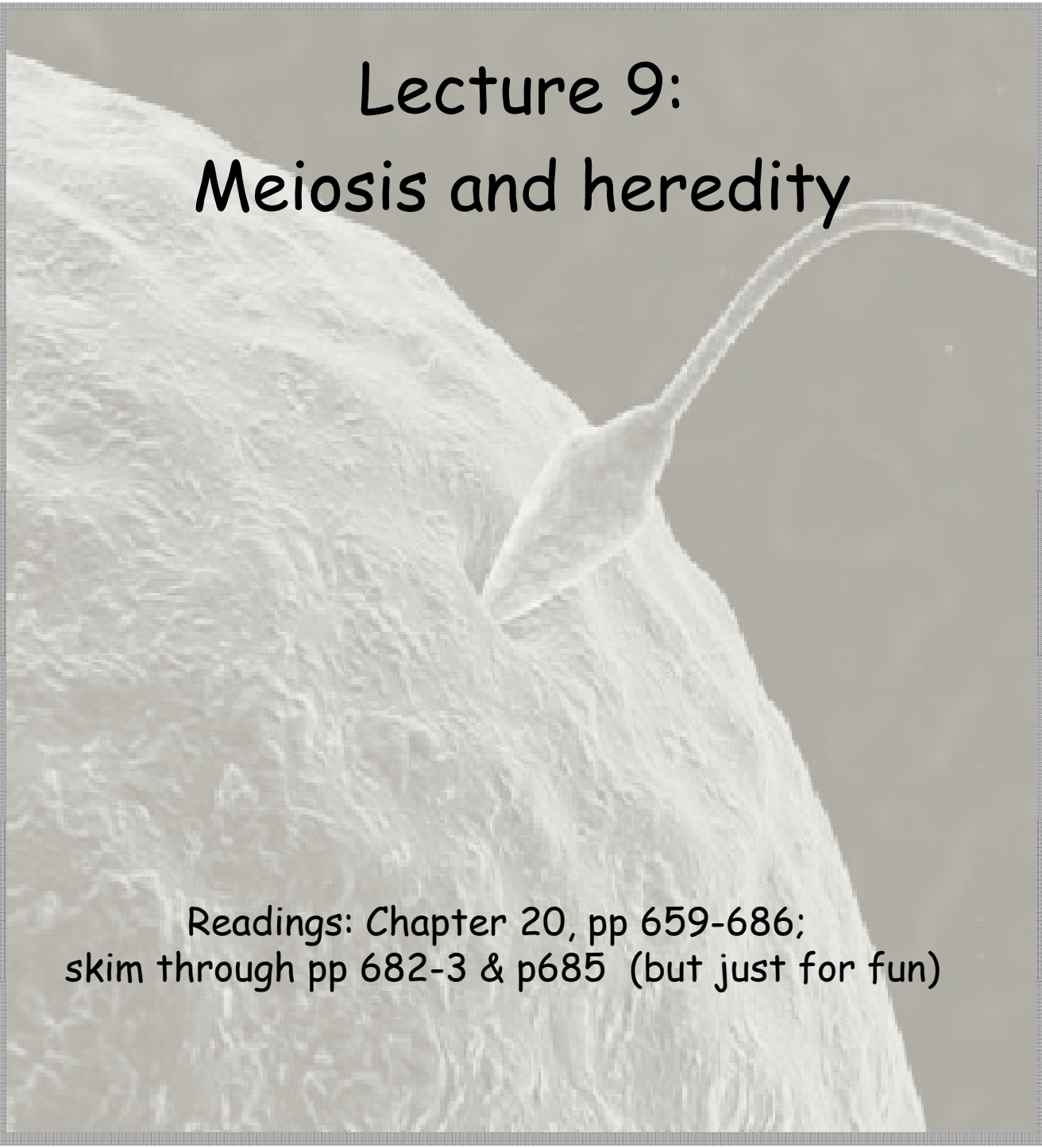
Lecture 9:
Meiosis and heredity



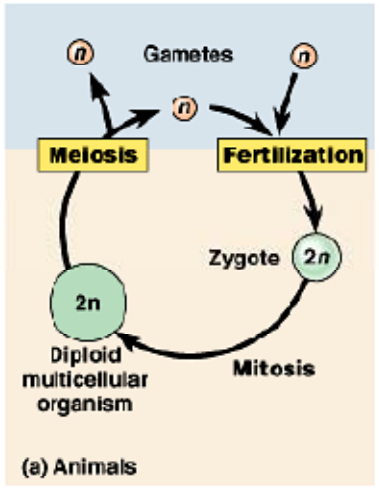
Readings: Chapter 20, pp 659-686;
skim through pp 682-3 & p685 (but just for fun)

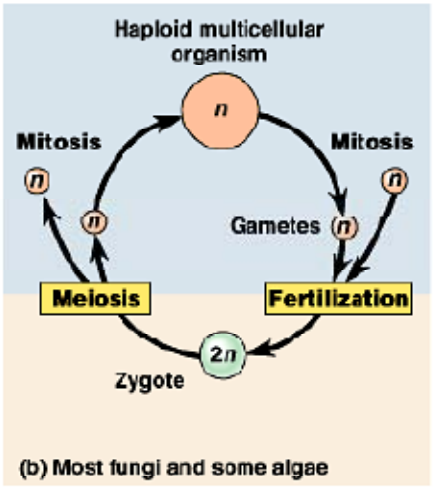
Chromosome number: haploid, diploid, polyploid

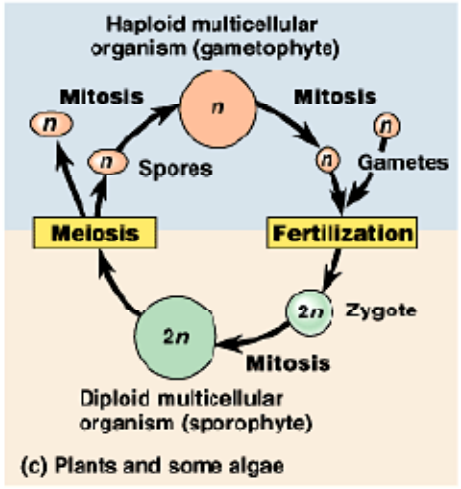
- Talking about the number of chromosome *sets* that represent the genome information content of an organism
- The haploid set of chromosomes in an organism is a certain number = n
- In diploid organisms, where the chromosomes come in pairs, the total number of chromosomes is 2n
- Some organisms (some plants, some fish etc) are polyploid – they have multiple sets of chromosomes

Alteration of Generations

Three sexual life cycles differing in the timing of meiosis and fertilization (syngamy)



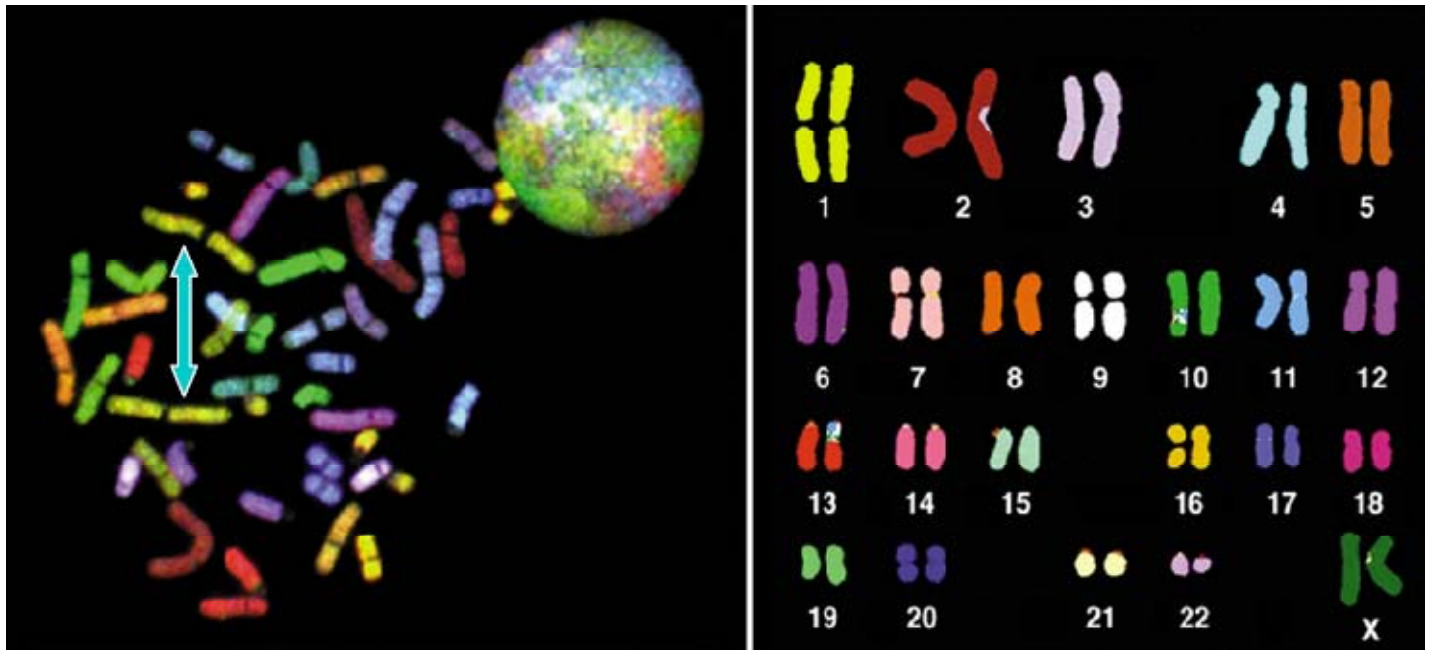




In sexual reproduction, two haploid gametes — one from each parent— unite in fertilization to form a genetically unique, diploid zygote.

The number shape and size of metaphase chromosomes constitute a karyotype.

