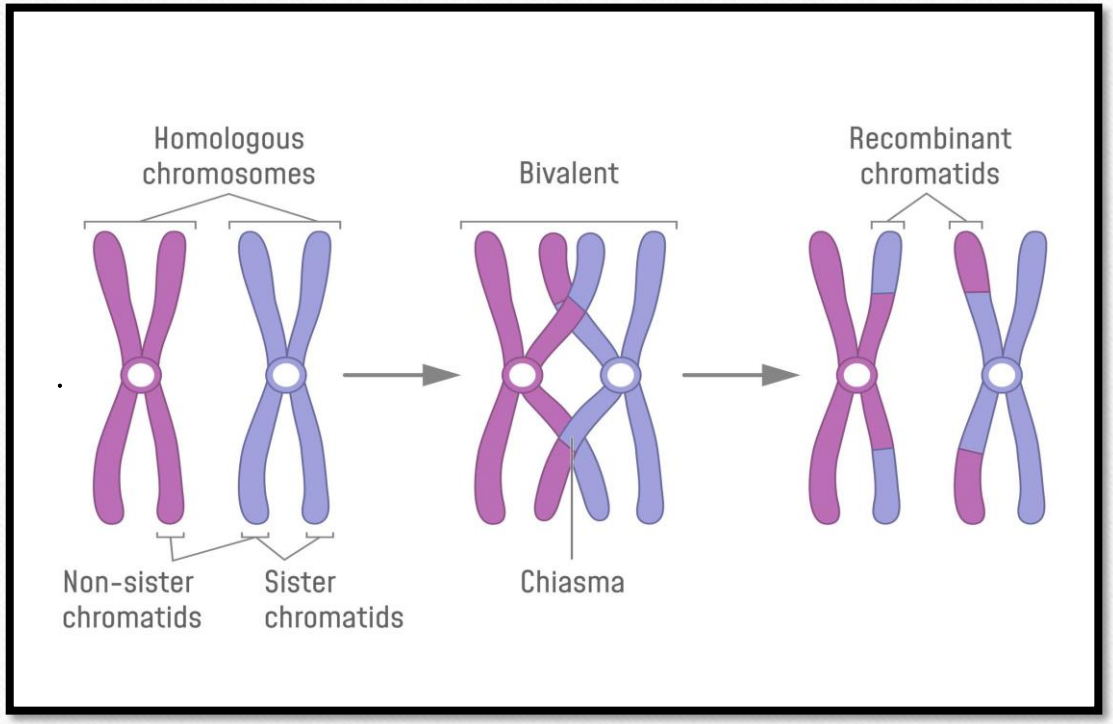
CROSSING OVER

CELL BIOLOGY, GENETICS AND EVOLUTION

DEFINITION OF CROSSING OVER

- Interchange of chromosomal parts or genes between non-sister chromatids of a homologous pair of chromosomes.
- **Homologous pair of chromosome**: Paternal chromosome + Maternal chromosome. Same size and shape.
- **Non-sister chromatids**: The 2 chromatids from 2 different chromosomes.



SALIENT FEATURES OF CROSSING OVER

- Discovered by **Morgan**
- Crossing over results in **recombination of genes** , thus promoting **genetic diversity**.
- Results in the formation of **chiasmata** ; the point of contact, the physical link, between two non-sister chromatids belonging to homologous chromosomes. At a given chiasma, an exchange of genetic material can occur. Absence of a chiasma generally results in improper segregation and aneuploidy.
- It occurs during **Meiosis > Prophase I > Pachytene.**
- It occurs only between **non-sister chromatids** of homologous chromosomes.

