Cell Reproduction

I. Cell division and Mitosis

A. Why is cell division important?

1. many organisms start as just one (1) cell

a. reproduction

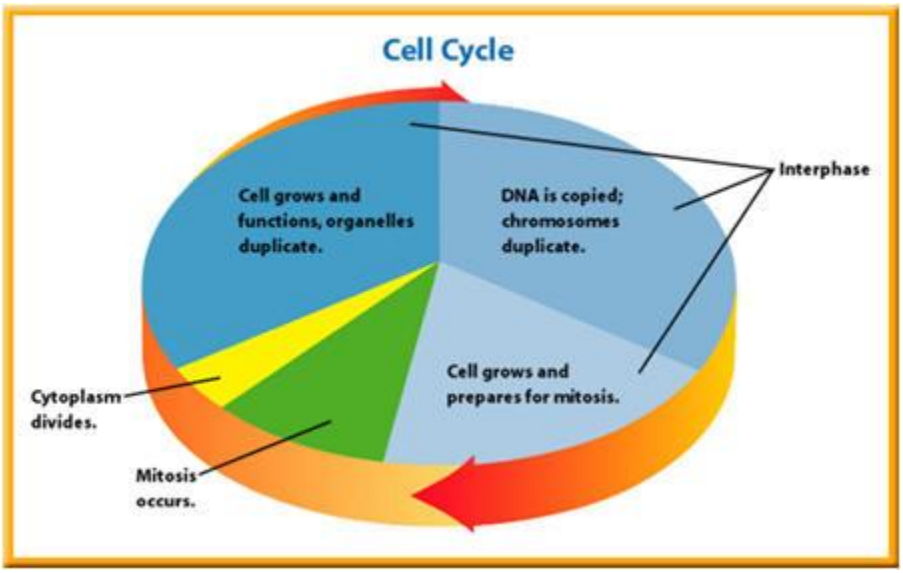
i. that cell divides and becomes two (2); two (2) becomes four (4); four (4) becomes eight (8); and so on

2. many-celled organisms, including you, grow because cell division increases the total number of cells in an organism

a. after growth stops, cell division is still important

i. every day, billions of red blood cells in your body wear out and are replaced

ii. during a the last few seconds, your bone marrow produced about six million red blood cells



B. The Cell Cycle

1. a living organism has a life cycle

a. the life cycle begins with the organism's formation, is followed by growth and development, and finally ends in death

2. individual cells also have life cycles

a. the cell cycle is a series of events that takes place from one (1) cell division to the next

b. the time it takes to complete a cell cycle is not the same for all types of cells

3. interphase

a. most of the life of any eukaryotic cell—a cell with a nucleus—is spent in a period of growth and development called interphase

b. cells in your body that no longer divide, such as nerve and muscle cells, are always in interphase

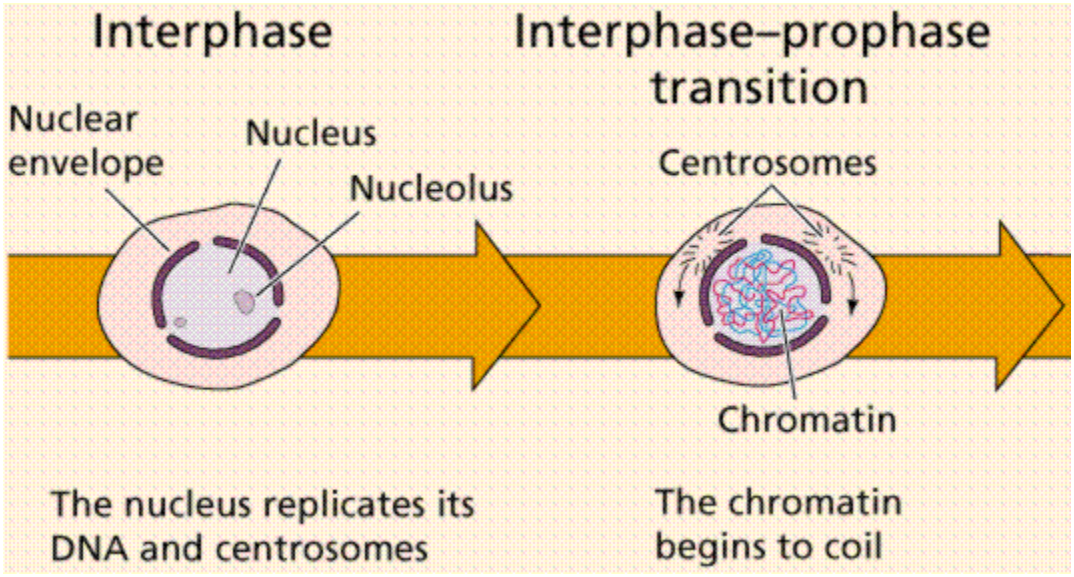
c. an actively dividing cell, such as a skin cell, copies its hereditary material and prepares for cell division during interphase

i. before a cell divides, a copy of the hereditary material must be made so that each of the two (2) new cells will get a complete copy
ii. each cell needs a complete set of hereditary material to carry out life functions