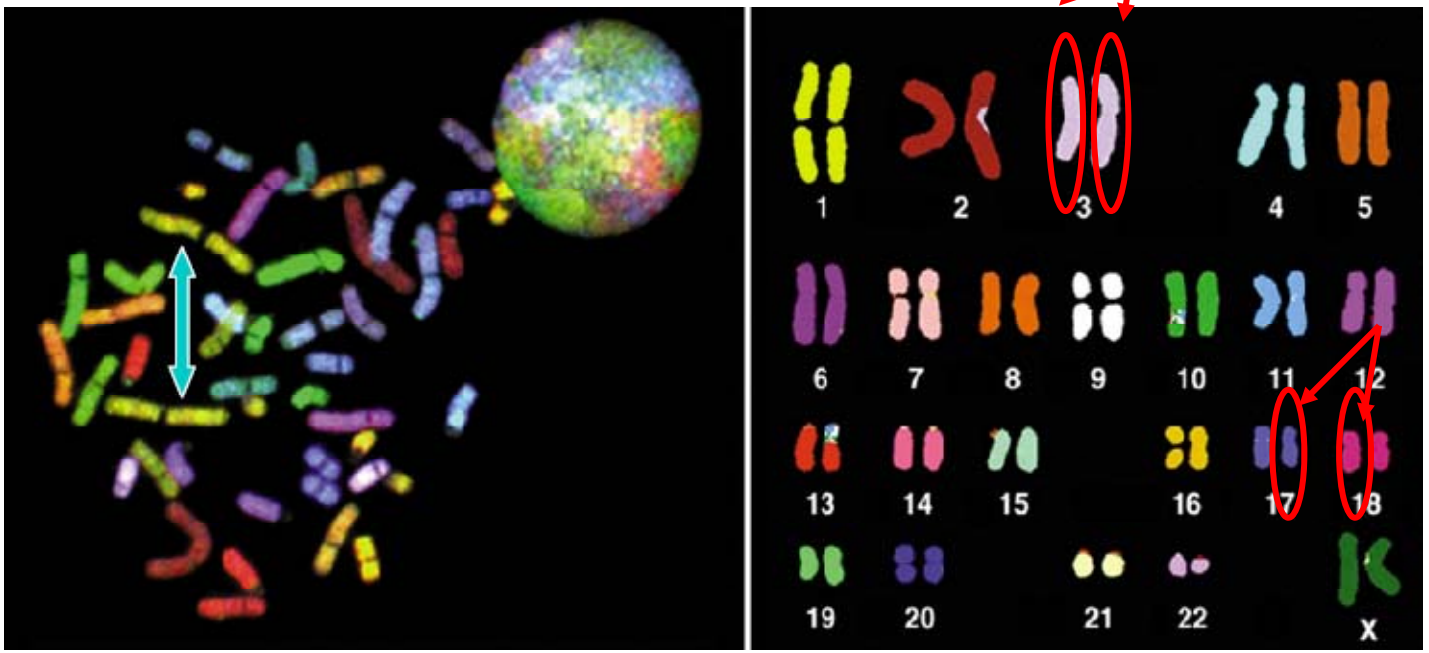
Humans have 23 *homologous pairs* of chromosomes.
Humans are *diploid*.



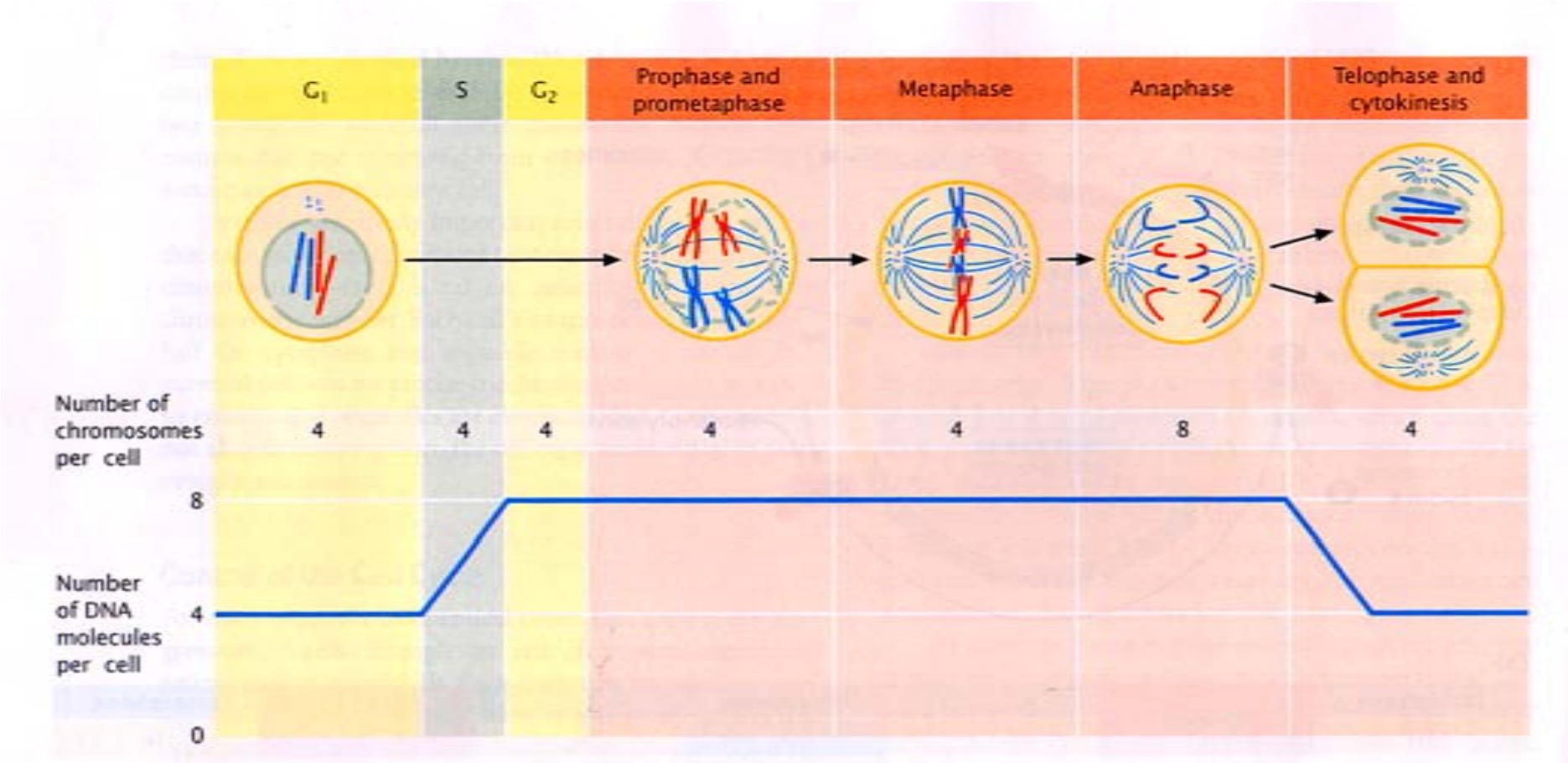
Whole chromosome painting: differently colored fluorescent probes covalently linked to libraries of DNA sequences that stretch over the entire length of the chromosome

Homologous chromosomes

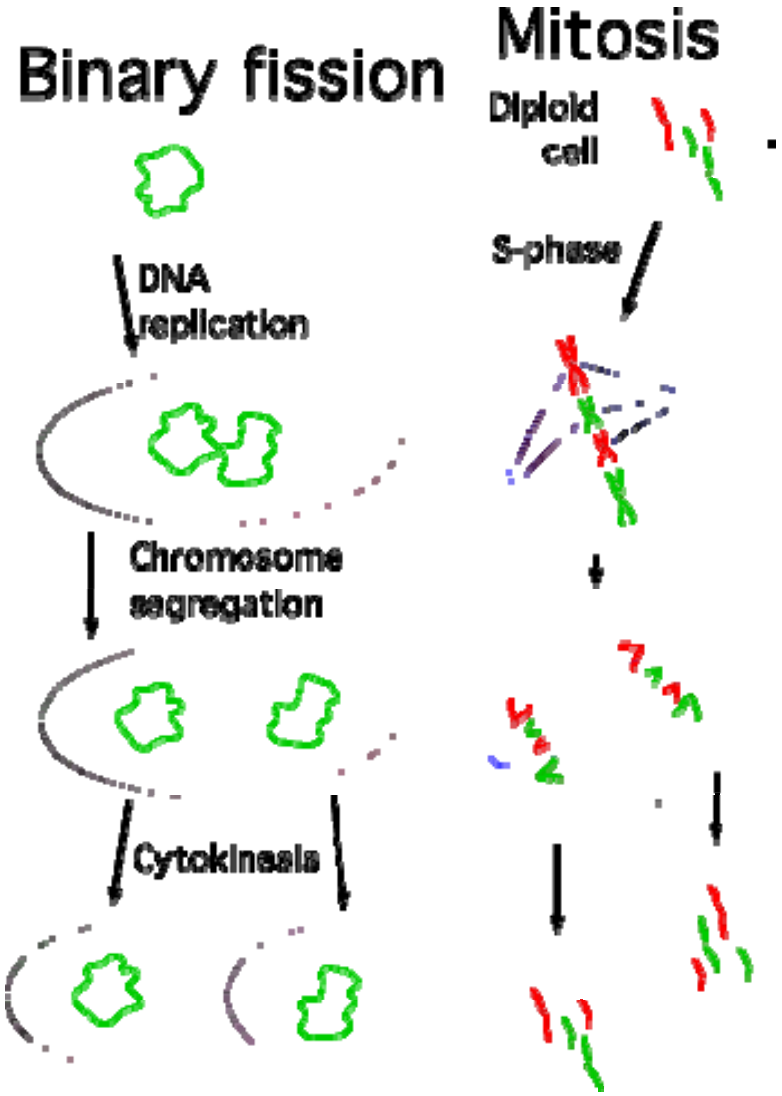
- Members of a chromosome pair that contain the same genes
- Each member is called a homolog
- One is inherited from each parent (so they are *not identical*)
- Chromosomes that contain different genes are *non-homologous*



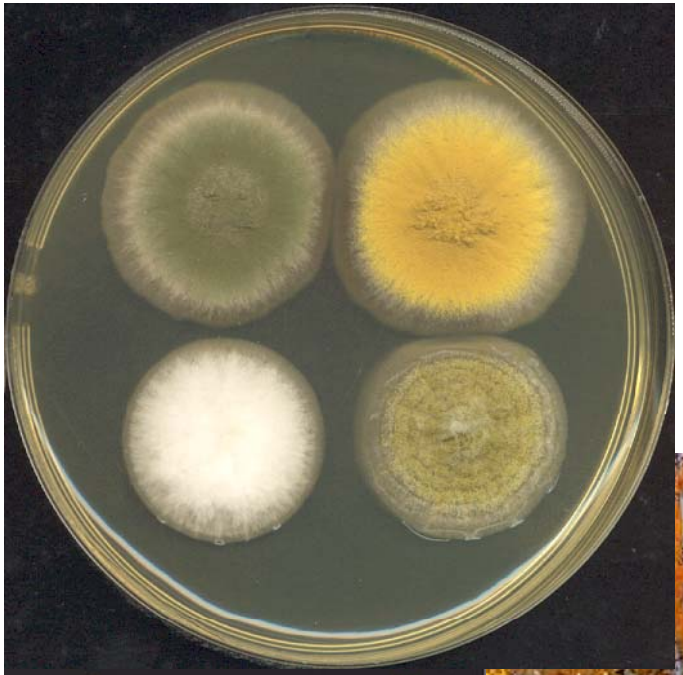
The cell cycle, ploidy, and DNA content during mitosis

