The Basis for Heritability: Mitosis and Meiosis

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- Ch. 12: less emphasis on 249-50

I. Overview
- A. What Darwin didn't know
- B. Getting cells from cells

II. Mitosis
- A. The bottom line
- B. How it happens

III. Meiosis
- A. Main points
- B. Terminology
- C. Basic process
- D. How meiosis increases genetic diversity
- E. Mistakes in meiosis

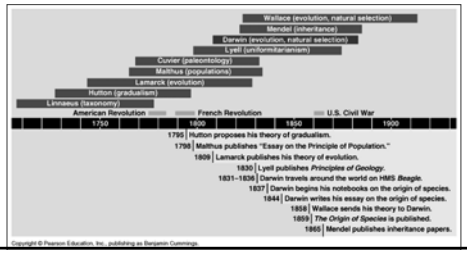
Let's start with a banana….

I. Overview and Context

A. What Darwin didn't know

Darwin's Theory of Natural Selection:

4 steps: Variation + Heritability + Differential reproduction → Altered genetic makeup in subsequent generations.

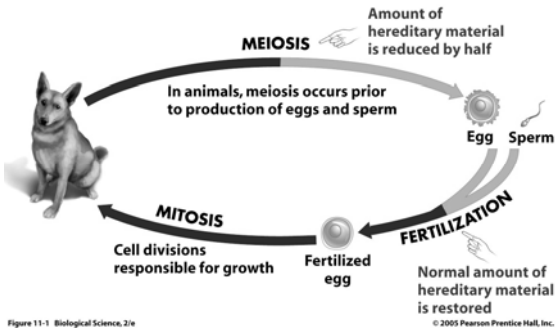


B. How do we get from cells to cells?

1. There are 2 types of cell division:

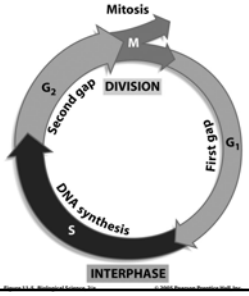
Mitosis – growth, wound repair, asexual reproduction. somatic cells

Meiosis – sexual reproduction only; formation of sex cells (gametes)

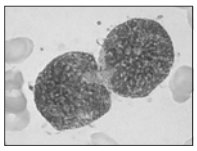


The Cell Cycle

• Two key cell-cycle events are the **replication** of the hereditary material and the separation of the copied chromosomes into two daughter cells.



II. Mitosis

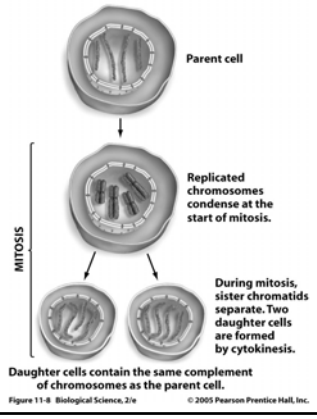


A. Main points

- "Duplication division"
  - * 1 cell → 2 cells identical to each other and starting cell
- Only mode of reproduction in asexual organisms
- Important for understanding cancer (but details in 205)
- Happens in ALL eukaryotic cells, except:
  - * Cells that have stopped dividing
  - * Cells that undergo meiosis (next topic)

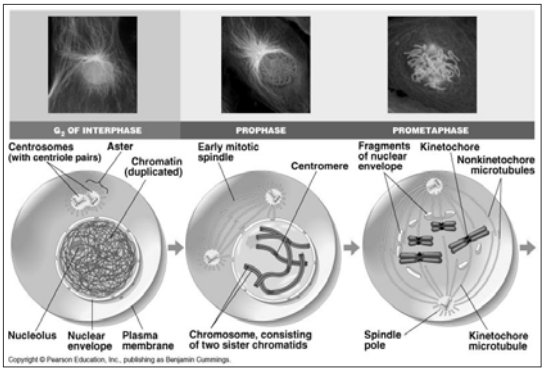
B. Mitosis – how it happens

Terminology:
Chromosome
Gene
Chromatin
Sister chromatids
Homologs
Centromere
Cytokinesis

