BIO 201

22 JAN 2007

SIX PROPERTIES OF LIFE

1. ORDER
2. REPRODUCTION & DEVELOPMENT
3. REQUIRE ENERGY
4. METABOLISM (ABLE TO OBTAIN, CONVERT & USE ENERGY)
5. SENSE & RESPOND TO ENVIRONMENT
6. ADAPTATION (MODIFICATIONS TO AN ORGANISM TO BETTER SUIT IT TO ITS ENVIRONMENT)

O R E M S A

A SMORE

BACTERIA

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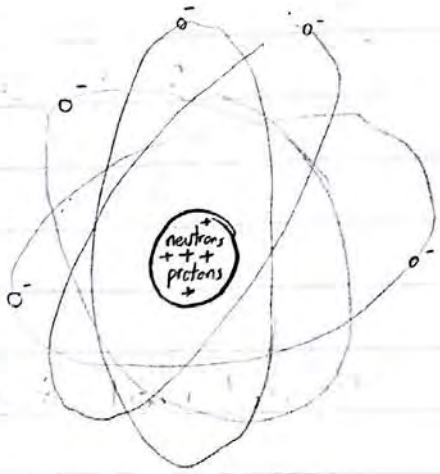
Matter - ANYTHING THAT TAKES UP SPACE AND HAS MASS
↳ CONSISTS OF elements

atom - SMALLEST PARTICLE THAT RETAINS THE PROPERTY OF AN ELEMENT

C, H, O, N ⇒ 97% of living organisms

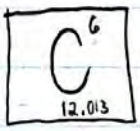
92 Naturally occurring elements

Subatomic particles



electrons = "−" charge
neutrons = "Ø" charge
protons = "+" charge

Atomic # = number of protons
Mass # = number of protons + neutrons



MASS # = 12 = 6 protons + 6 neutrons

Atoms are neutral (no charge) ∴ proton # = electron #

The greater the number of electrons, the larger the electron cloud will be, since they tend to stay far apart from eachother

Electron shells

First shell
(MAX 2)

Second Shell
(MAX 8)

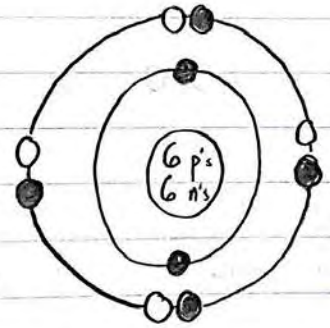
Valence (outermost) shell ⇒ vacancies

Radioactive Isotopes - unstable atoms, spontaneously emit particles until they become stable; useful in research (tracers, reactions, etc.)

Isotopes - atoms of a particular element that vary in their neutron number

Ex: C^6_{12}, C^6_{13}, C^6_{14} (12, 13, 14 = mass)

Electron shell model of **Carbon** (reactive)

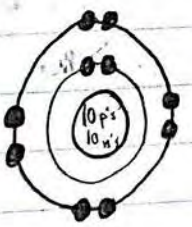


1st shell - 2 of 2

2nd shell - 4 of 8

~~3rd shell - 0 of 8~~

Neon



Valence shell full = inert (unreactive)

INTERACTIONS

- Bonds or interactions between atoms occur due to e^- vacancies in the outermost shell (VALENCE)
- Atoms are <u>reactive</u> when they contain vacancies.
- To fill vacancies, they will lose electrons, gain electrons, or share electrons

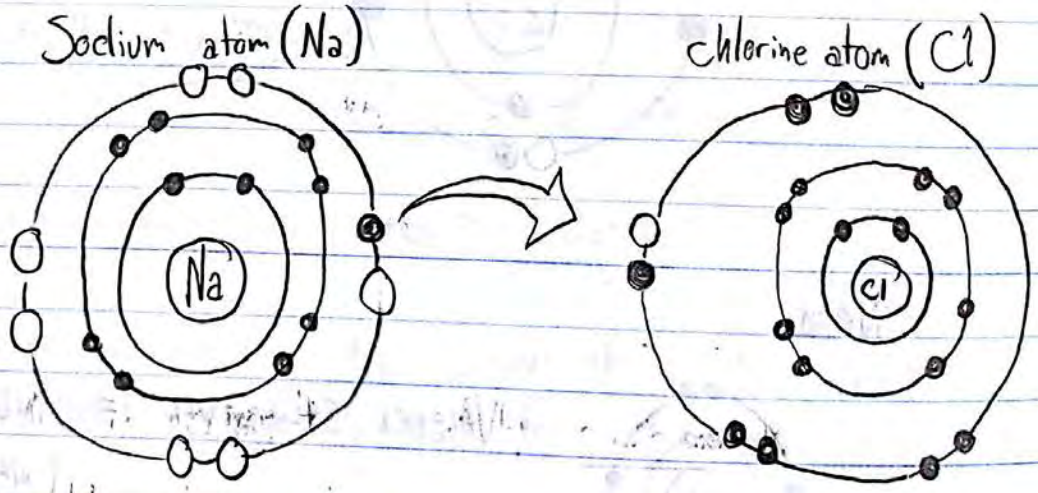
TYPES OF BONDS/INTERACTIONS

STRONG BONDS

① <u>Ionic bond</u> - an association between two ions with opposing charges

- ONE ATOM GAINED AN ELECTRON (<u>anion</u>)
- ONE ATOM HAS LOST AN ELECTRON (<u>cation</u>)

EXAMPLE: NaCl



Na^+ (POSITIVELY CHARGED SODIUM)

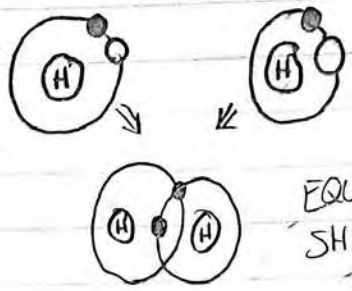
Cl^- (NEGATIVELY CHARGED CHLORINE)

② Covalent bond - SHARING OF A PAIR OF ELECTRONS

non-polar - equal sharing of a pair of electrons
(usu. occurs between atoms of the same type)

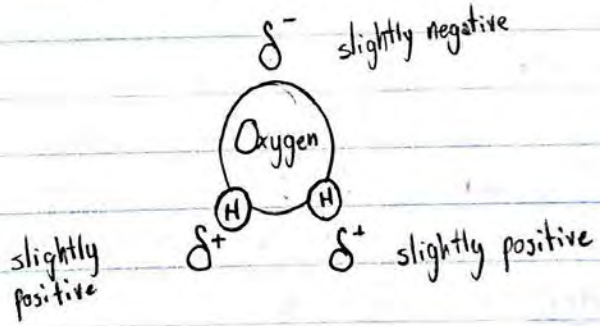
CO - VALENCE
↓ TOGETHER - ↓ OPENING

EXAMPLE



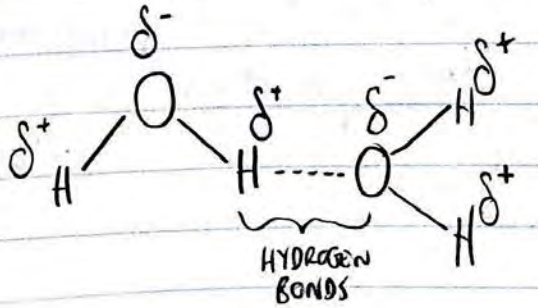
polar - UNEQUAL SHARING OF A PAIR OF ELECTRONS

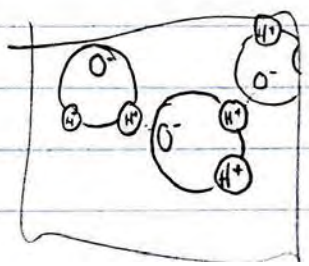
An electronegative atom pulls the shared electrons closer
(N, O)



WEAKER BONDS

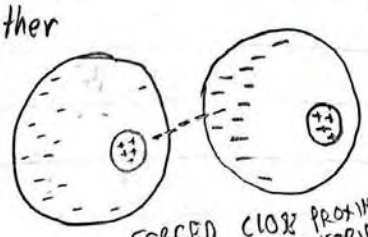
HYDROGEN BONDS - Hydrogen that δ^+ is attracted to a δ^- or electronegative atom (in another molecule)





(Van der Waals) forces
- requires close proximity to one another
- has to do with uneven charge distributions

"Gecko"



FORCED CLOSE PROXIMITY + UNEVEN DISTRIBUTION OF (NEGATIVE) ELECTRON CLOUD

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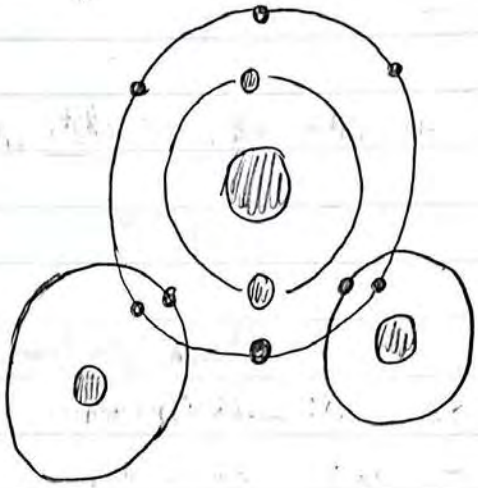
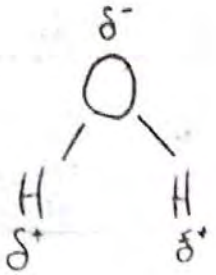
H_2O



Overview of water
- life originated in H_2O
- 70-95% of cell volume is water
- many reactions are dependent on the presence of water
- one of a very few molecules that naturally occurs on Earth in all three states (solid, liquid, gas)

Structure - UNIQUE STRUCTURE LEADS TO UNIQUE PROPERTIES AND INTERACTIONS BETWEEN OTHER HYDROGEN-BEARING MOLECULES



polar molecule due to polar covalent bonds
→ OPPOSITE CHARGES AT OPPOSITE ENDS

- IF IT WERE NOT FOR HYDROGEN BONDS WATER WOULD FREEZE AT -100°C AND BOIL AT -91°C

PROPERTIES

1. **TEMPERATURE-STABILIZER** - RESISTS INCREASES/DECREASES IN TEMP.
   a) **HIGH "SPECIFIC HEAT"** - HOW MUCH HEAT ENERGY IS NEEDED TO INCREASE 1gm OF A SUBSTANCE BY 1 degree
   WATER: 1 cal heat ↑ 1gm H_2O by 1°C
   ETHANOL: 0.6 cal heat ↑ 1gm ethanol by 1°C
   b) **HIGH VAPORIZATION** - IT TAKES A LOT OF HEAT ENERGY TO TURN IT TO A GASEOUS STATE - FOR ONE GRAM, IT TAKES 540 calories of heat TO GO FROM HOTTEST POINT OF WATER TO STEAM

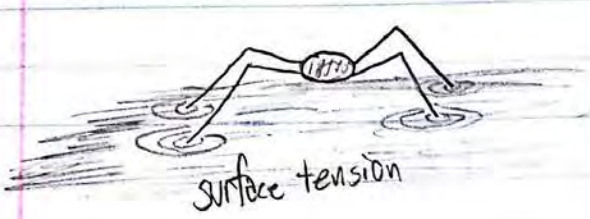
WHY?
HYDROGEN BONDS!
TEMPERATURE - MOLECULAR MOTION (FASTER = HOTTER, SLOWER = COOLER)
Hydrogen BONDS HAVE TO BE **BROKEN FIRST** BEFORE MOVEMENT CAN OCCUR

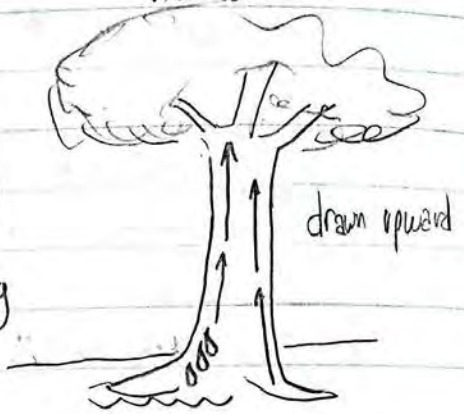
GLOBAL TEMPERATURES

IN COASTAL AREAS, OCEAN ABSORBS HEAT DURING HOT TIMES AND RELEASES STORED HEAT DURING COLD TIMES

(2) PROPERTIES: COHESION - TO RESIST RUPTURING ("STICKY")

DUE TO HYDROGEN BONDS





(3) PROPERTIES: LESS DENSE IN SOLID FORM (ICE) THAN IN LIQUID FORM (WATER)

- AT 0°C (FREEZING) EACH H_2O MOLECULE CAN INTERACT TO FORM FOUR HYDROGEN BONDS, FORMING A LATTICE STRUCTURE

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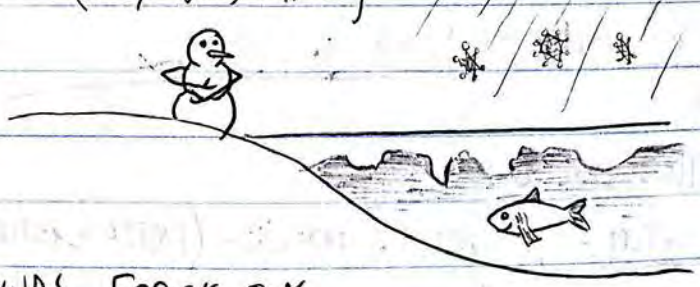
- THIS PROPERTY ALLOWS LAYERS OF ICE TO FLOAT ON TOP OF THE WATER, ALLOWING ORGANISMS TO SURVIVE BELOW
- THE ICE ABOVE ACTUALLY INSULATES THE WATER BELOW FROM THE COLD ABOVE (i.e., WIND CHILL)



- IN ICE, THE BONDS FORCE THE MOLECULES FARTHER APART ∴ LESS DENSE

④ PROPERTIES: GOOD SOLVENT: SOLUTES CAN DISSOLVE IN IT... AND DISPERSE EQUALLY THROUGHOUT SOLUTION

hydrophilic = POLAR MOLECULES (ONES WITH A CHARGE, WHETHER POSITIVE OR NEGATIVE) ARE MORE ATTRACTED TO H_2O

non-polar = NO CHARGE / hydrophobic

ACIDS, BASES, AND BUFFERS

WATER CAN IONIZE:

$$H_2O \rightleftharpoons \underset{\text{hydrogen ion}}{H^+} + \underset{\text{Hydroxyl ion}}{^-OH}$$

THESE TWO MOLECULES ARE THE BASIS OF THE pH SCALE

acid - A SUBSTANCE WHICH, WHEN DISSOLVED IN WATER, RELEASES H^+ IONS (INCREASING THE H^+ CONCENTRATION)

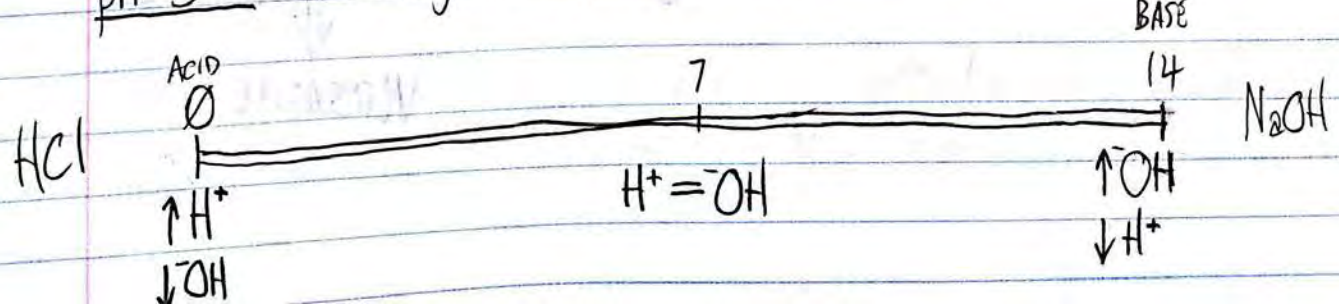
base - A SUBSTANCE WHICH REMOVES H^+ IONS FROM SOLUTION OR RELEASES OH^- (DECREASING H^+ CONCENCTRATION)

"ALL YOUR BASE ARE BELONG TO US"

$$\overset{\text{ACID}}{HCl} \rightleftharpoons \underbrace{H^+ + Cl^-}$$

$$\overset{\text{BASE}}{NaOH} \rightleftharpoons Na^+ + {}^-OH$$

pH SCALE: $-\log(\text{base } 10)$ H^+ concentration



H^+ AND ^-OH ARE VERY REACTIVE

Blood pH 7.4 → 7.0 COMA

Stomach pumps out HCl ∴ ↑pH (From 5.0 – 7.0)

Inside a cell → 7.2 Lemon juice → 2.0

Bleach → 9 Urine → 5–7

buffer - A SUBSTANCE THAT MINIMIZES Δ IN pH

Ex: CARBONIC ACID CAN GO EITHER WAY, ACTING AS A BASE OR AN ACID

$\underbrace{HCO_3^- + H^+}_{\text{RELEASE } H^+ \text{ IN CASE OF BASE}} \rightleftharpoons \underbrace{H_2CO_3}_{\text{ABSORB } H^+ \text{ IN CASE OF ACID}}$

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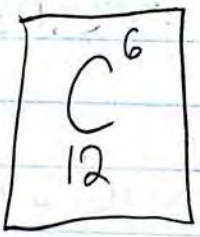
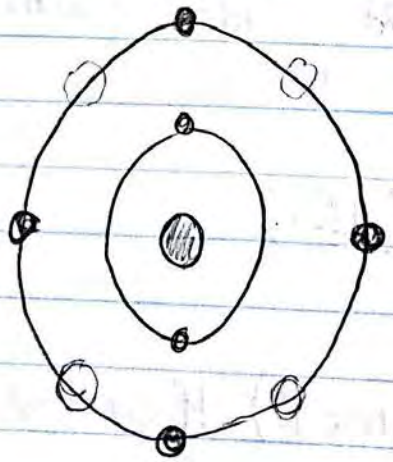
ORGANIC COMPOUNDS - CONTAIN **CARBON**, HYDROGEN & OTHER CLUSTERS

CARBON



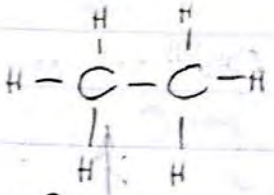


4 OPENINGS

⇓

VERSATILE

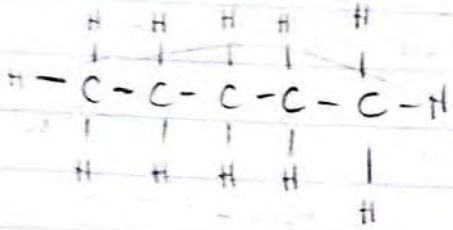
HYDROCARBON MOLECULE - CONTAINS ONLY Hydrogen & Carbon

Ex. 

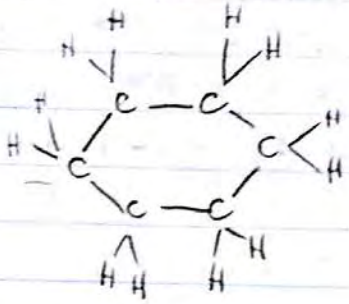
- VERY STABLE
- NONPOLAR MOLECULE
- ALL NON-POLAR COVALENT BONDS

∴ HYDROPHOBIC

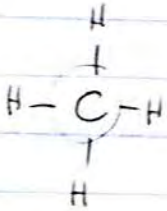
CARBON CHAIN (LINEAR STRUCTURES)



RING STRUCTURES

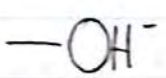


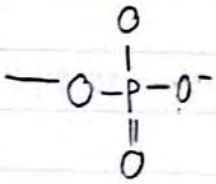
"CARBON BACKBONE"

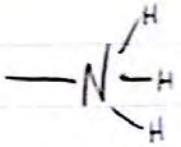


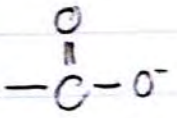
FUNCTIONAL GROUPS - CLUSTERS OF ATOMS ATTACHED TO THE CARBON BACKBONE

EX. (SEE TABLE IN BOOK)

 Hydroxyl group

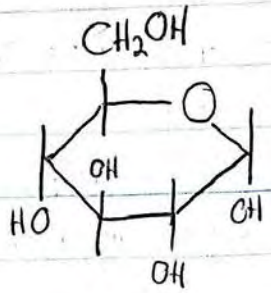
 Phosphate group

 Amine group

 Carboxyl group

Functional groups can increase polarity (neg. or pos. charge) of organic compounds, increasing their solubility

Glucose



Polymers - LONG CHAINS OF SIMILAR OR IDENTICAL SUB-UNITS.

