# Warm up

1. Compare sexual to asexual reproduction.

2. What are homologous chromosomes?

3. Describe what major processes occur during a sexual life cycle.

# Warm-Up

*Assume that the number of cells in a certain phase is an indication of the time spent in that phase during mitosis. The average human embryonic cell takes 1800 minutes to divide.*

1. If 58 embryonic cells were counted in anaphase and 520 total cells were counted, how long does a dividing embryonic cell spend during anaphase? Give the answer in minutes to the nearest whole number.
2. List 3 similarities between mitosis & meiosis.
3. List 3 differences between mitosis & meiosis.
4. What is nondisjunction? What causes it?

# Warm up

1. Describe what occurs during crossing over.

2. What are 3 sources of genetic variation?

3. Mitosis, Meiosis, or Both?
   A. Chromosomes line up at metaphase plate
   B. Crossing over
   C. Cytokinesis
   D. Chromosomes are replicated
   E. Four haploid daughter cells result
   F. Two diploid daughter cells result

# Chapter 10
# Meiosis & Sexual Life Cycles

# What you must know:

- The difference between asexual and sexual reproduction.
- The role of meiosis and fertilization in passing traits from parents to offspring.
- The importance of homologous chromosomes to meiosis.
- How the chromosome number is reduced from diploid to haploid in meiosis.
- Three that occur in meiosis, but not mitosis.
- The importance of crossing over, independent assortment, and random fertilization to increasing genetic diversity.

# Genes & Chromosomes

- Genes: segments of DNA that code for basic units of heredity

- Offspring acquire genes from parents by inheriting chromosomes

# Types of Reproduction

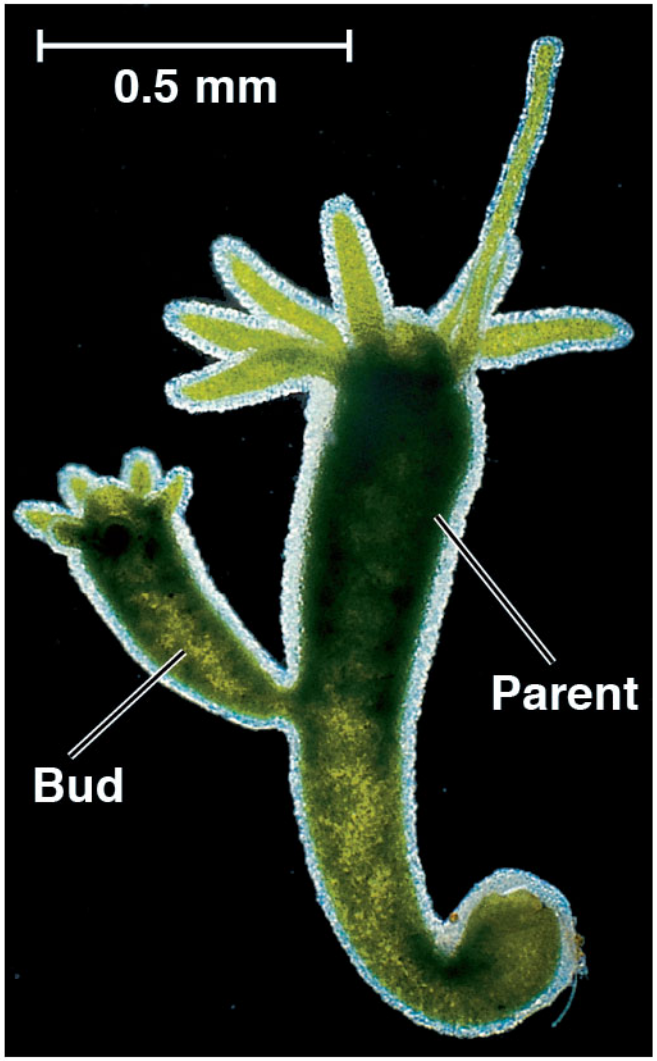
## ASEXUAL

- Produces clones (genetically identical)
- Single parent
- Little variation in population - only through mutations
- Fast and energy efficient
- Eg. budding, binary fission

## SEXUAL

- Meiosis produces gametes (sex cells)
- 2 parents: male/female
- Lots of variation/diversity
- Slower and energy consumptive
- Eg. humans, trees

# Asexual vs. sexual reproduction



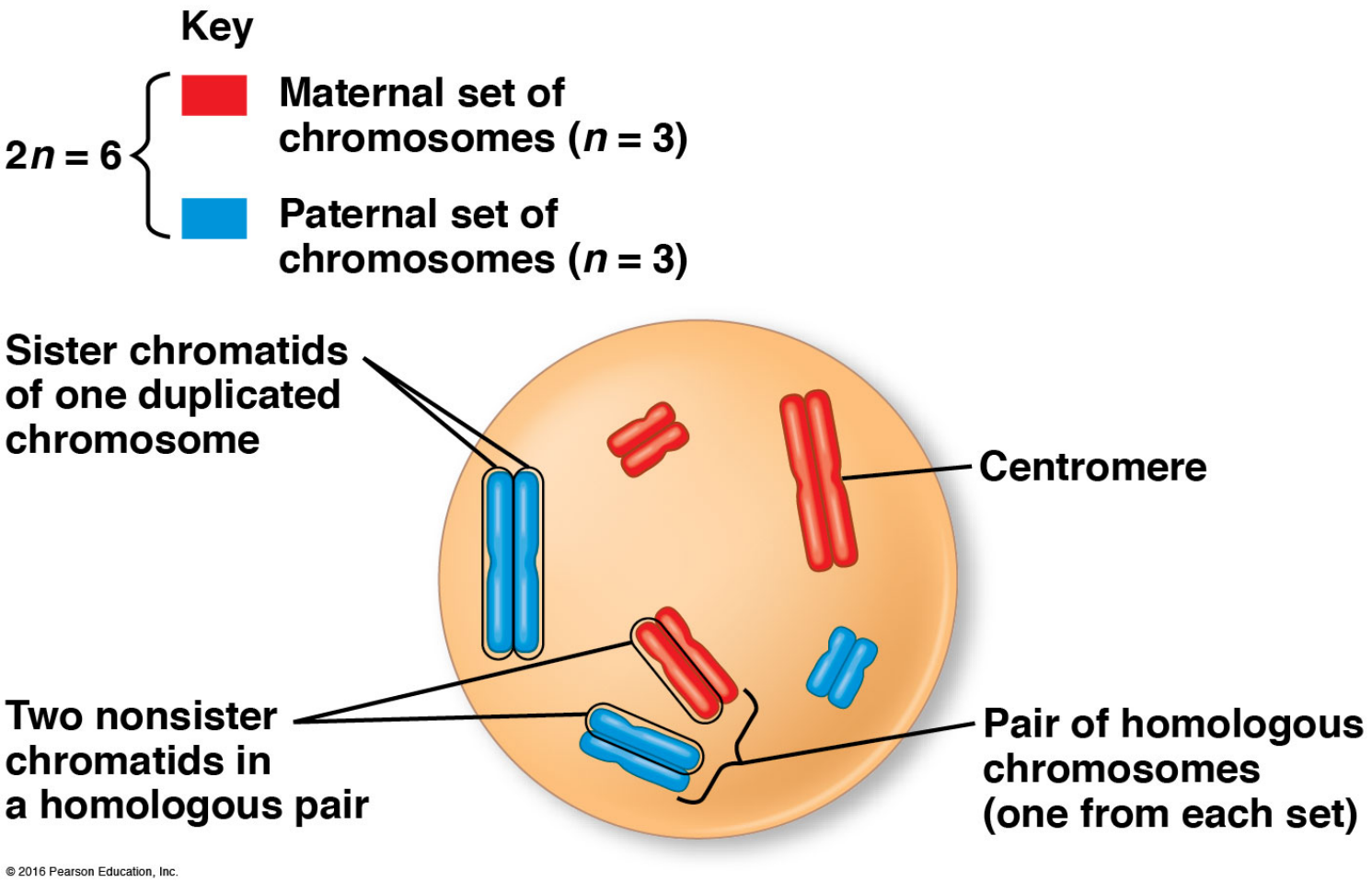

(a) Hydra

(b) Redwoods

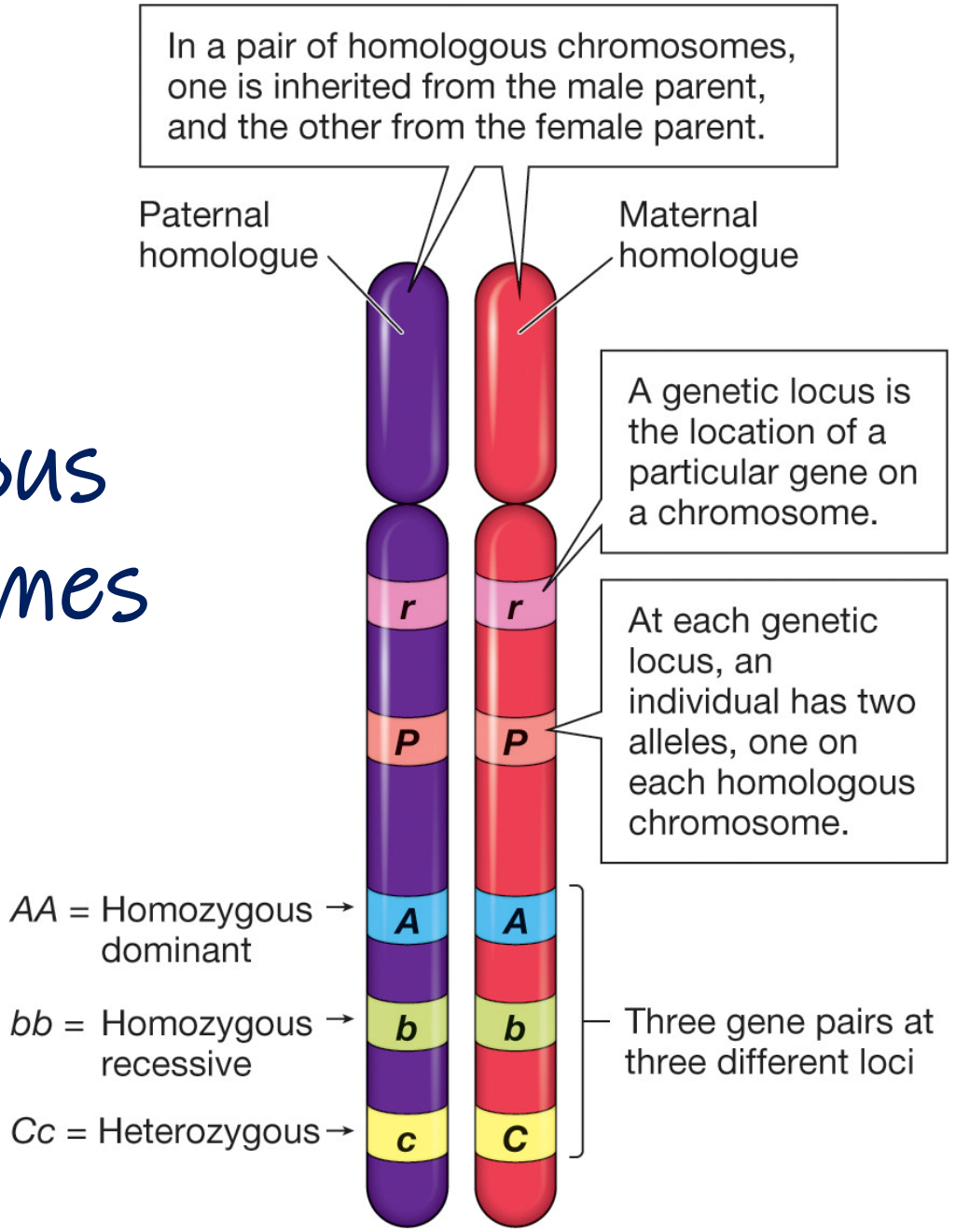
# Chromosomes

- **Somatic (body) cell:** 2n = 46 chromosomes
- Each pair of **homologous chromosomes** includes 1 chromosome from each parent
- **Autosomes**: 22 pairs of chromosomes that do not determine sex
- **Sex chromosomes:** X and Y
  - Females: XX
  - Males: XY
- **Gametes (n=23)**: 22 autosomes + 1 sex chromosome
  - Egg: 22 + X
  - Sperm: 22 + X **or** 22 + Y