SALIENT FEATURES OF CROSSING OVER

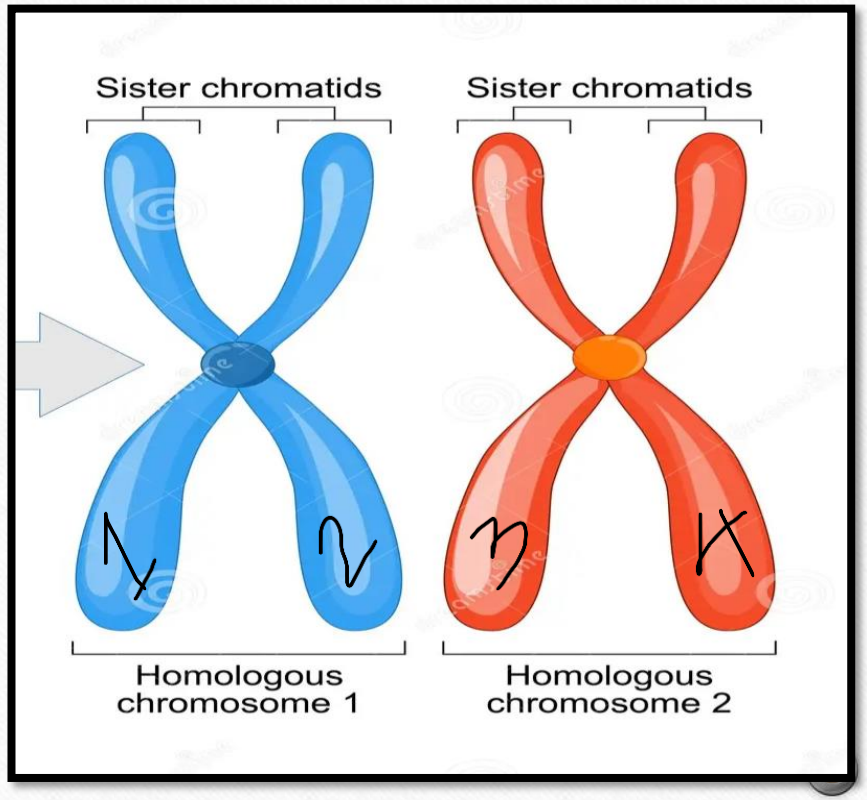
- During prophase I, the homologous chromosomes come very close together in a process called synapsis. At certain points, the chromatids from the homologous chromosomes physically overlap. These overlapping points are called chiasmata.
- Once the chromatids overlap, crossing over occurs. This is when segments of DNA are exchanged between the chromatids. Specifically, parts of the chromatids from the mother's chromosome swap with corresponding parts of the chromatids from the father's chromosome. This leads to recombination, meaning new combinations of genetic information that didn't exist before in either parent.

SALIENT FEATURES OF CROSSING OVER

- **For Example:**
- Let's say you inherit a chromosome pair from your parents, with one chromosome having the gene for brown eyes (from your mother) and the other for blue eyes (from your father). During crossing over, a part of the chromosome with the blue eye gene could swap with a part of the chromosome with the brown eye gene. As a result, the gametes might carry a mix of these genes, leading to unique combinations in your offspring.

