General Biology 1
BIO1101
Syllabus & Textbook: http://goo.gl/rvgdrH

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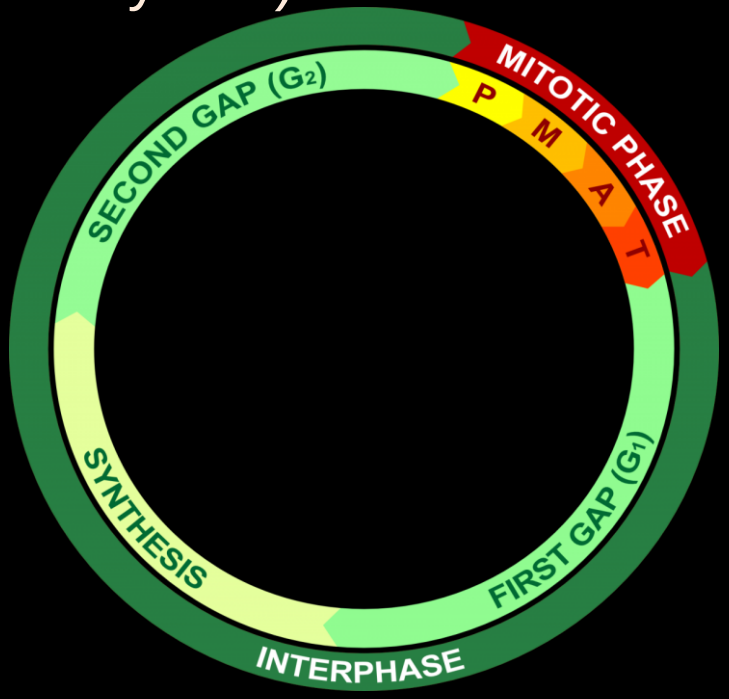
Letter Grade	Numerical Ranges
A	93-100
A-	90-92.9
B+	87-89.9
B	83-86.9
B-	80-82.9
C+	77-79.9
C	70-76.9
D	60-69.9
F	59.9 and below

OER
Lecture:https://openlab.citytech.cuny.edu/bio-oer/page/2/
Lab: https://openlab.citytech.cuny.edu/bio-oer/

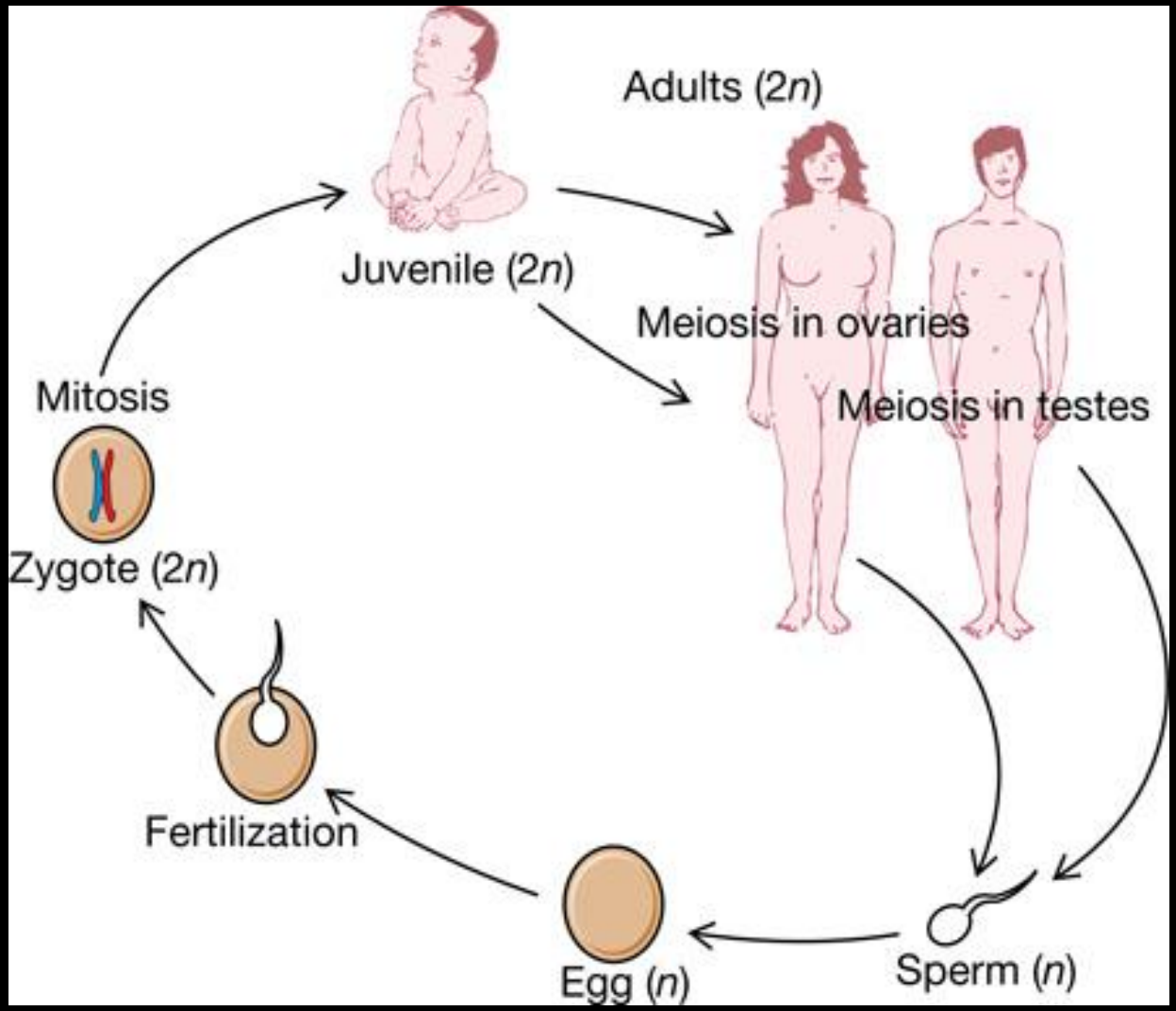
Grade Breakdown:
Exams (4): 20% Each
Quizzes: 20% Average

Recap Lecture 20:The Cell Cycle

- **Asexual Reproduction** – when a single organism gives rise to offspring (no exchange of DNA)
- **Binary Fission** (Prokaryotes -- bacteria) produces clones
- **Clone** – genetically identical individuals
- **Life Cycle** – the generation-to-generation sequence of genetic "stages" in the reproductive process (how cells replicate)
- The two major stages of the cell cycle (Eukaryotes):
  - Interphase,
    - G1, S, G2
  - Mitosis
    - Karyokinesis
      - Prophase
      - Metaphase
      - Anaphase
      - Telophase
    - Cytokinesis



