Genetics: Cell Reproduction and Inheritance
ENVS 10
Lecture 6

You began life as a single cell, but there are now more cells in your body than stars in the Milky Way.

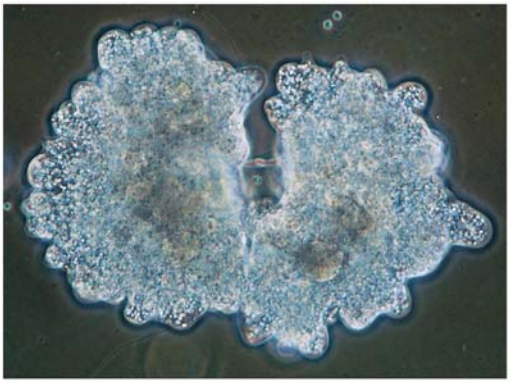
Just in the past second, millions of your cells have divided in two.

What Cell Reproduction Accomplishes

- Reproduction
  - Is the birth of new organisms.
  - Occurs much more often at the cellular level.
- Cell reproduction (*cell division*) plays a role in
  - The replacement of lost or damaged cells.
  - Cell growth.

The Reproduction of Organisms

- In asexual reproduction, single-celled organisms reproduce by simple cell division.
  - No fertilization.
  - Inherit all chromosomes from a single parent so parent and offspring are genetically identical.
  - **Mitosis**: type of cell division responsible for asexual reproduction and growth and maintenance of multicellular organisms.



(a) Amoeba.

Figure 8.2a

- Sexual reproduction is different.
  - It requires fertilization of an egg by a sperm.
  - **Meiosis**: Production of egg and sperm cells.
  - **Mitosis**: Used for growth and maintenance in sexually reproducing organisms.

Eukaryotic Chromosomes

- Chromosomes are lead players in cell division.
  - Each eukaryotic chromosome contains one very long DNA molecule, typically bearing thousands of genes.
  - Chromosomes are made of chromatin, a combination of DNA and protein molecules.
  - Located in the cell nucleus.

- The DNA in a chromosome is packed into an elaborate, multilevel system of coiling and folding.
- Allows long molecules of DNA to fit in the nucleus.

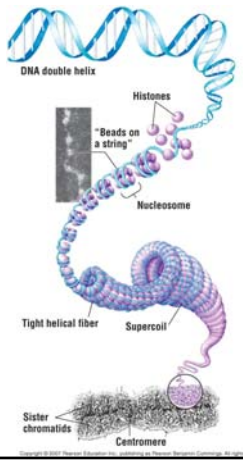


Figure 8.5

- Before a cell divides, it duplicates all of its chromosomes, resulting in two copies called sister chromatids.
  - Contain identical genes.
  - Joined tightly at narrow waist called **centromere**.
- When the cell divides, the sister chromatids separate from each other.

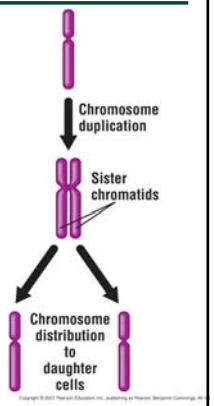


Figure 8.6

The Cell Cycle

- Eukaryotic cells that divide undergo an orderly sequence of events called the cell cycle.
- The cell cycle consists of two distinct phases:
  1. ***Interphase***: normal cell functions, cell growth, *chromosome duplication*, cell preparation to divide.
  2. ***Mitotic phase***: Cell is dividing!
     - Mitosis: nucleus and its contents (duplicated chromosomes) divide and are evenly distributed, forming two daughter nuclei
     - Cytokinesis: the division of the cytoplasm.
- **Result**: Production of two genetically identical daughter cells, each with a single nucleus, surrounding cytoplasm with organelles, and a plasma membrane.

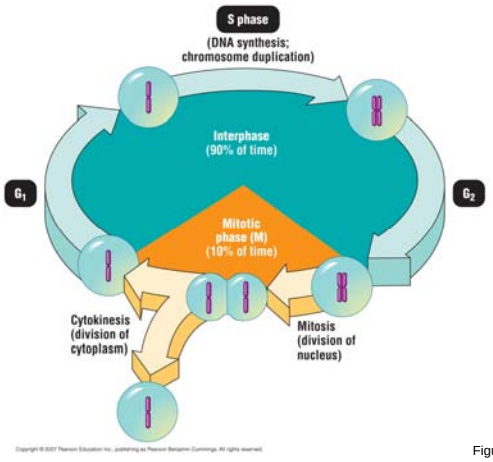


Figure 8.7

- **Interphase** - time when cells perform normal functions within the organism.
  - Cell growth - cell makes new molecules and organelles.
  - Chromosome duplication!
  - Cell prepares to divide and contains 2 sister chromatids.

