3d molecular designs

Transforming Science Learning

Go With the Flow!

Modeling DNA to RNA to Proteins and Beyond

Mary Howard

Science Teacher at Washington Township High School in Sewell, NJ

Mary Howard Basic Background

- **Education:**
  - Biochemistry
  - Physiology
  - Education
- **Experience:**
  - Researcher
  - Instructor

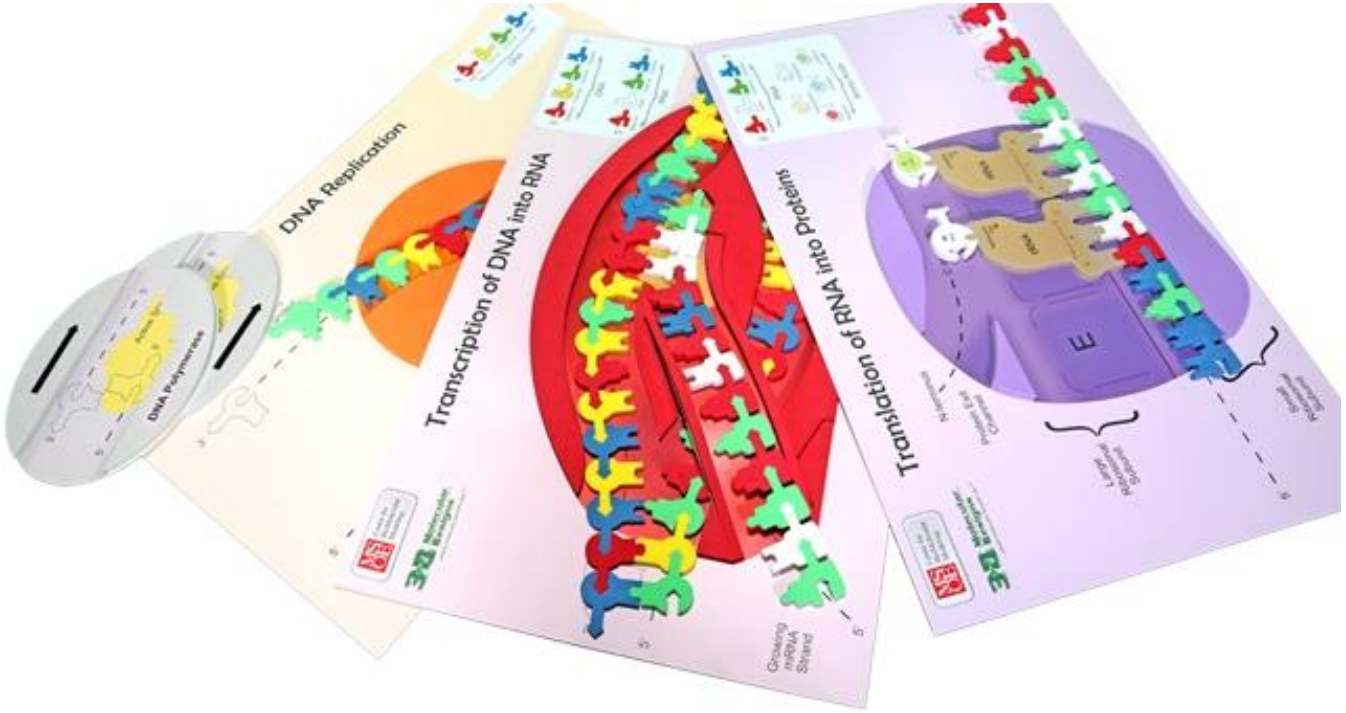
- **Science Classroom Strategies**
  - Lectures
  - Digital Activities
  - Laboratory Activities
  - Projects
  - Assessments

Icebreaker

Let’s Get Talking with Conversati

Cubes

Flow of Genetic Information

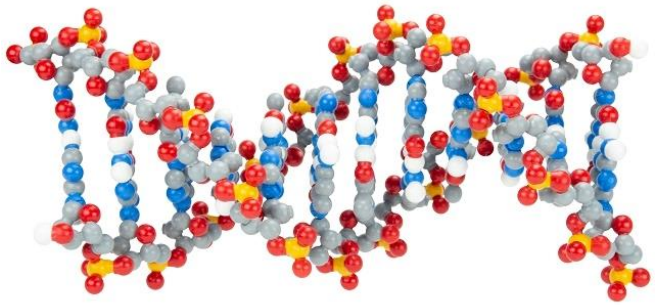


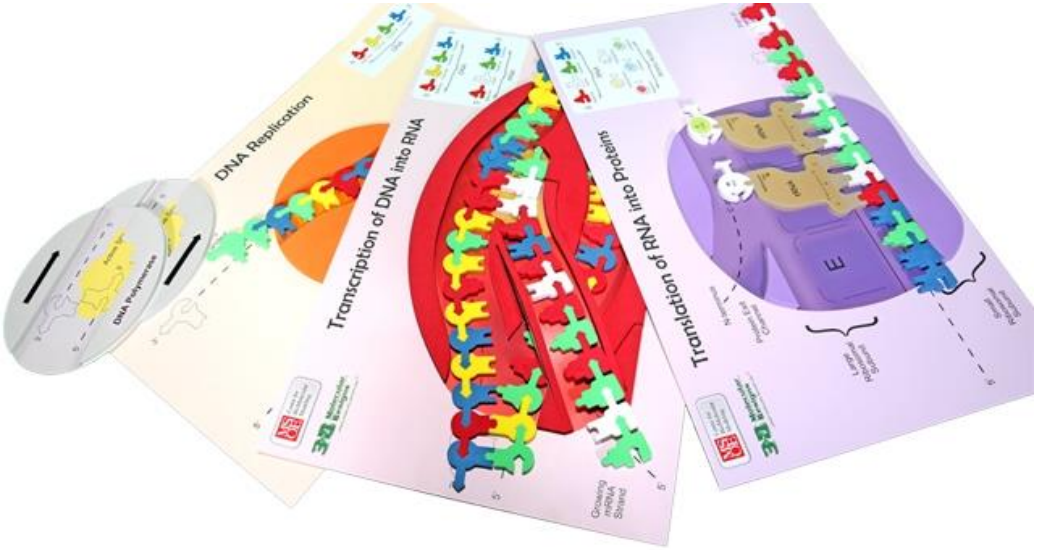
Resources found at:
https://3dmoleculardesigns.com/classroom_resources/flow-of-genetic-information-kit/

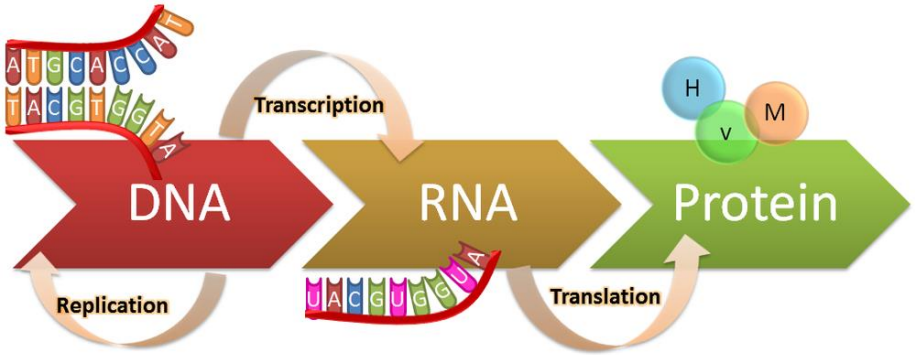
Resources and Materials

Kits Used in this workshop:

- Dynamic DNA
- Flow of Genetic Information

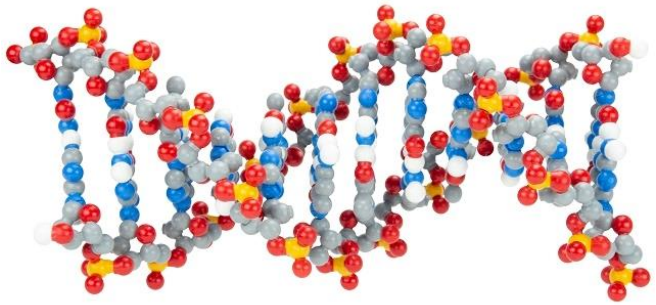






Central Dogma and Modeling; How do I start?

DNA Structure



The Double Helix

Video found at: https://www.youtube.com/watch?v=1vm3od_UmFg

DNA Models

- **Can you build it?**

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The Discovery of DNA

On April 25, 1953, a one-page paper entitled, *A Structure for Deoxyribonucleic Acid*, appeared in the British journal, *Nature*. The authors of this paper were James Watson, a young American post-doctoral candidate who had recently received a Ph.D. from the University of Illinois, and Francis Crick, a physicist who was completing his doctoral dissertation at Cambridge University, England. The paper began; *"We wish to suggest a structure for the salt of deoxyribose nucleic acid (D. N. A.). This structure has novel features which are of considerable biological interest."*

This initial description of the structure of DNA marked a major milestone in the development of molecular biology. In addition to reporting the correct structure of DNA, the paper also contained their classic understatement in scientific literature: *"It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material."* Their paper serves as an excellent example of what has become a recurring theme in the molecular biosciences — ***Forms Follows Function***. That is, the structure of a macromolecule often explains the macromolecule's function (how the macromolecule) works.

Watson and Crick's achievement is notable in several ways, including the fact that they determined the structure of DNA without performing a single experiment. They used the information from numerous other scientists who were investigating various properties of DNA.
Modeling was the major approach Watson and Crick used. Using paper cut-outs of the shapes of the four nitrogenous bases (A,T, G and C), they were able to combine all of the different facts that had accumulated to that date into a plausible model for the structure of DNA.

...The structure has two helical chains coiled around the same axis (see diagram). We have made the usual chemical assumptions, namely, that each chain consists of phosphate diester groups joining B-D-deoxyribofuranose residues with 3',5' linkages. The two chains (but not their bases) are related by a dyad perpendicular to the fibre axis. Both chains follow right-handed helices, but owing to the dyad the sequences of the atoms in the two chains run in opposite direction.

— Watson, J.D. and Crick, F.H.C., *Nature*, 171, 737-738 (1953)

Student Handout

The DNA Student Challenge

Your challenge today is to see if you can discover the correct structure of double-stranded DNA, just as Watson and Crick did over 50 years ago.

Your model should satisfy all of the pieces of experimental information that was known in 1953, as noted in the blue box below. Rather than using paper cut-outs to represent the DNA bases, you will use plastic models of the four deoxyribonucleotides whose 3D structures are based on known atomic coordinates of the B-form DNA. In these nucleotide models, magnets are used to represent both:

- the phosphodiester bonds that link the nucleotide units together into a long, linear polymer
- the hydrogen bonds that bond one base to another.

Information Available to Watson and Crick in 1953

DNA is a Polymer: Previous studies identified DNA as the genetic material of cells, and that DNA was a polymer consisting of three components:

- A nitrogenous base
- A pentose (5-carbon) sugar called deoxyribose
- A phosphate group.

Moreover, experiments suggested that the DNA molecule was unbelievably large, with molecular weights ranging from 25 x 10^6 to 3 x 10^9 daltons. (Since each nucleotide has a mass of 330 daltons, DNA molecules were believed to be composed of between 76,000 and 9,000,000 nucleotides.)

DNA is more dense than protein. At a density of 1.6 gm/cm^3, DNA was known to be more dense than protein (1.3gm/cm^3). This suggested that DNA was a densely packed structure.

Chargaff's Rules: In 1947, Erwin Chargaff demonstrated that while the four nucleotides were not present in equal amounts in the DNA from different organisms, the amount of adenine was the same as thymine, and the amount of guanine was the same as cytosine. This became known as *Chargaff's Rules:*

- The proportion of A always equals that of T, and the proportion of G always equals that of C. Thus, A = T and G = C.

