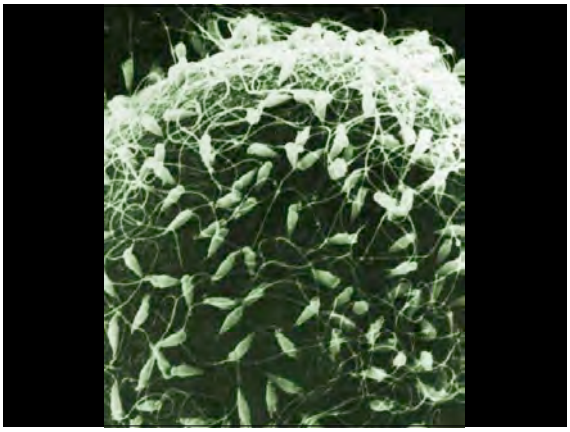
Sexual Reproduction and Meiosis

Chapter 13 in Campbell et al.

- Mitosis (along with cytokinesis) produces two daughter cells, each *genetically identical to the parental cell*.
- But there is one situation where you want to produce cells genetically different from the parental cell…



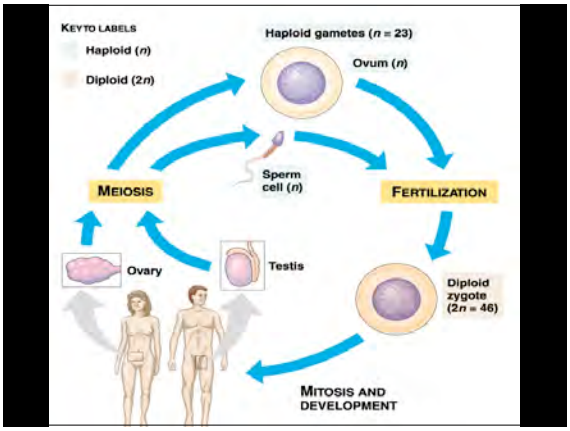
Asexual reproduction, sexual reproduction

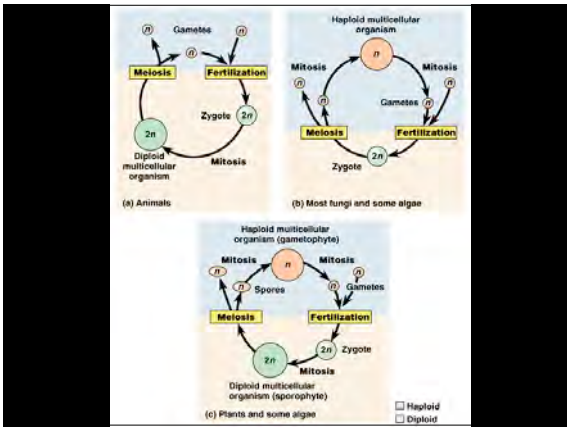
Asexual reproduction

- New individuals form by budding from parent
- Typically rapid
- Offspring are genetically identical to parent
- Mitotic cell division only

Sexual reproduction - overview

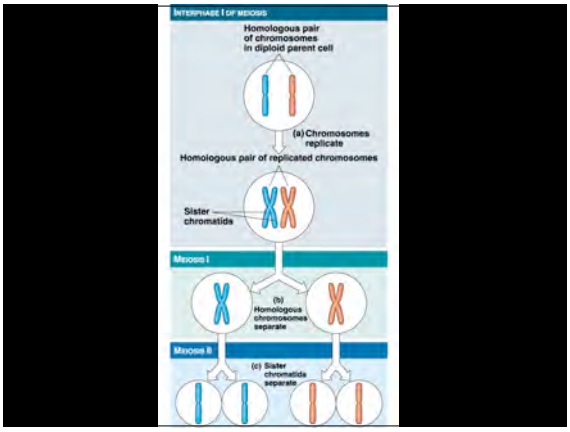
- Parents form haploid gametes
- Two gametes unite to form a zygote
- Zygote grows into a new individual (offspring)
- Offspring are *not* identical to parents
- Meiosis is a special form of cell division that produces haploid cells (gametes)
- There are disadvantages and advantages to sexual reproduction
- There are a variety of sexual life cycles



