genes are functional units of DNA. They express themselves by the proteins they dictate. DNA is found in the nucleus, but protein is synthesized at the ribosomes in the cytoplasm. Thus a messenger molecule is needed to carry the DNA code. This messenger molecule is called messenger RNA (mRNA). It is rich in ribose sugar, is formed in the nucleus and tests mildly acidic. Therefore it was named ribonucleic acid.

The purpose of this lab activity is to review the molecular make-up of DNA as it relates to RNA and protein synthesis. Replication of DNA, transcription and translation of RNA are modeled as well.

PROCEDURE:

DNA MODEL BUILDING. Working in pairs, you will construct a 9 rung DNA model using the following components:

nitrogen (pyrimidine) base:

4 Cytosine (C) (blue)
5 Thymine (T) (green)

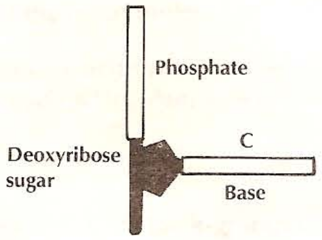
nitrogen (purine) base:

5 Adenine (A) (orange)
4 Guanine (G) (yellow)

20 Phosphates(white tube)
9 Hydrogen bonds (white rod)
18 Deoxyribose sugar (black pentagon)

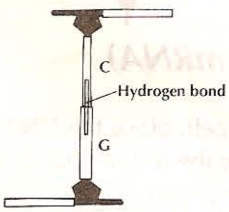
1. Build 18 nucleotides:

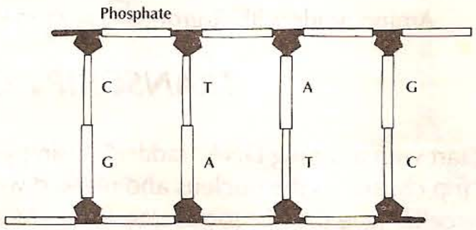
4 each of Cytosine (C) and Guanine (G)
5 each of Adenine (A) and Thymine (T)



A nucleotide of DNA consists of a phosphate, a deoxyribose sugar and oneof the four bases (A, T, C, or G).

2. Use these nucleotide units to construct a 9 rung ladder of DNA. Match DNA nucleotides of adenine (orange) with thymine (green) and cytosine (blue) with guanine (yellow) using white rods (hydrogen bonds). You may choose the sequence of bases, but have at least one of each color on both sides of your ladder. Bond the phosphate of each nucleotide to the sugar unit of the neighboring nucleotide. Have teacher check your DNA model before continuing.





4 rung DNA ladder

3. Build 18 more nucleotides of DNA (four C and G and five A and T), but do not make a second ladder.
4. Unzip the DNA ladder at weak hydrogen bonds.

REPLICATION OF DNA.

1. As the DNA ladder is unzipped, bring in the new nucleotides (built in step 3) complementary to the "old" ones on the half ladders. You now have two identical models, one half of each model is old and one half is newly formed. This process of replication results in an x-shaped duplicated chromosome. As the two sides of the duplicated chromosomes separate during cell division each resulting daughter cell will have a copy of each chromosome.

2. Set aside one model to be used for additional parts.

PROTEIN SYNTHESIS.

PART II

The sugar units used in DNA are deoxyribose, however, the sugar units in RNA nucleotides are ribose. Protein synthesis involves two major steps, each with its own kind of RNA.

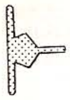
In the first step called **TRANSCRIPTION**, a messenger RNA (mRNA) molecule will be produced by pairing mRNA nucleotides with a half "ladder" of a DNA molecule. You will choose one side of your DNA model to use as the sense side. The sense side is the side with exposed nitrogen bases that will bond to the bases of the mRNA as it has the code for protein production. This mRNA will leave the nucleus and go to a ribosome in the cytoplasm. The ribosome (ribose rich body) is made of a form of RNA also.

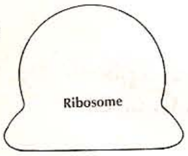
In the second step called **TRANSLATION**, the mRNA will attract a second form of RNA called transfer RNA (tRNA). These tRNAs will bring in and place amino acids in the proper sequence to produce the specific protein as ordered by the gene that was transcribed.

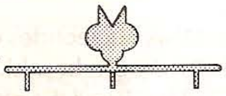
II. PROCEDURE:

RNA AND PROTEIN SYNTHESIS

Use the following components:

Cytosine (C)	blue tube
Uracil (U)	lavender tube-(Uracil is a molecule similar to thymine andsubstitutes for it in RNA. Uracil *will always* bond to adenine.)
Adenine (A)	orange tube
Guanine (G)	yellow tube
Phosphate group	white tube
Hydrogen bond	white rod
Ribose sugar 	purple pentagon-Ribose sugar is similar to deoxyribose and is found in all forms of RNA. (Deoxyribose has one less oxygen atom.)

Ribosome 

tRNA 

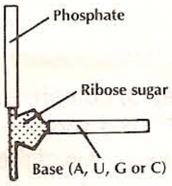
Peptide bonds 

Amino acids with R-groups (◊, O, □) 

TRANSCRIPTION (production of mRNA)

1. Start with a 9 rung DNA "ladder". Using your desk top to simulate a cell, place the DNA on a portion of the desk top chosen as the nucleus and marked with chalk or a piece of tape; the rest of your desk can be the cytoplasm of the cell. Place the ribosome, transfer RNAs and amino acids in the cytoplasm.