X-ray Crystallography Data: In the laboratory of Maurice Wilkins, Rosalind Franklin used X-ray diffraction to analyze fibers of DNA. The pattern of spots on the X-ray diffraction pattern suggested that:

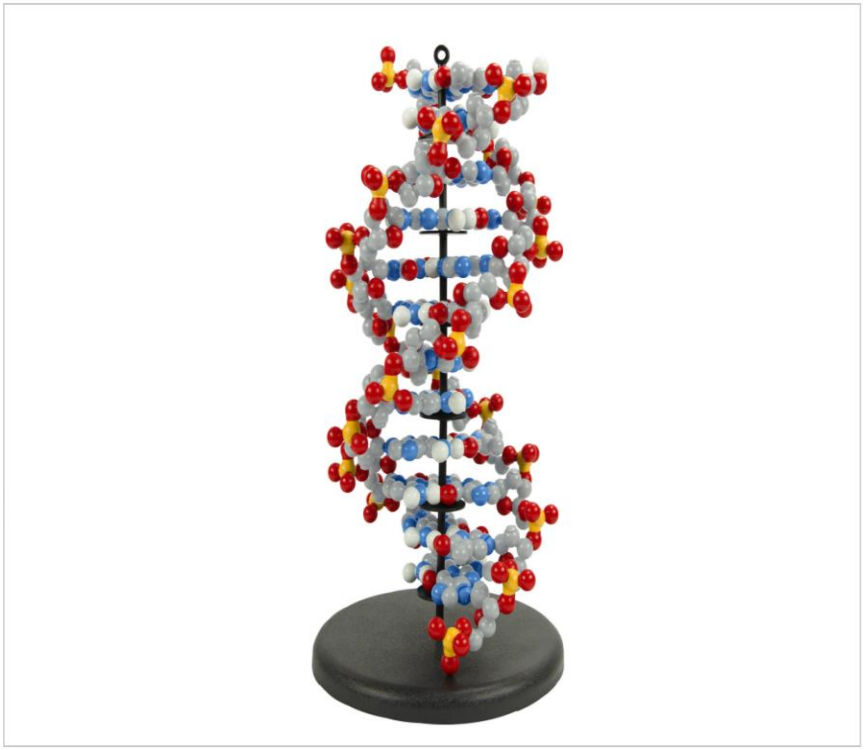
- Phosphate was on the outside, nitrogenous bases were on the inside.
- DNA was a double helix, made up of two strands.
- The two strands of DNA run in opposite directions (anti-parallel).
- There are 10 base pairs per turn of the double helix.
- The base pairs were the same width, since the double helix was uniformly wide.

Dynamic DNA Resources found at:
https://3dmoleculardesigns.com/classroom_resources/dynamic-dna-kit/

Dynamic DNA

- **Give it a try!**

Dynamic DNA Resources found at: https://www.3dmoleculardesigns.com/Teacher-Resources/Dynamic-DNA-Kit.htm



Dynamic DNA Kit©

DNA & Genetics

Sturdy, colorful pieces and magnets make it easy for students to snap, bend, twist, and interact as they build DNA. Thanks to our patented design innovations, the structure of this molecule is revealed to students through their own investigation. Truly a must have kit!

- Construct individual nucleotides with nitrogenous bases, sugars, and phosphate groups
- Feel the hydrogen bonding of the A-T and G-C base pairs
- Twist and unwind the double helix to set the stage for replication and transcription
- Convert thymine to uracil

Additional pieces allow them to make ATP, consider epigenetics and gene expression, and much more.

Learn more about **Dynamic DNA Kit©**

3d molecular designs
Transforming Science Learning

And Beyond!

- **Additional activities I could pull into my classroom to further engage my students?**

Current Event: DNA

- Find a current article focused on DNA
- Read the Article
- Write a Summary
  - One paragraph – What was the article about?
  - One paragraph - What did you find most interesting?
- Be Prepared to Share

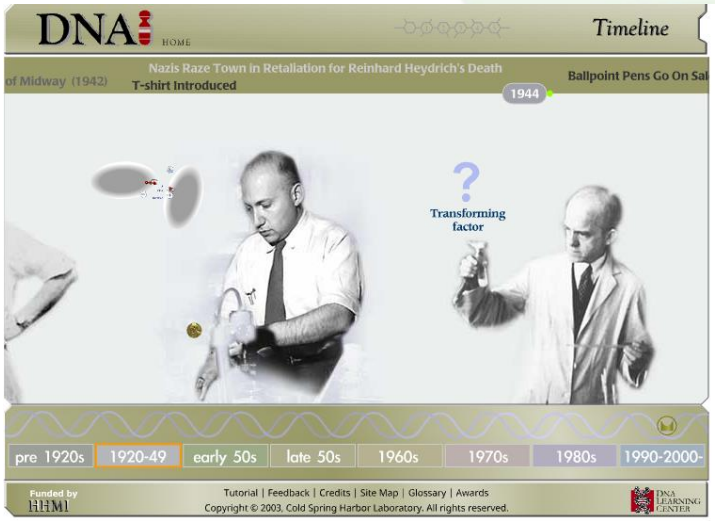
Unraveling Stem Cells' Secrets: Immortality of Germline Cells and the Function of "Junk DNA"

TOPICS: Cell Biology DNA Genetics MIT Stem Cells

By ANNE TRAFTON, MASSACHUSETTS INSTITUTE OF TECHNOLOGY APRIL 15, 2022

DNA History Challenge

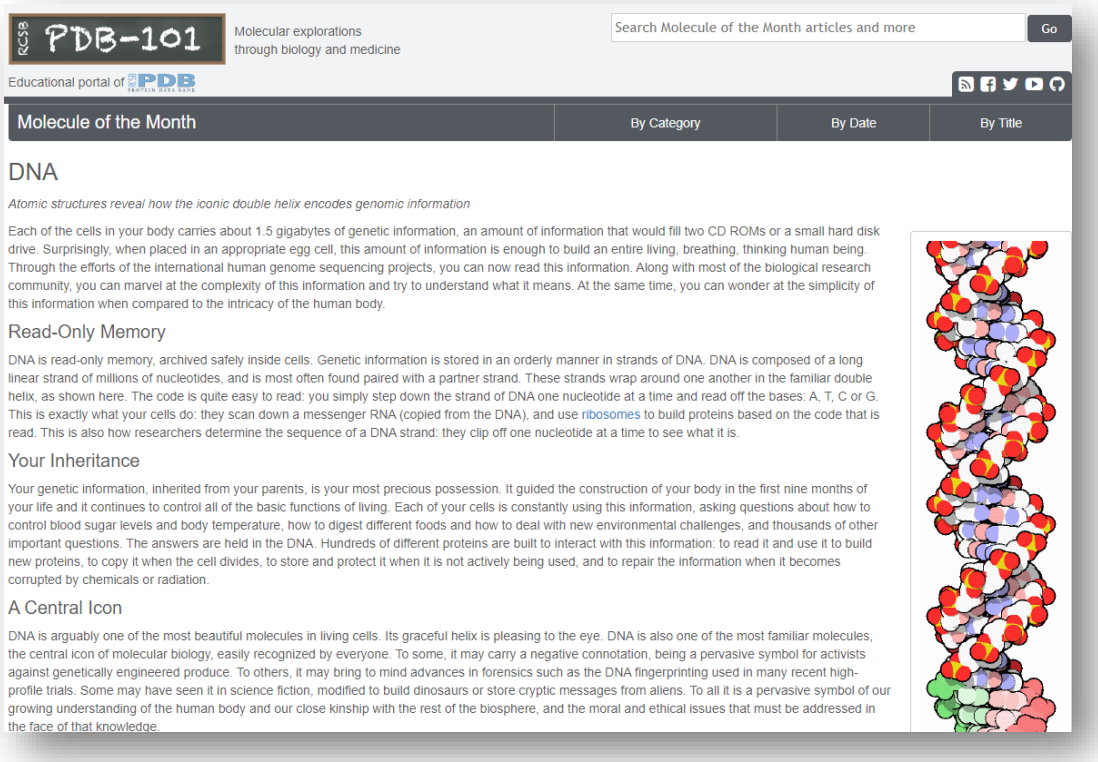
- Follow link to DNA Timeline
- Pick two scientists from the timeline
  - Communicate
  - Each person in group MUST have different scientists
- Create a Note Card
  - What did they discover!
  - Find at least three interesting facts
- Be Prepared to Share!



Timeline found at:
http://www.dnai.org/timeline/

Molecule of the Month

- **Student Enrichment Activity**
- **Protein Data Bank**



PDB-101 Molecular explorations through biology and medicine

Search Molecule of the Month articles and more Go

Educational portal of PDB

Molecule of the Month | By Category | By Date | By Title

DNA

Atomic structures reveal how the iconic double helix encodes genomic information

Each of the cells in your body carries about 1.5 gigabytes of genetic information, an amount of information that would fill two CD ROMs or a small hard disk drive. Surprisingly, when placed in an appropriate egg cell, this amount of information is enough to build an entire living, breathing, thinking human being. Through the efforts of the international human genome sequencing projects, you can now read this information. Along with most of the biological research community, you can marvel at the complexity of this information and try to understand what it means. At the same time, you can wonder at the simplicity of this information when compared to the intricacy of the human body.

Read-Only Memory

DNA is read-only memory, archived safely inside cells. Genetic information is stored in an orderly manner in strands of DNA. DNA is composed of a long linear strand of millions of nucleotides, and is most often found paired with a partner strand. These strands wrap around one another in the familiar double helix, as shown here. The code is quite easy to read: you simply step down the strand of DNA one nucleotide at a time and read off the bases: A, T, C or G. This is exactly what your cells do: they scan down a messenger RNA (copied from the DNA), and use ribosomes to build proteins based on the code that is read. This is also how researchers determine the sequence of a DNA strand: they clip off one nucleotide at a time to see what it is.

Your Inheritance

Your genetic information, inherited from your parents, is your most precious possession. It guided the construction of your body in the first nine months of your life and it continues to control all of the basic functions of living. Each of your cells is constantly using this information, asking questions about how to control blood sugar levels and body temperature, how to digest different foods and how to deal with new environmental challenges, and thousands of other important questions. The answers are held in the DNA. Hundreds of different proteins are built to interact with this information: to read it and use it to build new proteins, to copy it when the cell divides, to store and protect it when it is not actively being used, and to repair the information when it becomes corrupted by chemicals or radiation.

A Central Icon

DNA is arguably one of the most beautiful molecules in living cells. Its graceful helix is pleasing to the eye. DNA is also one of the most familiar molecules, the central icon of molecular biology, easily recognized by everyone. To some, it may carry a negative connotation, being a pervasive symbol for activists against genetically engineered produce. To others, it may bring to mind advances in forensics such as the DNA fingerprinting used in many recent high-profile trials. Some may have seen it in science fiction, modified to build dinosaurs or store cryptic messages from aliens. To all it is a pervasive symbol of our growing understanding of the human body and our close kinship with the rest of the biosphere, and the moral and ethical issues that must be addressed in the face of that knowledge.

