Energy

Key

Vocabulary

Photosynthesis
cellular respiration
electron transport chain
ATP

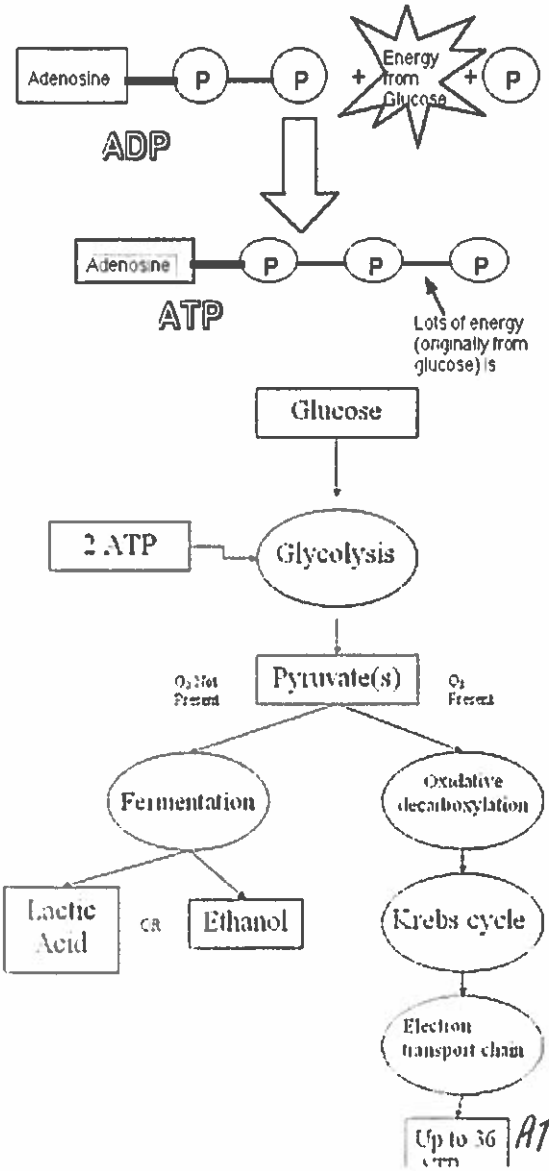
Concepts to Know

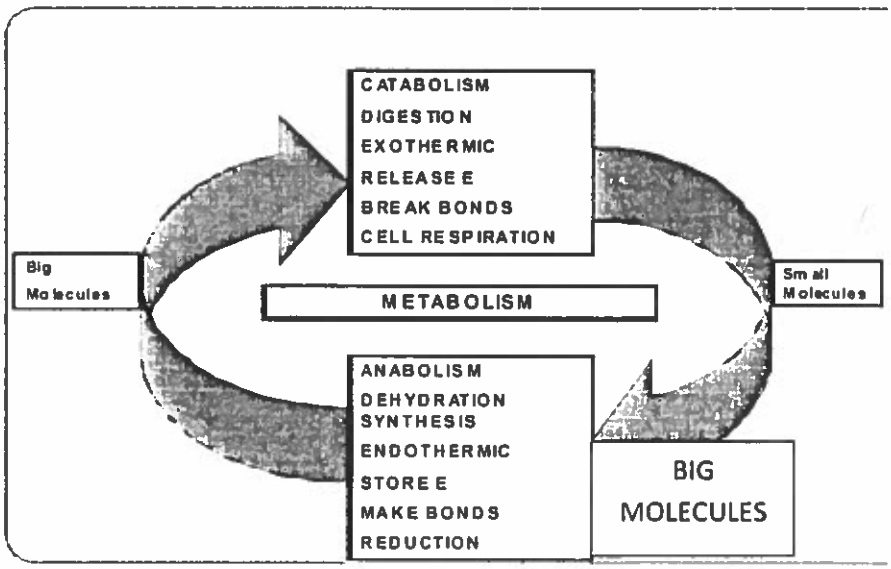
WHAT DOES LIFE NEED? ENERGY!!