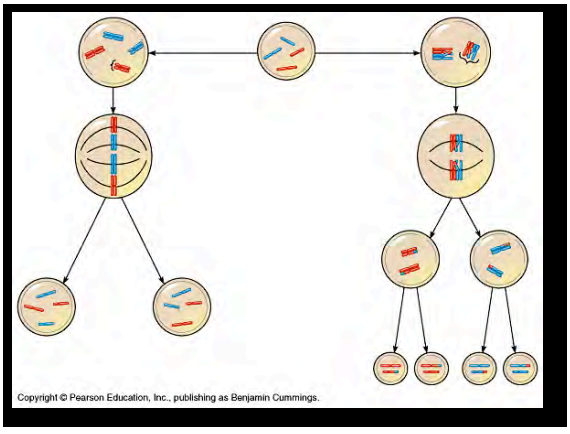


Meiosis is how haploid gametes are produced

- A cell undergoes a normal cell cycle before a meiotic division - DNA is duplicated
- Meiosis involves two separate divisions, producing four haploid cells
- Each gamete produced is genetically unique



Mitosis and Meiosis Compared…



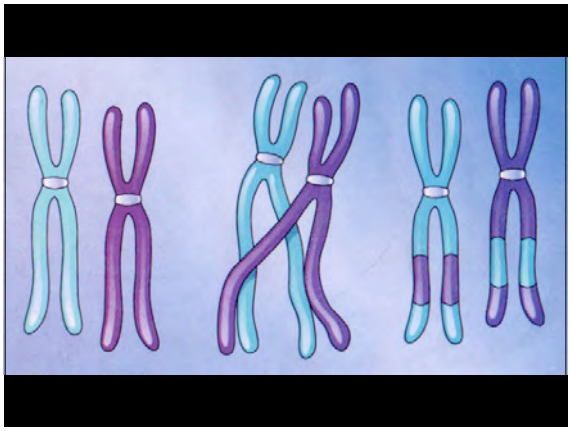
First Key Difference:

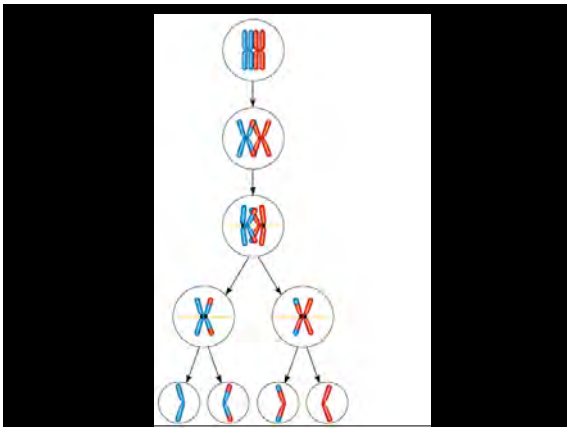
Meiosis involves two rounds of cell division, not just one.

The first meiotic division reduces the chromosome number to the haploid number; the second division separates sister chromatids.

Second Key Difference:

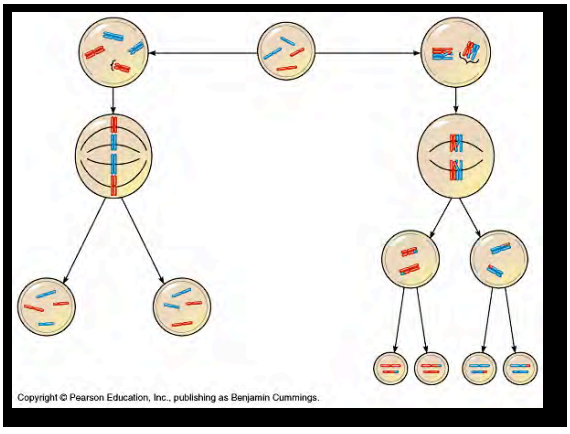
Pairing up of chromosomes in prophase I of meiosis - synapsis and crossing over lead to genetic exchange between homologous chromosomes





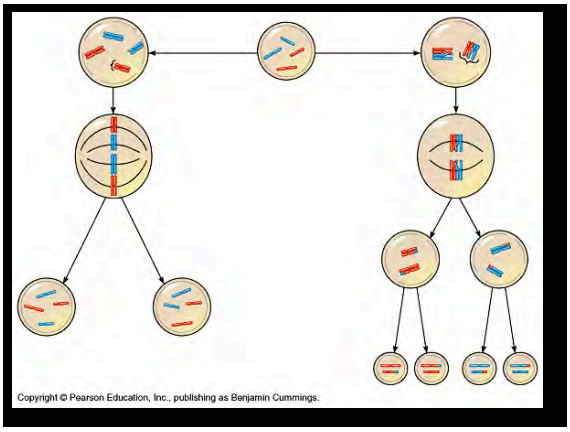
Third Key Difference

- In metaphase of meiosis I, homologous chromosomes line up in **pairs** at the equatorial plane, unlike in mitosis (or the second meiotic division), where chromosomes line up individually at the equatorial plane.



