

## HOMOLOGOUS CHROMOSOMES

- pairs of similar looking chromosomes (length, centromere position, staining pattern) found in a diploid cell
- one chromosome of each homologous pair was originally inherited from the female parent and one from the male parent to create that offspring's unique genetic make-up; these chromosomes have been replicated faithfully many many times as the fertilized egg divided by mitosis to produce the many genetically identical cells that came to make up the offspring's body
- the homologous pairs contain an identical sequence of genes (that is they have information for the same physical and biochemical characteristics), thus diploid cells have TWO copies of each gene (one from Mom and one from Dad)
  - the sequence of genes on a particular homologous pair (ex, chromosomes #1 in humans) is the same for all members of that species
- what exact trait is expressed in an offspring will depend on the particular combination inherited from the two parents on the homologous chromosomes; the specific information carried on each gene (the alleles) will not necessarily be the same on the two homologues

## MEIOSIS

(FIRST AN OVERVIEW OF ITS IMPORTANCE)

- process of cell division that occurs only in multicellular diploid organisms' reproductive organs to produce haploid gametes
- meiosis is important to sexual reproduction because by generating haploid cells, it allows each parent to contribute equally to the genetic make-up of their offspring
- meiosis insures that each gamete contains one of each of the different sized chromosomes (thus a copy of each of the genes of that species)
- the particular combination of chromosomes grouped together in a gamete from a single individual will vary each time gametes are produced
  - which chromosomes are grouped together in a particular gamete depends on how the homologous pairs arrange themselves at metaphase I (which ones are on the same side of the equator)
- meiosis combined with fertilization insures that
  - offspring will have the same number of chromosomes as the parent
  - each parent contributes equally to the genetic make-up of their offspring (one of each homologous pair, thus one of each gene)
  - offspring are not identical to parents (increases variety)
    - new combinations of alleles in offspring (half from each parent)
    - exact combinations will vary with each offspring
      - each parent produces somewhat different gametes each time cells in his/her reproductive organs undergo meiosis
      - which gametes are joined by fertilization determines exact outcome (many possible combinations)

## MEIOSIS

### (SUMMARY OF THE STAGES)

- occurs in two sequential divisions (one after another)
  - Meiosis I
    - divides one diploid cell into two haploid cells
    - separates homologous pairs
    - reduces chromosome number in half
  - Meiosis II
    - divides each of the two haploid cells from meiosis I into two haploid gametes (to produce a total of four cells)
    - separates sister chromatids

#### Meiosis I – “the reduction division”

- Interphase I
  - DNA is in the form of chromatin and enclosed in nuclear envelope
  - DNA replicates to produce identical copies of each strand of chromatin
- Prophase I
  - like mitosis, during prophase I
    - the nuclear envelope and nucleolus break up
    - the chromatin condenses to form visible chromosomes
    - the centriole duplicates and the two move toward opposite poles as the microtubules begin to assemble into the spindle
  - chromosomes synapse with their homologous partner
- Metaphase I
  - chromosomes align IN PAIRS along on the equator with spindle fibers attached on either side of the pair
- Anaphase I
  - chromosomes move toward the opposite poles based on their position at metaphase I
  - this separates the members of each homologous pair but leaves the sister chromatids attached
- Telophase I
  - like mitosis, during telophase I
    - nuclear envelopes re-form around the two sets of separated chromosomes to form daughter nuclei
    - the chromosomes decondense to less compact chromatin
    - the spindle fibers disassemble
- Cytokinesis I
  - like mitosis in mechanism (cell plate or contractile ring/cleavage furrow for plants and animals respectively)
  - usually occurs concurrently with telophase I
  - divides cytoplasm to form two separate daughter cells
- Resulting daughter cells
  - have half the number of chromosomes of original cell (chromosome number has been REDUCED)

- have only one of each homologous pair (therefore, making the cells haploid)
- have chromosomes that are still made of two attached sister chromatids

#### Meiosis II – “the mitotic division of meiosis”

- process is like mitosis of other cells in this organism with the following exceptions
  - having already been through meiosis I, these cells have half the number of chromosomes of the somatic cells (cells of the body) dividing by mitosis
  - these cells are also haploid whereas the somatic cells are diploid
  - since they already have sister chromatids (synthesized in Interphase I but never separated in meiosis I), no DNA replication occurs in Interphase.

The steps: (occurring simultaneously in both cells from meiosis I)

##### Interphase II

- DNA is in the form of chromatin and enclosed in nuclear envelope
- there is no DNA replication
- Prophase II
  - like mitosis, during prophase II
    - the nuclear envelope and nucleolus break up
    - the chromatin condenses to form visible chromosomes
    - the centriole duplicates and the two move toward opposite poles as the microtubules begin to assemble into the spindle
- Metaphase II
  - like mitosis, chromosomes align IN SINGLE FILE along on the equator with spindle fibers attached on either side of each chromosome
- Anaphase II
  - like mitosis, centromeres separate and individual chromosomes are moved to opposite poles (separating formerly attached sister chromatids)
- Telophase II
  - like mitosis, during telophase I
    - nuclear envelopes re-form around the two sets of separated chromosomes to form daughter nuclei
    - the chromosomes decondense to less compact chromatin
    - the spindle fibers disassemble
- Cytokinesis II
  - like mitosis in mechanism (cell plate or contractile ring/cleavage furrow for plants and animals respectively)
  - usually occurs concurrently with telophase II
  - divides cytoplasm to form two separate daughter cells from each or a total of four cells (gametes)
- Since meiosis II is like mitosis, the resulting daughter cells (gametes)
  - are identical to the cells that began meiosis II in number of chromosomes and ploidy (both are haploid)
  - no longer contain attached sister chromatids; they were separated into different cells beginning at anaphase II.
- However, since the cells that begin meiosis II have already been through meiosis I, the gametes
  - have half the number of chromosomes of the single cell we started with

- are haploid rather than diploid (like the original cell that began meiosis)

The diploid state will be restored only if fertilization occurs. If fertilization does not occur, the gametes will ultimately die.

### **FERTILIZATION**

- unites chromosomes contained in the female gamete and chromosomes contained in male gamete into a single nucleus forming a zygote
- since each gamete contains one of each of the different sized chromosomes, the zygote again has homologous pairs of chromosomes (or is diploid)
- the chromosomes from the two parents do NOT attach to one another at the centromere but remain separate
  - they are not identical
  - attached sister chromatids will not form again until each replicates its DNA in preparation for its first cell division. Remember sister chromatids are identical copies which are produced by DNA replication.
- by joining “n” chromosomes from Mom and “n” chromosomes from Dad, the zygote has  $2n$  chromosomes or the normal diploid number for that species
- the resulting zygote will begin to divide by mitosis to produce the many cells of the developing embryo