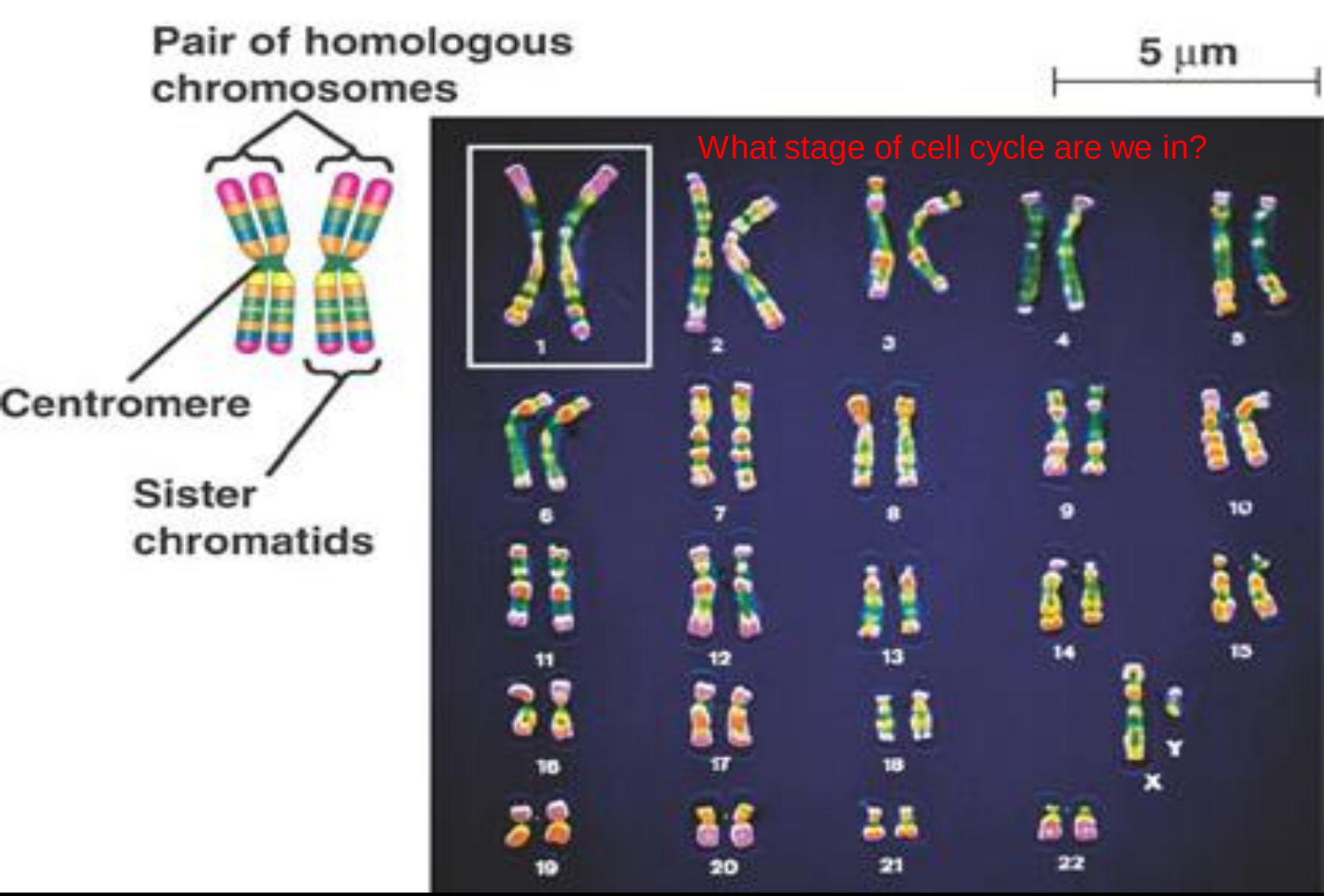
SEXUAL REPRODUCTION



https://openlab.citytech.cuny.edu/bio-oer/cell-division/

Human Chromosomes

- Humans : 23 pairs of chromosomes:
  - n = 23. So 2n = 46
- 22 pairs of **autosomes** (non-sex)
- 1 pair of **sex chromosomes** (X and Y)
  - XX = female, male = XY
  - Thus, X chromosome is *essential*, Y is not
    - X is large, Y is very small
- 22 So Total = 23 pairs, (n=23)
- **Karyotype** – arrangement (by length) of a person's chromosomes, longest to shortest, (sex chromosomes last).


Pair of homologous chromosomes
5 μm
Centromere
Sister chromatids
What stage of cell cycle are we in?
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
X
Y

Human Life Cycle

- Somatic cells are all **diploid** (2n)
  - Two copies of every chromosome.
- Gametes (germ cells) are all **haploid** (one copy, 1n)
- Humans : 23 pairs of chromosomes n = 23. So 2n = 46
- Fusion of two gametes (1n) results in a 2n **zygote**.
- Pairs are called **Homologous** and are NOT identical
  - One is maternal, one paternal
  - Homologues have the same genes, but different VERSIONS of some genes

Definitions for Sexual Reproduction

- **Gene** – a heritable trait (characteristic)
- **Genetics** – study of heredity
- **Heredity** – the transmission of traits (characteristics) from one generation to the next
- **Variation** – in sexual reproduction, offspring are not identical to parents or each other
  - Individuals have unique combinations of parental genes

–Homologous Chromosomes

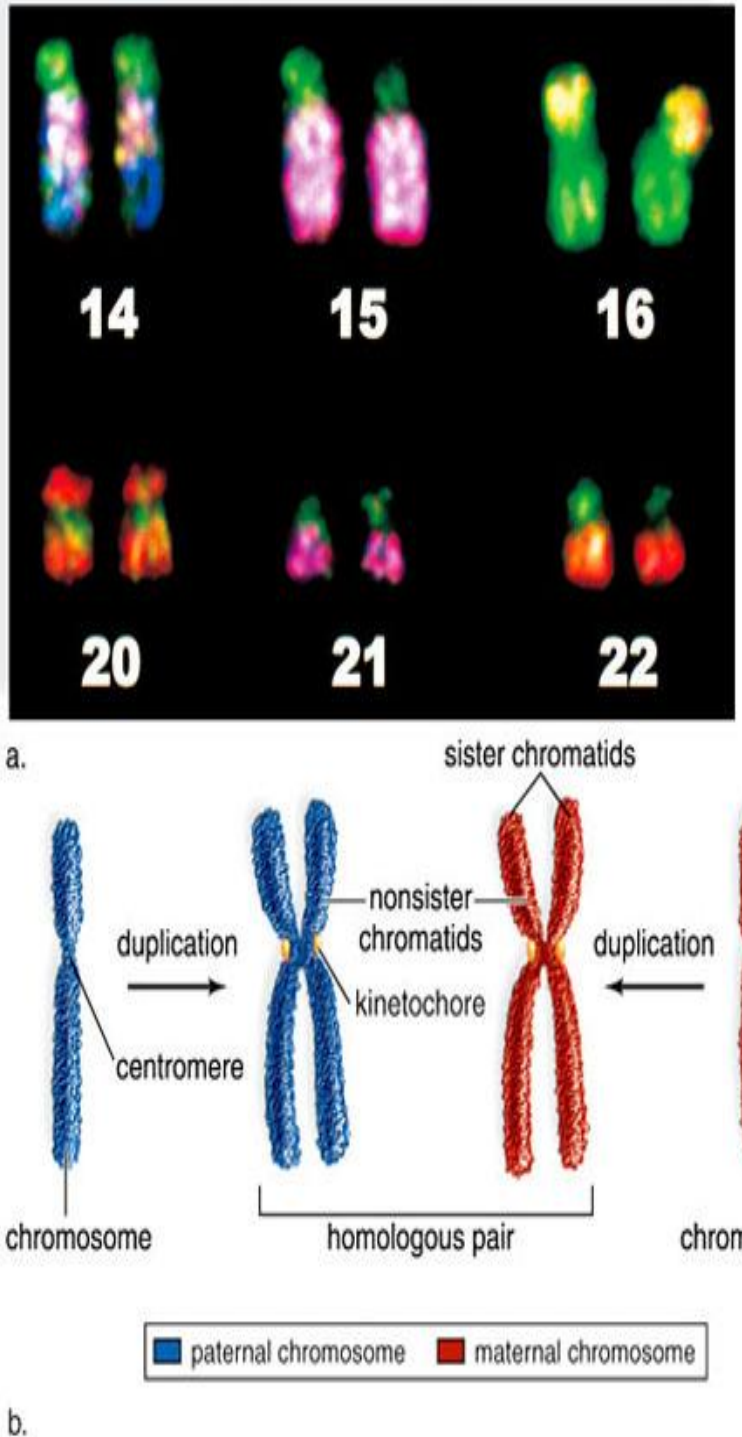
-They have the same length

- centromeres are positioned in the same place

- One came from the father (the paternal homolog) the other from the mother (the maternal homologue)