PDB Resource Link: https://pdb101.rcsb.org/motm/23

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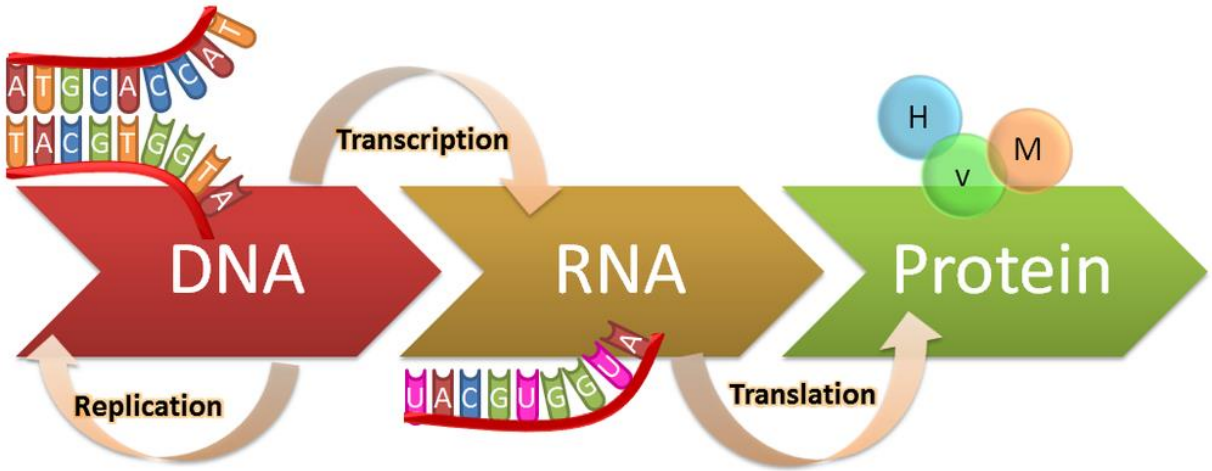
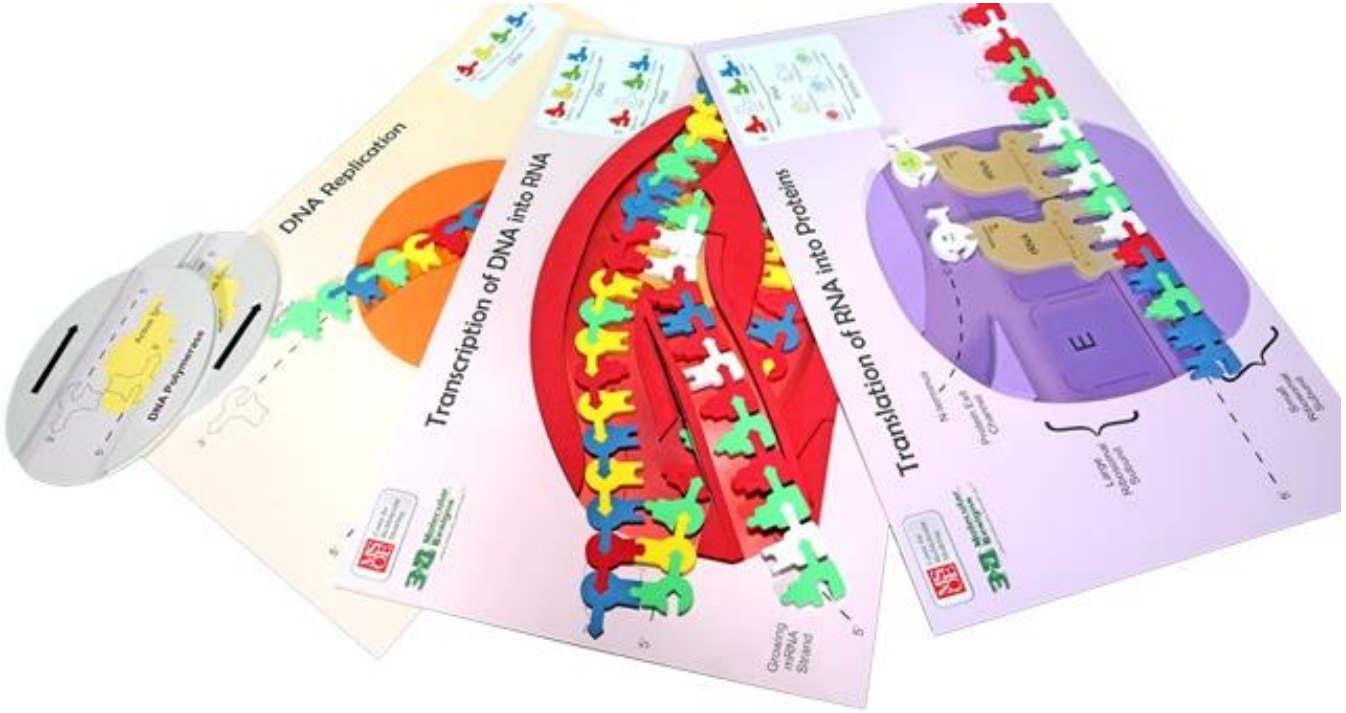


Central Dogma

- Replication
- Transcription
- Translation

How can students learn the concept of the Central Dogma through Modeling?

Flow of Genetic Information

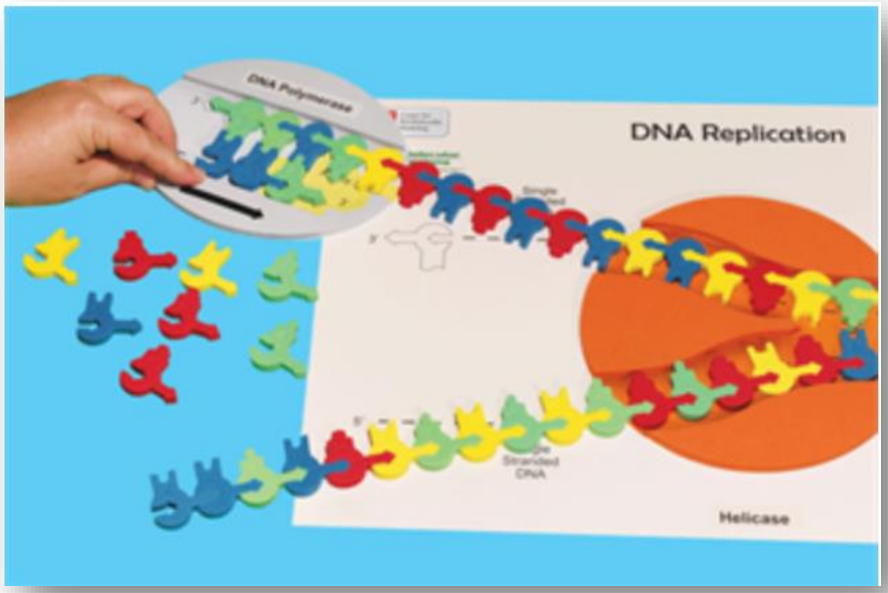


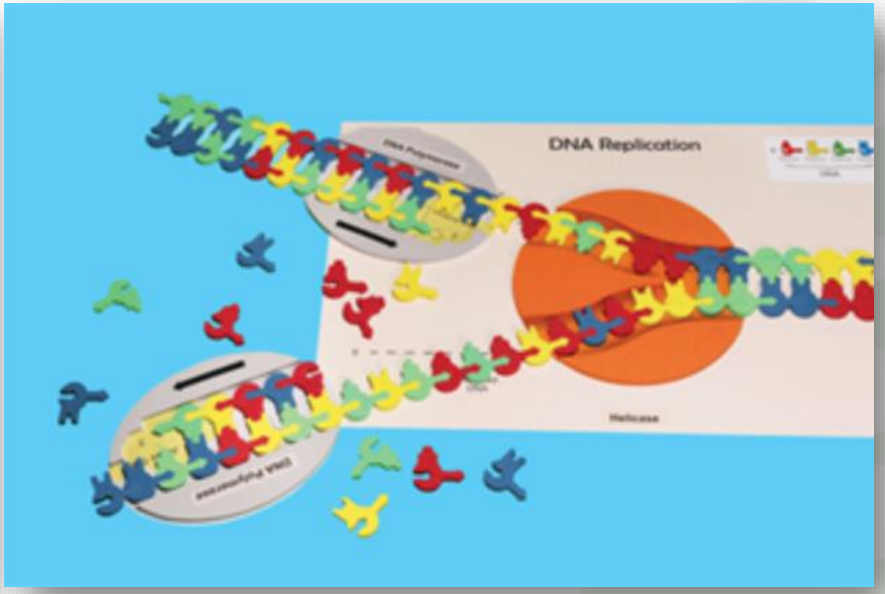
Resources found at:
https://3dmoleculardesigns.com/classroom_resources/flow-of-genetic-information-kit/

DNA Replication

Components:

- DNA Sequence
- DNA Replication Mat
- DNA Polymerase
- Foam Nucleotides





Replication Handouts

3D Molecular Designs
...where molecules become real™

Flow of Genetic Information Kit©

Teacher Notes

Contents

Activity Guide

This activity guide for the Flow of Genetic Information Field Test Kit© will help you consider different ways you may use these materials. We encourage you to modify these lessons and activities to meet the learning objectives and needs of your specific students.

Replication Activity

Objectives

Students will

- **Identify** the directionality of a DNA strand.
- **Explain** the implications of the anti-parallel structure of DNA as it relates to replication.
- **Model** the replication of the leading and lagging strands of DNA.
- **Describe** the semiconservative nature of DNA replication.
- **Describe** the semi-discontinuous process of DNA replication.
- **Explain** how a change in the DNA code may result in a change in the encoded protein.

Prerequisite Knowledge and Skills

- Hydrogen bonding and covalent bonding
- Cell structure
- DNA structure
- Cell cycle basics
- Prokaryotic and eukaryotic cell structure

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DNA Replication Activity Guide

Student Handout

Deoxyribonucleic Acid (DNA)

Engaging in a Discussion of DNA

1. List at least three reasons why a cell must undergo division.

2. Imagine you are cutting a bagel (one of the most common household injuries) and you get a cut. The cut heals. How do the new cells compare to the original (pre-cut) cells?

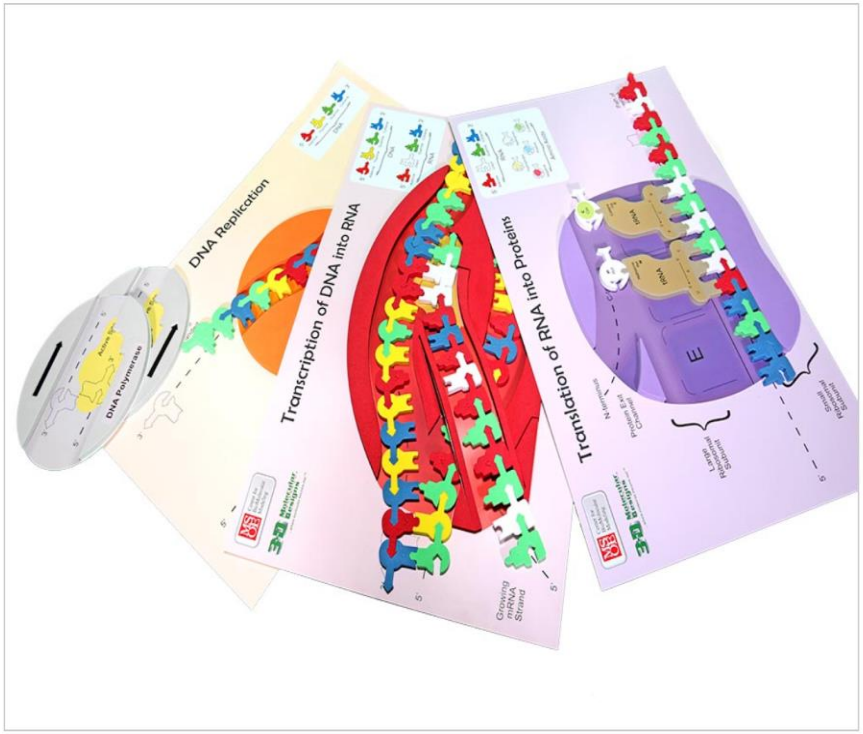
3. How does your body ensure that the new cells are the same?

4. How does DNA get into the new cells?

Introduction

No molecular structure has gained more world-wide recognition than the DNA double helix. The famous *Nature* paper written by James Watson and Francis Crick in 1953 entitled, *Molecular Structure of Nucleic Acids*, ends with, "It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material." Since then, many scientists have focused on researching the mechanism of DNA replication.

Resources and Handouts found at:
https://3dmoleculardesigns.com/classroom_resources/flow-of-genetic-information-kit/



Flow Of Genetic Information Kit©

The Central Dogma of Biology makes sense when your students can make it happen right before their eyes. Don't be surprised if someone blurts **"Now I get it!"** while using this kit. You can also purchase the Side Chain Expansion Pack or use the side chains from the Amino Acid Starter Kit© to add even more authenticity and connections!

