Premedical- Biology

Meiosis

Reproduction

The ability to produce new individual organisms,

either **asexually** from a single parent organism,

or sexually from two parent organisms.

Asexual reproduction

is not limited to **uni-cellular organ**isms - **most plants**

- binary fission- Bacteria

- budding - yeasts and Hydras

- conjugation - bacteria may exchange genetic information

- **parthogenesis, fragmentation** and **spore formation**

Aphis
Aphid
Green-fly

Wingless
female giving
birth

baby hammerhead

Parthenogenesis

unusual reproductive process, in which the ovum develops without being fertilized by a spermatozoon

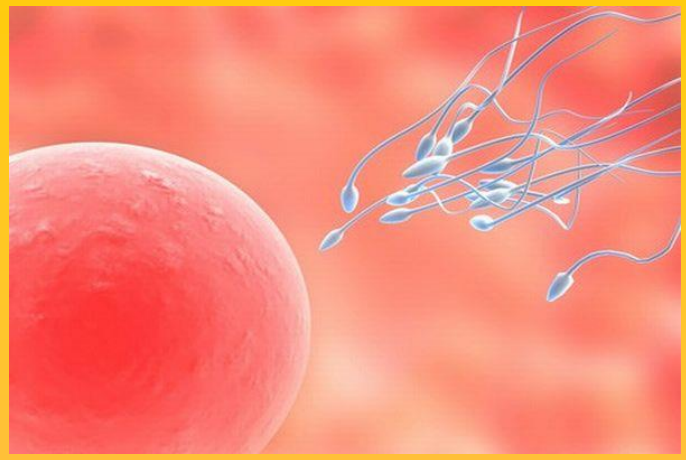
- **lower plants** (where it is called **apomixis**)
- **invertebrates** - water fleas, aphids, some bees and parasitic wasps
- **vertebrates** - some reptiles, fish, and very rarely birds and sharks

Sexual reproduction

by **combination of genetic material**

contributed from two different members

of the species



- reproduction by the fusion of female and male germ cells

Each contributes **half of the offspring's genetic material**

male produce sperm or microspore in *anisogamous* species

and **female produce ovum or megaspore**

Sexually reproducing organisms

have **two sets of genes for every trait**

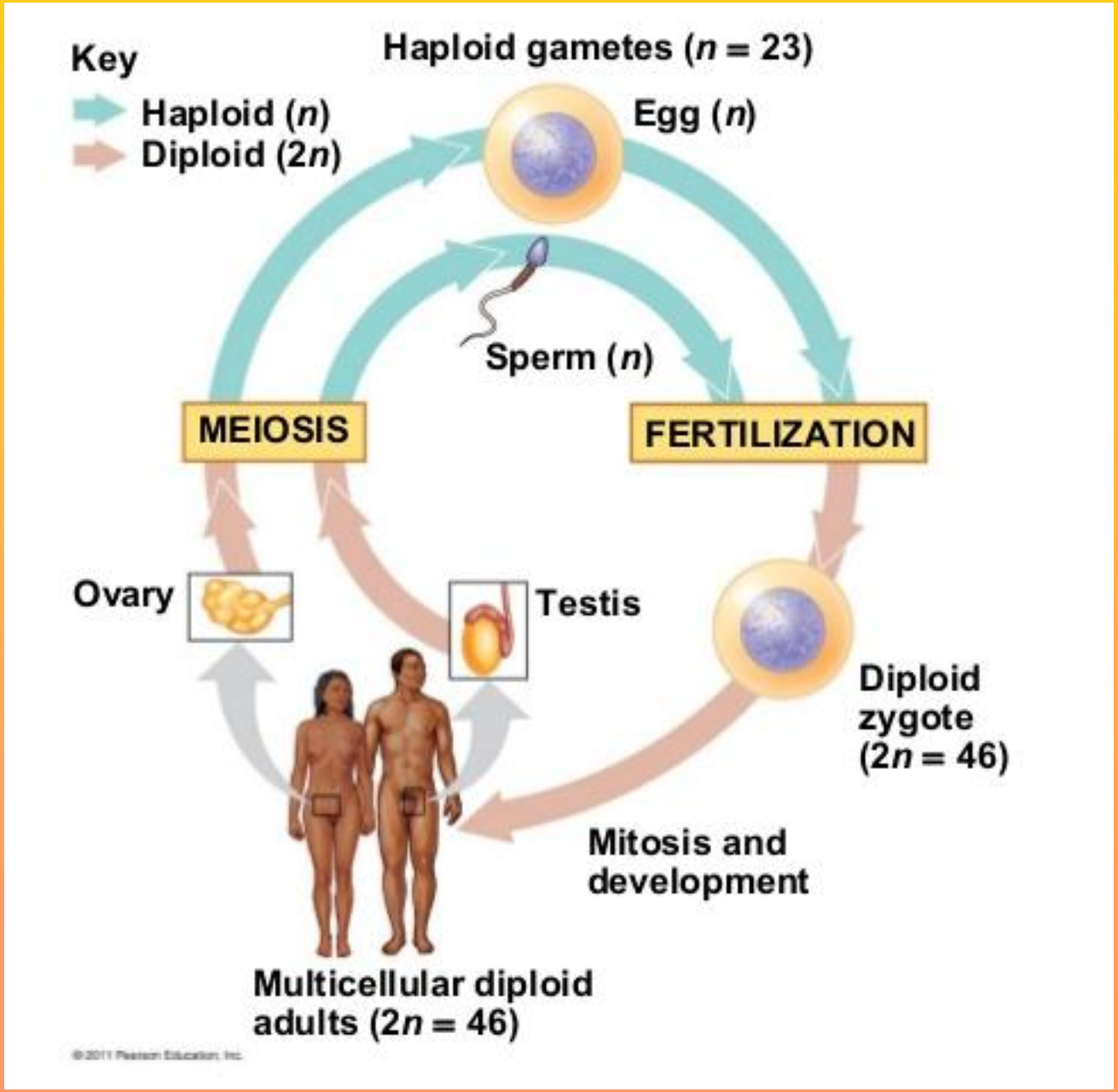
called alleles, offspring inherit one allele from each parent