- When stained, they show similar banding patterns

-Because they have genes controlling the same traits at the same positions



Homologous Pairs of Chromosomes

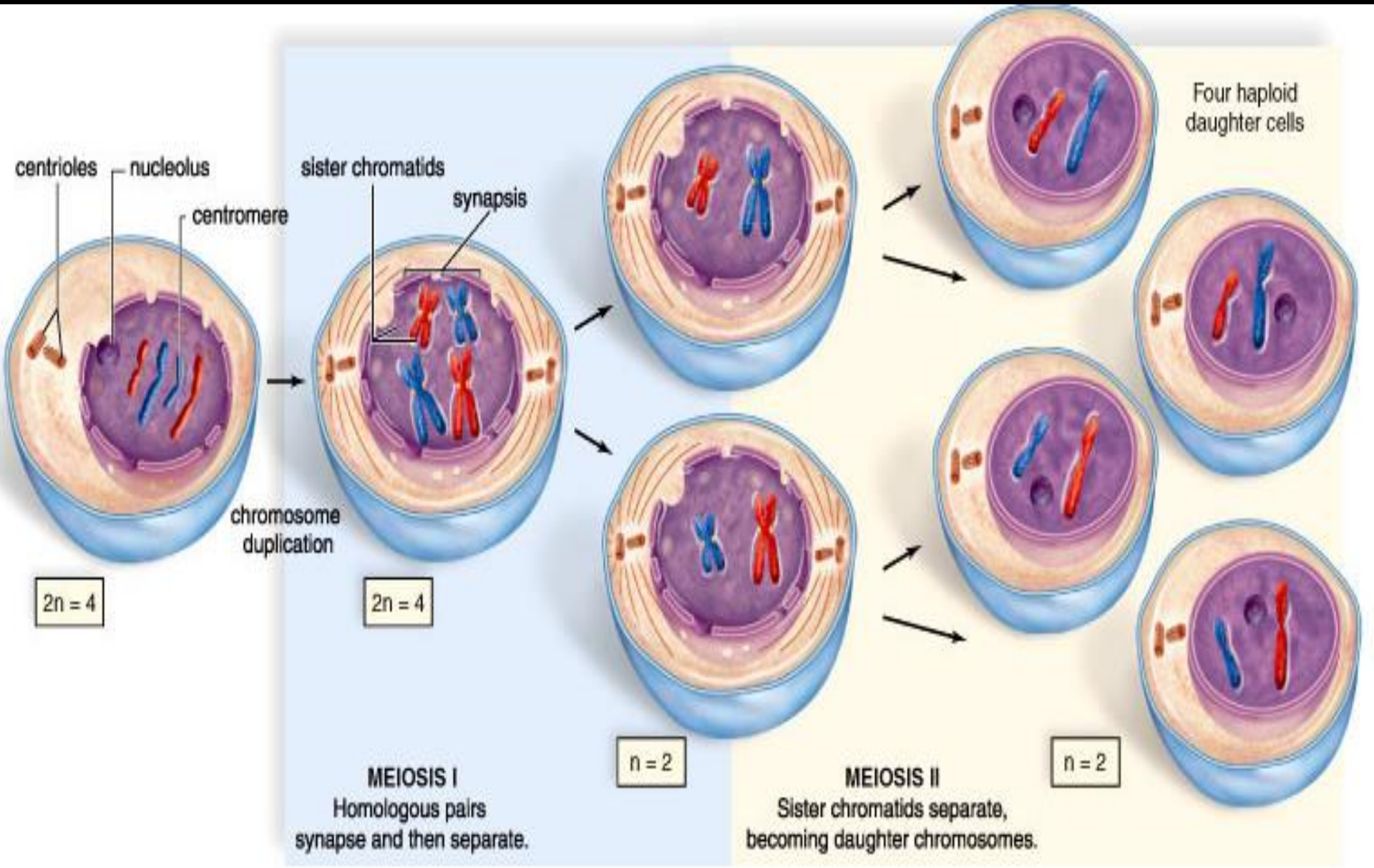
- Many genes exist in several variant forms in a large population
- Homologous copies of a gene may encode identical or differing genetic information
- The variants that exist for a gene are called **alleles**
- An individual may have:
  - Identical alleles for a specific gene on both homologs (**homozygous** for the trait), or
  - A maternal allele that differs from the corresponding paternal allele (**heterozygous** for the trait)

Meiosis: Halves the Chromosome Number

- Special type of cell division
- Used only for sexual reproduction
- Halves the chromosome number prior to fertilization
  - Parents diploid
  - Meiosis produces haploid gametes

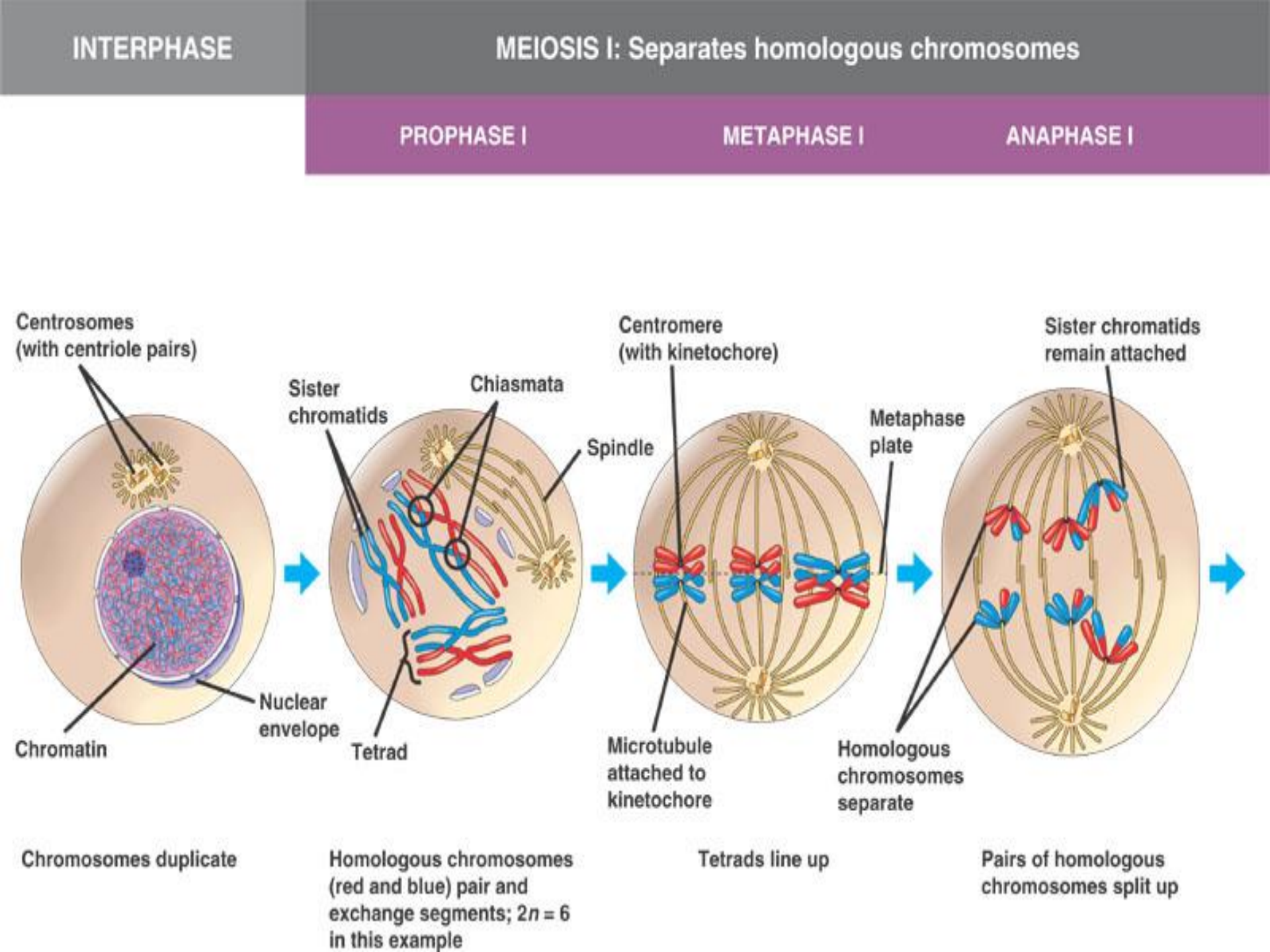
- **Fertilization** (or syngamy) is when gametes fuse.
  - This re-establishes the diploid state
  - Resulting individual will have a unique combination of maternal and paternal chromosomes

Overview of Meiosis



Meiosis I: Prophase I & Metaphase I

- Meiosis I (reductional division):
  - Prophase I
    - Each chromosome internally duplicated (consists of two identical sister chromatids)
    - Homologous chromosomes pair up – **synapsis**
    - Physically align themselves against each other end to end
    - End view would show four chromatids – **Tetrad**
  - Metaphase I
    - Homologous pairs arranged onto the metaphase plate

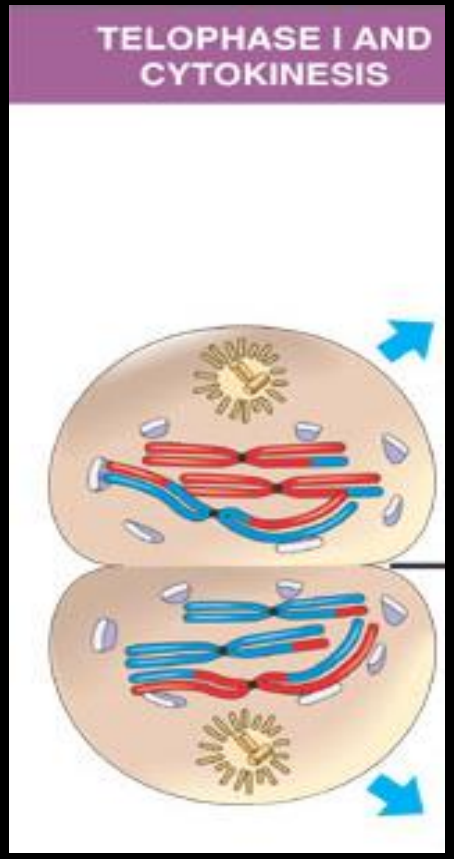

INTERPHASE
MEIOSIS I: Separates homologous chromosomes
PROPHASE I
METAPHASE I
ANAPHASE I
Centrosomes (with centriole pairs)
Chromatin
Nuclear envelope
Sister chromatids
Chiasmata
Spindle
Tetrad
Centromere (with kinetochore)
Microtubule attached to kinetochore
Metaphase plate
Homologous chromosomes separate
Sister chromatids remain attached
Chromosomes duplicate
Homologous chromosomes (red and blue) pair and exchange segments; 2n = 6 in this example
Tetrads line up
Pairs of homologous chromosomes split up

Meiosis I: Anaphase I & Telophase I

- Anaphase I
  - Synapsis breaks up
  - Homologous chromosomes separate from one another
  - Homologues move towards opposite poles
  - Each is still an internally duplicate chromosome with two chromatids
- Telophase I
  - Daughter cells have one internally duplicate chromosome from each homologous pair
  - One (internally duplicate) chromosome of each type (1n, haploid)

