

Meiosis

Octopus Sex and Other Stories

- A. There are many variations of reproductive activity both sexual and asexual.
- B. Sexual reproduction requires meiosis and fertilization.

I. Comparing Sexual With Asexual Reproduction

A. In asexual reproduction, one parent passes a duplicate of its genes (DNA molecules) to its offspring, which can only be genetically identical clones of the parent.

B. In sexual reproduction, each parent contributes one gene for each trait.

1. Genes for each trait come in slightly different forms called alleles, originally produced by mutations.

2. Meiosis shuffles the alleles during gamete formation, and fertilization produces offspring with unique combinations of alleles.

3. The variation generated by sexual reproduction is the testing ground for natural selection and is the basis for evolutionary change.

II. How Meiosis Halves the Chromosome Number

A. Think "Homologues"

1. Meiosis begins with diploid ($2n = 46$) germ cells and produces haploid gametes ($n = 23$).

a. In $2n$ cells there are two chromosomes of each type, called homologous chromosomes.

b. Homologous chromosomes line up (even unequally matched sex chromosomes!) during meiosis.

2. Meiosis produces gametes that have *one of each pair* of homologous chromosomes, i.e., they are haploid.

B. Two Divisions, Not One

1. In some ways meiosis resembles mitosis:

a. The chromosomes are duplicated during interphase to form sister chromosomes held together at the centromere.

b. Chromosomes are moved by the microtubules of the spindle apparatus.

2. Unlike mitosis, meiosis has two series of divisions—meiosis I and II.

a. During meiosis I, homologous chromosomes pair and the cytoplasm divides later.

1) Each of the two daughter cells receives a haploid number of chromosomes.

2) Each chromosome *is still duplicated*.

b. In meiosis II, the sister chromatids of each chromosome separate; the cytoplasm divides again, resulting in four haploid cells.

III. A Visual Tour of the Stages of Meiosis

[This section is exclusively a two-page figure of meiosis I and II.]

IV. A Closer Look at Key Events of Meiosis I

A. What Goes On in Prophase I?

1. Homologous chromosomes pair up.

a. Nonsister chromatids exchange segments in a process called crossing over.

b. Because alleles for the same trait can vary, new combinations of genes in each chromosome can result; this is one source of genetic variation.

2. Crossing over leads to genetic recombination.

B. Metaphase I Alignments

1. During metaphase I, homologous chromosomes randomly line up at the spindle equator.

2. During anaphase I, homologous chromosomes (still duplicated) separate into two haploid cells, each of which has a *random* mix of maternal and paternal chromosomes.

V. From Gametes To Offspring

A. Gamete Formation in Plants

1. Events such as spore formation may occur between meiosis and gamete formation.

2. Haploid spores germinate into haploid gamete-producing bodies.

3. Gamete-producing bodies and spore-producing bodies develop during the life cycle of plants.

B. Gamete Formation in Animals

1. In males, meiosis and gamete formation are called spermatogenesis.

a. Germ cell ($2n$) → primary spermatocyte ($2n$) → MEIOSIS I → two secondary spermatocytes (n) → MEIOSIS II → four spermatids (n).

b. Spermatids change in form; each develops a tail to become a mature sperm.

2. In females, meiosis and gamete formation are called oogenesis.

a. Germ cell ($2n$) → primary oocyte ($2n$) → MEIOSIS I → secondary oocyte (n , and large in size) plus polar body (n , and small in size) → MEIOSIS II → one large ovum (n) plus three polar bodies (n , small).

b. The single ovum is the only cell capable of being fertilized by a sperm; the polar bodies wither and die.

C. More Shufflings at Fertilization

1. The diploid chromosome number is restored at fertilization when two very different gamete nuclei fuse to form the zygote.

2. Variation present at fertilization is from three sources:

a. Crossing over occurs during prophase I.

b. Random alignments at metaphase I lead to millions of combinations of maternal and paternal chromosomes in each gamete.

c. Of all the genetically diverse gametes produced, chance will determine which two will meet.

VI. Meiosis and Mitosis Compared

A. Mitotic cell division produces clones; this type of division is common in single-celled, asexually reproducing organisms and in the growth process of multicelled forms.

B. Meiosis occurs only in the germ cells used in sexual reproduction; it gives rise to novel combinations of alleles in offspring.

VI. *Focus on Science*: Henrietta's Immortal Cells