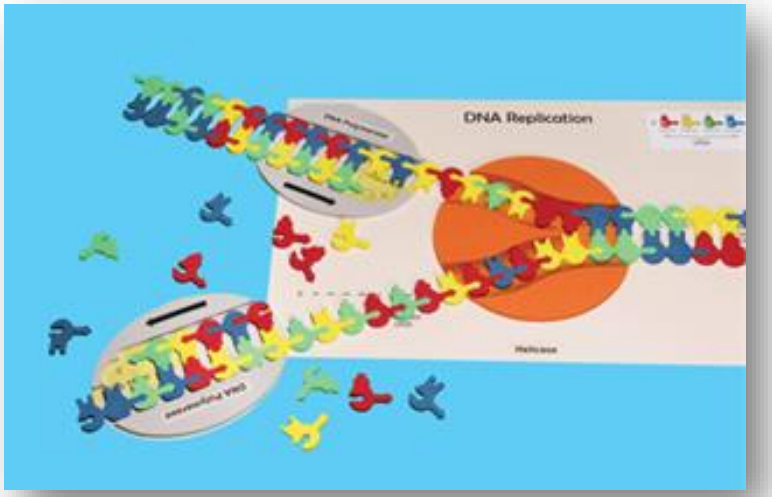
- Identify essential enzymes like helicase and polymerase
- Model replication of the leading and lagging strands of DNA
- Explore transcription as they copy one strand of DNA into mRNA using an RNA polymerase
- Engage in translation/protein synthesis as they decode the mRNA into protein on the ribosome placemat
- Reenact the different results of the Meselson and Stahl experiments

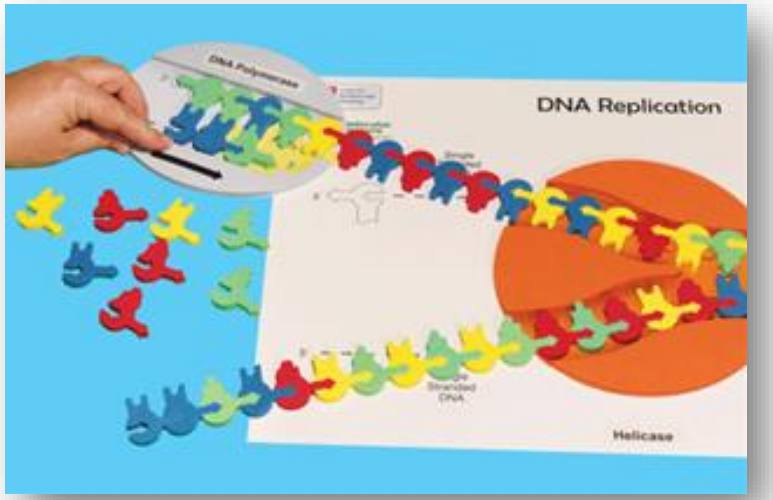
You can also purchase the Side Chain Expansion Pack or use the side chains from the **Amino Acid Starter Kit©** to add even more authenticity and connections!

Flow of Genetic Information

- **Give it a try!**

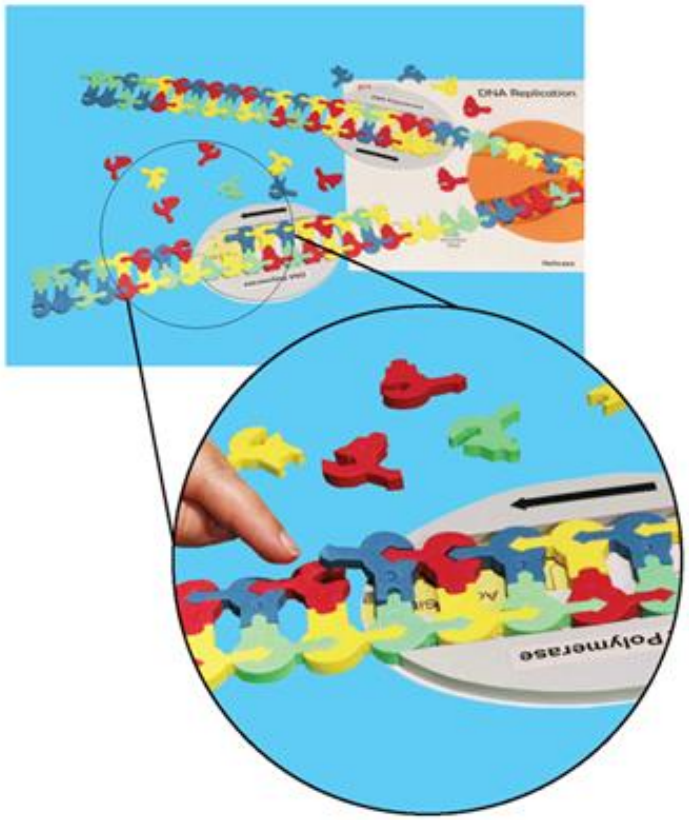
Assemble the non-template strand of the DNA sequence according to the pattern shown below.



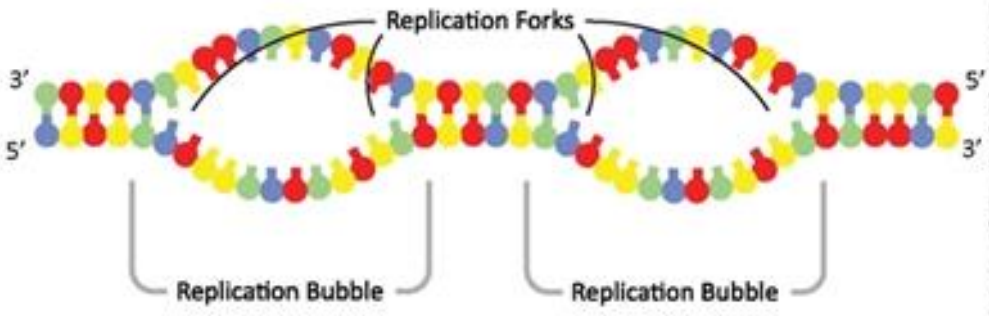


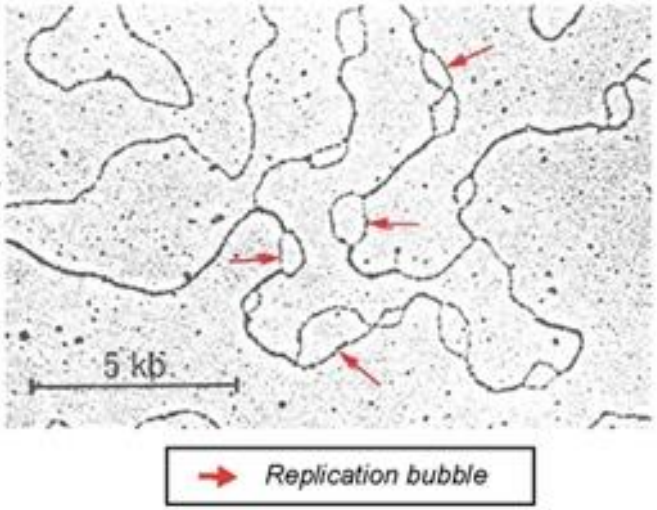
Highlights: Continuous and Discontinuous Replication

- Leading Strand
- Lagging Strand
- Okazaki Fragments



Highlights: Origins of Replication





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And Beyond!

- What About Assessment?
- Any Enrichment?

Show Me What You Know!

- **Group Activity**
  - **Review what you learned**
  - **Demonstrate DNA Replication**
    - **Make sure to explain each step**
    - **Use all components that are necessary for replication**
    - **Everyone has a role**
  - **Practice**
    - **This is a graded demonstration**
    - **Know Before You Go!**

Want to dig deeper?

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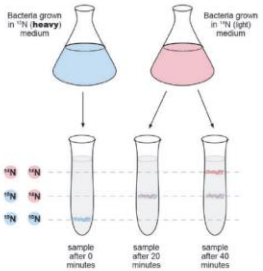
Flow of Genetic Information Kit©

DNA Replication Continued

Three Models for the Process of DNA Replication

In 1958 at the California Institute of Technology, Matthew Meselson and Franklin Stahl devised an elegant series of experiments to determine which one of three models explained the mechanism of DNA replication. (You can find and read their published paper on our website at 3dmoleculardesigns.com/Teacher-Resources/Flow-of-Genetic-Information-Kit/Replication-Student-Handout-and-Key.htm.) Meselson and Stahl cultured *E. coli* in a medium containing nucleotides labeled with a heavy isotope of nitrogen, ^{15}N. They transferred the bacteria to a medium with only ^{14}N, a lighter isotope. A sample was taken after the DNA had replicated once (20 minutes). Another sample was taken after the DNA replicated again (40 minutes). The DNA was extracted from the bacteria in the samples and then centrifuged to separate the DNA of different densities. Their results are shown below.



Obtain and assemble 4 nucleotide base pairs of the colored DNA foam pieces. Find the matching gray base pair pieces but DO NOT assemble them. These colored DNA strands represent the parental strands from *E. coli* grown in a medium tagged with ^{15}N nucleotides. The gray foam pieces represent the nucleotides used to synthesize new DNA.

You will use the foam DNA models to detect which mechanisms of replication would most likely explain Meselson and Stahl's results.

You will create a physical representation of the three models of DNA replication: (1) conservative, (2) semiconservative, and (3) dispersive. Begin with modeling the first round of replication of the DNA after the bacteria were transferred to a medium with only ^{14}N.

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DNA Replication Student Handout
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Appearances of regeneration from naked masses of protoplasm have sometimes been noted, but never in examples in which it had been established that there were no small, fully formed cells from which the growth might have arisen. It is, of course, possible that cultural conditions will be found under which masses of naked protoplasm will revert to cellular growth, such as has been reported by Nečas[4] in *Saccharomyces cerevisiae* and by Pease[11] in *Proteus vulgaris*.

[1] C. Weibull, *Symposium Soc. Gen. Microbiol.*, **6**, 111, 1956.
[2] J. Lederberg, these PROCEEDINGS, **42**, 574, 1956; K. McQuillen, *Biochim. et Biophys. Acta*, **27**, 410, 1958.
[3] K. McQuillen, *Symposium Soc. Gen. Microbiol*, **6**, 127, 1956; S. Spiegelman, in *The Chemical Basis of Heredity*, ed. W. D. McElroy and B. Glass (Baltimore: Johns Hopkins Press, 1957), pp. 232–267; J. Spizizen, these PROCEEDINGS, **43**, 694, 1957; D. Fraser, H. R. Mahler, A. L. Shug, and C. A. Thomas, Jr., these PROCEEDINGS, **43**, 939, 1957; E. Chargaff, H. M. Schulman, and H. S. Shapiro, *Nature*, **180**, 151, 1957.
[4] O. Nečas, *Biol. Zentr.*, **75**, 268, 1956; A. A. Eddy and D. H. Williamson, *Nature*, **179**, 1252, 1957.
[5] Mary R. Emerson, in manuscript. Our mutant strain, Em 11200, has been shown to be allelic to a number of others of independent origin: B 135 and M 16 obtained from Dr. D. D. Perkins, Stanford University; "wooly," from Dr. H. L. K. Whitehouse, Cambridge University; and "ginger" and an unnamed mutant from Dr. J. R. S. Fincham, University of Leicester. From published descriptions it is likely that these are also allelic to the "cut" mutant of Dr. H. Kuwana (*Cytologia*, **18**, 235, 1953).
[6] Mary B. Mitchell and H. K. Mitchell, these PROCEEDINGS, **38**, 442, 1952.
[7] Mary B. Mitchell, H. K. Mitchell, and A. Tissieres, these PROCEEDINGS, **39**, 606, 1953.
[8] G. W. Beadle and E. L. Tatum, these PROCEEDINGS, **27**, 499, 1941.
[9] The hemicellulase preparation was obtained from the Nutritional Biochemical Corporation, Cleveland 28, Ohio, who inform us that it is a concentrate of microbiological origin, containing cellulase, gumase, and maltase in addition to hemicellulase. A single test in our laboratory indicated strong chitinase activity.
[10] J. Lederberg and Jacqueline St. Clair, *J. Bacteriol.*, **75**, 143, 1958.
[11] Phyllis Pease, *J. Gen. Microbiol.*, **17**, 64, 1957.

