CELLULAR REPRODUCTION

Objectives

1. Define lifecycle and biogenesis.
2. Contrast sexual and asexual reproduction.
3. Define chromatin, chromosome and chromatid.
4. Describe the stages of interphase, mitosis, and cytokinesis.
5. Describe how cell cycles are regulated and the effects from lack of control.
6. Define somatic cells, gametes, fertilization, haploid, diploid and homologous chromosomes.
7. Describe the stages of meiosis.
8. Contrast meiosis with mitosis.
9. List three sources of variation among offspring from sexual reproduction.
10. Define karyotype, autosomes, and sex chromosomes.
11. State how sex is determined.
12. Define nondisjunction and recognize illnesses caused by it.
13. List four types of chromosomal abnormalities.

Outline

A. Life Cycles
   1. Biogenesis
B. Genetic Material
C. Cell Cycle
   1. Interphase
      a. G_1 – Gap 1 phase
      b. S – Synthesis phase
      c. G_2 – Gap 2 phase
   2. Mitosis (M)
      a. Prophase
      b. Metaphase
      c. Anaphase
      d. Telophase
   3. Cytokinesis
   4. Functions of Mitosis
   5. Control System
      a. Growth Factors
      b. Uncontrolled Growth
D. Sexual Reproduction
E. Meiosis
   1. Stages
      a. Prophase I
      b. Metaphase I
      c. Anaphase I
      d. Telophase I
      e. Meiosis II
      f. Differentiation
   2. Differences among Offspring
F. Karyotypes
   1. Karyotype Abnormalities
   2. Chromosome Abnormalities

A. Life Cycles

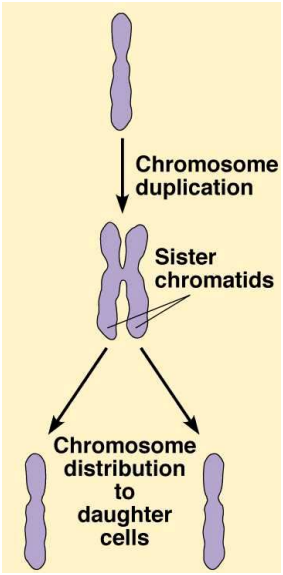
- Sequence of life stages
- Growth
- Reproduction
    - Sexual
        - Combination of two parents
            - Each gives ½ genetic material
        - Offspring genetically distinct
    - Asexual
        - Only one parent (mother cell)
        - Genetically identical to mother
        - Binary fission

1. Biogenesis

- All cells come from preexisting cells
- Cell division
    - Cellular repair
    - Multicellularity
    - Reproduction

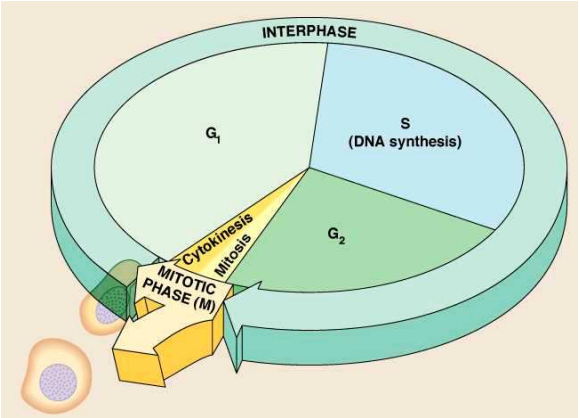
B. Genetic Material

- DNA
    - Complexed with protein
- Genes
    - Heritable traits
- Chromatin
- Chromosomes
- Chromatids
    - Connected at centromere



C. Cell Cycle

- Interphase
- Mitosis (M)
- Cytokinesis
    - Often coupled with mitosis
- Mother cell becomes two daughter cells
    - Exact replicas
        - Genetic Material
        - Organelles



