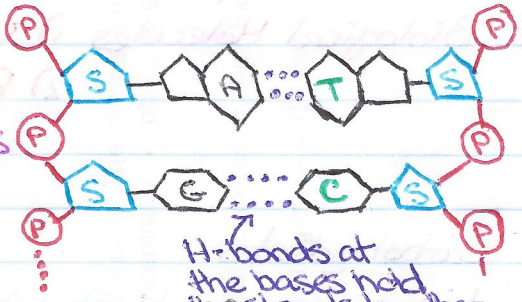
LESSON 22

Unit 2: Biochemistry

Struture of DNA (deoxyribose nucleic acid)

- DNA is a double helix
- DNA is a polymer of nucleotides
- each nucleotide is made of a 5 carbon (deoxyribose) sugar, a phosphate group, a nitrogen base (guanine, adenine, thymine, cytosine)

- DNA is double stranded
- the 2 strands are held together by hydrogen bonds
- Adenine always bonds to Thymine and Guanine always bonds to Cytosine. (Complementary Base Pairing)
- 2 strands in DNA coil to form a double helix.



DNA function

- the sequence of bases in DNA forms a code.
- type and number of proteins produced in your body depend on the code.

RNA (ribose nucleic acid)

- sugar is ribose
- single stranded
- bases are adenine, urasil, cytosine, guanine.

First Nations BI12 Resources DNA/RNA Structure and Function Written Response Questions

Assignment

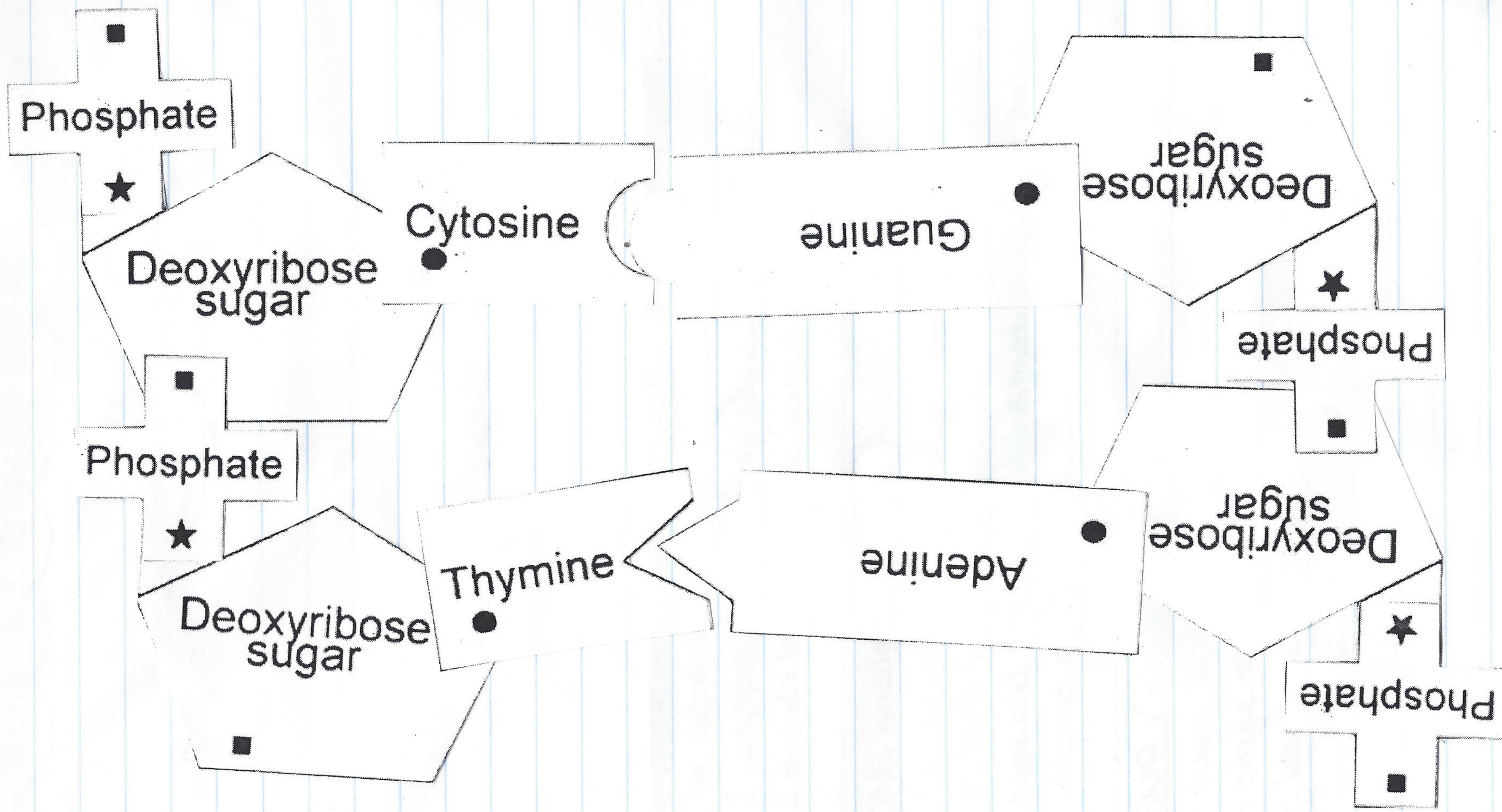
1. Describe the structure of DNA. Double helix, polymer of nucleotides
5 carbon sugar (deoxyribose), phosphate group, nitrogen base G,C,A,T
2. Name the three main components of a nucleotide.
5 carbon sugar, phosphate group, nitrogen base
3. How does the structure of RNA differ from that of DNA? a. sugars are different (DNA-deoxy, RNA-ribose)
b. RNA-single stranded DNA-double stranded.
c. in RNA, uracil replaces thymine.
4. What is meant by complimentary base pairing?
refers to pairing of bases between
5. The following is a sequence of bases along a polynucleotide:

5'-TCCGAGTACGCGATA-3'
3' -AGGCTCATGCGCTAT-5'

DNA: no uracil

a) What would be the complimentary sequence of base pairs?

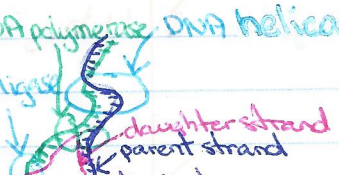
b) Is the polynucleotide in this question DNA or RNA? How do you know?


Phosphate
Deoxyribose sugar
Cytosine
Guanine
Deoxyribose sugar
Phosphate
Phosphate
Deoxyribose sugar
Thymine
Adenine
Deoxyribose sugar
Phosphate

LESSON 23

DNA replication

- the process by which DNA makes a copy of itself.
- when cells divide for growth or healing DNA replication occurs.
- every cell in your body has a complete copy of your DNA.
- the length of DNA that codes for one complete protein is called a gene.
- every cell in your body contains every gene your body needs.



3 STEPS: 1) Unzipping
- double helix is unwound and the 2 strands have the hydrogen bonds between complimentary base pairs broken.

*DNA Helicase is the enzyme that performs this step

2) Complimentary Base Pairing
- DNA nucleotides floating in the nucleus are paired up to the exposed strands by DNA polymerase.
- 2 identical double sided strands are produced.
- each new strand contains 1 parent strand and 1 daughter strand.