THE REPLICATION OF DNA IN ESCHERICHIA COLI*

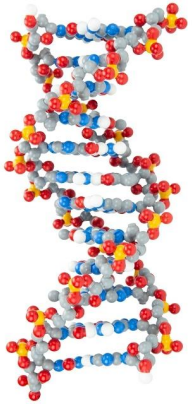
BY MATTHEW MESELSON AND FRANKLIN W. STAHL

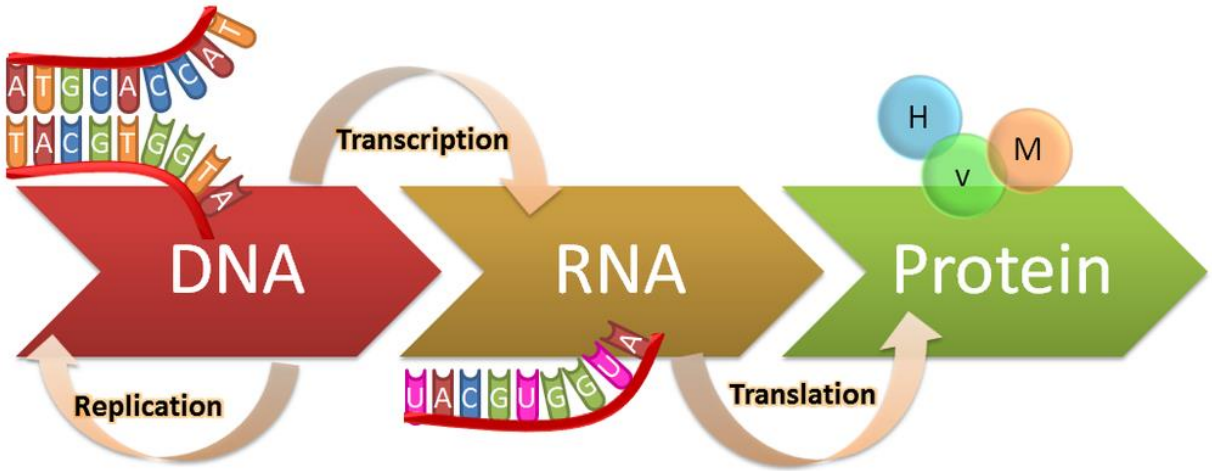
GATES AND CRELLIN LABORATORIES OF CHEMISTRY,† AND NORMAN W. CHURCH LABORATORY OF CHEMICAL BIOLOGY, CALIFORNIA INSTITUTE OF TECHNOLOGY, PASADENA, CALIFORNIA

Communicated by Max Delbrück, May 14, 1958

Introduction.—Studies of bacterial transformation and bacteriaphage infection[1–5] strongly indicate that deoxyribonucleic acid (DNA) can carry and transmit hereditary information and can direct its own replication. Hypotheses for the mechanism of DNA replication differ in the predictions they make concerning the distribution among progeny molecules of atoms derived from parental molecules.[6]

Radioisotopic labels have been employed in experiments bearing on the distribution of parental atoms among progeny molecules in several organisms.[6–9] We anticipated that a label which imparts to the DNA molecule an increased density might permit an analysis of this distribution by sedimentation techniques. To this end, a method was developed for the detection of small density differences among





Central Dogma

- Replication
- Transcription
- Translation

How can students learn the concept of the Central Dogma through Modeling?

Transcription

Components:

- DNA Sequence
- Transcription Mat
- Foam DNA Nucleotides
- Foam RNA Nucleotides

Transcription Handouts

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Flow of Genetic Information Kit©

Teacher Notes

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- **Describe** the semi-discontinuous process of DNA replication.
- **Explain** how a change in the DNA code may result in a change in the encoded protein.

Prerequisite Knowledge and Skills

- Hydrogen bonding and covalent bonding
- Cell structure
- DNA structure
- Cell cycle basics
- Prokaryotic and eukaryotic cell structure

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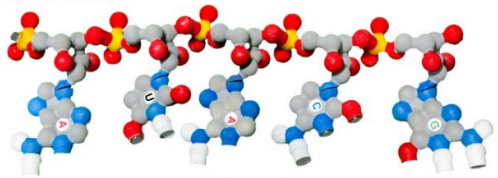
Flow of Genetic Information Kit©

Transcription Activity Guide

Student Handout



Ribonucleic Acid (RNA)

Introduction

Central Dogma: DNA to RNA to Protein

Almost all dynamic functions in a living organism depend on proteins. Proteins are molecular machines that perform a wide variety of essential functions, including:

- Support
- Transport
- Movement
- Metabolic Regulation
- Coordination
- Control
- Defense

Scientists currently believe that there are approximately 100,000 different proteins in the human body. Given the important role that these molecules play in an organism's survival, it is understandable that scientists focus a considerable amount of attention studying them. Central to their study is the question of how these molecules are produced in a cell. The molecular chain of command that dictates the directional flow of genetic information from DNA to RNA to protein was dubbed the **central dogma** by Francis Crick in 1956.

DNA Is the Universal Code

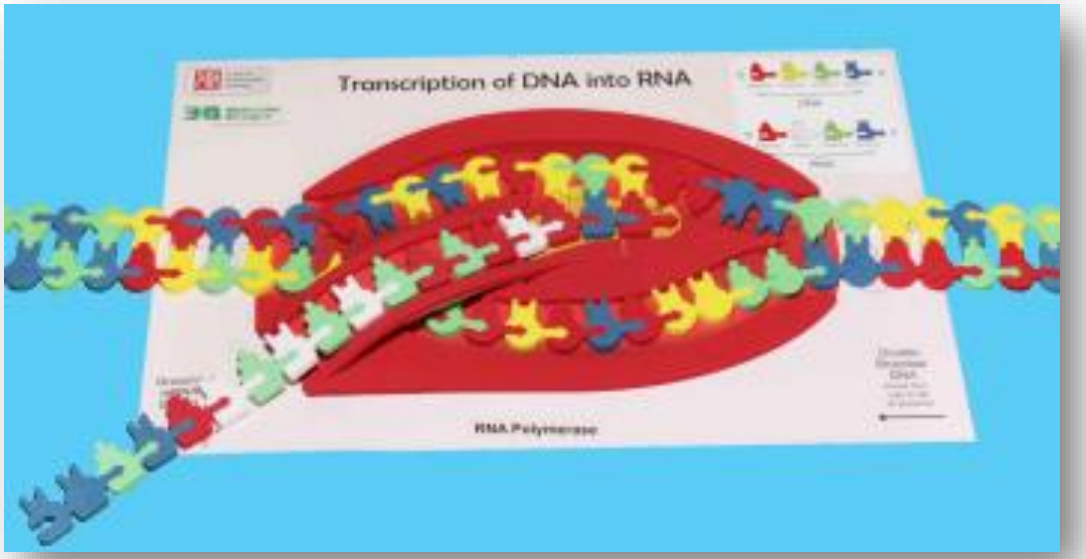
DNA carries all of the instructions for making the proteins found in our bodies. In fact, DNA is the universal code for the characteristics of simple organisms such as bacteria, and for complex organisms such as plants or animals. DNA codes for the characteristics of all living things! In this lesson you will learn how to interpret the DNA code to make the proteins that determine these characteristics. In the process of protein synthesis there are two important types of nucleic acids: DNA and RNA.

DNA has only four nitrogen bases: A, T, G, and C. But there are 20 amino acids that serve as the building blocks (monomers) for all proteins. How can only four letters (bases) code for all of these amino acids? The key to deciphering DNA is called a **triplet code**, in which the sequence of three adjacent DNA nitrogen bases (nucleotides) codes for a specific amino acid.

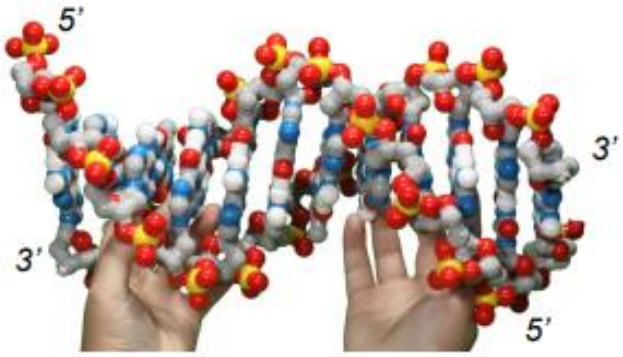
Resources and Handouts found at: https://3dmoleculardesigns.com/classroom_resources/flow-of-genetic-information-kit/

Flow of Genetic Information

- **Give it a try!**

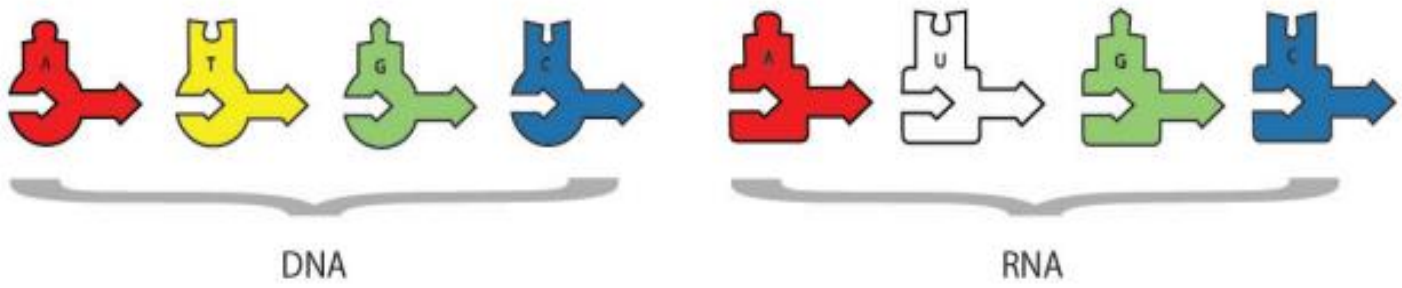


Highlights: Making Connections



- **Comparing Various Models**
  - **Foam Models**
  - **Any Classroom DNA Models**
  - **Alternate Protein Synthesis Models**

Highlights: DNA vs. RNA Pieces



- **Consistent Shapes/Similar But Different**
  - **Consistent Across All Products**
  - **Similar Nucleotide Components**
  - **Different Shape**

Highlights: Differentiated Instruction

Provides Understanding of Complex Process at Different Levels

- Include: Initiation, Elongation, Termination
- Ribosome Structure and Function

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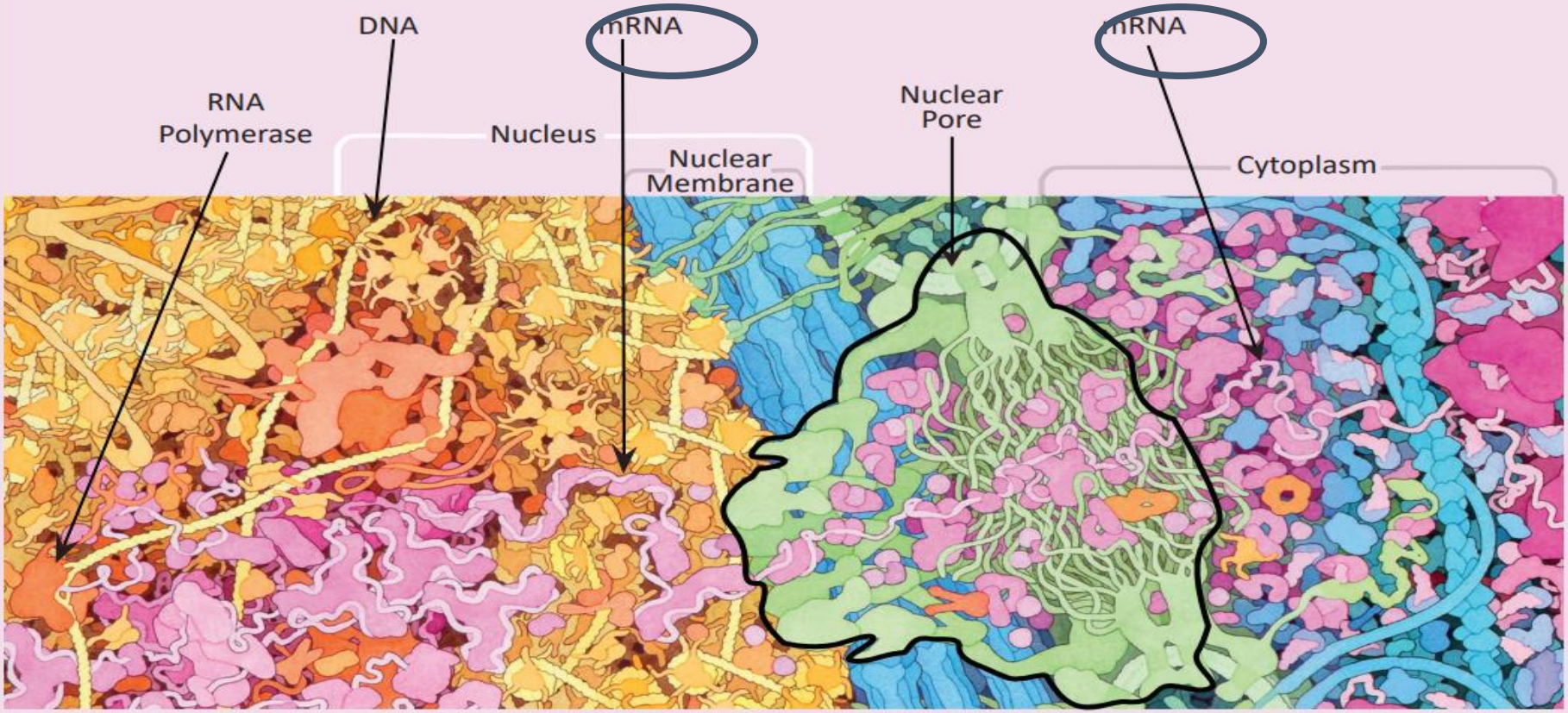
And Beyond!