1. Interphase

- Metabolically very active
  - Not a resting stage

- Increasing volume
- Producing materials needed for life
- Duplicating DNA

a. G_1 – Gap 1 phase

- Stage after cell division
- Not committed to divide
  - Lasts minutes to months
    - Some never divide (G_0)

b. S – Synthesis phase

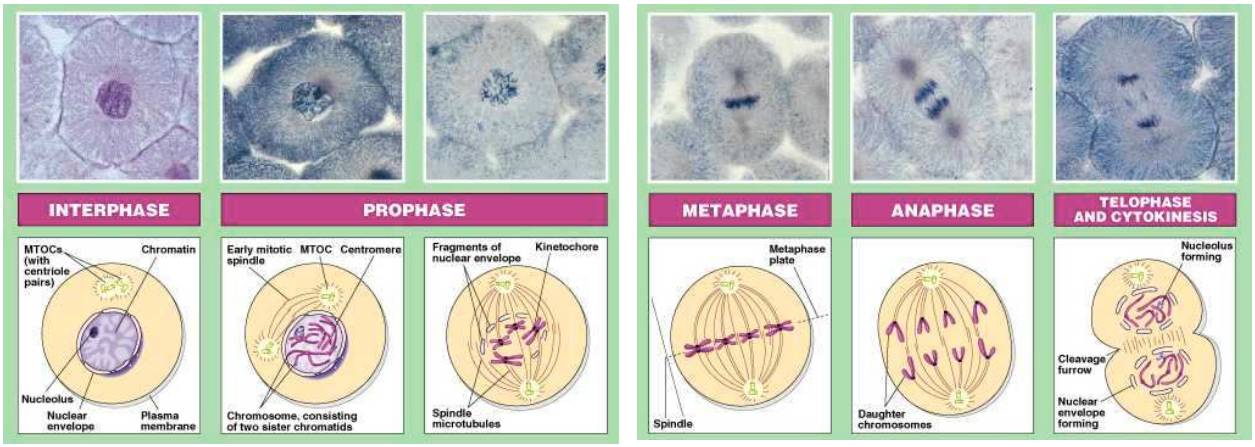
- DNA replicated
  - Not visible under microscope

c. G_2 – Gap 2 phase

- Between S and M phases
- Synthesize proteins for cell division

2. Mitosis (M)

- Nuclear division
    - Produces two identical nuclei
- Short phase
- Continuous process
    - Divisions somewhat arbitrary



a. Prophase

- Chromatin condenses
    - Chromosome – two chromatids
- Nuclear membrane, nucleolus vanish
- Mitotic spindle forms
    - Made of microtubules
    - Anchored at ends by centrioles

b. Metaphase

- Spindle attaches to centromere
- Chromosomes pulled into line
    - Equatorial plate

c. Anaphase

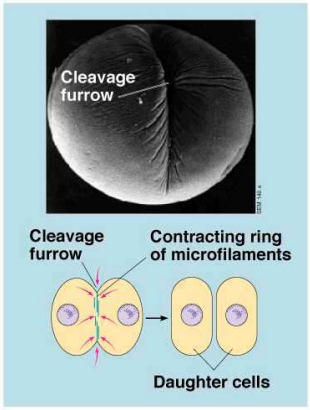
- Centromeres divide
    - Chromatids separate
        - Each now called a chromosome
- Fibers pull chromosomes to poles
- Spindle stretches cell

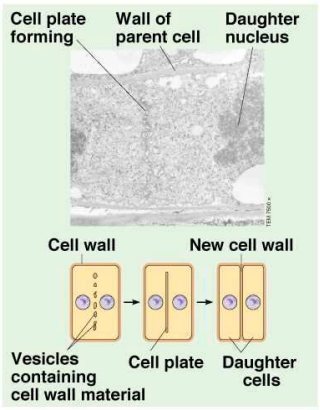
d. Telophase

- Chromosomes arrive at poles
    - Unwind into chromatin
- Spindle disappears
- Nuclear membrane, nucleoli reappear

3. Cytokinesis

- Generally occurs with telophase
- Animals
  - Furrow forms in middle
    - Pinches cells apart





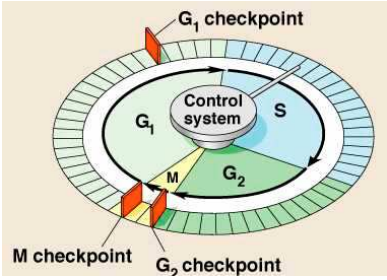
- Plants
  - Vesicles lay down membrane
    - Wall grows from middle of cell
- Division is usually equal