Monomers - SUB-UNITS USED TO MAKE POLYMERS

Macromolecules - "Molecules of life"

Lipids - monomer
FATS, OILS

Proteins - POLYMER, the monomers are AMINO ACIDS

Carbohydrates - POLYMER, the monomers are SIMPLE SUGARS (SINGLE MOLECULES)

Nucleic acids - POLYMER, the monomers are NUCLEOTIDES
(DNA, RNA)

CARBOHYDRATES - SIMPLE TO COMPLEX SUGAR MOLECULES

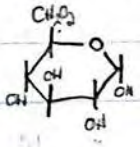
- STRUCTURE: 3 - 7 CARBONS
  - USU. 1:2:1 RATIO OF C:H:O
  - AT LEAST 2 -OH GROUPS (HYDROXYL GROUPS)
  - LINEAR OR RING STRUCTURE (IN SOLUTIONS, FOUND AS RINGS)
    - THE MOST COMMON/IMPORTANT RINGS ARE 5-6 CARBONS

PROPERTIES: MOST ABUNDANT MOLECULES

- MOSTLY POLAR/WATER SOLUBLE
- STORAGE, TRANSPORTABLE FORM OF ENERGY
- USED TO BUILD STRUCTURAL COMPONENTS

TYPES: Monosaccharides - SINGLE MONOMER OF SUGAR

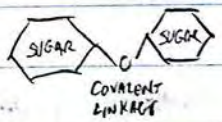
EX. GLUCOSE (6-CARBON)



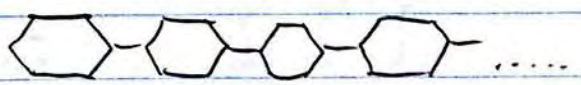
RIBOSE, DEOXYRIBOSE (5-CARBON)

Disaccharides - CHAIN OF 2 SUGAR MONOMERS COVALENTLY LINKED TOGETHER

EX. SUCROSE (GLUCOSE + FRUCTOSE)
TABLE SUGAR



Polysaccharides - COVALENTLY LINKED CHAIN OF HUNDREDS TO THOUSANDS OF SUGAR MOLECULES



STORAGE FORMS OF ENERGY:

① GLYCOGEN - STORAGE FORM OF SUGAR IN ANIMAL CELLS

② STARCH - STORAGE FORM OF SUGAR IN PLANT CELLS

STRUCTURAL POLYSACCHARIDES

① CELLULOSE - MAIN COMPONENT OF CELL WALL OF PLANTS

② CHITIN - COMPONENT OF EXOSKELETON OF INSECTS, ETC., FUNGI

Lipids -

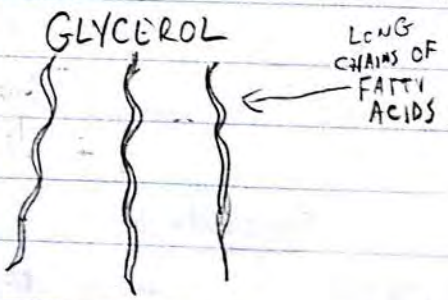
TYPES: FATS & OILS, PHOSPHOLIPIDS, STEROIDS, WAXES

PROPERTIES: - Hydrophobic, grouped together due to their hydrophobic nature
- greasy or oily to the touch
- insulation
- long-term storage form of energy

STRUCTURE - COMPRISED LARGELY OF HYDROCARBONS, MAKING THEM HYDROPHOBIC (NON-POLAR)

Types: ① FATS & OILS -

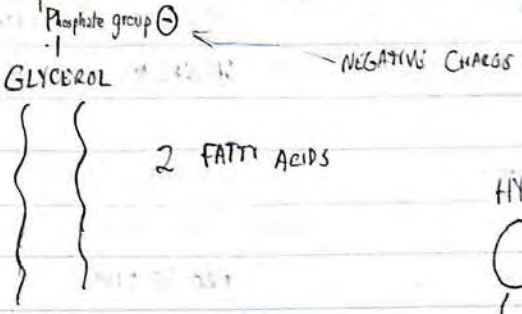
STRUCTURE: GLYCEROL + 3 FATTY ACIDS
(16-18 CARBONS LONG, LONG CHAINS OF HYDROCARBONS)

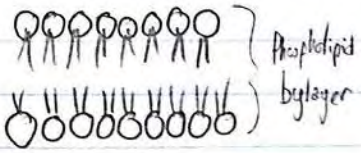


= triglyceride

Fats	vs.	Oils
ANIMAL		PLANT
SOLID	(AT ROOM TEMPERATURE)	LIQUID
SATURATED		UNSATURATED (KINK IN BONDS)
TIGHTLY PACKED FIT		KINKY OILS

② Phospholipids - main component of cell membranes





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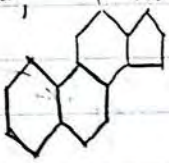
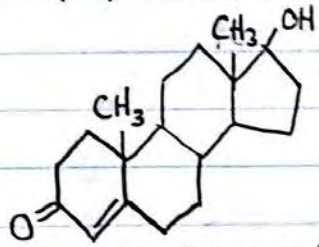
③ STEROIDS - contain NO fatty acids instead, 4 fused carbon rings



Functions - making cell membranes more rigid
∴ STRUCTURAL (i.e., CHOLESTEROL)

- hormones



TESTOSTERONE ($C_{19}H_{28}O_2$)

④ WAXES - long chain fatty acids attached to alcohols or carbon rings
- protection (water resistant)
- lubricant

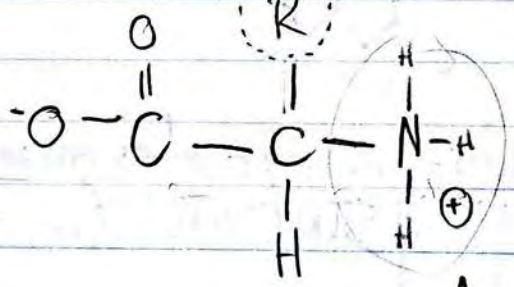
PROTEINS

FUNCTIONS
- ENZYMES
- HORMONES
- TRANSPORT
- CONTRACTILE
- SIGNALING
- STORAGE
- PROTECTIVE
- STRUCTURE

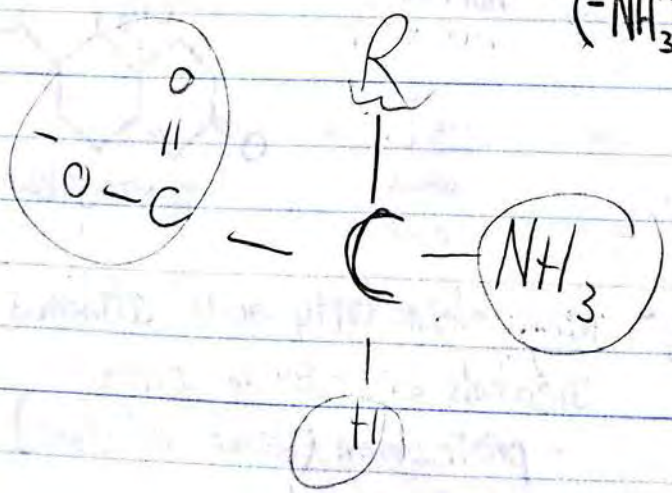
Structure - COMPRISED OF **amino acids** (MONOMER)

20 NATURALLY OCCURRING AMINO ACIDS
- SOME ARE CHARGED (+/-)
- SOME ARE HYDROPHOBIC
- SOME ARE REACTIVE
- SOME ARE UNIQUE / SPECIALIZED (SHAPE)

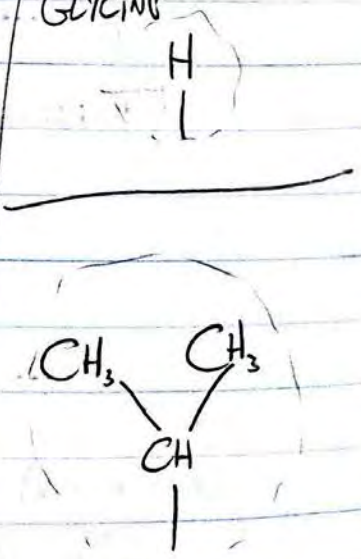
R-GROUPS - different clusters of atoms for every amino acid



Amino group ($-NH_3$)



GLYCINE



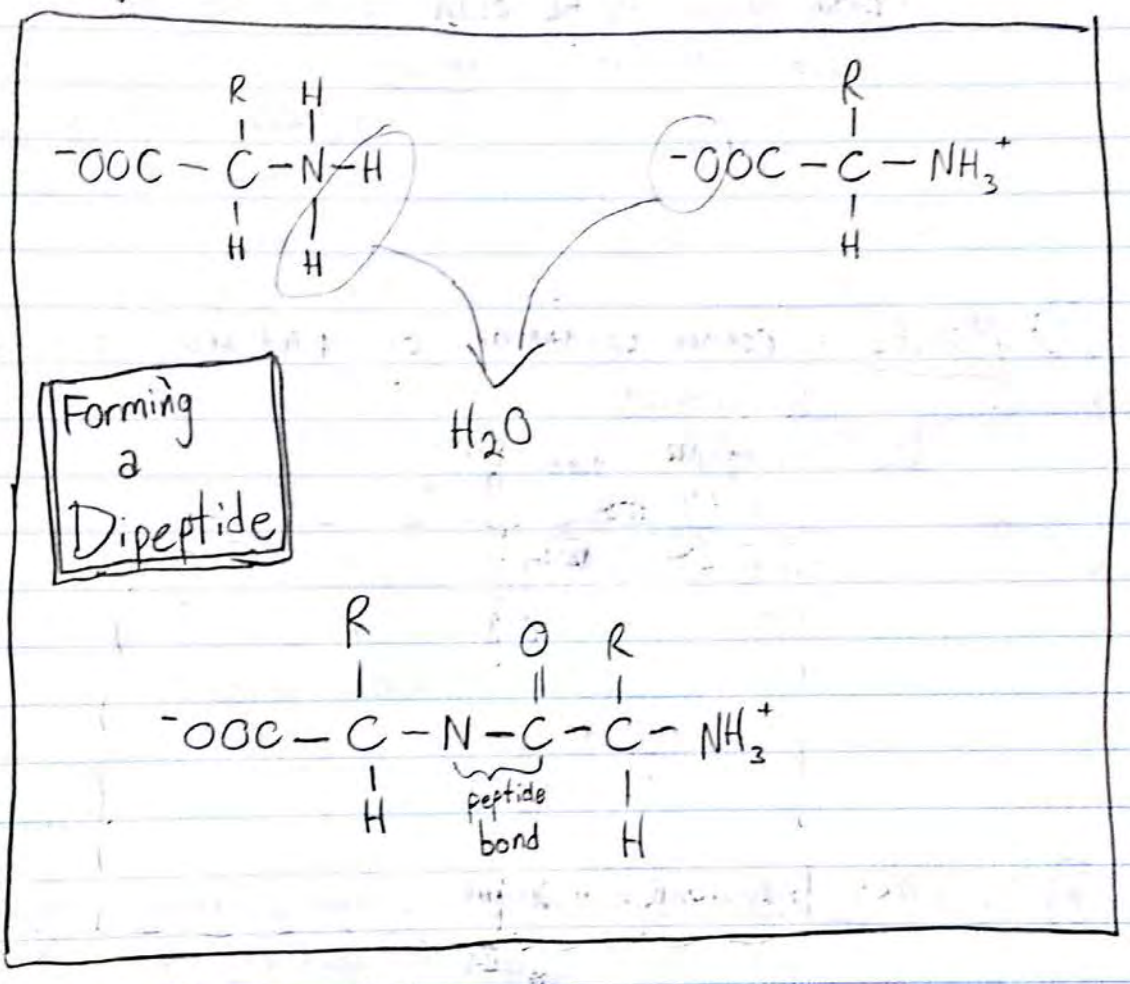
How do you make proteins from amino acids?

- DNA CONTAINS THE CODING SEQUENCE OF HOW TO MAKE EVERY TYPE OF PROTEIN IN A CELL
- DNA LINKS AMINO ACIDS IN A SPECIFIC SEQUENCE OR ORDER

BUILDING A PROTEIN:

dipeptide - CHAIN OF TWO AMINO ACIDS

polypeptide - CHAIN OF MANY AMINO ACIDS

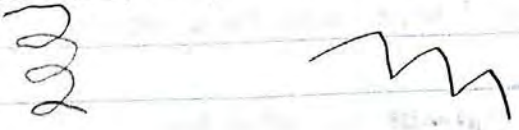


Amino acids → polypeptide chain → protein (SECONDARY STRUCTURE)

How do proteins fold?

① polypeptide chain - DIRECTS THE FOLDING/STRUCTURE & FUNCTION OF A PARTICULAR PROTEIN BASED ON ITS SEQUENCE OF AMINO ACIDS (PRIMARY STRUCTURE)

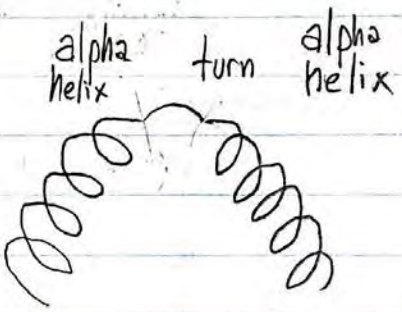
(2) Secondary structure —
alpha helix and/or beta sheet or NONE OF THE ABOVE



FOLDING/STRUCTURE ARE THE RESULT OF HYDROGEN BONDS BETWEEN ATOMS OF THE BACKBONE OF THE PROTEIN
→ (CARBOXYL GROUP OR AMINE GROUPS)

(3) MOTIFS - COMMON COMBINATIONS OF ALPHA HELICES & BETA SHEETS

EX.



(4) TERTIARY STRUCTURE - ADDITIONAL LOOPING & FOLDING OF THE PROTEIN DUE TO R-GROUP INTERACTIONS
(H-bonds, ionic bonds, covalent bonds, hydrophobic interactions, etc.)

(5) DOMAINS - SPECIFIC REGIONS OF A PROTEIN THAT USUALLY FOLD INDEPENDENTLY OF OTHER REGIONS AND HAVE A SPECIFIC FUNCTION

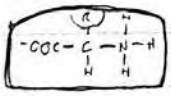
EX. ENZYME (a protein) — ONE SITE BINDS SUBSTRATE ← ONE DOMAIN
— ANOTHER SITE BINDS A COFACTOR ← A DIFFERENT DOMAIN

⑥ QUATERNARY STRUCTURE – MULTIPLE POLYPEPTIDES INTERACT TOGETHER TO FORM A LARGE PROTEIN COMPLEX

EX. – HEMOGLOBIN – oxygen carrying protein

REVIEW

AMINO ACID



ORDER DETERMINES SHAPE

POLYPEPTIDE CHAIN
PRIMARY STRUCTURE

SECONDARY STRUCTURE

AND/OR

MOTIFS

OR OR

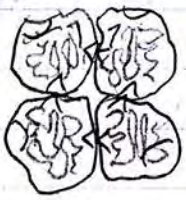
TERTIARY STRUCTURE

CHAPERONES – PROTEINS THAT AID IN FOLDING PROTEINS CORRECTLY

DOMAIN

BINDING SITE

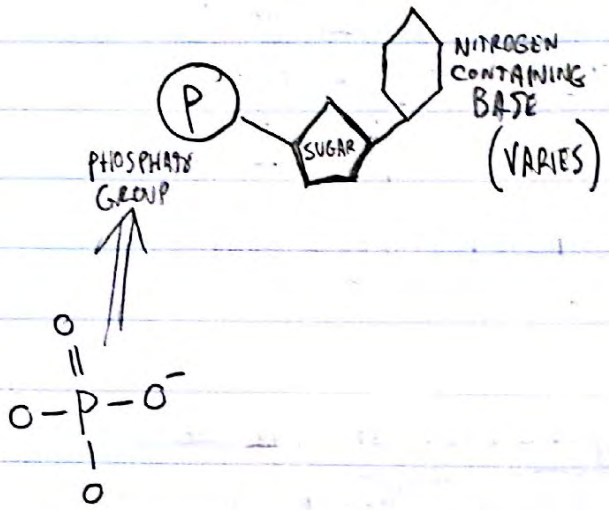
QUATERNARY



DIMERS, POLYMERS

Nucleic Acids – DNA deoxyribonucleic acid
RNA ribonucleic acid

STRUCTURE – nucleotides (MONOMER)



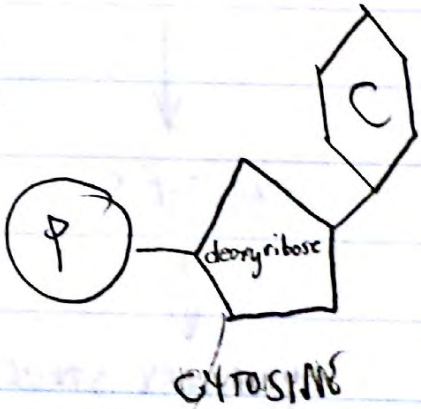
THERE ARE OTHER TYPES OF NUCLEOTIDES BESIDES DNA & RNA:

- ATP (energy type)
- signal molecules
- coenzyme

Nucleotides found in DNA

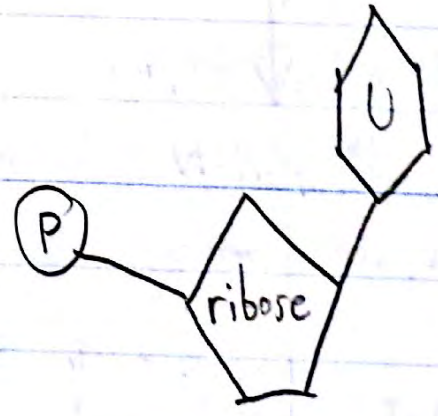
adenine (A)
guanine (G)
thymine (T)
cytosine (C)

} DIFFERENT NITROGENOUS BASE



Nucleotides found in RNA

adenine (A)
guanine (G)
uracil (U)
cytosine (C)



DNA vs. RNA

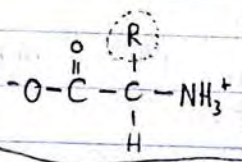
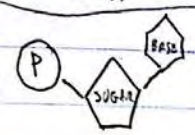
DOUBLE - STRAND HELIX — HEREDITARY MATERIAL

SINGLE - STRAND HELIX — PLAYS ROLE IN MAKING PROTEINS

ADENINE, GUANINE } DOUBLE-RINGED BASES → purines

SINGLE-RINGED BASES { THYMINE, CYTOSINE, URACIL } → pyrimidines

7 FEB 2007

	TYPES	STRUCTURE	PROPERTIES
Carbohydrates	- MONOSACCHARIDES DISACCHARIDES POLYSACCHARIDES	RINGS WITH OH GROUPS	HYDROPHILIC STRUCTURE ENERGY
Lipids	FATS & OILS WAXES STEROIDS PHOSPHOLIPIDS -	MOSTLY COMPRISED OF HYDROCARBONS (LONG CHAINS OF CARBON AND HYDROGEN)	HYDROPHOBIC LONG TERM ENERGY PROTECTION, STRUCTURE GREASY, OILY
Proteins	MONOMER: AMINO ACIDS		DIVERSE: MANY FUNCTIONS
Nucleic acids	MONOMER: NUCLEIC ACIDS		HEREDITARY MATERIAL ENERGY (ATP) SIGNALLING PROTEIN BUILDING (RNA)

PROTEINS ARE SENSITIVE TO CHANGES IN THE SURROUNDING ENVIRONMENT
- pH
- TEMP.
- SALT CONCENTRATION

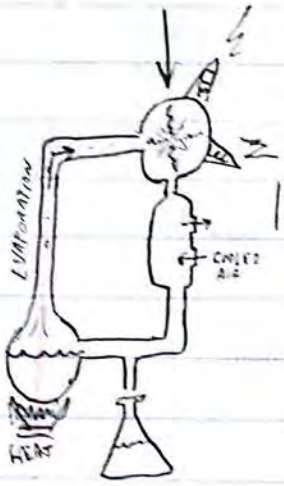
↑ SALT
↑ TEMP ⇒ UNFOLD PROTEIN = Denaturation

Origin of Life

- Earth formed 4.6 BYA (unstable environment)
- First cells found, about 2.5 BY old
- Hypotheses:
  - → (1) Special creation - supernatural or divine forces brought life to the earth
  - → (2) Extraterrestrial origin - Life started elsewhere and came to earth
  - (3) Spontaneous origin - Life arose from inanimate matter
    - I. Inanimate matter came together to form organic compounds (monomers)
    - II. Monomers came together to form polymers
    - III. Membrane-bound "bubble" formation containing the polymers that then maintains a different chemistry from the outside
    - IV. Bubble acquires ability to pass on heritable material

Conditions on Earth (at that time) that suggest the possibility of spontaneous life

- water vapor
- Low O_2 (reducing environment)
- ↑ heat → more likely to put molecules together due to less energy
- ↑ lightning → energy
- ↑ UV radiation → energy
- Gases: Hydrogen sulfide, CH_4 (methane), CO_2, NH_4 (ammonia), etc.