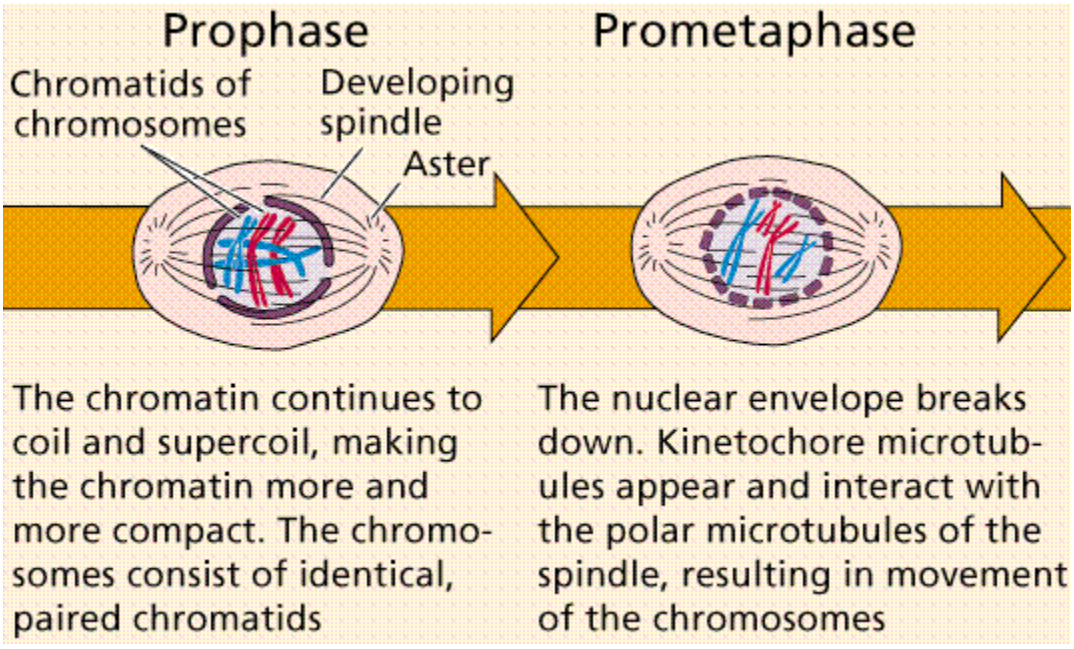
d. after interphase, cell division begins
i. the nucleus divides and then cytoplasm separates to form two (2) new cells

4. mitosis
a. this is the process in which the nucleus divides to form two (2) identical nuclei
i. each new nucleus is identical to the original nucleus
b. mitosis can be described as a series of phases, or steps
i. the steps in order are:
a. prophase
b. metaphase
c. anaphase
d. telophase

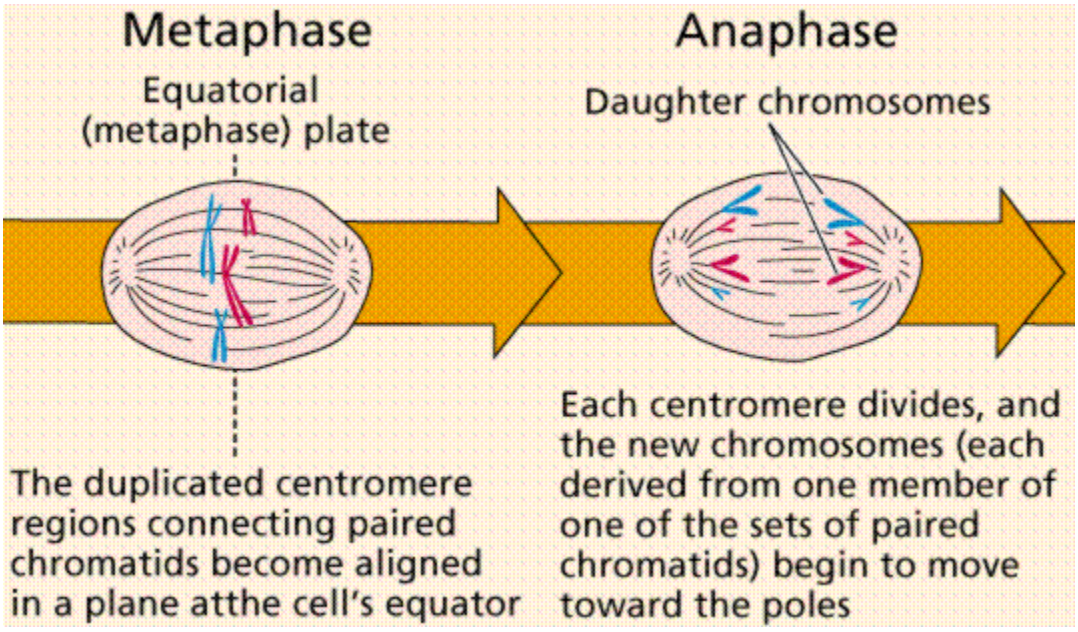
5. steps of mitosis
a. a chromosome is a structure in the nucleus that contains hereditary material
i. during interphase, each chromosome duplicates
ii. when the nucleus is ready to divide, each duplicated chromosome coils tightly into two thickened, identical strands called chromatids