4. Functions of Mitosis

- Growth
- Cell Replacement
- Asexual Reproduction

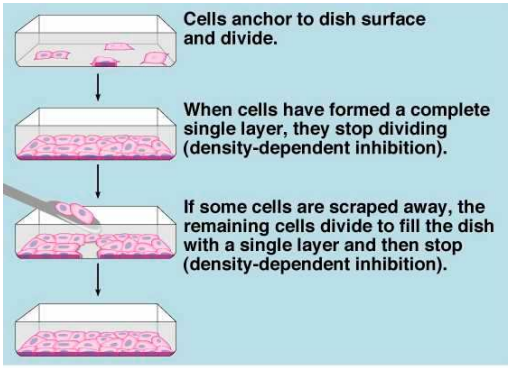
5. Control System

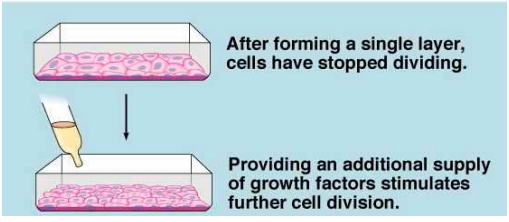
- How do cells know when to divide?
  - Too often – cancer
  - Not often enough – death
- Checkpoints
  - G_1, G_2 and M
    - M checkpoint during metaphase



a. Growth Factors

- Signal cells to continue cycle
  - Proteins
- Anchorage dependence
- Density-dependent inhibition
  - Contact inhibition





b. Uncontrolled Growth

- Do not need growth factors
  - Do not stop at checkpoints
  - No density-dependent inhibition
  - May not have anchorage dependence

- Can live forever in culture

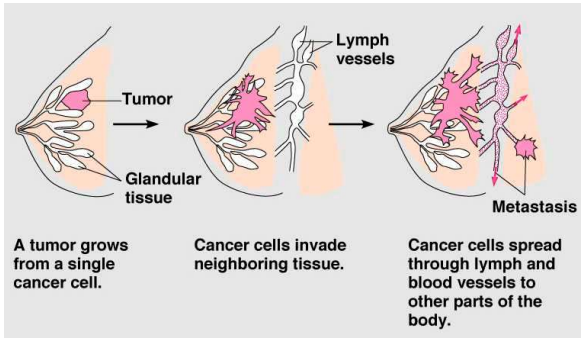
- Tumor

  - Benign

  - Malignant (Cancerous)
    - Metastasis

  - Treatment with radiation or drugs

    - Attack rapidly growing cells



D. Sexual Reproduction

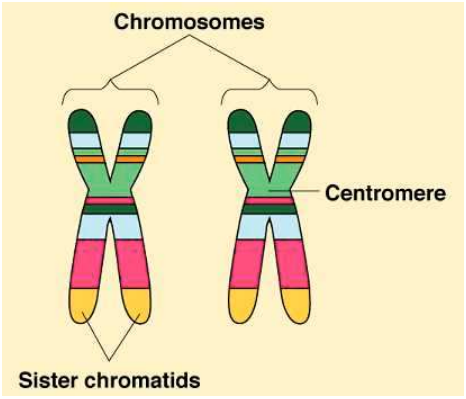
- Somatic cells

  - Diploid (2n)

