Sexual life cycles produce genetic variation among offspring

- The behavior of chromosomes during meiosis and fertilization is responsible for most of the variation that arises each generation during sexual reproduction.
- Three mechanisms contribute to genetic variation:
  - independent assortment
  - crossing over
  - random fertilization
- Independent assortment of chromosomes contributes to genetic variability due to the ***random orientation of tetrads*** at the metaphase plate.
  - There is a fifty-fifty chance that a particular daughter cell of meiosis I will get the maternal chromosome of a certain homologous pair and a fifty-fifty chance that it will receive the paternal chromosome.
- Each homologous pair of chromosomes is ***positioned independently*** of the other pairs at metaphase I.
- Therefore, the first meiotic division results in independent assortment of maternal and paternal chromosomes into daughter cells.
- The number of combinations possible when chromosomes sort independently into gametes is 2^n, where n is the haploid number of the organism.
  - If n = 3, there are eight possible combinations.
  - For humans with n = 23, there are 2^{23} or about 8 million possible combinations of chromosomes.
- Independent assortment ***alone*** would allow for each individual chromosome in a gamete to be exclusively maternal or paternal in origin.
- However, **crossing over** produces **recombinant chromosomes w**hich combine genes inherited from each parent.

- Crossing over begins very early in prophase I as homologous chromosomes pair up gene by gene.

- In crossing over, homologous portions of ***two non sister chromatids*** trade places – so this means that genes from the "daddy" chromosome trades places with genes from the "mommy" chromosome.

    - For humans, this occurs two to three times per chromosome pair.

- One sister chromatid may undergo different patterns of crossing over than its match.

- Also, the farther apart genes are from each other on a particular chromosome, the more likely they will be involved in crossing over

- Independent assortment of these nonidentical sister chromatids during meiosis II increases still more the number of genetic types of gametes that can result from meiosis.

- The random nature of fertilization adds to the genetic variation arising from meiosis.

- Any sperm can fuse with any egg.

    - A zygote produced by mating of a woman and man has a unique genetic identity.

    - An ovum is one of approximately 8 million possible chromosome combinations (actually 2^{23}).

    - The successful sperm represents one of 8 million different possibilities (actually 2^{23}).

    - The resulting zygote is composed of 1 in 70 trillion ($2^{23} \times 2^{23}$) possible combinations of chromosomes.

    - Crossing over adds even more variation to this.

- The three sources of genetic variability in a sexually reproducing organism are:

    - Independent assortment of homologous chromosomes during meiosis I and of non identical sister chromatids during meiosis II.

    - Crossing over between homologous chromosomes during prophase I.

    - Random fertilization of an ovum by a sperm.

- All three mechanisms reshuffle the various genes carried by individual members of a population.

- Mutations, still to be discussed, are what ultimately create a population's diversity of genes.

Evolutionary adaptation depends on a population's genetic variation

- Darwin recognized the importance of genetic variation in evolution via natural selection.
- A population evolves through the differential reproductive success of its variant members.
- Those individuals best suited to the local environment leave the most offspring, transmitting their genes in the process.
- This natural selection results in adaptation, the accumulation of favorable genetic variations.
- As the environment changes or a population moves to a new environment, new genetic combinations that work best in the new conditions will produce more offspring and these genes will increase.
    - The formerly favored genes will decrease.
- Sex and mutations are two sources of the continual generation of new genetic variability.
- Gregor Mendel, a contemporary of Darwin, published a theory of inheritance that helps explain genetic variation.
    - However, this work was largely unknown for over 40 years until 1900.