# Homologous Chromosomes in a Somatic Cell



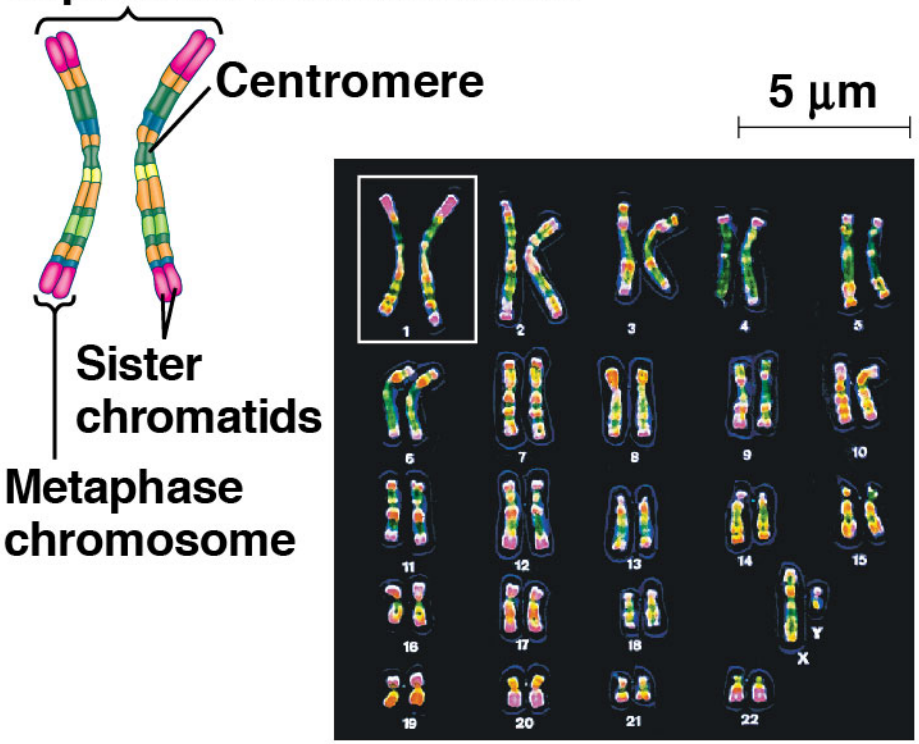
# Homologous Chromosomes



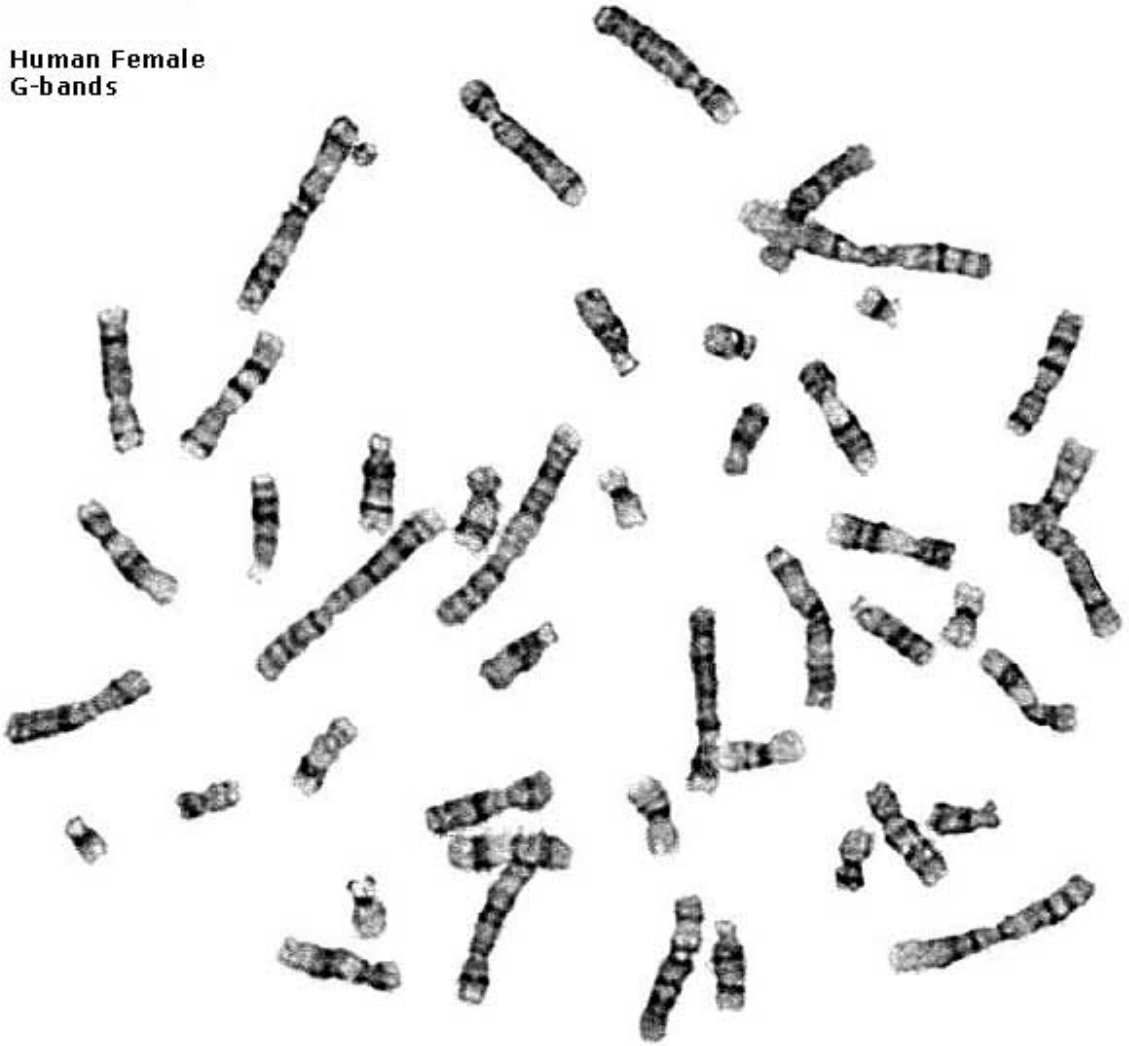
# Karyotype: a picture of an organism's complete set of chromosomes

## Technique

## Results



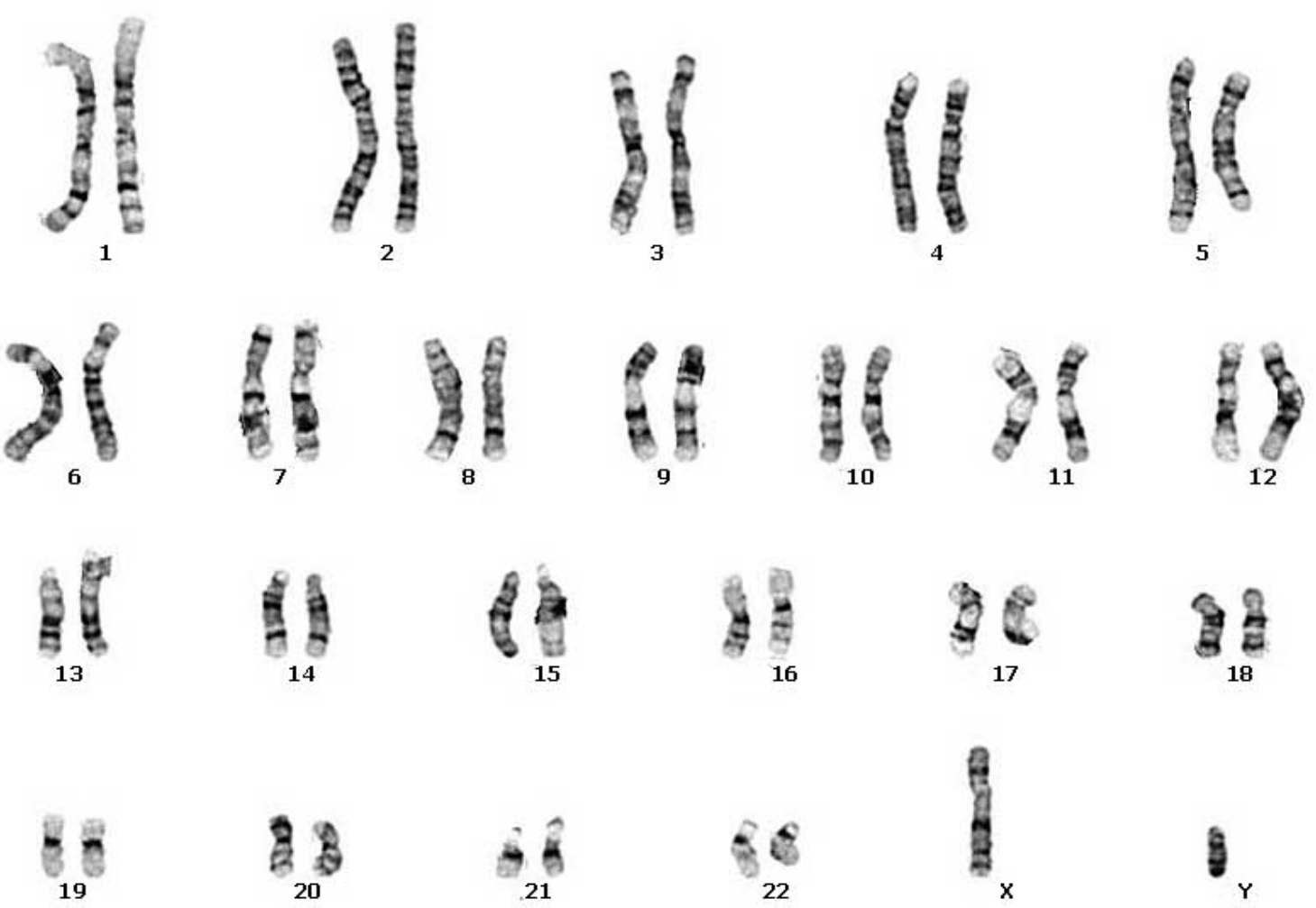
# Making a karyotype – unsorted chromosomes



# 22 pairs of autosomes + 1 pair of sex chromosomes


Male or female?

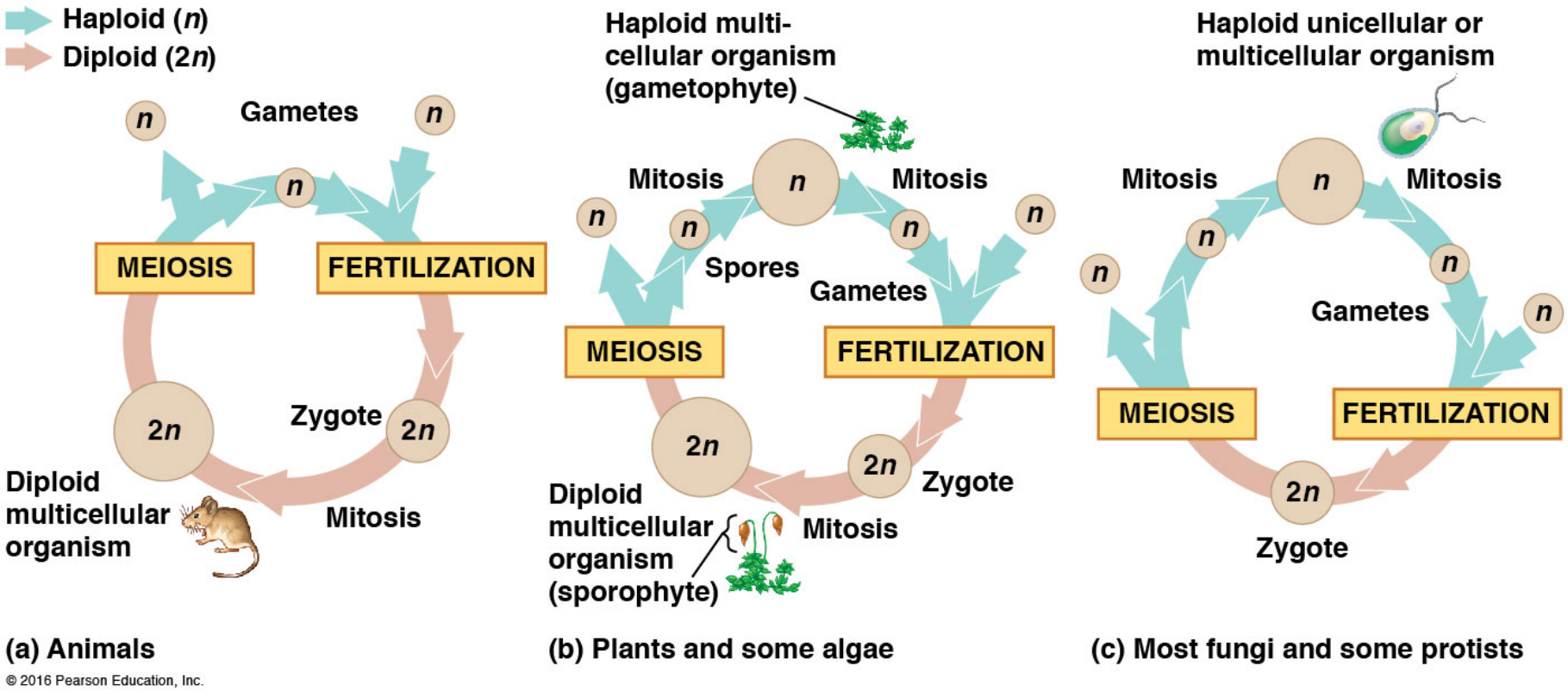
# Male or female?



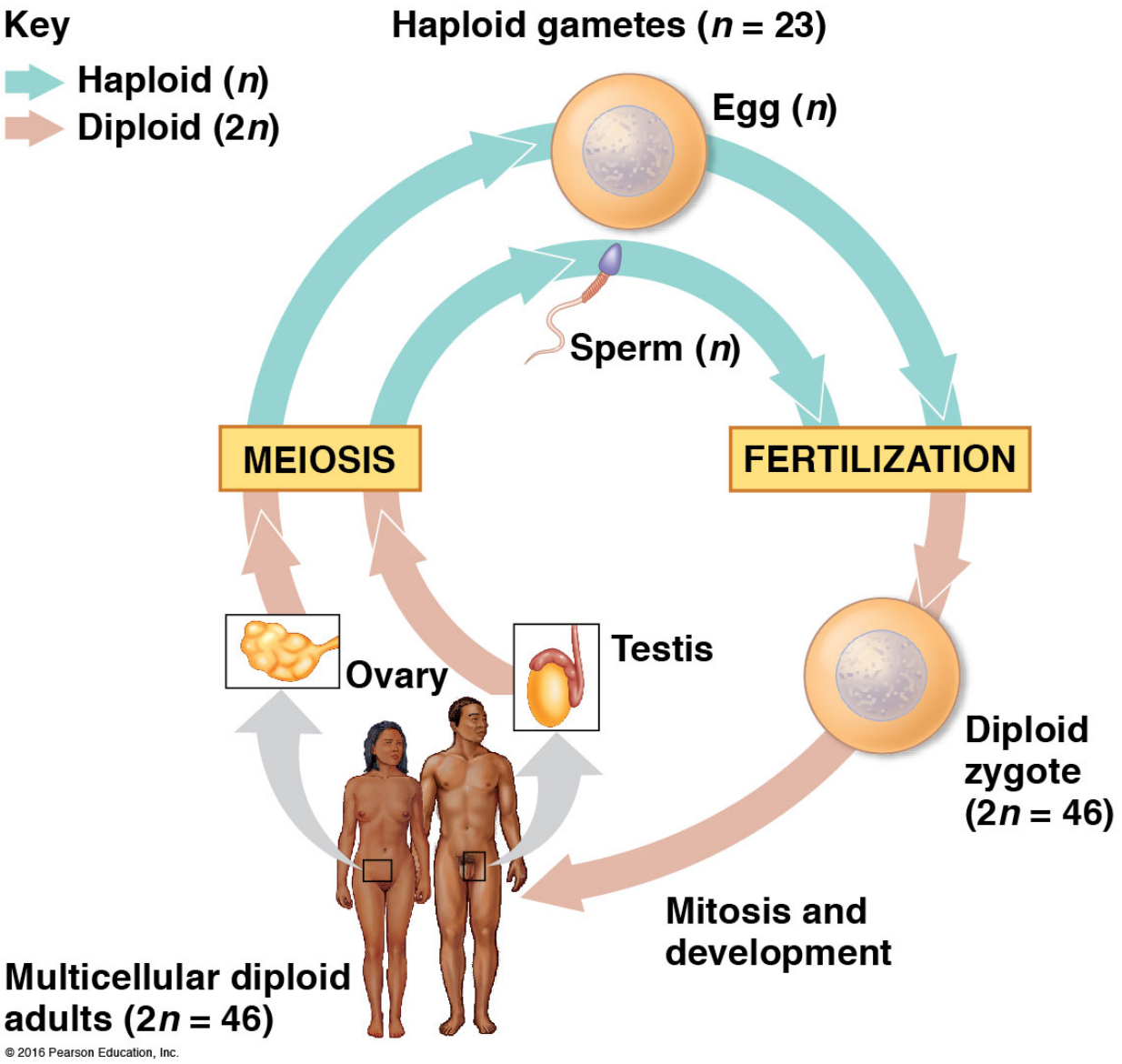
## Life cycle: reproductive history of organism, from conception → production of own offspring