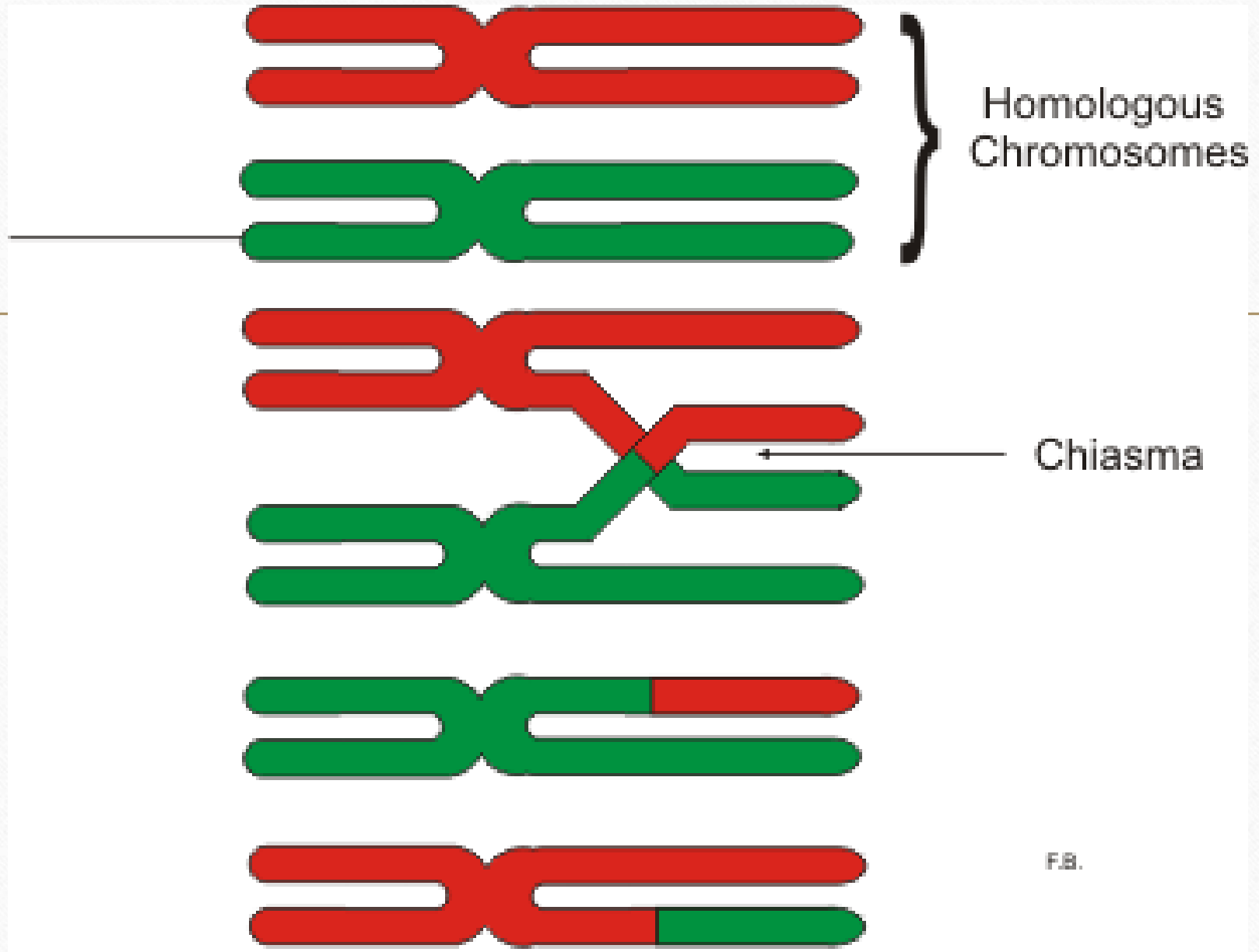
TYPES OF CROSSING OVER

- Single Crossing Over:
- Double Crossing Over:
- Multiple Crossing Over:
- Sister Chromatid Crossing Over
- Induced Crossing Over