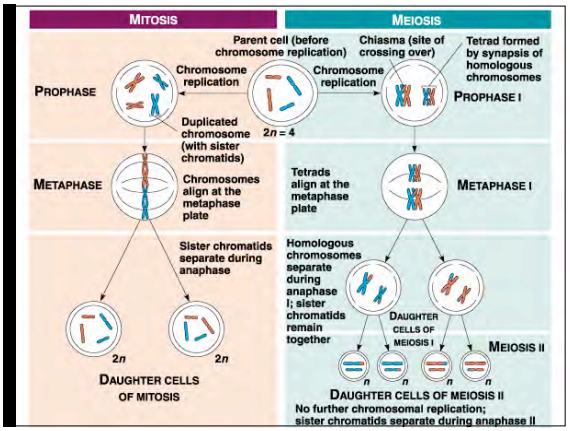
Fourth key difference

- At anaphase of meiosis I, one homologous chromosome from each pair goes to the opposite pole (compare anaphase of mitosis, or of meiosis II, where sister chromatids separate)



Meiosis II

- The second meiotic division is similar to a mitotic division with only N duplicated chromosomes - the sister chromatids separate at anaphase



Bottom line

- Meiosis produces four haploid gametes, each genetically unique

Another Movie

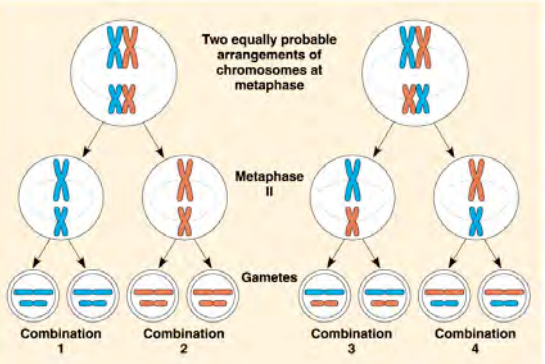
Where the variation in offspring comes from

- One human (or frog, or tree) can produce a huge number of different possible gametes. Variation in offspring is caused by
  - Independent assortment of chromosomes at metaphase/anaphase I (shuffle the chromosomes)
  - Crossing over during prophase I (shuffle the parts of each chromosome)
  - Union of gametes from two individuals

Variation due to independent assortment

- How many ways are there to pick a haploid set of chromosomes from the same diploid set?
- You can calculate this…

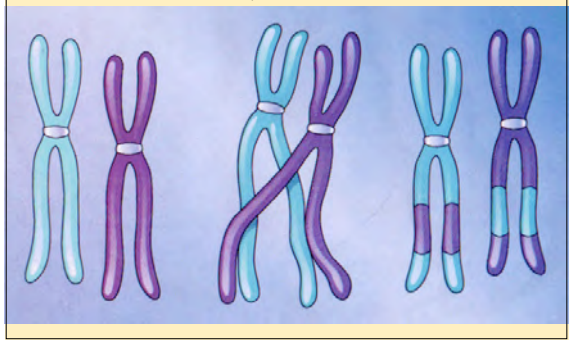
Independent assortment



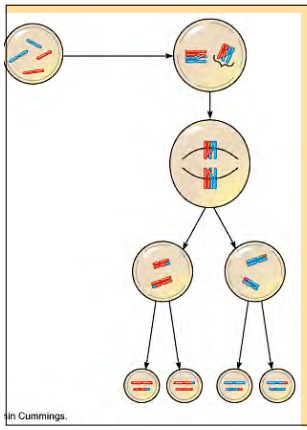
- If you are choosing one of two chromosomes from each of N pairs of chromosomes, then the total number of possible ways to form a gamete is 2^N
- $2^2 = 4$, $2^3 = 8$, $2^{23} = 8{,}388{,}608$

Variation due to Crossing over

Millions of ways to shuffle each chromosome



- If you are choosing one of one million different chromosomes from each of N pairs of chromosomes, then the total number of possible ways to form a gamete is $1{,}000{,}000^N$
- $1{,}000{,}000^{23}$ = AVBN



Crossing over *plus* independent assortment - AVBN of possible gametes

Variation due to Random Fertilization

- How many types of egg? AVBN
- How many types of sperm? AVBN
- How many ways to combine one sperm with one egg? AVBN x AVBN