- ***Fertilization*** and ***meiosis*** alternate in **sexual life cycles**
- Meiosis: cell division that reduces # of chromosomes (2n → n), creates gametes
- Fertilization: combine gametes (sperm + egg)
  - Fertilized egg = zygote (2n)
- Zygote divides by mitosis to make multicellular diploid organism

# Varieties of Sexual Life Cycles

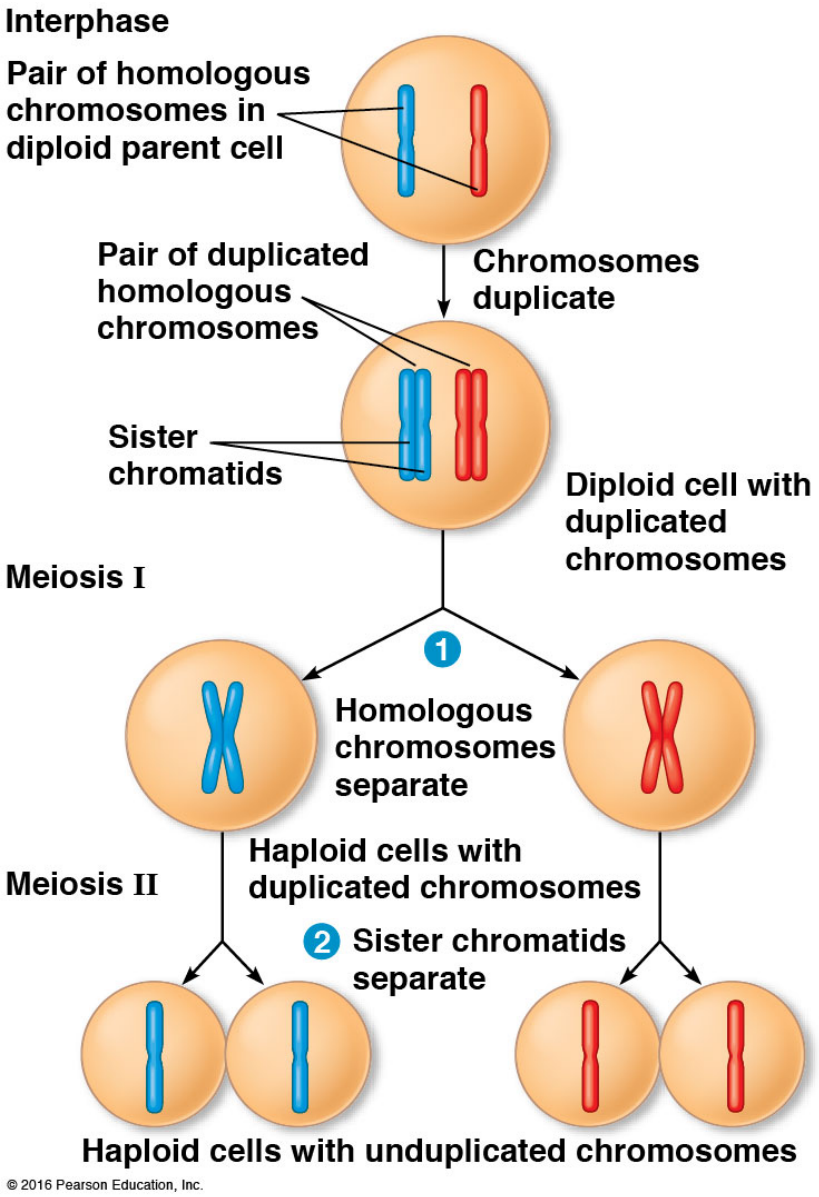


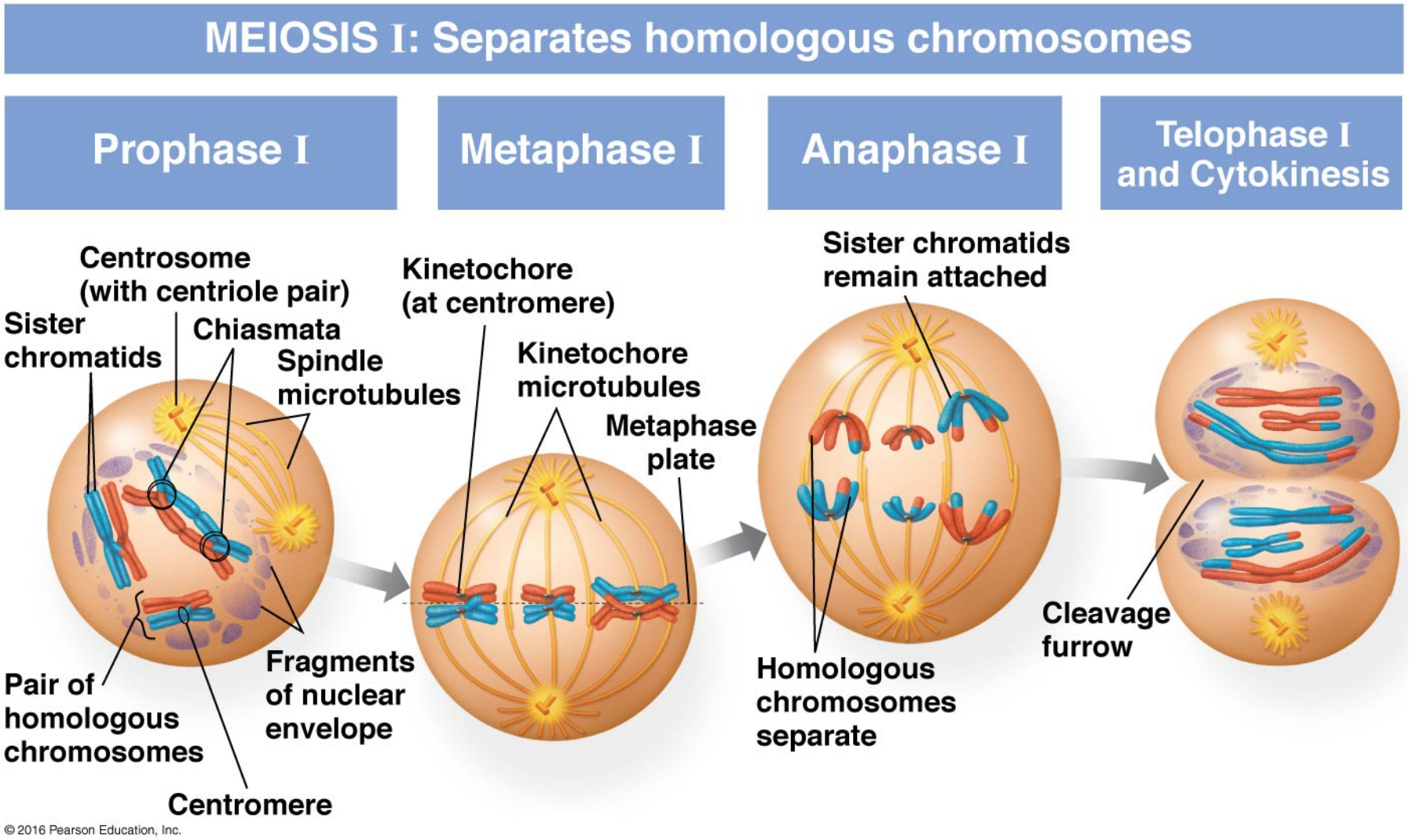
# Human Life Cycle



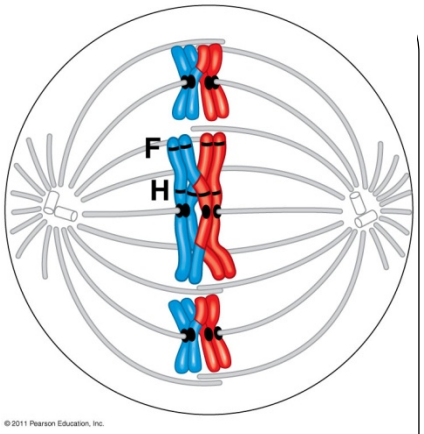
# Meiosis = reduction division

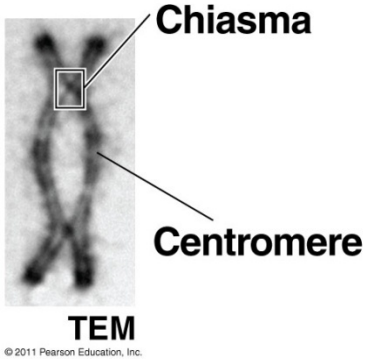
- Cells divide <u>twice</u>
- Result: 4 daughter cells, each with half as many chromosomes as parent cell




MEIOSIS I: Separates homologous chromosomes
Prophase I
Metaphase I
Anaphase I
Telophase I and Cytokinesis
Centrosome (with centriole pair)
Sister chromatids
Chiasmata
Spindle microtubules
Kinetochore (at centromere)
Kinetochore microtubules
Metaphase plate
Sister chromatids remain attached
Cleavage furrow
Pair of homologous chromosomes
Fragments of nuclear envelope
Centromere
Homologous chromosomes separate
© 2016 Pearson Education, Inc.

# **Meiosis I** (1st division)




Interphase: chromosomes replicated

Prophase I:

- **Synapsis**: homologous chromosomes pair up
- Tetrad = 4 sister chromatids
- **Crossing over** at the **chiasmata**

Metaphase I: Tetrads line up

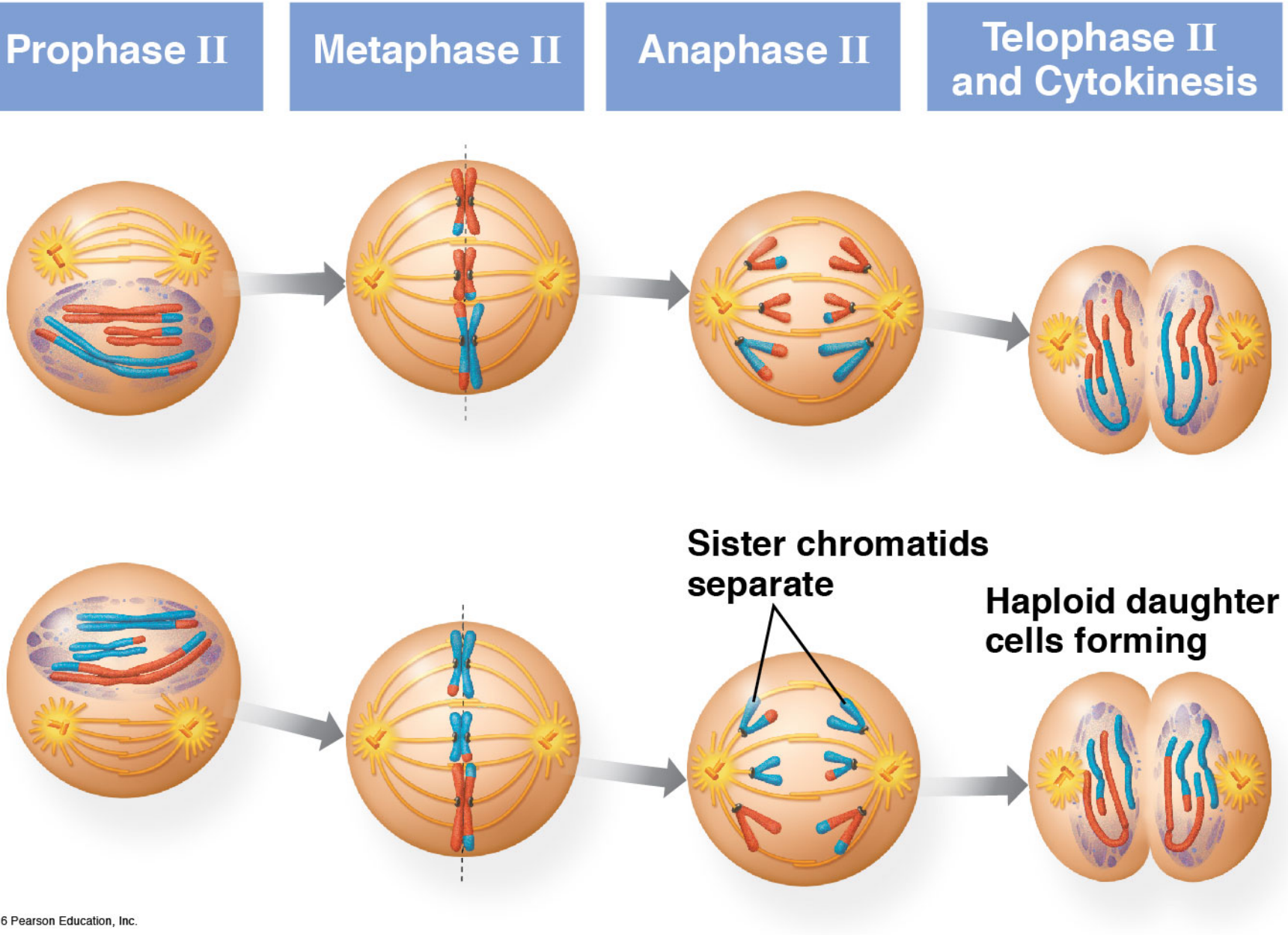
Anaphase I:

- **Pairs** of homologous chromosomes separate
- (Sister chromatids still attached by centromere)

Telophase I & Cytokinesis:

- **2 haploid cells**
- Each chromosome = 2 sister chromatids
- Some species: chromatin & nucleus reforms

# MEIOSIS II: Separates sister chromatids



# Meiosis II (2nd division) = create gametes

Prophase II:

- No interphase
- No crossing over
- Spindle forms

Metaphase II:

- Chromosomes line up

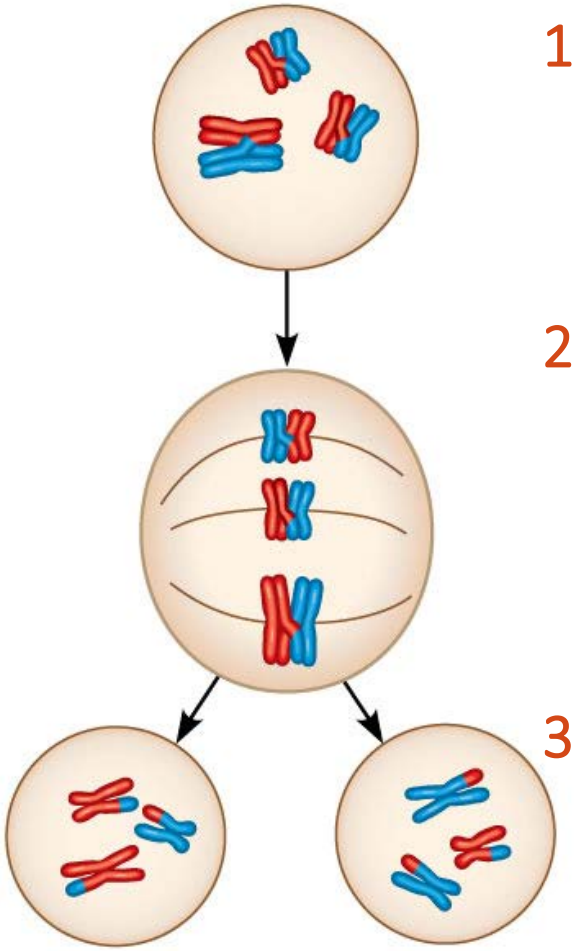
Anaphase II:

- Sister chromatids separate

Telophase II:

- 4 haploid cells
- Nuclei reappear
- Each daughter cell genetically unique

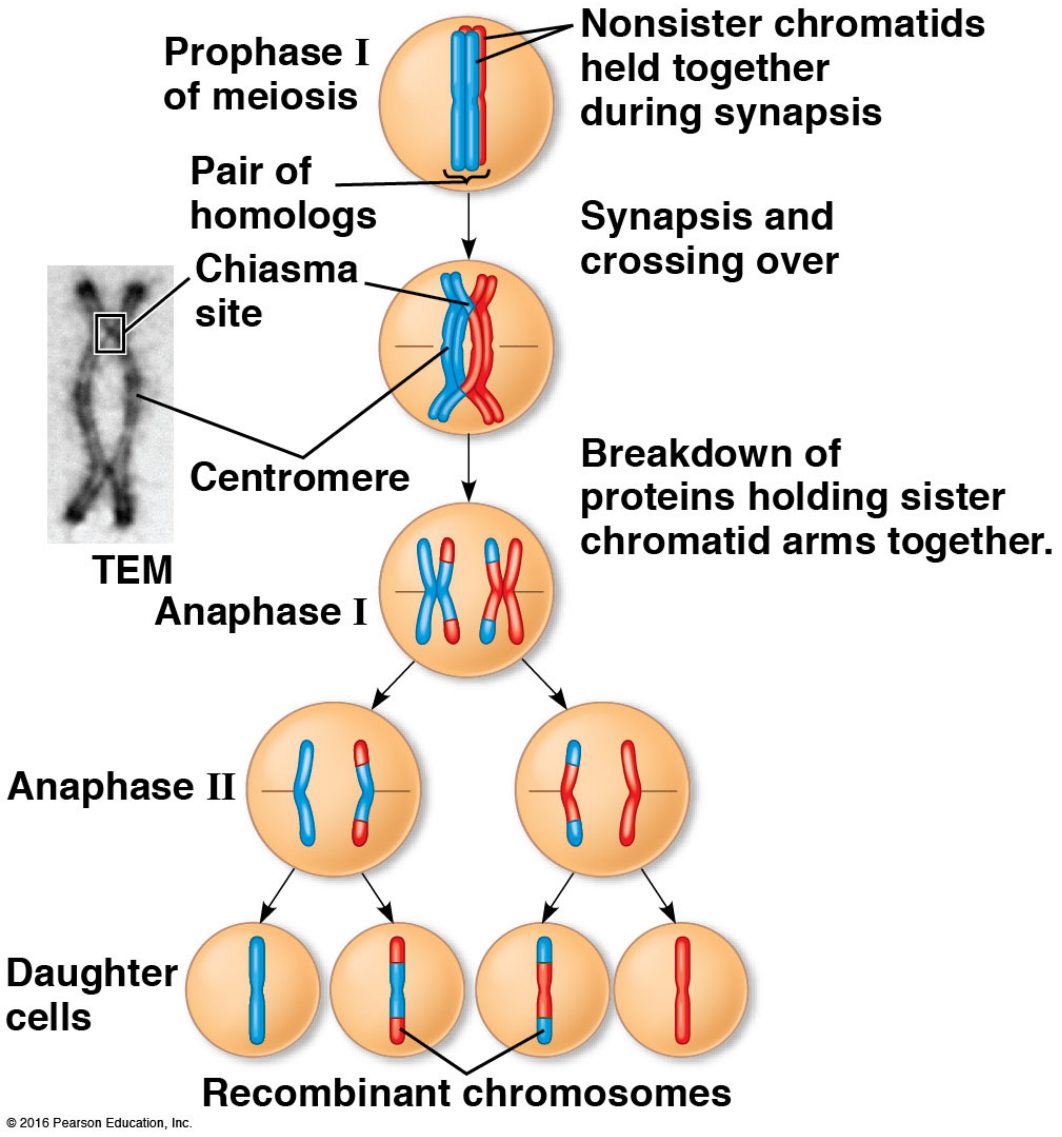
# Three Ways Meiosis is DIFFERENT than Mitosis




1. Prophase I: Synapsis and crossing over
2. Metaphase I: **pairs** of homologous chromosomes line up on metaphase plate
3. Anaphase I: homologous pairs separate → sister chromatids **still attached** at centromere

# 3 Sources of Genetic Variation:

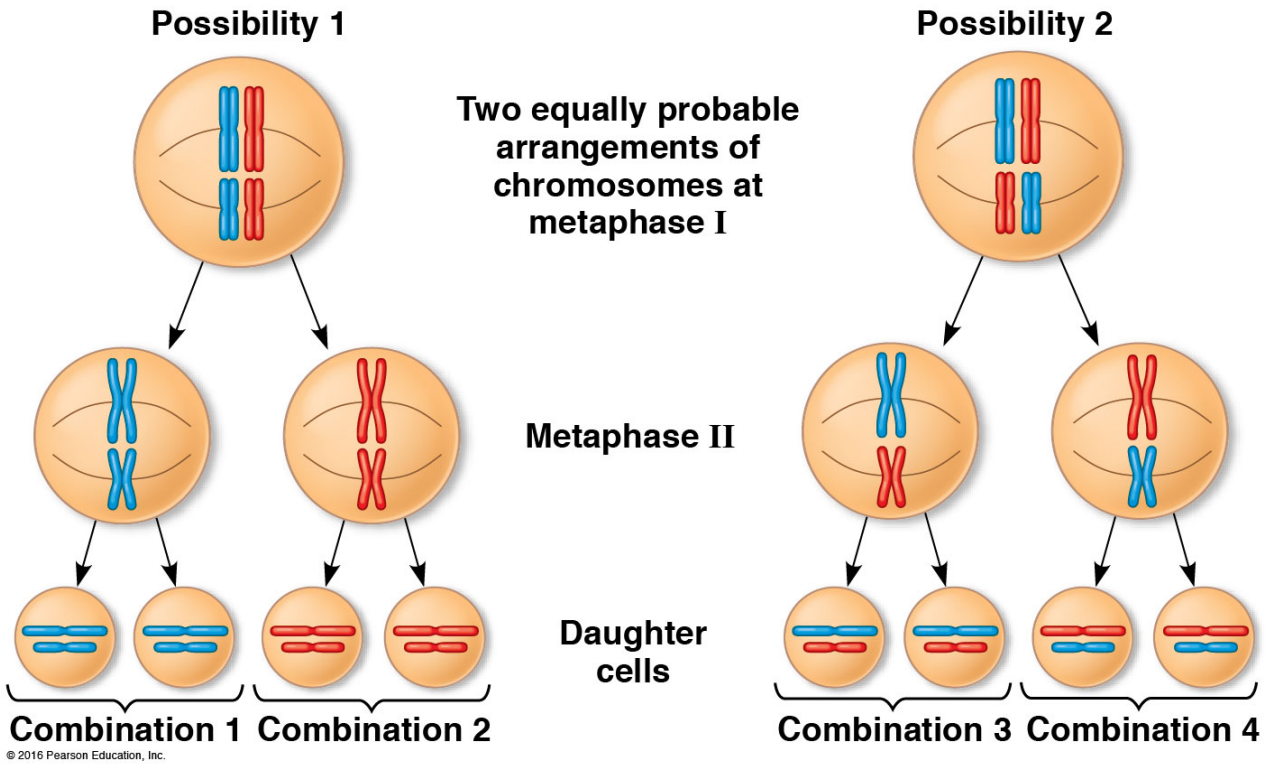
1. Crossing Over
   - Exchange genetic material
   - Recombinant chromosomes



# 3 Sources of Genetic Variation:

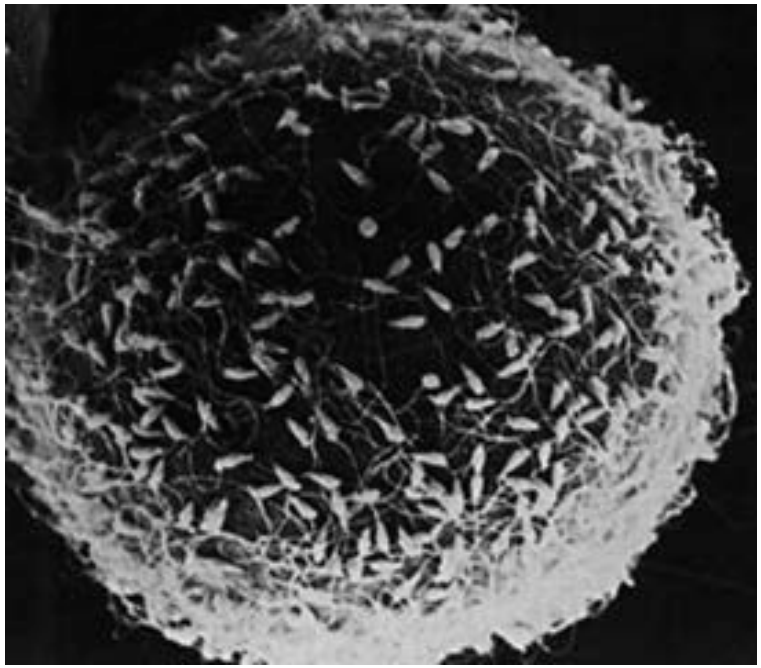
## 2. Independent Assortment of Chromosomes