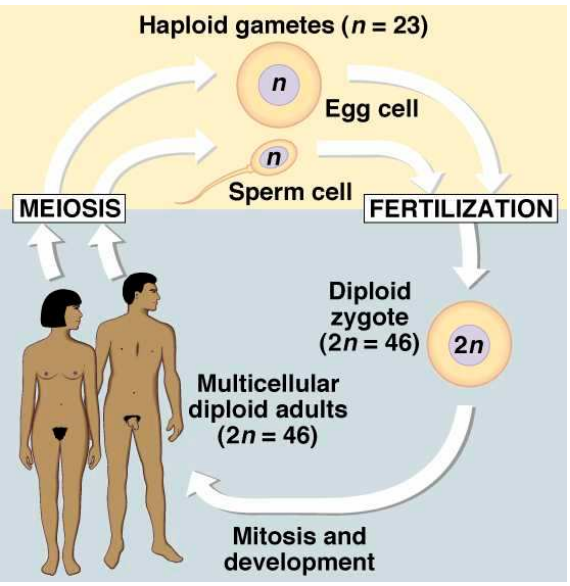
  - Homologous Chromosomes

    - locus

    - allele



- Germ cells
  - Gametes
  - Haploid cells (n)
- Fertilization
  - Zygote

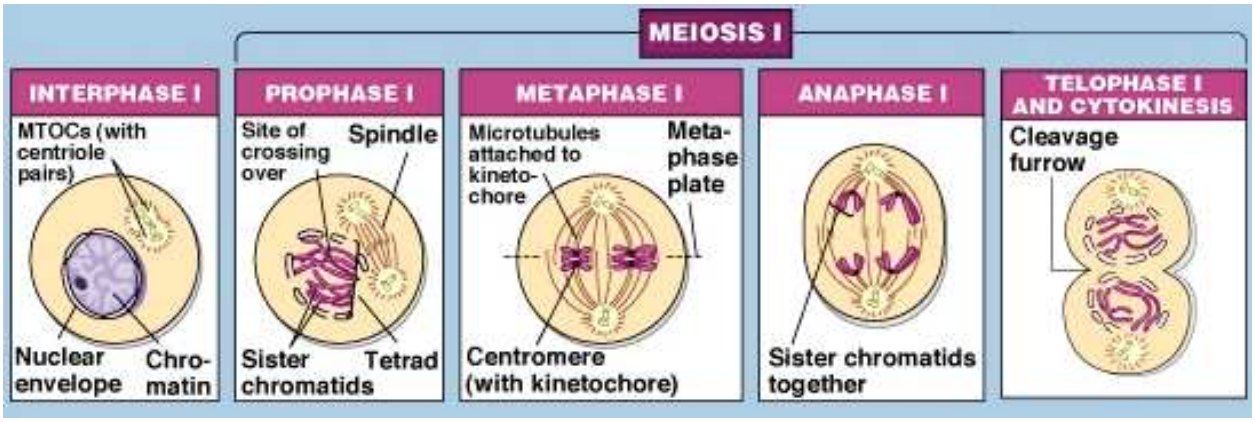


E. Meiosis

- Reduction division
- Similar to mitosis except
  - *Number of chromosomes halved*
  - *Requires two successive divisions*
    - No S phase in between
  - *Synapsis during first division*
  - *Produces 4 haploid daughter cells*
    - *Daughter cells not identical*

1. Stages

- Two successive cell divisions
  - Meiosis I
    - Homologous chromosomes separate
  - Meiosis II
    - Chromatids split



a. Prophase I

- Chromatin condenses
- *Synapsis*
    - *Homologous chromosomes pair*
    - *Tetrad*
- *Chiasmata (sing. chiasma) form*
    - *Crossing over*
- Nuclear membrane, nucleolus vanish
- Meiotic spindle forms

b. Metaphase I

- *Tetrads line up*
    - *Homologous chromosomes disengage*
- Spindle fibers attach to centromeres

c. Anaphase I

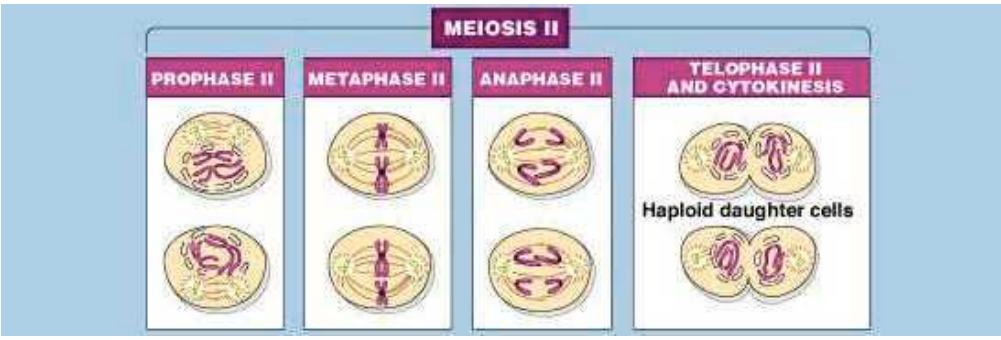
- *Homologous chromosomes separate*
    - *Centromeres do not separate*
- Fibers pull chromosomes to poles
- Spindle stretches cell

d. Telophase I

- Chromosomes arrive at poles
- Spindle disappears
- Cells divide
- *Each cell has one-half of chromosomes*
- *Second division immediately follows*