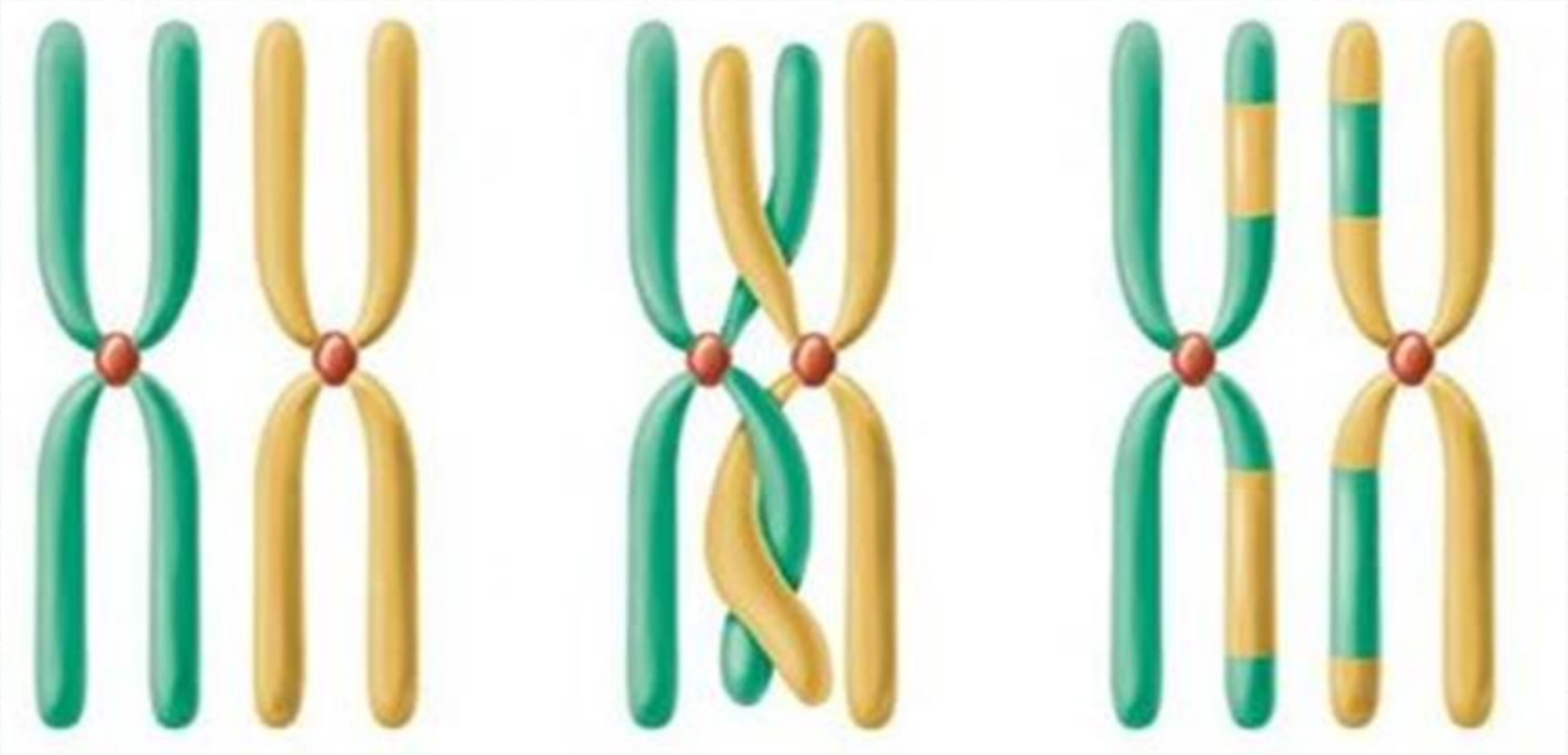
Single Crossing Over

- In single crossing over, one chiasma forms between two homologous chromosomes, resulting in the exchange of genetic material between one pair of chromatids. This is the simplest and most common form of crossing over.
- During prophase I of meiosis, two chromatids from homologous chromosomes overlap and exchange segments at one location.
- The resulting gametes have new combinations of genetic material at one specific gene location.


Homologous
Chromosomes
Chiasma
F.B.