- Random orientation of homologous pairs in Metaphase I

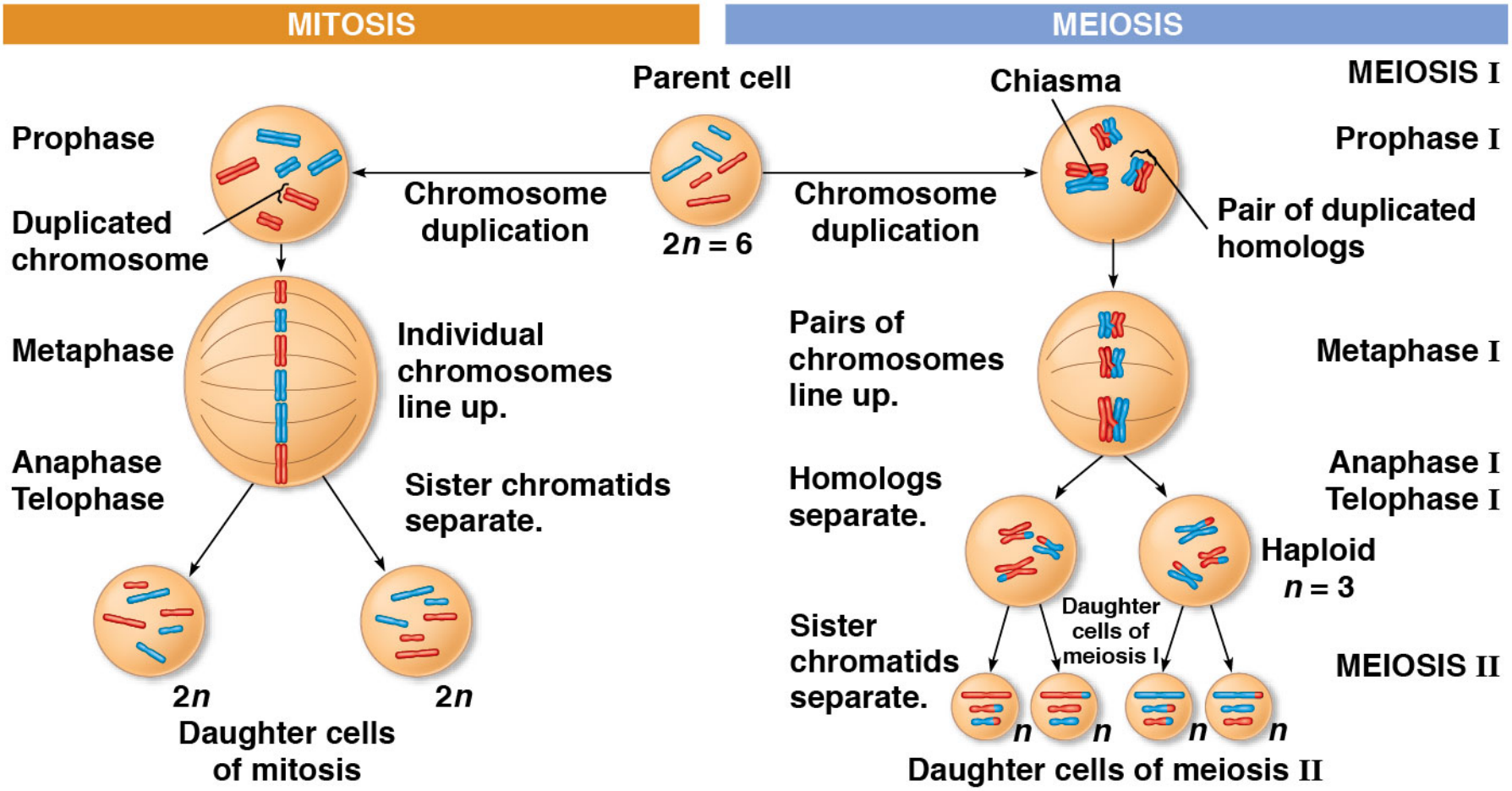


# 3 Sources of Genetic Variation:

3. **Random Fertilization**
   - Any sperm + Any egg
   - 8 million X 8 million = 64 trillion combinations!



# Summary: Mitosis vs. Meiosis



# Summary: Mitosis vs. Meiosis

| SUMMARY | | |
|---|---|---|
| **Property** | **Mitosis (diploid and haploid)** | **Meiosis (diploid only)** |
| DNA replication | Occurs during interphase before mitosis begins | Occurs during interphase before meiosis I begins |
| Number of divisions | One, including prophase, prometaphase, metaphase, anaphase, and telophase | Two, each including prophase, metaphase, anaphase, and telophase |
| Synapsis of homologous chromosomes | Does not occur | Occurs during prophase I along with crossing over between nonsister chromatids; resulting chiasmata hold pairs together due to sister chromatid cohesion |
| Number of daughter cells and genetic composition | Two, each genetically identical to the parent cell, with the same number of chromosomes | Four, each haploid (*n*); genetically different from the parent cell and from each other |
| Role in the animal or plant body | Enables multicellular animal or plant (gametophyte or sporophyte) to arise from a single cell; produces cells for growth, repair, and, in some species, asexual reproduction; produces gametes in the gametophyte plant | Produces gametes (in animals) or spores (in the sporophyte plant); reduces number of chromosome sets by half and introduces genetic variability among the gametes or spores |

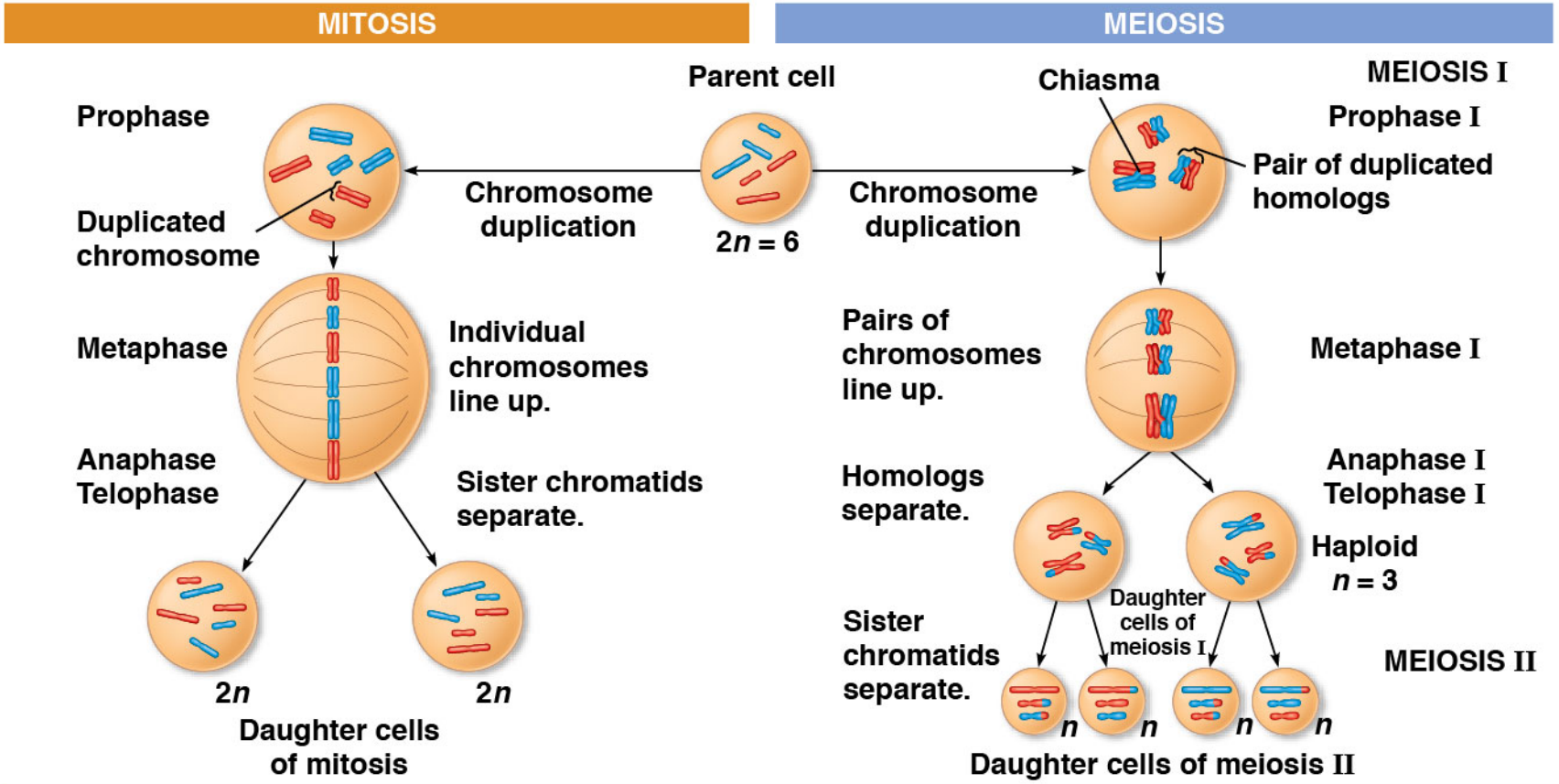
## Mitosis

- Somatic cells
- 1 division
- 2 diploid daughter cells
- Clones
- From zygote to death
- Purpose: growth and repair
- No synapsis, crossing over

## Meiosis

- Gametes
- 2 divisions
- 4 haploid daughter cells
- Genetically different-less than 1 in 8 million alike
- Females before birth follicles are formed. Mature ova released beginning puberty
- Purpose: Reproduction

Both are divisions of cell nucleus




## SUMMARY

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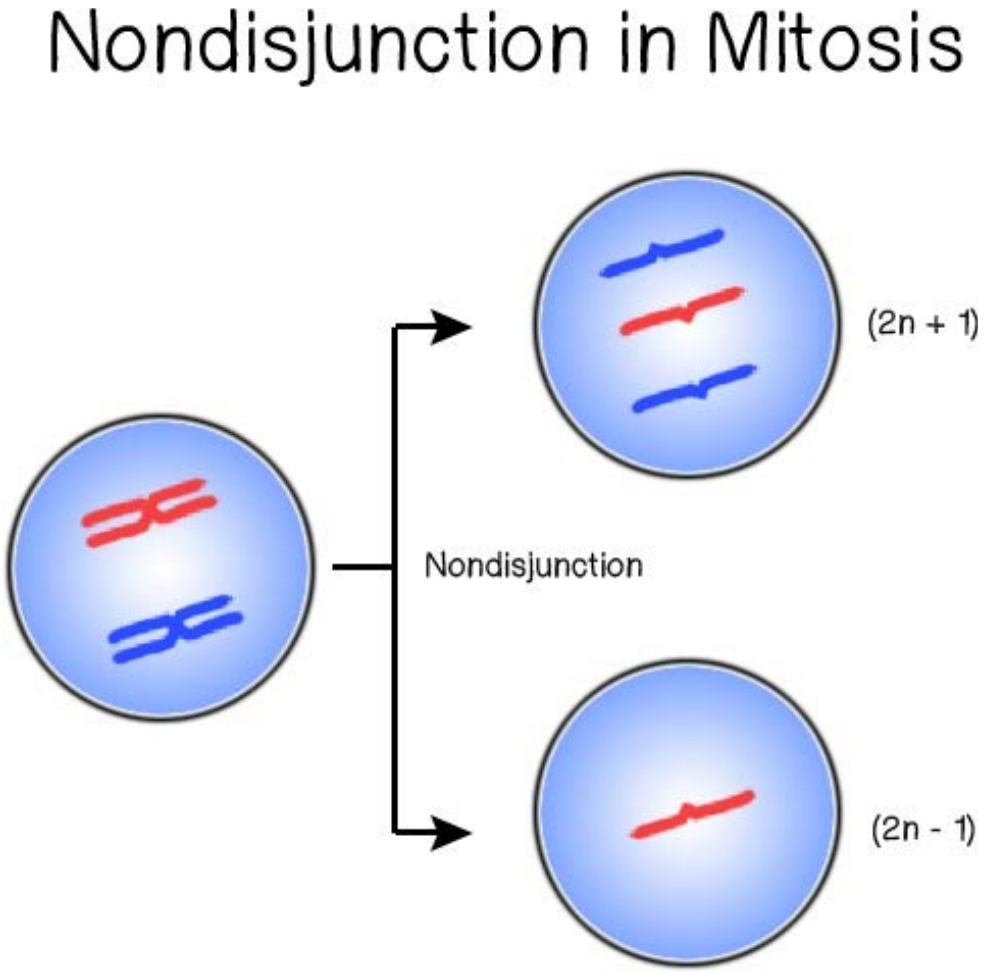
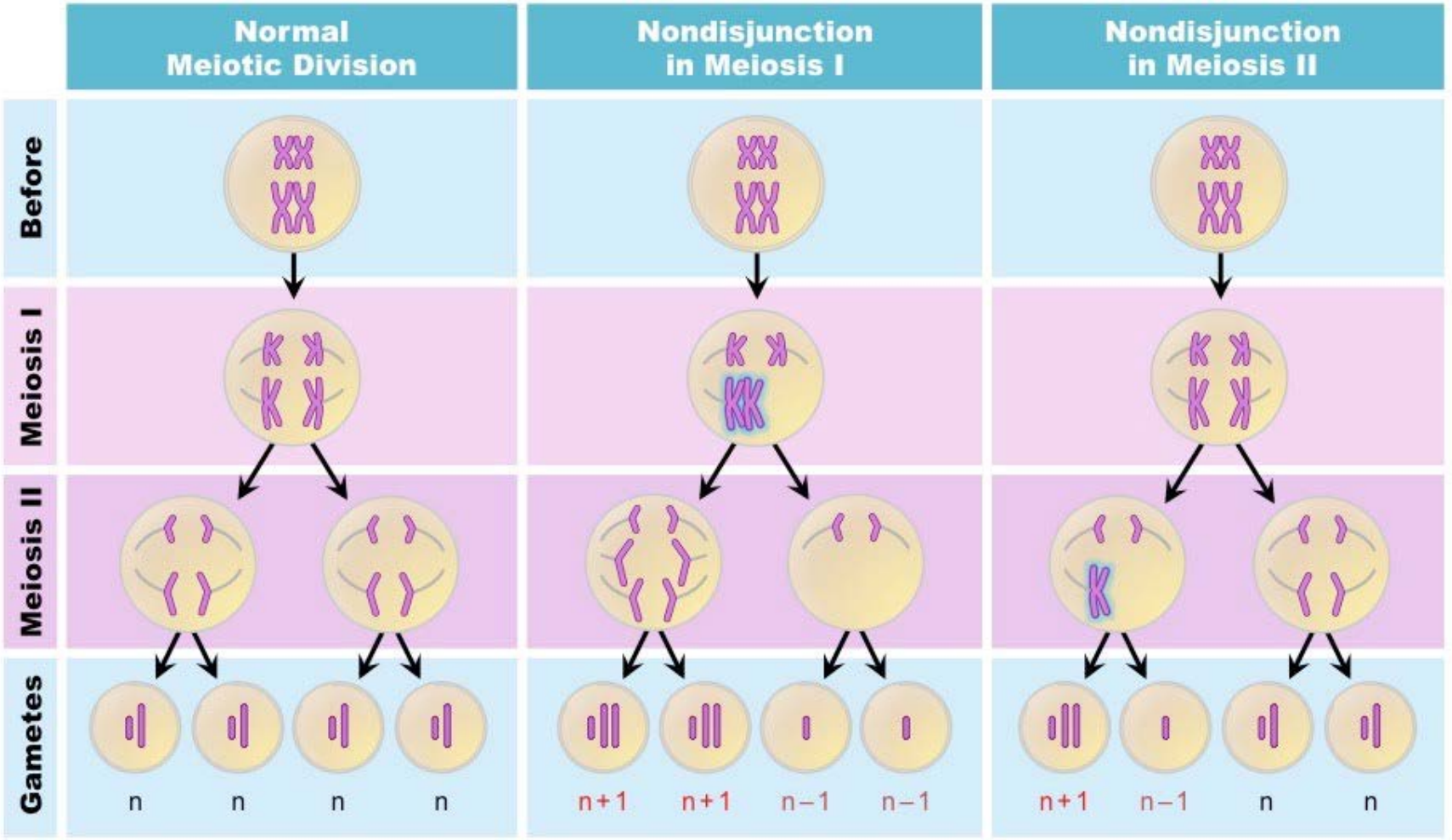
# Human Chromosomal Disorders