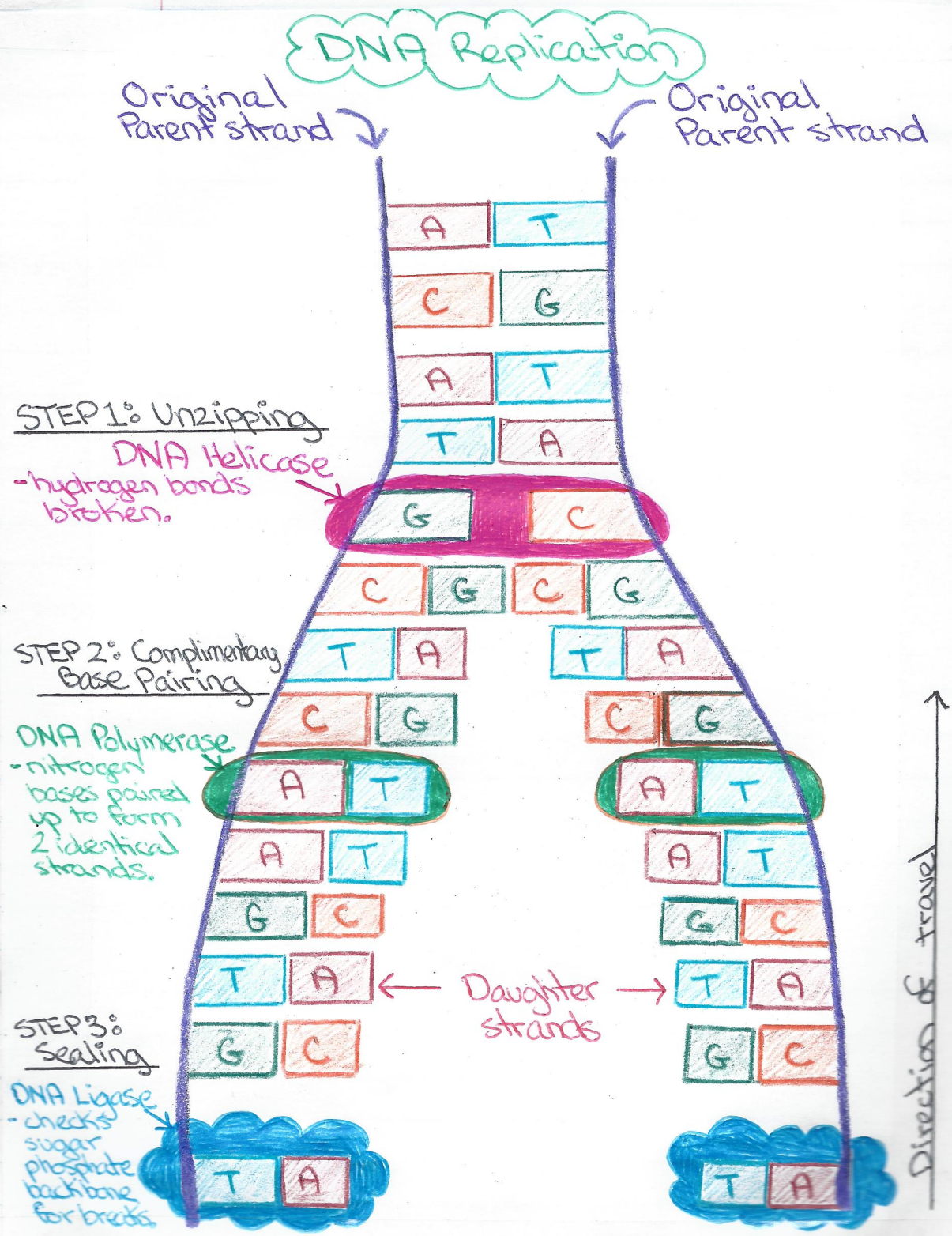
(semi-conservative replication) - 1 parent strand is conserved during replication.

3) Sealing
- DNA ligase checks the sugar-phosphate backbone for breaks.

Recombinant DNA (rDNA)

- combining DNA from 2 different species produces recombinant DNA.
- a gene is removed from one organism and placed into the DNA of another. ex. Insulin gene from human DNA is placed into the DNA of bacteria.
  - bacteria can now produce insulin.

DNA Replication



- human growth hormone (hGH)
- hemophilia: blood clotting factors
both are produced using rDNA

Review Questions

1) When do cells replicate their DNA?
- when cells divide for growth or healing.

2) Why is DNA replication said to be semi-conservative?
- 1 parent strand is conserved during replication.