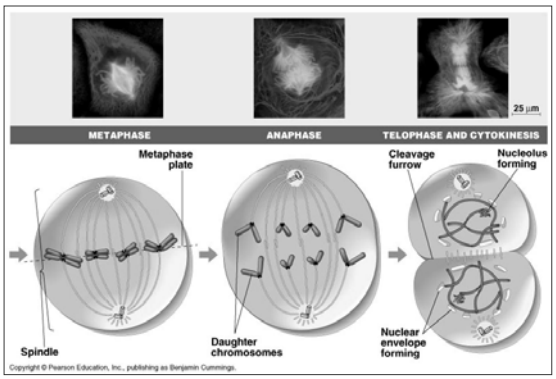


mitosis animation
http://www.youtube.com/watch?v=s1ylUTbXyWU&mode=related&search=The%20Mitosis%20Cycle%20Cells%20Cell%20Jacob%20Movie%20Quirke%20Coolness%20Funny%20HaHa%20Movies%20for%20Squares

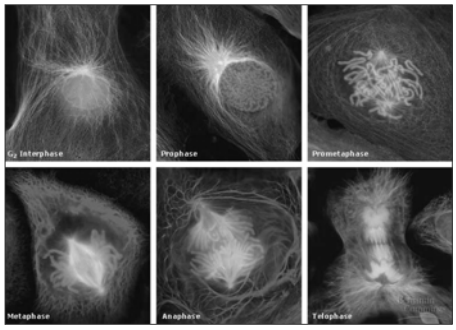
http://www.youtube.com/watch?v=DD3IQknCEdc&feature=related



See fig. 11.9



See fig. 11.9

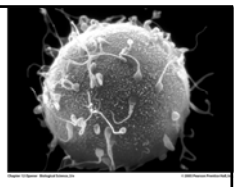


See fig. 11.11

What is the result of mitosis?

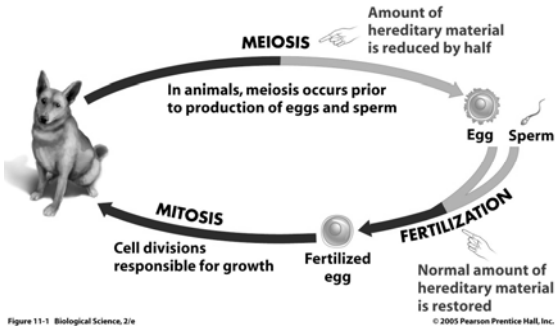
- # of cells?
- Ploidy?
- Similar/dissimilar?
- "Dance of the chromosomes"
- http://www.youtube.com/watch?v=eFuCE22agyM

III. Meiosis



A. Main points

- Meiosis = sex
- Only happens to form "sex" cells of eukaryotes:
  - Gametes – sperm and eggs (unite as zygotes in fertilization)
  - Haploid spores (grow into haploid adults)
- "Reduction division"
  - 1 cell → 4 cells, each daughter cell has half the number of chromosomes as parent cell (e.g., diploid → haploid)
- Meiosis increases genetic variation
  - Daughter cells and resulting zygotes are genetically distinct from parents



B. Definitions

- Gamete– haploid sex cells that fuse to form a zygote
- Syngamy (fertilization) – the process of sexual fusion
- Zygote – first diploid cell following fertilization
- Chromosome number
- Ploidy – number of copies of each chromosome
  - Diploid – 2n – double set of chromosomes
  - Haploid – 1n – single set of chromosomes
  - Polyploid - >2 copies of each chromosome

Normal human karyotype

Homologous chromosomes – same kind, from different parents
Allele – copy of a gene on one homolog
Sex chromosomes – determine sex of offspring
Autosomes – all the rest

TABLE 12.1 The Number of Chromosomes Found in Some Familiar Organisms

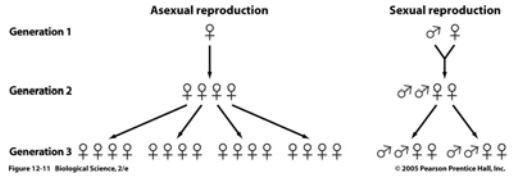
Organism	Number of Different Types of Chromosomes (haploid number *n*)	Diploid Chromosome Number (2*n*)
Humans	23	46
Domestic dog	36	72
Fruit fly	4	8
Chimpanzee	24	48
Bulldog ant	1	2
Garden pea	7	14
Corn (maize)	10	20