e. Meiosis II

- Essentially like mitosis

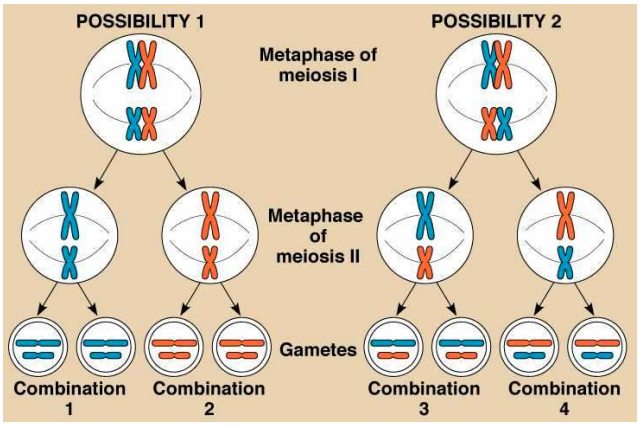


f. Differentiation

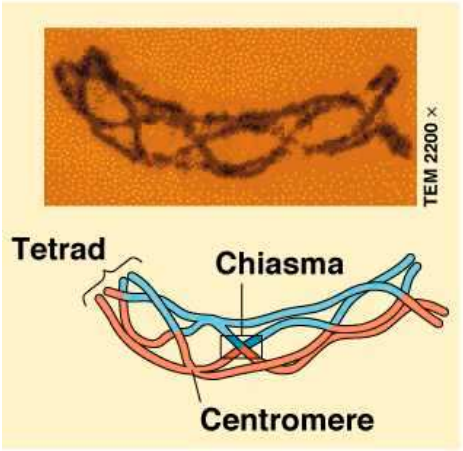
- Differentiation into mature sexual cells
    - Spermatagenesis
        - Four functional sperm
    - Oogenesis
        - One functional ovum
        - Three cells are non-functional

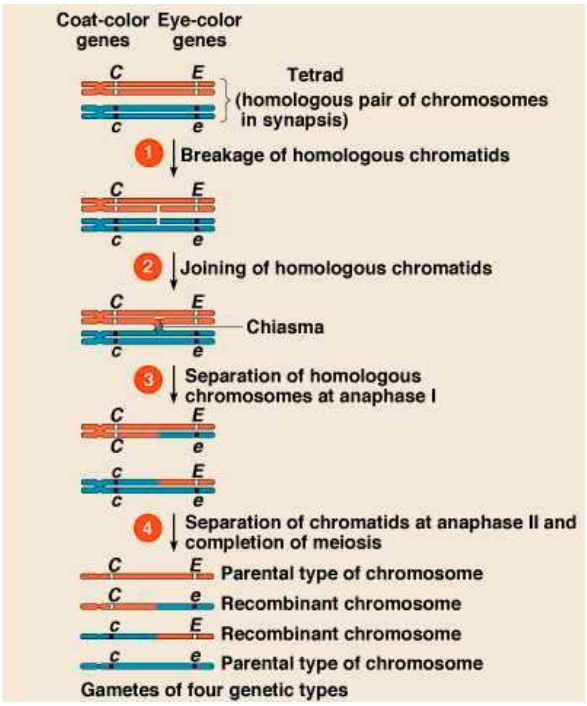
2. Differences among Offspring

- Random assortment of chromosomes
    - 50% chance for each chromosome
        - Number of different gametes
            - 2^n where n = haploid number
        - For humans, 2^{23} = 8,388,608



- Crossing over (Recombination)
    - During synapsis
        - Homologous chromosomes break
        - Fragments reattach to wrong chromosome



