5-DNA STRUCTURE AND FUNCTION

WHAT WE'LL COVER:

Start with the structure of DNA: (Nucleic Acids were one of our 4 types of biological molecules)
made of nucleotides (a sugar, a phosphate and a base-A, G, T and C), and these nucleotides are stuck together. The sugar and phosphate make up the "backbone"—the sides of the ladder (so it's called the sugar-phosphate backbone), and the nucleotides are the rungs of the ladder.
For double-stranded DNA, the rungs of the ladder under go **specific base pairing**:
A—T and G—C. Held together with H-bonds down the middle
DNA's structure allows it to do 2 very important functions:

It allows DNA to be replicated faithfully when cells divide (so this is how it is the hereditary information—it needs to get passed down from parents to offspring)

Each strand of DNA serves as a new template for a new growing strand of DNA because of specific base pairing: A with T and G with C

The second function is DNA needs to be the instructions to make proteins (this is how a genotype can cause a phenotype):
Parts of DNA that are **genes** can be copied via specific base pairing into mRNA.
mRNA is the temporary instructions that the ribosome "reads" in order to make a protein.
DNA→mRNA = transcription (similar to DNA replication)
mRNA→protein = translation

Translation is tricky:
proteins have 20 different building blocks (amino acids)
DNA and RNA only have 4.
How can we get from 4 different blocks to spelling out for 20 things?
Read 3 bases at once: AUG = amino acid name methionine

REVIEW

Biological molecules are large molecules made up of smaller parts.
The smaller parts are called_____
When those parts are stuck together, they don't come apart easily.
It requires energy to make large molecules from smaller molecules: anabolic reactions
What are the building blocks of proteins?
How many types of those building blocks are there?

DNA Structure and Replication

By the 1940's (so WWII) we knew chromosomes were what allowed for inheritance
We knew chromosomes were made of protein and DNA.
Other studies indicated that it was the DNA that was the molecule of heredity (kinda unexpected).
In 1953, the structure of DNA was discovered. But how did that structure allow DNA to be read?

***DNA's structure allows for its 2 important functions:

1. allows DNA to be copied accurately when a cell reproduces: so allows DNA to be the molecule of heredity
2. Allow DNA to spell out for proteins and proteins produce the phenotype: by containing the instructions for the order of amino acids in a protein

More History

Franklin discovered DNA was a double helix via X-ray crystallography (you make a crystal of the substance, and then take an X-ray of that)

Found something like this, which is like looking down on top of a spiral staircase:

So knew it was a spiral helix with evenly spaced rungs! (look at the bases above)

Structure of DNA

So the sequence of amino acids (primary structure) determines how a protein folds.
What determines the order of those amino acids? The **genes** within our DNA.

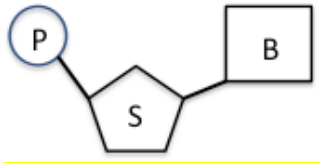
The flow of information goes from DNA→RNA→protein

(The Central Dogma)

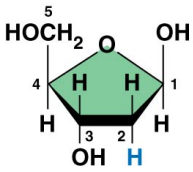
THE MONOMER OF NUCLEIC ACIDS IS A NUCLEOTIDE

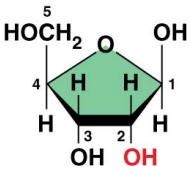
NUCLEOTIDES ARE MADE OF THREE THINGS:

The backbone: 1. a sugar
2. Phosphates
3. The bases: GATC (in DNA)



1: Sugars: Deoxyribose in DNA





-2' carbon: does it have an oxygen or is it deoxy-?

3. The Bases: GATC

POLYMERS OF NUCLEOTIDES:

Nucleotides (monomer) come together in a condensation/dehydration reaction

The bond between nucleotides is in the backbone.