Meiosis I: Cytokinesis I & Interkinesis

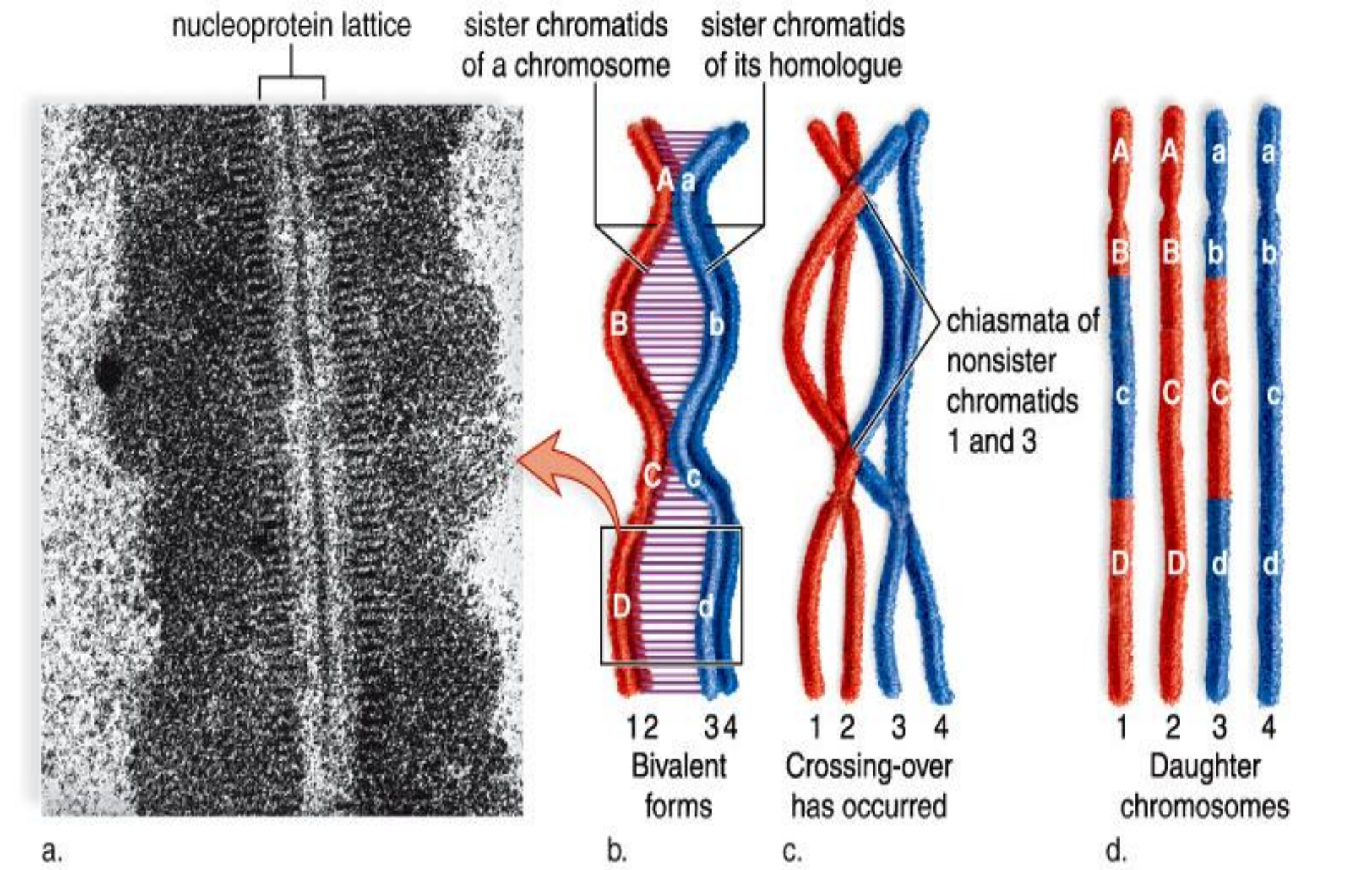
- Cytokinesis I
  - Two daughter cells
  - Both with one internally duplicate chromosome of each type
  - Haploid
  - Meiosis I is reductional (halves chromosome number)
- Interkinesis
  - Similar to mitotic interphase
  - Usually shorter
  - **No replication of DNA**



Genetic Variation: **Crossing Over**

- Meiosis brings about genetic variation in two key ways:
  - Crossing-over
  - Independent assortment of homologous chromosomes
- 1. **Crossing Over**:
  - **Exchange of genetic material** between nonsister chromatids during meiosis I
  - At synapsis, a **nucleoprotein** lattice (called the **synaptonemal complex**) appears between homologues
    - Holds homologues together
    - Aligns DNA of nonsister chromatids
    - Allows crossing-over to occur
  - Then homologues separate and are distributed to different daughter cells