3) Summarize the steps in replication and identify the enzymes involved in each step.
Step 1 - Unzipping, double helix unwound & hydrogen bonds broken. DNA Helicase
Step 2 - Complementary Base Pairing - 2 identical strands produced
DNA nucleotides picked up forming new daughter strand DNA polymerase.
Step 3 - Sealing, sugar-phosphate backbone checked for breaks.
DNA Ligase

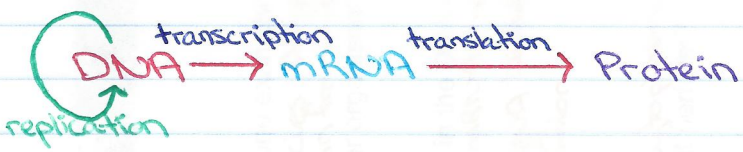
4) What is recombinant DNA?
- combining DNA from 2 different species.
- gene from 1 organism placed into DNA of another.

5) What benefit does rDNA technology have for human society?
- Insulin production, growth hormone, hemophilia

LESSON 24

Protein Synthesis

- DNA contains the code to produce proteins.
- the length of DNA that codes for one protein is called a gene.
- DNA exists only in the nucleus.
- Protein production occurs outside the nucleus in the cytoplasm.
- DNA creates a messenger (messenger RNA) mRNA to carry the code out of the nucleus.



Transcription

- the process of creating a complimentary strand of RNA from a DNA template.
- occurs in the nucleus.
- RNA polymerase performs all 3 steps:

1) Promotion

RNA polymerase binds to the DNA at a promoter region.
- DNA double helix is unwound and unzipped.
- occurs at the start of a gene.

LESSON 25

2) Formation

RNA polymerase moves down the DNA strand complimentary base pairing RNA nucleotides to the DNA, forming a chain.
- RNA nucleotides are free floating in the nucleus.
- once the end of a gene is reached, RNA polymerase is removed and the new mRNA is released.

3) Modification

Introns (sections not needed) are removed leaving only the EXONS (sections needed). A mature RNA molecule remains.
RNA molecule leaves the nucleus and enters the cytoplasm.

Assignment

1. Explain in your own words what recombinant DNA is. Give one example for which this technology would be beneficial to humans.

2. What is your personal opinion on modifying the DNA of other organisms to suit our needs? Is it ok or not and why do you think so?

3. Give a brief description as to how the information contained in the DNA molecule is translated into a protein.

4. Where along the DNA strand does transcription start?

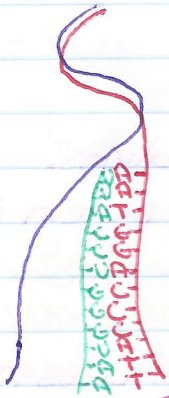
5. Where does transcription take place?

6. What is the end result of transcription?

7. Which enzyme is involved transcription and what role does it perform?

8. What part of the DNA is transcribed?

9. Where does the mRNA go once it is produced?



Transcribe this DNA base sequence into mRNA.

Translation

- translates code from mRNA into a polypeptide. (primary protein structure)
- occurs in the cytoplasm

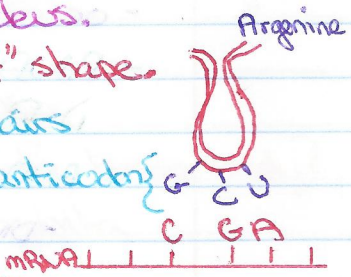
→ the following structures are involved in translation:

1) mRNA: created by transcription of DNA in the nucleus.
   - the bases are organized into groups of 3, called Codons.
   - each codon specifies one amino acid.

mRA - UUACCUGGUAA

leucine - proline - glycine - stop } Polypeptide

2) tRNA (transfer RNA): created by transcription of DNA in the nucleus.
   - folds in on itself to create a "t" shape.
   - contains an anticodon which pairs with the mRNA codon.
   - transfers amino acids to the area where proteins are forming.