1953 - Miller & Urey

Chamber → water vapor + gases + simulated lightning

After several days, small organic molecules

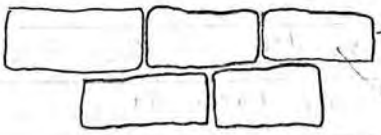
After more time, amino acids formed

Prokaryotic cell - first type of cell 2.5 BYA

Eukaryotic cell - 1.5 BYA

Cells - THE SMALLEST UNIT CAPABLE OF LIFE

FIRST IDENTIFIED BY Robert Hooke IN 1665 LOOKING AT A PIECE OF CORK



cellula: "empty chamber"

MICROSCOPES

Magnification - RATIO OF A SPECIMEN (IMAGE) TO THE ACTUAL SIZE OF THE SPECIMEN

Resolution - HAS TO DO WITH CLARITY; PUT 2 DOTS TOGETHER AS CLOSE TOGETHER AS POSSIBLE & STILL DISTINGUISH AS 2 DOTS

TYPES:

LIGHT MICROSCOPE

UP TO 1000x MAGNIFICATION; RESOLUTION 200nm

ELECTRON MICROSCOPE

SEM: Scanning EM → SURFACES (OUTSIDE SURFACES OF CELL)

TEM: Transmission EM → SECTIONS (INTERNAL PARTS)

UP TO 100,000x; RESOLUTION 2nm

→ **CELLS** - ALL CELLS ARE DIVIDED INTO TWO TYPES:

① **PROKARYOTIC** - Domain Bacteria; Domain Archaea

② **EUKARYOTIC** - Domain Eukarya - (Animals, Plants, Fungi, Protists)

ALL CELLS HAVE THREE COMMON STRUCTURAL FEATURES

① **CELL MEMBRANE** - A BARRIER THAT REGULATES MOVEMENT OF SUBSTANCES IN & OUT

② **CYTOPLASM** - SEMI-FLUID-LIKE MATRIX INSIDE OF CELLS

③ **DNA** - HEREDITARY MATERIAL PASSED FROM CELL TO CELL

CELLS CAN ONLY GROW TO A MAXIMUM SIZE (SIZE RESTRAINTS)

WHY? - AS THEY GROW LARGER, THE VOLUME INCREASES FASTER THAN THE SURFACE AREA

SURFACE AREA vs. VOLUME ISSUE: THE LARGER A CELL GETS, THE MORE NUTRIENTS, WASTE, ETC NEED TO BE BROUGHT

12 FEB 2007

PROKARYOTIC	vs.	EUKARYOTIC
1 - 10 μm		10 - 100 μm
LACK ORGANELLES		CONTAIN ORGANELLES (MORE COMPLEX) - NUCLEUS, MITOCHONDRIA, CHLOROPLASTS, ER, GOLGI & VESICLES, VACUOLE

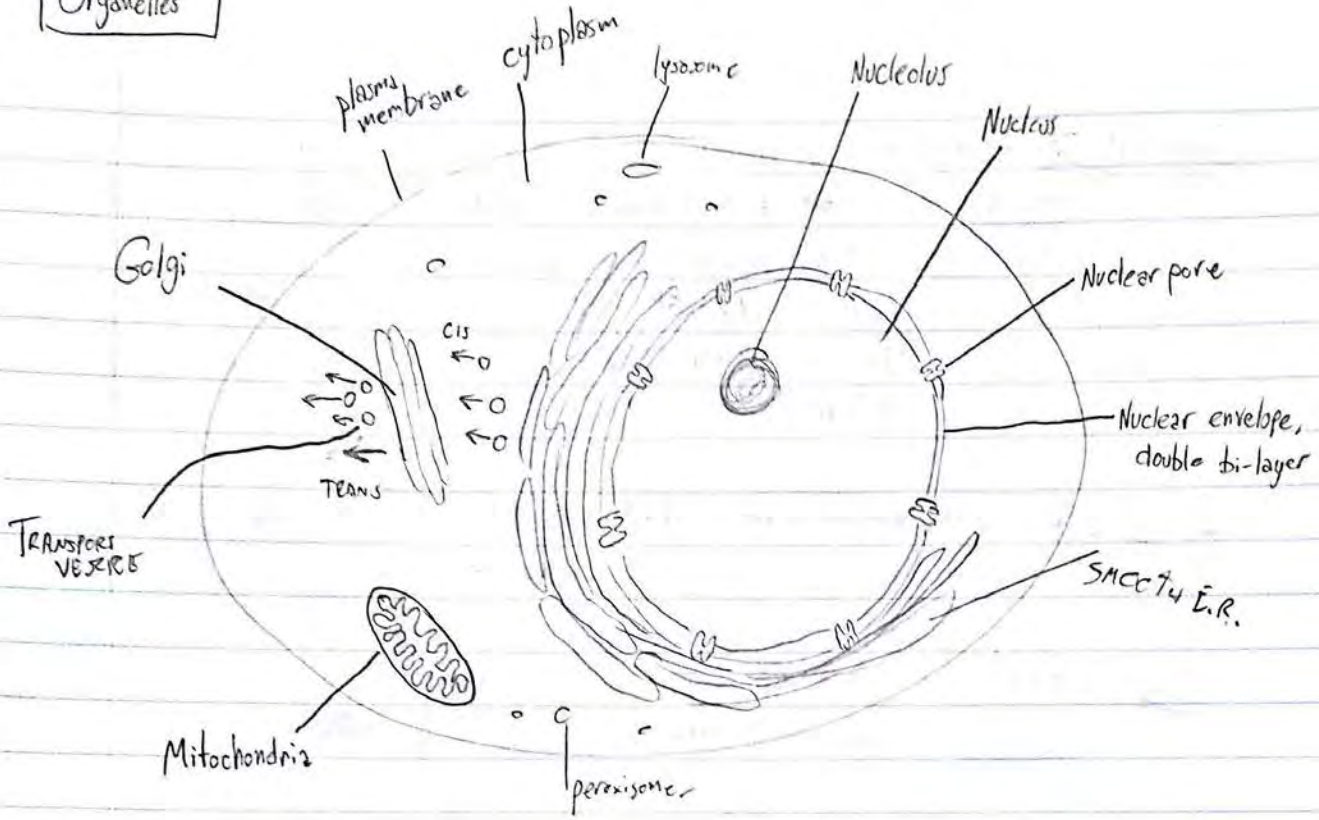
Organelle - INTERNAL MEMBRANE-BOUND COMPARTMENT THAT HAS ONE OR MORE SPECIALIZED FUNCTIONS

DISCRETE SACS PERMIT MULTIPLE FUNCTIONS TO OCCUR AT ONCE WHICH OTHERWISE MAY HAVE BEEN INCOMPATIBLE

EUKARYOTIC: Animalia, Plantae, Fungi, Protista

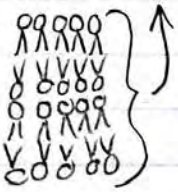
PLANT CELLS	vs.	ANIMAL CELLS
Cell wall		lysosomes - DIGESTIVE ORGANELLE
Chloroplasts		
Vacuoles		

Eukaryotic Organelles



I. Nucleus - FUNCTION: ① STORE DNA ② HAS A BARRIER THAT REGULATES MOVEMENT OF MOLECULES IN OR OUT OF THE NUCLEUS

STRUCTURE: TWO MEMBRANES > DOUBLE BI-LAYER > "NUCLEAR ENVELOPE"



NUCLEAR PORES - CLUSTERS OF PROTEINS THAT FORM OPENINGS THAT SPAN THE NUCLEAR ENVELOPE

NUCLEAR LAMINA - MATRIX OR NETWORK OF FIBROUS PROTEINS LINE THE INTERIOR OF THE NUCLEUS, GIVING IT SHAPE

Nucleolus - DENSE STAINING REGION OF THE NUCLEUS, ↑ CONCENTRATION OF rRNA

DNA - SEPARATED INTO INDIVIDUAL PIECES (CHROMOSOMES)

II. Endomembrane system

ER (Endoplasmic Reticulum), golgi ; vesicles

OVERALL FUNCTION: PROTEIN MODIFICATION, SORTING & SHIPPING

Smooth E.R. - Endoplasmic reticulum

STRUCTURE - A NETWORK OF MEMBRANOUS TUBULES AND SACS OF SACS

ROUGH E.R.

FUNCTIONS - LIPID SYNTHESIS (phospholipids, STEROIDS, HORMONES)
- DRUG DETOXIFICATION
- STORE Ca^{++}

Rough E.R - RIBOSOMES ARE ATTACHED TO THE ROUGH E.R
- PRODUCTION OF PROTEINS
- DOTTED WITH ribosomes

Golgi: LOOKS LIKE STACK OF PANCAKES

FUNCTION: PROTEIN MODIFICATION, SORTING & SHIPPING

TRANSPORT VESICLE: SMALL MEMBRANE COMPONENT THAT TRANSPORT PROTEINS, ETC. FROM THE E.R. TO GOLGI, GOLGI TO OTHER LOCATIONS

LYSOSOMES - DIGESTIVE ORGANELLE
HYDROLYTIC ENZYMES (BREAK APART/DOWN LARGE MACROMOLECULES, ORGANELLES, INTO MONOMERS, RAW MATERIAL ⇒ RECYCLE)

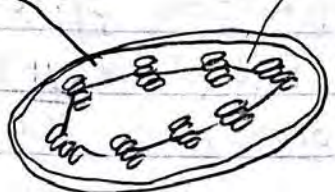
PEROXISOMES - DIGESTIVE ORGANELLE
- H_2O_2 (HYDROGEN PEROXIDE) IS A BYPRODUCT OF DIGESTION

- GRIDLIKE STRUCTURE INTERNALLY

MITOCHONDRIA - DOUBLE MEMBRANE, WITH INNER MEMBRANE FOLDING & RIPPLING IN UPON ITSELF

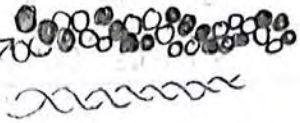
FUNCTION: ATP PRODUCTION SITE
- BREAK DOWN SUGARS, ETC. TO RELEASE ENERGY TO MAKE ATP
# of MITOCHONDRIA DEPENDS ON ENERGY USE

Chloroplasts - STRUCTURE: DOUBLE MEMBRANE + INTERNAL Thylakoid MEMBRANE
INTERIOR FLUID: Stroma
FUNCTION - PHOTOSYNTHESIS

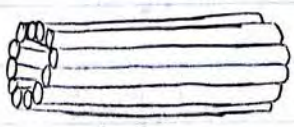


VACUOLES - FOUND IN PLANT CELLS & SOME FUNGI
STORAGE ORGANELLE, DIGESTION
↳ AMINO ACIDS, SUGARS, IONS, WASTE, ETC.
50-90% OF CELL VOLUME

Cytoskeleton - interconnecting network of fibers, threads, and lattices
FUNCTION - MAINTAIN CELL SHAPE
SUPPORT
CELL MOVEMENT
COMPONENTS: ① actin (AKA microfilaments)
② intermediate filaments -
③ microtubules -

I. Actin
SIZE: 5-7 nm in width
STRUCTURE:

two linear ropes wrapped around each other

Dynamic: ACTIN FILAMENTS GROW (POLYMERIZE) & SHORTEN (DEPOLYMERIZE)
FUNCTIONS: cell shape & support
* cell motility (migration)
* cell division (pinching into 2 cells)
* muscle contraction

II. Intermediate filaments


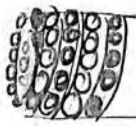
VERY STABLE! (NOT DYNAMIC)
FUNCTION: STRENGTH, SUPPORT, CELL SHAPE
SIZE: 8-10 nm IN WIDTH

III. MICROTUBULES

13 protofilaments form tube

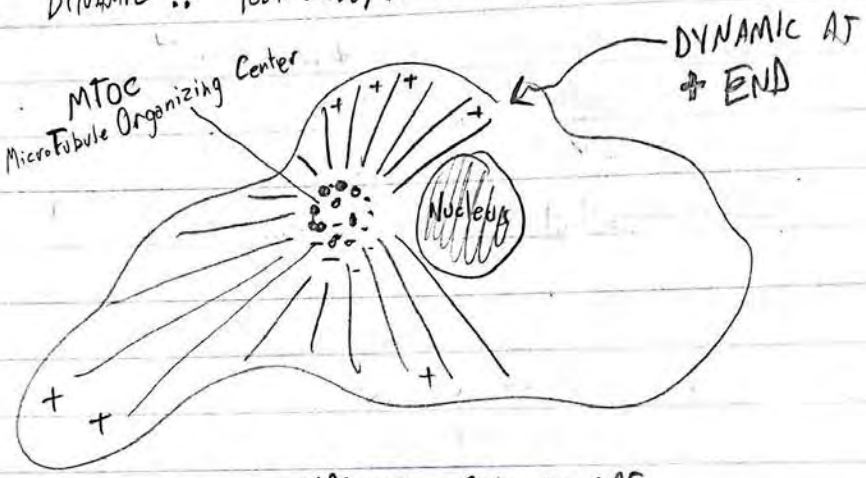
SIZE: 25 nm WIDTH

STRUCTURE:



protein = α/β tubulin

DYNAMIC ∴ POLYMERIZE/DEPOLYMERIZE



FUNCTION: -SUPPORT, CELL SHAPE
- MOVEMENT OF VESICLES & ORGANELLES (ROAD)
- SEPARATION OF DNA DURING CELL DIVISION
- LARGE COMPONENTS OF FLAGELLA, CILIA

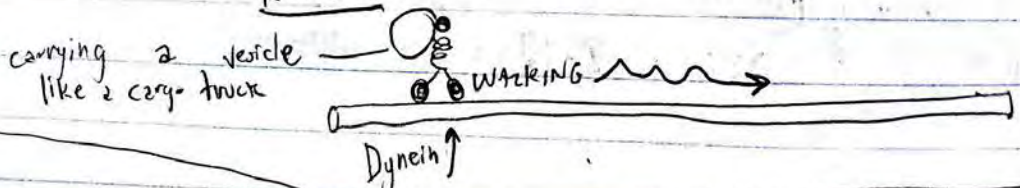
MOTOR PROTEINS

many different types - work in coordination with Actin, microtubiles, to perform specific functions

Myosin - MYOSIN + ACTIN = MUSCLE CONTRACTION

Dynein - "walks" along microtubule = deliver cargo

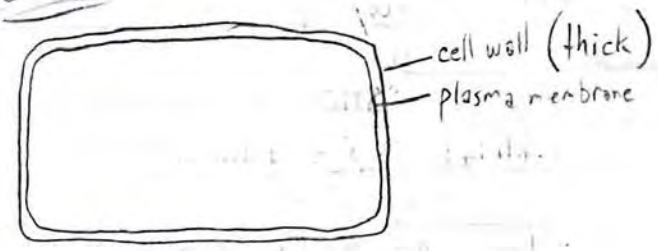
kinesin - " " "



CELL WALL

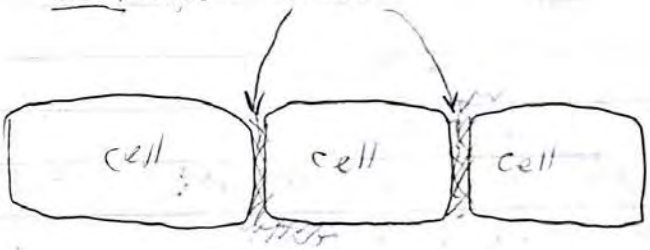
FUNCTION - PROTECTION (RIGID), SHAPE
PREVENTS CELL FROM BURSTING IN HYPOTONIC SOLUTIONS

POROUS



STRUCTURE - Cellulose + other proteins + other polysaccharides
FORM MESH OF PROTEINS & SUGARS
(PLANTS & PROTISTS)
IN FUNGI, CELL WALL MADE OF Chitin INSTEAD OF CELLULOSE

E.C.M - EXTRACELLULAR MATRIX



= MATERIAL BETWEEN CELLS

COMPONENTS: INTEGRINS, FIBRONECTIN, COLLAGEN
(GLYCOPROTEINS = proteins w/ sugars)

FUNCTIONS: ATTACHMENT, SIGNALING BETWEEN CELLS

PROKARYOTIC CELLS

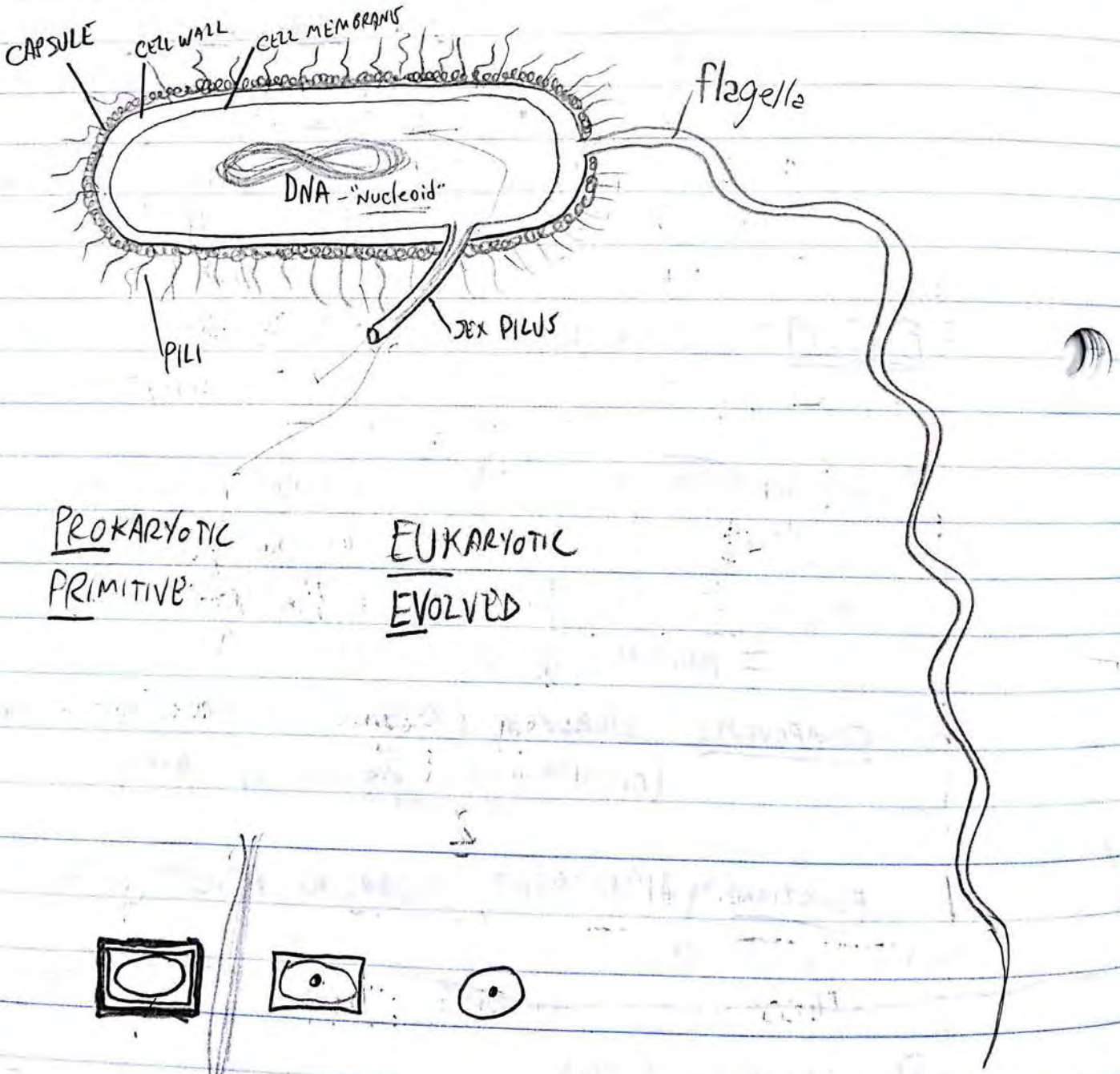
- FLAGELLA (MADE OF DIFFERENT STUFF)
- CELL WALL (MADE OF DIFFERENT STUFF)
- NUCLEOID - SPOT WHERE DNA CLUSTERS
- RIBOSOMES - PROTEIN SYNTHESIS
- PLASMA MEMBRANE - INSIDE CELL WALL
- CAPSULE (OUTSIDE CELL WALL)
- PILI - ATTACHMENT STRUCTURES
- SEX PILI - DNA XΔ

PROKARYOTIC CELLS

SIZE: 1-10 μm

- NO INTERNAL ORGANELLES
- ONE, CIRCULAR MOLECULE/CHROMOSOME OF DNA

STRUCTURES:
- CELL WALL
- CAPSULE: "STICKY" POLYSACCHARIDE OUTER LAYER
- PILI/FIMBRIAE - HAIRLIKE PROJECTIONS; ATTACHMENT, DEFENSE
- SEX PILUS - TUBULE STRUCTURE ON CELL SURFACE FOR DNA XΔ
- FLAGELLA - MOTILE STRUCTURE



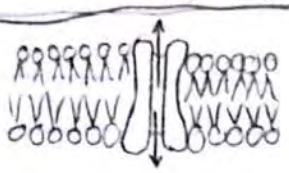
PROKARYOTIC	EUKARYOTIC
PRIMITIVE	EVOLVED

Feb 26: Phospholipid bilayer / Fluid mosaic model

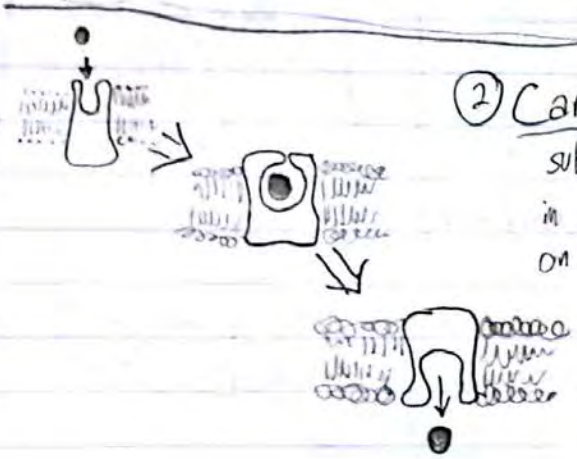
Can readily cross: hydrophobic molecules
CO_2, CO, O_2

Cannot readily cross: polar / hydrophilic molecules
- sugars
- water
- ions

NEED HELP OF Transport proteins



① Channel proteins - contain a pore that spans the bilayer that allows molecules of a specific size to move through
Ex. aquaporous, ion proteins



② Carrier proteins: bind a particular substance, causing a conformational change in the protein, releasing the molecule on the other size
Ex. for glucose

Mechanisms by which substances cross cell membranes

① Passive transport

② Active transport

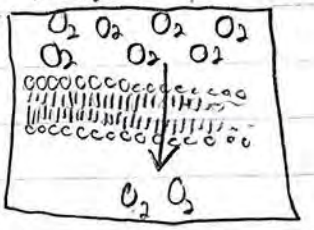
③ Transport of large macromolecules = ENDOCYTOSIS & EXOCYTOSIS

RULE: All substances move from dense to less dense
(HIGH CONCENTRATION) ⇒ (LOW CONCENTRATION)

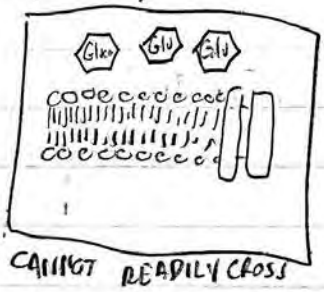
I. Passive transport: REQUIRES NO ENERGY

TYPES: ① DIFFUSION: 

NET MOVEMENT OF A SUBSTANCE FROM A ↑ CONC. TO A ↓ CONC.

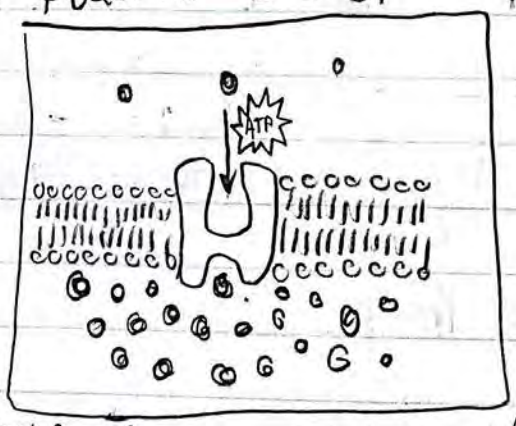


② FACILITATIVE TRANSPORT: A SUBSTANCE THAT CANNOT READILY CROSS DOES SO by means of a transport protein FROM A ↑ CONC. TO A ↓ CONC.