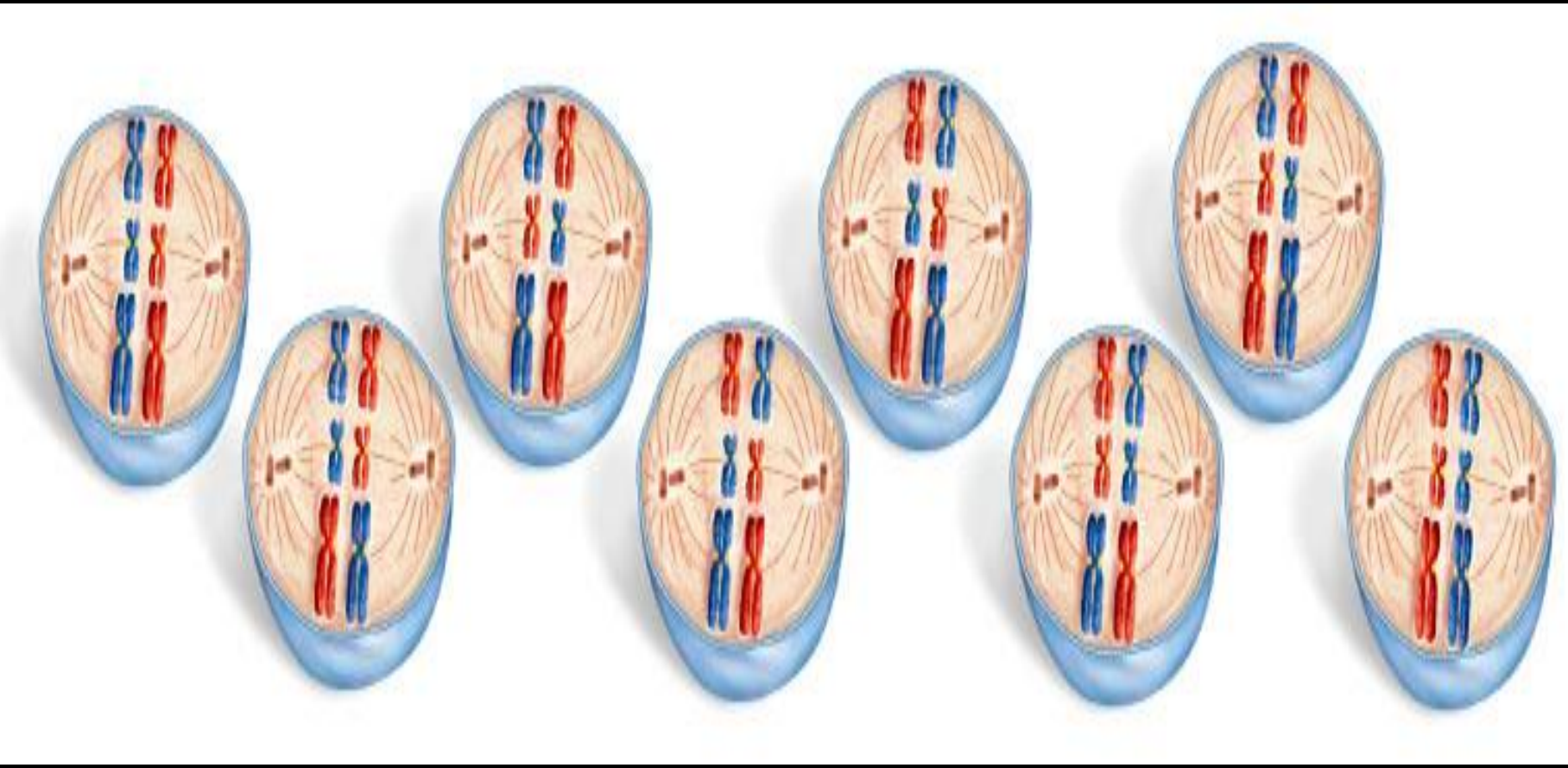
Crossing Over



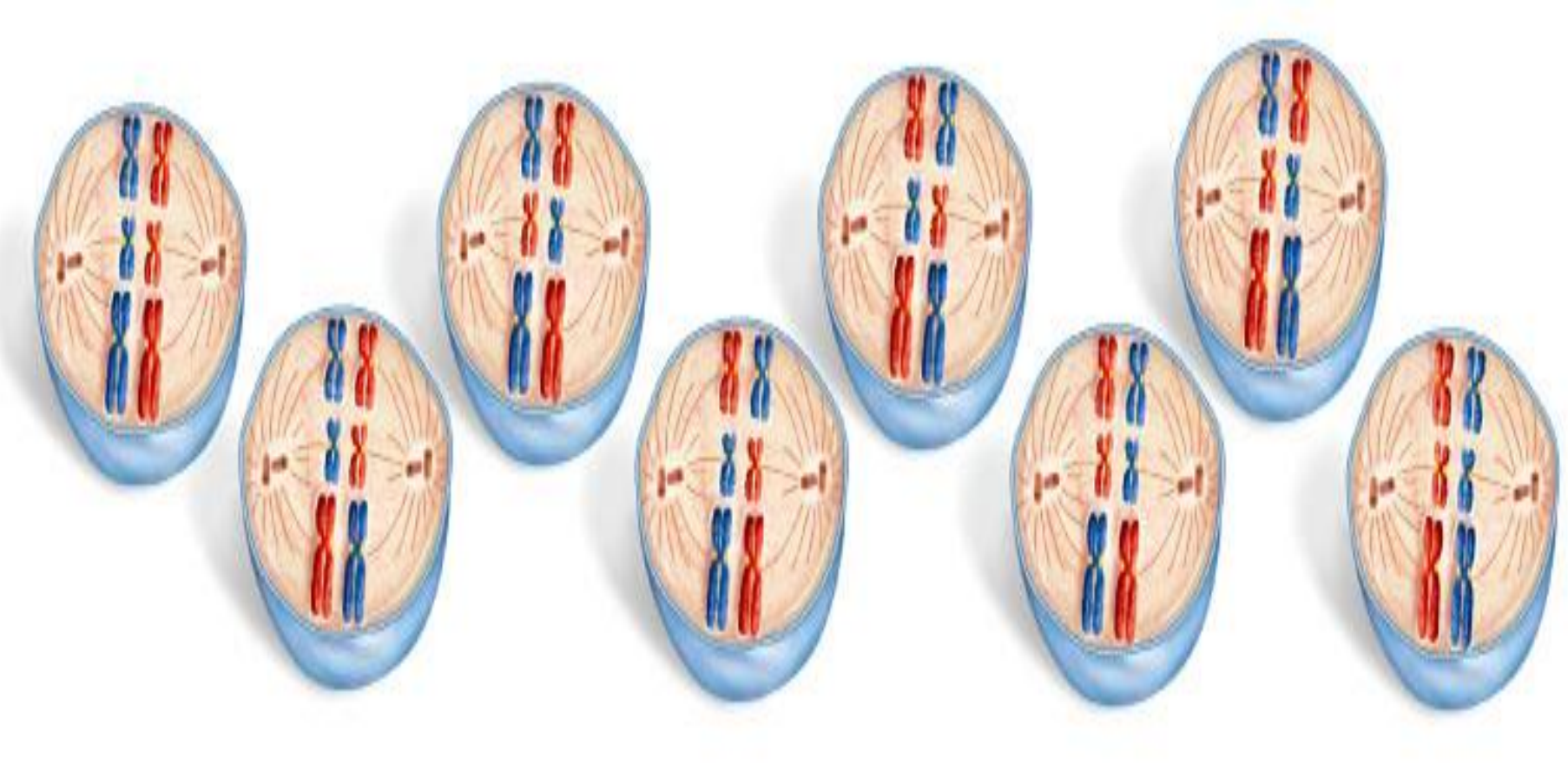
Genetic Variation: **Independent Assortment**

- 2**. Independent assortment**:
  - When homologues align at the metaphase plate:
    - They separate in a **random** manner
    - The maternal or paternal homologue may be oriented toward either pole of mother cell
  - Causes random mixing of blocks of alleles into gametes

Independent Assortment



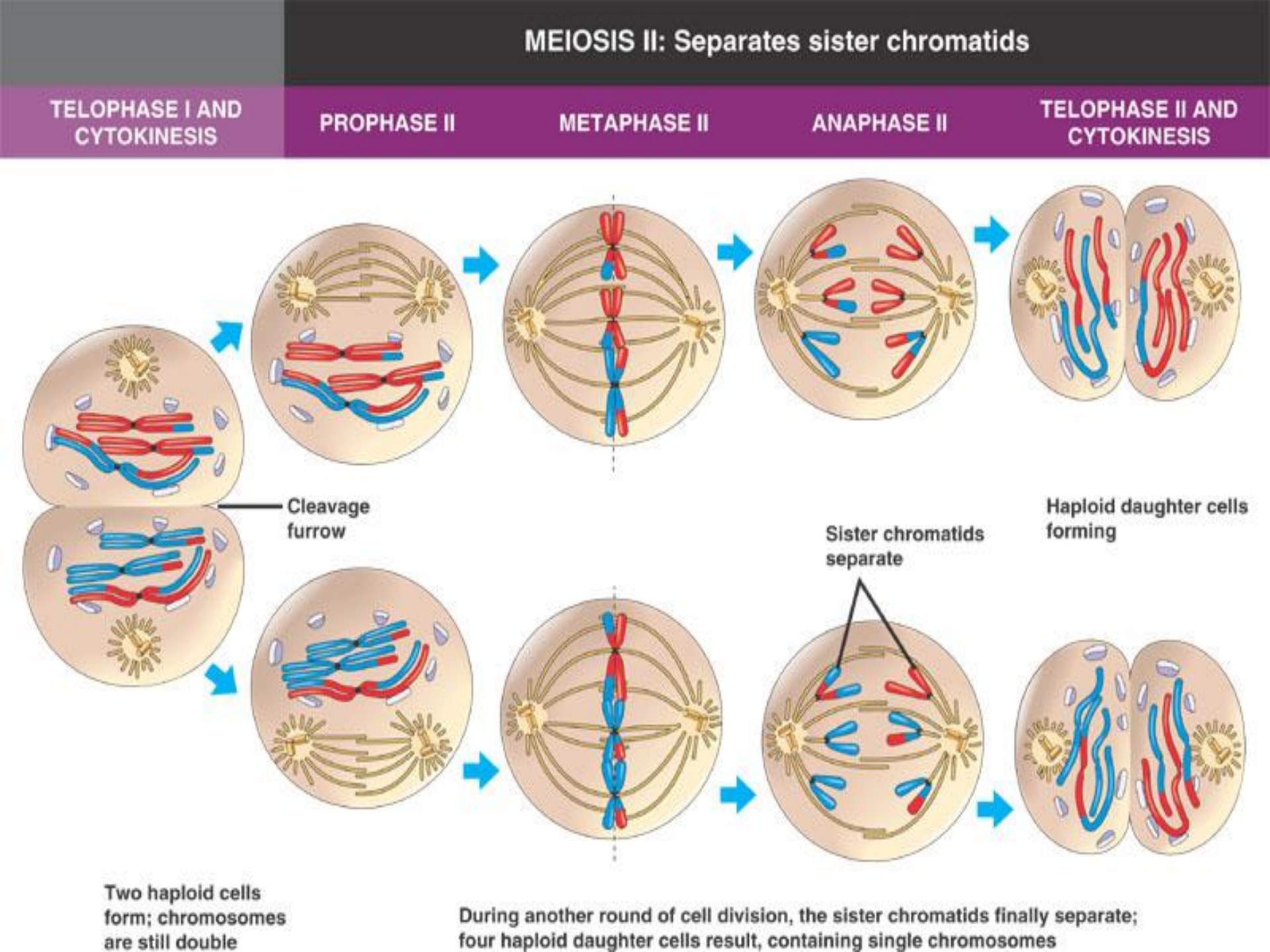
3. Anaphase I – Homologous Chromosomes separate