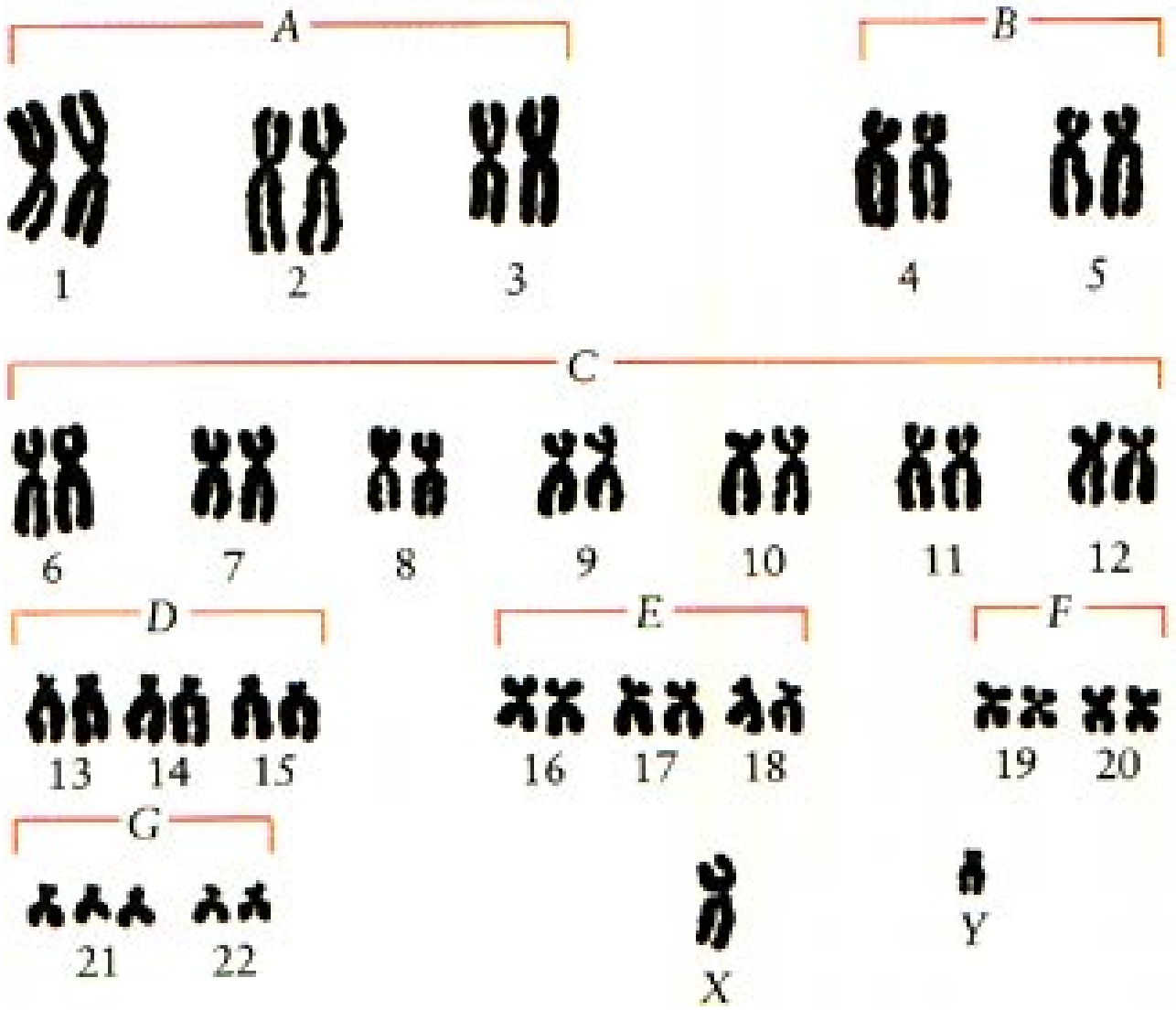
**Nondisjunction**: chromosomes fail to separate properly



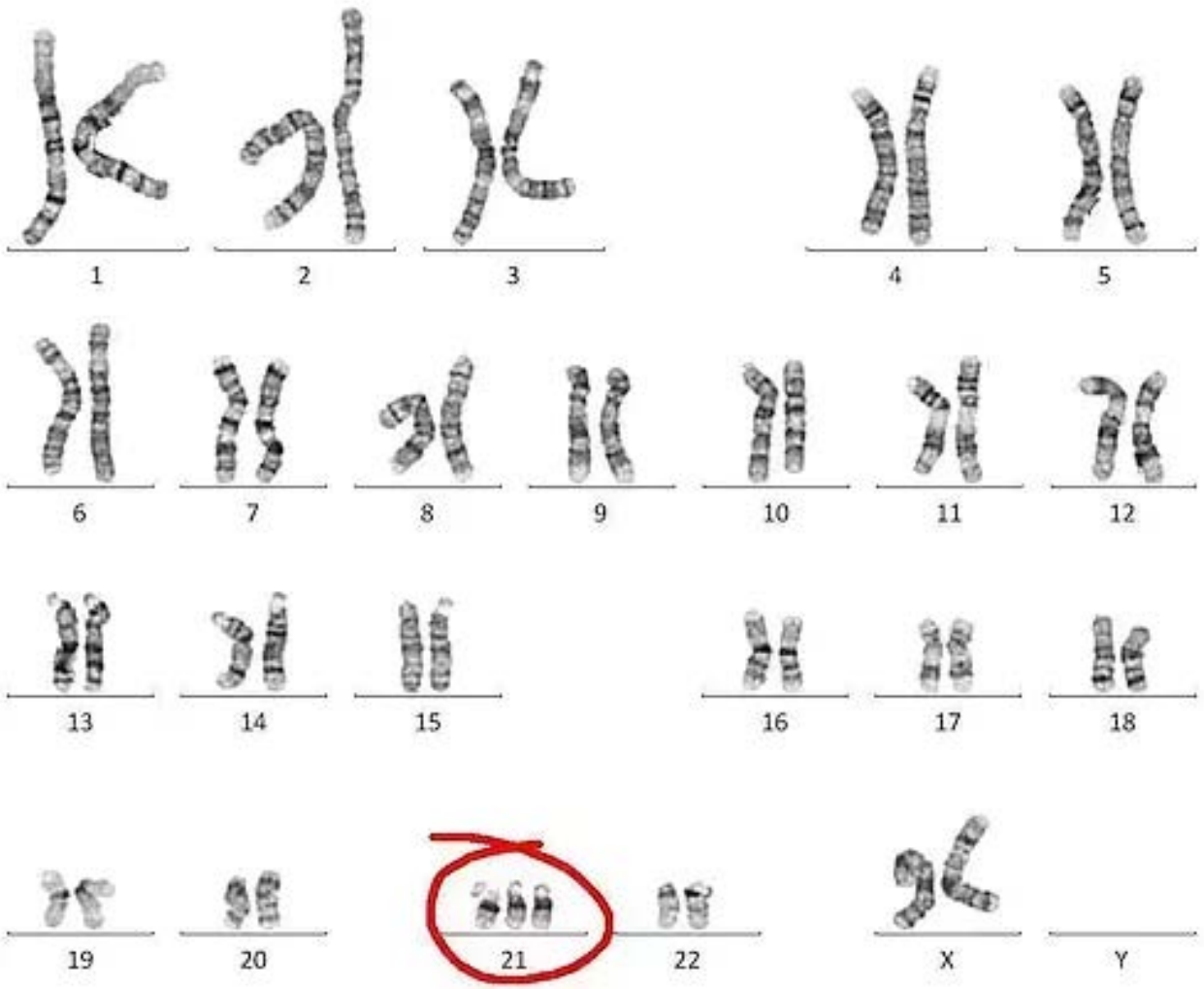
# Nondisjunction: chromosomes fail to separate properly



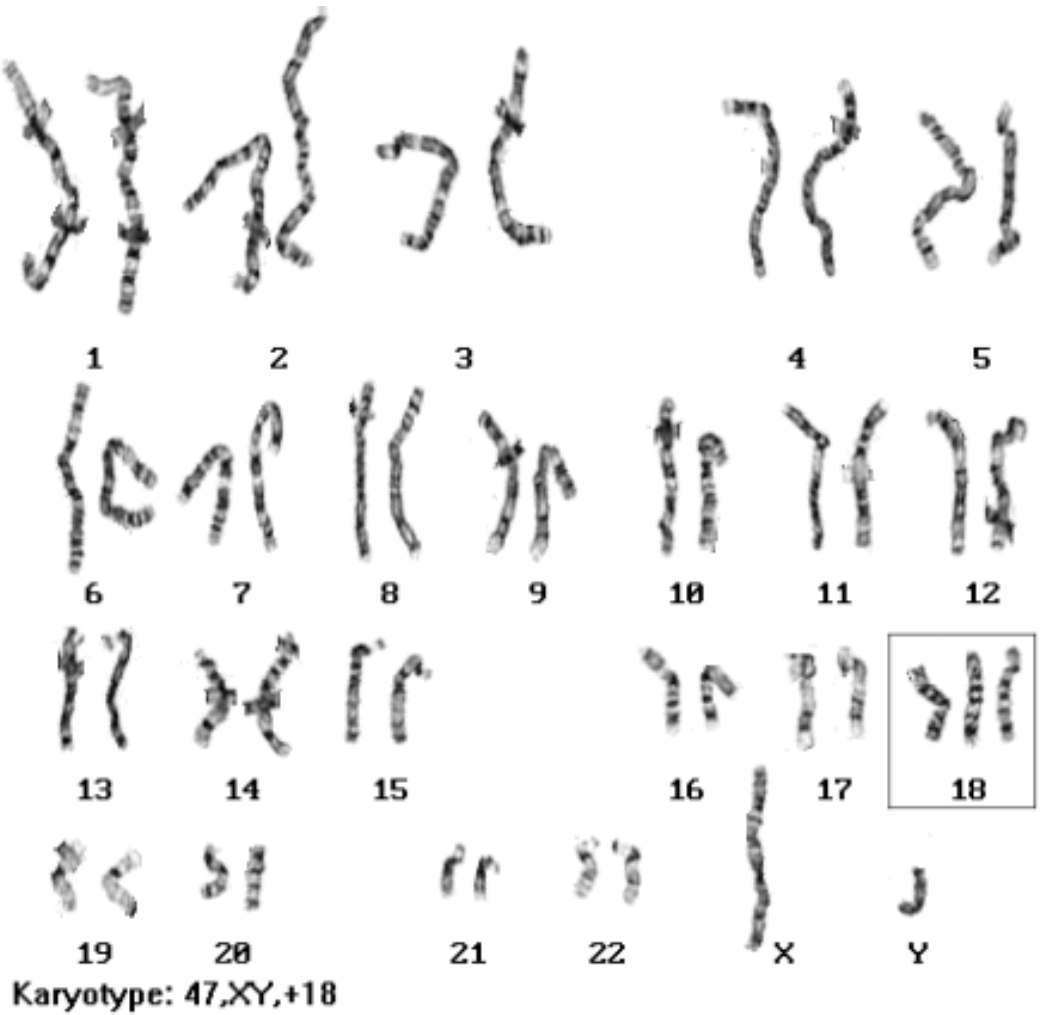
# Karyotype: Used to determine genetic abnormalities



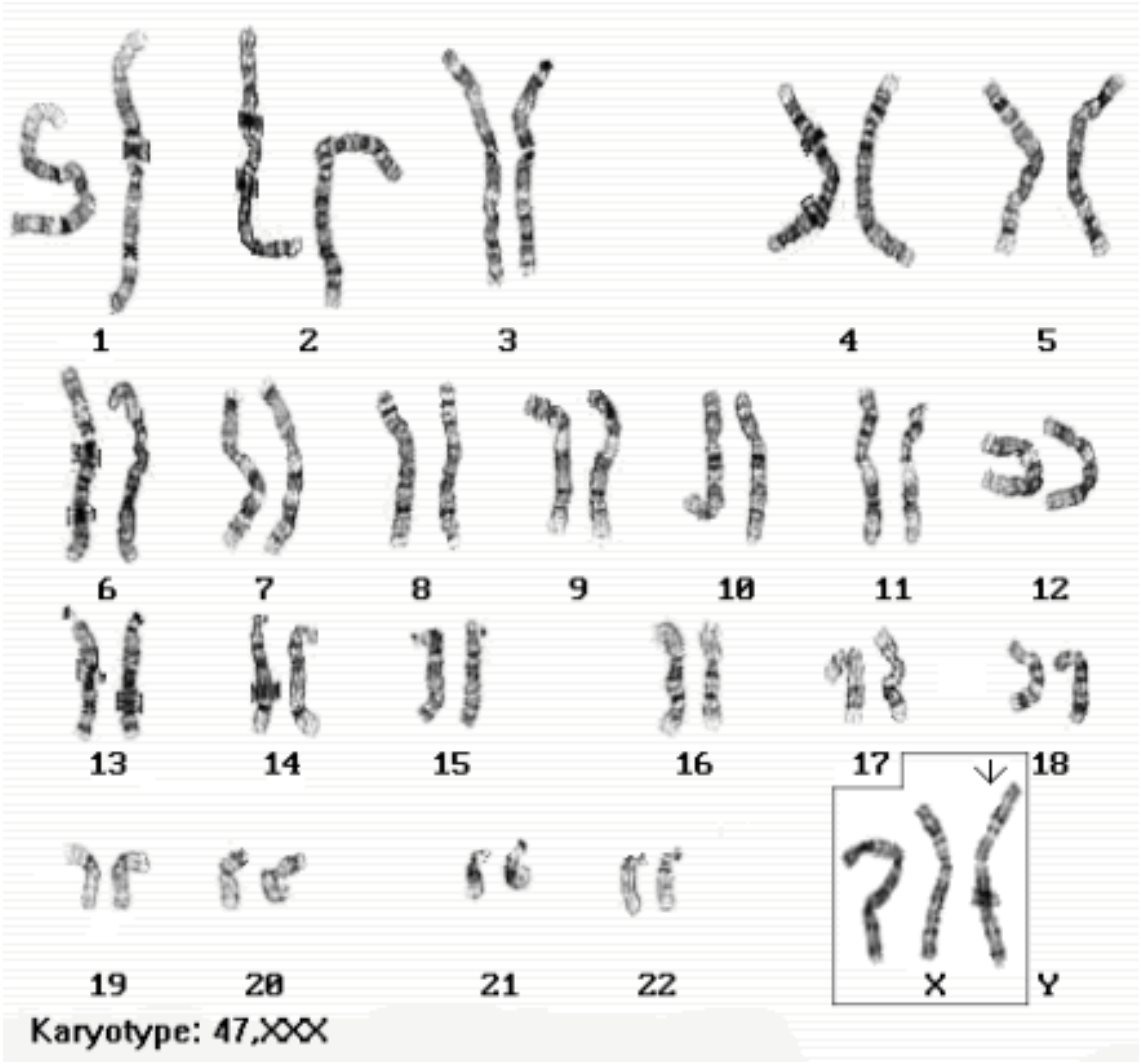
# Down Syndrome (Trisomy 21)