CANNOT READILY CROSS

II. ACTIVE TRANSPORT: MOLECULES MOVED FROM ↓ CONC. TO ↑ CONC. (AGAINST GRADIENT) BY A TRANSPORT PROTEIN; THIS REQUIRES ENERGY



Ex. Nerve cells: ↓↓↓ conc. of Na^+ ions INSIDE CELL COMPARED TO OUTSIDE
Also, ↑↑↑ conc. of K^+ inside cf. OUT

TO MAINTAIN THESE EXTREME DIFFERENCES IN CONCENTRATION, (INSIDE vs. OUT) REQ. ACTIVE TRANSPORT

Na^+/K^+ pump = CARRIER PROTEIN

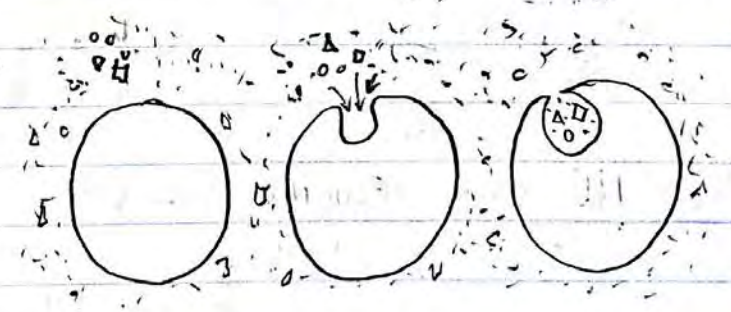
III. (INVOLVES A VESICLE)

A. EXOCYTOSIS: A VESICLE CARRYING MACROMOLECULES (e.g., POLYPEPTIDES, POLYSACCHARIDES, ETC.) GOES TO CELL MEMBRANE, FUSES W/ CELL MEMBR., AND RELEASES ITS CONTENTS OUTSIDE THE CELL

B. ENDOCYTOSIS: ENTERING OF A VESICLE

① RECEPTOR-MEDIATED ENDOCYTOSIS: RECEPTORS AT CELL SURFACE WILL BIND SPECIFIC SUBSTANCES — RECEPTORS + BINDING MOLECULES WILL FORM A VESICLE THAT WILL ENTER THE CELL

② PINOCYTOSIS: RANDOM ENGULFING AND INTERNALIZATION OF EXTRACELLULAR MATERIAL VIA A VESICLE OF E.C.M. MATERIAL/FLUID

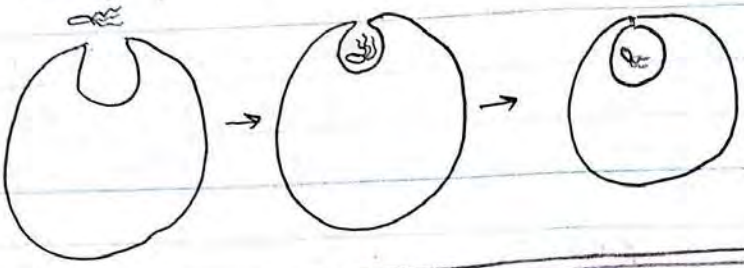


used to balance exocytosis (contracting back cell membrane)

③ PHAGOCYTOSIS: CELLS (USU. IMMUNE CELLS [macrophages]) ENGULF FOREIGN MATERIALS (microbes [bacteria & viruses]) AS A DEFENSE MECHANISM OR AS SOURCE OF FOOD

↓ ↓ ↓

PHAGOCYTOSIS



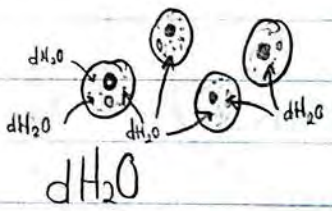
MOVEMENT OF H_2O ACROSS A CELL MEMBRANE

OSMOSIS- NET MOVEMENT OF H_2O MOLECULES ACROSS A SEMI-PERMEABLE MEMBRANE FROM A ↑CONC. TO A ↓CONC.

FACTORS THAT INFLUENCE THE MOVEMENT OF H_2O

① SOLUTE CONCENTRATION

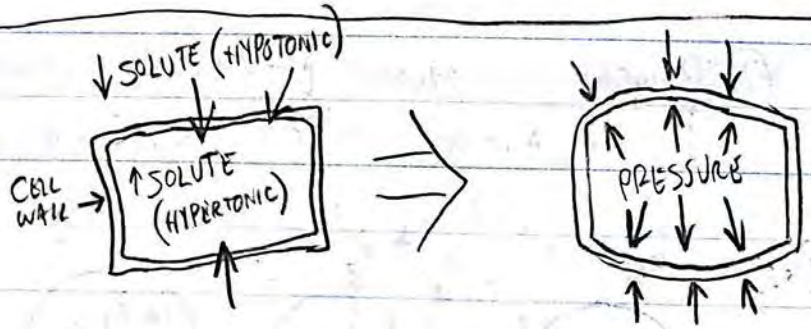
RULE: WATER ALWAYS MOVES TOWARD A HIGHER SOLUTE CONC. (less H_2O)



Ex. INSIDE CELL, HIGHER SOLUTE CONC. ⇒ HYPERTONIC

dH_2O, LOWER SOLUTE CONC. ⇒ HYPOTONIC

EQUAL ON BOTH SIDES ⇒ ISOTONIC



CELL WALL DOES NOT BURST, BUT H_2O MOVEMENT STOPS DUE TO INTERNAL PRESSURE EQUALIZATION

② **PRESSURE**; CAN INFLUENCE MOVEMENT

(CONCEPT: RIFTERS' LUNGS, H_2O PRESSURE EQUALIZATION)

Hypertonic
(HIGH SOLUTE, NEEDS H_2O)

Hypotonic
(LOW SOLUTE, GETS RID OF H_2O)

ISOTONIC
When two solutions have equal solute levels

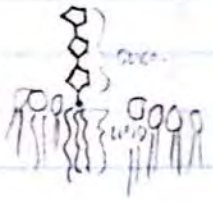
TISSUES

TISSUE = SPECIFIC CELL TYPE THAT WORKS TOGETHER TO CREATE COMMON FUNCTION

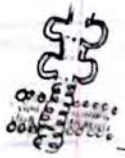
EX. EPITHELIAL (SKIN), MUSCLE, NERVE, BLOOD, LYMPHOID, CONNECTIVE TISSUE

- CELLS WITHIN A TISSUE ARE CONNECTED BY CELL-CELL JUNCTIONS AND/OR E.C.M (EXTRACELLULAR MATRIX)
- MULTIPLE TISSUE COORDINATED TOGETHER FORM ORGANS

IDENTITY MARKERS: WHAT ARE THEY?



- GLYCOLIPIDS = POLYSACCHARIDE ATTACHED TO A LIPID (FATTY ACID TAILS)
  SUGARS ARE ON THE CELL SURFACE
  BLOOD TYPES: A, B, or O AB



- MHC Proteins = major histocompatibility complex
  - EVERY INDIVIDUAL HAS A UNIQUE SET OF MHC PROTEINS
  - WHAT YOUR IMMUNE SYSTEM USES TO IDENTIFY AS "SELF"/"NON-SELF"
  - ON SURFACE OF CELLS
  (CELLULAR ID CHECKS BY SECURITY GUARDS)

ADHESION:

CELL-CELL JUNCTIONS: CELLS WITHIN A TISSUE FORM LONG-LASTING OR PERMANENT CONNECTIONS BY ESTABLISHING CELL-CELL JUNCTIONS

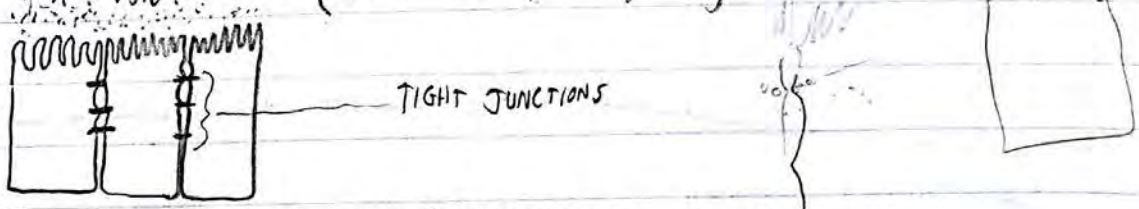
↓ ↓ ↓

TYPES OF CELL-CELL JUNCTIONS
1. TIGHT JUNCTIONS
2. COMMUNICATING JUNCTIONS
3. ANCHORING JUNCTIONS

ACT

(1) TIGHT JUNCTIONS:

FUNCTIONS - FORM A SEAL BETWEEN ADJACENT CELLS PREVENTING LEAKAGE BETWEEN THE CELLS (INTERCELLULARLY)
- PREVENT MOVEMENT OF TRANSMEMBRANE PROTEINS (TRANSPORT PROTEINS) FROM MOVING/DRIFTING FROM ONE SIDE OF THE CELL TO THE OTHER (LOCKS THEM IN PLACE)



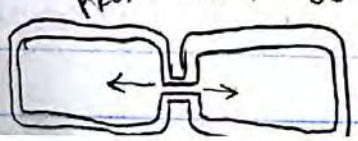
STRUCTURE - NETWORK OF TRANSMEMBRANE PROTEINS THAT ARE CONNECTED ACROSS THE CELL LIKE A BELT CINCHING IN
- TRANSMEMBRANE PROTEINS CONNECT TO OTHER " " OF OTHER CELLS TO SEAL THE CELLS TOGETHER

(2) COMMUNICATING JUNCTIONS

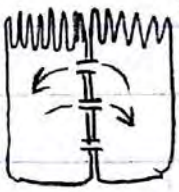
- CONNECTS THE CYTOPLASM OF CELLS TOGETHER
- ALLOWS XΔ OF INORGANIC IONS & OTHER SMALL WATER SOLUBLE MOLECULES
- CREATES AN ELECTRICAL & METABOLIC COUPLING ⇒ SPEEDY SYNCHRONIZATION
- EX. CONTRACTION OF ♡ MUSCLE, NERVE TRANSMISSION

TYPES: (a) GAP JUNCTIONS (ANIMAL CELLS)
(b) PLASMA DESMATA (PLANTS)

STRUCTURE: PLASMA MEMBRANE LINED TUBE PIERCES THROUGH CELL WALL TO CONNECT CHANNELS FROM CELL TO CELL

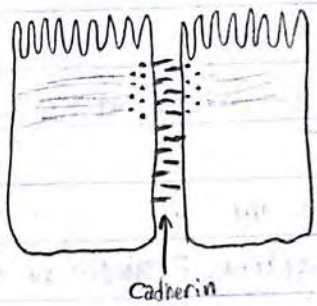


STRUCTURE: PORE = 6 TRANSMEMBRANE PROTEINS, CREATING CONNEXON

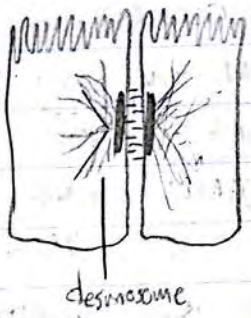


③ ANCHORING JUNCTIONS. CONNECT CYTOSKELETON OF CELLS
- COMMON IN TISSUES THAT UNDERGO MECHANICAL STRESS (e.g., SKIN TISSUE)

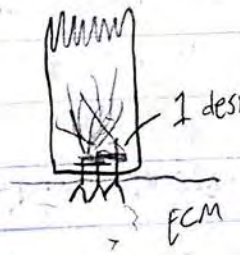
TYPES: (a) Adherens junctions - FORM CONNECTIONS BETWEEN actin filaments
- ACTIN CONNECTS WITH ACTIN FROM ANOTHER CEL BY PROTEINS CALLED cadherins OR integrins
ACTIN ≡ ACTIN ACTIN ≡ ECM



(b) Desmosomes: INTERMEDIATE FILAMENTS CONNECTING TO INT. FILAMENTS OF ANOTHER CELL BY ATTACHING TO CADHERIN PROTEINS



(c) Hemidesmosome: ATTACH INTERMEDIATE FILAMENTS TO E.C.M.



(*) EXAM II: MONDAY, MARCH 12th (*)
(*) DOWNLOAD & PRINT REVIEW QUESTIONS (*)

Cell Communication

STAGES: I. RECEPTION - binding of a signal
II. TRANSDUCTION - relaying signal internally
III. RESPONSE - Δ DUE TO SIGNAL TO CELL

TYPES
ⓐ DIRECT CONTACT - VIA GAP JUNCTIONS
ⓑ PARACRINE SIGNALING - SECRETION OF SIGNAL (SHORT TERM)
ⓒ ENDOCRINE SIGNALLING - HORMONE SECRETION (LONG LASTING)
ⓓ SYNAPTIC SIGNALING - NERVE CELLS, NEUROTRANSMITTERS

ⓐ DIRECT CONTACT - OCCURS BETWEEN TWO CELLS THAT ARE ATTACHED VIA GAP JUNCTIONS; XΔ IONS, ETC.

ⓑ PARACRINE SIGNALLING - CELLS SECRETE local regulators, WHICH ARE SHORT DISTANCE SIGNAL MOLECULES, SO THAT CELLS ADJACENT TO THE SIGNALLING CELL CAN RESPOND
★ SHORT DISTANCE, SHORT DURATION ★

ⓒ ENDOCRINE SIGNALLING - SIGNALLING VIA SECRETION OF HORMONES INTO THE BLOODSTREAM (CIRCULATORY SYSTEM) AND SENT THROUGHOUT THE BODY (ANY CELL W/ CORRECT RECEPTOR WILL RESPOND)
★ LONG DISTANCE, LONG TERM ★

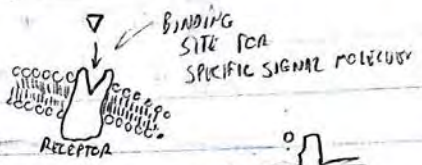
ⓓ SYNAPTIC SIGNALLING - NEUROTRANSMITTERS ARE RELEASED BY NEURON AND RECEIVED BY TARGET CELL

I. RECEPTION - BINDING OF A SPECIFIC SIGNAL MOLECULE BY A RECEPTOR PROTEIN

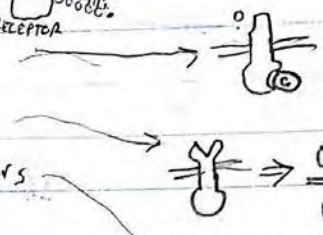
Types of signal molecules: peptides, individual amino acid, nucleotides, steroids, other lipids

↓ ↓ ↓ ↓ ↓ ↓

TYPES OF RECEPTORS: ① SURFACE RECEPTORS - EMBEDDED IN CELL MEMBRANE AT THE SURFACE



Ex. - G-protein linked
- enzymic receptors
- ion channel receptors



- SURFACE RECEPTORS PICK UP SIGNAL MOLECULES WHICH ARE USU. H_2O-SOLUBLE, ∴ CANNOT READILY CROSS.

② INTRACELLULAR RECEPTORS - RECEPTORS LOCALIZED TO THE CYTOPLASM OR NUCLEUS; RECEIVE HYDROPHOBIC (NON H_2O-SOLUBLE) MOLECULES, WHICH CANNOT EASILY CROSS (Nitrous Oxide, hormones)

II. TRANSDUCTION - Relaying the message internally in the cell, ultimately reaching the target
- RELAY MOLECULES (USU. INVOLVES ACTIVATION OF SEVERAL RELAY MOLECULES)

E.g. • PROTEIN KINASES, • PROTEIN PHOSPHATASES
ADD PHOSPHATE GROUPS +Ⓟ REMOVE PHOSPHATE GROUPS -Ⓟ
• SECOND MESSENGERS
cAMP, Ca^{++}, IP_3

- AMPLIFICATION USUALLY OCCURS

III. RESPONSE: A change in cellular activity due to a signal

TYPES OF CHANGES: ① Gene expression = MAKING PROTEINS
② REARRANGEMENT OF CYTOSKELETON
③ CHANGES IN METABOLISM

LOCATION: NUCLEUS or CYTOPLASM

Advantages of Multi-step transduction pathways:

① SPECIFICITY

② AMPLIFICATION → ↑ # SIG. MOLEC. ACTIVATED / STEP

Metabolism - ALL THE CHEMICAL REACTIONS IN AN ORGANISM

TYPES: BREAKING DOWN MACROMOLECULES TO GET ENERGY,
BUILDING MACROMOLECULES, CONVERTING RAW MATERIALS

All reactions are usually in a metabolic pathway (A → B → C → D → E)
(B: SUGAR; C: ENZYME MEDIATED; D: AMINO ACID)

Catabolic reactions - BREAKDOWN OF LARGE MOLECULES, RELEASING ENERGY

Anabolic reactions - building of larger molecules from smaller molecules, CONSUMING energy

Energy - the capacity to do work

ORGANISMS TRANSFORM/TRANSFER ENERGY

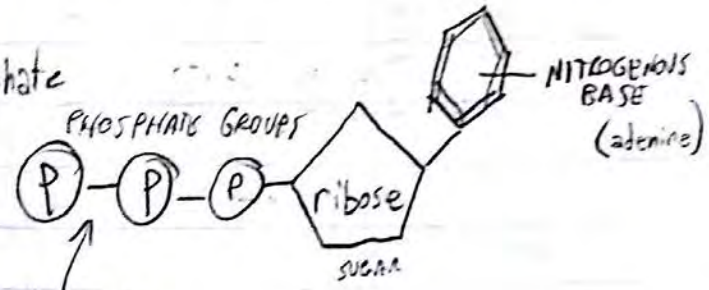
Laws of Energy Thermodynamics

① ENERGY IS CONSTANT, NEITHER CREATED NOR DESTROYED; ONLY TRANSFERRED

② WHEN ENERGY IS TRANSFERRED, ENTROPY INCREASES

ENERGY MOLECULE USED IN CELLS TO DRIVE MOST REACTIONS = ATP

ATP = Adenosine Triphosphate



Phosphorylation leads to activation

ALSO, GTP

$ATP \rightarrow P_i + ADP$

ATP TRANSFERS P_i GROUPS ONTO A SUBSTRATE, $\rightarrow$ ACTIVATION OF SUBSTRATE

Enzymes -

- ESSENTIAL TO METABOLIC REACTIONS $\therefore$ TO CELLS
- MOSTLY PROTEIN

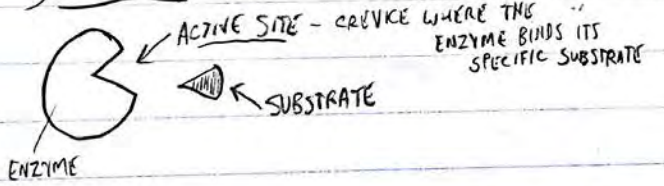
FUNCTION: SPEED UP RATE OF A REACTION (CATALYSIS)

- REACTIONS THEY MEDIATE: CONDENSATION
  CLEAVAGE
  FUNCTIONAL GROUP TRANSFERS
  ELECTRON XFER

HOW DO ENZYMES SPEED UP RATE OF REACTION?

