

The Puzzle of Life

A Lesson Plan for Life Science Teachers

From: The Great Lakes Science Center, Cleveland, OH

Introduction:

In the Puzzle of Life activity, students will demonstrate how the message in DNA becomes the raw material (protein) used by cells. By using the RNA and amino acid puzzle pieces, students will demonstrate how the RNA molecule translates into a chain of amino acids (protein) and explore how changes (mutations) in the genetic code can impact cellular activities. Students will work in collaborative groups to translate a RNA sequence (DNA transcript) into protein, discover the outcomes of mutations and errors in the genetic code, and “treat” a genetic disorder using gene therapy. Each group of students will work through one additional, unique scenario and present the outcomes to the class. Alternatively, each group of students will work through all four scenarios to demonstrate the outcomes of mutations and future treatments. As an assessment, students (individually or in groups) will design a new scenario to demonstrate to the class. Use The Puzzle of Life activity to introduce translation (following transcription activities, discussion, and analyses), to review translation concepts, or to stimulate a discussion of genetic therapy.

The Puzzle of Life lesson plan was adapted for classroom use from a facilitated exhibit developed at the Great Lakes Science Center (Cleveland, OH) in the Biomedical Technology gallery. This “from science center to classroom” initiative was supported by the National Center for Research Resources (NCRR) Science Education Partnership Award (SEPA).

Grade Level: Middle school to high school (Grades 7-12)

Goals:

Students will...

1. Understand how RNA (transcribed from DNA) becomes protein (raw material used by the cell).
2. Demonstrate how a point mutation (change of one base pair) can cause a disease like sickle cell anemia.
3. Appreciate the redundancy of the genetic code (not all mutations are lethal).
4. Understand how gene therapies (now utilized in animal models like mice) may soon be available to humans.

Objectives:

Students will...

1. Demonstrate how RNA translates into amino acids (subunits of protein).
2. Identify the mutation in the genetic code that results in sickle cell anemia.
3. Perform "gene therapy" to fix the the sickle-cell mutation in the genetic code.
4. Simulate missense and silent point mutation and describe their impacts on protein translation and cellular activities.
5. Simulate frame-shift mutations and describe their impacts on protein translation and cellular activities.
6. Discuss the implications of genetic therapy for the treatment of diseases and medical conditions.
7. Work in collaborative groups.

Materials:

Per group:

4 pieces of each amino acid (from *Protein Pieces* master)
8 pieces of each RNA base pair (from *RNA Pieces* master)
Genetic De-Coder (from *Genetic Decoder* master)
Images of red blood cells (normal vs. sickle cell)
Quart-sized Ziploc® bag
Masking tape

Teacher preparation:

Make copies of *RNA Pieces* and *Protein Pieces* masters. Each group of students should have 4 amino acid pieces of each type (i.e., 4 Glu, 4 Lys, etc.) and 8 pieces of each RNA base pair (8 adenine [A], 8 guanine [G], 8 uracil [U], and 8 cytosine [C]).

Make one copy of *the Genetic Decoder* master for each student group

Place the above items with a small roll of masking tape in the Ziploc® bags (one set per group)

Helpful Hints: Copy on cardstock. This will allow for multiple uses of the pieces. If time permits, laminate cards to lengthen life and usage.

Background information:

- Deoxyribonucleic acid (DNA) is found inside the nucleus of our cells
- DNA holds information about our physical traits (what is seen on the outside - eye color, height, etc.)
- A transcript of DNA (messenger RNA or mRNA) is made inside the nucleus during the process of transcription and moves into the cytoplasm of the cell
- RNA is considered to be a transcript, not a copy, of DNA because, during the process of transcription, thymine (T) in DNA is replaced with a closely related molecule uracil (U) in RNA.
- The information in RNA (DNA transcript) is used to make cellular parts or perform cellular functions (metabolism, growth and development, etc.)
- RNA is translated into protein in the cytoplasm with the help of ribosomes
- The sequence (order) of information in the RNA molecule indicates which cell part(s), i.e., protein(s), should be made.
- Mutations or errors in the DNA and/or RNA sequences may produce defective cell parts, disease, or even death
- Not all mutations cause diseases because the code is redundant (many sequences code for the same amino acid)
- Mutations can result from errors in copying the DNA (which may be transferred to the RNA), damage from ultraviolet light, or hazardous chemicals. (These can damage DNA or RNA directly.)
- Biomedical technology holds the promise of fixing DNA and/or RNA errors and curing diseases.

How are DNA and RNA different?