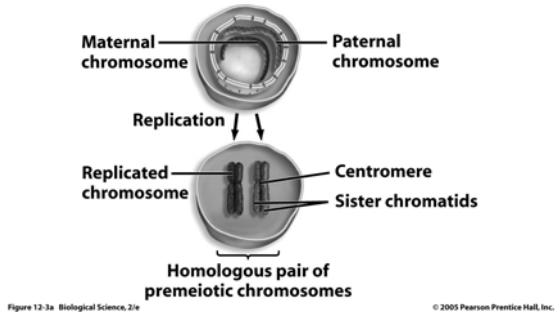
Table 12-1 Biological Science, 2/e

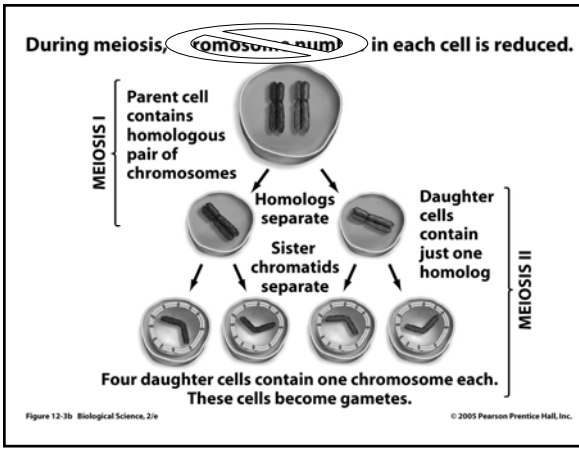
C. Overview of Meiosis

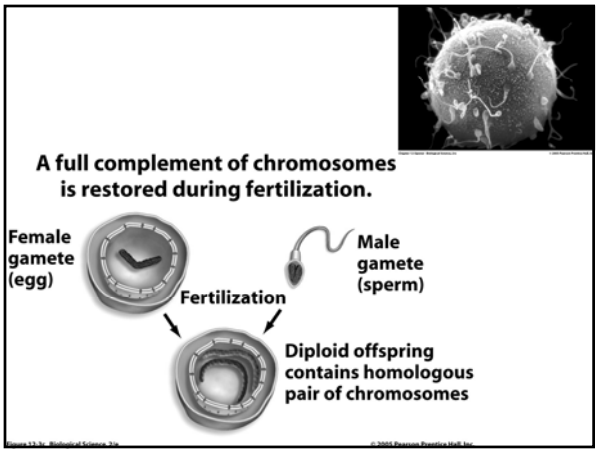
Why have sex?

Why meiosis?

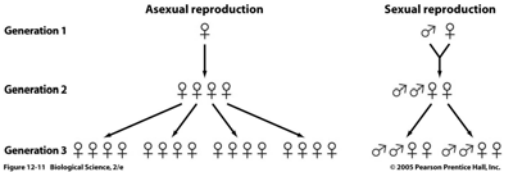








D. Why sex? Why meiosis?

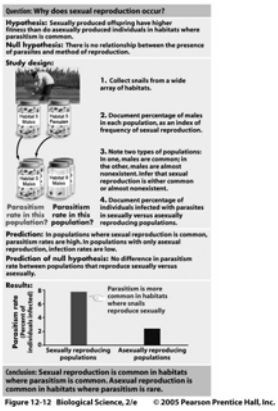


-Purifying selection hypothesis
-Changing environment hypothesis

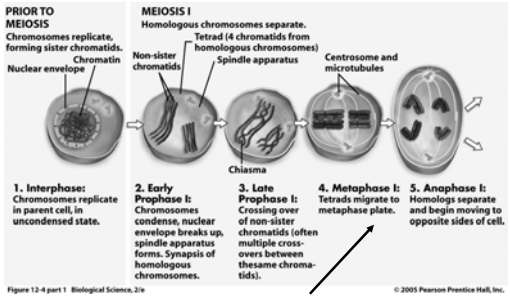
Changing environment hypothesis

- Being genetically identical is fine is your environment is relatively constant;
- Genetic variation may be better if environment changes; provides the fodder for evolutionary adaptation.
- Abiotic environment does change;
- Biotic environment can change even faster: new diseases and parasites → strong selection pressure

