Translation and Transcription and Replication, Oh My!

Introduction

Transcription, translation, and replication are often very hard concepts for students to grasp when discussing DNA, RNA, and protein synthesis. This simple paper-and-pencil activity will take the fear out of this lion and tiger and bear of a concept.

Concepts

- Transcription vs. translation
- Replication
- DNA
- RNA

Background

DNA is an example of a complex biological polymer called a nucleic acid, which is made up of small subunits called nucleotides. The components of the DNA nucleotide are deoxyribose (a simple sugar), a phosphate group, and a nitrogen base. There are four possible nitrogen bases in DNA—adenine (A), guanine (G), cytosine (C), and thymine (T). In DNA, the nucleotides pair using hydrogen bonds to form a double strand. Because these two strands are twisted, it is referred to as a double helix. When base pairs are formed, adenine will only pair with thymine and guanine will only pair with cytosine.

The mechanism by which DNA creates exact copies of all genetic information is called *replication*. The hydrogen bonds between the bases are broken by an enzyme which "unzips" the two strands of DNA. Free nucleotides fill in and form base pairs that are bonded into a chain by another enzyme. The result is two identical copies of the DNA molecule.

How is information from nuclear DNA brought to the ribosomes for protein synthesis? The answer is simple—by a single strand of RNA called messenger RNA (mRNA). RNA is composed of a single strand rather than a double strand as in DNA. RNA contains a sugar called ribose, a phosphate group, and four nitrogen bases. Rather than thymine (T), RNA contains uracil (U). Messenger RNA molecules that are complementary to specific gene sequences in DNA are made in the nucleus by a process called *transcription*. The genetic information from DNA is transcribed into a single strand RNA "message" to be sent from the nucleus to the ribosomes for protein synthesis.

During protein synthesis at the ribosome, mRNA sequences are read and translated into amino acids. The amino acids are linked together into chains by enzymes to form proteins. The 20 amino acids are brought to the ribosomes by transfer RNA (tRNA). Every three nitrogen bases on a tRNA molecule are called an anticodon. This anticodon must match a codon, three nitrogen bases of the mRNA molecule, to translate into an amino acid. An infinite variety of proteins can be formed from the 20 amino acids, which can occur in any number and in any order.

Materials

Paper, 8½″ × 11″, plain or 1-cm graph

Pencil

Safety Precautions

Although the materials in this activity are considered nonhazardous, please use all normal laboratory safety precautions. Wash hands thoroughly with soap and water after performing laboratory activities.

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Preparation

1. Fold one sheet of paper in half width-wise as shown in Figure 1.
2. Divide each side in half again by folding each side *back* to the crease of the original fold. The paper should have an "M" shape when folded, as shown in Figure 2.
3. Lay the paper out in a landscape orientation.
4. Number the panels 1–4 from left to right as shown in Figure 3.
5. Fold the paper together so that only panels 1 and 4 are visible.
6. On the edge of panel 1 that touches panel 4, write the following DNA sequence (vertically).

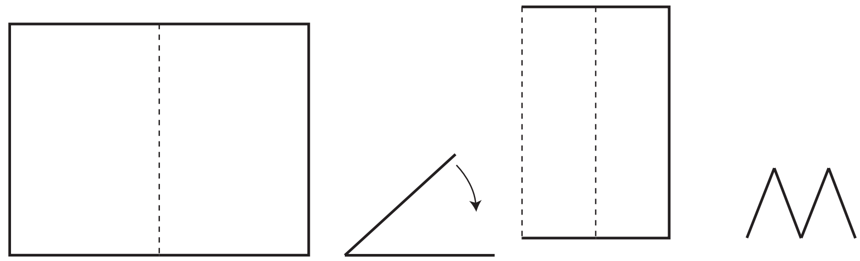


Figure 1.

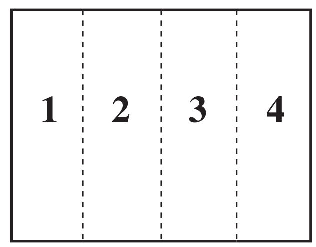


Figure 3.

