

### Cell Division / Asexual Reproduction

- **Mitosis**
  - ◆ produce cells with same information
    - identical daughter cells
  - ◆ exact copies
    - clones
  - ◆ same amount of DNA
    - same number of chromosomes
    - same genetic information

### Asexual reproduction

- **Single-celled eukaryotes reproduce asexually**
  - ◆ yeast
    - ◆ *Paramecium*
    - ◆ *Amoeba*
- **Simple multicellular eukaryotes reproduce asexually**
  - ◆ *Hydra*
    - budding

budding in yeast

binary fission in amoeba

### diploid = 2 copies      Human female karyotype

46 chromosomes  
23 pairs

XX

### diploid = 2 copies      Human male karyotype

46 chromosomes  
23 pairs

XY

### Fertilization

- in sexual reproduction, a gamete from each parent fuses (called **fertilization**)
  - joining of egg + sperm
- Do we make egg & sperm by mitosis?

### How do we make sperm & eggs?

- Must reduce 46 chromosomes → 23
  - must **half** the number of chromosomes
  - diploid (2n) to haploid (n) (meiosis)**

### Meiosis: Production of Gametes

- Alternating processes, alternating stages
  - chromosome number must be reduced
    - diploid → haploid
    - $2n \rightarrow n$ 
      - humans:  $46 \rightarrow 23$
    - meiosis** reduces chromosome number
  - fertilization** restores chromosome number
    - haploid → diploid
    - $n \rightarrow 2n$

### Sexual Reproduction: Fertilization

### Paired Chromosomes

- both chromosomes of a pair carry "matching" genes
  - control same inherited characters
  - homologous = same information**

### Making Gametes for the Next Generation

### Meiosis = Reduction Division

- Meiosis
  - special cell division in sexually reproducing organisms
  - reduce  $2n \rightarrow 1n$
  - diploid  $\rightarrow$  haploid
    - half
  - makes gametes
    - sperm, eggs

**WARNING:** Meiosis evolved from mitosis, so stages & “machinery” are similar but the processes are radically different. Do not confuse the two!

### 2 Divisions of Meiosis

**DNA replication**

**1st division of meiosis separates homologous pairs**

**2nd division of meiosis separates sister chromatids**

### Preparing for meiosis

- 1st step of meiosis
  - Duplication of DNA
  - Why bother?
    - meiosis evolved after mitosis
    - convenient to use “machinery” of mitosis
    - DNA replicated in S phase of **interphase** of **MEIOSIS** (just like in mitosis)

### Meiosis 1

- 1st division of meiosis separates **homologous pairs**

### Meiosis 2

- 2nd division of meiosis separates **sister chromatids**

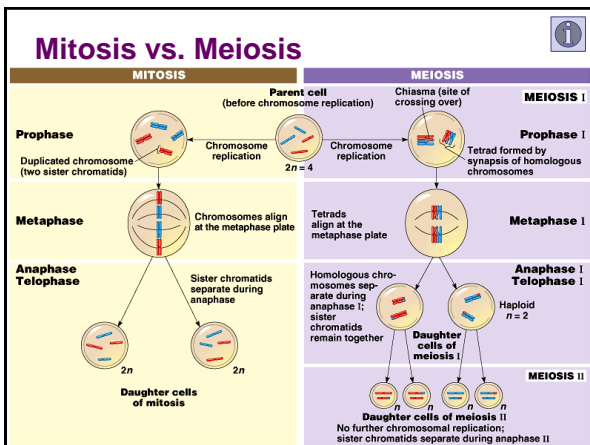
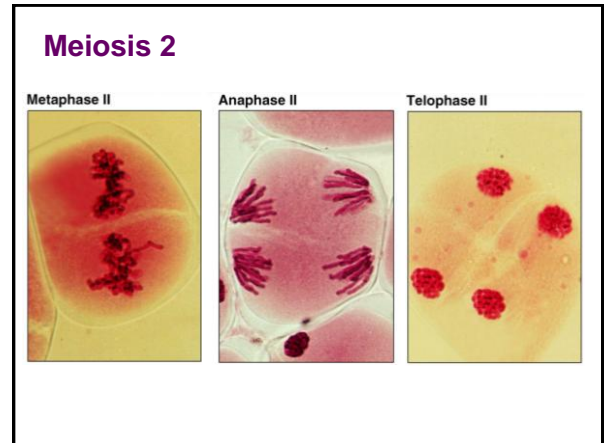
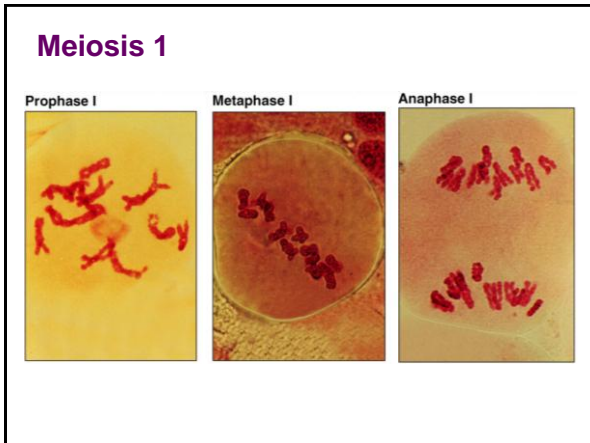
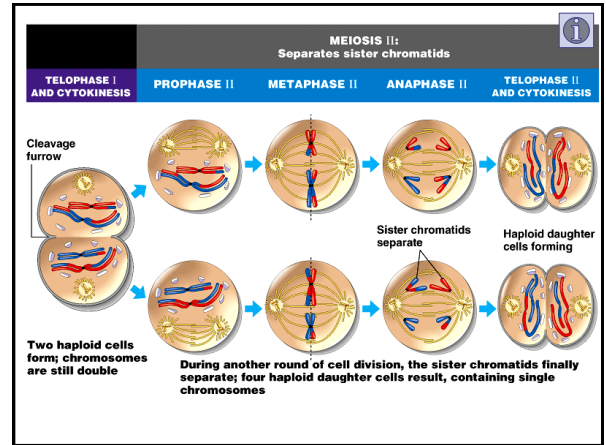
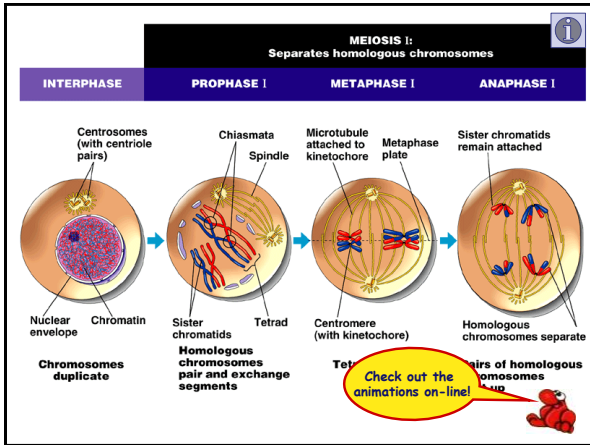
### Steps of Meiosis