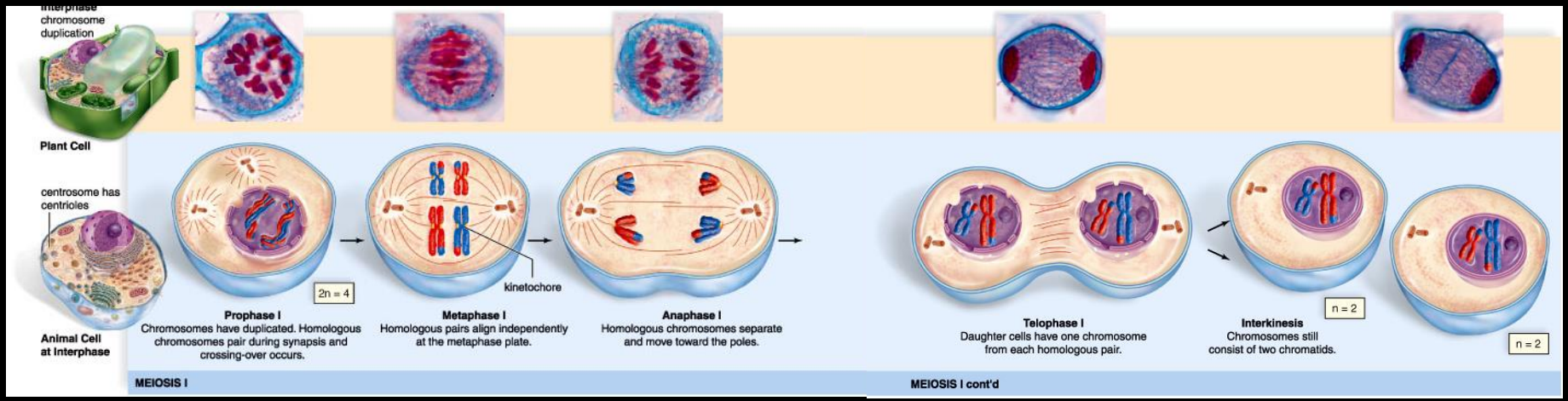
Meiosis II: Similar to Mitosis

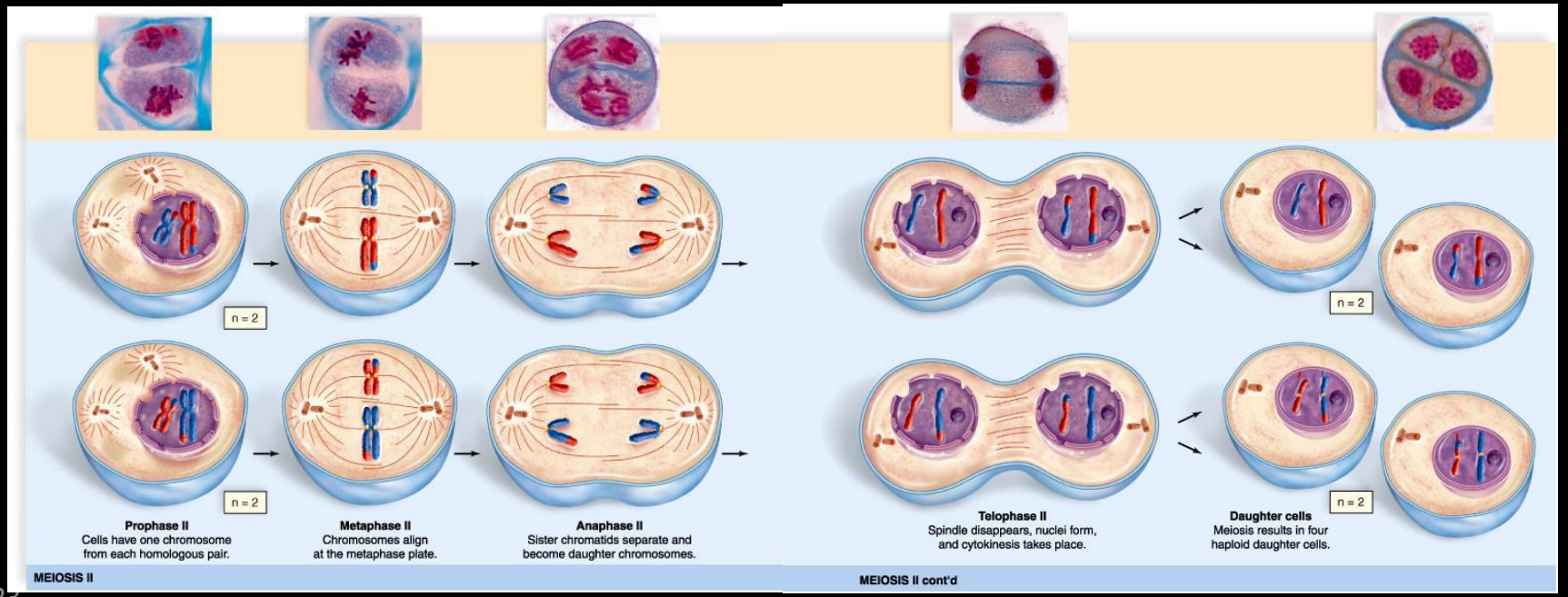
- Unremarkable
- Virtually indistinguishable from mitosis of two haploid cells

– Prophase II – Chromosomes condense
– Metaphase II – chromosomes align at metaphase plate
– Anaphase II
  - Centromere dissolves
  - Sister chromatids separate and become daughter chromosomes
– Telophase II and cytokinesis II
  - Four haploid cells
  - All genetically unique


MEIOSIS II: Separates sister chromatids
TELOPHASE I AND CYTOKINESIS
PROPHASE II
METAPHASE II
ANAPHASE II
TELOPHASE II AND CYTOKINESIS
Cleavage furrow
Sister chromatids separate
Haploid daughter cells forming
Two haploid cells form; chromosomes are still double
During another round of cell division, the sister chromatids finally separate; four haploid daughter cells result, containing single chromosomes

Meiosis I & II in Plant and Animal Cells





Genetic Variation: Fertilization

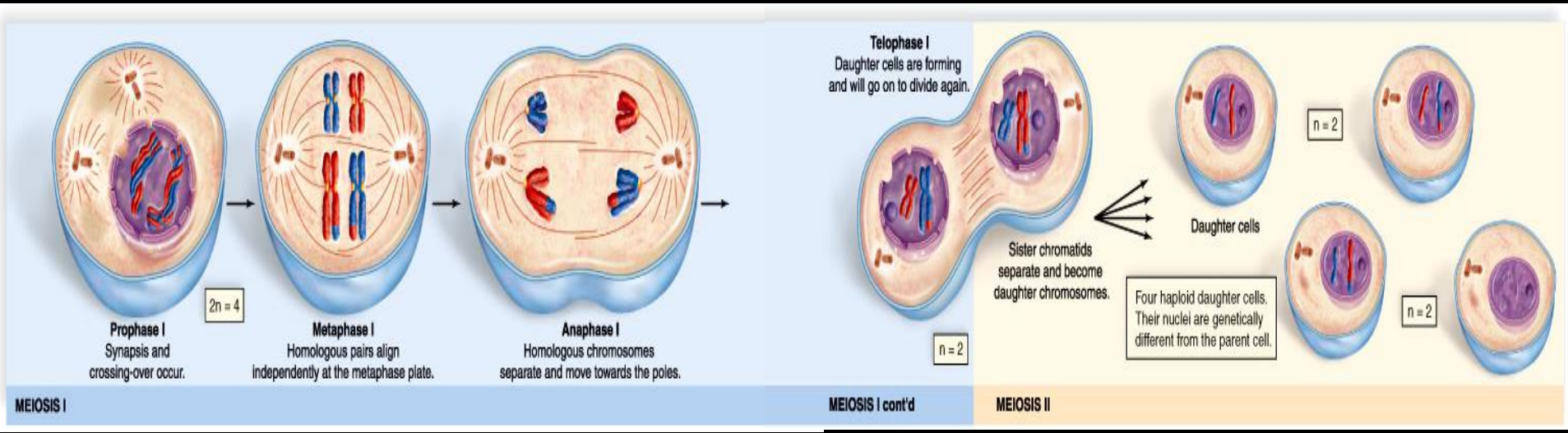
- When gametes fuse at fertilization:
  - Chromosomes donated by the parents are combined
  - In humans, $(2^{23})^2 = 70{,}368{,}744{,}000{,}000$ chromosomally different zygotes are possible
- If crossing-over occurs only once
  - $(4^{23})^2$, or 4,951,760,200,000,000,000,000,000,000 genetically different zygotes are possible