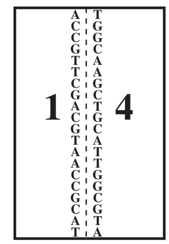


Figure 4.

A C C G T T C G A C G T A A C C G C A T

7. Now write the complementary DNA sequence on the edge of panel 4 next to the letter on panel 1 as shown on Figure 4. The result is a double-stranded DNA sequence.

Procedure

Replication

1. Pull apart panels 1 and 4 to expose all panels, as if "unzipping" the double-stranded DNA.
2. On panel 2 write the complementary DNA for panel 1 and on panel 3 write the complementary DNA for panel 4 in the same manner as completed for step 7 in the preparation section. See Figure 5. The original double-stranded DNA has now been replicated to form two identical double-stranded DNA molecules.

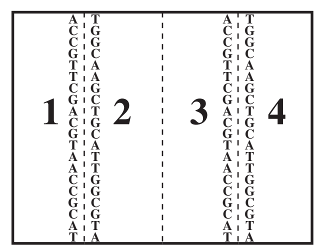


Figure 5.

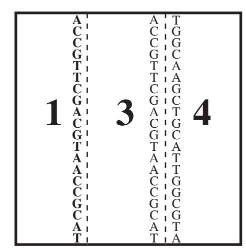


Figure 6.

Transcription

1. Fold panel 2 in half so that only panels 1, 3, and 4 show (the crease between panels 1 and 2 touches the crease between panels 2 and 3) as shown in Figure 6.
2. On panel 3 write the complementary RNA strand for the DNA on panel 1 as shown in Figure 7. *Note:* RNA does not contain thymine; the complementary base for adenine is uracil.
3. Lay the paper out in a landscape orientation. The single strand on the left edge of panel 3 is mRNA—label the strand "mRNA."

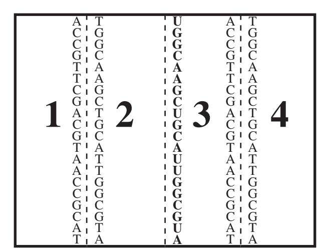
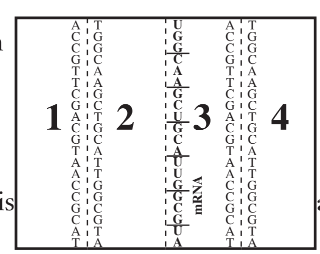
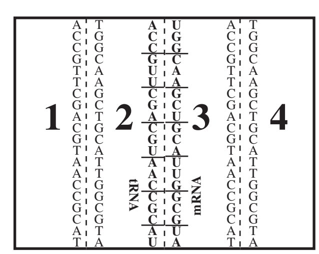


Figure 7.

Translation

1. Draw a line under every third base on the single strand of mRNA on panel 3 as shown in Figure 8. Each set of three mRNA bases is a codon.
2. Write the complementary tRNA strand on the edge of panel 2 next to the mRNA strand on panel 3—label this strand "tRNA."
3. Draw a line under every third base on the single strand of tRNA on panel 2 as shown in Figure 9. Each set of three tRNA bases is an anticodon.





Tips

- Graph paper (1 cm) will work well in helping students keep the base pairs aligned.
- Use the Genetic Code at Work Poster, Flinn Scientific Catalog No. FB1663, to determine the actual protein that would be formed from each mRNA codon.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Content Standards: Grades 5–8
Content Standard C: Life Science, structure and function in living systems, reproduction and heredity.
Content Standards: Grades 9–12
Content Standard C: Life Science, the cell, molecular basis of heredity.

Additional DNA Study Kits are available from Flinn Scientific, Inc.

Catalog No.	Description
FB1663	Genetic Code at Work Poster
FB1441	Genetic Code Kit
FB1223	DNA in Action Kit

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.