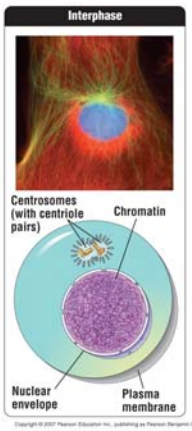


Figure 8.8.1

Mitosis

- Four main stages:
  - Prophase, Metaphase, Anaphase, Telophase.
- Chromosomes are “stars” of mitotic drama.
  - Chromosome movement depends on ***mitotic spindle*** - football shaped structure of microtubules that guides the separation of two sets of daughter chromosomes.
  - Spindle grows from centrosomes, clouds of cytoplasmic material that contain centrioles.

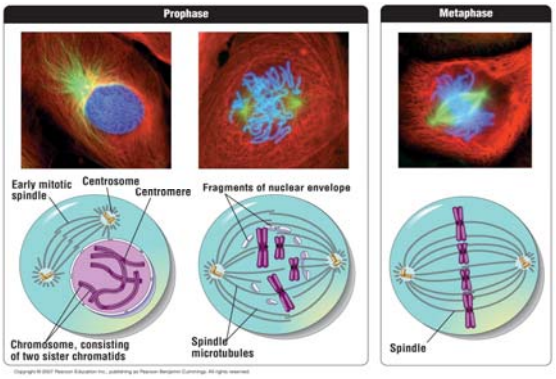


Figure 8.8.2

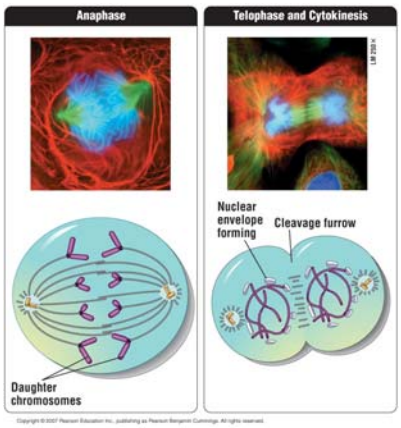


Figure 8.8.3

Meiosis, The Basis of Sexual Reproduction

- Sexual reproduction depends on
  - Meiosis.
  - Fertilization.

Homologous Chromosomes

- Different organisms of the same species have the same number and types of chromosomes.
- A somatic cell
  - Is a typical human body cell.
  - Has 46 chromosomes.
- Homologous chromosomes are matching pairs of chromosomes.
  - Carry versions of the same genes.
- Sex chromosomes and autosomes.

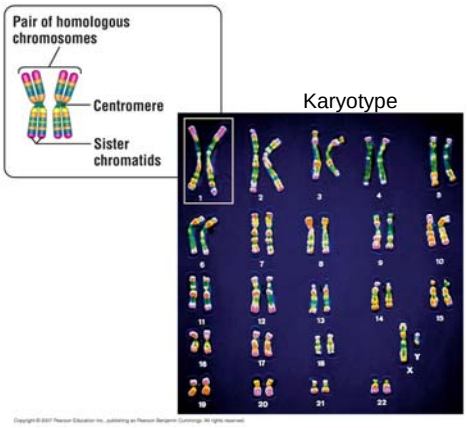


Figure 8.13

Gametes and the Life Cycle of a Sexual Organism

- The life cycle of a multicellular organism is the sequence of stages leading from the adults of one generation to the adults of the next.
- Humans are ***diploid*** organisms.
  - Their cells contain homologous pairs of chromosomes.
- Human gametes (egg and sperm) are ***haploid***, having only one set of chromosomes that through fertilization, produce a diploid zygote.

The Process of Meiosis

- Meiosis - the process that produces haploid daughter cells in diploid organisms.
  - Meiosis I: Homologous chromosomes separate.
  - Meiosis II: Sister chromatids separate.