- **Further Engagement?**

16. Trace the mRNA from the arrow point in the nucleus, through the nuclear pore and to the arrow point in the cytoplasm.



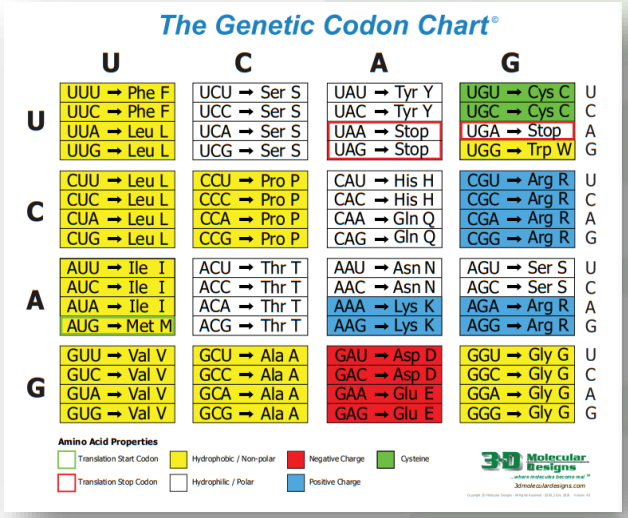
This image is an excerpt from Tour of a Human Cell by David Goodsell, as shown in 3D Molecular Designs' Tour of a Human Cell© poster and David Goodsell's book, ***The Machinery of Life.***

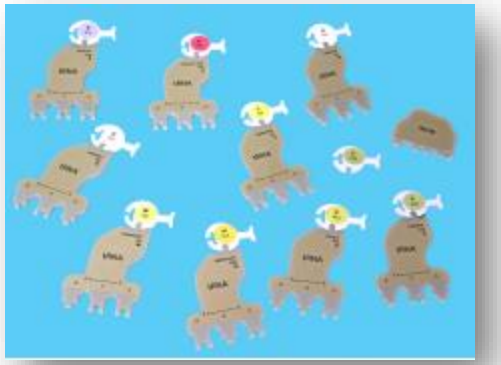
- Coloring Pages
  - Protein Data Base at: https://pdb101.rcsb.org/learn/coloring-books/coloring-molecular-machinery
  - Embedded in Activity found at: https://3dmoleculardesigns.com/classroom_resources/flow-of-genetic-information-kit/

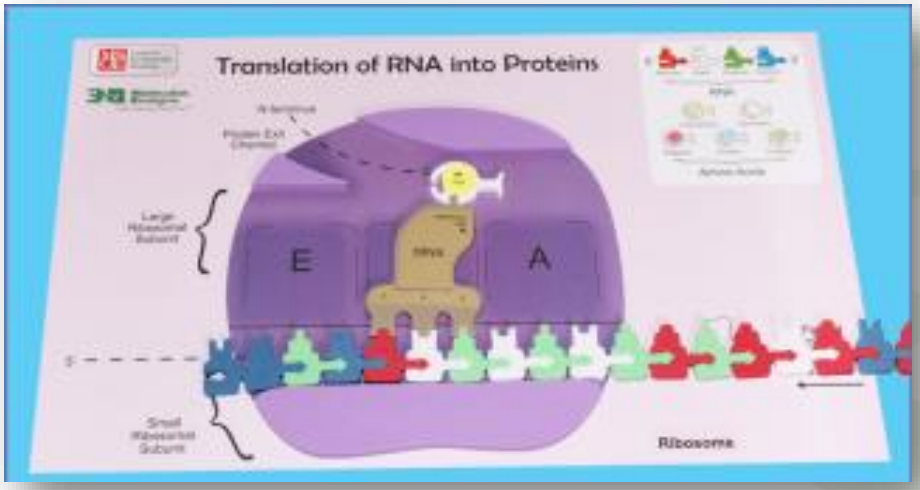
Translation

Components:

- Genetic Codon Chart
- Translation Mat
- Foam RNA Nucleotides
- Foam tRNA Nucleotides
- Foam Amino Acids







Translation Handouts

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Flow of Genetic Information Kit©

Teacher Notes

Contents

Activity Guide

This activity guide for the Flow of Genetic Information Field Test Kit© will help you consider different ways you may use these materials. We encourage you to modify these lessons and activities to meet the learning objectives and needs of your specific students.

Replication Activity

Objectives

Students will

- **Identify** the directionality of a DNA strand.
- **Explain** the implications of the anti-parallel structure of DNA as it relates to replication.
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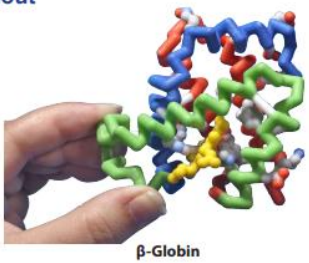
Translation Activity Guide

Student Handout



β-Globin

Translation

Translation occurs in the cytoplasm of the cell and is defined as the synthesis of a protein (polypeptide) using information encoded in an mRNA molecule. In the process of protein synthesis there are two important types of nucleic acids: DNA and RNA (ribonucleic acid). Messenger RNA (mRNA) has the information for arranging the amino acids in the correct order to make a functional protein.

The key to deciphering DNA is called a **triplet code**, in which the sequence of three adjacent DNA nitrogen bases codes for a specific amino acid. Translation of the mRNA occurs in groups of three nitrogenous bases called codons. The order in which the amino acids are put together depends on the sequence of bases in the mRNA. Proteins can consist of as few as 100 or as many as thousands of amino acids.

1. What part of the mRNA nucleotide contains the information to make a protein?

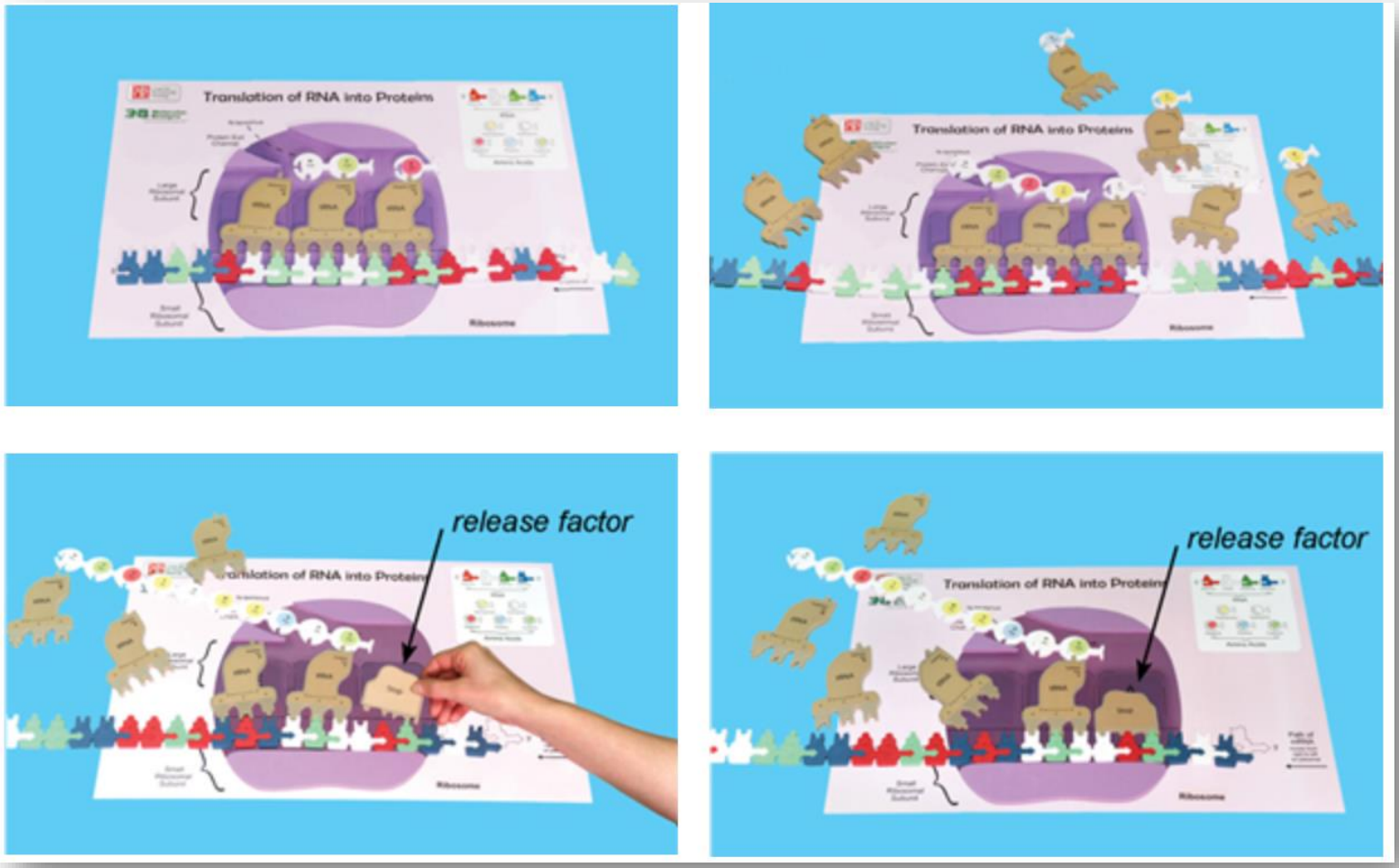
_____

The identity of the amino acids in the protein sequence can be determined using the mRNA strand you created in transcription. Starting from the 5' end of the mRNA **at the start codon**, every three bases determines a particular amino acid.

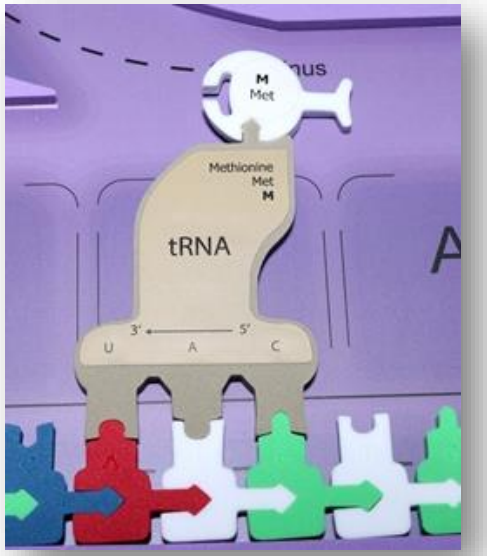
Resources and Handouts found at:
https://3dmoleculardesigns.com/classroom_resources/flow-of-genetic-information-kit/

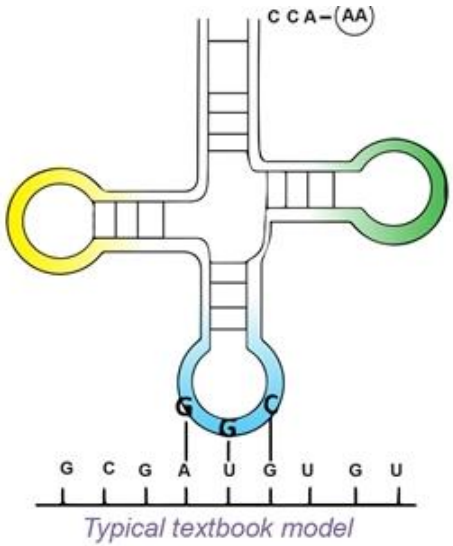
Flow of Genetic Information

- **Give it a try!**



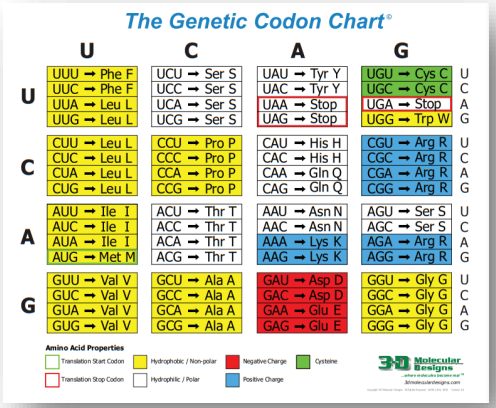
Highlights: Making Connections





- **Comparing Various Models**
  - **Typical Textbook Models**
  - **3D Printed Models**
  - **Foam Models**