- offspring is combination of parental genes
- **the alternation of diploid and haploid phase in cell lines**

inbreeding = *reproduction from mating of two genetically related parents*

inbred line – genesis of homozygote offspring by sexual reproduction

Human reproduction cycle



Meiosis

= division of germ cells - reduction of diploid chromosomal number to haploid

- formation **of haploid gametes**

First meiotic division

M I = reduction 2n → **n** / **n** **= heterotypic**

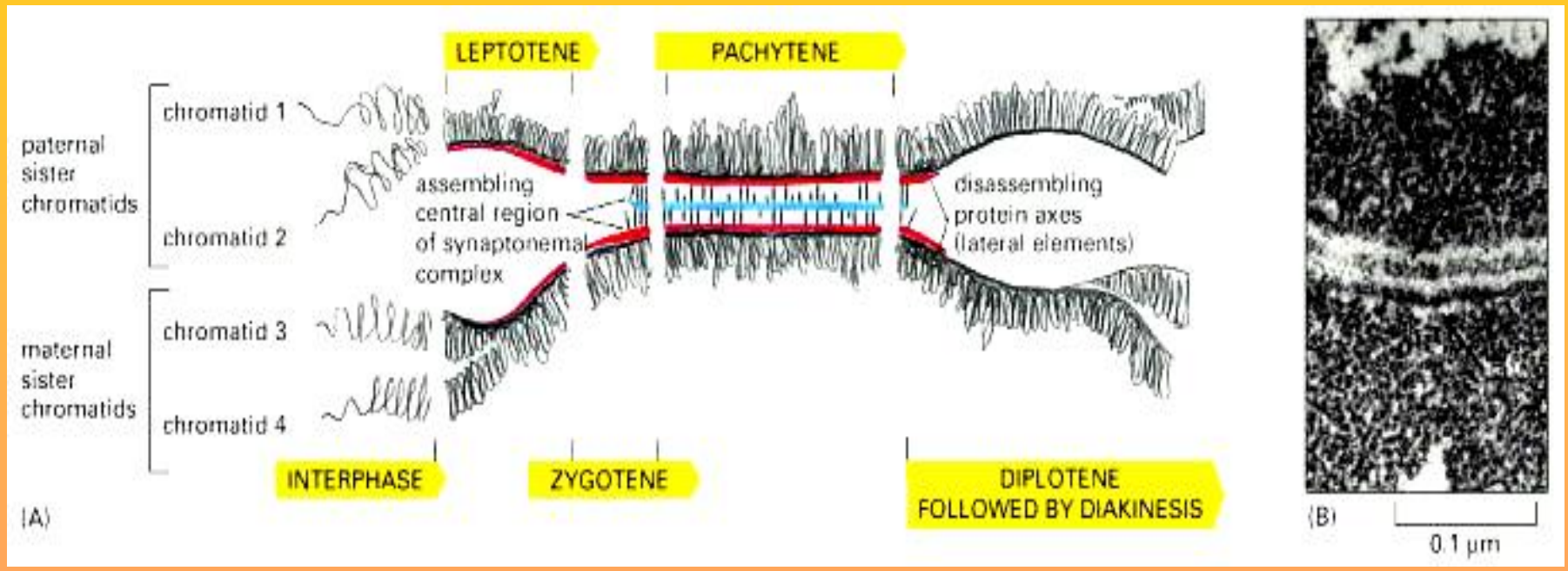
Prophase I:

1. **leptotene** – condensation of chromosomes
2. **zygotene** – pairing of homologous chromosomes –

synapsis - bivalents

synaptonemal complex

Synaptonemal komplex



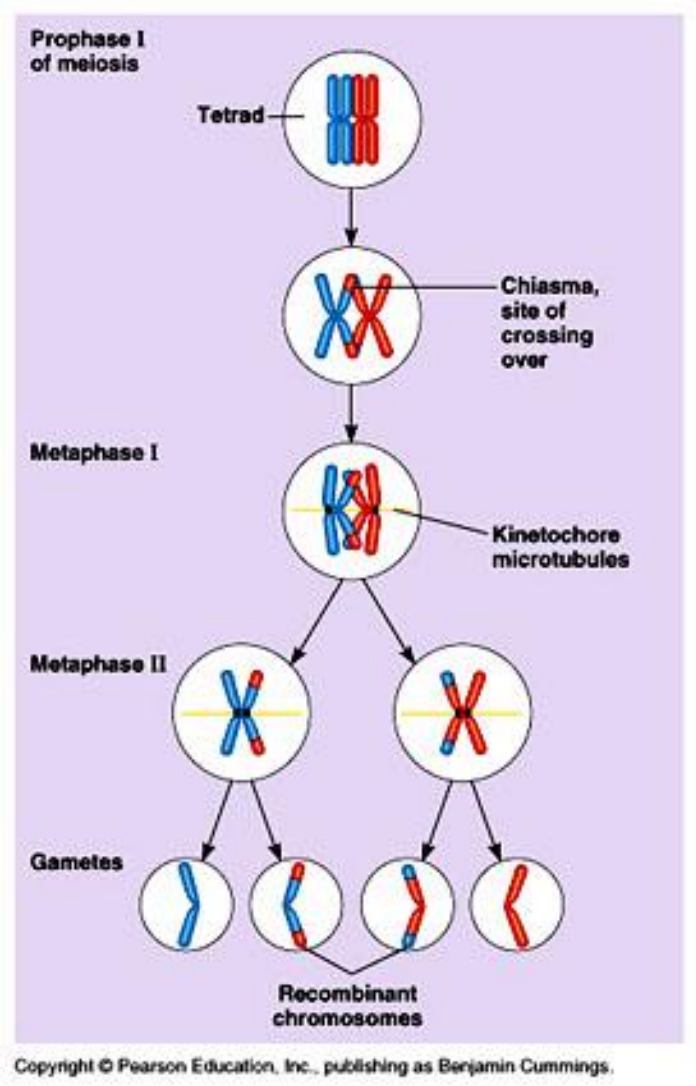
= three levels of protein structure

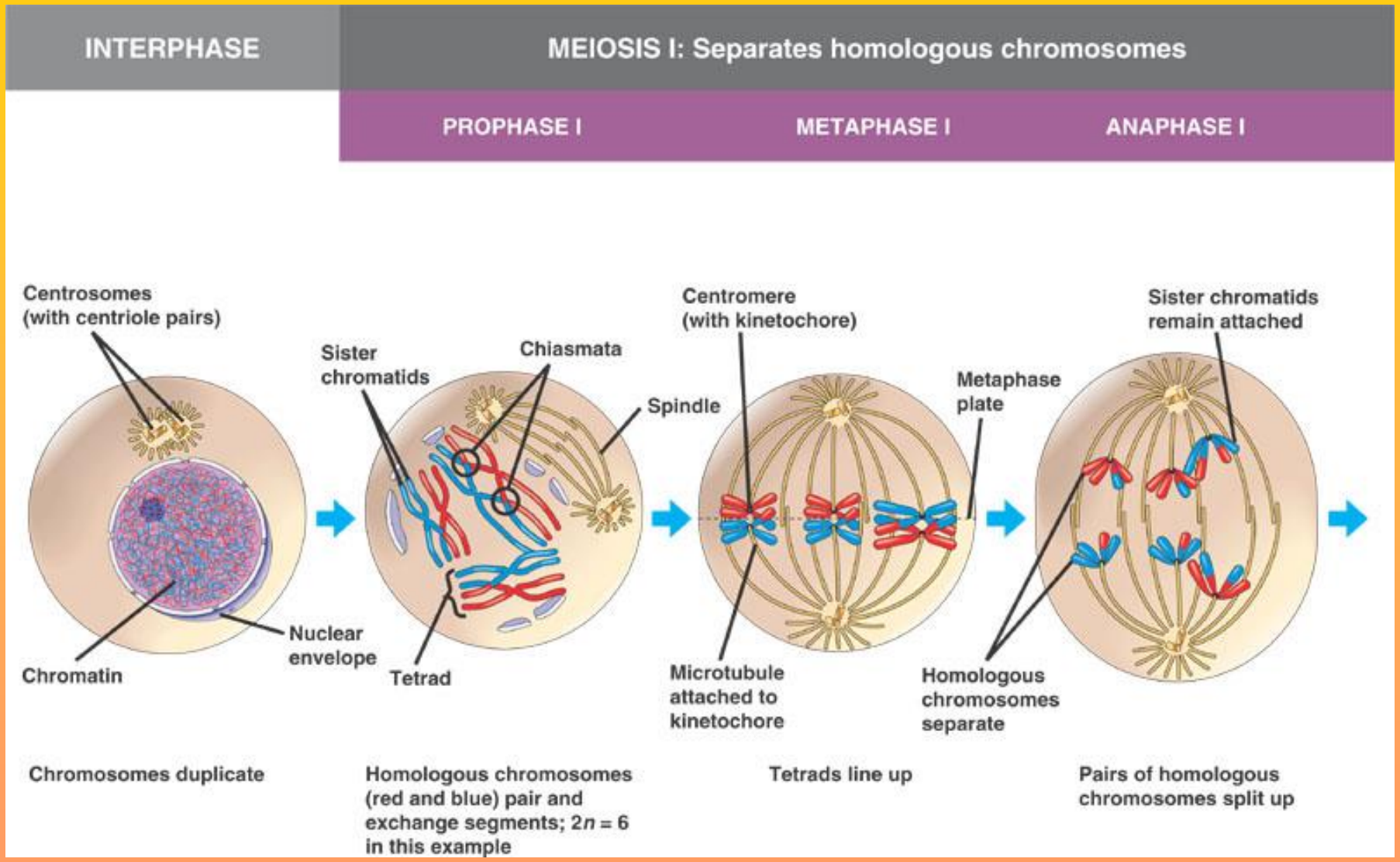
Molecular Biology of the Cell. 4th edition.
http://www.ncbi.nlm.nih.gov/books/NBK26840/figure/A3699/