Testing the changing environment hypothesis

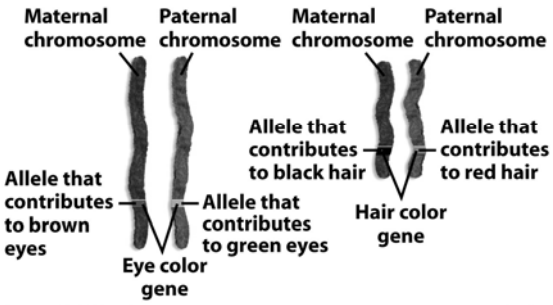


D. How does meiosis increase genetic diversity?

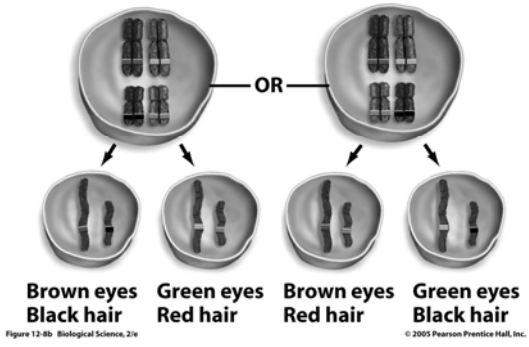


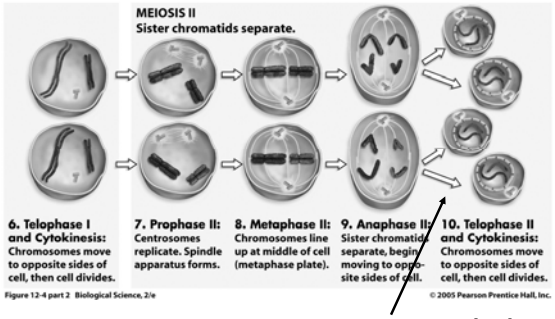
1. Mixing maternal and paternal chromosomes

Example: individual who is heterozygous at two genes



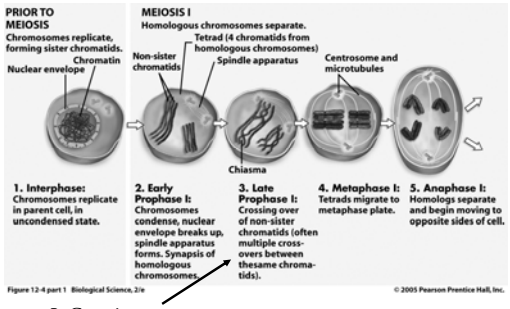
During meiosis I, tetrads can line up two different ways before the homologs separate.





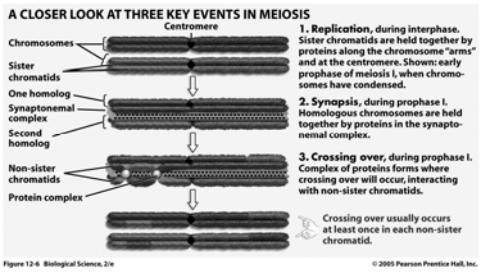
1. Mixing maternal and paternal chromosomes

D. How does meiosis increase genetic diversity?



2. Crossing over

Crossing over mixes alleles from parental homologs



Bottom line: after crossing over, none of the chromatids resemble the parental version or each other

3. Random fertilization leads to genetic variability:

The random assortment of a woman's 23 chromosomes leads to 8 million possible combinations.

The random assortment of a man's 23 chromosomes leads to 8 million different possible combinations.

