(Genetics Intro)

Learning Objectives:
- Understand the genetic material that all living organisms are composed of.
- Learn the components of the DNA molecule, its shape and bonds, how it is stored and passed down.
- Identify differences between the genetic material of a human and a strawberry.

Key Vocabulary:
- Organism
- DNA
- Nucleotide
- Polymer
- Monomer
- Base pairs
- Pyrimidine
- Purine
- Phosphodiester bonds
- Hydrogen bonds

INTRODUCTION (15 MIN. OPEN DISCUSSION)
Name some of the things that are made up of DNA.

Sample answers
- You!
  —Humans have enough DNA to stretch from the earth to the sun 100 times!
- Plants and fruits
  —60% of out DNA matches a banana's
- Fungi
  —Humans are more closely relate to mushrooms than plants
- Bacteria
- Animals
  - 25% of your genetic sequence matches a dog, 90% matches a cat, 80% a cow, 98.8% chimp and bonobos.

All living things store their genetic material in the form of DNA. Every single one of us, and every organism around us is made up of the exact same material you are!

By the way, what is an organism?
A living entity that can sustain its own life, is capable of growth and development, reproduction, and reaction to stimuli.

All living things contain the same genetic material, but **what nonliving things contain DNA?** Viruses and fossils

What is a fossil?
Remains of organisms, dating back as far as 4.1 billion years old.
Currently, about 50 new dinosaur species are uncovered each year!

15-20 min Background Info.

How do they survive so long?
Most died near wet environments and were covered in mud soon after their death, protecting them from the elements until they eventually turned to stone.

What is a monomer?
A molecule that joins others just like it, to form a larger, more complex structure, called a polymer.

Monomers are very much like small lego pieces, they're all exactly the same, and you stack them together to form a larger structure.

What are nucleotides?
The monomers of DNA, and the actual DNA molecule is the polymer .
Nucleotides are your lego pieces and the DNA molecule is that super cool lego set you built by putting all of the pieces together.

Nucleotides are made up of three basic components: a backbone made up of sugar and phosphate, and a base.

What are the different DNA bases?
Adenine, Guanine, Thymine, Cytosine

These three components together form a single lego piece, which then stack together to form a DNA molecule. Consecutive nucleotides are stacked together like legos forming strong bonds, much like a lego tower, and you know how hard those are to completely knock off.

[Show image of nucleotides bonded together]
Where's the backbone?
Count the carbons, and point out that the sugar is bonded to phosphate on the 5' carbon, and there is an OH group on the 3' carbon.

The nucleotides are connected by their sugars, with the H of the alcohol in the 3' carbon being lost and a phosphate group from another nucleotide taking its place.

Those two phosphates, the one at carbon 3 and at carbon 5, can bond to each-other, locking the backbone in place.

Where are the bases?
On the other side of the sugar, is the base, which sticks outwards and hydrogen bonds to bases on opposite strands.

Where is DNA stored?

DNA is kept inside the nucleus of every living cell (80% water), in the form of chromosomes (DNA molecules with an organism's genome). In eukaryotic cells, DNA is protected by two double membranes.

Why does DNA have its spiral ladder shape?

DNA's backbone is hydrophilic (phosphate is negatively charged and sugar is polar). The nitrogenous bases are non polar, and undergo hydrophobic interactions in the cell's polar medium, caving inwards, while the phosphate and sugar stick outwards.

Why is DNA double stranded?

All of our genetic material is made up of only 4 nucleotides: Adenine, Guanine, Cytosine, Thymine. Adenine and Guanine are Purines, made up of 2 rings containing 5 nitrogens each (two of which have an N-H capable of hydrogen bonding). Cytosine and Thymine are pyrimidines, made up of a single ring containing 2 nitrogens and one oxygen capable of hydrogen bondings. Purines bond with pyrimidines. C-G form two hydrogen bonds, and A-T form 2 bonds, tying the two strands together.

Why don't the purines hydrogen bond to each other, instead of to pyrimidines?

Each base pair is made up of 1 purine and 1 pyrimidine, because that is the only way they will fit together close enough to hydrogen bond.

Why does Adenine only bind to Thymine and Guanine only bind to Cytosine?

Why can't adenine bind to cytosine (since they're a pyrimidine-purine pair too)? Why can't guanine bind to thymine?