Characteristic	DNA	RNA
Backbone sugar	Deoxyribose	Ribose
Structure	Double-stranded	Single-stranded
Base pairs	A, T, G, C	A, U, G, C
Location	Nucleus (in eukaryotes)	Cytoplasm

(A = adenine, T = thymine, G = guanine, C = cytosine)

DNA facts and trivia

- Number of base pairs in the human genome \approx 3.4 billion
- Number of genes in the human genome: 20,000-25,000
- Length of human DNA (46 chromosomes stretched end-to-end) is about 6 feet.
- Diameter of DNA \approx 2 nm. (It would take 12,500 DNA molecules to approximate the size of a human hair.)
- Cells in human body - 75-100 trillion
- Length of all DNA in the body (6 ft x 100 trillion cells) - over 113 billion miles (182 billion km) or to the Sun and back 610 times (Centre for Integrated Genomics).
- Chromosomes in human cell = 46
- Organism with the largest genome: The amoeba (*Amoeba dubia*) has 670 billion base pairs.

- Organism with the smallest genome - bacterium living inside an insect, the gall psyllid (*Carsonella ruddi*) - 160,000 base pairs
- Humans are 99.8% genetically identical to each other - the remaining 0.2% accounts for the variation seen in the human population
- It would take 9.5 years to read the human genome without stopping!
- Date human genome sequence completed: April 2003
- Viruses have DNA or RNA, not both, and need a host DNA's machinery to reproduce.

Organism	Scientific Name	Number of Genes	% Similarity to Human Genome
Chimpanzee	<i>Pan troglodytes</i>	30,000	98
Mouse	<i>Mus musculus</i>	30,000	90
Zebrafish	<i>Danio rerio</i>	30,000	85
Fruit fly	<i>Drosophila melanogaster</i>	13,600	36
Thale cress	<i>Arabidopsis thaliana</i>	25,000	26
Yeast	<i>Saccharomyces cerevisiae</i>	6275	23
Roundworm	<i>Caenorhabditis elegans</i>	19,000	21
Bacterium	<i>Escherichia coli</i>	4800	7

Source: *The GEEE! In Genome*: www.nature.ca/genome

Did you know?

- Only one strand of DNA is used as a template to make RNA.
- RNA is read from left to right (5' to 3' direction).
- In eukaryotes, only one codon starts translation (AUG). However, three codons can stop translation (UAG, UGA, or UAA).
- The start codon defines the reading frame and specifies the first amino acid to lead off the chain.
- There are three types of RNA:
 - Messenger RNA (mRNA) carries the DNA message or transcript into the cytoplasm.
 - Transfer RNA (tRNA) guides and directs the transfer of each amino acid added to the protein chain (cloverleaf-shaped molecule).
 - Ribosomal RNA (rRNA) are components of the ribosome and direct protein synthesis.
- Other molecules (including RNA polymerases, amino-acetyl tRNA synthetases, and ribosomes) are involved in the process of translation.
 - RNA polymerases are enzymes that serve as the template for the creation of RNA from DNA. The polymerases only work in the presence of DNA.
 - Aminoacetyl tRNA synthetases link tRNA to their corresponding amino acids.
 - Ribosomes direct protein synthesis by:
 - ◆ Associating and de-associating with RNA during translation,
 - ◆ Moving the mRNA in and developing the protein strand out,
 - ◆ Catalyzing the formation of peptide bonds between amino acids (ribozyme), and initiating the stop codon release.

- Many ribosomes can work on translating one protein at a time. At any given time, the majority of ribosomes in the cell are engaged in translation.
- A sequence of base pairs precedes the start codon to facilitate binding of the ribosome.
- Synthesis on one protein requires 100 proteins and RNAs working together.
- During translation, the transcript is proofread for mutations and defects. If no stop codon is present in the transcript, tmRA (a tRNA/mRNA hybrid) rescues stalled ribosomes. If an early stop codon is present, the 5' cap is removed and the transcript is degraded by cellular enzymes.

Differences between Bacteria and Eukaryotes (Nucleated Organisms):

Characteristic	Bacteria	Eukaryotes
Site of transcription	Cytoplasm	Nucleus
Start codon	AUG, GUG, UUG	AUG only
Reading frames	Frequently multiple	Usually one
Proteins formed per RNA	Multiple	One
5' cap (recruits ribosome)	Absent	Present
Poly(A) tails (promotes recycling of ribosomes)	Absent	Present
Translation rate	20 amino acids/second	2-4 amino acids/second
Coupling of transcription and translation	Yes	No

Sources (Searched February 2009):

The GEEE! In Genome: www.nature.ca/genome

Human Genome Projects Information: www.genomics.energy.gov

Centre for Integrated Genomics: www.cigenomics.bc.ca

J. Craig Venter Institute: www.jcvi.org

Biotechnology Institute: www.biotechinstitute.org

Genome News Network: www.genomeneWSnetwork.org

National Human Genome Research Center: www.geome.gov

Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R. *Molecular biology of the gene*, 5th ed. : San Francisco, Calif: Benjamin Cummings; 2003.