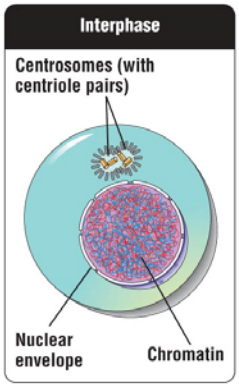


Figure 8.16.1

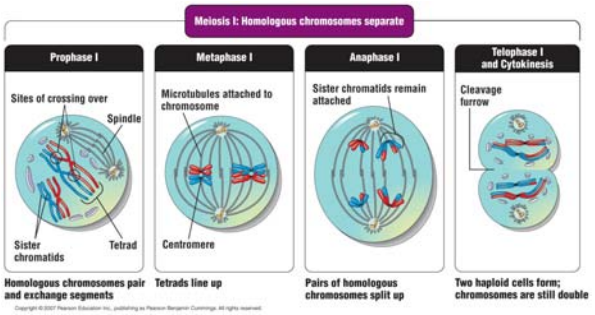


Figure 8.16.2

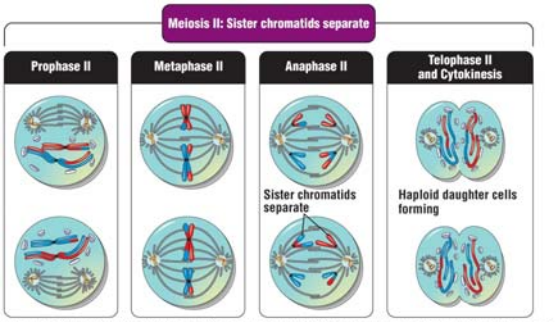


Figure 8.16.3

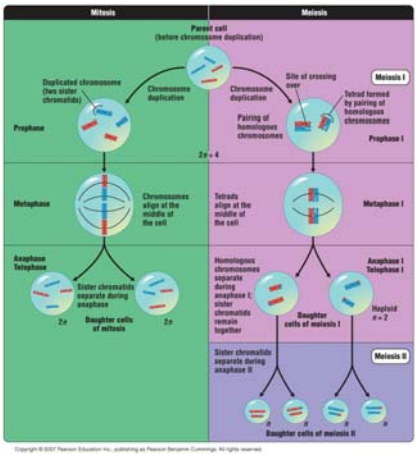


Figure 8.17

	MITOSIS	MEIOSIS
# chromosomal duplications		
# cell divisions		
# daughter cells produced		
# chromosomes in daughter cells		
How chromosomes line up during metaphase		
Genetic relationship of daughter cell to parent		
Functions performed in human body		

	MITOSIS	MEIOSIS
# chromosomal duplications	1	1
# cell divisions	1	2
# daughter cells produced	2	4
# chromosomes in daughter cells	2*n*	*n*
How chromosomes line up during metaphase	Individually	By homologous pair
Genetic relationship of daughter cell to parent	Identical	Unique
Functions performed in human body	Repair, growth, development	Gamete formation

The Origins of Genetic Variation

- Offspring of sexual reproduction are genetically different from their parents and from one another.
- This genetic variety in offspring is the raw material for natural selection.

When Meiosis Goes Awry

- What happens when errors occur in meiosis?
- One example: Down Syndrome
  - Is a condition where an individual has an extra chromosome 21.
  - Is also called trisomy 21.

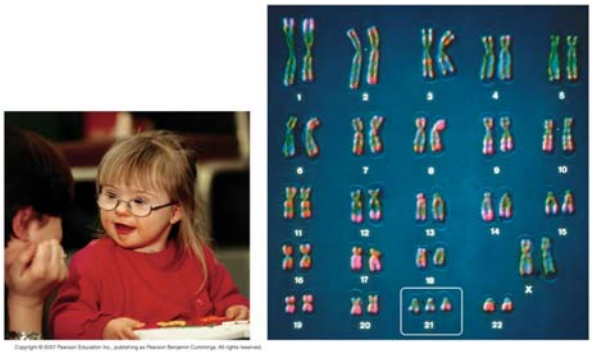


Figure 8.22

Heritable Variation and Patterns of Inheritance

- Gregor Mendel
  - Was the first person to analyze patterns of inheritance.
  - Deduced the fundamental principles of genetics.
  - Experiments with garden peas.

Figure 9.2

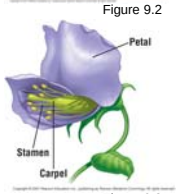


Figure 9.3

In an Abby Garden

- Mendel carried out some self- and cross-fertilization experiments.
- He also created true-breeding (purebred) varieties of plants.
- Mendel then crossed two different true-breeding varieties to make hybrids.