The backbone will alternate: sugar-phosphate-sugar-phosphate

The base is attached to the sugar (in a strong bond)
You always add a new nucleotide to the sugar end of a strand.
*read through page 1 of your lab. As a group carry out step 1 on page 2: make a single strand of DNA 10 bases long. Make sure you attach nucleotides together between the sugar of 1 nucleotide and the phosphate of another nucleotide.

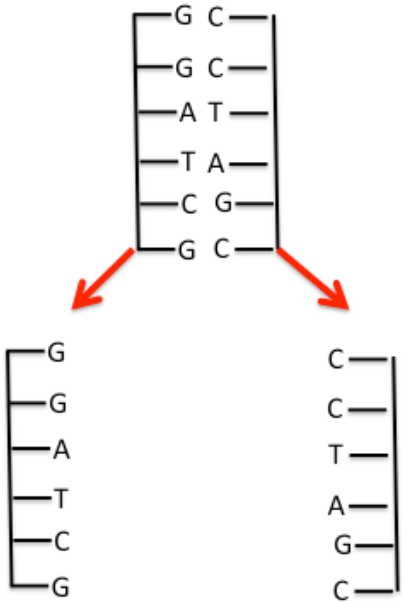
MAKING THE COMPLEMENTARY STRAND

DNA

DNA is double-stranded: two single strands come together.
SPECFIC BASE PAIRING between the bases of 2 strands is what holds the strands together.
A pairs with T (Apples and Trees)
C pairs with G (Cars in garages)

STRANDS OF COMPLEMENTARY

If you know the sequence of one strand, you can work out the sequence of the other:



Very important if you're copying DNA (which is necessary in heredity!)

Strands are parallel: they never touch, and they run in opposite directions

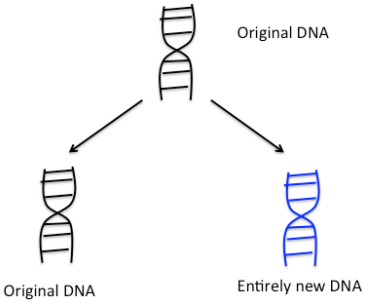
Antiparallel: at one end of a molecule you start with a phosphate and end with a sugar. The other strand will start with phosphate at the bottom and end up with a sugar at the top.

**Now continue with steps 2-4: the 3' end= the sugar end*

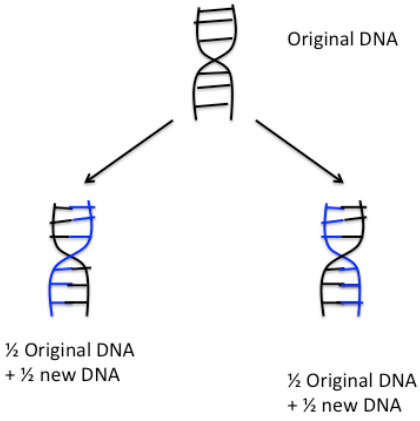
Amoeba sisters: DNA structure and Function:
https://www.youtube.com/watch?v=_POdWsii7AI&list=PLwL0Myd7Dk1F0iQPGrjehze3eDpcoleVz&index=9
Starts with cloning 8.53 minutes
4.30: starts on DNA structure: start here for now

THE STRUCTURE OF DNA (SPECIFIC BASE PAIRING) ALLOWS FOR THE FUNCTION OF DNA GETTING COPIED

We weren't always sure how DNA was replicated:

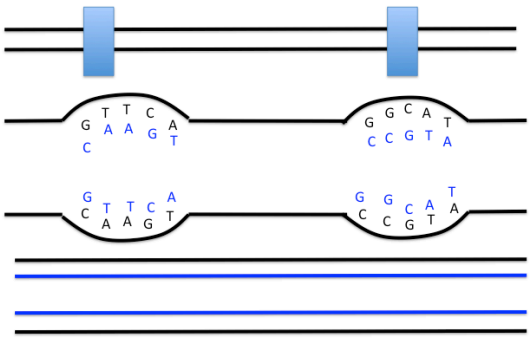


Thought maybe this happened…but the **above is wrong!**
DNA is replicated in a semi-conservative manner:



Each new DNA molecule has 1 new strand, and 1 original strand

SO DNA replication unzips the H-bonds down the middle, and uses each old strand as a **template** to make a new strand:



An enzyme will stick together new nucleotides to build the two new blue strands: **DNA polymerase**

Still on Page 2 of the lab, carry out procedure: Modeling the replication of the DNA segment. Before you do: write down the initial sequence of DNA.