3. pachytene – each chromosome has two chromatids – **tetrades**

crossing-over = reciprocal exchange of homologous parts of non-sister chromatids

= recombination of maternal and paternal genetic material




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

4. diplotene – separation of homologs, connected only in sites of chiasmata.

prerequisite of crossing-over = chiasma formation

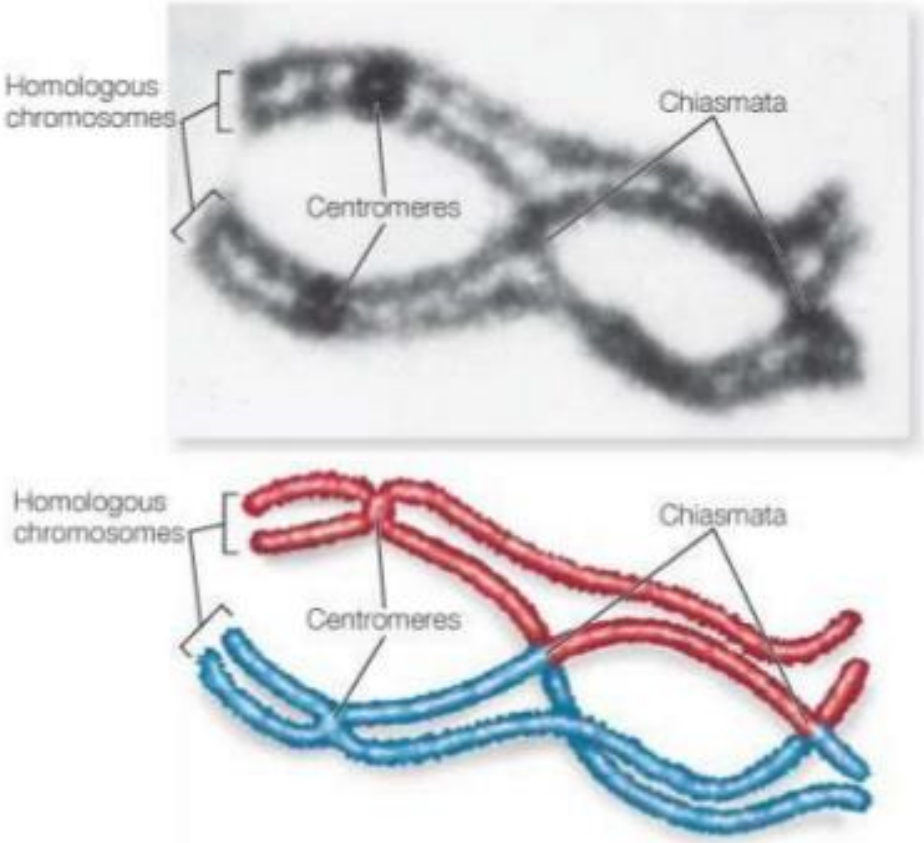
5. diakinesis – terminalisation of chiasmata and maximal contraction of chromosomes