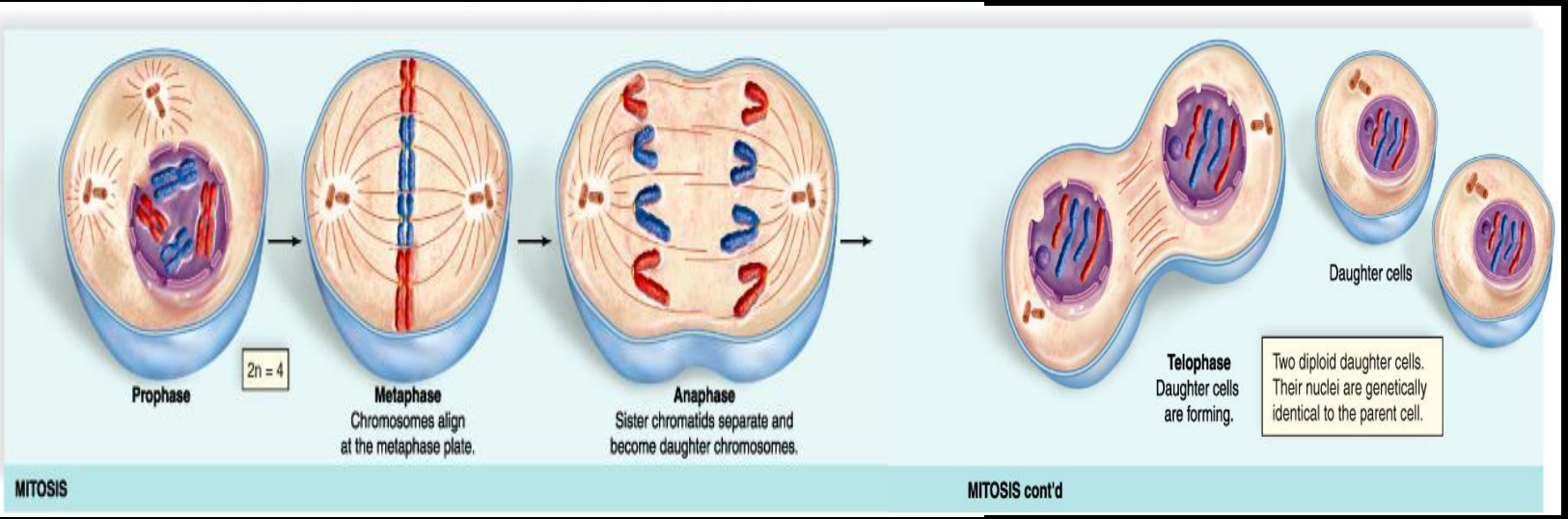
Who cares about genetic variation?

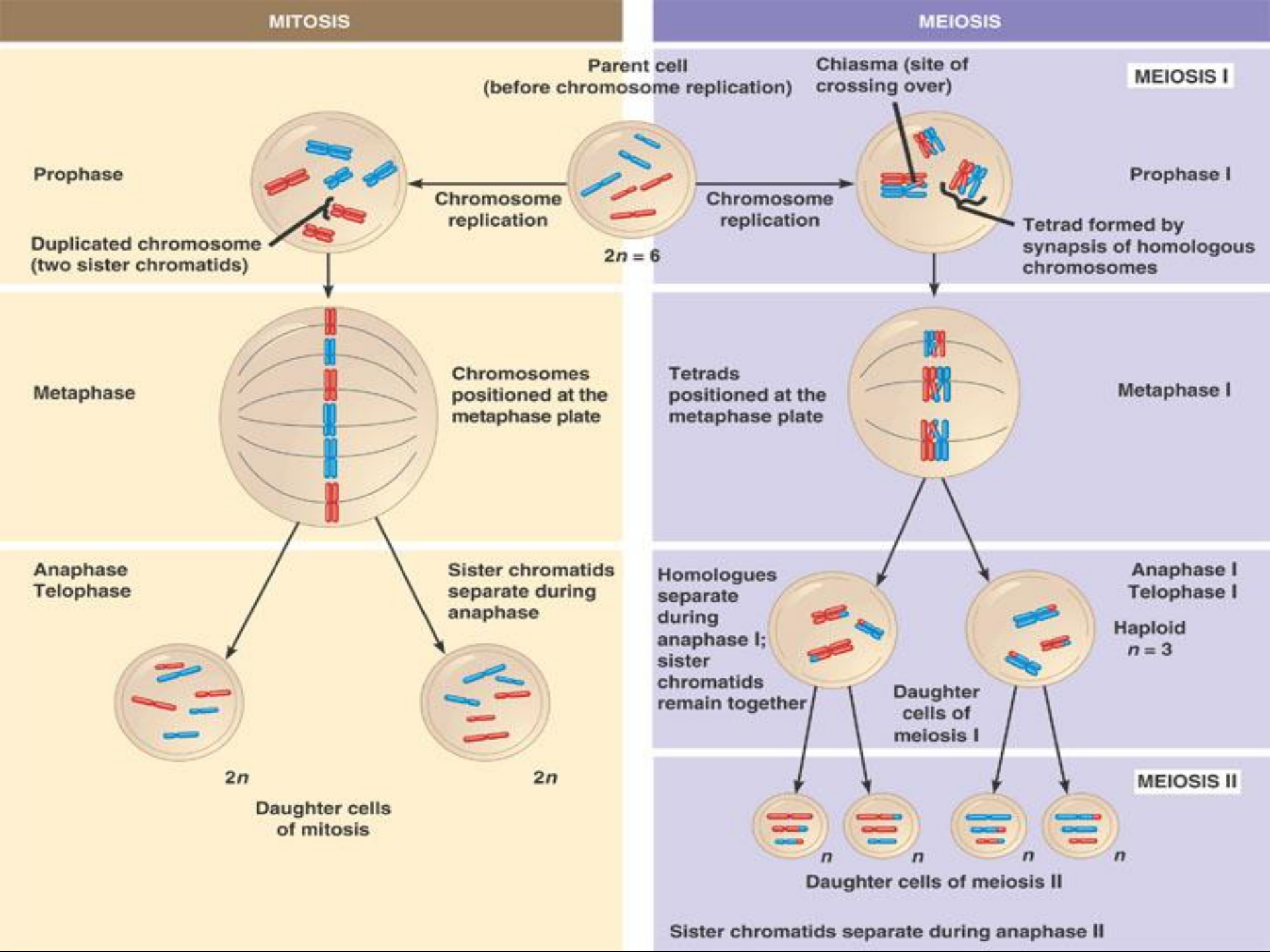
Genetic Variation: Significance

- Asexual reproduction produces genetically **identical clones**
- Sexual reproduction cause novel genetic **recombinations**
- Asexual reproduction is advantageous when environment is stable
- However, if environment changes, genetic variability introduced by sexual reproduction may be advantageous

Meiosis Compared to Mitosis






MITOSIS
MEIOSIS
Parent cell
(before chromosome replication)
Chiasma (site of crossing over)
MEIOSIS I
Prophase
Chromosome replication
Chromosome replication
Prophase I
Duplicated chromosome
(two sister chromatids)
2n = 6
Tetrad formed by synapsis of homologous chromosomes
Metaphase
Chromosomes positioned at the metaphase plate
Tetrads positioned at the metaphase plate
Metaphase I
Anaphase
Telophase
Sister chromatids separate during anaphase
Homologues separate during anaphase I; sister chromatids remain together
Anaphase I
Telophase I
Haploid
n = 3
Daughter cells of meiosis I
2n
2n
Daughter cells of mitosis
MEIOSIS II
n
n
n
n
Daughter cells of meiosis II
Sister chromatids separate during anaphase II

Summary of Cell Division

	Mitosis	Meiosis
Number of Cells at start	A. 1	B. 1
Number of Cells at end	C. 2	D. 4
Number of Cell divisions	E. 1	F. 2
Chromosome number (N)	Start: 2N G. End: 2N I.	Start: 2N H. End: 1N J.
Number of chromosomes in the cell at start of process (human cell)	K 23X2 = 46	L 23X2 = 46
Number of chromosomes in the cell at end of process (human cell)	M 46	N 23
Daughter cells (N or 2N)	O 2N	P 1N
Daughter cell genetics (identical or non-identical)	Q Identical	R Non-Identical
Purpose of division	S Growth/Regeneration	T Gamete Production

https://www.youtube.com/watch?v=KzraEW0TpnY

Meiosis versus Mitosis

- **Meiosis**
  - Requires two nuclear divisions
  - Chromosomes synapse and cross over
  - Centromeres survive Anaphase I
  - Halves chromosome number
  - Produces four daughter nuclei
  - Produces daughter cells genetically different from parent and each other
  - Used only for sexual reproduction