Activity instructions:

- 1) Working in small groups, instruct the students to arrange the base pair pieces along a desk or table from left to right in the following order:

AUG - GUU - CAU - CUG - GUG - GAA - GAG - CAC - GUA - GAA - CAC - UAG

- Write/display this sequence on the chalkboard or SMART Board. This is the core sequence that will be used for all scenarios.
- Remind students that RNA is translated in 3 base pair chunks called codons. One codon (a 3 base pair unit) will translate into one amino acid.

- Use masking tape to secure RNA and amino acid pieces to the desk/table.
- 2) Instruct students to identify the amino acid piece that corresponds with each codon (3 base pair sequence) using the Genetic Decoder. Place the amino acid pieces beneath the corresponding codon (3 base pair sequence).
- Work through the first few amino acids together as a class, as an example.
 - AUG codes for Start or the amino acid methionine. Methionine or Start always leads off the amino acid chain.
 - GUU codes for Val, the amino acid valine.
 - CAU codes for the His, the amino acid histidine.
 - Each of these amino acids is bonded to the previous one via peptide bonds to create a protein (or amino acid chain).
 - Once it is completed, the protein will become part of the cell or perform metabolic functions for the cell.
- 3) Guide all student groups through Scenario #1 – Missense Point Mutation

A mutation has occurred! A DNA replication error or DNA transcription error produced a mutation in this RNA sequence. This individual has sickle cell anemia, a blood disorder in which red blood cells are sickle or half-moon shaped instead of round (the normal condition). Sickle-shaped red blood cells are not as efficient in transporting oxygen throughout the body as normal red blood cells. Mutations can result from random errors in replication/transcription/translation, or from damage to the DNA or RNA caused by chemicals and/or ultraviolet radiation from the sun. Some mutations are inherent in the genetic code of an individual and are passed along from parent to offspring following patterns of inheritance.

The amino acid sequence for the normal red-blood cell part is:

Start - Val - His - Leu - Glu - Glu - Glu - His - Val - Glu - His - Stop

Use the Genetic Decoder to identify the codon(s) with the mutation.
How many base pairs are involved in this mutation?

Perform gene therapy on this patient! Use the Genetic Decoder to change the mutated base pair back to the normal condition. How does this treatment work? Normal red blood cells can be transplanted into the bone marrow of an afflicted individual. Due to the adaptive nature of blood cells, these new cells will become healthy red blood cells. Bone marrow cells are a type of stem cells that will develop into many types of blood cells. This treatment is currently only available in mice.

4) Scenario #2 - Frame-shift Mutation (assign to one or more group[s])

Starting with the normal condition, explore what happens when a letter is deleted accidentally? Remove the guanine (G) from the first base pair position of codon #9 (piece #25). Shift all the other blocks to the left. What happens to the amino acid sequence? Use the Genetic Decoder to decode the new amino acid sequence for each codon (3 base pairs). Can genetic therapy correct this mutation?

5) Scenario #2 - Silent Point Mutation (assign to one or more group[s]).

Another mutation has occurred! Either a mistake in replication, transcription, or translation, or an outside environmental factor (ultraviolet radiation or chemical) caused a change in the genetic code. Substitute a cytosine (C) for a uracil (U), in the third base pair position of codon #2 (position #6). What happens? Does the mutation alter the amino acid sequence? Can genetic therapy correct this mutation?

6) Scenario #3 - Insertion (assign to one or more group[s])

An error occurred as DNA was transcribed into RNA! A small piece of DNA was inserted into the base pair sequence. Starting with the normal condition, add a guanine (G) to the genetic sequence after codon #10 (between positions #27 and #28). What happens? Does the mutation alter the amino acid sequence? Can genetic therapy correct this mutation?

7) Scenario #4 - Inversion (assign to one or more group[s])

An error occurred as DNA was transcribed into RNA! A small piece of RNA was overlapped and switched around before it was translated into protein. The uracil (U) in the third position of codon #3 (position #12) was exchanged with the cytosine (C) in the third position of codon #6 (position #18). This exchange or reversal of a base pair or piece of DNA is called an inversion. What happens? Does the mutation alter the amino acid sequence? Can genetic therapy correct this mutation?