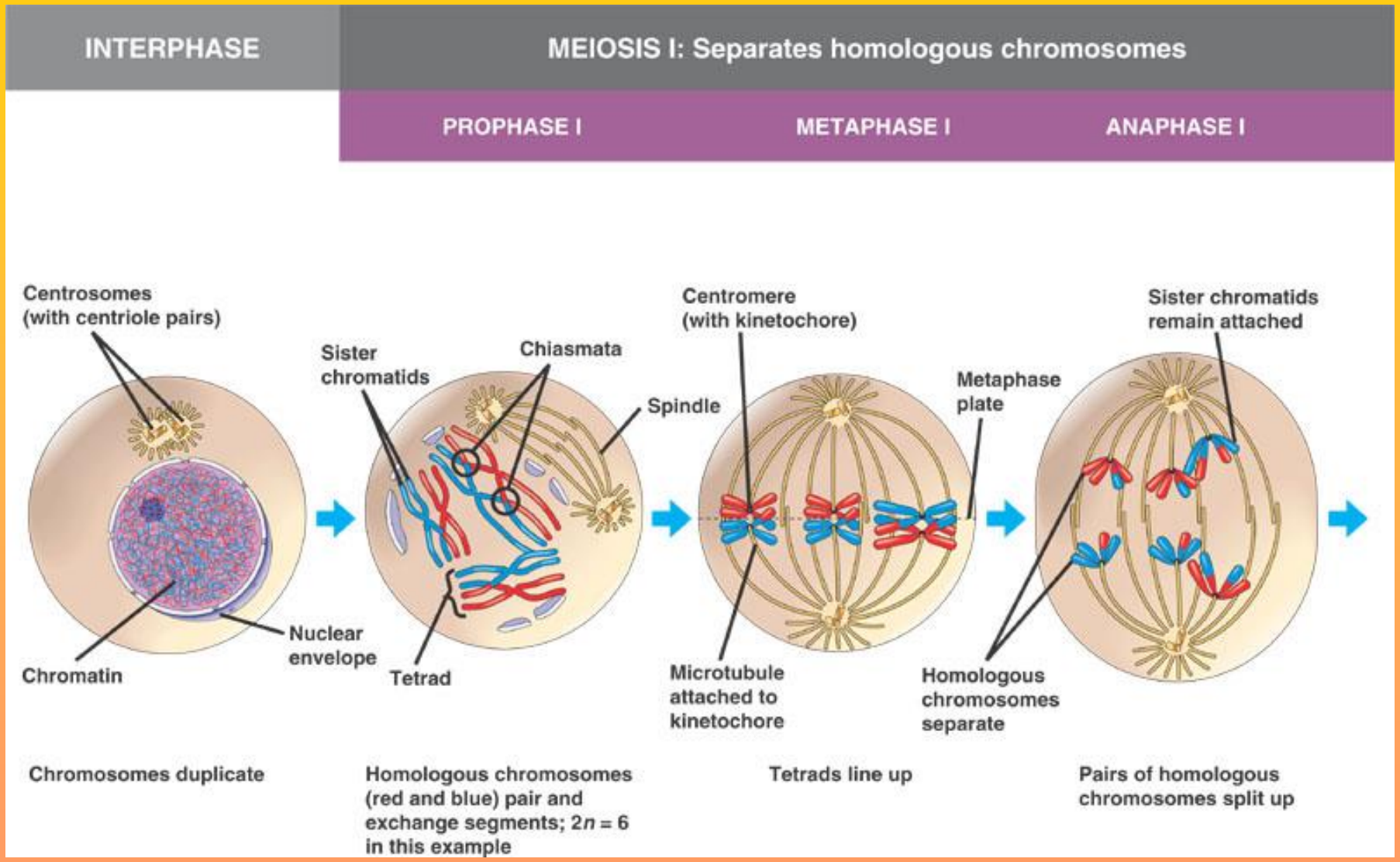
Metaphase I – lining of bivalents in equatorial plane of the cell. Chromosomes from the pairs split.

Chiasmata: evidence of exchange between chromatids

This micrograph shows a pair of homologous chromosomes, each with two chromatids, during prophase I of meiosis in a salamander.

Two chiasmata are visible.

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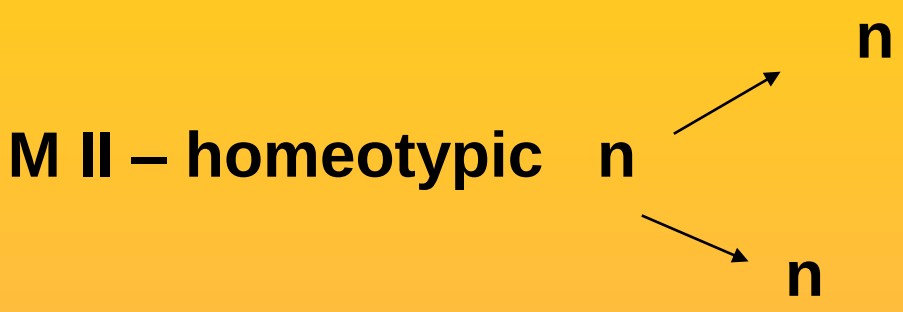
Anaphase I – migration of homologous chromosomes to the opposite poles - random according to their parental origin

Telophase I **-** chromosomes in opposite poles

Cytokinesis – division of cytoplasm - equal in spermiogenesis, unequal in oogenesis