It either supplies itself (AUTO-TROPH / self – feed) or it eats something (HETERO – TROPH / other – feed)

The **Laws of Thermodynamics** dictate that no energy can be created or destroyed, it can only change forms. Chemical bonds are literally energy. When you eat something, you get energy for movement or growth from the energy locked in the food's bonds. The trick to life is how to store that energy until you need it. **The short-term storage molecule that ALL life has evolved to use is adenosine triphosphate, or ATP.**

Catabolic Pathways → break down molecules so that **Anabolic Pathways → build up molecules**
ATP IS THE GO BETWEEN



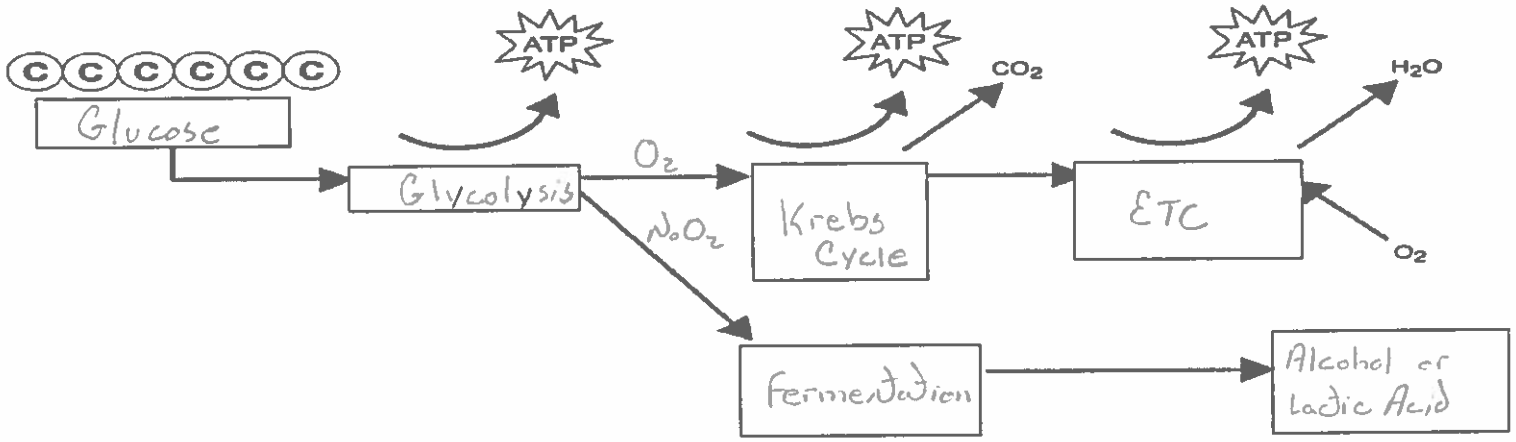


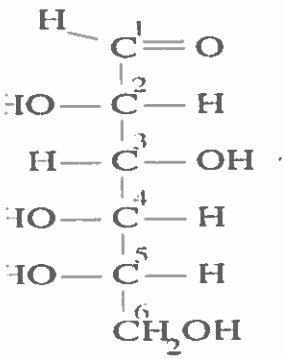
1st Idea: Cell Respiration

- The major way organisms harness energy.
- Large food molecules are taken in and ultimately the monosaccharide GLUCOSE is digested to capture its energy
- $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_20 +$ **energy**
- There are multiple steps to the breakdown of glucose so that not all of the energy is released at once
- The steps are different depending if oxygen (**aerobic**) is present or not (**anaerobic**)

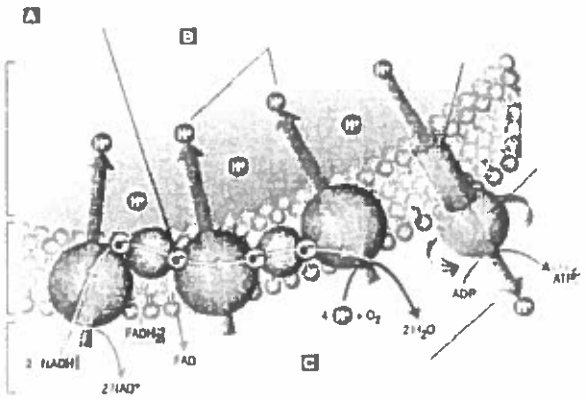
- Aerobic Respiration: glycolysis → Krebs cycle → electron transport chain (ETC)
- Anaerobic Respiration: glycolysis → fermentation
- Glycolysis occurs in the cytoplasm for prokaryotes and eukaryotes
- The Krebs Cycle and ETC occur in the mitochondria of eukaryotes
- Prokaryotes use their cell membranes to create an electron transport chain