8) Scenario #5 - Inversion (Assign to one or more group(s))

An error occurred as DNA was transcribed into RNA! A small piece of RNA was overlapped and switched around before it was translated into protein. The uracil (U) in the third base pair position of codon #2 (position #6) was exchanged with the guanine in the third base pair position of codon #4 (position #12). This exchange or reversal of a base pair or piece of DNA is called an inversion. What happens? Does the mutation alter the amino acid sequence? Can genetic therapy correct this mutation?

9) Encourage students to present their scenarios to the class and share the various cellular outcomes resulting from genetic mutations.

Discussion

- 1) Describe the mutations that you observed in the scenarios?
- 2) Which mutations were the most dangerous? The least dangerous? Explain
- 3) Examine the Genetic De-Coder for redundancy (more than one triplet codon codes for the same amino acid). Why is this characteristic of the genetic code advantageous to organisms? Which amino acids have greater redundancy? Why?
- 4) Explain why only one triplet codon codes for methionine (Met) or the start signal.
- 5) What surprised you the most about the genetic code? Why?
- 6) Genetic therapy holds the promise of treating and/or curing a wide range of genetic diseases (including sickle-cell anemia). Do you agree that genetic therapy should be utilized as a treatment option for humans? Why or why not?

Assessment

Design your own mutation scenario using the genetic sequence provided in the previous activities.

- 1) Describe the location of the mutation.
- 2) What type of mutation is it?
- 3) Describe the impacts on translation and the amino acid sequence formed.
- 4) Predict what may happen to the new protein's function in the cell (normal, reduced, or non-functional). Explain.

Share your scenario with other students in your class. Help them to decode the effects of your mutation.

Answers:

3) Guide all student groups through Scenario #1 - Missense Point Mutation

Start - Val - His - Leu - Val - Glu - Glu - His - Val - Glu - His - Stop

The mutation is found in codon #5. GUG codes for the amino acid valine (Val). This mutated protein causes folding or sickling of the red blood cells, the hallmark of sickle-cell anemia. GAG codes for the amino acid glutamic acid (Glu). This protein produces normal red blood cells without sickling. This is an example of a missense point mutation - one mutation changed the protein/cell parts made. This individual has abnormally-shaped red blood cells. It is more difficult for the red blood cells to carry oxygen throughout the body. He/she has sickle cell anemia or sickle cell disease.

Start - Val - His - Leu - Glu - Glu - Glu - His - Val - Glu - His - Stop

Change the uracil (U) in the second base pair position of the 5th codon to an adenine (A). With this change, the codon will code for glutamic acid (the normal condition).

4) Scenario #2 - Frame-shift Mutation (assign to one or more group[s])

Start - Val - His - Leu - Glu - Glu - Glu - His - Stop

This deletion caused a frame-shift mutation that shifted the entire reading frame for translation and altered the amino acid chain. The amino acid valine (Val) changed to a stop codon. The protein formation will end prematurely with an early stop codon. This type of mutation may cause severe disease or may be lethal. Thankfully, the cell employs proofreading mechanisms to replace missing base pairs or edit the sequence. However, this procedure is not 100% efficient.

5) Scenario #2 - Silent Point Mutation (assign to one or more group[s]).

Start - Val - His - Leu - Glu - Glu - Glu - His - Val - Glu - His - Stop

This is an example of a silent point mutation, a mutation involving one base pair that has no effect on the protein or cell parts made. This phenomenon is due to the redundancy of the genetic code. More than one triplet codon codes for the same amino acid. Thankfully, most mutations are like this. Genetic therapy is not necessary.

6) Scenario #3 - Insertion (assign to one or more group[s])

Start - Val - His - Leu - Glu - Glu - Glu - His - Gly - Thr - Leu (no STOP)

This insertion or the addition of one or more base pairs to the base pair sequence caused a frame-shift mutation which changed the remainder of the amino acid chain and omitted the stop codon. This protein would not become part of the red blood cell. Without the stop codon, it would be recognized by the cellular machinery as incomplete. Cellular enzymes would digest this protein and return the raw materials to the cell. Genetic therapy is not an adequate fix for this type of frame-shift mutation.