Interkinesis – a phase without replication

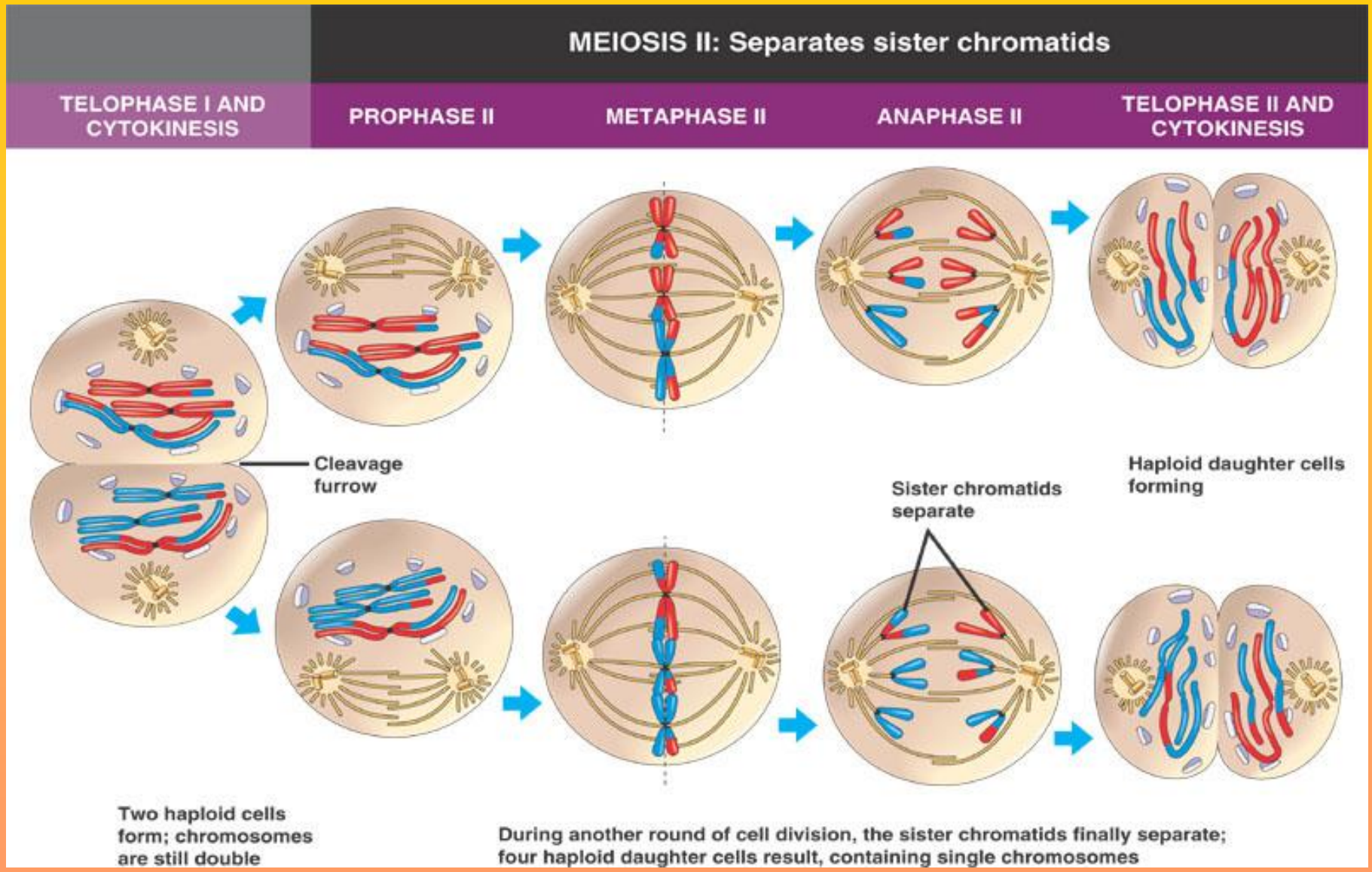
Second meiotic division



in Prophase II division and separation of centriols – spindle of microtubules

in Metaphase II centromers of chromosomes split

in Anaphase II separation of chromatids


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

Gametogenesis

– **formation of gametes**

- migration of primordial germ cells to the gonads during early fetal development number of mitotic division

Spermatogenesis

is continuous process, which starts in the time of sexual maturity (top off testosterone threshold)