DNA	mRNA	Anti-Codon tRNA	Amino Acid
ATG →	UAC →	AUG	Tyrosine
AAT	UUA	AAU	Leucine
CGG	GCC	CGG	Alanine
TAT	AUA	UAU	Isoleucine

Guided Practice 2.2B 2

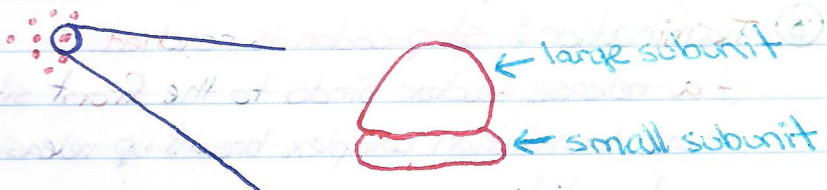
Codon/Anticodon Problem-Solving

Fill in the missing spaces to complete the following table (codons, amino acids, and anticodons dictated by a DNA base sequence). The first row is done for you as an example.

This DNA base sequence…	is transcribed into this mRNA codon…	which codes for this amino acid…	and binds with this tRNA anticodon at a ribosome during protein synthesis.
TTC	AAG	lysine	UUC
GAC	CUG		GAC
ACG	UGC	cysteine	ACG
ATT	UAA		AUU
GTA	CAU		GUA
CGT	GCA		CGU

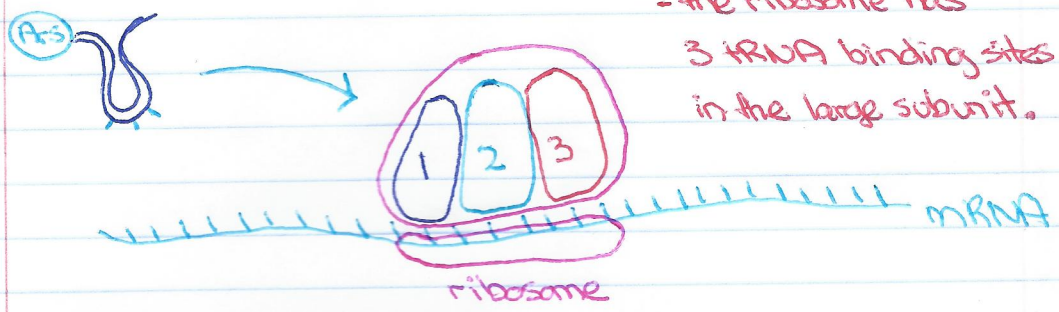
LESSON 26:

Ribosome → enlarged



- mRNA fits between 2 subunits during translation.

Translation Complex



- the ribosome has 3 tRNA binding sites in the large subunit.

Translation occurs in 3 steps:

1. Initiation: the small ribosomal subunit binds to the mRNA at a ~~start~~ codon. (AUG)
   - a tRNA with the anti-codon, UAC and the amino acid methionine bonds to the start codon
   - the large ribosomal subunit binds next.
   - arranged so the tRNA is in the middle binding site.
2. Elongation: a second tRNA bind to the front binding site
   - a peptide bond forms between the 2 amino acids present.
   - the ribosome moves one codon down the mRNA.
   - the first tRNA is released and another tRNA enters the front site.
   - this process continues and the polypeptide grows until a stop codon is reached.
3. Termination: stop codon is reached.
   - a release factor binds to the front site and the translation complex breaks up releasing the polypeptide.