Label the diagram with the following terms: alchohol/lactic acid; Krebs Cycle, glucose, fermentation, glycolysis, ETC





- It's all about rearrangement
- Every line in the picture of glucose to the left is energy (a line = a bond)
- During glycolysis, glucose (6C) is broken in half so a little energy is released with that broken bond…it is put into making ADP into ATP
- Whenever a bond breaks in this process, an electron and a hydrogen need to be accounted for. A molecule NAD+ picks them up to form NADH
- This concept continues in the Kreb Cycle – which will eventually break all of the bonds of the original glucose molecule. The carbons will leave as CO2. The hydrogens and electrons were put into NADH.
- **The MOST important part of Cell Respiration is the electron transport chain.** All of the NADH that was formed so far drops off the electrons and the hydrogens at the inner membrane of the mitochondria (for eukarytoes). This membrane has proteins in it that pass the electrons to each other. Electrons are a different form of energy and can power the protein channels to open (this is active transport).



- **The point of the electron transport chain** is to pump hydrogen ions (also from the NADH) across the membrane into a tiny space.
- **WHY?** It seems silly, but almost all life does this process. By building a gradient of H+ ions in this tiny mitochondrial space, the H+ build up and need to diffuse out, through a special channel called ATP synthase (this is passive transport). This molecule literally spins as H+ goes through it and makes ATP from ADP.
- **What about the oxygen?** After passing the electron down the chain to make the gradient happen (which is known as *chemiosmosis*), the electron has to go somewhere. It would cause damage in your cell otherwise. Oxygen is there to pick it up and combine it with the hydrogens to make….WATER!

What do I need to know?

The overall equation: _____

What organisms undergo cellular respiration? Eg All Aerobes

What are the 3 major steps of aerobic respiration? Gly, Krab, ETC

What will happen if there isn't oxygen present? Ferm

What is the purpose of cellular respiration? Make ATP

2nd Idea: Photosynthesis

Where does the sugar come from in the first place that will get broken down in cellular respiration?!?!

- Occurs in photosynthetic **autotrophs** (plants, algae, some bacteria); in the chloroplast of eukaryotes
- Has **2 major steps: the light reaction and the Calvin cycle** Carbon Fixation
- The **Light Reaction generates ATP and NADPH** (an electron and hydrogen carrier) so that the Calvin Cycle can run
- The **Calvin Cycle is the part that makes the sugar.** Carbon dioxide comes into a plant (via leaf stomata) and is joined together with other carbons in the cell to ultimately make glucose (6 carbons). Making bonds requires energy in this process, which is why ATP and some extra electrons and hydrogens are needed.
- **$6CO_2 + 6H_20 + energy \rightarrow C_6H_{12}O_6 + 6O_2$**
- The input of energy to start the light reaction is from sunlight!
- The **sunlight** is powerful enough to knock an electron from a molecule of chlorophyll in the chloroplast. That electron then opens a protein channel in the electron transport chain in a chloroplast. This process is just like chemiosmosis in cell respiration. The difference is oxygen is a product of this reaction. We have to water plants because the electron from the chlorophyll molecule needs to get replaced to keep the process going.

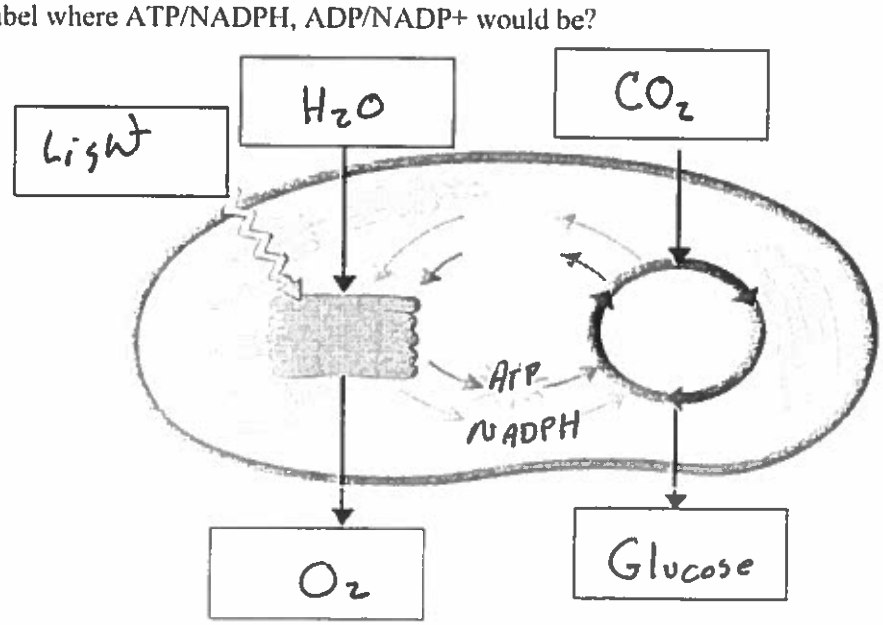
What you need to know:

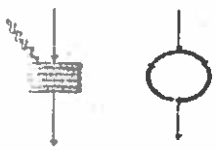
PLANTS PHOTOSYNTHESIZE **AND** DO CELL RESPIRATION!!!! They have chloroplasts AND mitochondria!

Major input and outputs of the process.

➔ Label the diagram below with the following: **CO_2, O_2, Water, Glucose, sunlight**

➔ Bonus: can you label where ATP/NADPH, ADP/NADP+ would be?





FYI: Photosynthesis Reminders

Light-Dependent Reactions "The Light Reactions"'	Light-Independent Reactions "The Dark Reaction"/The Calvin Cycle
WHAT→ photosynthetic reactions that requires light. **WHERE** → thylakoid (membrane & inside) **HOW** → uses light & water to produce oxygen and converts ADP to ATP and NADP+ to NADPH **"WHO"** → Photosystem II & Photosystem I Various proteins embedded in the thylakoid membrane **WHY** → captures sunlight energy to produce ATP which will eventually be used to construct the glucose molecules. **WHEN** → when the sunlight shines	**WHAT** → produces sugars by using the energy from ATP & NADPH formed during light-dep rxn **WHERE** → in the stroma of the chloroplast **"WHO"** → Rubisco; uses CO2 from outside & existing carbon molecules in the cell (RuBP) **WHEN** → doesn't depend on sun **WHY** → plant needs to produce high-energy glucose molecules for growth & dev't **HOW** → uses the ATP & NADPH energy stored in those bonds to create the new bonds of glucose

COMPARISON QUESTIONS

Answer P for Photosynthesis, CR for Cell Respiration, or B for both

P Releases O_2 — CR Releases CO_2 — P Uses CO_2

B Creates ATP during the process — P Produces sugar — CR Uses sugar

Answer A for Animals, P for Plants, or B for both

P Releases O_2 — B Releases CO_2 — P Uses CO_2

B Creates energy in the form of ATP — P Produces sugar — A Uses sugar

Key Connections

- Autotrophs (photosynthesizers) are always the basis of the food chain. The energy in glucose has to come from somewhere!
- The oxygen on the planet is from photosynthesizers

Cell Reproduction

Vocabulary

Cell cycle
Chromosomes
Cloning
Crossing over
Cytokinesis
DNA replication
Gamete
Interphase
Meiosis
Mitosis
Nondisjunction
Semiconservative replication