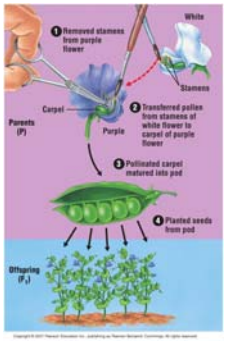


Figure 9.4

Mendel's Law of Segregation

- Mendel performed many experiments.
  - He tracked several characteristics in pea plants from which he formulated several hypotheses.

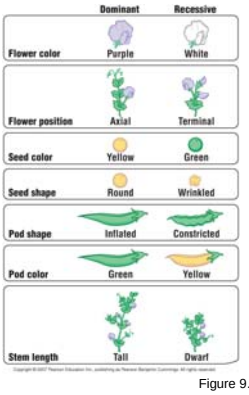


Figure 9.5

Monohybrid Crosses

- A monohybrid cross is a cross between parent plants that differ in only one characteristic.
- F_1 generation are all purple - was heritable factor for white flowers lost?
- No! White appears in F_2

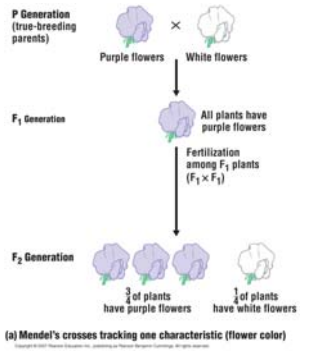


Figure 9.6a

- Mendel developed four hypotheses from the monohybrid cross:
  - There are alternative forms of genes, called alleles.
  - For each characteristic, an organism inherits two alleles, one from each parent.
  - Alleles can be dominant or recessive.
  - Gametes carry only one allele for each inherited characteristic.

- Mendel developed four hypotheses from the results of the monohybrid cross:
  1. There are alternative forms of genes, the units that determine heritable traits - called ***alleles***.

     Example: the gene for flower color in pea plants exists in one form for purple and another for white.

- Mendel developed four hypotheses from the monohybrid cross:
  2. For each inherited characteristic, an organism inherits two alleles, one from each parent.
  - Alleles may be the same or different.
    - Organism that has two identical alleles for a gene is said to be ***homozygous*** for that gene.
    - Organism that has two different alleles for a gene is said to be ***herterozygous*** for that gene.

- Mendel developed four hypotheses from the monohybrid cross:

  3. Alleles can be dominant or recessive.

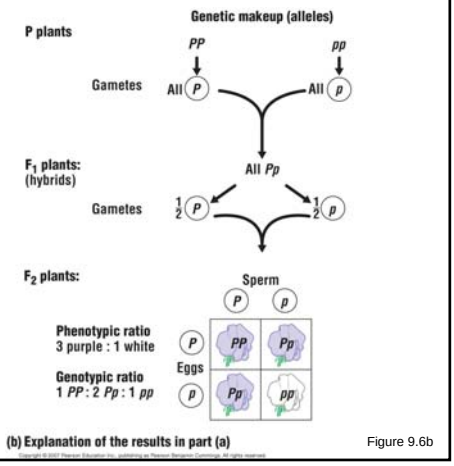
  – If the two alleles of an inherited pair differ, then one determines that organism's appearance and is called the ***dominant*** allele (e.g., *P* - purple flower allele).

  – The other allele has no noticeable affect on the organism's appearance and is called ***recessive*** (e.g., *p* - white flower allele).

- Mendel developed four hypotheses from the monohybrid cross:

  4. A sperm or egg carries only one allele for each inherited characteristic because the two members of an allele pair segregate (separate) from each other during production of gametes. Now known as ***Law of Segregation***.

Punnett Square



(b) Explanation of the results in part (a)

Figure 9.6b

Appearances Don't Tell Everything!

- Phenotype
  - An organism's physical traits.
  - E.g., purple or white flowers
- Genotype
  - An organism's genetic makeup.
  - E.g., *PP*, *Pp*, *pp*

Genetic Alleles and Homologous Chromosomes

- Homologous chromosomes
  - Have genes at specific loci.
  - Have alleles of a gene at the same locus.