- DECREASING ACTIVATION ENERGY (THE AMOUNT OF ENERGY NEEDED TO PUSH A REACTION FORWARD)

STRUCTURE



ALL ENZYMES HAVE THE FOLLOWING IN COMMON:

1. ONLY MAKE REACTIONS HAPPEN THAT WOULD ALREADY HAPPEN ON THEIR OWN NATURALLY (Hasten the inevitable) $\Rightarrow$ MEDIATE
2. VERY SPECIFIC FOR SUBSTRATES
3. USUALLY LOCK IN THE FORWARD & REVERSE DIRECTION OF A REACTION
4. NOT PERMANTLY ALTERED OR USED UP IN A REACTION

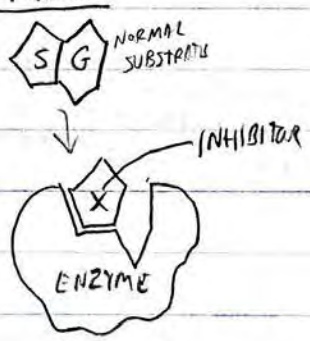
MECHANISMS BY WHICH ENZYMES LOWER ACTIVATION ENERGY OF REACTIONS

1. BRINGING SUBSTRATES CLOSER TOGETHER
2. BINDING SUBSTRATES INTO POSITION WHERE BOND IS STRAINED AND MORE LIKELY / EASIER TO BREAK
3. ENZYMES ACTIVE SITE CAN PROVIDE AN ENVIRONMENT MORE CONDUCIVE TO WHAT REACTION NEEDS (ACIDIC, BASIC, HYDROPHOBIC, ETC)
4. AMINO ACIDS IN THE ACTIVE SITE CAN FORM TEMPORARY BONDS WITH THE SUBSTRATE TO HELP PUSH THE REACTION FORWARD

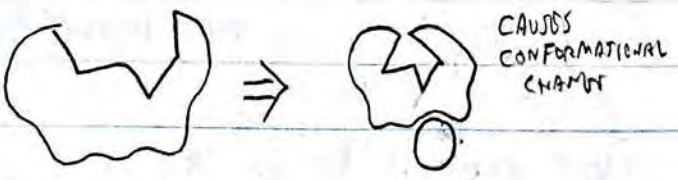
FACTORS THAT INFLUENCE ENZYME ACTIVITY (PRODUCT FORMATION)

1. TEMPERATURE (OPTIMUM = 98.6°F / 37°C)
2. pH (EACH HAS OPTIMUM pH)
3. CO-FACTORS – NON PROTEIN MOLECULES (USU. IONS) THAT ARE REQUIRED FOR ENZYME FUNCTION
4. (influences amt. of product) – SUBSTRATE CONCENTRATION / ENZYME CONCENTRATION
5. inhibitors – binding inhibitor will inhibit enzyme activity

   a. COMPETITIVE INHIBITOR



   b. NONCOMPETITIVE INHIBITOR – INFLUENCES ACTIVE SITE IN SUCH A WAY AS TO PREVENT BINDING OF SUBSTRATE



6. SALINITY – ↑ SALT = ↓ ACTIVITY

Cellular respiration is for making ATP

I. OVERVIEW -

* ORGANISMS CANNOT DIRECTLY USE FOOD AS AN ENERGY SOURCE
* BREAKING DOWN FOOD RELEASES ENERGY, WHICH IS THEN USED TO MAKE ATP
* ATP IS THE ENERGY MOLECULE USED TO DRIVE MOST REACTIONS IN THE BODY

PLANTS - USE LIGHT ENERGY TO MAKE ATP

ANIMALS - RELY DIRECTLY OR INDIRECTLY ON PLANTS FOR ORGANIC COMPOUNDS → USED TO MAKE ATP

II. TYPES

A. AEROBIC
- REQUIRES OXYGEN
- OCCURS IN MITOCHONDRIA (MOSTLY)

STAGES - ① GLYCOLYSIS
② KREB'S CYCLE
③ OXIDATIVE PHOSPHORYLATION

1 GLUCOSE METABOLIZED ⇒ 36 ATP MOLECULES

B. ANAEROBIC
- OCCURS IN OXYGEN-FREE ENVIRONMENTS

STAGES - ① GLYCOLYSIS
② LACTIC ACID PRODUCTION
— OR —
ALCOHOLIC FERMENTATION

1 GLUCOSE (PARTIALLY) METABOLIZED ⇒ 2 ATP MOLECULES

Aerobic Respiration

STAGE 1: GLYCOLYSIS:

- OCCURS IN THE CYTOPLASM

(c-c-c-c-c-c) ① ONE GLUCOSE MOLECULE IS METABOLIZED; AFTER A SERIES OF REACTIONS (EACH IS ENZYME MEDIATED),
(c-c-c)(c-c-c) THE GLUCOSE IS BROKEN INTO 2 PYRUVATES (3 CARBONS LONG EACH)

② USE 2 ATP IN THE INITIAL REACTIONS
MAKE 4 ATP
NET 2 GAINED

③ NAD^+ (nicotinamide adenine dinucleotide)
▶ COENZYME, CARRYING MOLECULE ⇒ PICKS UP H^+'s AND e^-'s
= 2 NADH's LOADED WITH e^-'s AND H^+'s

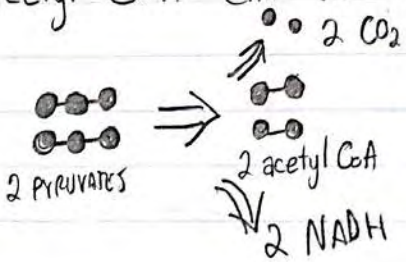
STAGE 2: KREB's CYCLE

START WITH 2 PYRUVATE MOLECULES

PREPARATORY STEP

KREB'S CYCLE CANNOT DIRECTLY USE PYRUVATE - PYRUVATE IS CONVERTED TO ACETYL COENZYME A

Acetyl CoA CAN NOW ENTER KREB'S CYCLE



RESULTS: 4 CO_2 6 NADH
2 ATP 2 $FADH_2$ (another co-enzyme)

STEPS OF THE KREB'S CYCLE

① Two Acetyl CoA EACH COMBINE WITH Oxaloacetate
(starting molecule of K. cycle)

② SERIES OF REARRANGEMENTS & REACTIONS OCCUR TO THE UNSTABLE COMBINED MOLECULE

③ AS THE REACTIONS PROCEED, IT WILL PRODUCE
- 2 ATP
- 2 $FADH_2$
- 6 NADH
- 4 CO_2

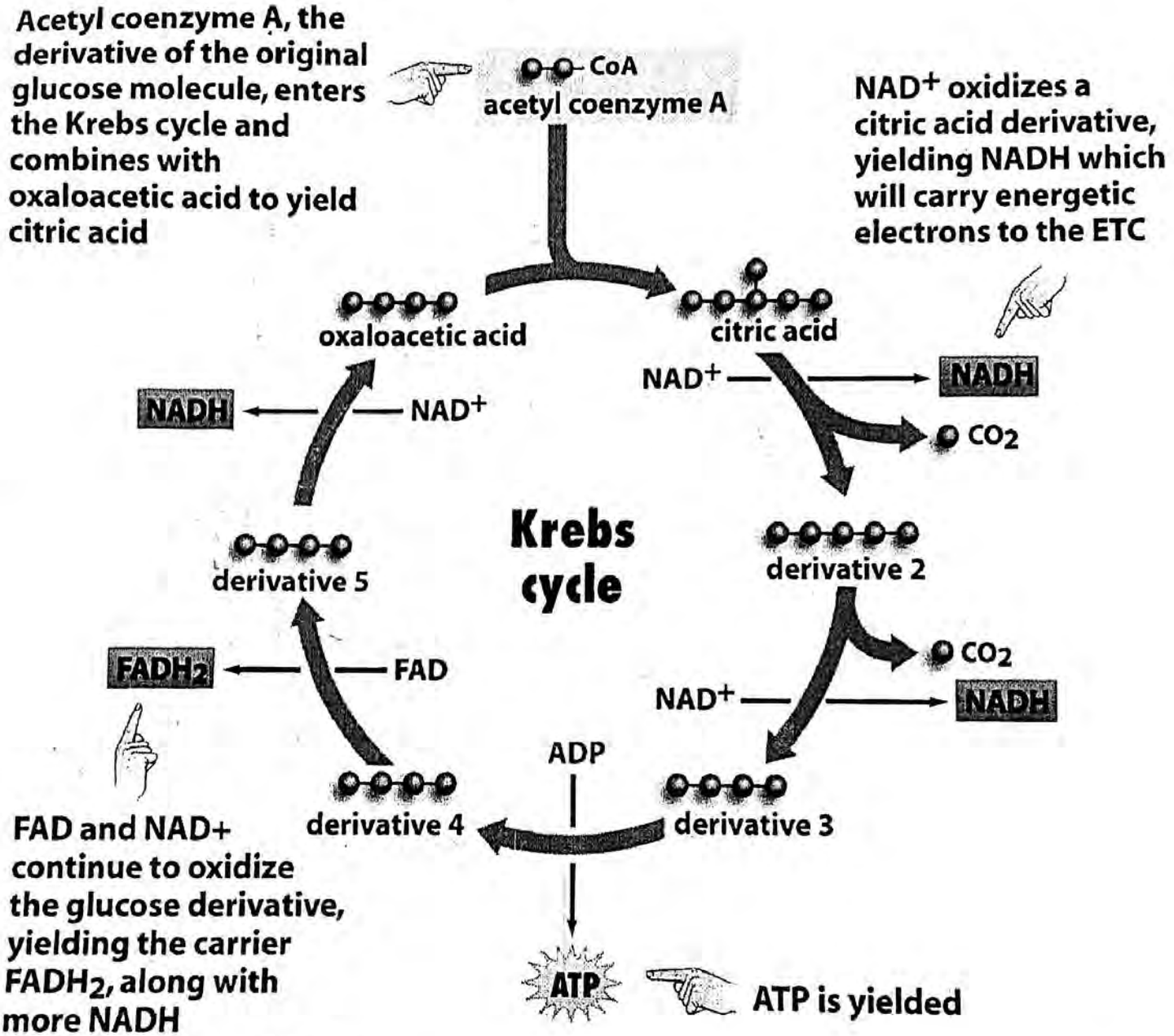
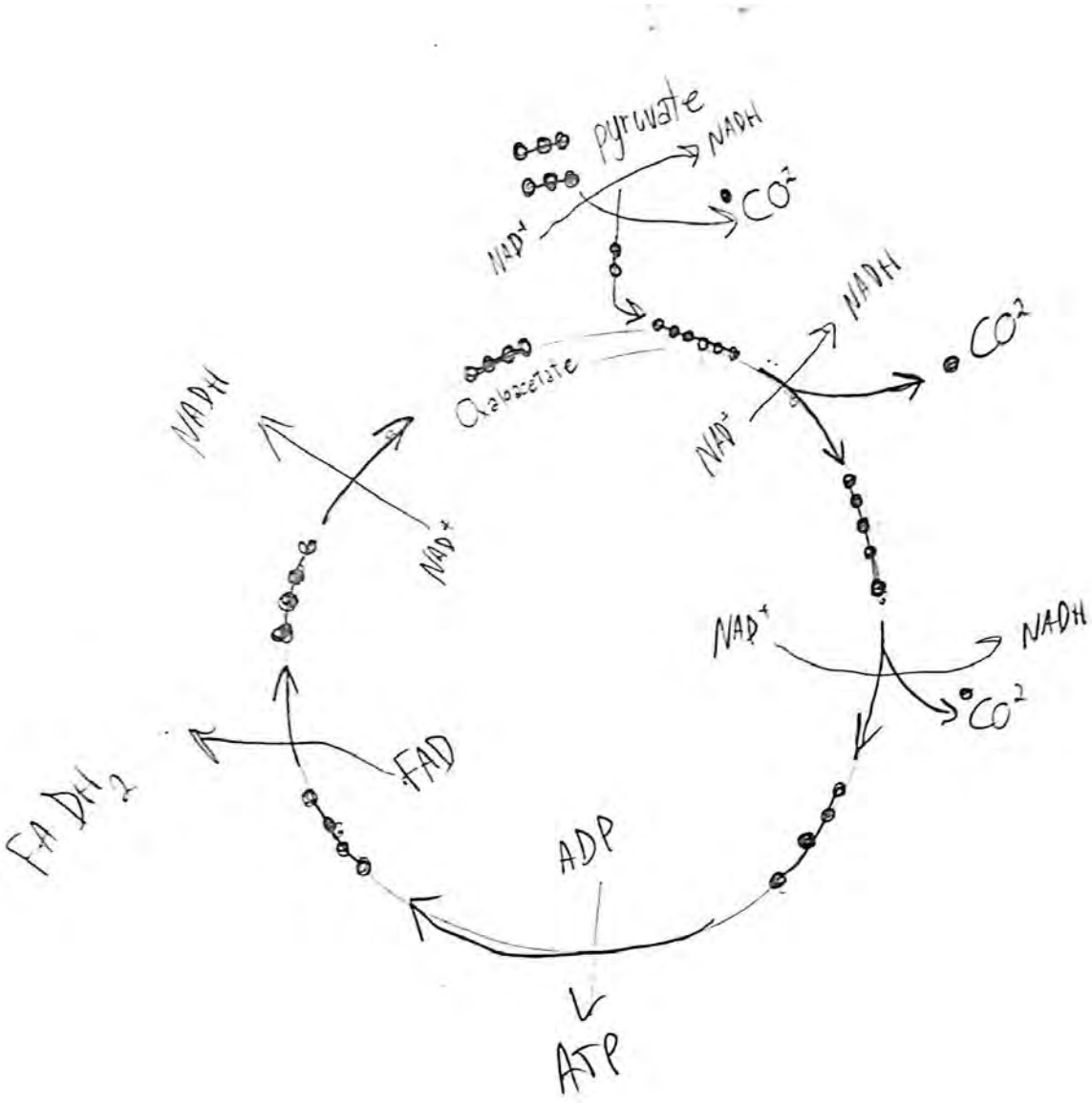
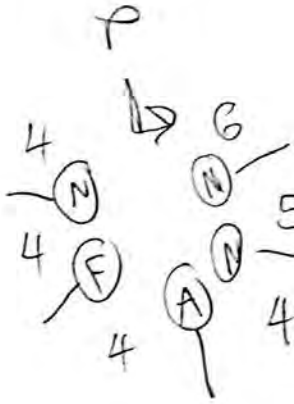
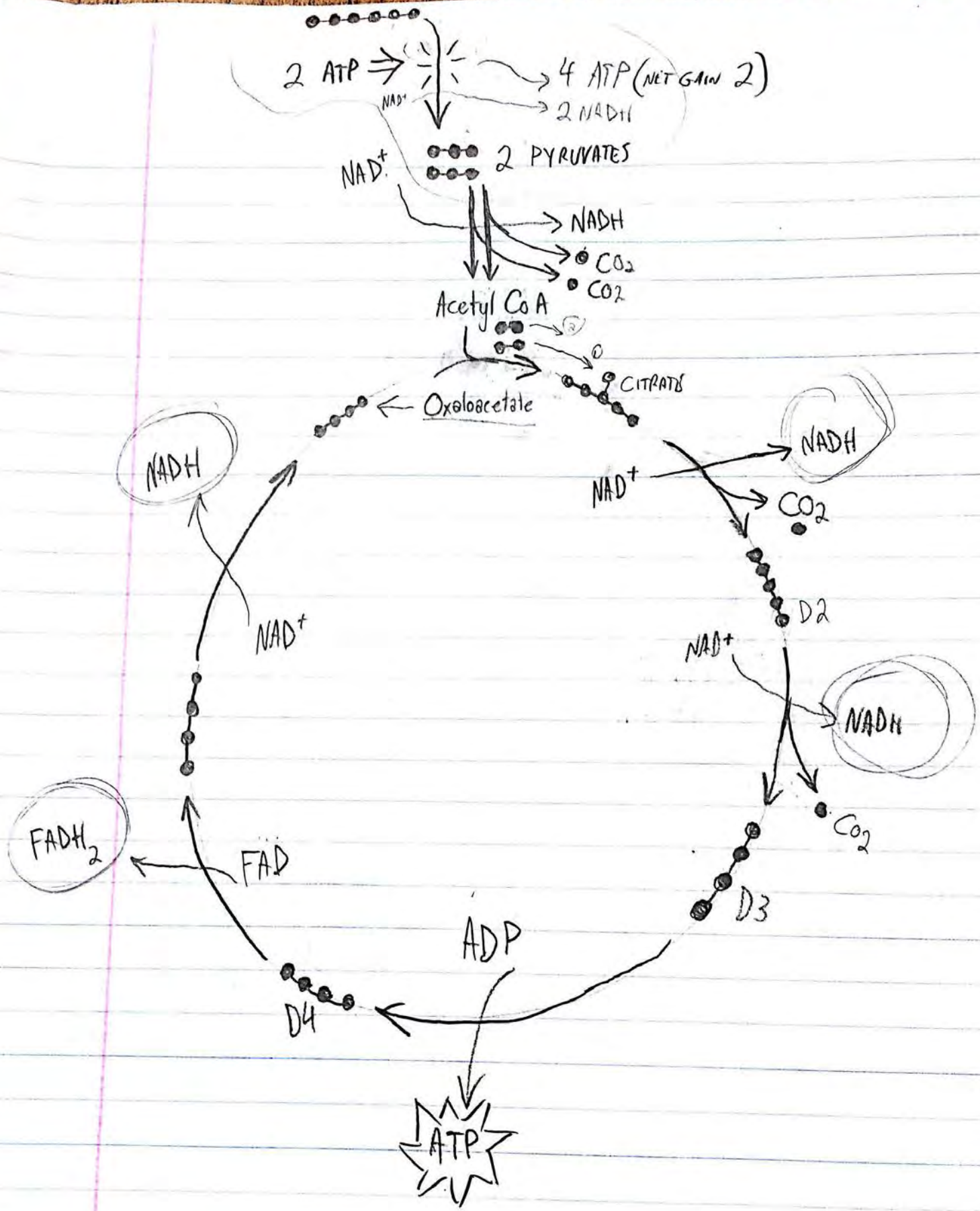
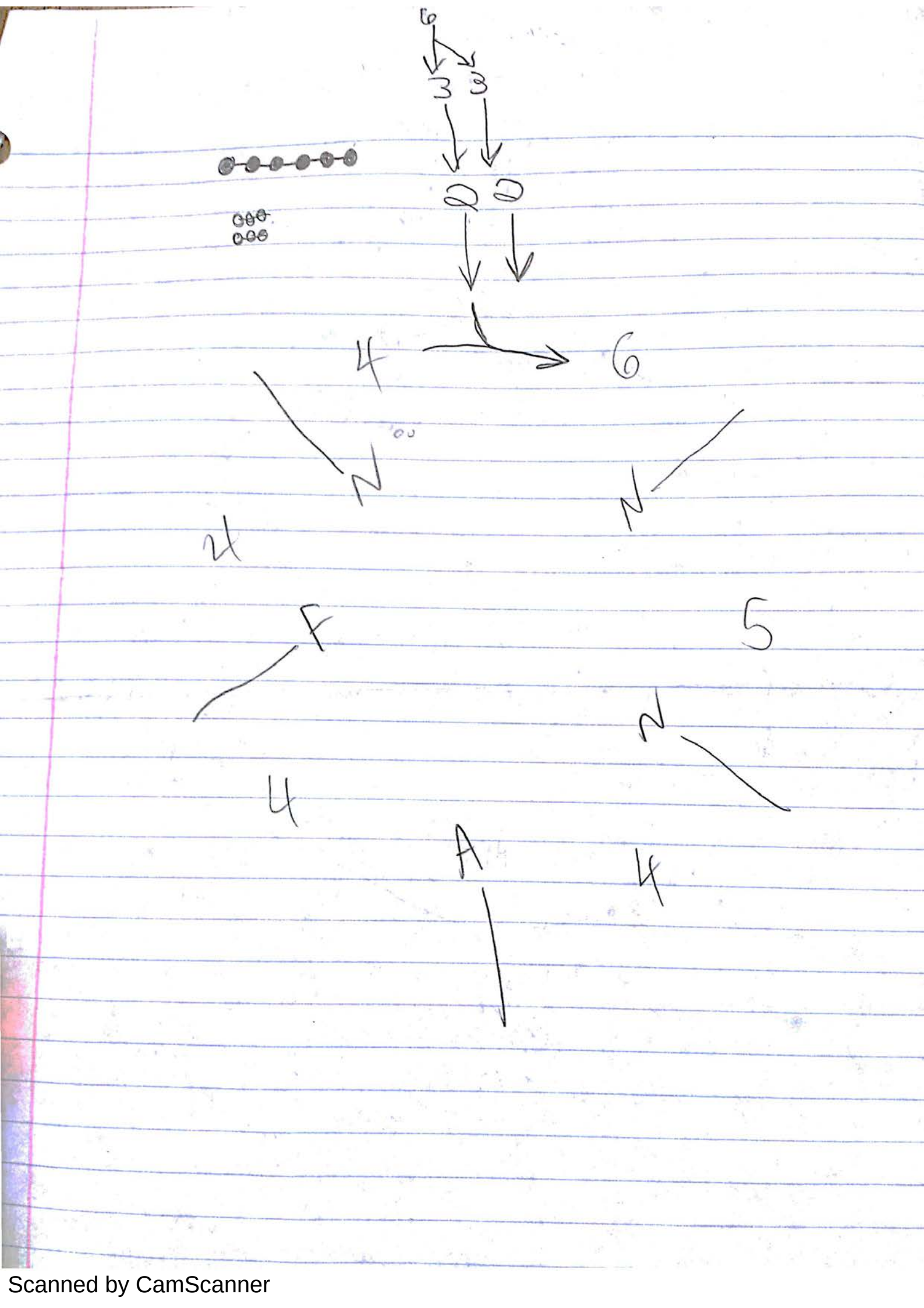


Figure 7-8 A Brief Guide to Biology, 1/e









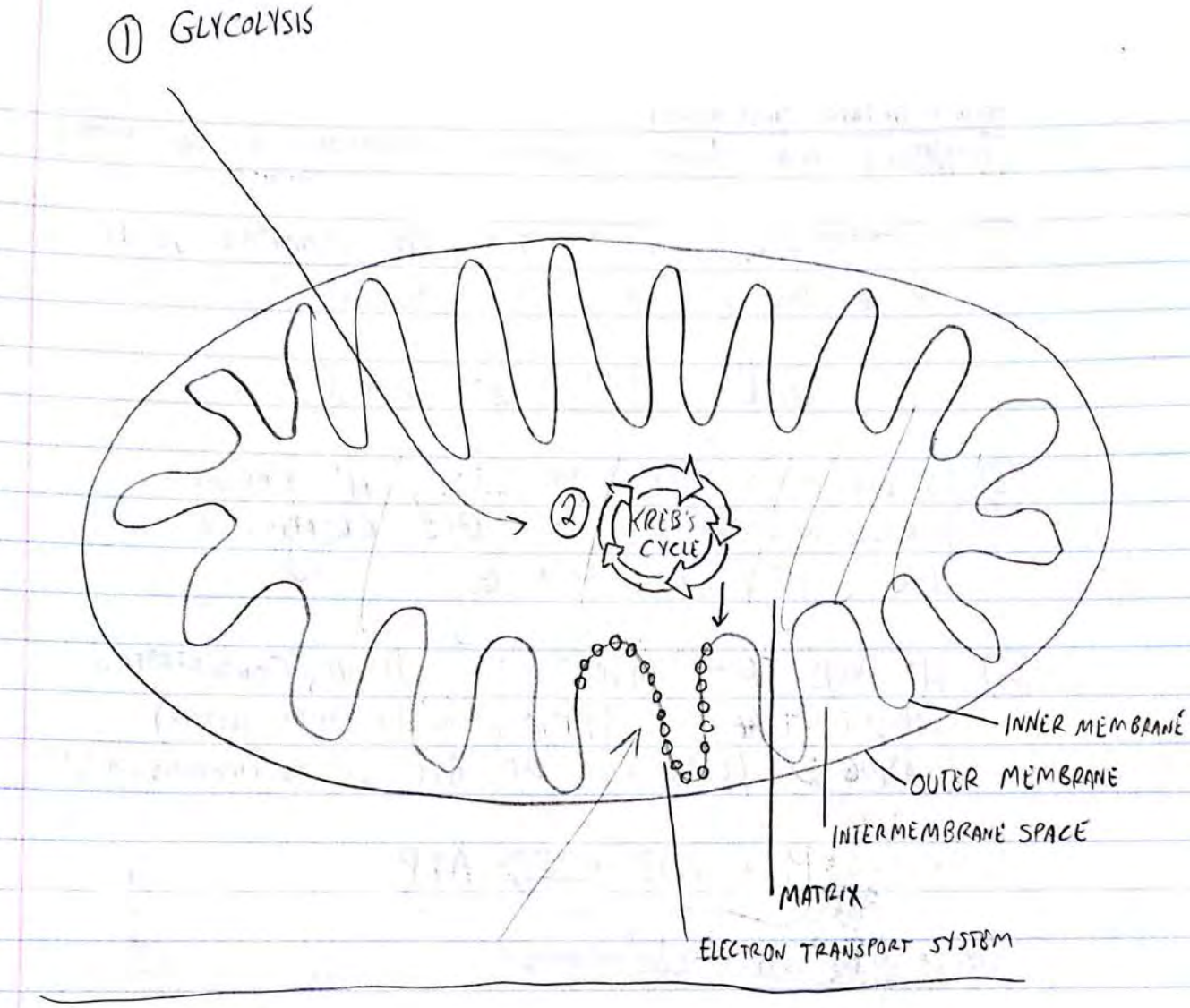
STAGE 3: Oxidative phosphorylation } IN MITOCHONDRIA
aka Electron Transport Chain (E.T.C.)