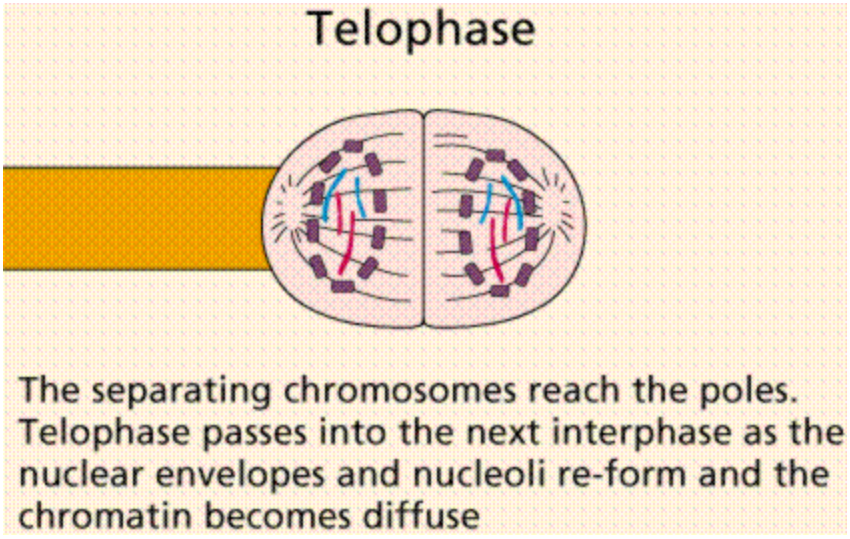
b. during prophase, the pairs of chromatids are fully visible when viewed under a microscope
i. the nucleolus and the nuclear membrane disintegrate
ii. two (2) small structures called centrioles move to opposite ends of the cell
iii. between the centrioles, threadlike spindle fibers begin to stretch across the cell
1. plant cells also form spindle fibers during mitosis but do not have centrioles



c. during metaphase, the pairs of chromatids line up across the center of the cell
   i. the centromere of each pair usually becomes attached to two (2) spindle fibers—one (1) from each side of the cell
d. during anaphase, each centromere divides and the spindle fibers shorten
   i. each pair of chromatids separates, and chromatids begin to move to opposite ends of the cell
   ii. the separated chromatids are now called chromosomes



e. in the final step, telophase, spindle fibers start to disappear, the chromosomes start to uncoil, and a new nucleus forms



f. for most cells, after the nucleus has divided, the cytoplasm separates and two (2) new cells are formed
i. in animal cells, the cell membrane pinches in the middle and the cytoplasm divides
ii. in plant cells, the appearance of a cell plate indicates that the cytoplasm is being divided
1. new cell walls form along the cell plate, and new cell membranes develop inside the cell walls
g. following division of the cytoplasm, new cells begin the period of growth (interphase) again

6. result of mitosis
a. produces two (2) new nuclei that are identical to each other and the original nucleus
i. each new nucleus has the same number and type of chromosomes
ii. every cell in your body, except sex cells, has a nucleus with 46 chromosomes—23 pairs
iii. each of the trillions of cells in your body, except sex cells, has a copy of the same hereditary material
iv. all of your cells use different parts of the same hereditary material to become different types of cells
b. cell division allows growth and replaces worn out or damaged cells
i. if you cut yourself, the wound heals because cell division replaces damaged cells

II. Asexual Reproduction
A. Reproduction is the process by which an organism produces others of the same kind
1. a new organism (sometimes more than one (1)) is produced from one (1) organism
a. the new organism will have hereditary material identical to the hereditary material of the parent organism.
2. cellular asexual reproduction
a. organisms with eukaryotic cells asexually reproduce by cell division
b. bacteria do not have a nucleus so they can’t use mitosis, hence they

reproduce asexually by fission
i. during fission, an organism whose cells do not contain a nucleus copies its genetic material and then divides into two (2) identical organisms

3. budding and regeneration
a. budding is a type of asexual reproduction made possible because of cell division
i. when the bud on the adult becomes large enough, it breaks away to live on its own

4. some organisms can regrow damaged or lost body parts
a. regeneration is the process that uses cell division to regrow body parts
i. sponges, planaria, sea stars, and some other organisms can use regeneration for asexual reproduction.

III. Sexual Reproduction

A. During sexual reproduction, two (2) sex cells, sometimes called an egg and a sperm, come together

1. sex cells are formed from cells in reproductive organs
a. sperm are formed in the male reproductive organs
b. eggs are formed in the female reproductive organs

B. The joining of an egg and a sperm is called fertilization, and the cell that forms is called a zygote

1. following fertilization, cell division begins
a. a new organism with a unique identity develops

C. Two (2) types of cells

1. diploid cells (body cell)
a. a typical human body cell has 46 chromosomes
i. each chromosome has a mate that is similar to it in size and shape and has similar DNA
ii. human body cells have 23 pairs of chromosomes
iii. when cells have pairs of similar chromosomes, they are said to be diploid.