7) Scenario #4 - Inversion (assign to one or more group[s])

Start - Val - Gln - Leu - Glu - Asp - Glu - His - Val - Glu - His - Stop

In this example, the amino acid histidine (His) in codon #3 was changed to the amino acid glutamine (Gln) and the amino acid glutamic acid (Glu) in codon #6 was changed to aspartic acid (Asp). Either a functional change, reduced functional change, or non-functional change would be made in the protein. Thankfully, the cell employs proofreading mechanisms to edit and correct errors in base pairs. However, this is not a 100% efficient process. In the future, gene therapy may be able to fix this type of error if the mutation is deemed harmful or lethal.

8) Scenario #5 - Inversion (assign to one or more group[s])

Start - Val - His - Leu - Glu - Glu - Glu - His - Val - Glu - His - Stop

This inversion did not cause any change in the original, normal amino acid sequence. This phenomenon is due to the redundancy of the genetic code in which more than one triplet codon codes for the same amino acid. Thankfully, most mutations are like this. Genetic therapy is not necessary.

National Science Education Standards

GRADES 5-8

Content Standard C: Life Science

Structure and Function in Living Systems

All organisms are composed of cells – the fundamental unit of life. Most organisms are single cells; other organisms, including humans, are multicellular.

Disease is a breakdown in structures or functions of an organism. Some diseases are the result of intrinsic failures of the system. Others are the result of damage by infection by other organisms.

Reproduction and Heredity

Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.

Heredity information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one or many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes

Content Standard F: Science in Personal and Social Perspectives

Science and Technology in Society

Science cannot answer all questions and technology cannot solve all human problems or meet all human needs. Students should understand the difference between scientific and other questions. They should appreciate what science and technology can reasonably contribute to society and what they cannot do. For example, new technologies often will decrease some risks and increase others.

GRADES 9-12

Content Standard C: Life Science

The Cell

Cells have particular structures that underlie their functions. Every cell is surrounded by a membrane that separates it from the outside world. Inside the cell is a concentrated mixture of thousands of different molecules which form a variety of specialized structures that carry out such cell functions as energy production, transport of molecules, waste disposal, synthesis of new molecules, and storage of genetic materials.

Cells store and use information to guide their functions. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires.

The Molecular Basis of Heredity

In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). The chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes (as a string of molecular “letters”) and replicated (by a templating mechanism). Each DNA molecule in a cell forms a single chromosome.

Changes in DNA (mutations) occur spontaneously at low rates. Some of these changes make no difference to the organism, whereas others can change cells and organisms. Only mutations in germ cells can create the variation that changes an organism’s offspring.

Content Standard G: History and Nature of Science

Historical Perspectives

Occasionally, there are advances in science and technology that have important and long-lasting effects on science and society. An example of such advances includes medical and health technology.

Ohio Academic Content Standards, Benchmarks and Grade-Level Indicators

GRADES 6-8

Science and Technology

Benchmark A: Give examples of how technological advances, influenced by scientific knowledge, affect the quality of life.

Understanding Technology

Recognize that science can only answer some questions and technology can only solve some human problems.

GRADES 9-10

Life Sciences

Benchmark B: Explain the characteristics of life as indicated by cellular processes and describe the process of cell division and development.

Characteristics and Structure of Life

Explain the characteristics of life as indicated by cellular processes including: a) homeostasis, b) energy transfers and transformation, c) transportation of molecules, d) disposal of wastes, and e) synthesis of new molecules

Benchmark C: Explain the genetic mechanism and molecular basis of inheritance.

Heredity

Illustrate the relationship of the structure and function of DNA to protein synthesis and the characteristics of an organism.

Explain that a unit of hereditary information is called a gene, and genes may occur in different forms called alleles (e.g., gene for pea plant height has two alleles, tall and short).

Describe that spontaneous change in DNA are mutations which are a source of genetic variation. When mutations occur in sex cells, they may be passed on to future generations; mutations that occur in body cells may affect the functioning of that cell or the organism in which that cell is found.

Benchmark J: Summarize the historical development of scientific theories and ideas, and describe emerging issues in the study of life sciences.

Historical Perspectives and Scientific Revolutions

Describe advances in life sciences that have important long-lasting effects on science and society (e.g., biological evolution, germ theory, biotechnology, and discovering germs).

Analyze and investigate emerging scientific issues (e.g., genetically modified food, stem cell research, genetic research, and cloning).

GRADES 11-12

Life Sciences

Benchmark A: Explain how processes at the cellular level affect the functions and characteristics of an organism.

Characteristics and Structure of Life

Recognize that information stored in DNA provides the instructions for assembling protein molecules used by the cells that determine the characteristics of the organism.

Benchmark C: Explain how the molecular basis of life and the principles of genetics determine inheritance.

Heredity

Examine the inheritance of traits through one or more genes and how a single gene can influence more than one trait.