Ameoba sisters: DNA replication**: https://www.youtube.com/watch?v=5qSrmeiWsuc**
Too detailed? Yes, probably! 8 minutes
4.40 minutes in: antiparallel direction

DNA'S STRUCTURE ALLOWS FOR ITS SECOND FUNCTION OF DETERMINING OUR PHENOTYPE: THE CENTRAL DOGMA IS A STATEMENT OF HOW INFORMATION FLOWS FROM DNA→RNA→PROTEIN

DNA'S STRUCTURE ALLOWS FOR ITS SECOND FUNCTION OF DETERMINING PHENOTYPE

We know information is stored in DNA, but it is only 4 different bases. How do 4 bases determine how to make thousands of proteins?

Some really smart people spent a long time trying to figure this out. Just like the letters in "ACT" and "CAT" are the same, its not the # of letters, but the ORDER of the letters that matters.

As you watch the video below, try to fill in the table comparing and contrasting (well, mostly contrasting) DNA and RNA structure

Feature	DNA	RNA
# of strands		
Bases (highlight the		

different one)		
sugar		

And list the 3 different types of RNA and their roles

Amoeba sisters: Why RNA is just as cool as DNA (4.25 minutes):
https://www.youtube.com/watch?v=0Elo-zX1k8M

NOW: MAKING PROTEINS FROM THE INSTRUCTIONS IN GENES

Amoeba sisters: Protein synthesis: 6.39 minutes:
https://www.youtube.com/watch?v=h5mJbP23Buo

THE FIRST STEP IS MAKING AN RNA SEQUENCE FROM THE DNA.

This is pretty easy—we can use specific base pairing again. Remember we're only making a single strand of RNA, so we'll only copy 1 of our DNA strands.
Also, RNA does not have the base T, instead it has U.

So a DNA sequence of:

TACGGCCGT
ATGCCGGCA

One of the strands will be copied. Which strand will I copy if I need an RNA sequence of AUGCCGGCA? That strand is called the **template.**

We call the process of making RNA from a DNA template **transcription**. (When you "transcribe" a document, you basically copy it, which is what we're doing here.)

Transcription takes place in the nucleus.
Start on Procedure 2 on Page 2 of the lab. The name of the protein that does the work of making the RNA strand is RNA polymerase. Work through steps 1-5 on Page 3 (LUNCH)

The second step is making Protein from the RNA

This step is a little more complicated. Remember how there are 20 different amino acids in proteins, and only 4 RNA bases? How can we get 20 different things from only 4 letters?
What if I try using more than 1 letter in a row to spell out an amino acid?
Will 2 letters work?
My first letter can be 1 of 4 bases, and my second letter can be 1 of four bases:
4*4=16 different amino acids=not enough
what about 3?
4*4*4=64 different combinations. That's a LOT!!! So sometimes different combinations of letters can spell out the same amino acid.

The genetic code is the combination of bases than spelled for different amino acids

It took some work to figure out the code, but we now know what 3 letter combinations spell for different amino acids. These three letter combinations are called **codons.**

Translation is making Proteins from RNA

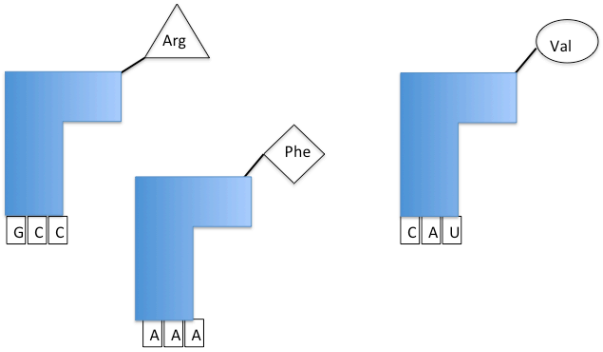
We are changing from the language of nucleotides to the language of amino acids, so this process is called **translation.**

We know that this requires Ribosomes! Ribosomes make proteins. The process of making proteins is called translation. It happens in the cytoplasm.