2. Construct nine mRNA nucleotides which will be complementary to the "sense" strand of DNA. (Remember that if DNA has adenine, it must match with uracil in RNA.)



A nucleotide of RNA consists of a phosphate, a ribose sugar (purple pentagon) and one of the four bases (A, U, G or C). (Figure 1)

Fig. 1.

3. Unzip the DNA model.

4. Bond the mRNA nucleotides with their partners on the DNA and to each adjoining mRNA between the sugar of one and the phosphate of the next in line. See Fig. 2.

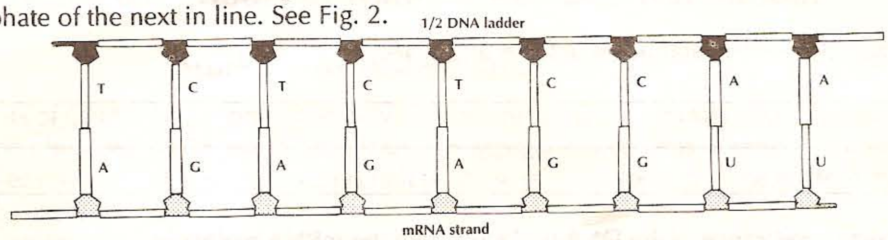


Fig. 2 (example)

5. Unzip the mRNA at the hydrogen bonds. (The DNA can zip back together or help form a new mRNA.)

6. Take the "free" mRNA molecule from the nucleus and place on the ribosome in the cytoplasm. This will be the site of protein synthesis. The sequence of bases of mRNA has the message for the construction of a specific protein. This code works in units of three nucleotides called "triplet" codons. A triplet codon of mRNA will attract another form of RNA called transfer RNA (tRNA), a small molecule which has a double attraction-to both a triplet codon of mRNA and to an amino acid. The tRNAs act as a construction worker bringing the amino acids into proper sequence at the mRNA in order to construct a protein.

e.g. triplet codon of mRNA-AGC (codon)
triplet codon of tRNA-UCG (anticodon)

The 20 basic amino acids are found in cytoplasm after being digested and absorbed from foods containing proteins.

7. Place the mRNA on the model ribosome, the site of protein synthesis.

III. Translation-Protein synthesis

1. Construct the tRNA molecules by matching three bases that are complementary to the bases of a codon on the mRNA.

2. Find the amino acids with the specific R-group (see Fig. 3) that matches each tRNA. (Amino acids differ in their R-group.)

Amino acids with R-groups (◊,O,□)

3. Attach the tRNA's to the R-groups of their specific amino acids. (see Fig. 4)

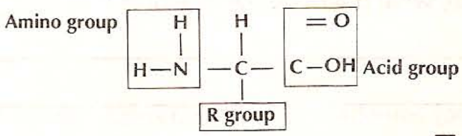


FIGURE 3

4. Bring the tRNA-amino acid complex to the codon of mRNA which codes for that tRNA. Attach with hydrogen bonds. (Fig.5)

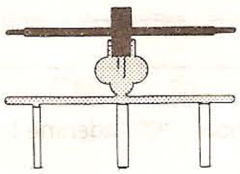


FIGURE 4

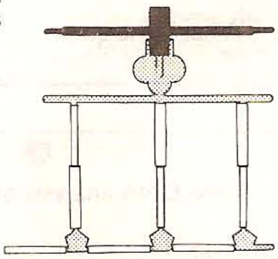


FIGURE 5

5. Attach covalent (peptide) bonds (grey tubes) between adjoining amino acids. These peptide bonds are formed through a series of dehydration syntheses. (Fig. 6)

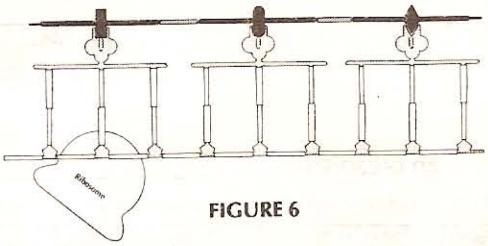


FIGURE 6

6. Disconnect the polypeptide (amino acid chain) from the tRNAs. The polypeptide chain will then coil, twist or fold and even may link with other chains. The result is a protein built to the exact specifications of the DNA code.

7. The tRNAs are then disconnected from the mRNA. Both are now available to be used again in the cytoplasm.

SUMMARY QUESTIONS:

1. Compare the phosphates, sugars and bases of DNA and RNA.

2. Compare the general appearance of the DNA molecule with the mRNA molecule.

3. What is produced in transcription?

4. What is produced in translation?

5. If a DNA triplet code is TAC, what is the complementary code of mRNA?

6. If mRNA codons are AUG, GGU, CAG, what three codons of tRNA will attach?

7. In an analogy between a factory and a cell: If DNA is the superintendent and mRNA is the order to the assembly line (ribosomes), what might be the role of tRNA?

8. What is the source of free amino acids in the cytoplasm?

9. If the DNA analysis of a gene shows 20% adenine bases, what would be the percentage of thymine?

cytosine? guanine? and uracil?

10. List by order of size the following: gene, cell, chromosome, atom, nucleus, base subunit, nucleotides.

*OPTIONAL

11. What are two general uses of protein in an organism?

12. What might be the result of a mutation of DNA in which a triplet code such as CAC now says CTC?