Benchmark G: Summarize the historical development of scientific theories and ideas within the study of life sciences.

Historical Perspectives and Scientific Revolutions

Describe advances in life sciences that have important long-lasting effects on science and society (e.g., biotechnology).

Science and Technology

BIO MED TECH:

ENGINEERING FOR YOUR HEALTH

Benchmark A: Predict how human choices today will determine the quality and quantity of life on Earth.

Understanding Technology

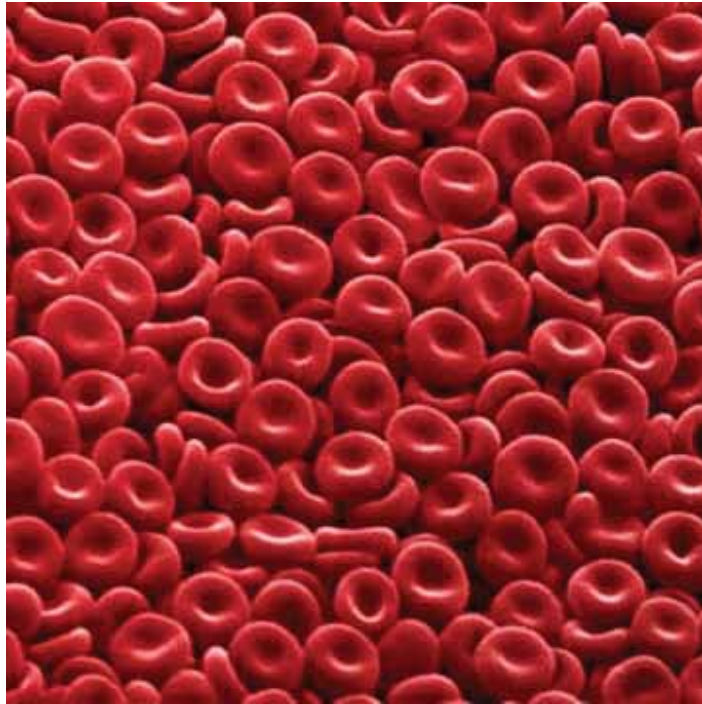
Explain how science often advances with the introduction of new technologies and how solving technological problems often results in new scientific knowledge.

Works Cited

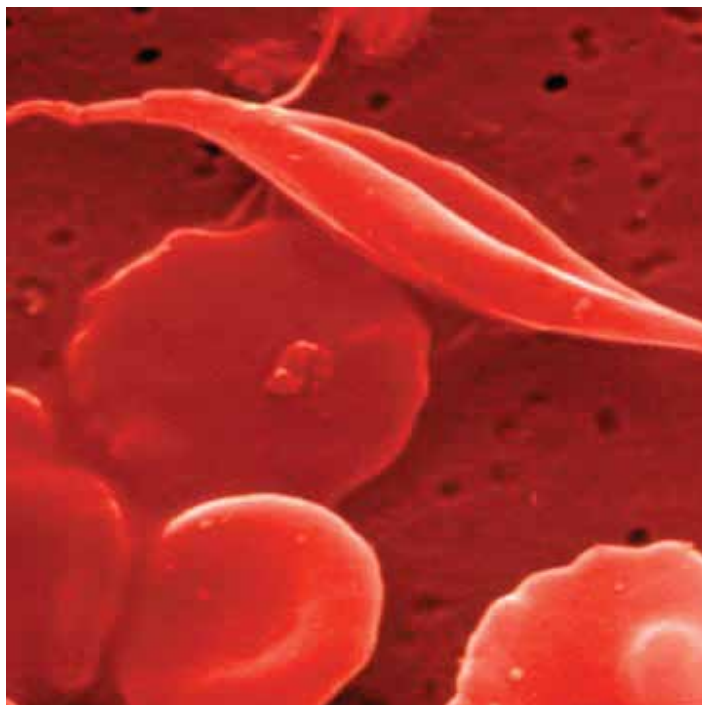
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Ohio Department of Education Center for Curriculum and Assessment. 2003. Ohio Department of Education: Columbus, OH.