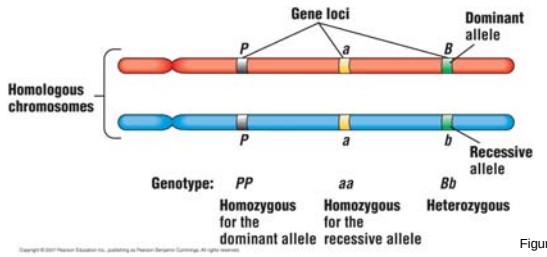


Figure 9.7

Mendel's Law of Independent Assortment

- Mendel then extended his experiments to look at crosses between parental varieties that differed in more than one characteristic - e.g., seed color and seed shape.
- Asked: Were the two characteristics transmitted as a package (dependent assortment) or were they inherited independently of each other?
- Tested using a dihybrid cross

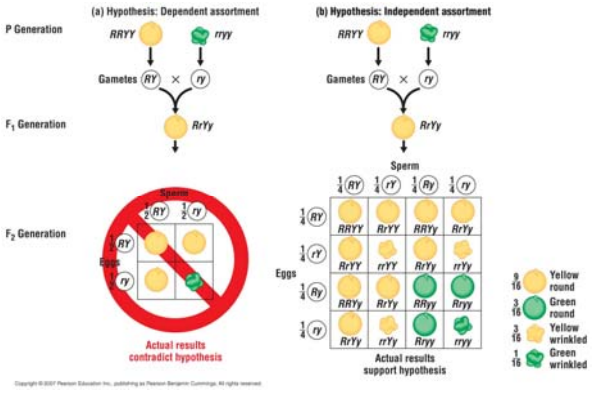


Figure 9.8

- Mendel found that four different phenotypes were produced - yellow round, green round, yellow wrinkled, green wrinkled.
- Mendel's **law of independent assortment** states that: inheritance of one characteristic has no effect on on the inheritance of another.
  - Each pair of alleles segregates independently of the other pairs during gamete formation.

Variations on Mendel's Laws

- Mendel's laws explain inheritance in terms of discrete factors - genes.
- Mendel's laws stop short of explaining some patterns of genetic inheritance that exist in more than two clear-cut variants - flower color (red, white, pink) or human skin color in all its range of shades.
- We will explore one example of a variation on Mendel's laws.

ABO Blood Type: An Example of Multiple Alleles and Codominance

- The ABO blood groups in humans are an example of ***multiple alleles.***

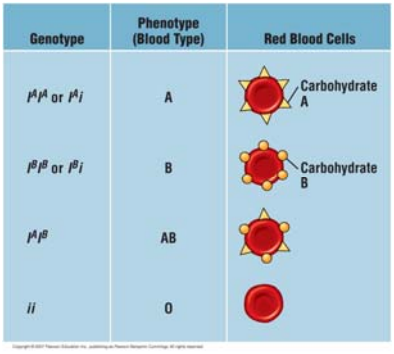


Figure 9.18

- The immune system produces blood proteins called antibodies that can bind specifically to the blood cell carbohydrates we lack.
  - When a donor's blood cells have a carbohydrate that is foreign to the recipient, the recipient's antibodies will cause the donated blood cells to clump together.
  - Can kill the recipient.

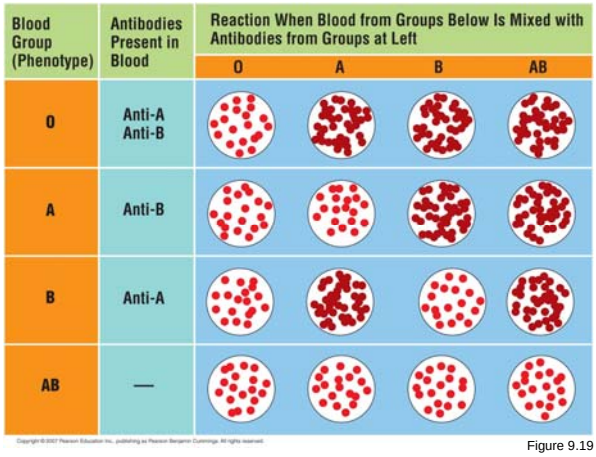


Figure 9.19

- Four blood types result from various combinations of three different alleles.
- Each person inherits one of these alleles from each parent.
  - Because 3 alleles, 6 possible genotypes.
- Two of the human blood type alleles exhibit ***codominance.***
  - Meaning that both alleles are expressed in the phenotype.