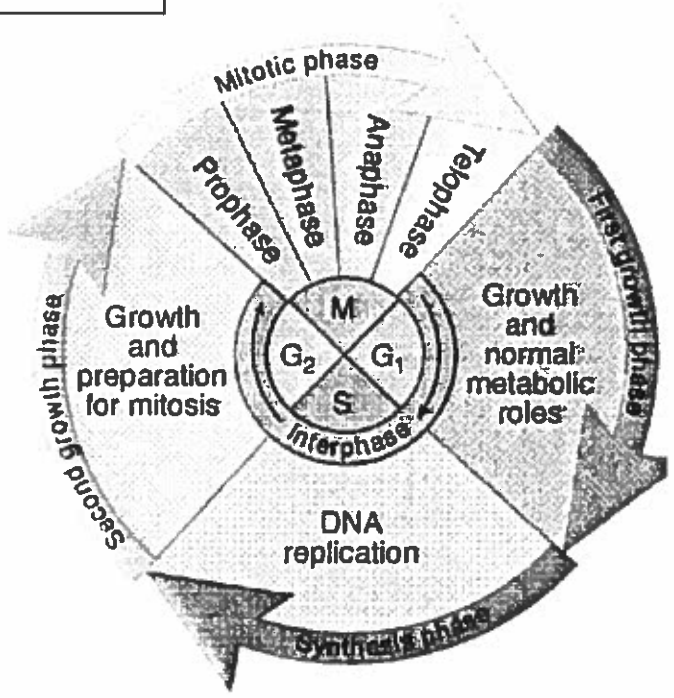
Concepts to Know

Main Concept #1: Describe the events that occur during the cell cycle: interphase, nuclear division (i.e. mitosis), cytokinesis.

- The Cell cycle – period of time from the beginning of one cell division to the beginning of the next
  - During the cell cycle, a cell grows, prepares for division, and divides to form two daughter cells, each of which then begins the cell cycle again
  - Consists of 4 phases
    - M phase – mitosis – the division of the cell nucleus and cytokinesis
    - G1 – intense growth and activity
    - S phase – copying of chromosomes
    - G2 – intense growth and activity
      - G stands for gap

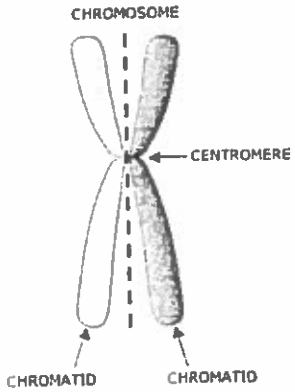
Interphase

- Interphase – time between two cell divisions
  - Interphase can be broken into 3 phases: G1, S, G2
    - G1 → cells do most of their growing, increasing in size and synthesizing new proteins and organelles
    - S → chromosomes are duplicated and the synthesis of DNA molecules takes place
      - Once cell enters S phase, it completes cell cycle
    - G2 → usually shortest of 3 phases
      - Organelles and proteins required for cell division are produced
      - Cell enters M phase once complete



MITOSIS

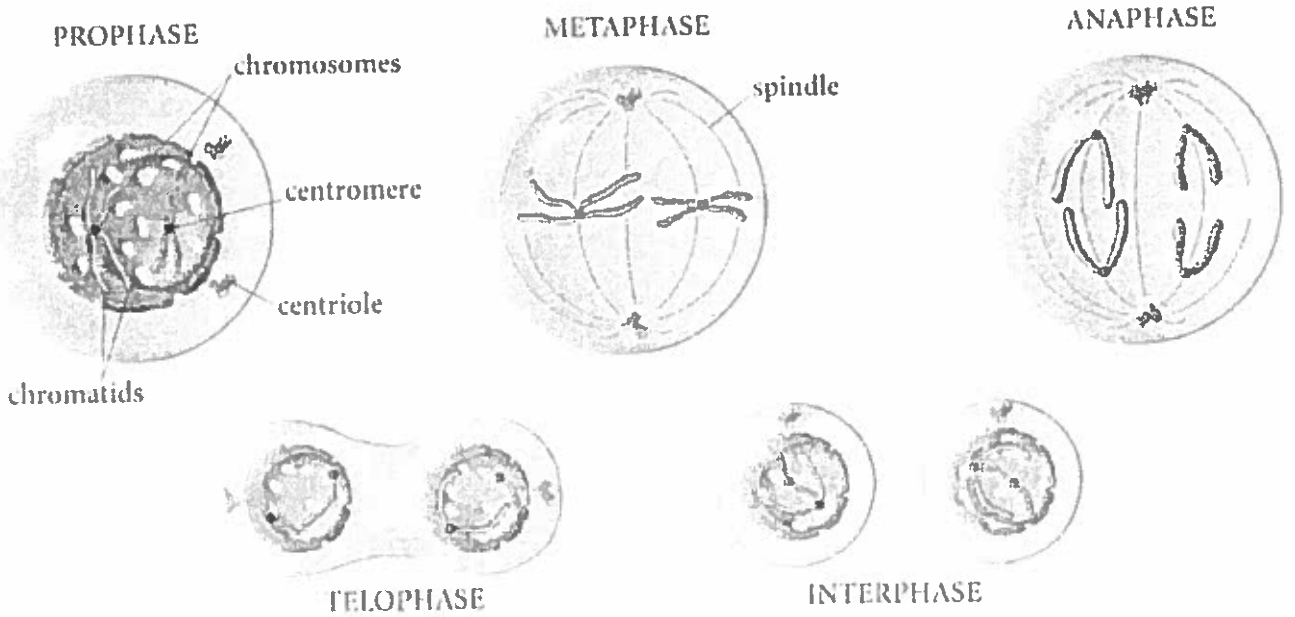
- Biologists divide the events of mitosis into 4 phases: prophase, metaphase, anaphase, and telophase
  1. prophase – 1st and longest phase of mitosis (50-60% of total time)
     - chromosomes become visible
     - centrioles separate and take up positions on opposite sides of the nucleus
       - focal point that helps organize spindle (fan-like microtubule structure that helps separate the chromosomes
       - chromosomes attach to spindle at the centromere
       - plants do not have centrioles
         - organize spindle from areas called centrosomes
     - nucleolus disappears
     - nuclear envelope breaks down