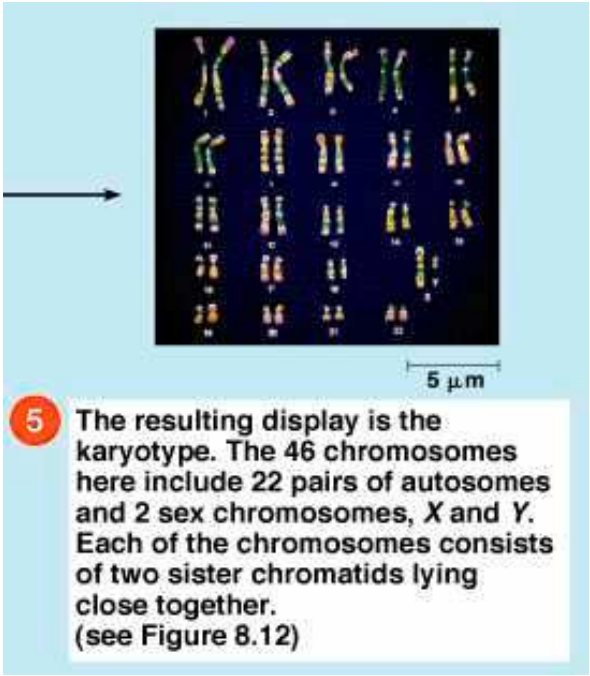


        - Genetic recombination
    - Can occur in nearly all locations

- Random fertilization
    - Chance two identical sperm fertilizes two identical ovum:
        - > 1:70 trillion

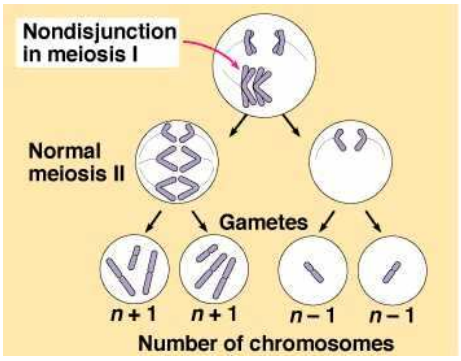
F. Karyotypes

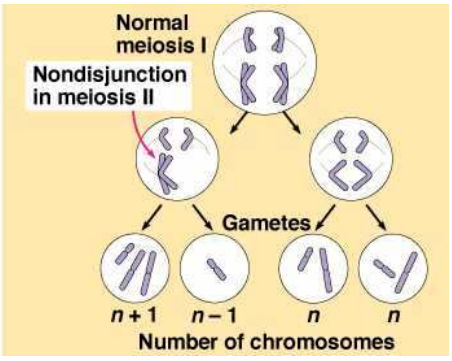
- Number and type of chromosomes
    - Count metaphase cell
- Autosomes
    - 22 pairs in humans
- Sex chromosomes
    - X – required in all humans
    - Y – determines maleness
    - XX – Human female
    - XY – Human male



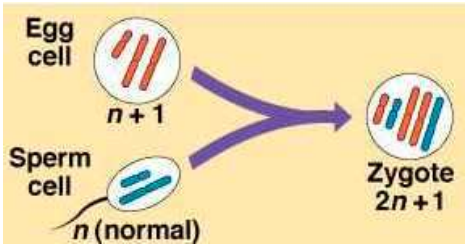
1. Karyotype Abnormalities

- Nondisjunction
    - Wrong number of chromosomes
    - Can live with unusual number
        - Only chromosomes 19-22, X, Y





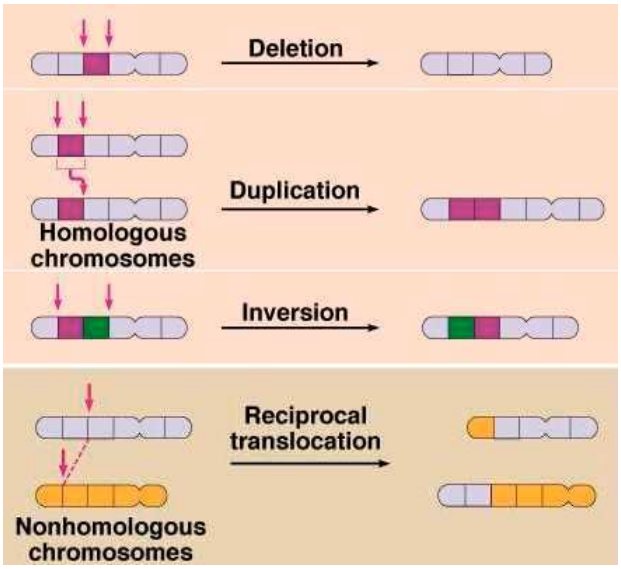
- Chromosome 21
  - Trisomy 21, Down Syndrome
    - Occurs in 1 in 600 children
      - Rate increases with age of mother



- Sex Chromosomes
  - XXY – Klinefelter's Syndrome
  - XYY
  - XO – Turner's Syndrome
  - XXX, XXXX – Metafemale

2. Chromosome Abnormalities

- Change in structure of chromosomes
  - Deletion
  - Duplication
  - Inversion
  - Translocation



- Heritable only if in germ cells
- May cause cancer in somatic cells