growth **MI**

mitotic division - **spermatogonia** → **primary spermatocyte (dipl)**

M II

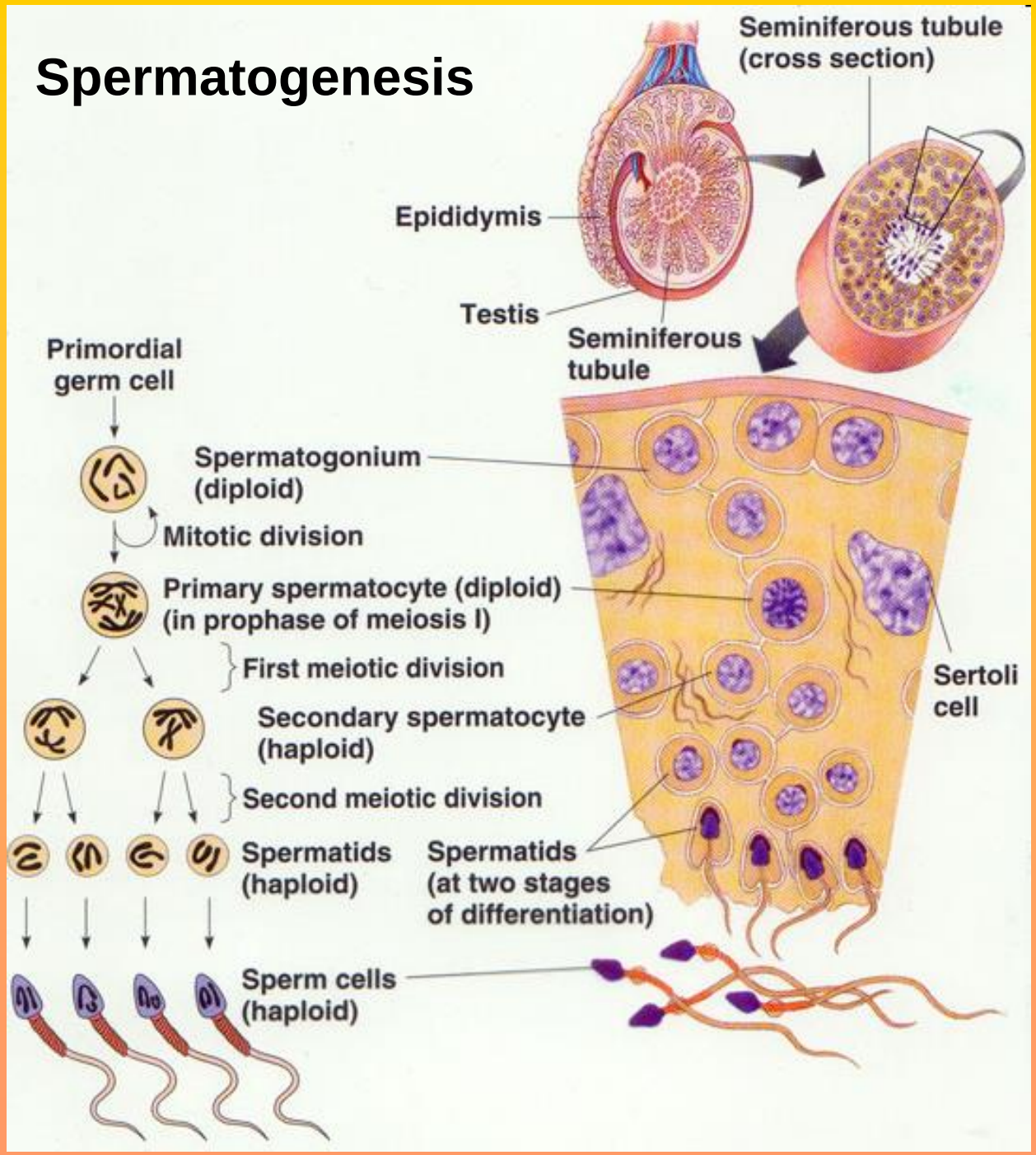
2 secondary spermatocytes (hapl) → **4 spermatids**