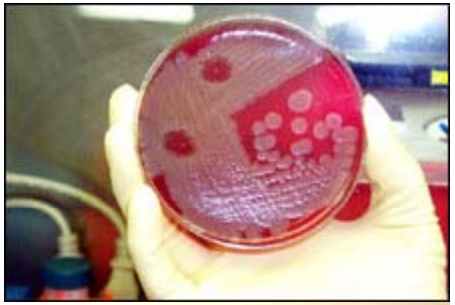


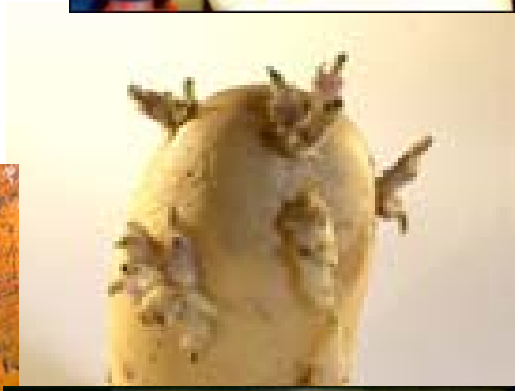
Asexual reproduction

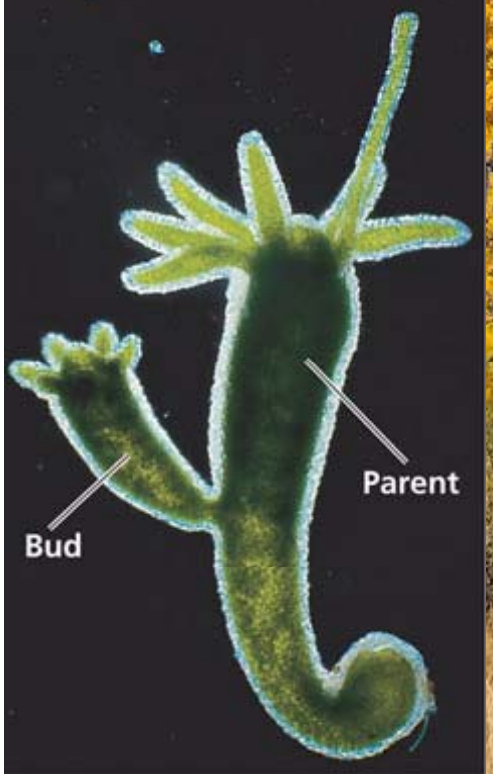


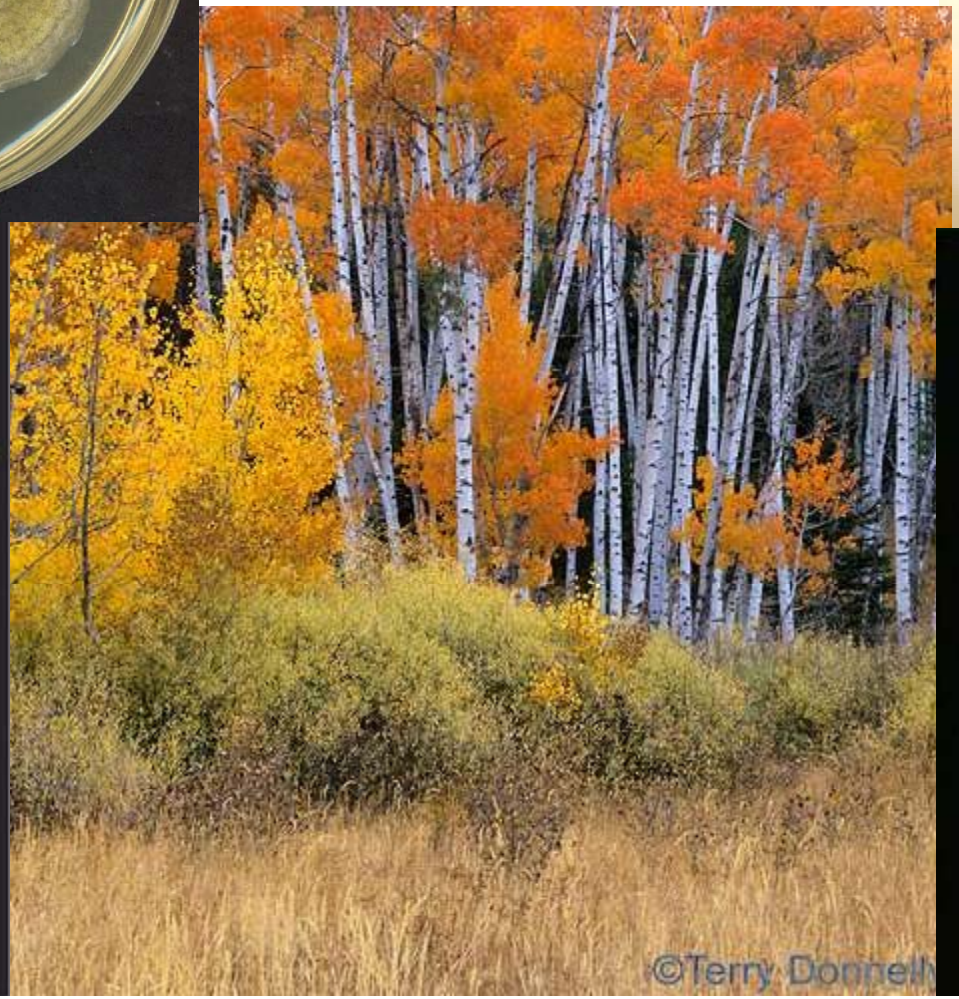
Asexual reproduction







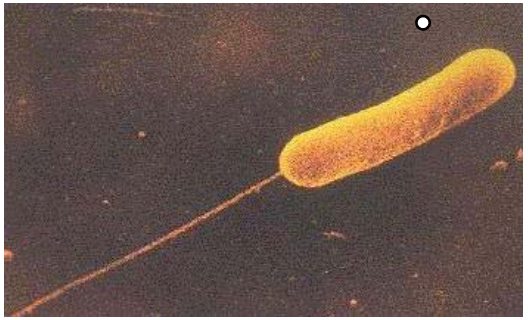


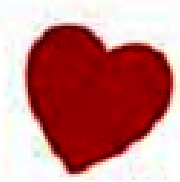


"It is perfectly possible to imagine a rather boring universe without sex, without hormones, and without nervous systems; a universe peopled only by individual cells reproducing *ad infinitum*. This universe, in fact, exists. It is the one formed by a culture of bacteria."

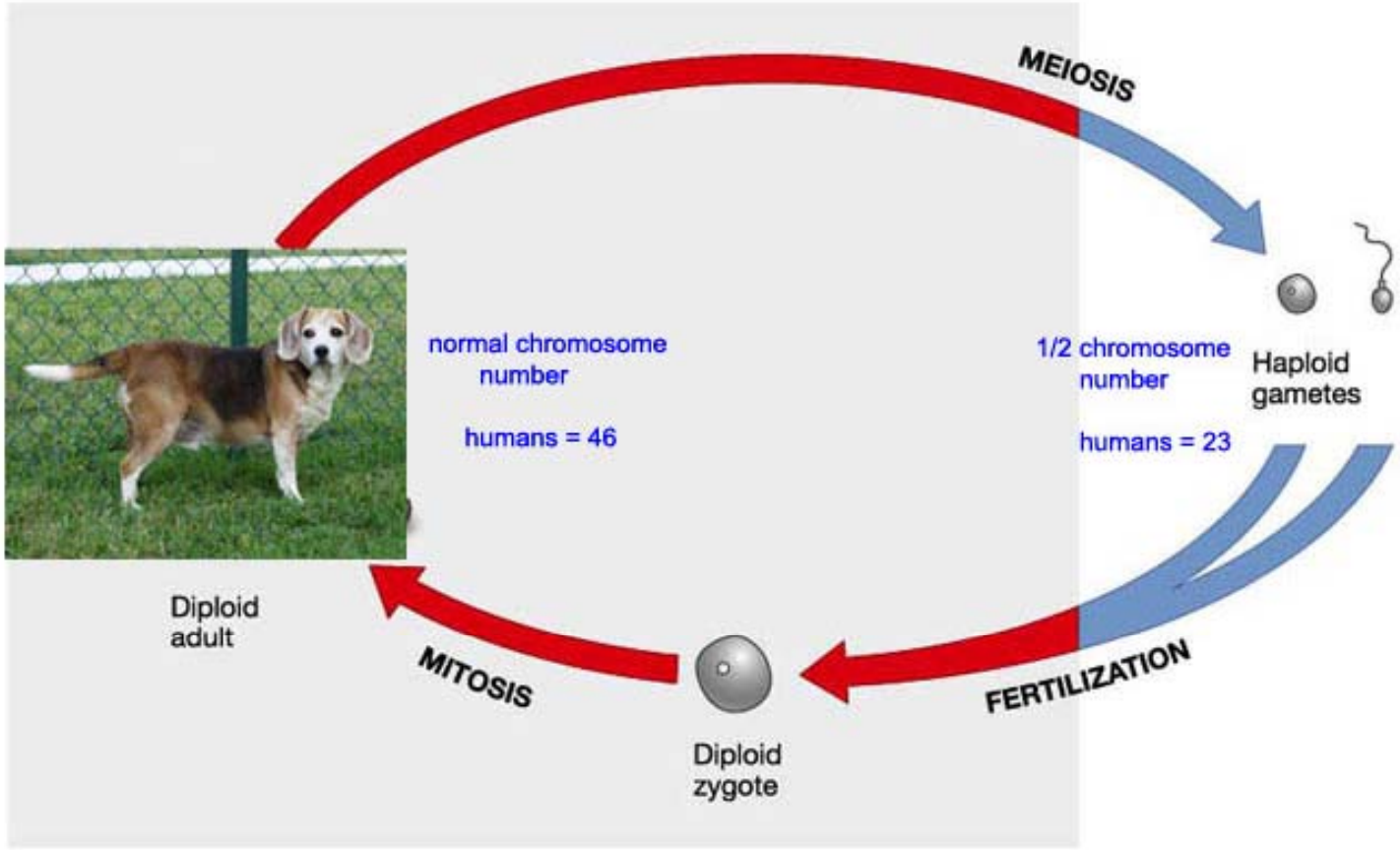
--Dr. Fancois Jacob, 1973

You underestimate me.