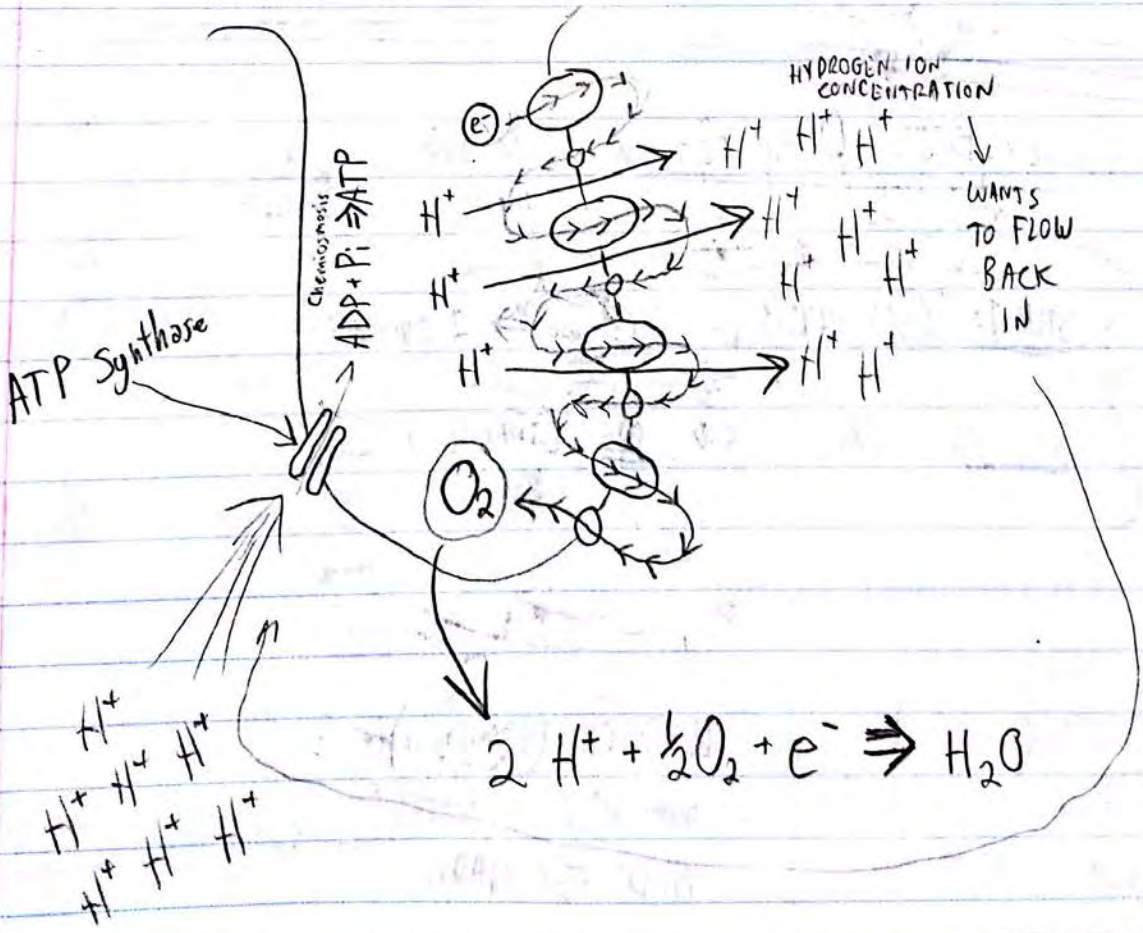
ELECTRON TRANSPORT SYSTEM - A SERIES OF TRANSMEMBRANE PROTEINS WHICH ARE ELECTRON ACCEPTORS AND H^+ PUMPS

AEROBIC RESPIRATION → REQUIRES OXYGEN
HAPPENS IN MITOCHONDRIA
REQUIRES 2 ATP
MAKES 36 ATP

STAGES	ATP	NADH	$FADH_2$
① GLYCOLYSIS (IN CYTOPLASM)	2	2	
② KREB'S CYCLE (IN MITOCHONDRIA)	2	(PREP: 2) KREBS: 6	2
③ OXIDATIVE PHOSPHORYLATION (aka ELECTRON TRANSPORT CHAIN) (IN MITOCHONDRIA)	32		
	36	10	2

ALL 10 COENZYMES USED HERE





STEPS OF OXIDATIVE PHOSPHORYLATION

① NADH's AND $FADH_2$'s DROP OFF ELECTRONS AT THE E.T.S.

② ELECTRONS MOVE THROUGH E.T.S. AND ULTIMATELY GET PICKED UP AT THE END BY OXYGEN, AN ELECTRON RECEPTOR

$$2H^+ + \tfrac{1}{2}O_2 + e^- \Rightarrow H_2O$$

③ AS ELECTRONS MOVE THRU E.T.S., H^+ IONS ARE PUMPED INTO INTERMEDIATE SPACE, CREATING A HIGH H^+ CONCENTRATION

④ H^+ MOVE FROM HIGH TO LOW DOWN CONCENTRATION GRADIENT THROUGH ATP Synthase (A TRANSPORT PROTEIN) LEADING TO PRODUCTION OF ATP VIA chemiosmosis

$$P_i + ADP \xrightarrow{\text{ATP SYNTHASE}} ATP$$

chemiosmosis

Anaerobic Respiration

FERMENTATION

- STEP 1: GLYCOLYSIS — Glucose ⇒ 2 pyruvates
- STEP 2: LACTIC ACID OR ETHANOL + CO_2

OXIDIZE (OXIDATION)
STRIP AWAY e^- AND H^+
NADH ⇒ NAD^+

REDUCE (REDUCTION)
ADD H^+'s
NAD^+ ⇒ NADH

Photosynthesis -

CAPTURING OF LIGHT ENERGY TO PRODUCE AN ORGANIC COMPOUND (SUGAR)

RAW INGREDIENTS: H_2O
CO_2
light

$$12\ H_2O + 6\ CO_2 \Rightarrow C_6H_{12}O_6 + 6\ O_2 + H_2O$$
(SUGAR)

PHOTOSYNTHETIC ORGANISMS: Plants, algae, cyanobacteria

All organisms can be divided into two types:

AUTOTROPHS
(self-feeders)
⇓
Self feeding, produce organic compounds and their own energy

HETEROTROPHS
(other-feeders)
⇓
Rely directly or indirectly on autotrophs for organic compounds and energy

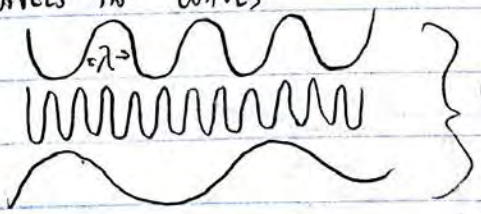
PHOTOSYNTHESIS

TWO STAGES:

1. LIGHT REACTIONS - CAPTURE LIGHT ENERGY TO MAKE ATP, NADPH
2. DARK REACTIONS - ATP, NADPH and CO_2 → (USED TO MAKE) → $C_6H_{12}O_6$ (SUGAR)
   (aka Calvin Cycle) makes sugar

Light

TRAVELS IN WAVES



different wavelengths (λ)
< nm's to > km's

VISIBLE LIGHT: 380nm – 700nm

LIGHT ENERGY STORED IN Photons

Light contains distinct packets of energy called photons

Pigments are the light-capturing molecules that absorb a specific λ or λ's that they absorb

ALL λ's THAT ARE NOT ABSORBED ARE TRANSMITTED

Ex: chlorophyll absorbs violet-blue light and red light

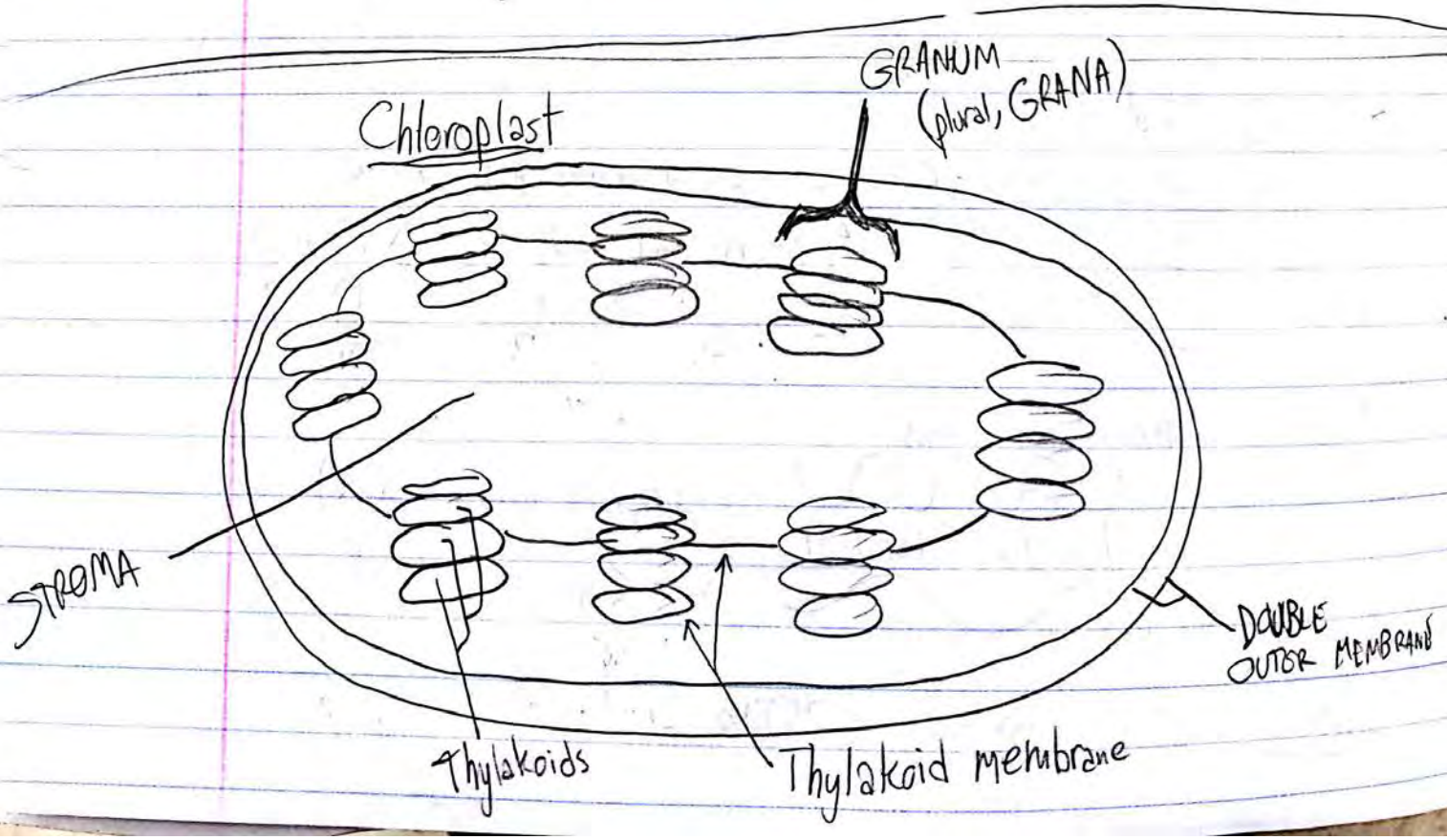
transmits green-yellow light (this is what we see)

What happens during light absorption (via pigment)?

λ's THAT CAN BE ABSORBED BY THE PIGMENT LEADS TO EXCITATION OF THAT PIGMENT

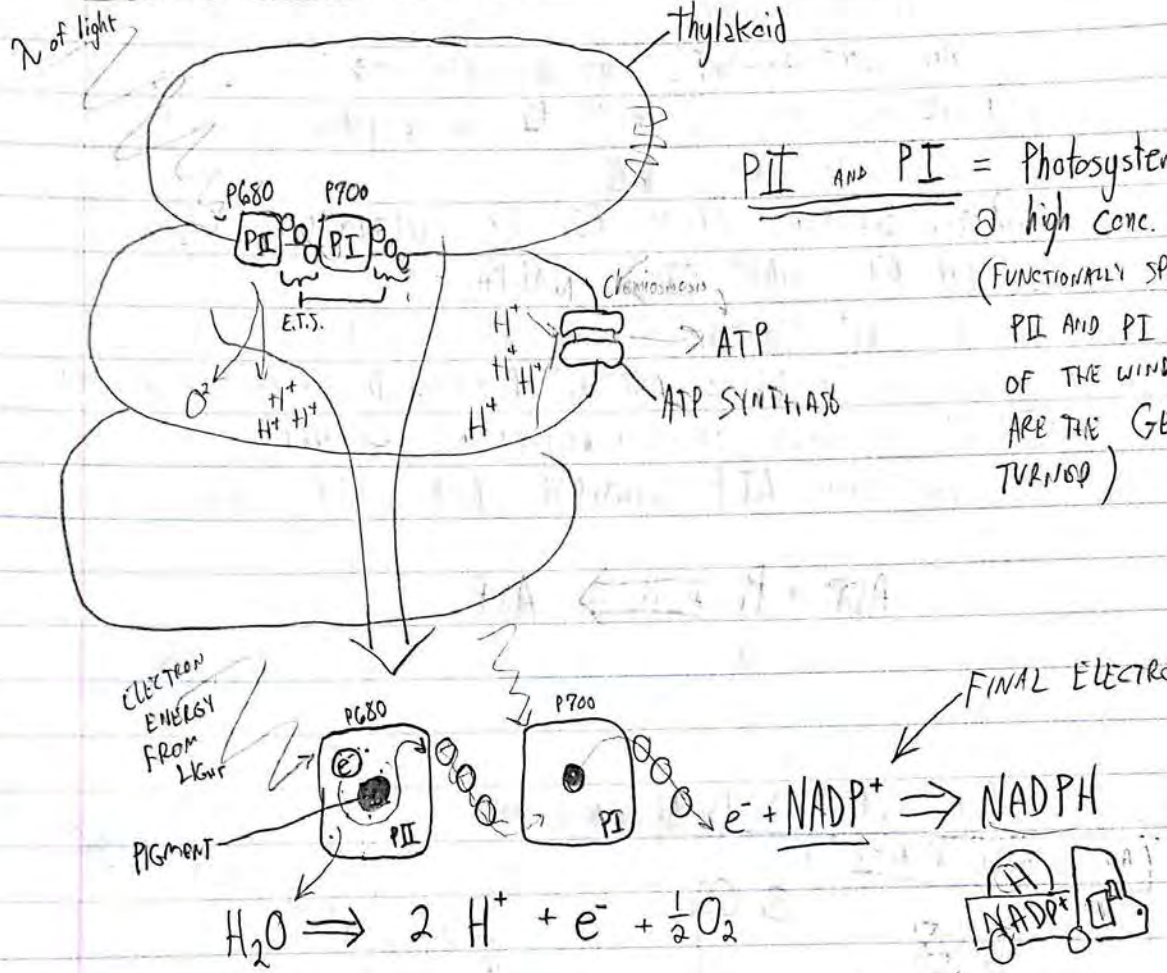
MAIN PIGMENTS IN PLANTS

chlorophyll a
chlorophyll b



Photosynthesis

I. THE LIGHT REACTIONS



PII AND PI = Photosystems, containing a high conc. of pigments and proteins (FUNCTIONALLY SPEAKING, THE PII AND PI ARE THE BLADES OF THE WINDMILL, THE E.T.S. ARE THE GEARS THAT ARE TURNED)

STEPS

1. LIGHT ENERGY IS CAPTURED BY THE PIGMENTS IN Photosystem II (PII); ULTIMATELY, THE ENERGY IS TRANSFERRED TO FINAL CHLOROPHYLL PIGMENT (C80) AND THIS PIGMENT DONATES AN ELECTRON TO AN ELECTRON ACCEPTOR
2. SPLITTING OF H_2O = PHOTOLYSIS ($H_2O \Rightarrow 2H^+ + e^- + \frac{1}{2}O_2$) THIS REPLACES THE ELECTRON LOST IN PII
3. THE ELECTRON IS TRANSPORTED THROUGH THE ELECTRON TRANSPORT SYSTEM (ETS.) FROM THE ELECTRON ACCEPTOR

④ MORE LIGHT IS ABSORBED IN PI BY PIGMENTS, ENERGY IS TRANSFERRED; ULTIMATELY TRANSFERRING AN ELECTRON → TO AN ACCEPTOR → TO E.T.S.

⑤ THE ELECTRON LOST FROM PI IS REPLACED BY THE ELECTRON FROM PII

⑥ THE ELECTRON FROM PI IS ULTIMATELY PICKED UP BY NAD^+ $\xrightarrow{H^+}$ NADPH

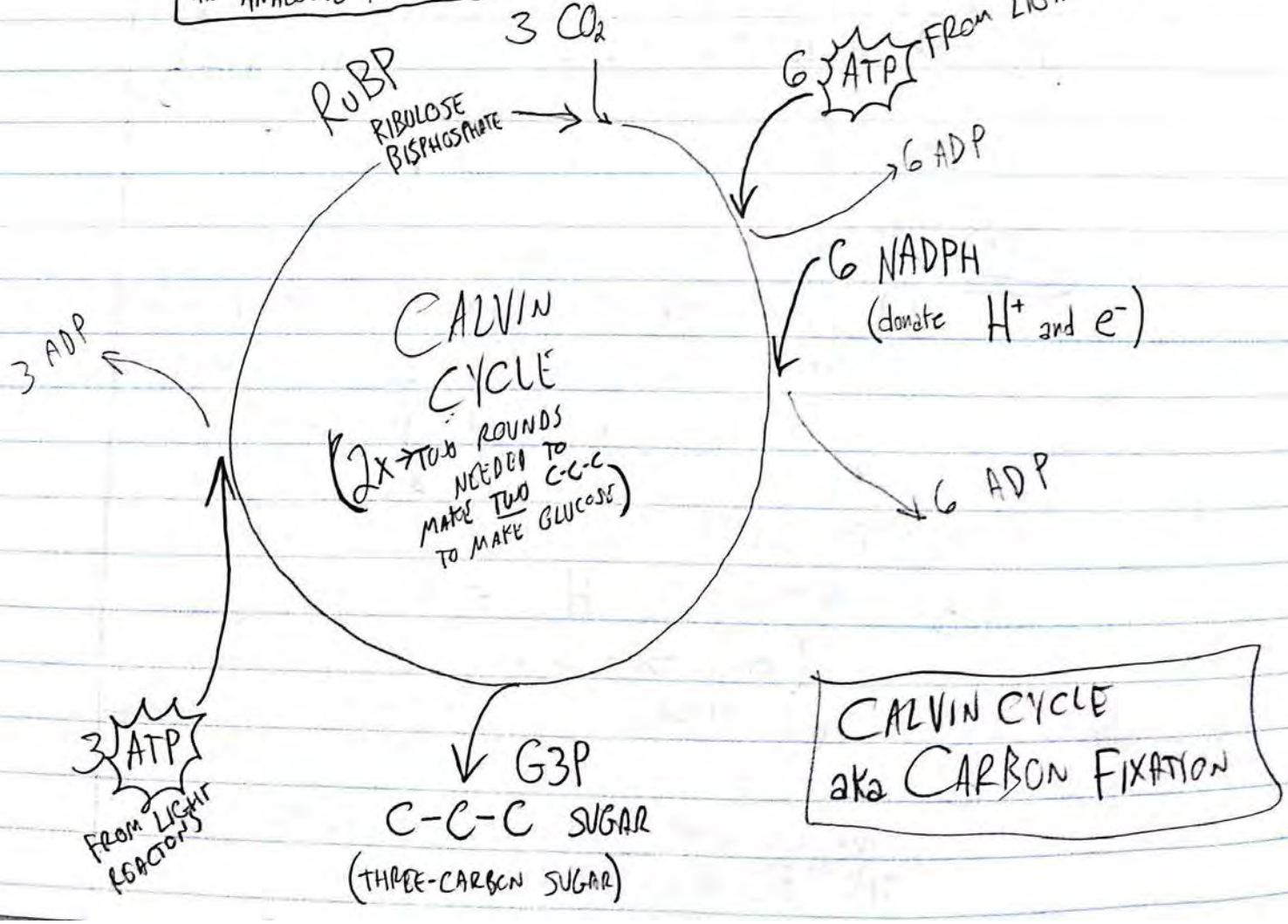
⑦ AN H^+ CONCENTRATION BUILDS UP IN THE STROMA DUE TO PHOTOLYSIS AND H^+ PUMPING DURING ELECTRON TRANSPORT