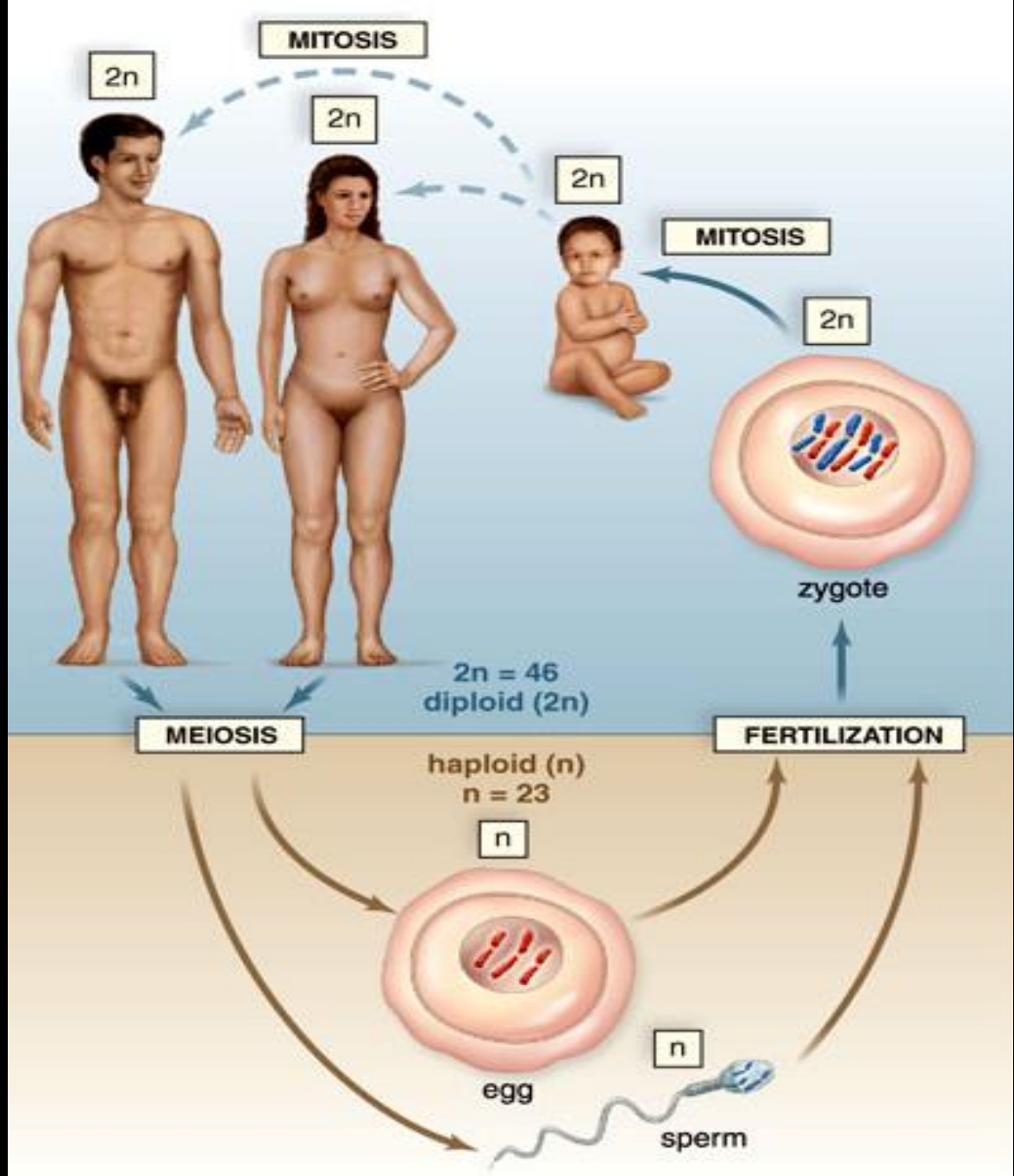
KNOW CHART WELL !!!

- **Mitosis**
  - Requires one nuclear division
  - Chromosome do not synapse nor cross over
  - Centromeres dissolve in mitotic anaphase
  - Preserves chromosome number
  - Produces two daughter nuclei
  - Produces daughter cells genetically identical and to each other
  - Used for asexual reproduction and growth

Alternation of Generation

- For species that reproduce sexually, they must alternate between haploid and diploid stages in order to exchange genetic information between individuals
- For animals, the haploid stage is very short – just the gametes.
- Many fungi are opposite: adults are haploid, when gametes fuse, a diploid zygote is created that quickly undergoes meiosis to go back to haploid.
- In many plants, both stages can be long, and multicellular

The Human Life Cycle

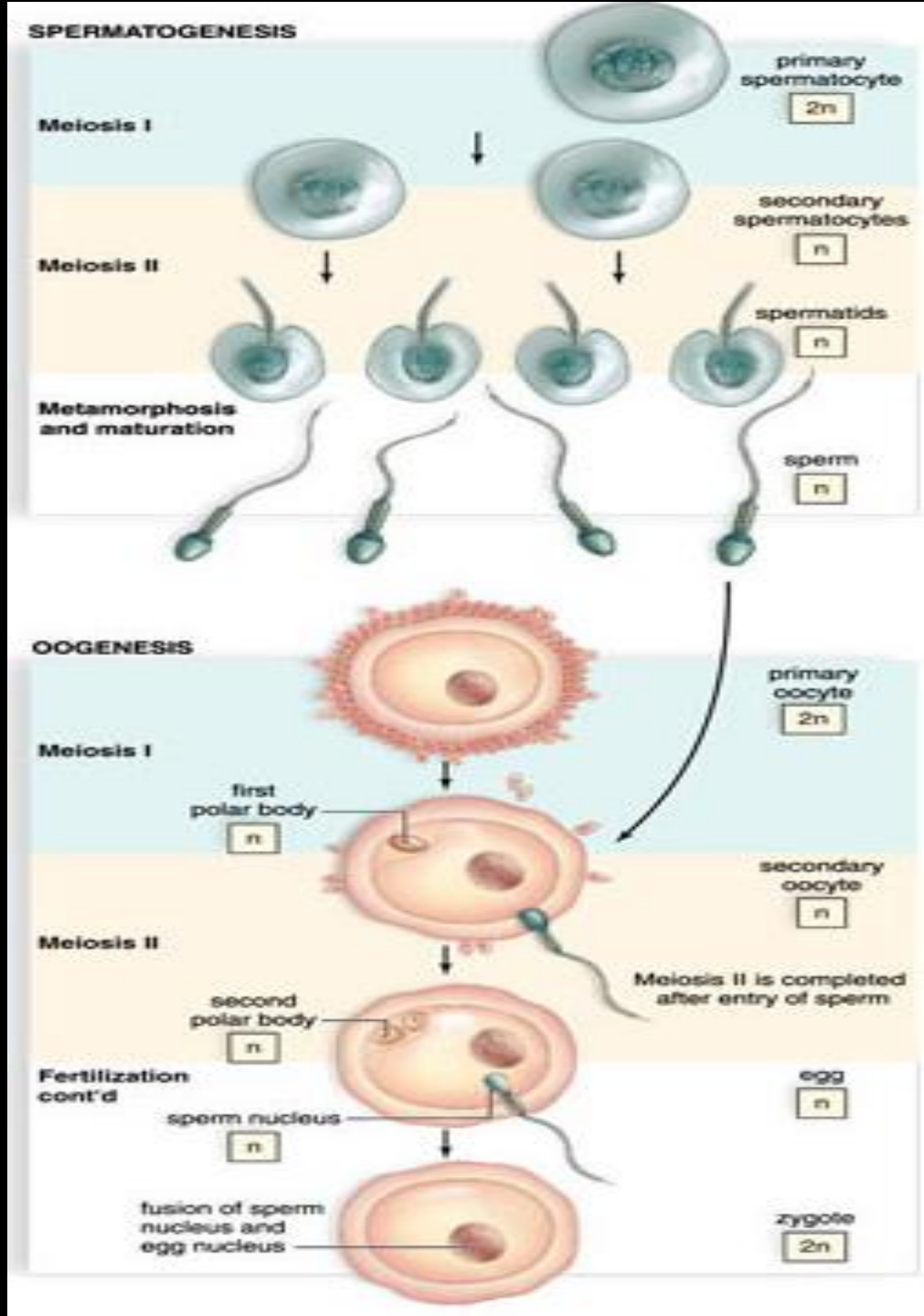


Life Cycle Basics: Animals

- In familiar animals:
  - "Individuals" are diploid; produce haploid gametes
  - Only haploid part of life cycle is the gametes
  - The products of meiosis are always gametes

  - Meiosis occurs only during **gametogenesis**
    - Production of sperm
      - **Spermatogenesis**
      - All four cells become sperm
    - Production of eggs
      - **Oogenesis**
      - Only one of four nuclei get cytoplasm
        - » Becomes the egg or ovum
        - » Others wither away as polar bodies

Gametogenesis in Mammals



The Human Life Cycle

- Sperm and egg are produced by meiosis
- A sperm and egg fuse at fertilization
- Results in a zygote
  - The one-celled stage of an individual of the next generation
  - Undergoes mitosis
- Results in multicellular embryo that gradually takes on features determined when zygote was formed
- All growth occurs as mitotic division
- As a result of mitosis, each somatic cell in body
  - Has same number of chromosomes as zygote
  - Has genetic makeup determined when zygote was formed

Review Mitosis & Meiosis

- Name three purposes for cell division in animals.
- How does the genome (DNA) exist during Interphase?
- In which phase of mitosis do sister chromatids separate from one another?
- What is a somatic cell?
- Name two things that happen during S phase. What is BEFORE S? After?
- What is the spindle apparatus made of? Anchored by what?
- Name one thing that happens during prometaphase.
- What is cytokinesis?
- In which phase of meiosis do sister chromatids separate from one another?
- A cell plate is to plants what a ____ is to animals.
- In humans, the haploid stage occurs in which cells?
- The G1 checkpoint is also called what?
- Meiosis II is very similar to mitosis… but how is it different?
- In which phase of mitosis do homologous pairs separate from one another?
- What are the proteins that control the cell cycle clock?
- What is a tetrad?What is crossing-over?
- Write three differences between mitosis and meiosis.
- How many autosomes do humans have?

Review Videos

https://www.khanacademy.org/science/biology/cellular-molecular-biology/mitosis/v/interphase