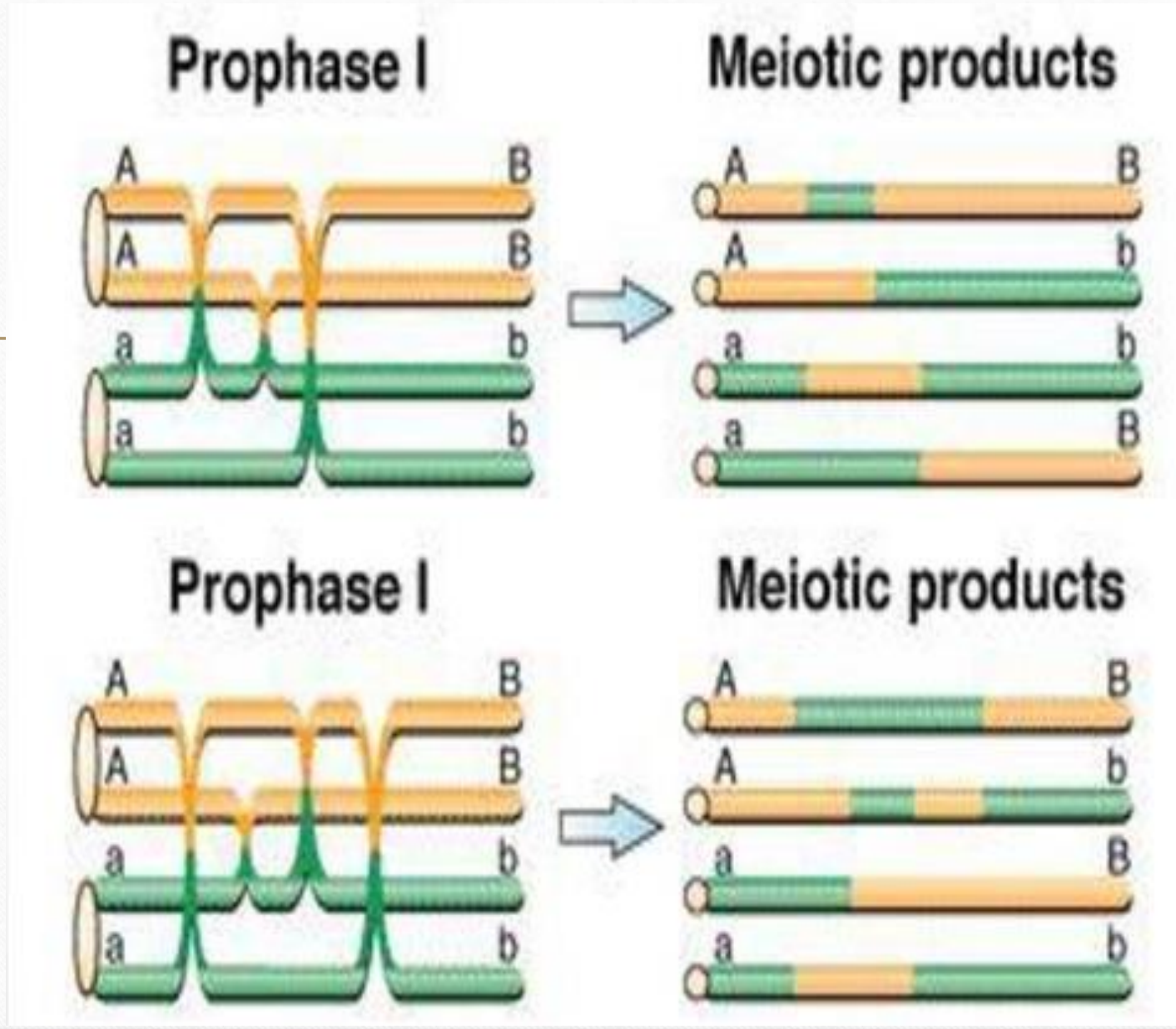
Double Crossing Over

- In double crossing over, two chiasmata form between homologous chromosomes, resulting in the exchange of two segments of the chromatids.
- During prophase I, two separate crossover events occur between homologous chromosomes, leading to a more complex reshuffling of genetic material.
- Double crossing over produces gametes with more varied combinations of genetic information, as two points of the chromosome exchange genetic material.