Summary comparison of mitosis and meiosis

Feature	Mitosis	Meiosis
Number of cell divisions	One	Two
Number of chromosomes in daughter cells, compared with parent cell	Same	Half
Synapsis of homologs	No	Yes
Number of crossing-over events	None	One or more per pair of homologous chromosomes
Makeup of chromosomes in daughter cells	Identical	Different—only one of each chromo-some type present, paternal and maternal segments mixed within chromosomes
Role in life cycle	Asexual reproduction in eukaryotes; cell division for growth of multicellular organisms	Precedes production of gametes in sexually reproducing animals

Figure 12-5 part 3 Biological Science, 2/e
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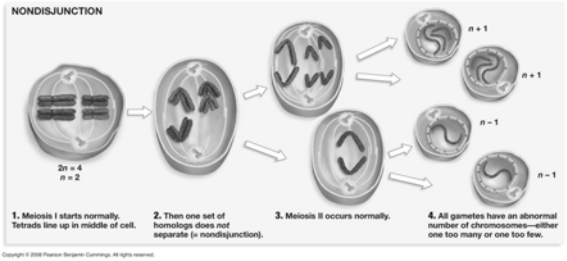
What about that banana?

E. Problems with meiosis



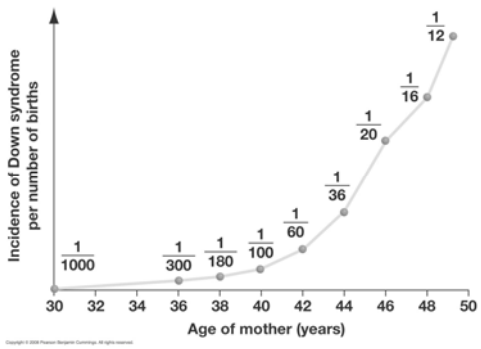
E. Problems with meiosis

TABLE 12.4 The Incidence of Trisomy in Humans: Effects of Chromosome Number and Paternal versus Maternal Origin

Trisomy (chromosome number)	Total Number of Cases	Due to Error in Sperm	Due to Error in Egg	Maternal Errors (%)
2–12	16	3	13	81
13	7	2	5	71
14	8	2	6	75
15	11	3	8	73
16	62	0	62	100
18	73	3	70	96
21	436	29	407	93
22	11	0	11	100

Table 12.4

Problems with meiosis



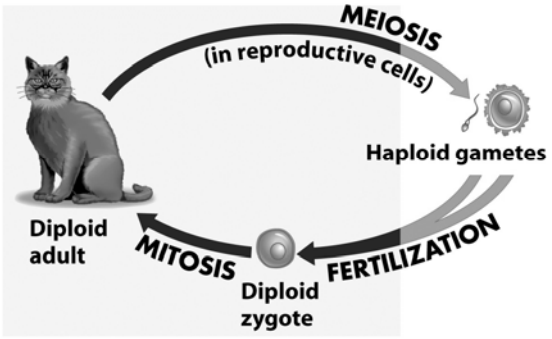
12.16

End here

IV. Life cycles

- Diagrams of a generation in the life of an organism
- A good way to remember some of the biological details of organisms
- Human life cycle typical for animals but there are many others

Diploid dominant



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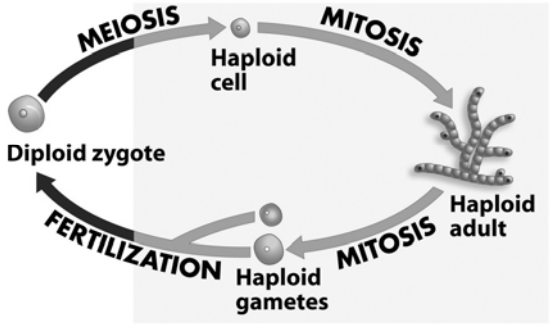
Haploid dominant



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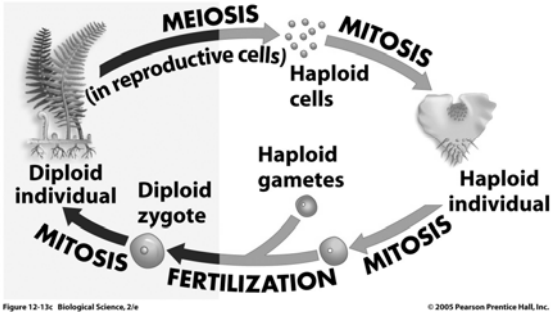
Alternation of generations



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