  2. metaphase – 2nd phase of mitosis
     - chromosomes line up along center of the cell
     - microtubules connect the centromere of each chromosome to the poles of the spindle

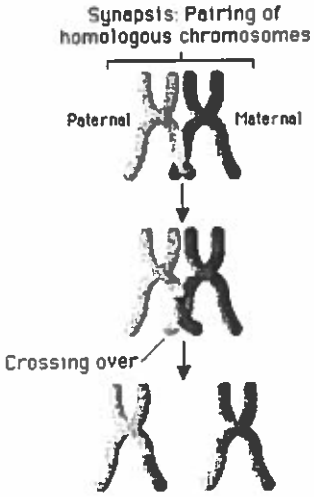
  3. anaphase – 3rd phase of mitosis
     - centromeres that join the sister chromatids split
     - chromatids separate and become individual chromosomes
     - chromatids get pulled apart, to the poles of the spindle
     - ends when they stop moving

  4. telophase – 4th phase of mitosis
     - chromosomes become loose and begin to disperse
     - nuclear envelope reforms
     - spindle breaks apart
     - a nucleolus reappears
     - cytokinesis – division of the cytoplasm
       - usually occurs at the same time as telophase
       - in animals, cell membrane pinches in at the middle
       - in plants, cell plate forms midway through the cell
         - beginning at the cell wall