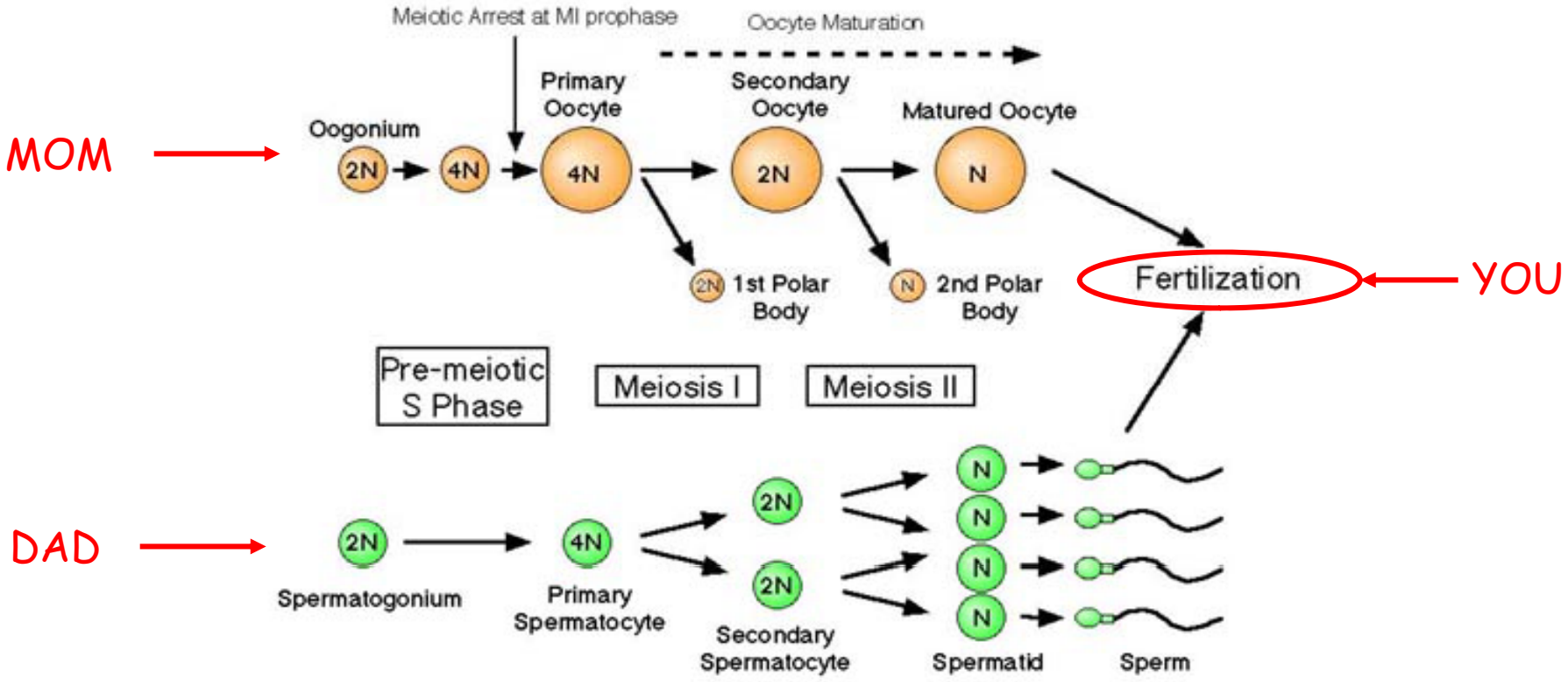
I  MEIOSIS

Sexual reproduction

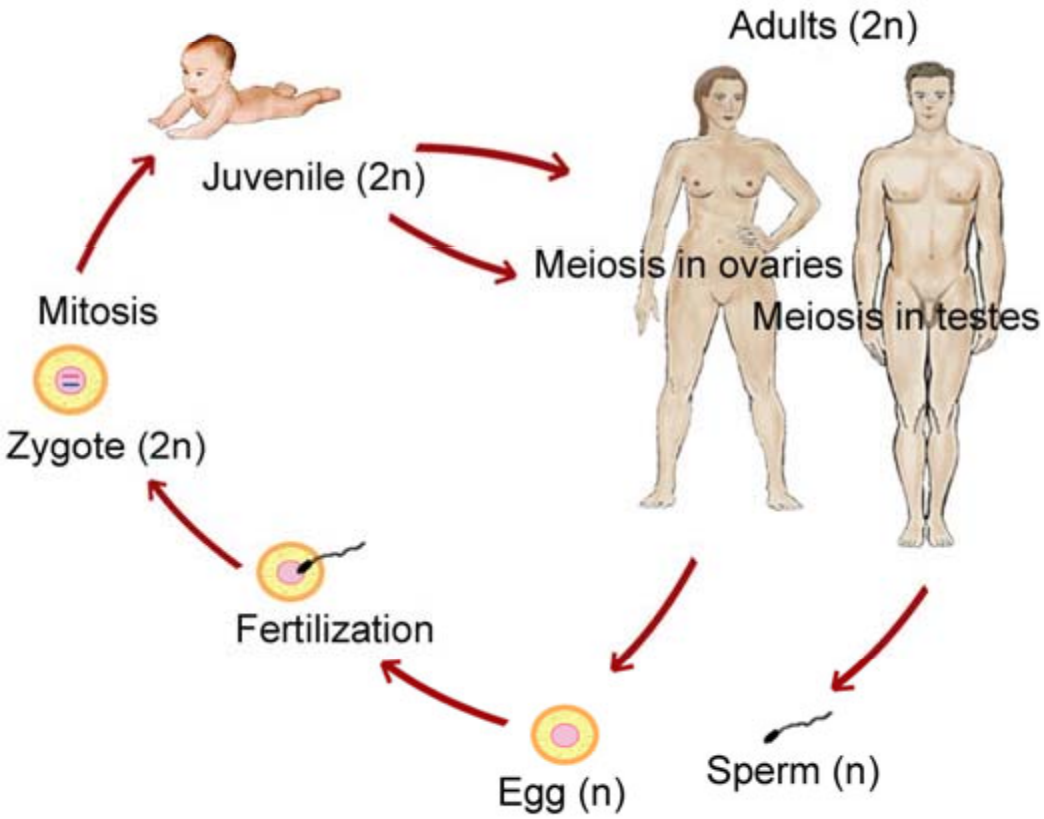


Meiosis is a *reductive* division

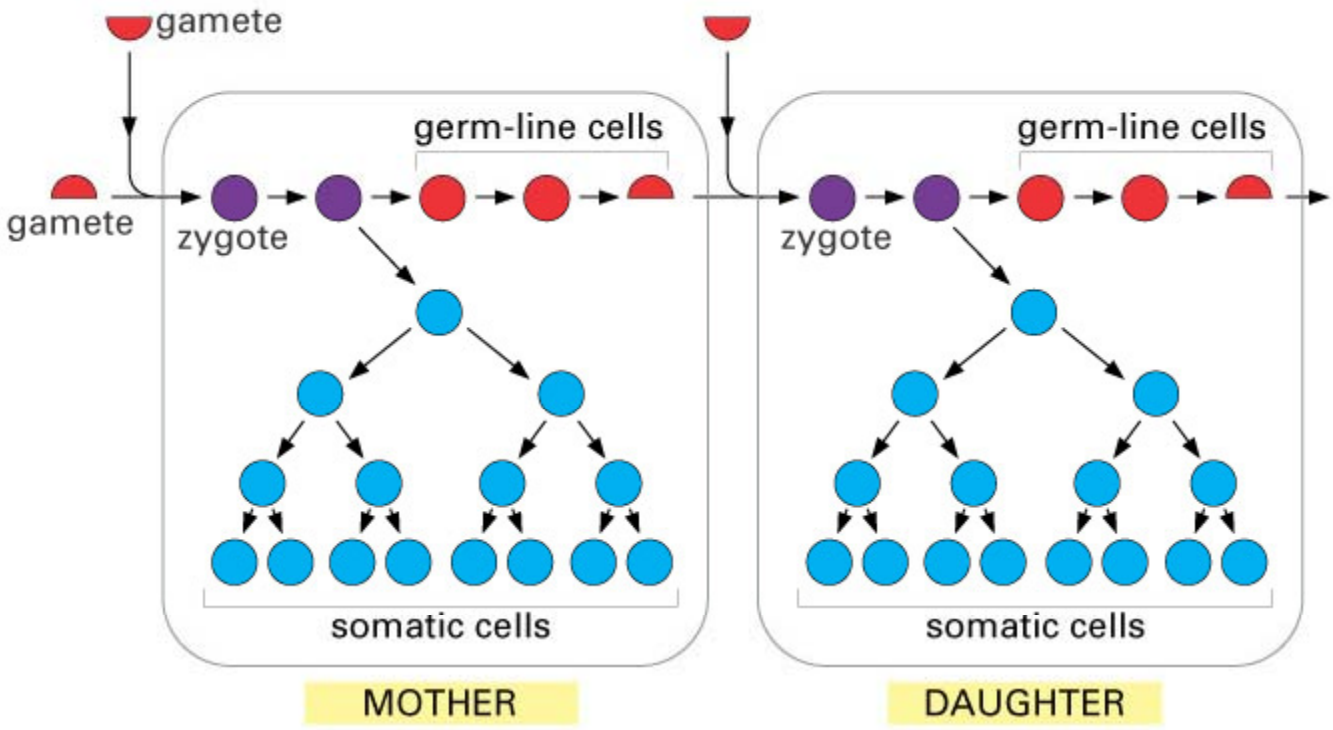
- Daughter cells have half the chromosome complement of parent cells
- Daughter cells become gametes



