



HANDS-ON STEM

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Sweet DNA Molecule

OBJECTIVES

Students will be able to:

- Explain that certain DNA sequences code for specific characteristics.
- List several types of engineers and engineering technologies that rely on DNA sequences.
- Investigate basic gene sequences to determine the genotype and phenotype of an individual.

OVERVIEW

Students reinforce their knowledge that DNA is the genetic material for all living things. This is accomplished by modeling it using toothpicks and gumdrops that represent the four biochemicals that pair with each other in a specific pattern, making a double helix. They investigate specific DNA sequences that code for certain physical characteristics such as eye and hair color. Student teams trade DNA “strands” and de-code the genetic sequences to determine the physical characteristics (phenotype) displayed by the strands (genotype) from other groups.

WHAT IS A BIOMEDICAL ENGINEER?

Biomedical engineers study which specific DNA sequences code for certain characteristics as they investigate genetic disorders such as color blindness, Down syndrome, cystic fibrosis and hemophilia. Engineers develop technologies to recognize certain DNA mutations. Biomedical engineers study genes and DNA to develop technologies that could manipulate or replace genes that are damaged or missing. Gene therapy has many implications for the diagnosis, treatment and possibly prevention of human diseases such as cancer, cystic fibrosis and heart disease.

MATERIALS

- Toothpicks: 25
- Multicolored gumdrops: 30
- Paper or plastic plate to work on so the table stays clean
- 1 DNA color key (cut apart to create three color keys)
- 1 DNA identity card (use the color key to create your own identity card)
- Blank sheet of paper for coding notes and sketching
- Pencil



ENGAGE THE STEM SOLUTION SEEKERS

1. Divide the class into groups of two students each.
2. Hand out supplies to each pair of students: 1 plate, 25 toothpicks, 30 gumdrops, 1 DNA identity card, and 1 color key.
3. Explain that the color key contains the three-base genotypes that code for certain phenotypes (physical characteristics).
4. Explain that they can create the DNA identity cards and it will contain the names and physical characteristics of people they select, which will be different for every team. This is the person's DNA that the team will construct. Remind students to keep this person's identity a secret from the other groups.
5. For each physical characteristic on the identity cards (phenotype), refer to the color key and have groups write down in columns the sequences of letters (genotypes, using A, T, G and C) for their person. Then, have students write the corresponding base pairs in the second column. This is where the background knowledge above will come into play. A always pairs with T and G always pairs with C.
6. Allow enough time (15–20 minutes) for teams to build the strand of DNA for their person.
7. Once all groups have completed building, have them trade DNA strands, and by working backwards from the strand only (no peeking at the identity cards), each group should determine whose DNA they have. Students really enjoy this “decoding” part!
8. Have students check with the original creator teams of the DNA strands to see if they determined the right DNA identities. Discuss with the class: How many groups were able to name the right identity for their DNA strands? What made decoding difficult?

PROCEDURE

1. While referring to the identity card and color key, write down in a column the base letters (A, T, G and C; genotype) and the corresponding base pairs in a second column for the first physical characteristic (phenotype).
2. Next, build each “gene” in the first column of three bases by placing three gumdrops (of the correct colors) on one toothpick. Refer to the color key.
3. Once all five “genes” from one column are built, repeat the process to build the corresponding base sequences from the second column of letters.
4. Connect the base pairs by placing a toothpick between each of the three gumdrops—this creates five “ladders” for each gene.
5. Now connect all the genes by sticking the end of the toothpicks with the gumdrops together. Be sure to keep the genes in the correct order and orientation.
6. Finally, gently twist the entire strand to shape the double helix!



QUESTIONS

- **What is DNA?**

Answer: DNA is the genetic material for all living things.

- **What is a gene?**

Answer: A gene is a segment of DNA that codes for a specific trait.

- **Is there a way to have different characteristics with the same DNA sequence?**

Answer: No, DNA sequencing is unique for each characteristic.

- **Do all humans have the same DNA? Explain.**

Answer: No, humans share about 99.99% of DNA. Only identical twins share 100% of their DNA.

- **What type of engineer would work with DNA and genes?**

Answer: A biomedical engineer.

- **How are engineers involved in DNA and gene sequencing?**

Answer: Biomedical engineers study which specific DNA sequences code for certain characteristics in order to recognize genetic disorders such as color blindness, Down syndrome, cystic fibrosis and hemophilia. Engineers design technologies that recognize certain DNA mutations and work with geneticists to diagnose and prevent the disorders.

DNA COLOR KEY

Cut along the dotted lines to create three different Color Keys. Distribute one per group.



DNA COLOR KEY

Gumdrop Color	DNA Base
Purple	A
Yellow	C
Green	G
Red	T

Phenotype		Genotype
Eyes	Blue	AGG
	Green	AGC
	Brown	TGG
	Hazel	TGC
Hair	Brown	GCC
	Black	GTG
	Blonde	GCT
	Red	GTC
Dominant Hand	Right	TAA
	Left	TTA
Height	Short	GAA
	Medium	GGG
	Tall	GTT
Nose Shape	Round	ATA
	Long	GTA
	Pointy	CAT

DNA COLOR KEY

Gumdrop Color	DNA Base
Purple	A
White	C
Yellow	G
Red	T

Phenotype		Genotype
Eyes	Blue	AGG
	Green	AGC
	Brown	TGG
	Hazel	TGC
Hair	Brown	GCC
	Black	GTG
	Blonde	GCT
	Red	GTC
Dominant Hand	Right	TAA
	Left	TTA
Height	Short	GAA
	Medium	GGG
	Tall	GTT
Nose Shape	Round	ATA
	Long	GTA
	Pointy	CAT

DNA COLOR KEY

Gumdrop Color	DNA Base
Purple	A
White	C
Green	G
Orange	T

Phenotype		Genotype
Eyes	Blue	AGG
	Green	AGC
	Brown	TGG
	Hazel	TGC
Hair	Brown	GCC
	Black	GTG
	Blonde	GCT
	Red	GTC
Dominant Hand	Right	TAA
	Left	TTA
Height	Short	GAA
	Medium	GGG
	Tall	GTT
Nose Shape	Round	ATA
	Long	GTA
	Pointy	CAT