# Edward's Syndrome (Trisomy 18)



# Trisomy X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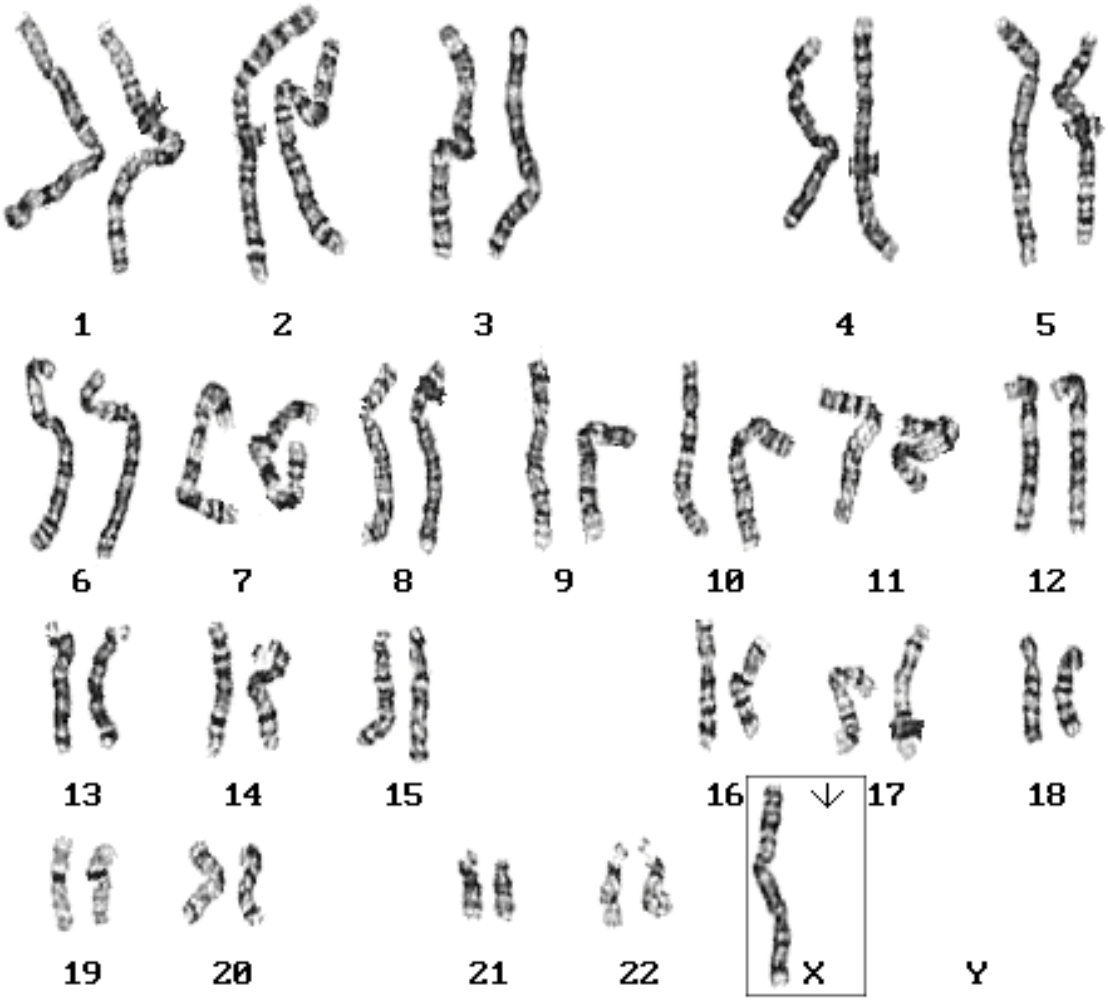
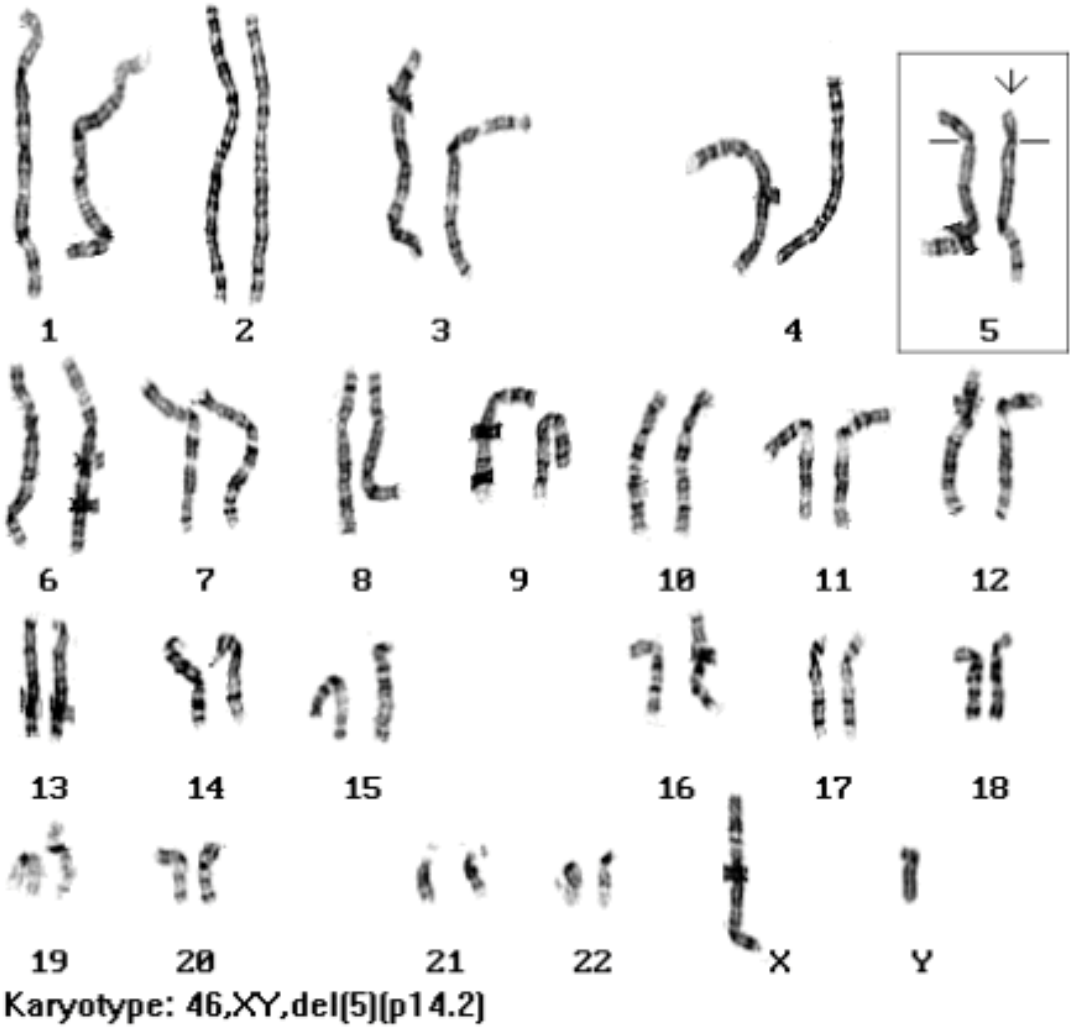
22
X
Y
Karyotype: 47,XXX