<u>Chargaff's Rule</u>: A always pairs with T, G always pairs with C.
Cytosine and guanine form three hydrogen bonds together. If adenine were to bond to cytosine, it would only be able to form two hydrogen bonds, which is less stable than three, so they quickly break apart and cytosine binds to its more stable partner. Same occurs with thymine and guanine: guanine will ditch thymine (which can only make 2 H bonds) and hook up with a cytosine to make 3 bonds.

<u>[Mini-Activity]</u>

1. ***If a double stranded DNA molecule is 20% guanine, what percentage of cytosine would you expect?***

   20% G = 20% C

   In the scenario above, what percentage of thymine would you expect?

20% G + 20% C = 40% C-G
100%- 40% = 60% A-T
60%/ 2 = 30% T

How do we get DNA out of you?

Your entire genome is found in almost every single one of your 37.2 trillion cells! All we need is a few.

DNA is stored inside the nucleus, which is protected by the nuclear envelope (a double lipid bilayer), and in turn, the nuclear envelope is surrounded by the cell's membrane (a phospholipid bilayer). Both of these membranes are made up of two rows of lipids, which have their hydrophobic tail facing inwards and the hydrophilic heads sticking to the extracellular matrix and the other set faces the cytoplasm, both mostly composed of water.

To free DNA from our cells, we have to break down all the walls protecting it, and then wash it, to make sure all we have at the end is pure DNA.

DNA EXTRACTION

Materials:	Procedure:
Plastic Bag, Strawberries,	1. Remove and green leaves from the strawberry, and place into the plastic bag. Seal the bag and gently smash the strawberries for 2 minutes.
Plastic Cup, Detergent, Salt, Water	2. In a cup, make your extraction liquid by mixing together 2 teaspoons of detergent, 1 tsp salt, 1/2 cup of water. Add 2 tsp of your extraction liquid to the smashed strawberries. Smash once more.
Plastic Cup and Filter	3. Place a filter inside a clean cup and pour the strawberry liquid into the filter.
Cold Alcohol	4. Into the cup containing the strawberries, pour enough alcohol, so that you have equal amounts of strawberry liquid and alcohol. Do not mix or stir.
Stick	5. With a small wooden stick, pick up the sticky DNA (white cloudy substance).

Materials:	Procedure:
Cup, Water, Salt	1. Mix water and salt into a cup, and swirl in mouth. Spit solution back into cup.

Materials:	Procedure:
Plastic Cup, Detergent, Salt, Water	2. In a cup, make your extraction liquid by mixing together 2 teaspoons of detergent, 1 tsp salt, 1/2 cup of water. Add 2 tsp of your extraction liquid to your saliva. Swirl gently for 2-3 minutes.
Cold Alcohol	4. Into the cup containing your sample, pour enough alcohol, so that you have equal amounts of saliva and alcohol. Do not mix or stir. Let stand for 1 minute.
Stick	5. With a small wooden stick, pick up the sticky DNA (white cloudy substance).
Small tubes, Alcohol, string	6. Fill tube with alcohol and tie string around it. Add DNA. Wear it!

Reinforcement.

Why do we use detergent to extract DNA?

In the same way that you wash your dishes, hands, or hair, detergents trap and pull apart the lipids in the membrane, poking holes. This is why your hands dry out if you wash them too much, or get handsy with the hand sanitizer.

We can then obliterate the membrane even further my mechanically breaking it apart, through mashing, or spinning.

What are salts?

Ionic compounds made of cations and anions that fully dissociate in water

How can we use salts to separate DNA from the rest of the cell?

Most of the cell parts are water soluble (they are 80% water after all), negatively charged DNA with its hydrophilic backbone included. We use salts (ionic compounds made of cations and anions, which completely dissociate in the cell's polar medium, ie. Na+ Cl-), to neutralize the DNA's negative charge by having the Na+ bond to the negative phosphate group. By making the DNA less negative, we are making it more stable and less water soluble.

Who do you think who will have more DNA, you or a strawberries?

Have the students share their hypothesis and back up their statements using the appropriate background information. Discuss why the are able to see chunks of DNA when it resides within their microscopic cells.

Wrap-Up! After the students have written down their observations and completed a concluding discussion about the results, review the learning objective by asking the students what new information they have learned and reviewing the key vocabulary words. Discuss why the are able to see chunks of DNA when it resides within their microscopic cells.