LESSON 27

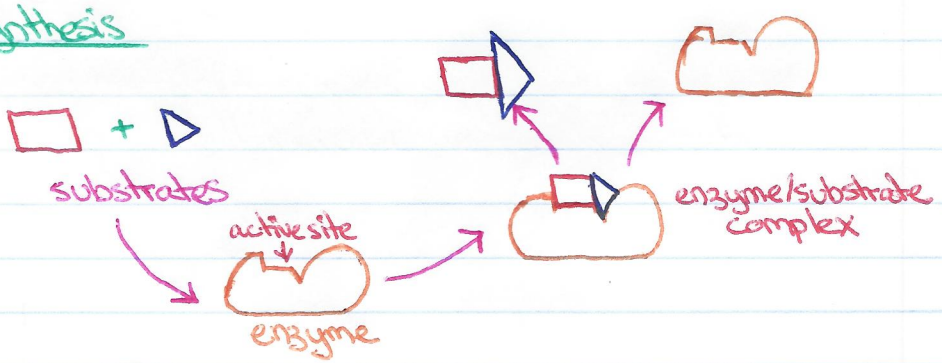
ENZYMES

- What class of Biological molecules are enzymes?
  Protein

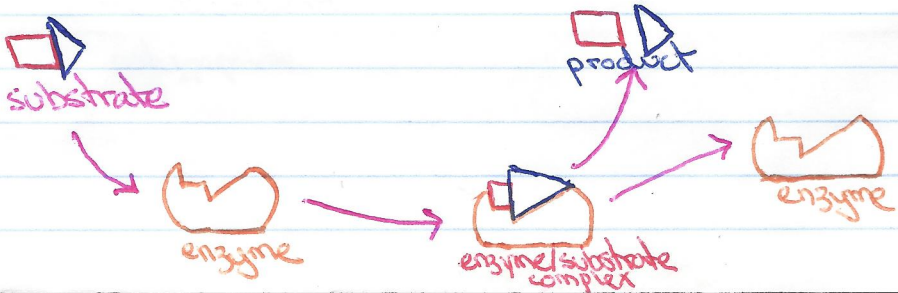
- Name an enzyme and its function.
  RNA polymerase - unwinds and unzips DNA during transcription.

- Enzymes are proteins produced by translation.
- Enzymes help perform chemical reactions in your body.
- Enzymes are Catalysts: catalysts speed up the rate of a chemical reaction, but do not take part.
- Enzymes increase the rate of a reaction by...
  a) bring molecules together (synthesis)
  b) breaking molecules apart (degradation)

Synthesis

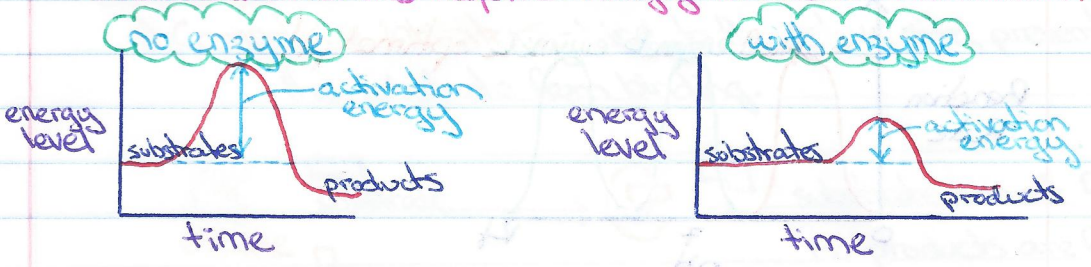


Degradation



* Enzymes are unchanged after the reaction and can be re-used.
- chemical reactions would occur on their own without enzymes, only much slower.

- Chemical reactions require energy to occur (activation energy)



substrate + enzyme ⟶ enzyme/substrate complex ⟶ product + enzyme

ex. lactase enzyme

lactose ⟶ glucose + galactose

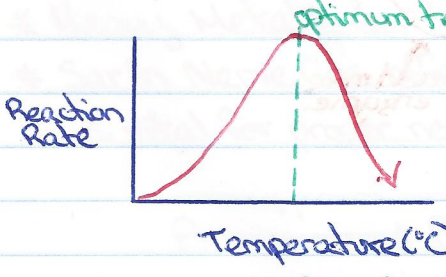
(disaccharide)