- Meiosis 1
  - interphase
  - prophase 1
  - metaphase 1
  - anaphase 1
  - telophase 1
- Meiosis 2
  - prophase 2
  - metaphase 2
  - anaphase 2
  - telophase 2

**1st division of meiosis separates homologous pairs ( $2n \rightarrow 1n$ )**

**2nd division of meiosis separates sister chromatids ( $1n \rightarrow 1n$ )**

**JUST LIKE MITOSIS**



- Mitosis vs. Meiosis**
- Mitosis**
    - 1 division
    - daughter cells genetically **identical** to parent cell
    - produces **2 cells**
    - $2n \rightarrow 2n$
    - produces cells for **growth & repair**
    - no crossing over
  - Meiosis**
    - 2 divisions
    - daughter cells genetically **different** from parent
    - produces **4 cells**
    - $2n \rightarrow 1n$
    - produces **gametes**
    - crossing over**

### Crossing Over

- During prophase 1
  - homologous pairs swap pieces of chromosome
  - sister chromatids intertwine
  - called "crossing over"

tetrad  
synapsis

### Crossing Over

- Involves 3 steps
  - cross over
  - breakage of DNA
  - re-fusing of DNA
- New combinations of traits

### Genetic Variation

- Meiosis & crossing over introduce great genetic variation to a population
  - drives evolution

Mom Dad Mom Dad  
A a A a  
B b B b  
C c C c  
D d D d  
Crossover Initiates  
After Meiotic I phase (4 chromatids)  
Reductional Division (MI)  
Equational Division (MII)  
4 Individual Haploid Products

### The Value of Meiosis

- Meiosis introduces genetic variation
  - gametes of offspring do not have same chromosomes as gametes from parents
  - genetic recombination
    - random assortment in humans produces  $2^{23}$  (8,388,608) different combinations
    - This does not even include new combos due to crossing over!

from Mom from Dad new gametes made by offspring

### Random fertilization

- Any 2 parents will produce a zygote with over 70 trillion ( $2^{23} \times 2^{23}$ ) diploid combinations (of chromosomes!)

Couple 1 Couple 2

### Sources of Genetic Variability

- Genetic variability in sexual reproduction!
  - independent assortment
    - homologous chromosomes in Meiosis 1
  - crossing over
    - between homologous chromosomes in prophase 1
  - random fertilization
    - random ovum fertilized by a random sperm

metaphase1

### Sexual Reproduction Creates Variability

Sexual reproduction allows us to maintain both genetic similarity & differences.



Baldwin brothers

Michael & Kirk Douglas



Martin & Charlie Sheen, Emilio Estevez

### Differences across Kingdoms

- Not all organisms use haploid & diploid stages in same way
  - ◆ which one is dominant ( $2n$  or  $n$ ) differs
  - ◆ but still alternate between haploid & diploid
    - have to for sexual reproduction