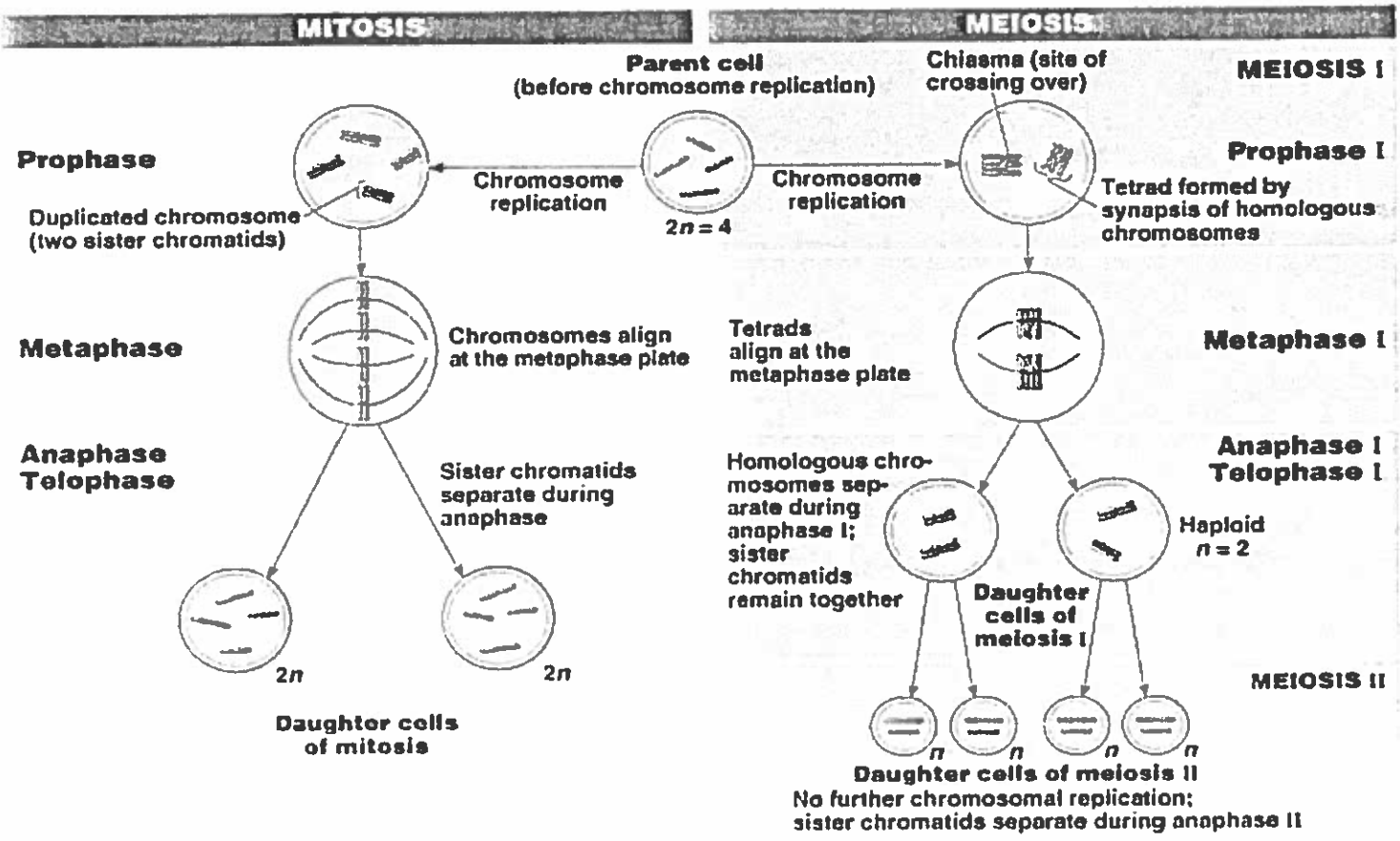


MEIOSIS

- meiosis is a process of reduction division in which the number of chromosomes per cell is cut in half and homologous chromosomes in a diploid cell are separated
  - involves two distinct stages: meiosis I and meiosis II
  - one diploid cell becomes 4 haploid cells
- homologous – two sets of chromosomes (one from mom and one from dad)
  - if a cell has both sets of chromosomes = diploid (2n)
    - 2 complete sets of chromosomes with 2 complete sets of genes
  - gametes with only one set of chromosomes = haploid (n)
    - contain only one set of genes
- meiosis I – prior to meiosis I, each chromosome is replicated
  - chromosomes line-up similar to mitosis, except the homologous chromosomes for a tetrad (4 chromatids)
    - occurs during prophase I
    - crossing over may occur – results in the exchange of alleles between homologous chromosomes and produces new combinations of alleles
  - homologous chromosomes separate and two new cells are formed
- meiosis II – cells from meiosis I enter meiosis II
  - cell does not undergo chromosome replication
  - anaphase II – chromatids separate



Main Concept #2: Compare the processes of mitotic and meiotic nuclear division.



In the table provided, check all of the parts of the cell cycle that apply to the description in the left column. In mitosis, meiosis I, and meiosis II columns – state whether it happens in prophase (P), metaphase (M), anaphase (A), or telophase (T)

Description / Event	Interphase	Mitosis	Meiosis I	Meiosis II	Neither
Nuclear membrane breaks down		P	P T		
Sex cells result				✓	
Daughter cells are identical to parent		✓			
Body cells result		✓			
Chromatids line up single file during metaphase		M			
Final chromosome # is the same as the parent cell		✓			
Diploid cells result at end		✓			
Homologous chromosomes join			P		
Tetrads form			P		
DNA is replicated	✓		M		
Chromosomes are double file					
Cytokinesis begins		T	T	T	
Transcription / translation occur					✓
Spindle fibers form		P	P	P	
Haploid Cells Result			✓	✓	
Sister chromatids separate		A		A	
Crossing over happens			P		
DNA Replication occurs	✓				

- nondisjunction – failure of homologous chromosomes to separate during meiosis
  - if nondisjunction occurs, abnormal numbers of chromosomes may find their way into gametes, and a disorder chromosome numbers may result