⑧ H^+ GOES DOWN ITS CONCENTRATION GRADIENT THROUGH ATP SYNTHASE AND ATP IS FORMED

$$ADP + P_i \xrightarrow{\text{ATP SYNTHASE}} ATP$$

II. THE DARK REACTIONS (WHERE SUGAR IS MADE)

AN ANABOLIC REACTION

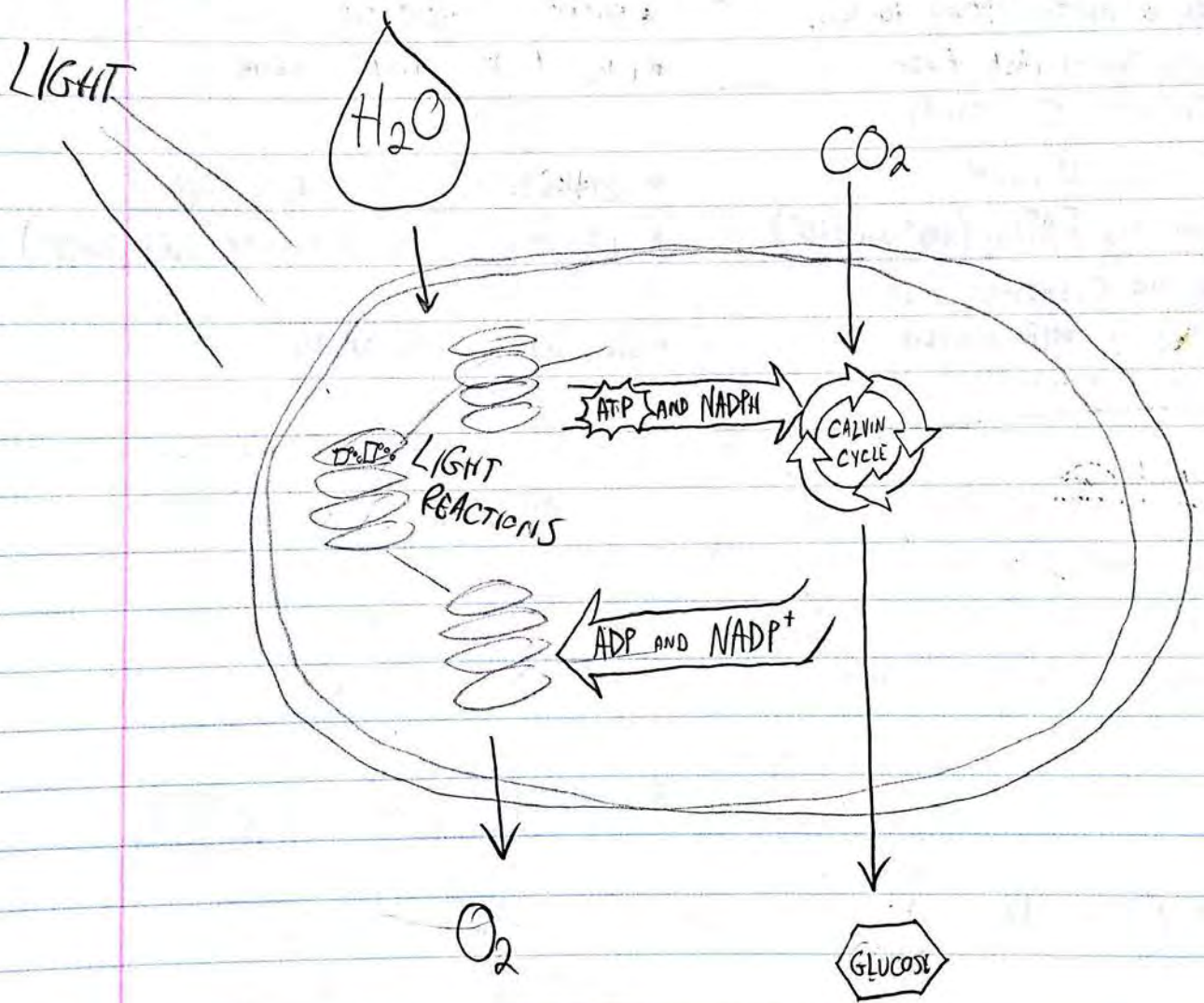


CALVIN CYCLE
aka CARBON FIXATION

STEPS ① ribulose bisphosphate COMBINES WITH CO_2

② AFTER A SERIES OF INTERMEDIATE REACTIONS, REQUIRING NADPH (e^-'s AND H^+'s) + ATP, A C-C-C (3 CARBON) SUGAR IS MADE

③ THE REMAINING ORGANIC MOLECULES IN THE CYCLE IS USED TO MAKE THE STARTING MOLECULE, ribulose bisphosphate



Cellular respiration vs. Photosynthesis

Similarities

- BOTH HAVE ETS AND MAKES ATP USING H^+ GRADIENTS AND ATP SYNTHASE
- BOTH USE COENZYMES TO PICK UP AND DROP OFF ELECTRONS (e^-) AND HYDROGEN IONS (H^+)

Differences:

CELLULAR RESPIRATION

- SUGAR IS BROKEN DOWN TO CO_2
- ENERGY TRANSFERRED FROM ORGANIC COMPOUNDS
- REQUIRES OXYGEN
- NADH AND $FADH_2$ (NAD^+ AND FAD^+) ARE THE COENZYMES USED
- OCCURS IN MITOCHONDRIA

PHOTOSYNTHESIS

- SUGAR IS PRODUCED USING CO_2
- ENERGY TRANSFERRED FROM LIGHT
- MAKES O_2 AS WASTE PRODUCT
- NADPH IS THE COENZYME USED ($NADP^+$)
- USU. OCCURS IN CHLOROPLAST

DNA

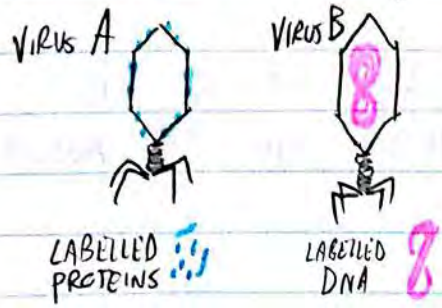
1920's - 1950's DNA WAS DISCOVERED TO BE THE HEREDITARY MATERIAL OF CELLS

1928 - FREDERICK GRIFFITH STUDIED PNEMONIAL BACTERIA DNA

non-pathogenic s. pneumonial bacteria + heat-killed pathogenic streptococcus pneumonial remains → (RESULTS) SOME OF THE NON-PATHOGENIC BACTERIA BECAME PATHOGENIC (HERITABLE CHANGE)

1940's - OSWALD AVERY
- CONTINUED GRIFFITH'S WORK
- IDENTIFIED WHAT MATERIAL WAS PASSED FROM HEAT-KILLED PATHOGENIC BACTERIA TO NON-PATHOGENIC BACTERIA
- PURIFIED DIFFERENT COMPONENTS OF HEAT-KILLED PATHOGENIC BACTERIA REMAINS
- ADDED EACH PURIFIED COMPONENT BACK, TO SEE WHICH TRANSFORMED THE NON-PATHOGENIC TO PATHOGENIC BACTERIA
- FOUND THAT DNA WAS THE COMPONENT THAT CAUSED NON-PATHOGENIC BACTERIA TO BECOME PATHOGENIC

1950's - ALFRED HERSHEY & MARTHA CHASE
- INVOLVED PHAGES (VIRUSES THAT INFECT BACTERIA) AND BACTERIA



- THEY CHEMICALLY LABELLED PROTEIN AND DNA AND THEN LET THEM INFECT BACTERIA TO SEE WHICH ENDED UP BEING XFERRED
- BACTERIA COLLECTED & TESTED: DNA WAS FOUND INJECTED INTO BACTERIA FROM THE VIRUS

1940's - Erwin Chargaff
- ANALYZED RELATIVE AMOUNTS OF A, G, T & C IN DIFFERENT ORGANISMS
- FOUND THAT A ALWAYS EQUALS T
AND G ALWAYS EQUALS C

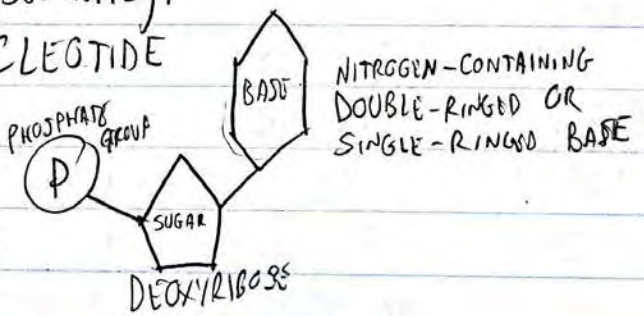
1953 - WATSON & CRICK
DEDUCED THE MOLECULAR STRUCTURE OF DNA TO BE A DOUBLE HELIX

ROSALIND FRANKLIN

DNA

STRUCTURE

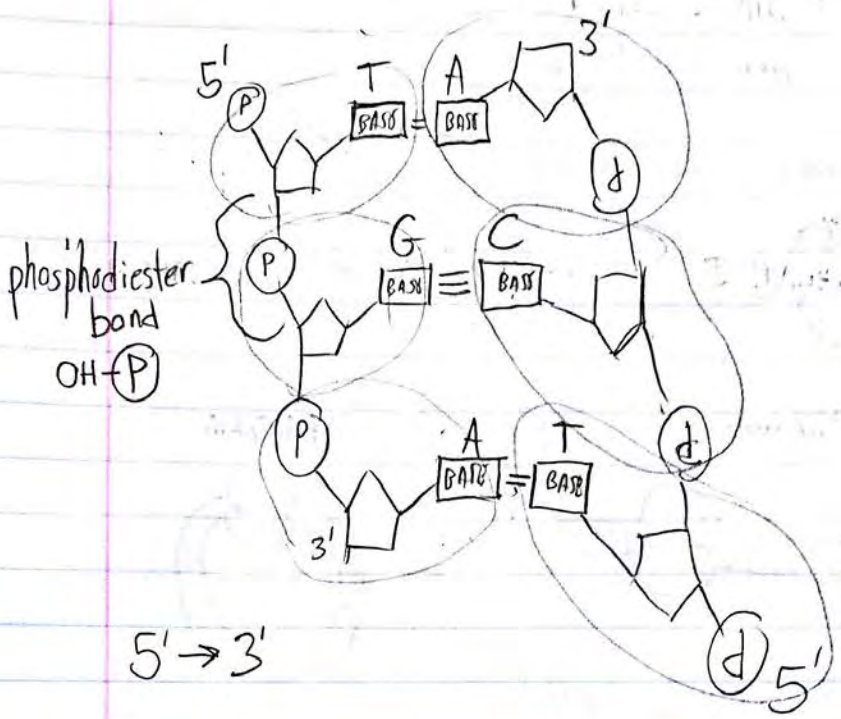
COMPONENTS (SUBUNITS):
- NUCLEOTIDE



- DOUBLE STRANDED
- HYDROGEN BONDS HOLD THE TWO STRANDS TOGETHER
A=T G≡C
G
- VARIATION OF DNA BETWEEN SPECIES IS THE SEQUENCE (OR ORDER) OF THE NUCLEOTIDES

A, G = double-ringed bases (purines)

T, C = SINGLE RINGED BASES (PYRIMIDINES)

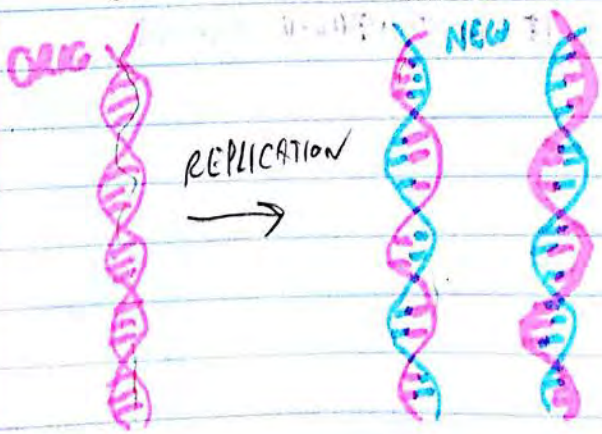


5' ATTCGCA 3'

3' TAAGCGT 5'

Semi-conservative replication

EACH ORIGINAL STRAND IS USED TO BUILD A COMPLEMENTARY NEW STRAND

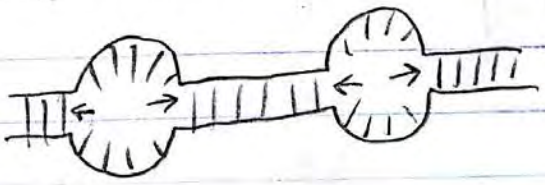


STEPS OF SEMI-CONSERVATIVE REPLICATION

① ORIGINS OF REPLICATION
- BACTERIA HAVE A SINGLE ORIGIN
- EUKARYOTIC CELLS HAVE MULTIPLE SITES

② BUBBLE FORMATION -
- THE TWO STRANDS ARE SEPARATED IN ORDER TO START COPYING EACH STRAND, BREAKING EACH STRAND

EUKARYOTIC CHROMOSOME



BACTERIA

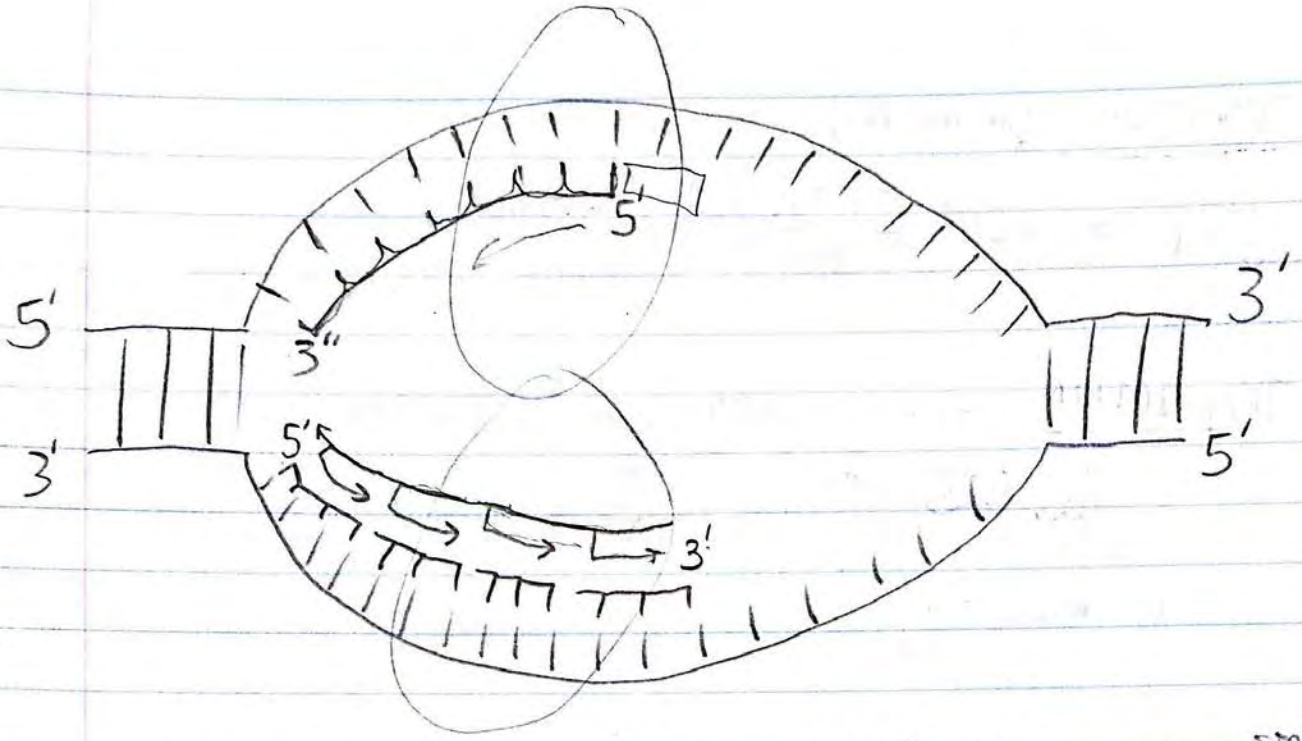
helicase - THE ENZYME THAT HELPS UNWIND THE STRAND

③ ELONGATION - MAKING OF THE COMPLEMENTARY STRANDS (NEW) ON EITHER SIDE

DNA Polymerase III - MATCHES OLD STRAND, BUILDS NEW

- THE TWO NEW STRANDS → LEADING: 5'→3'
  → LAGGING: 3'→5'

LAGGING: BUILT IN FRAGMENTS
LEADING: BUILT IN CONTINUOUS STRING



(4) PRIMERS ARE REQUIRED TO START THE LEADING STRAND AND EACH FRAGMENT OF THE LAGGING STRAND

DNA Primase

(5) THE FRAGMENTS ARE LINKED TOGETHER (ON THE LAGGING STRAND) BY DNA Ligase

TRANSCRIPTION (IN NUCLEUS)

GENE → mRNA → AGUCAGUA / TCAGTCAT → DNA

TRANSLATION TO FORM POLYPEPTIDE CHAIN OF AMINO ACIDS

AUG GCC

CODON

AMINO ACID

THREE TYPES OF RNA

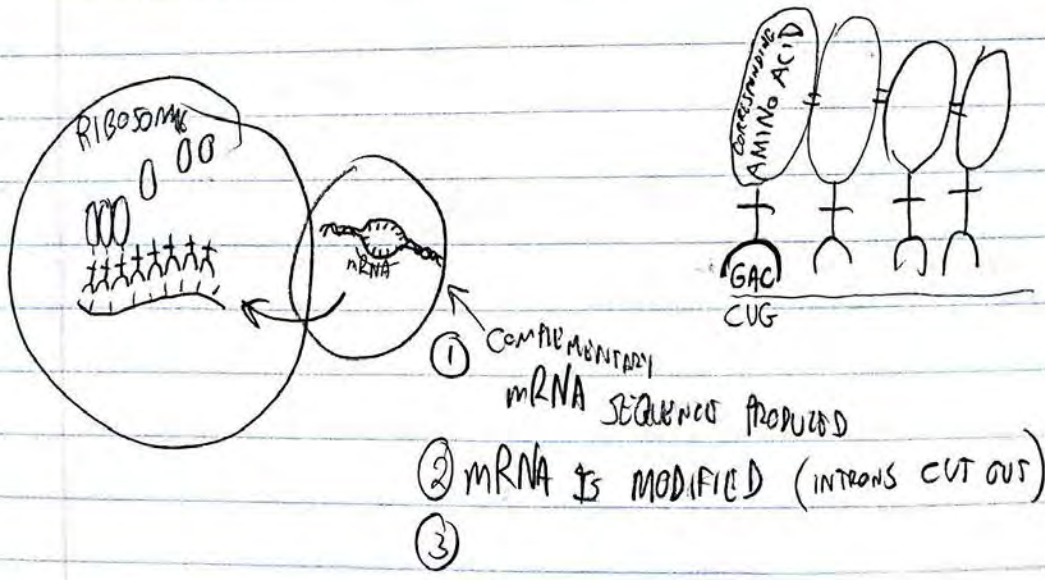
messenger mRNA - MESSENGER

transfer tRNA - BRINGS IN AMINO ACID

ribosomes rRNA - MAKES RIBOSOMES

poly A TAIL ???

- A SEQUENCE OF AMINO ACIDS IS FORMED FROM mRNA TRANSCRIPT IN BASE TRIPLETS (CODONS)



① COMPLEMENTARY mRNA SEQUENCE PRODUCED

② mRNA IS MODIFIED (INTRONS CUT OUT)

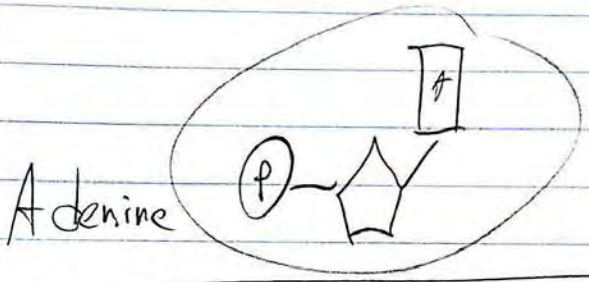
③

3 STAGES OF TRANSLATION

① INITIATION
ATTACH RIBOSOMES TO mRNA

② ELONGATION
MAKING CHAIN OF AMINO ACIDS

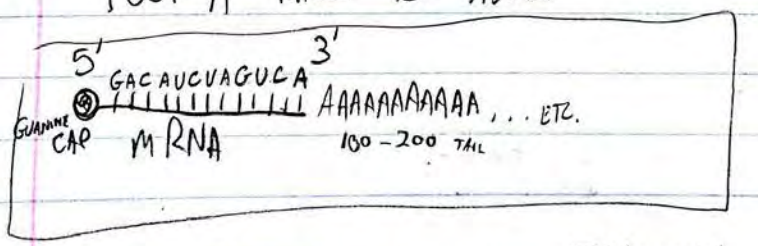
③ TERMINATION
REACHING A "STOP" CODON



Adenine

MODIFICATIONS THAT TMS EUKARYOTIC mRNA UNDERGOES FOR TRANSCRIPTION ⇒ MAKES PROTEIN

- CAP IS ADDED TO 5' END OF THE mRNA
- POLY A TAIL IS ADDED



EXON | INTRON - | EXON | EXON

AUGCAC|GGAUUGC|ACUGA|CGAUUU|

INTRON - GETS CUT OUT

EXON - GETS PIECED TOGETHER

SUMMARY OF MISSED SECTION

TWO STEP PROCESS: TRANSCRIPTION AND TRANSLATION

DNA → → Proteins
mRNA ↗

I. TRANSCRIPTION
gene → mRNA

II. TRANSLATION
mRNA → polypeptide chain of amino acids

✳ STUDY FOR TEST

MUTATION - A Δ IN GENETIC MATERIAL

TYPES:

① Point mutations - A SINGLE NUCLEOTIDE CHANGE

ⓐ BASE SUBSTITUTION: A CHANGE IN ONE BASE IN A DNA SEQUENCE

PM

ATTCG → AATGC

ⓑ CHEMICAL MODIFICATION: SOME CHEMICAL AGENT BINDS TO A BASE AND CHANGES ITS BASE PROPERTIES (MAKING IT LOOK LIKE A DIFFERENT BASE). CAUSED BY mutagens

ID

② Insertions and deletions - A BASE OR BASES ARE ADDED OR REMOVED

Consequences: IF THE ADDITIONS OR REMOVALS ARE NOT IN DIVISIONS OF THREE (BASE TRIPLETS) THE CODING WILL SHIFT ⇒ frame-shift mutation

TR

ATT CGG ~~CAA~~ TGC → ATT CGG TGC

OR ATT CGG ~~X~~AA TGC
NEW TRIPLET JUNK CODE

③ Triplet (expansion) repeat - ADDING ADDITIONAL TRIPLET REPEATS TO A SEQUENCE = INCREASE AMINO ACIDS

GAT GAT GAT (3x) ⇒ GAT GAT GAT GAT (4x)

CR ④ Chromosomal rearrangements - XΔ of DNA BETWEEN CHROMOSOMES

transposons - MOVABLE PIECES OF DNA → POP OUT & REINSERT INTO OTHER AREAS OF THE GENOME

NOTE: • MUTATIONS ARE ONLY INHERITABLE IF THEY HAPPEN TO GERM LINE CELLS.