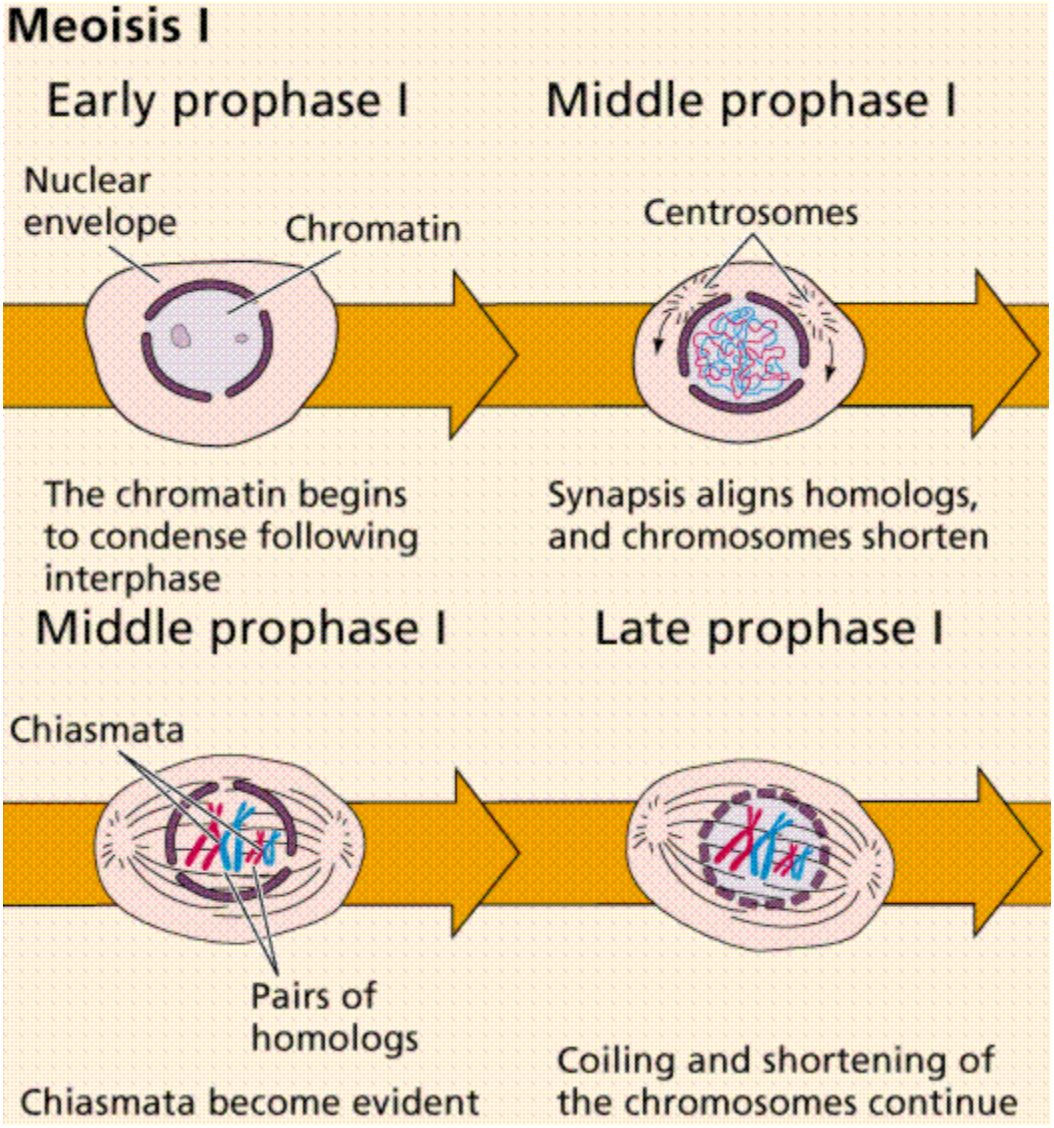
2. haploid cells (sex cell)
a. sex cells do not have pairs of chromosomes
i. they have only half the number of chromosomes as body cells

3. meiosis and sex cells
a. meiosis produces haploid sex cells

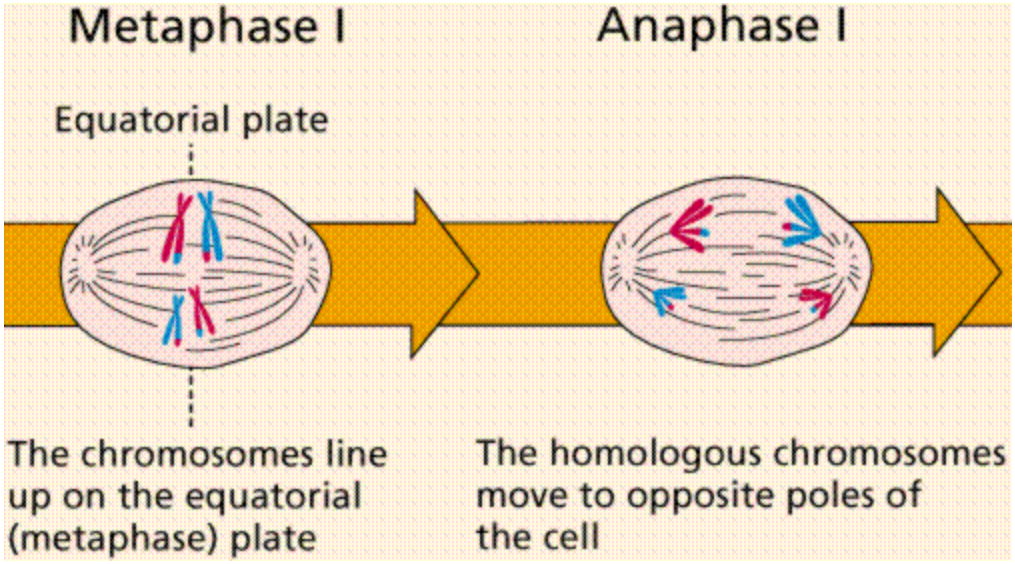
i. meiosis ensures that the offspring will have the same diploid number as its parent
1. after two (2) haploid sex cells combine, a diploid zygote is produced that develops into a new diploid organism

b. during meiosis, two (2) divisions of the nucleus occur
i. these divisions are called meiosis I and meiosis II
1. the steps of each division have names like those in mitosis and are numbered for the division in which they occur