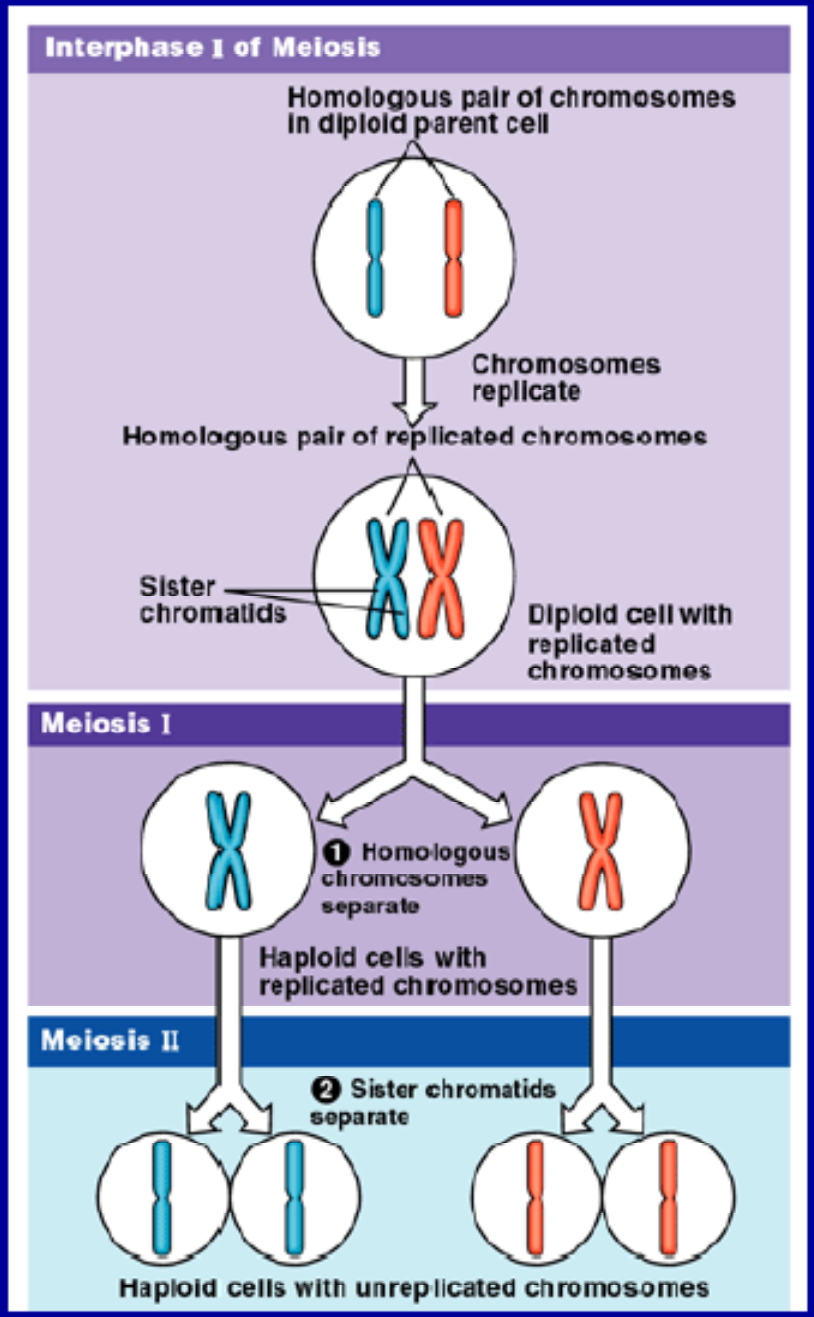
Germ line versus somatic cells



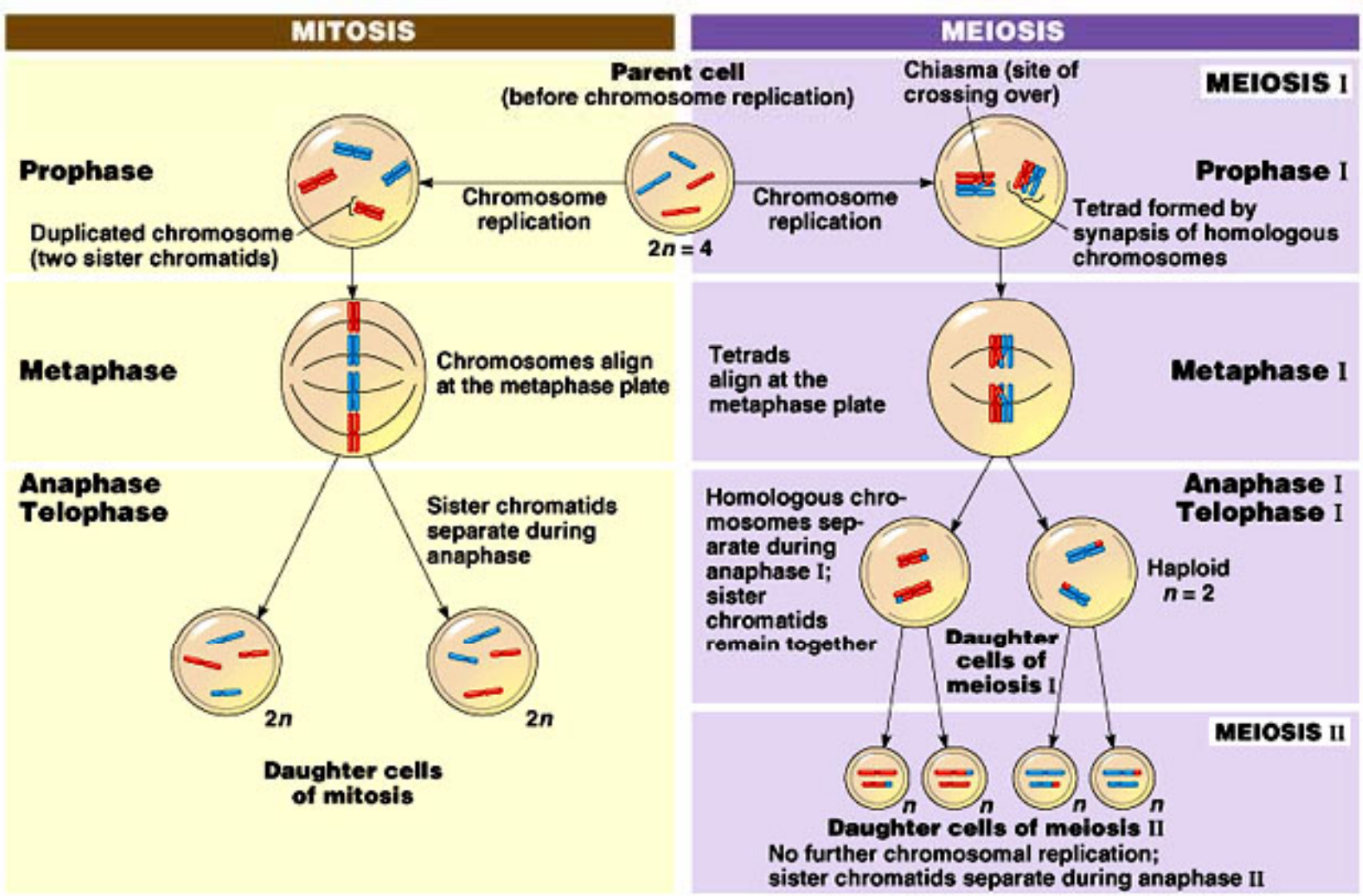
Germ line versus somatic cells



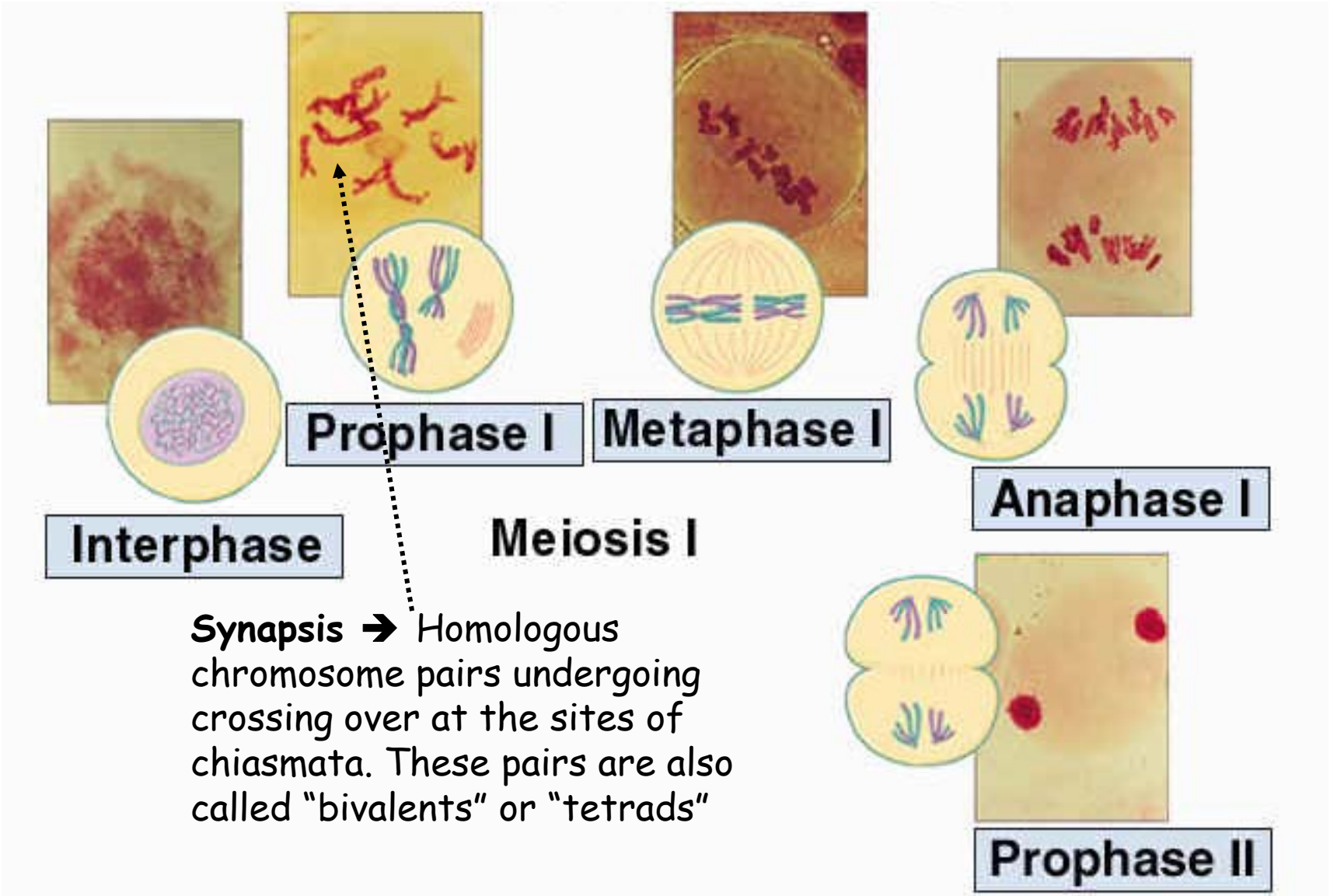
Overview of meiosis: how meiosis reduces chromosome number