Multiple Crossing Over

- Multiple crossing over involves the formation of more than two chiasmata along the length of homologous chromosomes, resulting in the exchange of multiple segments.
- Multiple crossover events occur at different points along the homologous chromosomes during meiosis, leading to a more extensive reshuffling of genes and diverse genetic variations.
- Multiple genes, such as those controlling traits like eye color, height, and blood type, might all undergo crossing over, leading to a complex mix of traits in the offspring.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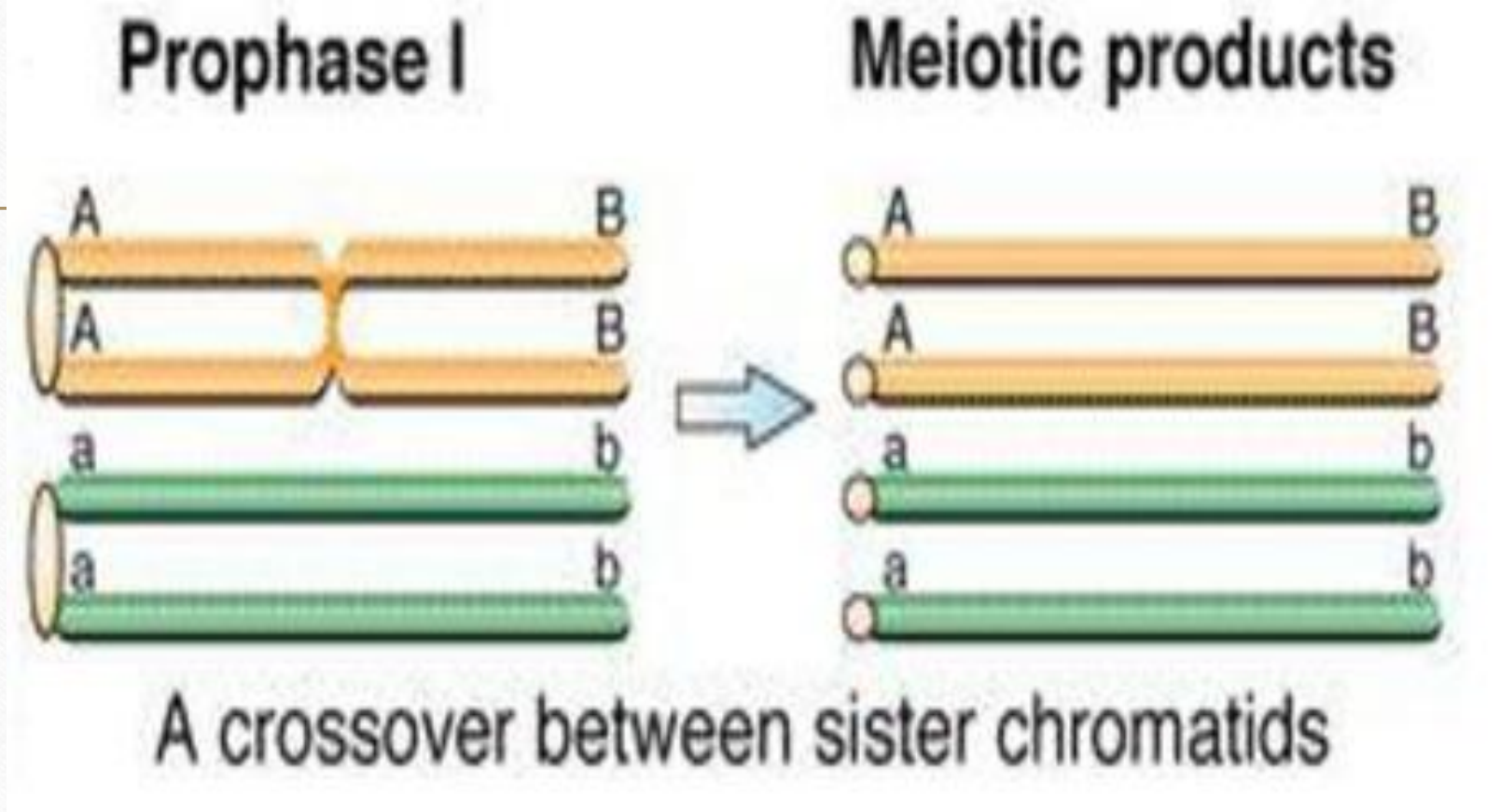
Sister Chromatid Crossing Over

- This is a rare form of crossing over that occurs between sister chromatids (identical chromatids of the same chromosome).
- Sister chromatids are exact copies of each other, so crossing over between them typically does not create new genetic combinations. However, SCE can happen and may be involved in DNA repair mechanisms.
- Since sister chromatids are identical, no genetic variation is produced. Instead, this process might be more involved in the repair of damaged DNA rather than in increasing genetic diversity.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Meiotic products
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A crossover between sister chromatids

Induced Crossing Over

- This type is triggered by external factors such as chemicals, radiation, or temperature changes.
- When cells are exposed to certain environmental factors, the rate of crossing over can increase. These factors can induce DNA breaks and promote more frequent recombination events.
- Induced crossing over can result in an increased rate of genetic variation, but it may also lead to mutations or chromosomal abnormalities.
- Exposure to radiation can cause DNA damage that promotes increased crossing over, which could either introduce new genetic combinations or lead to harmful mutations.

FACTORS AFFECTING CROSSING OVER

- Temperature
- X Rays
- Age
- Inversion of chromosome
- Location
- Mutation

SIGNIFICANCE

- Generates genetic diversity within populations, which is key to the survival and adaptation of species.
- Drives evolution by producing new genetic combinations that may enhance an organism's fitness in changing environments.
- Ensures the proper separation of chromosomes during meiosis, reducing the likelihood of genetic disorders.
- Maintains chromosome stability across generations, safeguarding the correct transfer of genetic information.

THANK YOU