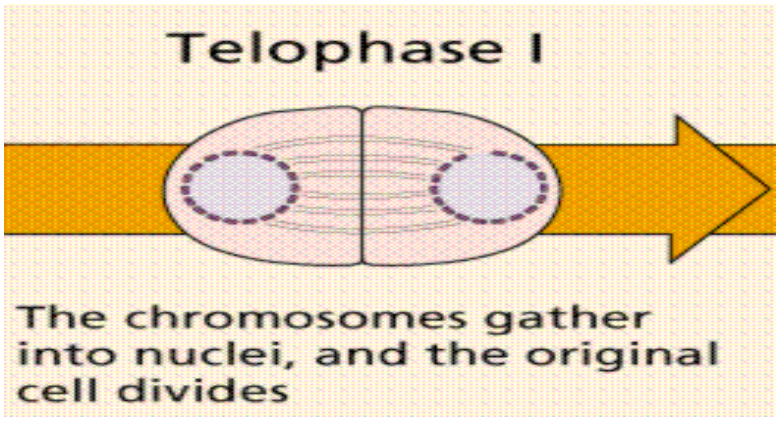
4. meiosis I
a. before meiosis begins, each chromosome is duplicated
b. when the cell is ready for meiosis, each duplicated chromosome is visible under the microscope as two chromatids
c. the events of prophase I are similar to those of prophase in mitosis



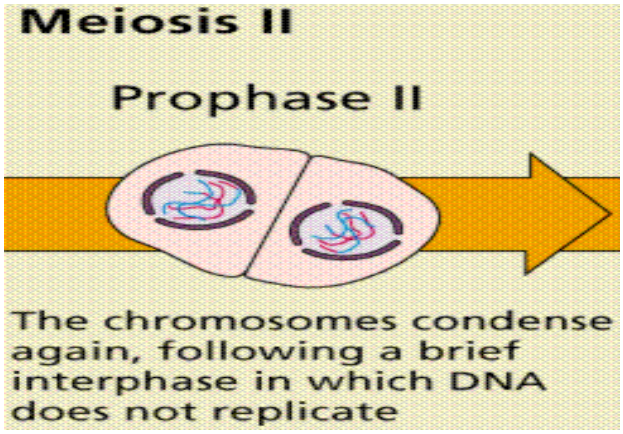
d. each duplicated chromosome comes near its similar duplicated mate
e. during metaphase I, the pairs of duplicated chromosomes line up in the center of the cell
i. the centromere of each chromatid pair becomes attached to one (1) spindle fiber, so the chromatids do not separate in anaphase I



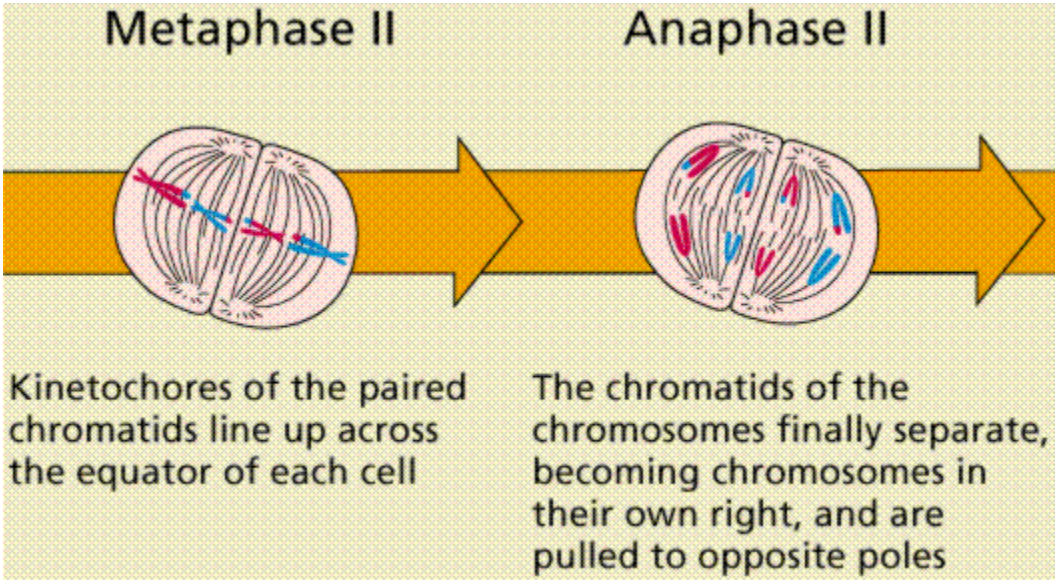
f. in anaphase I, the two (2) pairs of chromatids of each similar pair move away from each other to opposite ends of the cell
   i. each duplicated chromosome still has two (2) chromatids
g. in telophase I, the cytoplasm divides, and two (2) new cells form
   i. each new cell has one (1) duplicated chromosome from each similar pair