Comparison of mitosis and meiosis



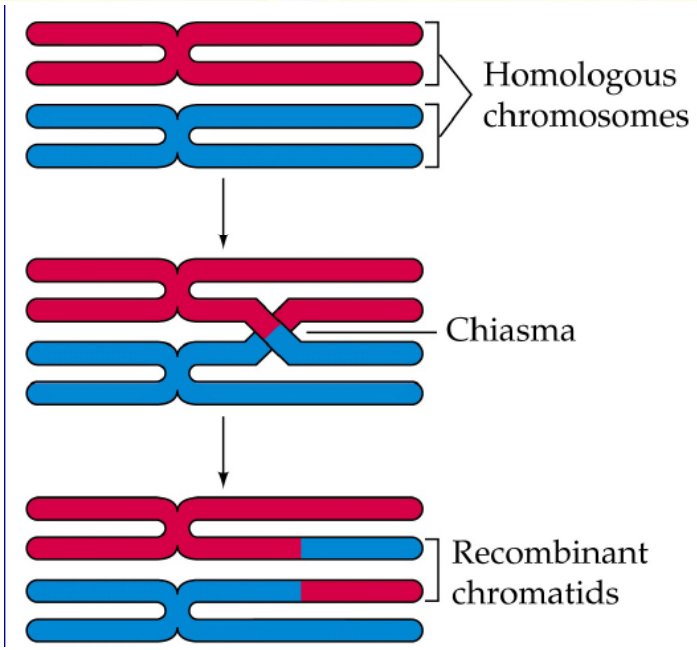
Stages of Meiosis I

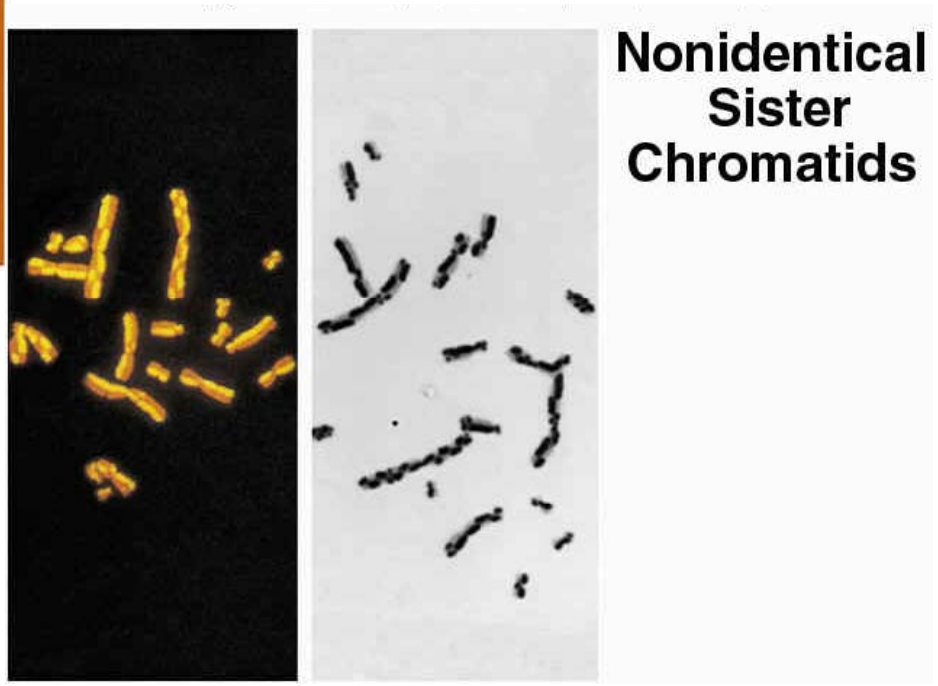


Synapsis ➔ Homologous chromosome pairs undergoing crossing over at the sites of chiasmata. These pairs are also called "bivalents" or "tetrads"