glucose-galactose

LESSON 28

Factors Affecting Reaction Rate

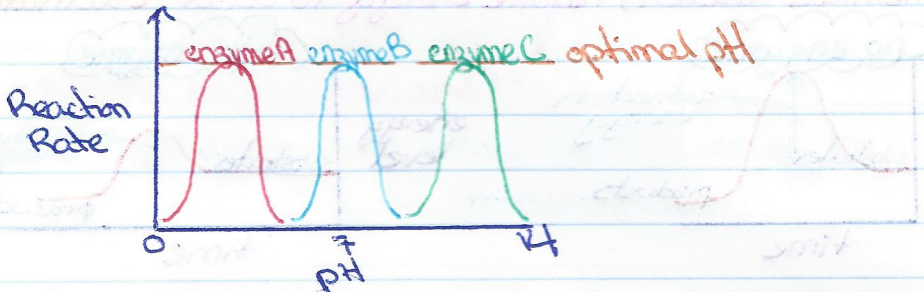
① Temperature - within the human body, enzymes have an optimal temperature of 37°C



- lowering the temp. will slow the rate because particles move slower.
- raising the temp. causes enzymes to denature (cook)

* Denaturing enzymes changes the shape of the active site, prevents the substrates from binding.

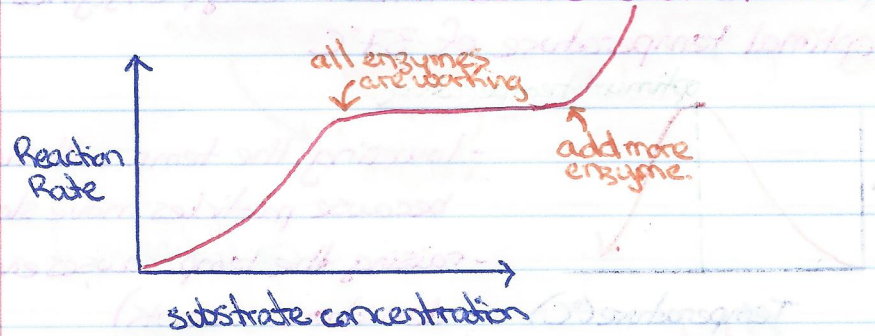
② pH - enzymes have an optimal pH, just like they have an optimal temperature.
- the optimal pH for an enzyme depends on where it is located.



- enzyme A has an acidic optimal pH, functions in the stomach.
- enzyme B has a neutral optimal pH, functions in the blood.
- enzyme C has a basic optimal pH functions in the small intestine.

* enzymes will denature if placed outside their optimal pH.

③ Concentration - increasing the substrate concentration will increase the reaction rate.



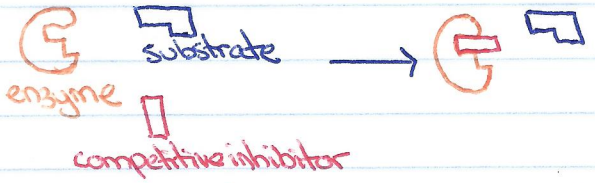
LESSON 29

Enzyme Inhibitors

- molecules that prevent enzymes from functioning.

2 TYPES:

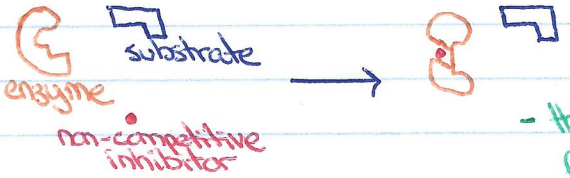
1) Competitive Inhibitors - bind to the active site, preventing the substrate from binding.



substrate cannot fit, no products are formed.

- some antibiotics work by competing for the active site of bacterial enzymes, killing them.

2) Non-Competitive Inhibitor - bind to a part of the enzyme other than the active site, changing the shape of the active site. The substrate cannot bind.



- the substrates no longer fits the active site.

* Heavy Metals (ex. Mercury, Lead) affect enzymes this way.
* Sarin Nerve Gas affects the enzyme acetylcholinesterase, which is vital for proper nerve function.

$$A \xrightarrow{\mathcal{E}_1} B \xrightarrow{\mathcal{E}_2} C \xrightarrow{\mathcal{E}_3} D$$

- If we added an inhibitor to $\mathcal{E}_2$, what would happen to the amounts of each?

A- no change C- less
B- more D- less