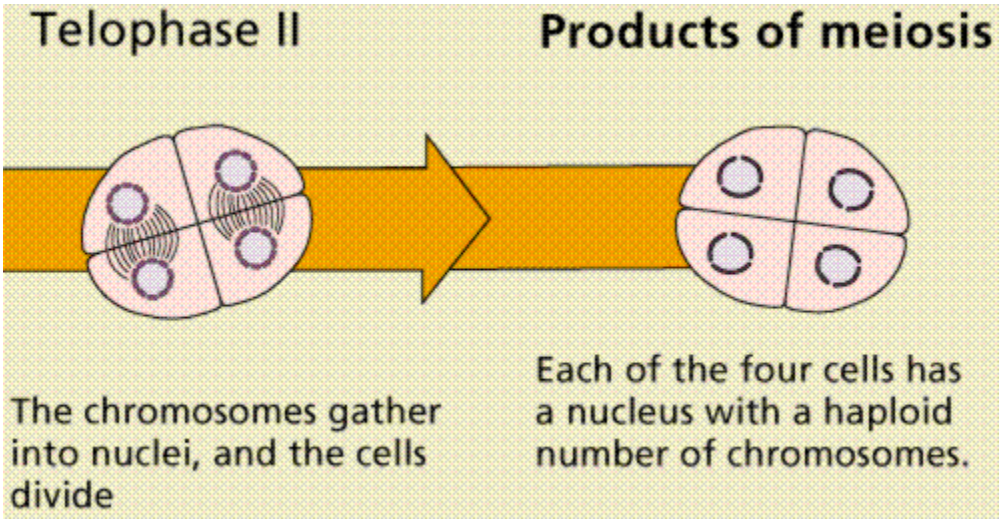
5. meiosis II
   a. the two (2) cells formed during meiosis I now begin meiosis II
      i. the chromatids of each duplicated chromosome will be separated during this division
   b. during prophase II, the duplicated chromosomes and spindle fibers reappear in each new cell



c. during metaphase II, the duplicated chromosomes move to the center of the cell
   i. unlike what occurs in metaphase I, each centromere now attaches to two (2) spindle fibers instead of one (1)
d. the centromere divides during anaphase II, and the chromatids separate and move to opposite ends of the cell
   i. each chromatid now is an individual chromosome



e. as telophase II begins, the spindle fibers disappear, and a nuclear membrane forms around the chromosomes at each end of the cell
f. when meiosis II is finished, the cytoplasm divides

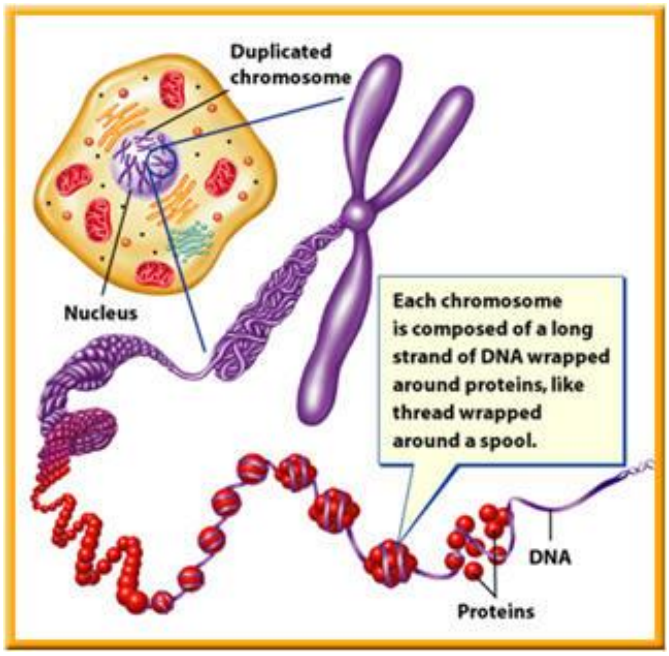


6. mistakes of meiosis
   a. mistakes can produce sex cells with too many or too few chromosomes
      i. usually zygotes produced from these sex cells die
      ii. if the zygote lives, every cell in the organism that grows from that zygote will have the wrong number of chromosomes
         1. organisms with the wrong number of chromosomes may not grow normally.

IV. What is DNA?

A. A cell uses a code in its hereditary material called deoxyribonucleic acid, or DNA

1. it contains information for an organism's growth and function



2. DNA is stored in cells that have a nucleus
   a. when a cell divides, the DNA code is copied and passed to the new cells
      i. new cells receive the same coded information that was in the original cell

B. Discovering DNA

1. since the mid-1800s, scientists have known that the nuclei of cells contain large molecules called nucleic acids
2. by 1950, chemists had learned what nucleic acid DNA was made of, but they didn't understand how the parts of DNA were arranged

C. DNA's structure

1. in 1952, scientist Rosalind Franklin discovered that DNA is two chains of molecules in a spiral form
   a. by using an X-ray technique, Dr. Franklin showed that the large spiral was probably made up of two spirals
2. in 1953, scientists James Watson and Francis Crick made a model of a DNA molecule