Normal Red Blood Cell



Sickle-Shaped Red Blood Cell



Protein Pieces

ARG

Arginine

GLU

Glutamic Acid

LEU

Leucine

TRP

Tryptophan

HIS

Histidine

ILE

Isoleucine

VAL

Valine

LYS

Lysine

SER

Serine

THR

Threonine

Start

MET = Methionine

Stop

Protein Pieces

ALA

Alanine

ASN

Asparagine

ASP

Aspartic Acid

CYS

Cysteine

GLN

Glutamine

GLY

Glycine

PHE

Phenylalanine

PRO

Proline

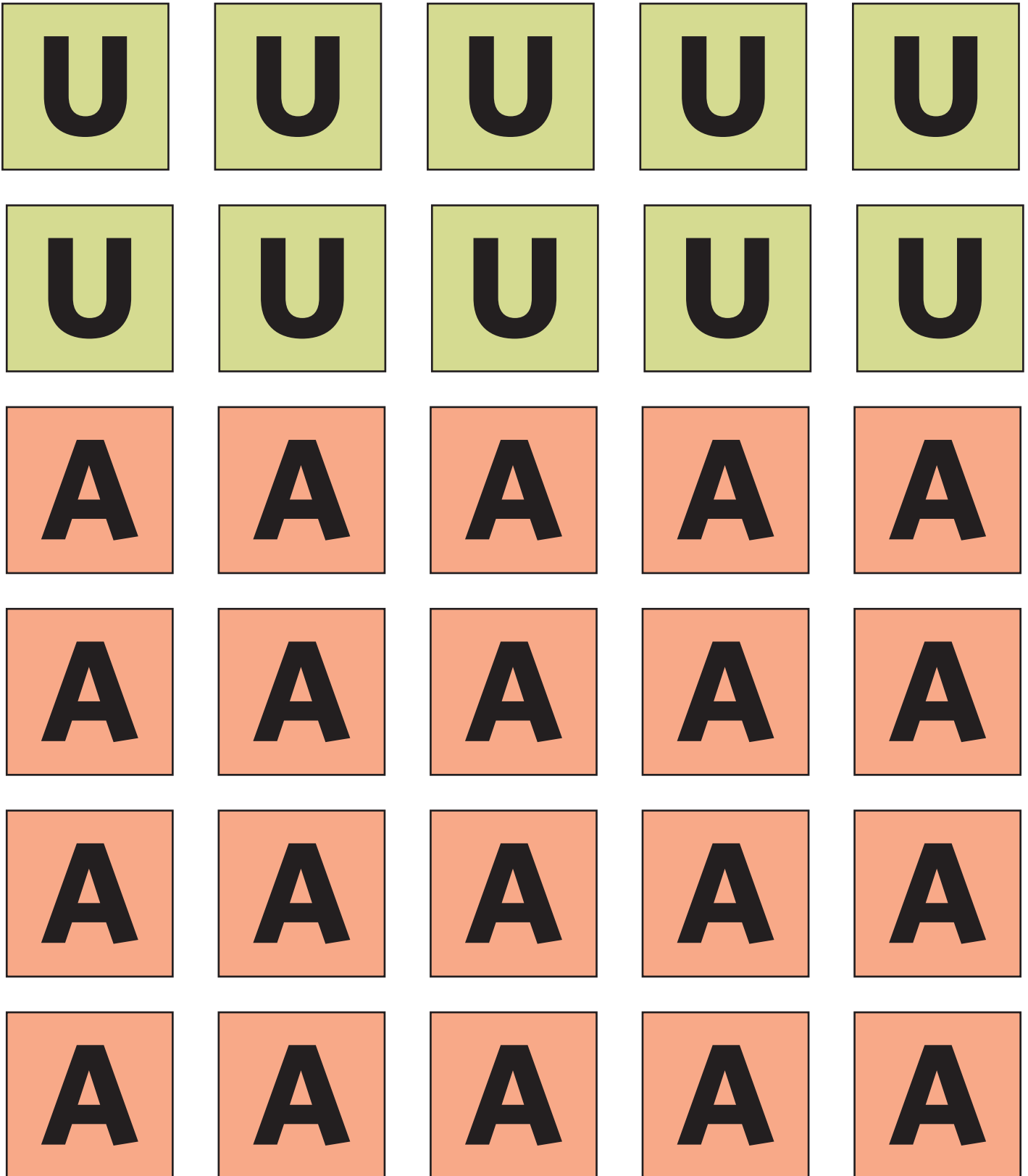
TYR

Tyrosine

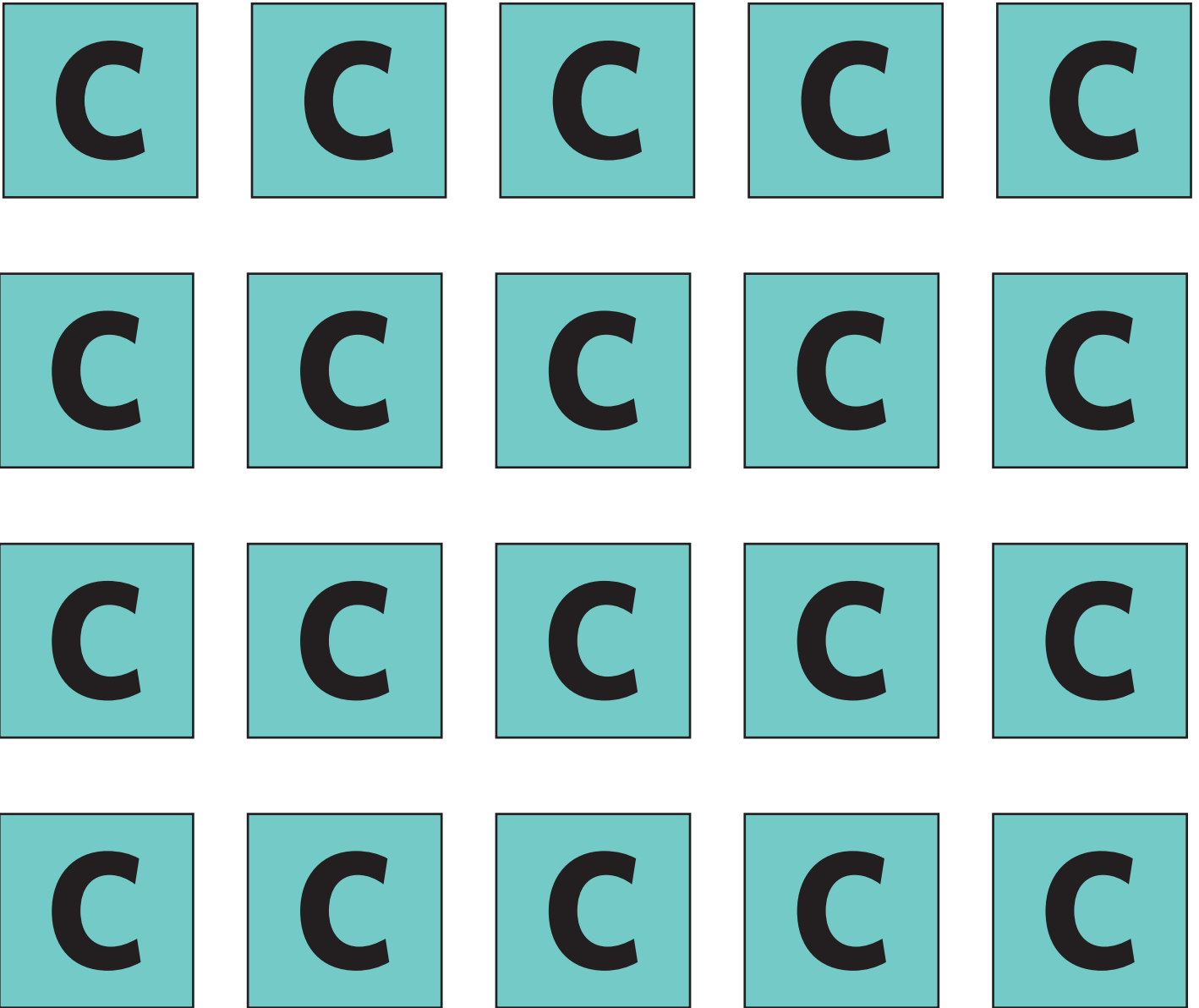
RNA Pieces



RNA Pieces



RNA Pieces



The Genetic Code

Second Position

		Second Position						
		U	C	A	G			
U	UUU	Phe	UCU	Ser	UAU	Tyr	UGU	Cys
	UUC		UCC		UAC		UGC	
	UUA	Leu	UCA	UAA	UGA	Stop	UGG	Trp
	UUG		UCG	UAG	Stop			
C	CUU	Leu	CCU	Pro	CAU	His	CGU	Arg
	CUC		CCC		CAC		CGC	
	CUA		CCA		CAA	Gln	CGA	
	CUG		CCG		CAG	CGG		
A	AUU	Ile	ACU	Thr	AAU	Asn	AGU	Ser
	AUC		ACC		AAC		AGC	
	AUA	ACA	AAA		Lys	AGA	Arg	
	AUG	ACG	AAG		AGG			
G	GUU	Val	GCU	Ala	GAU	Asp	GGU	Gly
	GUC		GCC		GAC		GGC	
	GUA		GCA		GAA	Glu	GGA	
	GUG		GCG		GAG	GGG		