Highlights: Allows to Demonstrate Understanding



5'----------->3'

mRNA Codons	AUG	UGU	GAG	AUA	CAU	UGG	CCA	AGA	CAC	UGU	UAG
tRNA anticodons											
Amino Acid											

Provides Understanding of Complex Process

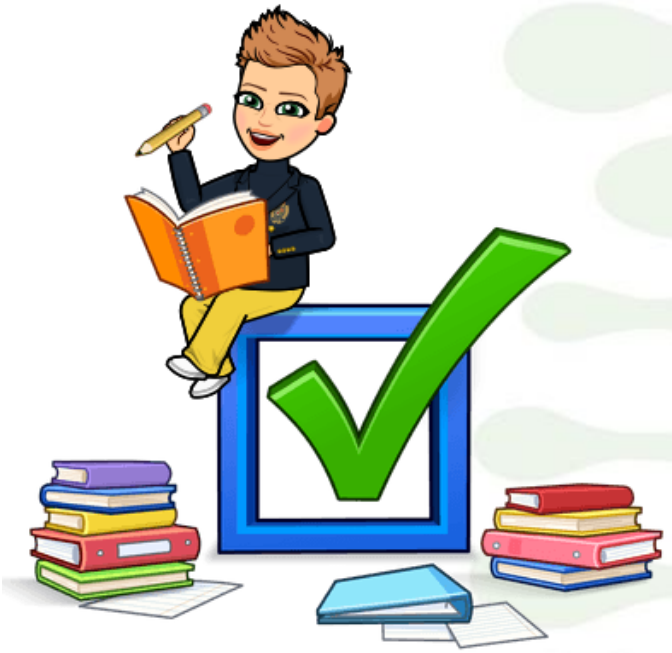
- Using Codon Charts
- DNA to RNA to Protein

And Beyond!

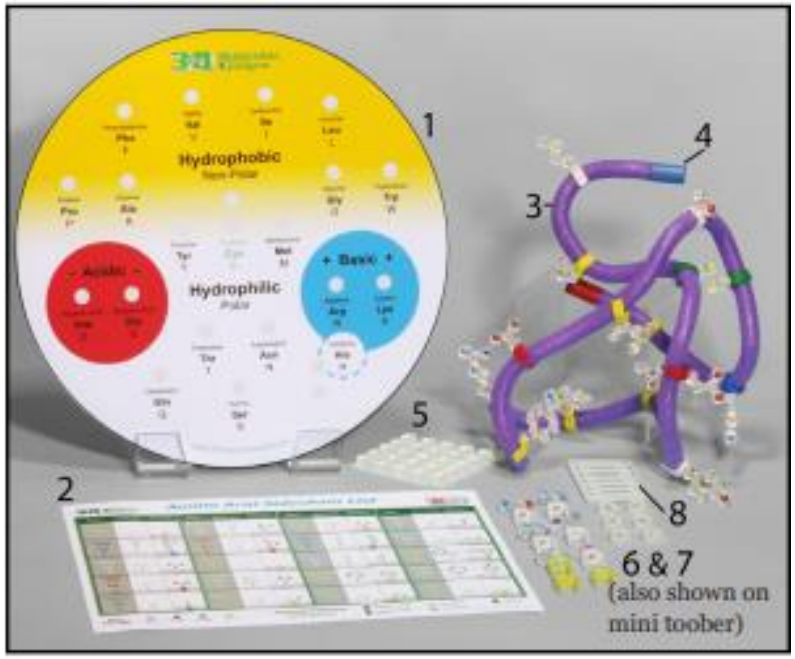
- **I finished the lab, Now What?**

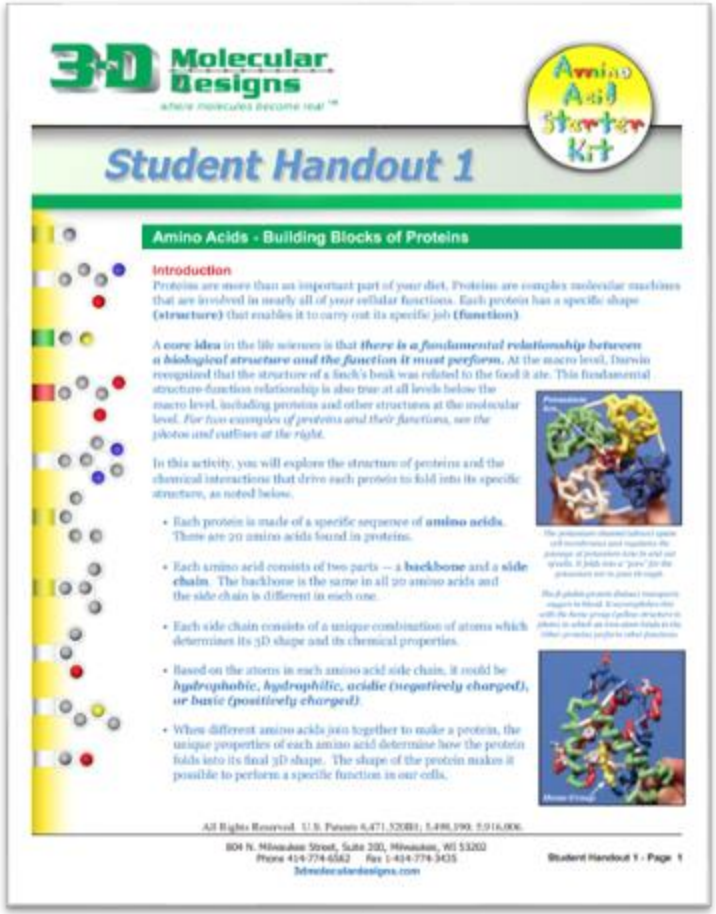
Examples and Suggestions

- **Proteins:**
  - Structure and Function
  - Protein Folding
- **Enzymes:**
  - Enzyme Action
  - Lactose Intolerance
- **Hemoglobin:**
  - Genetics
  - Sickle Cell Anemia



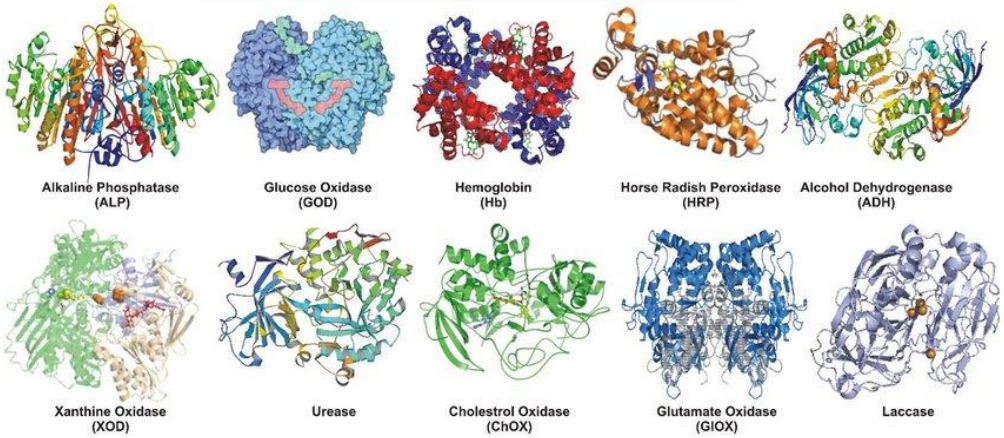
Lab: Protein Folding

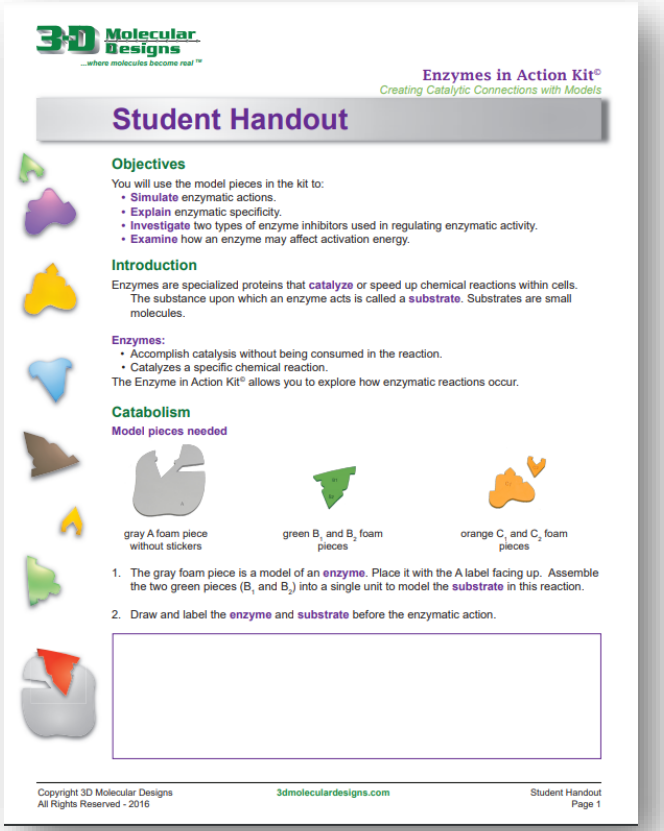




Resources for this lab found at:
https://3dmoleculardesigns.com/classroom_resources/amino-acid-starter-kit/

Lab: Enzymes in Action





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Enzymes in Action Kit©
Creating Catalytic Connections with Models

Student Handout

Objectives

You will use the model pieces in the kit to:
- **Simulate** enzymatic actions.
- **Explain** enzymatic specificity.
- **Investigate** two types of enzyme inhibitors used in regulating enzymatic activity.
- **Examine** how an enzyme may affect activation energy.

Introduction

Enzymes are specialized proteins that **catalyze** or speed up chemical reactions within cells. The substance upon which an enzyme acts is called a **substrate**. Substrates are small molecules.

Enzymes:
- Accomplish catalysis without being consumed in the reaction.
- Catalyzes a specific chemical reaction.

The Enzyme in Action Kit© allows you to explore how enzymatic reactions occur.