There are a few key players:
The mRNA is the message—it is the gene
The Ribosome is the machinery—made of proteins and RNA (ribosomal RNA)
The tRNAs are the interpreters=transfer RNAs They "read" the mRNA sequence on one side, and carry a specific amino acid on the other side.

tRNA molecule

Three bases specifically base pair with the **codon** of the mRNA. These three bases are the **anticodon**. At the other side, a tRNA has an amino acid attached. The tRNA is specific—different anticodons correlate to different amino acids:



THE RIBOSOME HAS SPACE FOR 3 DIFFERENT TRNAS AT ONCE

Each tRNA sits in position and slides across as the ribosome slides down the mRNA molecule. The Ribosome has to attach the growing amino acids to each other.

What protein sequence will you get with the mRNA that we made above?
AUGCCGGCA

What protein sequence would you get from:
AUGCAUCACCGUUAA

Start codon is what generates the "punctuation and spacing":
THE CAT SAT OFF THE HAT
Vs. HEC ATS ATO FFT HEH AT

3D animation video: https://www.youtube.com/watch?v=gG7uCskUOrA
2.41 minutes

Finish lab handout

Ameoba sisters protein synthesis worksheet too.

VIRUSES AREN'T CELLS (AREN'T ALIVE) AND CAUSE INFECTION

ANIMAL VIRUSES

These viruses have proteins and carbohydrates on the surface that our immune system recognizes, so they trick our body into thinking that they are not foreign. They then inject parts of themselves.

They hijack our cellular machinery to make more of themselves.

Then our cell lyses, spreading more viruses.

See the Hidden life of the cell: http://www.youtube.com/watch?v=cVgh-5vkXJs

One way we fight viruses is by using vaccines.

Vaccines were discovered by Jenner

Smallpox is caused by 2 different strains of virus. The more lethal strain resulted in around 40% mortality rate.
Jenner noticed that milk maids tended not to get small pox—they had had cowpox—a related virus that wasn't as deadly.

He decided that infecting people with cowpox (or a damaged form of it) could help prevent them from getting smallpox. Vaccine is from the Latin for cow (for cow pox).

Vaccines are made from pieces of viruses, so they will not cause infection themselves, but they "teach" our immune system to recognize viruses as foreign, and so if we are infected, we fight the disease before it truly makes us ill. They also help prevent the spread of viruses

2nd letter in codon

1st letter in codon	U	C	A	G	3rd letter in codon
U	UUU Phe (F) UUC UUA Leu (L) UUG	UCU UCC UCA Ser (S) UCG	UAU Tyr (Y) UAC UAA STOP UAG STOP	UGU Cys (C) UGC UGA STOP UGG Trp (W)	U C A G
C	CUU CUC CUA Leu (L) CUG	CCU CCC CCA Pro (P) CCG	CAU His (H) CAC CAA Gln (Q) CAG	CGU CGC CGA Arg (R) CGG	U C A G
A	AUU AUC Ile (I) AUA AUG Met (M) START	ACU ACC ACA Thr (T) ACG	AAU Asn (N) AAC AAA Lys (K) AAG	AGU Ser (S) AGC AGA Arg (R) AGG	U C A G
G	GUU GUC GUA Val (V) GUG	GCU GCC GCA Ala (A) GCG	GAU Asp (D) GAC GAA Glu (E) GAG	GGU GGC GGA Gly (G) GGG	U C A G