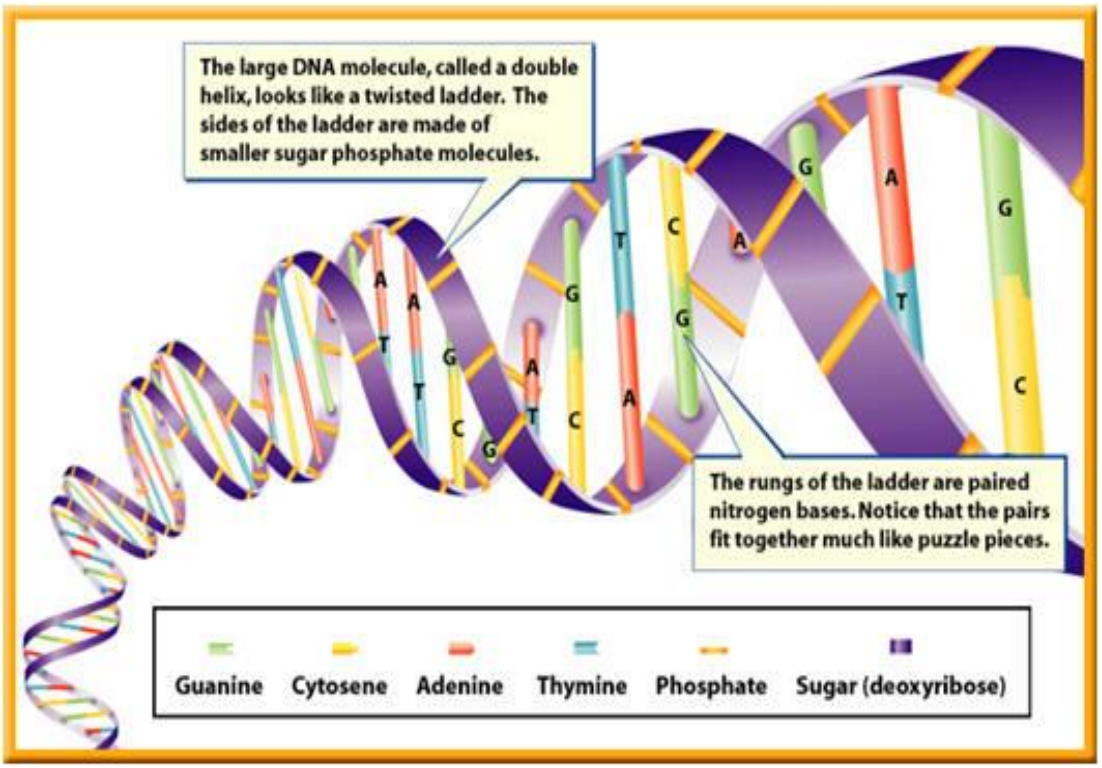
D. DNA model

1. according to the Watson and Crick DNA model, each side of the ladder is made up of sugar-phosphate molecules
   a. each molecule consists of the sugar called deoxyribose and a phosphate group
   b. the rungs of the ladder are made up of other molecules called nitrogen bases
   c. four kinds of nitrogen bases are found in DNA

1. adenine (A)
2. guanine (G)
3. cytosine (C)
4. thymine (T)

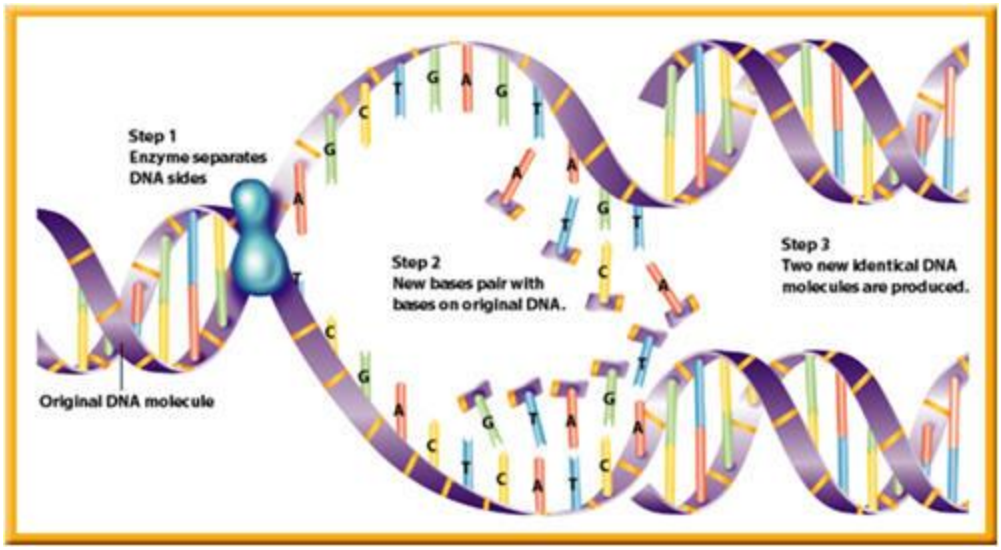
d. the amount of cytosine in cells always equals the amount of guanine and the amount of adenine always equals the amount of thymine

e. adenine always pairs with thymine, and guanine always pairs with cytosine



E. Copying DNA

1. when chromosomes are duplicated before mitosis or meiosis, the amount of DNA in the nucleus is doubled
2. the two (2) sides of DNA unwind and separate
3. each side then becomes a pattern on which a new side forms
4. the new DNA has bases that are identical to those of the original DNA and are in the same order



F. Genes
1. most of your characteristics, such as the color of your hair, your height, and even how things taste to you, depend on the kinds of proteins your cells make
2. DNA in your cells stores the instructions for making these proteins
   a. proteins build cells and tissues or work as enzymes
   b. the instructions for making a specific protein are found in a gene which is a section of DNA on a chromosome
      i. each chromosome contains hundreds of genes
3. proteins are made of chains of hundreds or thousands of amino acids
4. the gene determines the order of amino acids in a protein
   a. changing the order of the amino acids makes a different protein.