DB ⑤ DNA breakage - DNA BREAKS CAN LEAD TO DELETIONS
CAN BE CAUSED BY IONIZING RADIATION

DNA REPAIR

→ During DNA replication

1/100,000 nucleotides = mismatched pairs
(DNA polymerase III)

Proofread by DNA pol III, removes and reinstates correct base

→ DNA repair systems for DNA damage after replication
= series of enzymes that work together to fix DNA

EX. nucleotide excision repair - REPAIRS MULTIPLE TYPES OF DNA LESIONS OR DAMAGE

PTION
CLUSION

STEPS:

① a DNA-removing enzyme = nuclease will remove damaged area of the DNA

② DNA polymerase will reinsert the correct bases & a ligase will join the newly made DNA WITH OLD DNA

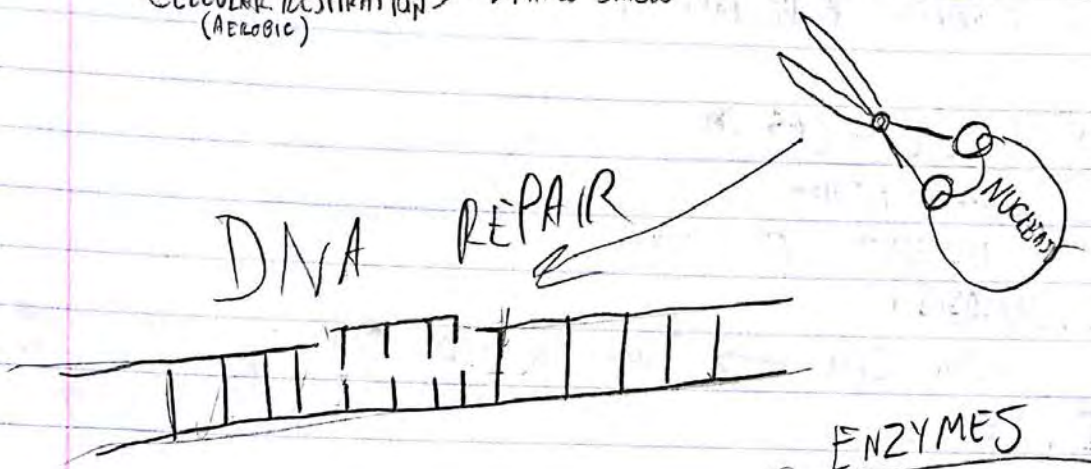
Other types of repair systems:
- UVR photorepair system
- Post-replication repair system

TEST REVIEW

CYCLES: WHAT IS MADE, WHAT IS USED

PHOTOSYNTHESIS → LIGHT REACTIONS
→ DARK REACTIONS (CALVIN CYCLE)

CELLULAR RESPIRATION (AEROBIC) → THREE STAGES



helicase = helps unzip

primase = primer

polymerase = produce

ligase = links

nuclease = nukes bad segments

ENZYMES

DURING

(POLY)

heli → prim → Poly → lig

AFTER

NU → (POLYM → LIG)

Cell Division

Intro

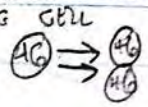
Functions of Cell Div.

1. Replenish & Repair Tissues
2. Reproduction – (Single Cell Org: Make New)
3. Growth & Development

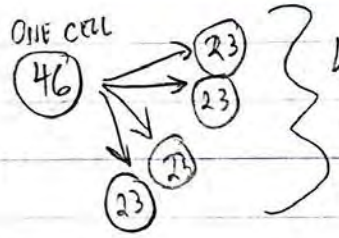
Types of Cell Division

I. Binary Fission
   Prokaryotic Cell Div.

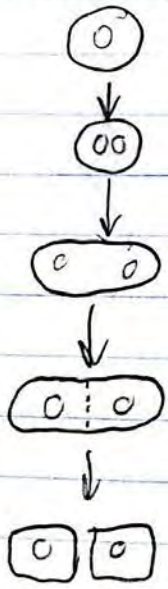
II. Mitosis
   One Cell → Two Daughter Cells w/ same amt. of DNA each daught. cell as in orig cell



III. Meiosis
   Sexual Reproduction



I. Binary Fission (Prokaryotic Cells)



Steps

1. Replication of the circular molecule of DNA
   O ⇒ OO
2. Elongation; mass doubles, membrane elongates
   OO ⇒ O--O
3. Septation – formation of new cell membrane to start to separate the 2 cells and a ring forms comprised of FtsZ
4. Pinch off into separate cells

CELL CYCLE

PHASE

G1 = GAP 1, prep. for S and growth

S = DNA synthesis phase (DOUBLES DNA)

G2 = GAP 2, prep. for M mitosis

M = MITOSIS, division of DNA

C = CYTOKINESIS division of cytoplasm

➡ ALL CELLS ARE IN A CELL CYCLE

➡ DIFFERENT TYPES OF CELLS CAN HAVE DIFFERENT CELL CYCLE LENGTH.

EXAMPLES Skin cells ~ 22-24 hrs.
Liver cells ~ 1 year

Changes to DNA during cell division

Chromosomes — individual molecules of DNA

Chromatin - a cell's collection of DNA & assoc. proteins

➡ SPECIES USUALLY HAVE A DISTINCT CHROMOSOME #

HUMANS = 46 chromosomes
GORILLAS = 48 chr.
PEA PLANTS = 14 chr.

CELLS CAN BE:

diploid: CONTAIN 2 OF EA. TYPE OF CHROMOSOME

humans

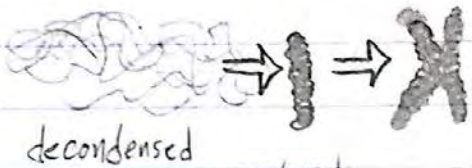
MOM	DAD	
1	1	homologous pairs
1	2	
3	3	

haploid: ONE OF EA. TYPE OF CHROMOSOME

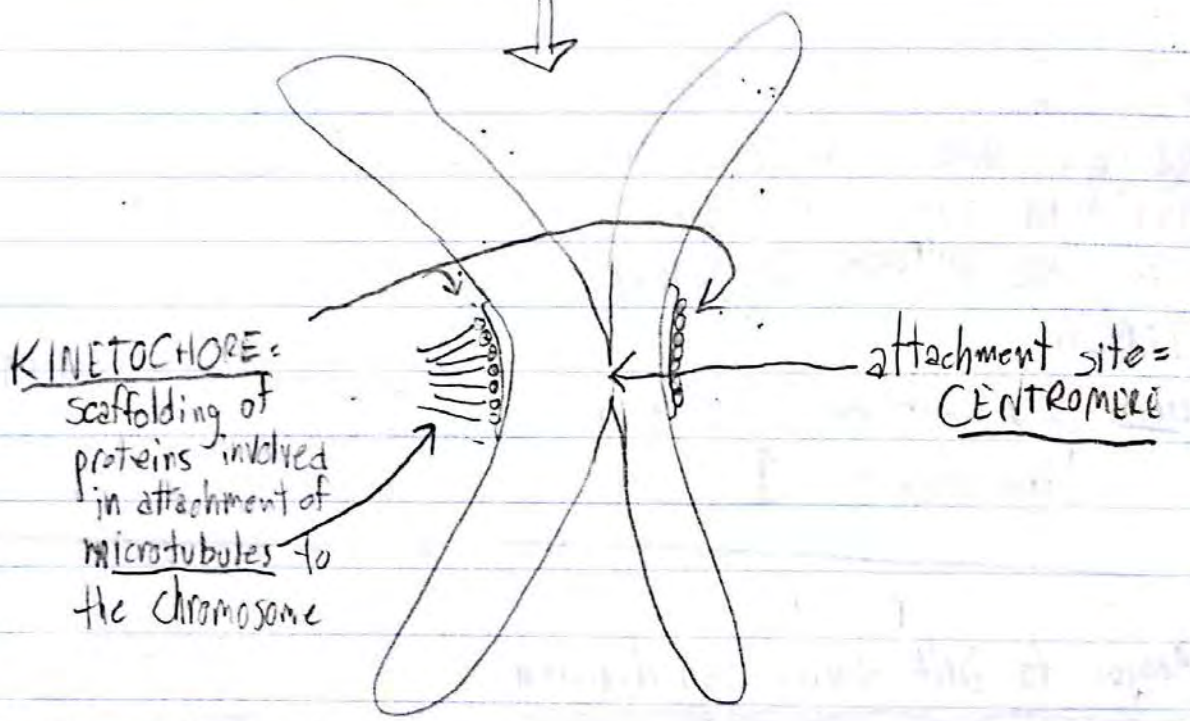
DNA-

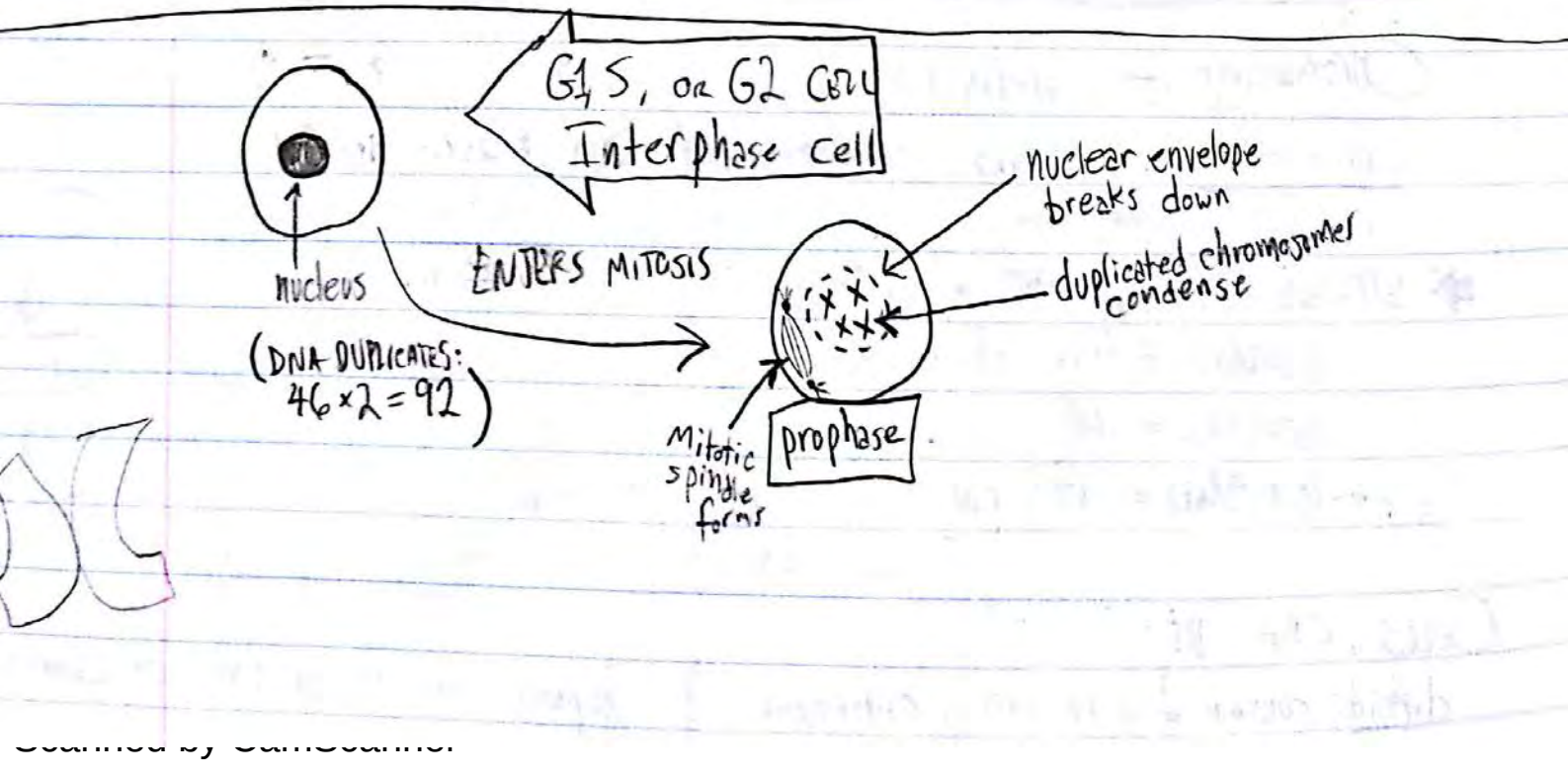
G1, S, G2 = uncondensed (↓ in compaction)

➡ At beginning of mitosis, DNA condenses into denser/thicker structures, which aids in separation



decondensed → condensed → condensed duplicated



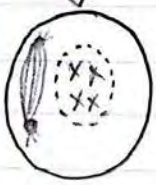


IPP MATC

interphase

DNA DUPLICATES BEFORE ENTERING MITOSIS

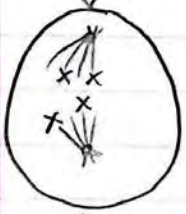
prophase



- NUCLEAR ENVELOPE DISSOLVES
- DUPLICATED CHROMOSOMES CONDENSE
- MITOTIC SPINDLE FORMS

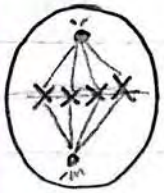
DAD = X
MOM = X

~~pro~~metaphase



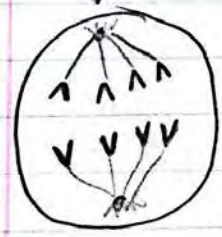
- MICROTUBULES START TO ATTACH TO CHROMOSOMES

metaphase



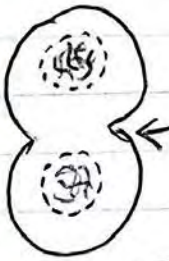
- CHROMOSOMES ALIGN IN THE CENTER OF THE CELL (METAPHASE PLATE) BY ATTACHING TO BOTH SIDES OF THE MITOTIC SPINDLE

anaphase



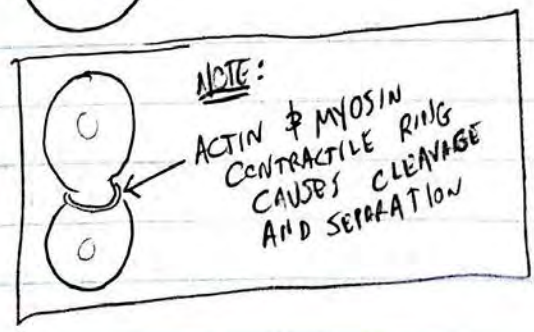
- SEPARATION OF DUPLICATED CHROMOSOMES (SISTER CHROMATIDS) TO OPPOSITE ENDS (SPINDLE POLES)

telophase
↓
cytokinesis



- INDENTATION FORMS (CLEAVAGE), SPLITTING INTO TWO DAUGHTER CELLS
- DNA BEGINS TO DECONDENSE
- NUCLEAR ENVELOPE REFORMS

CLEAVAGE FURROW

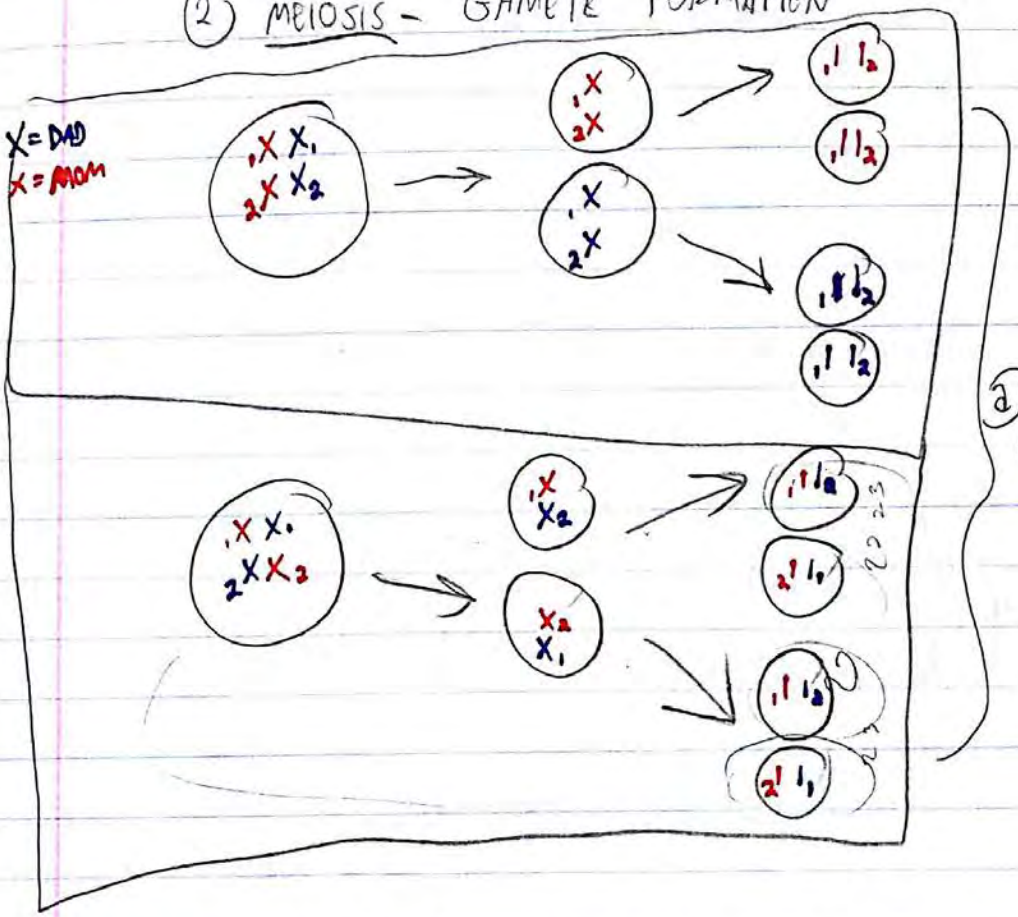


(SEE PHOTOS OF NOTES)

MEIOSIS (CONT.)

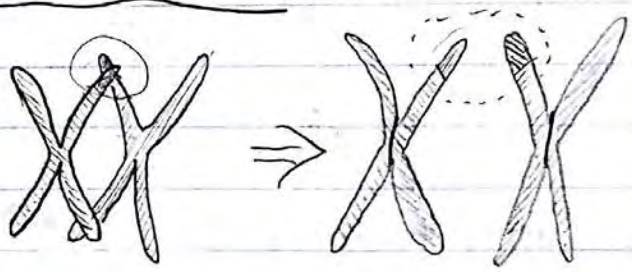
HOW SEXUAL REPRODUCTION CREATES GENETIC DIVERSITY:

1. FERTILIZATION - JOINING OF DNA FROM MOM & DAD
2. MEIOSIS - GAMETE FORMATION



a) RANDOM ASSORTMENT - VARIOUS COMBINATIONS OF CHROMOSOMES THAT CAN END UP IN A PARTICULAR GAMETE

b) CROSSING OVER - OCCURS DURING PROPHASE I



EXCHANGE OF DNA BETWEEN HOMOLOGOUS CHROMOSOMES

MENDELIAN GENETICS -

Gregor Mendel - studied garden pea plant in late 1800's in Czech Republic

↳ THEORIES ① THEORY OF SEGREGATION (ONE TRAIT)

② THEORY OF INDEPENDENT ASSORTMENT (TWO TRAITS)

Ex. 1 TRUE-BREEDING PURPLE-FLOWERED PEA PLANT × TRUE-BREEDING WHITE FLOWERED PEA PLANT = F_1 OFFSPRING: 100% PURPLE

Ex. 2 SELF-FERTILIZED F_1 GENERATION = F_2: SOME PURPLE, SOME WHITE

CONCL. ① SOME TRAITS = DOM. (PURPLE), SOME = REC. (WHITE)

② THE ORGANISMS MUST RECEIVE 2 PIECES OF INFORMATION FOR EACH SPECIFIC TRAIT (ONE FROM MOM, ONE FROM DAD)

PURPLE

PP × pp

GAMETES (P) × (p)

(Pp) =

genotype = 100% Pp

phenotype = 100% Purple

Pp × Pp

(P) or (p) × (P) or (p)

	P	p
P	PP	Pp
p	Pp	pp

genotype = 1PP : 2Pp : 1pp

phenotype = 3 purple : 1 white

genotype:

phenotype:

allele: diffent molecular forms of a gene

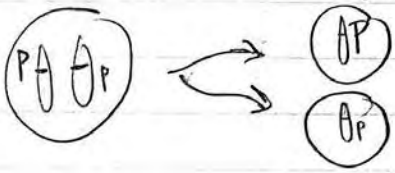
homozygous:

heterozygous (aka hybrid)

F_1 = FIRST GEN OFFSPRING
F_2 = 2ND GEN

Homologous Chromosomes = chr. which contain same info about particular trait (eye color, height, etc.); are same

Theory of Segregation (modified): A GENE PAIR ON HOMOLOGOUS CHROMOSOMES WILL SEPARATE INTO DIFFERENT GAMETES DURING MEIOSIS



TALL DWARF
Tt × tt
GAMETES T or t × t

OFFSPRING

	t	t
T	Tt	Tt
t	tt	tt

genotypes: 50% Tt, 50% tt
phenos: 50% TALL, 50% DWARF

Blood types: A, B, AB, AND O

A = ^{A}ti or $^{A}tt^{A}$
B = ^{B}ti or $^{B}tt^{B}$
AB = $^{A}tt^{B}$
O = ii

AB blood × O blood
$^{A}tt^{B}$ × ii

	i	i
A	^{A}ti	^{A}ti
B	^{B}ti	^{B}ti