Gene Expression

Learning Objectives:
- Understand the functional role of DNA in living organisms.
- Learn the central dogma of biology.
- Identify the various errors that can occur during DNA replication and protein synthesis.

Key Vocabulary:
- Replication
- RNA
- Amino acids
- Polypeptides
- Transcription
- Translation
- Mutation

INTRODUCTION (15 MIN. OPEN DISCUSSION)

Why do we package things?

Sample answers
- To store them
- To protect them
- To make them fit somewhere

What body parts need to be tightly packaged in order to make them fit inside of us?

Sample answers
- Intestines
  —Human intestine is almost 30 feet long
- Brain
  —The human brain is the size of 2 fists. If we unfolded it and straightened it out, it would be the size of a basketball
- Human Genome
  - Our entire genetic code takes up 2 CDs worth of space. If all of the DNA in every single one of our cells was lined up, it would stretch from the earth to the sun 100 times.

How do we make so much DNA fit inside our cells?

We store it as chromosomes, which are then further condensed into chromatin

Chromatin is how our cells package DNA, both for safekeeping and to make sure they fit. The DNA molecule is wrapped around circular proteins called histones. The DNA and histone together are called a nucleosome, and it looks like a beads on a string.

In our cells we have two types of chromatin: **Euchromatin** and **Heterochromatin.**

Heterochromatin is way too tightly packaged to be used, so Euchromatin, which is much less tightly wound, is what actually codes for proteins.

15-20 min Background Info.

To ensure that every cell has the genetic information it needs, DNA needs to be replicated. **What do we need to do before we can replicate the DNA?**
We need to unzip the strands, so that we can get in there and start
The unwinding of the two strands is done by the enzyme helicase

By the way, what is an enzyme?
A protein that makes a reaction occur by providing the exact conditions the reaction needs. It speeds up a lot of reactions, but many would not occur at all if it were not for the enzyme.

When is an enzyme active?
Only when it is around its target and under very specific conditions, when the cell wants its reaction to occur.

Why is it important that only a very specific enzyme can unwind DNA?
The DNA in our cells would be damaged or replicated when unwanted, which can cause mutations, and impair the body's functions.

Helicase binds between the two strands and starts to pull them apart, **but what can occur as helicase does this?**
Imagine you have yarn made of two threads. You pull apart both threads, but eventually, the bottom is going to form a big fat knot, and your threads get stuck. DNA is the same way. To keep the two strands from tangling a tiny protein binds to one of the two strands, and keeps it from getting tangled. To keep the yarn knot at the very bottom from occurring, enzymes at the other end of the helicase go in and break up the threads into smaller pieces and then bind them together again, keeping the strand straight the entire time.

Our strands, now separate and tangle-free are ready to be replicated.

The enzyme DNA Polymerase binds to one of the strands, and makes a complimentary partner for it. This enzyme, like most other enzymes, is very picky, and will only read from the 3' to the 5'.

Who remembers what a nucleotide looks like?
[Show image of two complimentary DNA strands where nucleotides are visible]
[Demonstrate the 5' carbon and the 3' carbon]

We know that DNA strands are antiparallel, meaning that if one starts with its 5' end, the one right next to it will start with its 3' end.

If DNA is only making a copy of the strand going from 3' to 5', how do we copy the other strand that is going from 5' to 3'?

DNA polymerase gets crafty and makes trips to the end of the strand, and reads it backwards, from the 3' to 5' direction. Every trip the enzyme makes from the beginning of the strand to the back, it assembles a small segment. At the end, you're left with a bunch of little, unattached segments, called Okazaki fragments.

How do we go from a bunch of separate fragments to an entire, continuous strand?

Another enzyme, called ligase, steps up and cleans the mess that polymerase made, by connecting all of the little fragments together.

Because the strand that starts with 3' is easier to replicate, it gets done faster, so it is called the leading strand. Because the 5' strand is replicated in pieces, its always a little behind, so it is called the lagging strand.

You've now got DNA in every single one of your cells, let's put it to work!

What is DNA's main job?
To make RNA, which then makes proteins that run all of the body's systems

What is RNA?
Ribonucleic acid that only differs from DNA in that it has an extra alcohol in its sugar that DNA lacks, and has uracil instead of thymine.

What are proteins?
Polymers of amino acids that do a lot of our cell's work. They regulate our organs and tissues.

How are proteins made?
[show image]. *We use our 3 types of RNA made from our DNA.*

mRNA: decides the sequence of our amino acids, in turn deciding what proteins are made.
tRNA: picks the amino acids and drops them off where mRNA wants them
rRNA: form ribosomes, the sites where mRNA and tRNA get the amino acids together to make proteins.

DNA replication is a long, laborious job, a lot can go wrong.

What are mistakes in genetic code called? *Mutations*

Our DNA is replicated millions of times throughout or lives and many errors occur. The body however, often corrects these errors before it's too late, and those mutations that are not fixed, are most of the time harmless. Once in a while though, they can have catastrophic outcomes.

The most common type of mutation is the point mutation, which only affects a single nucleotide. These can be a substitution, or a more serious deletion, or insertion, which completely shift the entire genetic code.

When mutations are silent, they still code for the same amino acid they were supposed to. Missense mutation code for new amino acids and nonsense mutation just completely stops the sequence.

How do you think a missense or nonsense mutation affects the body?

A missense mutation will code for an entirely new amino acid that may not fit in well within its protein, therefore affecting its function

A nonsense mutation may even keep a protein from being formed, or cause it to be a lot shorter than it should be, affecting its function.

Mini-Activity: Secret Codon Bracelet

Using beads and string, students can write a message using genetic code Assign each nucleotide a color and the students can make a secret code and convert it to genetic code using the amino acid abbreviations and the genetic code table. Add mutations to make it interesting!

GENE EXPRESSION: STUDENTS EXPLORE THE EFFECTS OF ENVIRONMENTAL CHANGE ON THE REGULATION OF GENE EXPRESSION. A GENE INVOLVED IN PRODUCING A RED PIGMENT IS TURNED ON (EXPRESSED) AT ROOM TEMPERATURE, CAUSING THE BACTERIA TO APPEAR RED. IT IS TURNED OFF (NOT EXPRESSED) AT 37° C, CAUSING THE BACTERIA TO APPEAR WHITE.

Materials:	Procedure:
64 oz. Jar	1. Lay the jar horizontally on a flat surface. Place a layer of gravel at the bottom and fill about 1/5 of the way with soil. Repeat this 2 other times with the other 2 jars.
150 Watt Lamp	2. Layer the first jar with plants, plant of few other ones in the second jar, and leave the third jar barren.
Assorted Small Plants	3. Fill in the remaining space of the second jar with the assorted litter and cover the soil of the third jar with the remaining litter.
Thermometer	4. Place a lamp at the base of each jar, covering the sides of the last jar with aluminum foil. Place a thermometer in the soil of each jar.
Soil	5. Tie a funnel around the opening of the jar so that it hangs off the side of your surface, with the stem leading to a smaller jar on the floor.
Varied Litter	6. Water each jar mildly and allow half an hour for the water to drain out. Observe any difference, take the pH of the water collected, and read the temperature in each thermometer.
Aluminum Foil	
Funnel	
Litmus Paper	

Reinforcement. Take the 30 minutes of waiting as an opportunity for students to discuss why the bacteria are changing colors, and highlight that is is gene expression that is being affected, that the bacteria are not purposefully changing colors. Talk about mutagens and carcinogens, and that radiation, chemicals can cause them.

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.

carolina kit: https://www.carolina.com/bacteria/temperature-dependent-gene-expression-kit-with-prepaid-coupon/154769.pr