Mixing genomes: crossing over

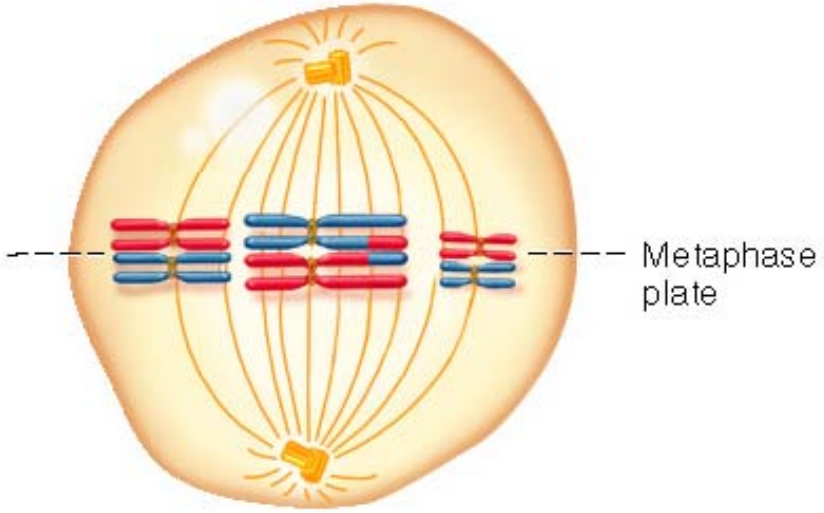
Chiasmata

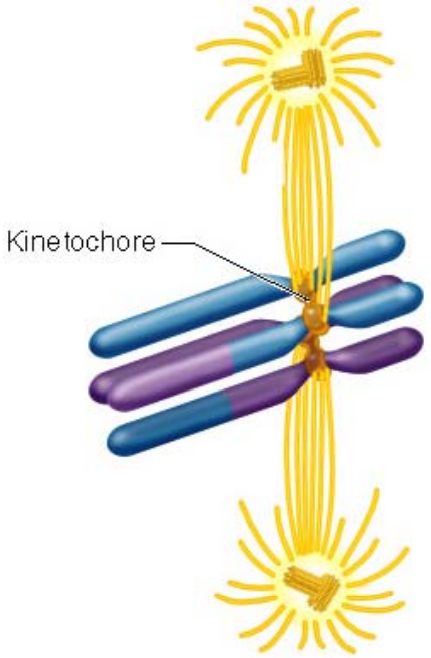




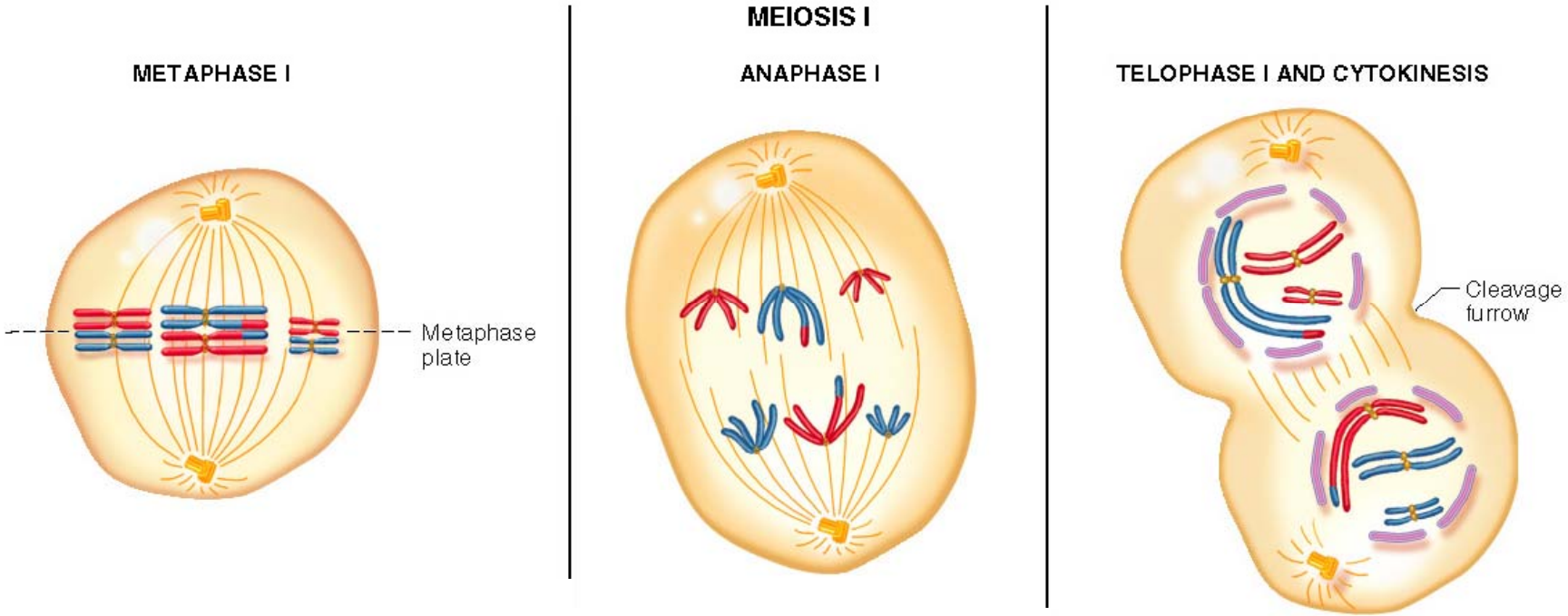
Nonidentical Sister Chromatids

Metaphase I of meiosis



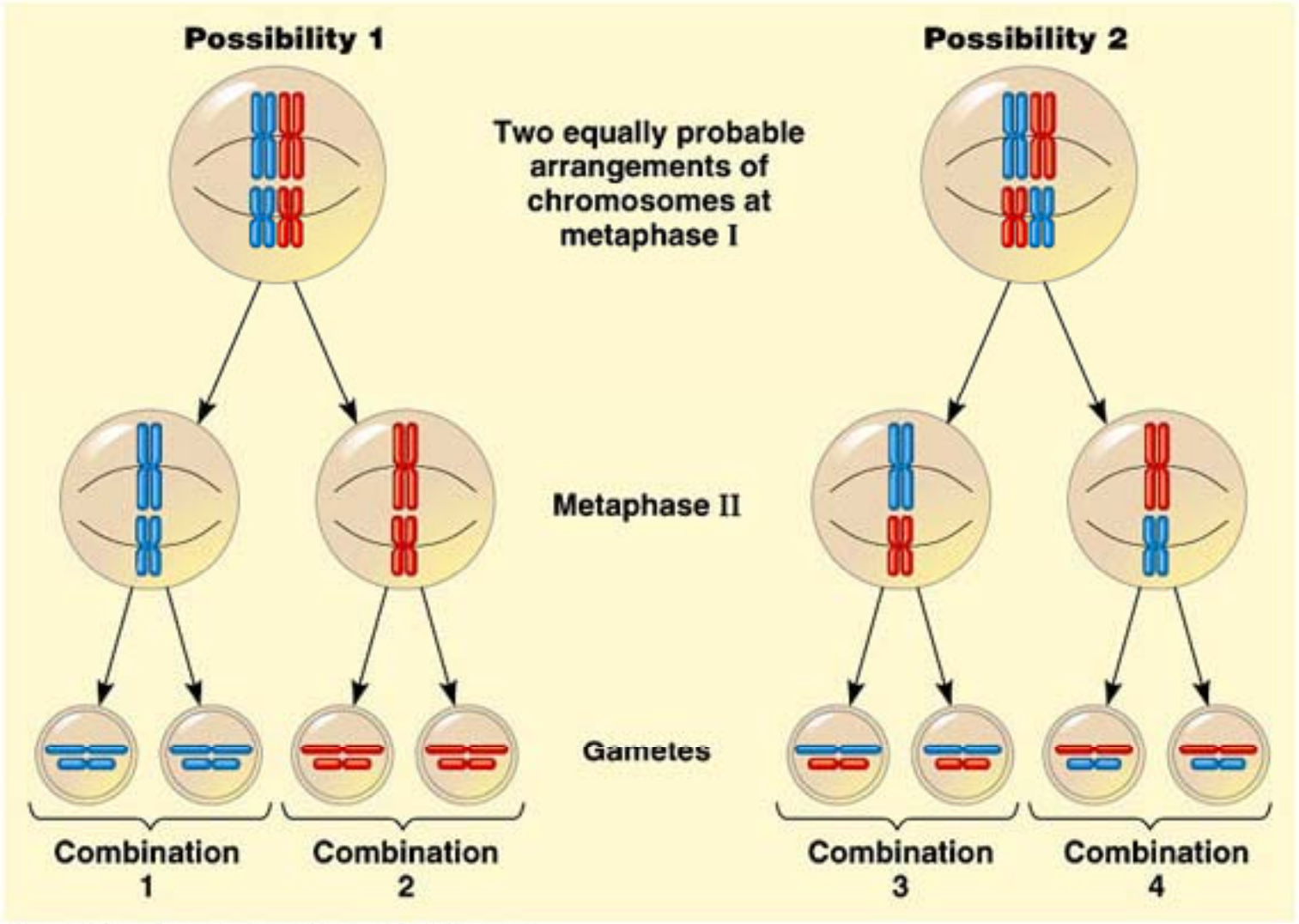


Metaphase, Anaphase and Telophase of Meiosis I



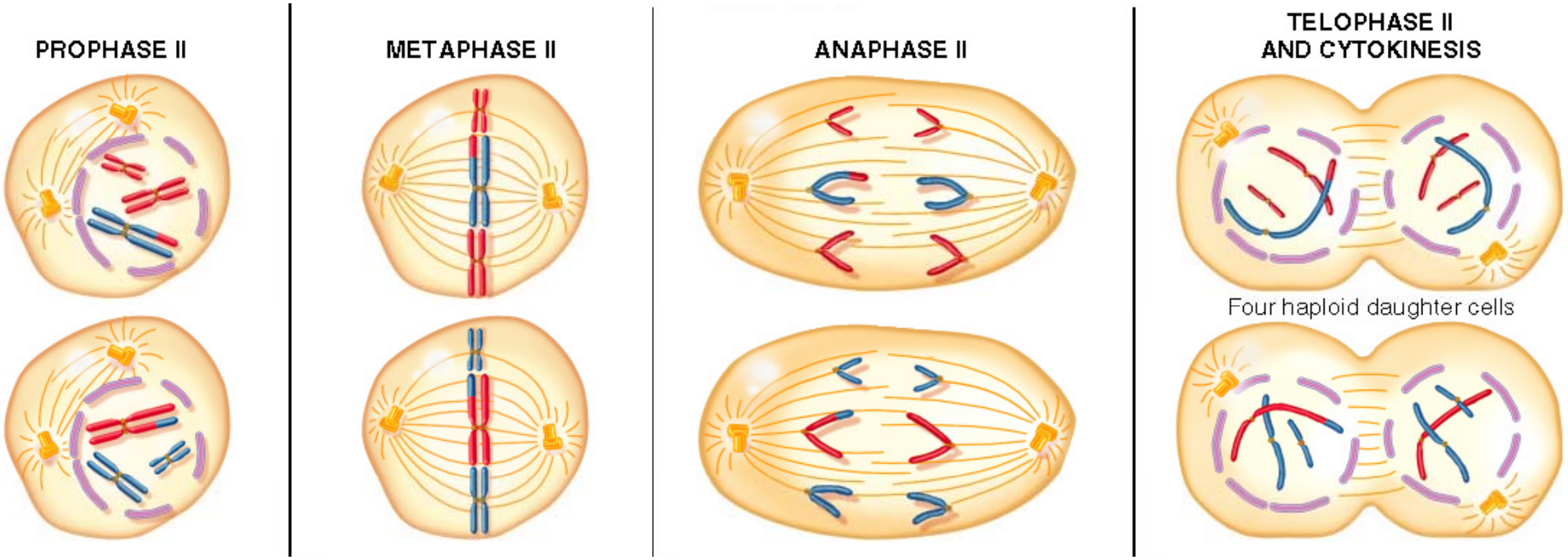
How many chromosomes?
How many sister chromatids?
How many genomes?
What is the ploidy level?

Mixing genomes: independent assortment



The more chromosome pairs there are in a diploid cell, the greater the diversity of chromosome combinations generated by meiosis.

Meiosis II


PROPHASE II
METAPHASE II
ANAPHASE II
TELOPHASE II
AND CYTOKINESIS
Four haploid daughter cells

Differences between meiosis and mitosis

1) Mitosis forms two identical daughters; meiosis forms four gametes that are **not** identical.
2) Meiotic Prophase I: Crossing over occurs, forming recombinant chromosomes.
3) Meiotic Interphase II: **No** DNA replication.
4) Prophase is considerably lengthened, relative to mitosis. In mammalian females, prophase begins in gestation and continues until the oocyte grows during an estrous or menstrual cycle.

So why are YOU so different from mom and dad???

- Two meiotic reasons
- Crossing over at Prophase I
- Independent assortment of chromosomes at anaphase I
- BOTH are forms of *recombination*

Crossing over and independent assortment are happening in the same meiosis…

- Crossing over happens because homologs pair in meiosis I
- Independent assortment happens because the chromosomes segregate randomly at anaphase I after their random alignment at metaphase I

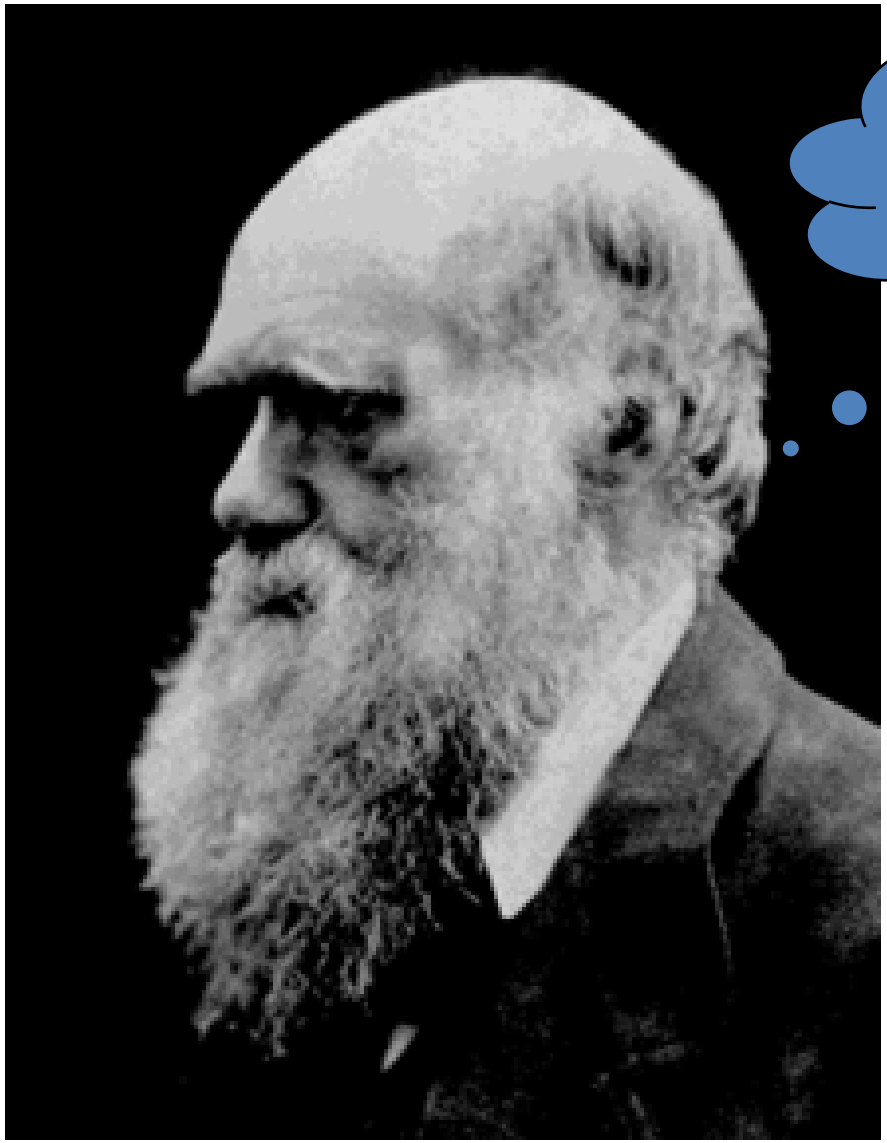
…and when you put them together in, say, a human context?