Catabolism

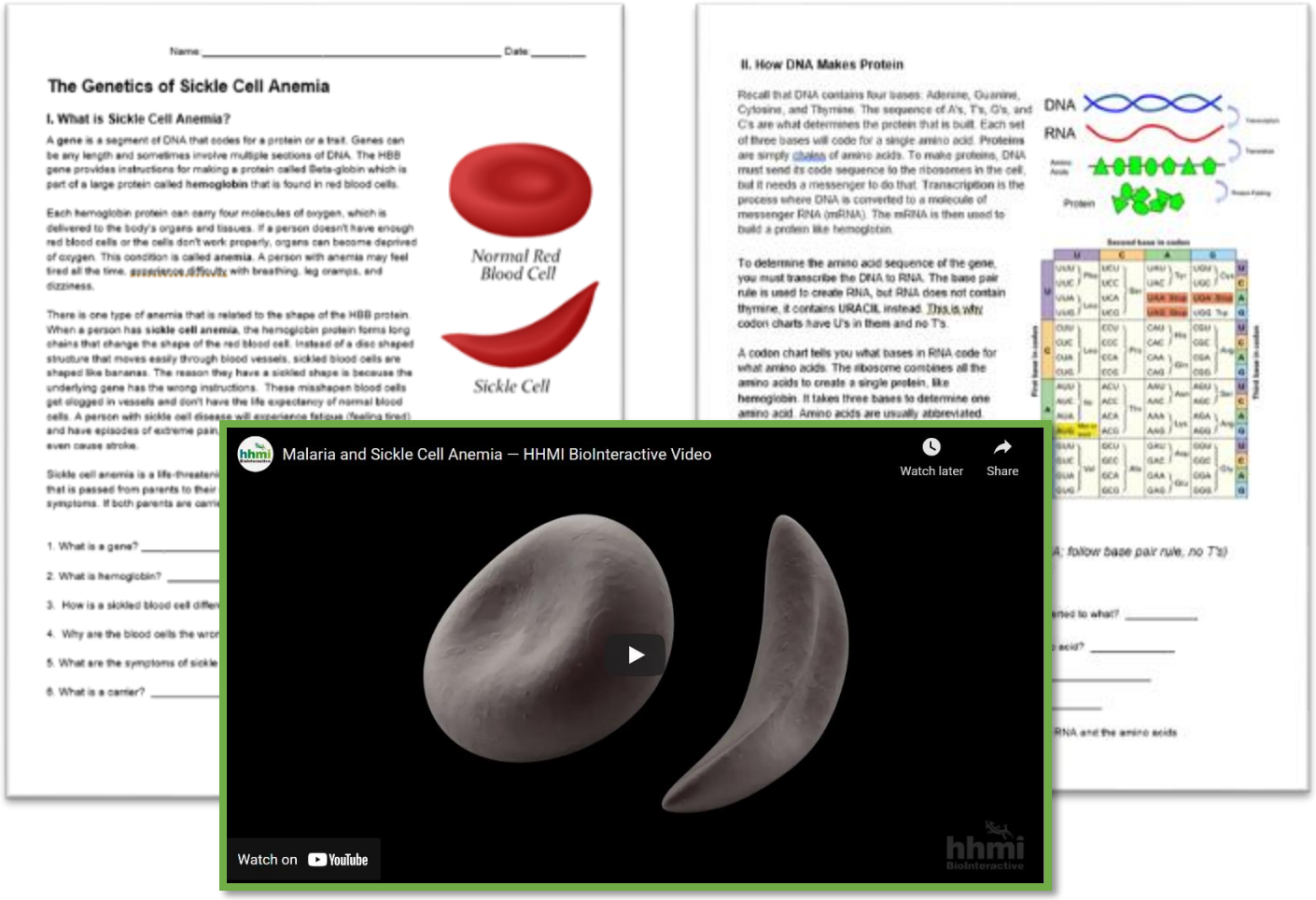
Model pieces needed

gray A foam piece without stickers | green B_1 and B_2 foam pieces | orange C_1 and C_2 foam pieces

1. The gray foam piece is a model of an **enzyme**. Place it with the A label facing up. Assemble the two green pieces (B_1 and B_2) into a single unit to model the **substrate** in this reaction.
2. Draw and label the **enzyme** and **substrate** before the enzymatic action.

Resources for this lab found at:
https://3dmoleculardesigns.com/classroom_resources/enzymes-in-action-kit/

Activity: Genetics of Sickle Cell



Sources for this activity found at: https://www.biointeractive.org/classroom-resources/sickle-cell-disease-and-malaria-lesson-nature-science

Activity: You and the GMO Mosquitoes

Genetically Modified Mosquitoes May Be Released in Fla and Calif

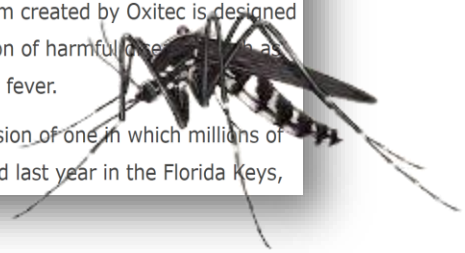
By Ralph Ellis

March 9, 2022

The U.S. Environmental Protection Agency has approved the release of 2 billion genetically altered mosquitoes in Florida and California, the company that created the genetically modified mosquitoes said.

The experimental program created by Oxitec is designed to reduce the transmission of harmful [illegible] as dengue, Zika, and yellow fever.

The program is an extension of one in which millions of mosquitoes were released last year in the Florida Keys,



Sources for this activity found at: https://www.biointeractive.org/classroom-resources/genetically-modified-mosquitoes and https://www.webmd.com/a-to-z-guides/news/20220309/genetically-modified-mosquitoes-may-be-released-in-fla-and-calif

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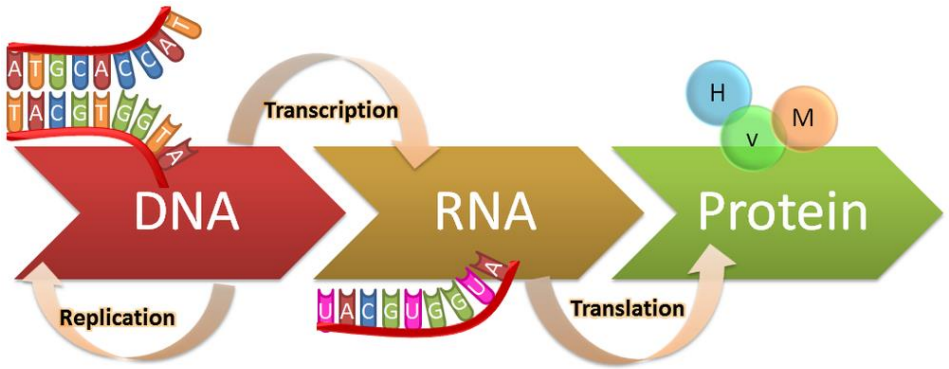
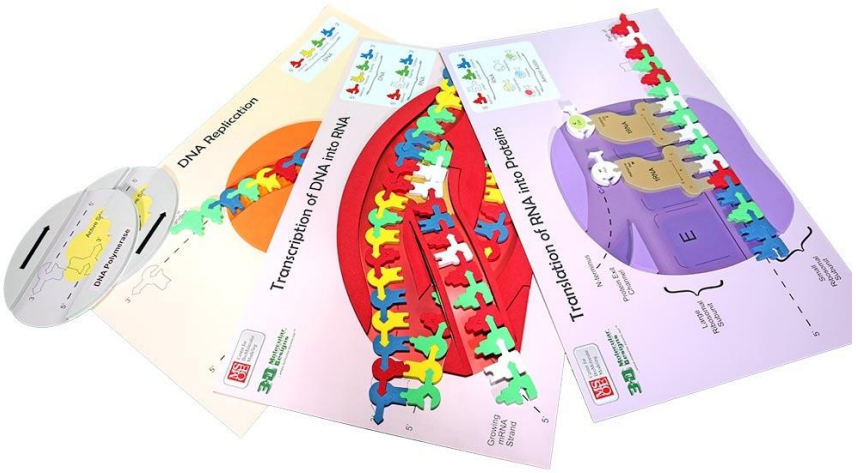
Reflection Activity

- Where do you see this fitting into your curriculum?
- What Lingering Questions Do You Still Have?
- What Does This Look Like Implemented in Your Classroom?
- What Other Resources Would You Use With this topic? (Make a Suggestion!)



Give Away!

Flow of Information Kit



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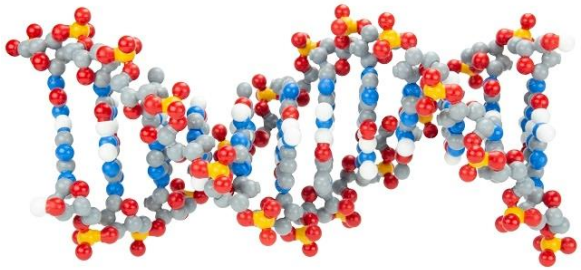
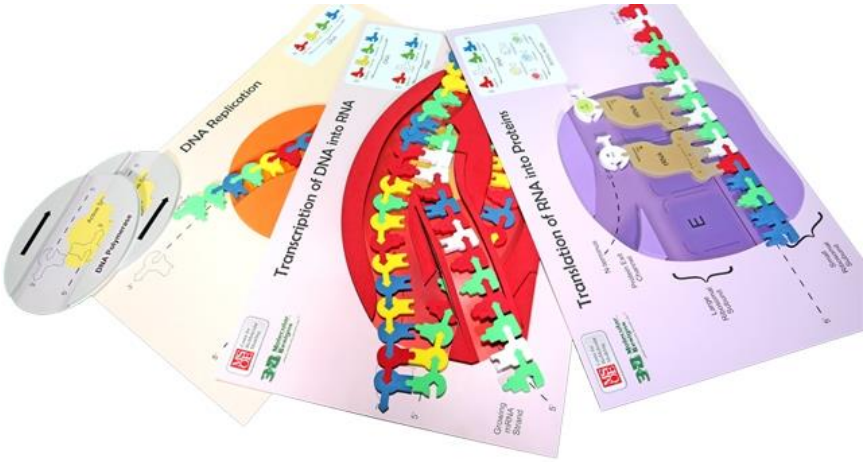
Resources and Materials

Kits Used in this workshop:

- Dynamic DNA
- Flow of Genetic Information





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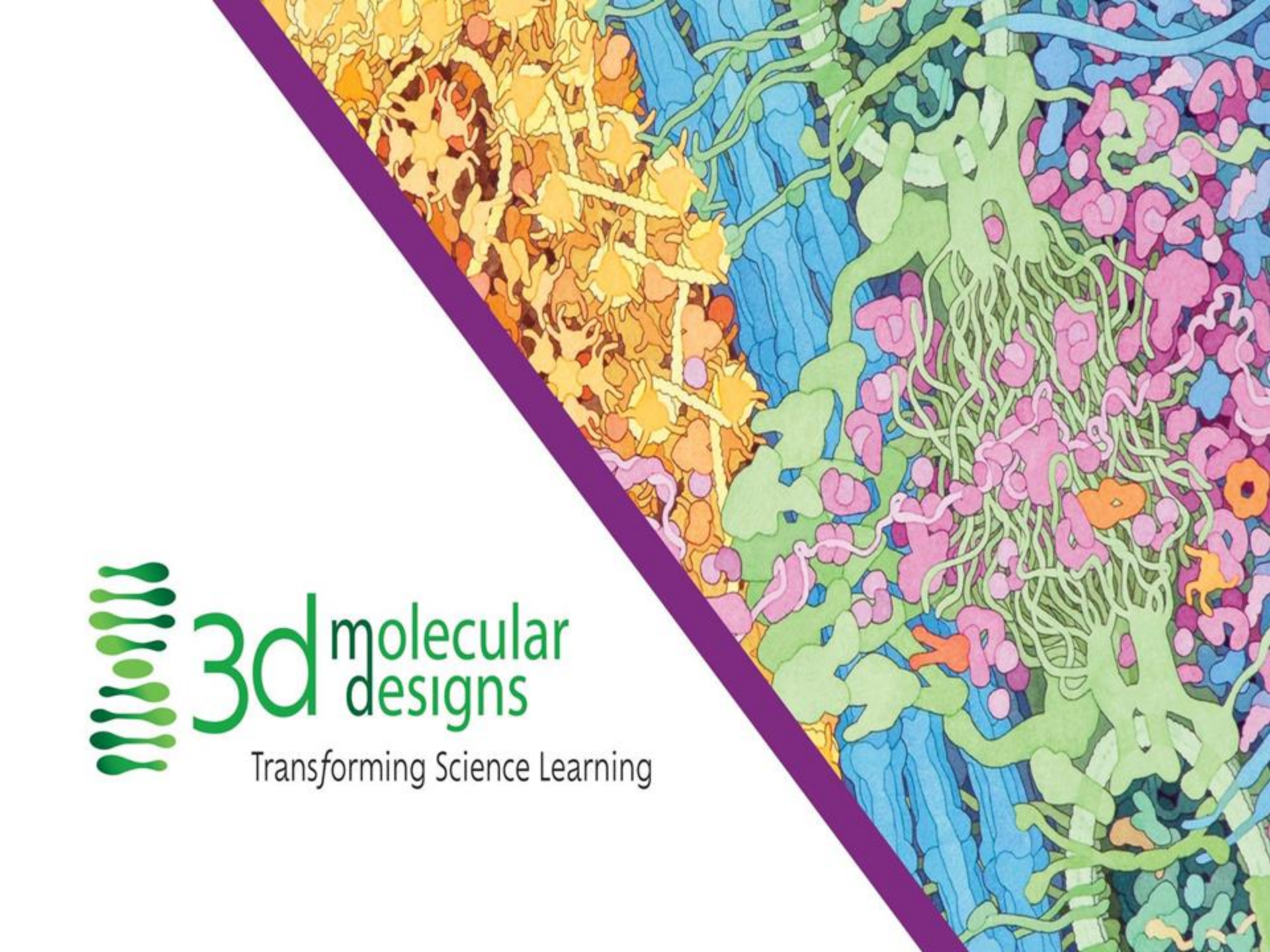

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