G. making proteins
1. genes are found in the nucleus, but proteins are made on ribosomes in cytoplasm
2. the codes for making proteins are carried from the nucleus to the ribosomes by another type of nucleic acid called ribonucleic acid, or RNA.

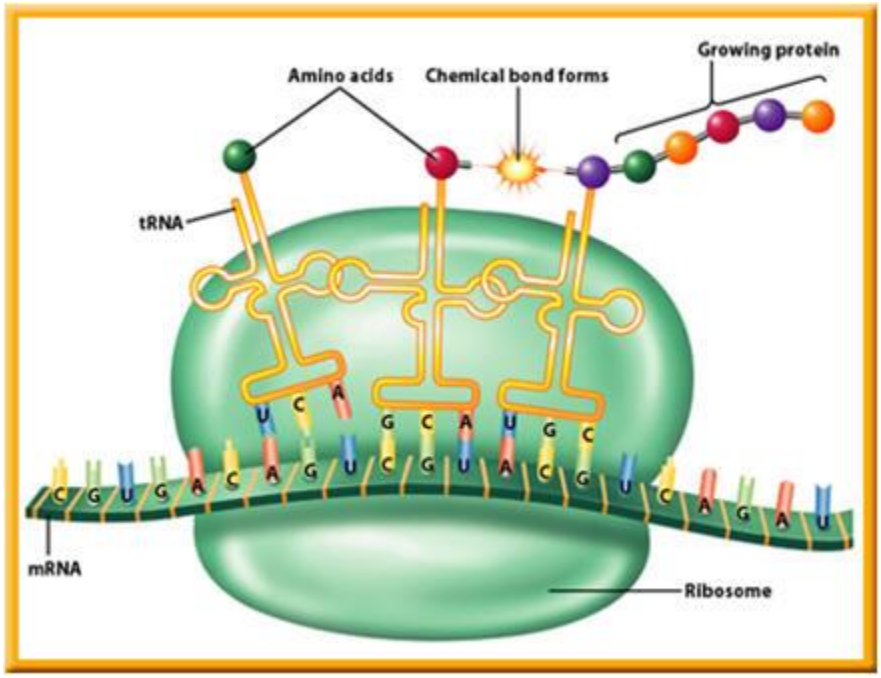
V. Ribonucleic Acid

A. RNA is made in the nucleus on a DNA pattern, but RNA is different from DNA
1. RNA is like a ladder that has all its rungs sawed in half
2. RNA has the bases adenine (A) guanine (G) and cytosine (C) DNA but has uracil (U) instead of thymine (T)
3. the sugar-phosphate molecules in RNA contain the sugar ribose, not deoxyribose

B. There are three (3) main kinds of RNA
1. messenger RNA (mRNA)
   a. protein production begins when mRNA moves into the cytoplasm; there, ribosomes attach to it
2. ribosomal (rRNA)
   a. ribosomes are made of rRNA
3. transfer RNA (tRNA)

a. transfer RNA molecules in the cytoplasm bring amino acids to these ribosomes
i. inside the ribosomes, three (3) nitrogen bases on the mRNA temporarily match with three (3) nitrogen bases on the tRNA
ii. the same thing happens for the mRNA and another tRNA molecule
iii. the amino acids that are attached to the two (2) tRNA molecules bond and form a protein
iv. the code carried on the mRNA directs the order in which the amino acids bond

b. after a tRNA molecule has lost its amino acid, it can move about the cytoplasm and pick up another amino acid just like the first one
i. the ribosome moves along the mRNA
ii. new tRNA molecules with amino acids match up and add amino acids to the protein molecule



C. Controlling genes
1. in many-celled organisms each cell uses only some of the thousands of genes that it has to make proteins
a. each cell uses only the genes that direct the making of proteins that it needs
i. for example, muscle proteins are made in muscle cells but not in nerve cells
2. cells must be able to control genes by turning some genes off and turning other genes on
a. sometimes the DNA is twisted so tightly that no RNA can be made
b. other times, chemicals bind to the DNA so that it cannot be used
c. if the incorrect proteins are produced, the organism cannot function properly

VI. Mutations

A. If DNA is not copied exactly, the proteins made from the instructions might not be made correctly

B. These changes, called mutations, are any permanent change in the DNA sequence of a gene or chromosome of a cell

1. outside factors such as X rays, sunlight, and some chemicals have been known to cause mutations

C. Results of a mutation

1. genes control the traits you inherit

a. without correctly coded proteins, an organism can't grow, repair, or maintain itself

b. a change in a gene or chromosome can change the traits of an organism

c. if the mutation occurs in a body cell, it might or might not be life threatening to the organism

d. if a mutation occurs in a sex cell, then all the cells that are formed from that sex cell will have that mutation

e. mutations add variety to a species when the organism reproduces

i. many mutations are harmful to organisms, often causing their death

ii. some mutations do not appear to have any effect on the organism, and some can even be beneficial