- 23 pairs of chromosomes, aligning on the metaphase plate independently of each other and segregating during the subsequent anaphase…well there's a formula:

  - 2^n where n = # chromosome pairs

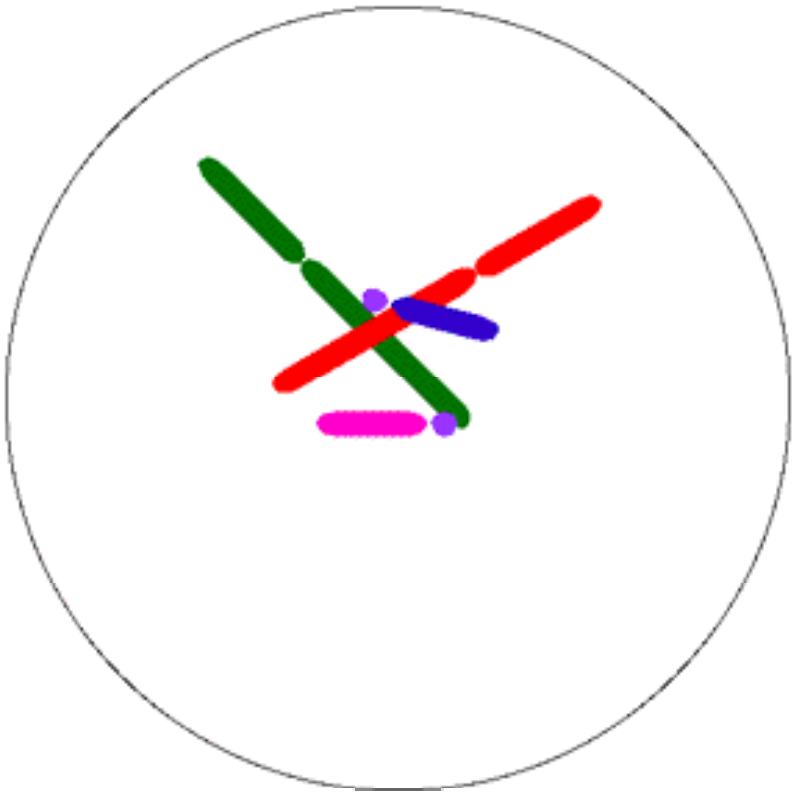
- Plug in the numbers and you get…well…millions of possible combinations (8.4×10^6)

- Add in recombination and, well….is it any wonder you're different from mom and dad?

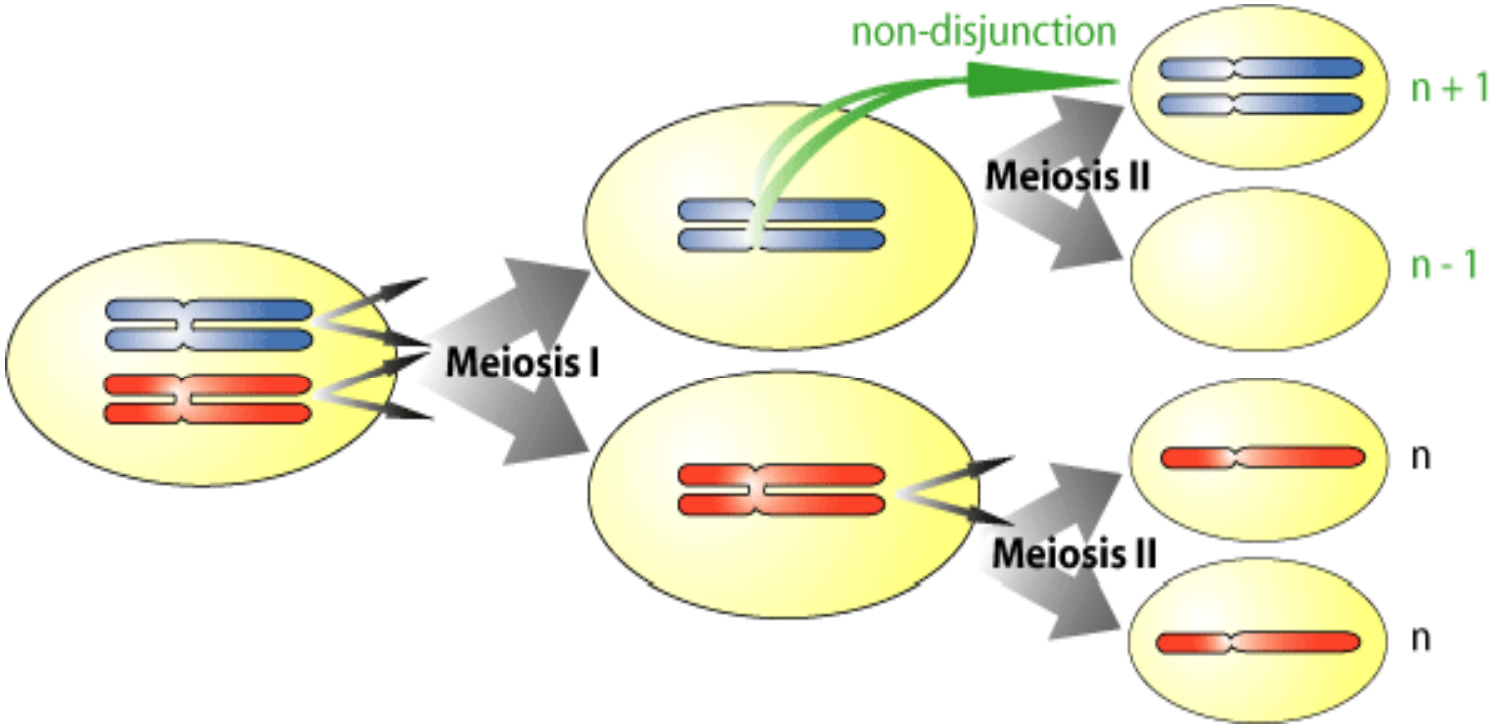


What's another ENORMOUS consequence of this variability?

Problems in meiosis: nondisjunction



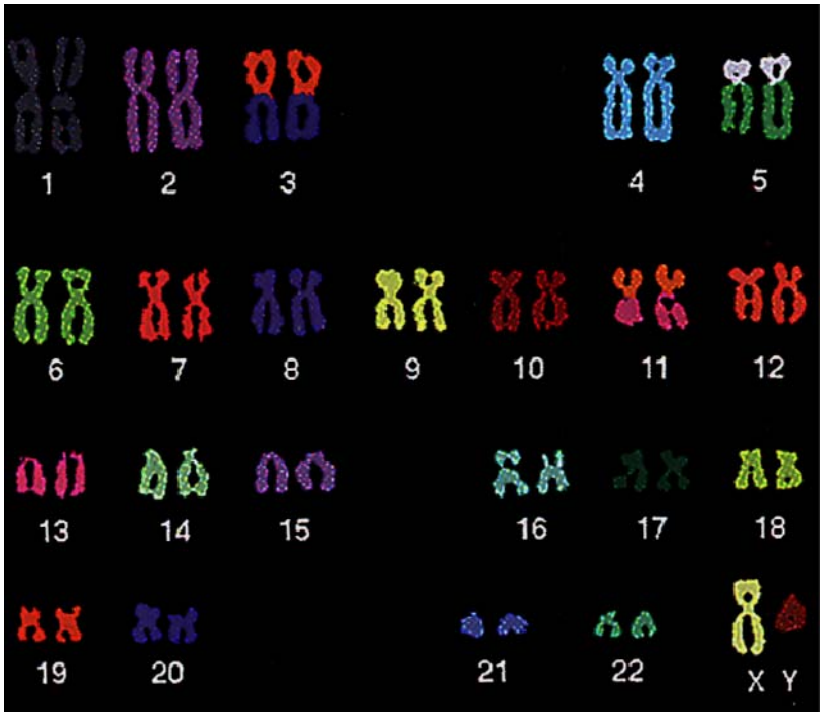
Consequences of nondisjunction



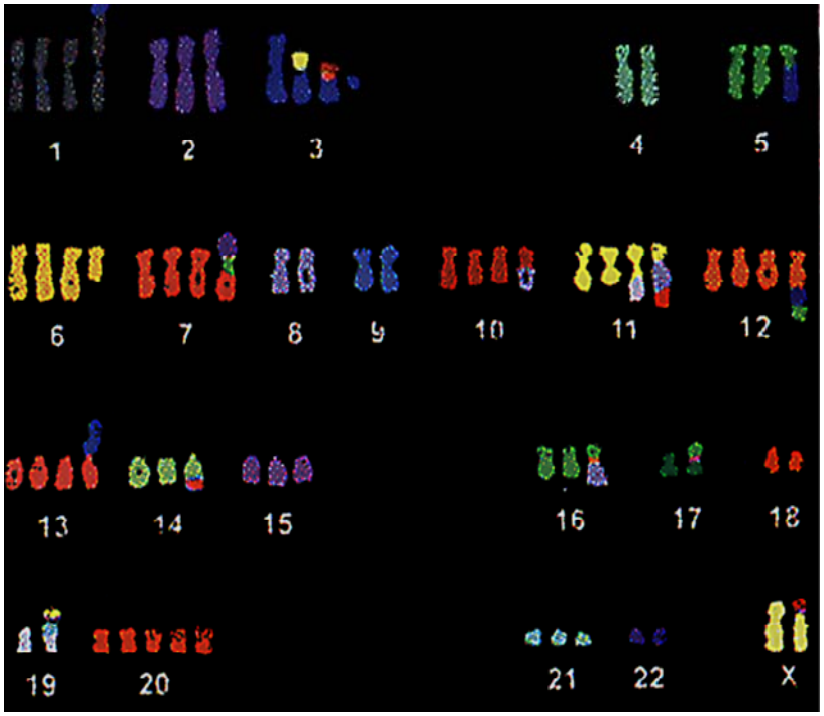
Consequences of nondisjunction
Trisomy 21

Aneuploidy:

one or more chromosomes is missing or added to a somatic cell



Normal (somatic) cell



Cancer cell