# Turner's Syndrome (Monosomy X)

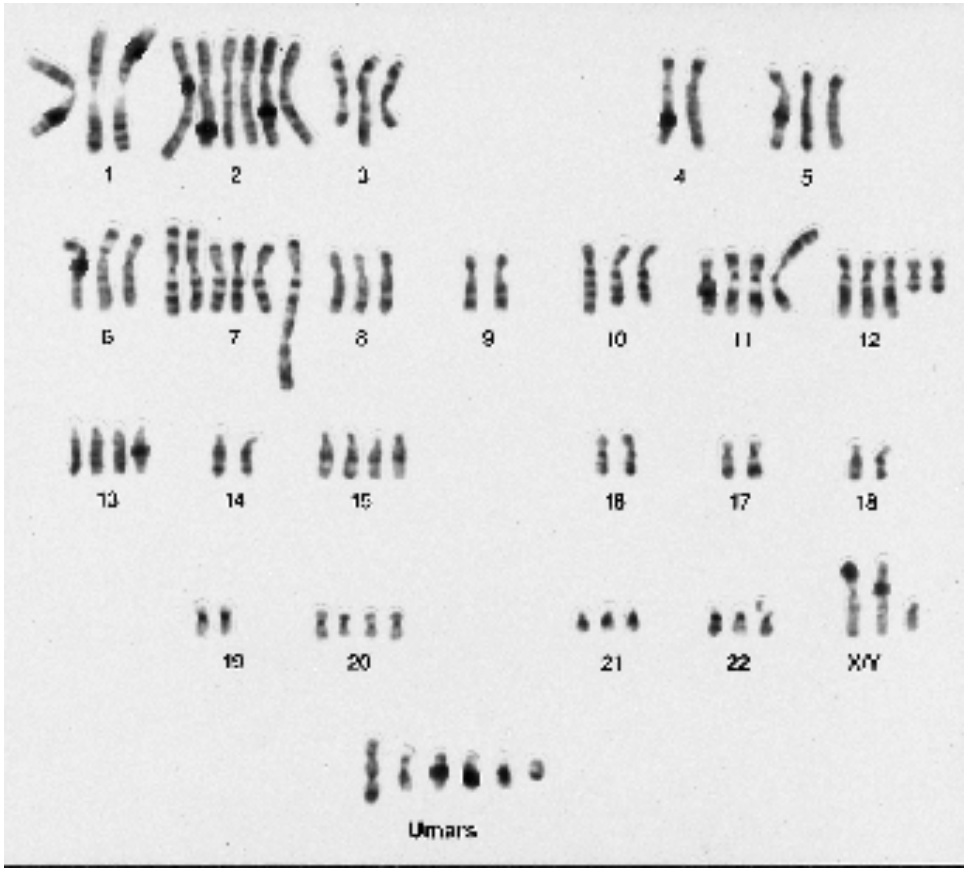


# Cri du chat
# Chromosome 5 deletion



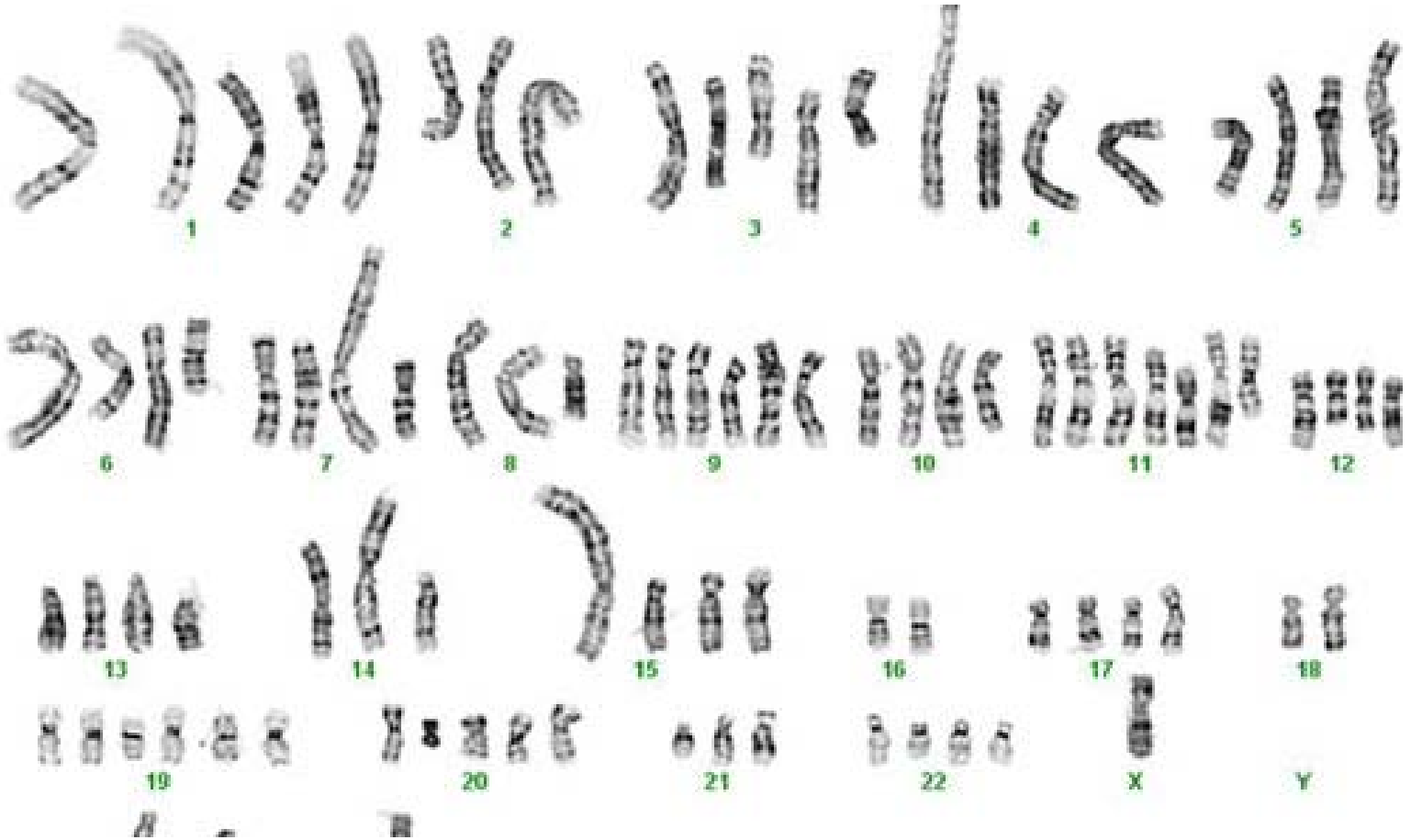
# Cancer cells

- Some have abnormal #'s of chromosomes
- Nondisjunction in mitosis



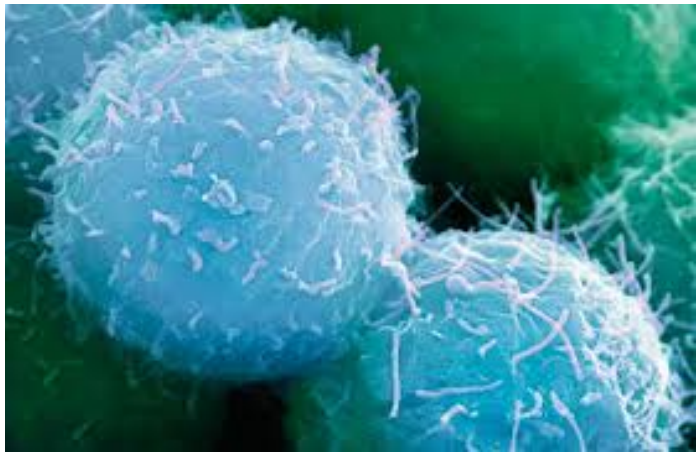

Karyotype of Metastatic Melanoma

# Breast Cancer Cell Karyotype



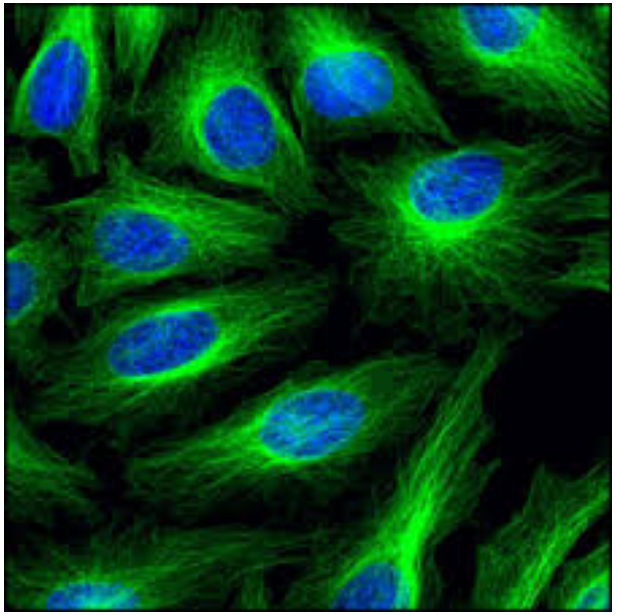
# HeLa Cells

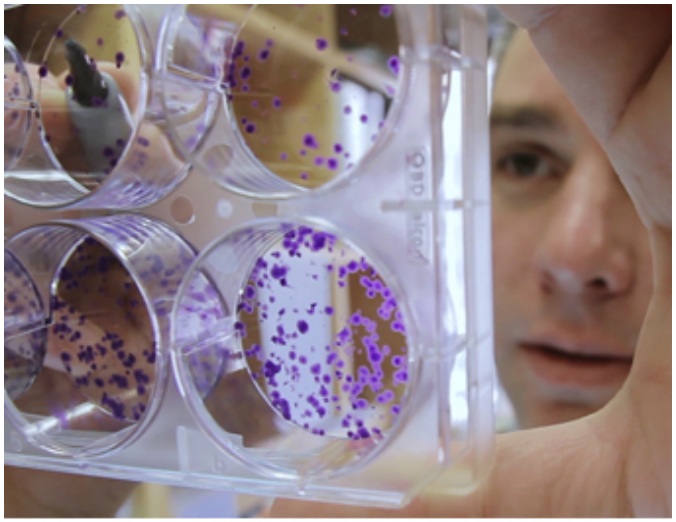
- Oldest and most commonly used human cell line
- Cervical cancer cells taken from Henrietta Lacks (d.1951)

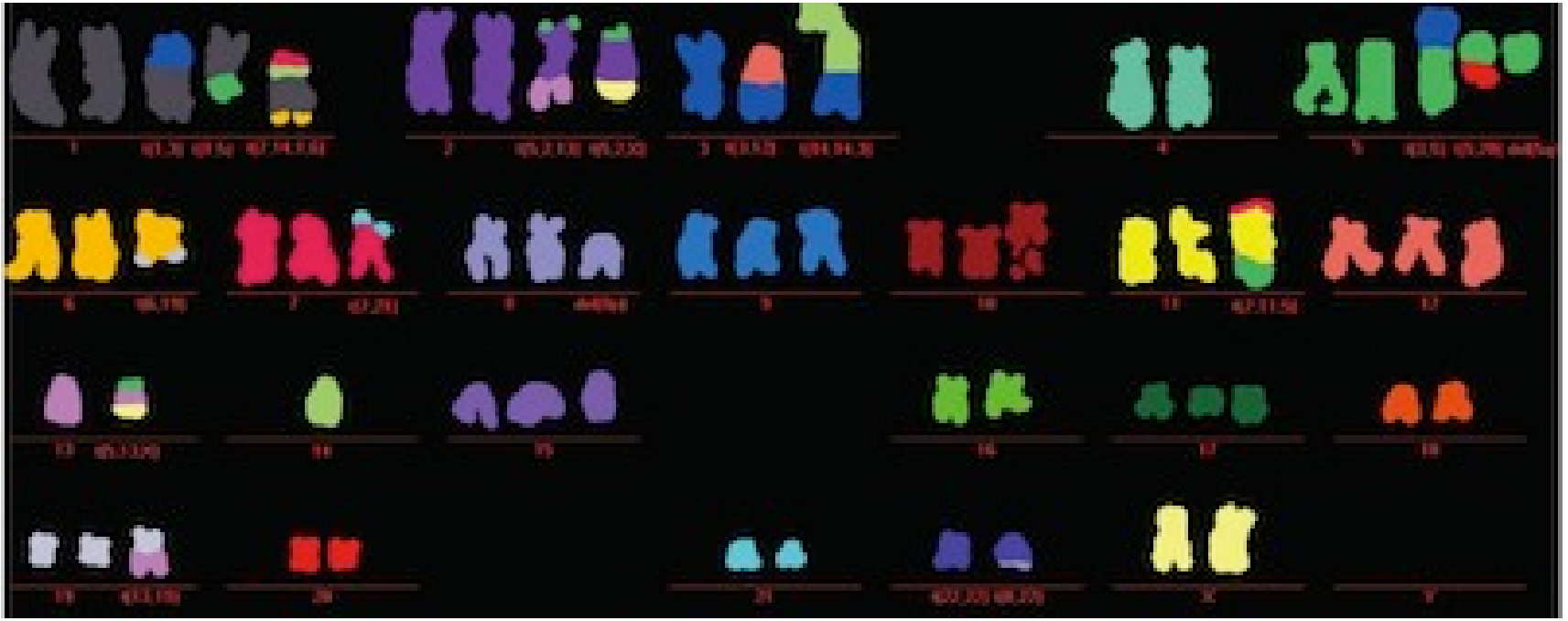


# HeLa Cells

- "Immortal" cells – do not die after a few divisions
  - Active version of telomerase
- Used in research:
  - Develop vaccine for polio
  - Cancer, AIDS, virus, radiation research
- Estimated that cells produced in culture exceeded # cells in Henrietta's body

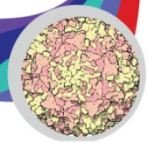




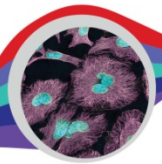


# *A trek through time: HeLa cells have aided scientific advancement, but at what cost?*

***1951: BIOPSY***
*Tissue was taken from Henrietta Lacks without her knowledge.*



***1953: POLIO VACCINE***
*Jonas Salk was supplied with HeLa cells from a cell culture factory established at Tuskegee University. Less than a year later, Salk's polio vaccine was ready for human trials.*

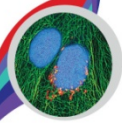


***1955: CLONING***
*Theodore Puck and Philip I. Marcus at the University of Colorado, Denver successfully cloned the first human cells.*

***1966: ETHICS***
*Scientists injected HeLa cells into unwitting test subjects to study how cancer spreads, prompting the NIH to establish medical internal review boards and informed consent.*

***1989: HPV***
*A German virologists used HeLa cells to show that the human papilloma virus causes cancer, a discovery that would land him a Nobel Prize.*

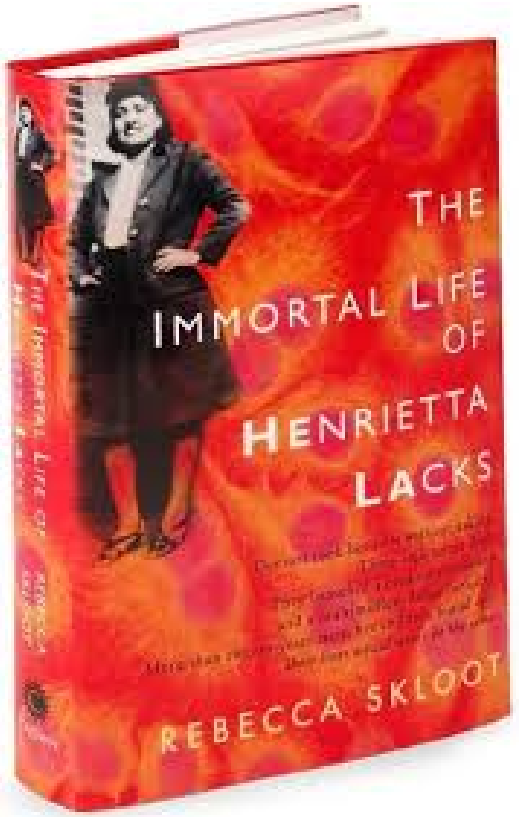
***2013: ETHICS***
*The complete HeLa cell genome was sequenced and published without the Lacks family's knowledge.*



***2013: ETHICS***
*NIH director Francis Collins announced a policy of controlled access to the cell line genome based on an agreement reached after several meetings with the Lacks family.*

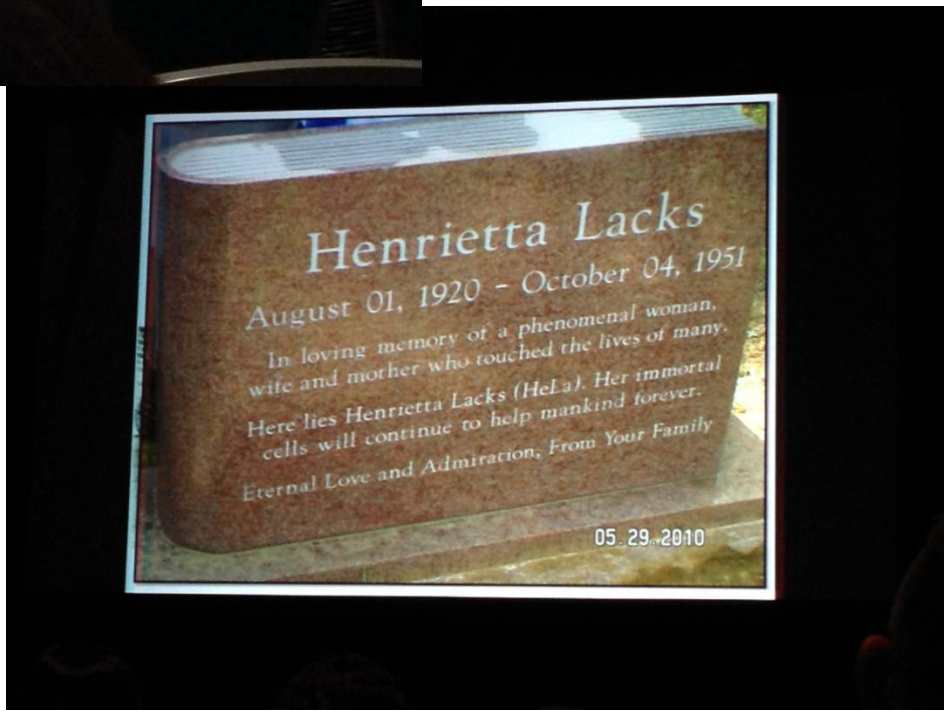
# HeLa Cells – Ethical Concerns

- Controversy: Cells harvested without patient consent
- "Discarded tissues can be commercialized" – sold for profit
- Genome published in 2013 without family's consent




"The Immortal Life of Henrietta Lacks"

- By Rebecca Skloot


Henrietta Lacks
August 01, 1920 - October 04, 1951
In loving memory of a phenomenal woman,
wife and mother who touched the lives of many.
Here lies Henrietta Lacks (HeLa). Her immortal
cells will continue to help mankind forever.
Eternal Love and Admiration, From Your Family
05.29.2010