differentiation - spermiogenesis

→ **4 sperm**

1 cycle = about 10 weeks

Spermatogenesis



Oogenesis

3 month of fetal life
growth

M I to the end of prophase
diplotene=dictyotene
at the time of birth

Oogonia → **primary oocyte (dipl)** →

mitotic division

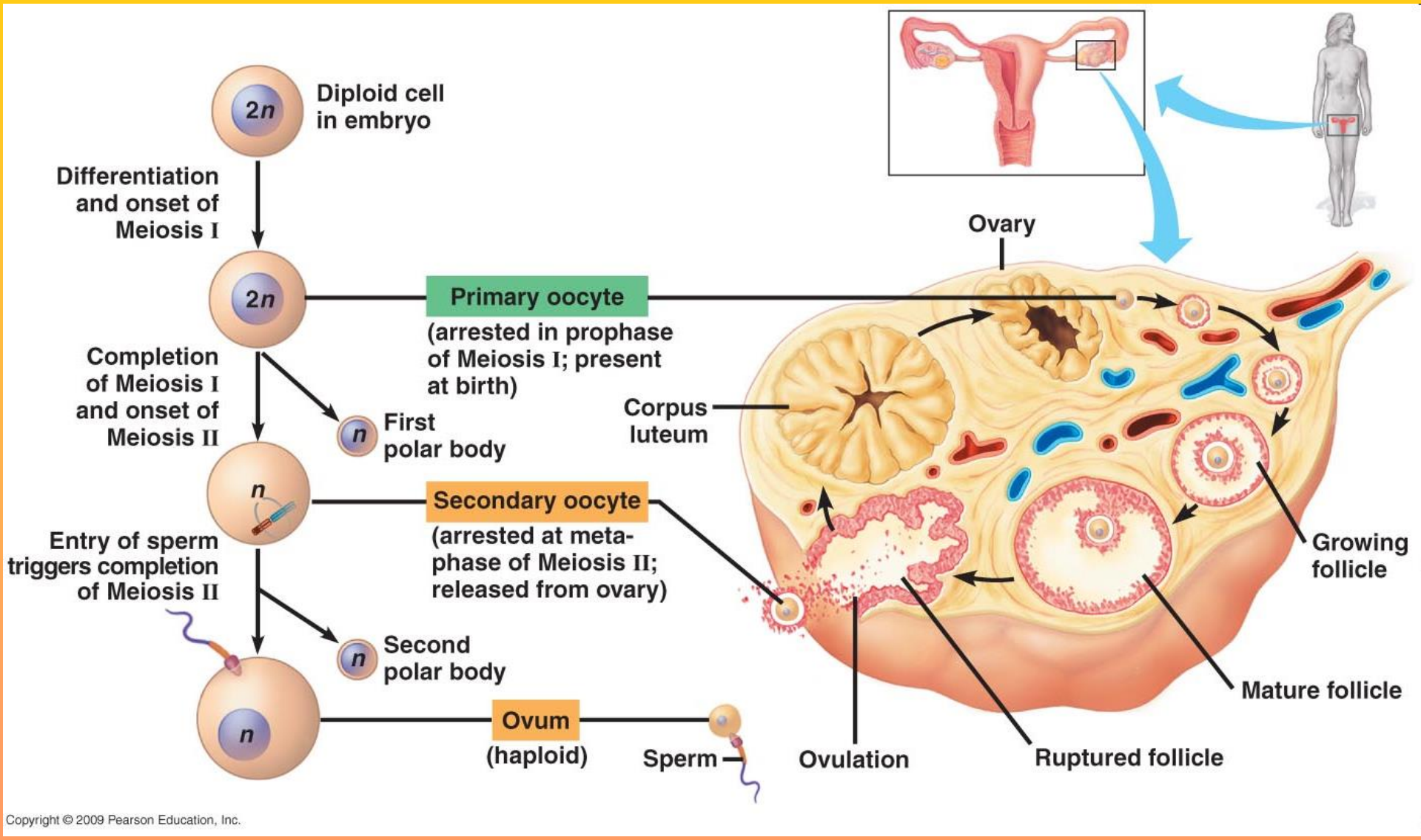
in the time of sexual maturity **M II**

M I continues → **secondary oocyte** — **ovulation in metaphase II**
+1st polar body

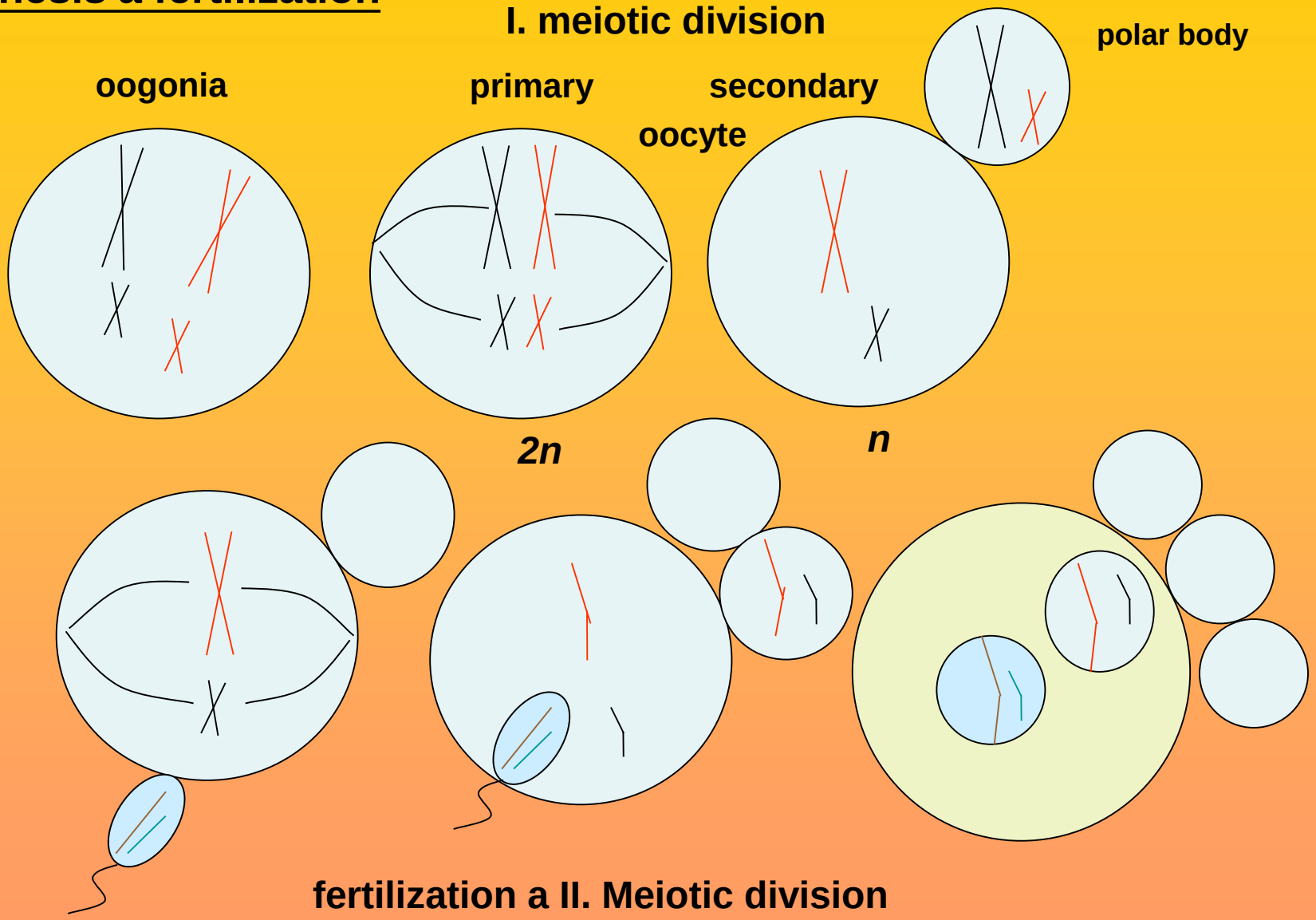
anaphase II + telophase II only after fertilization → **oocyte**

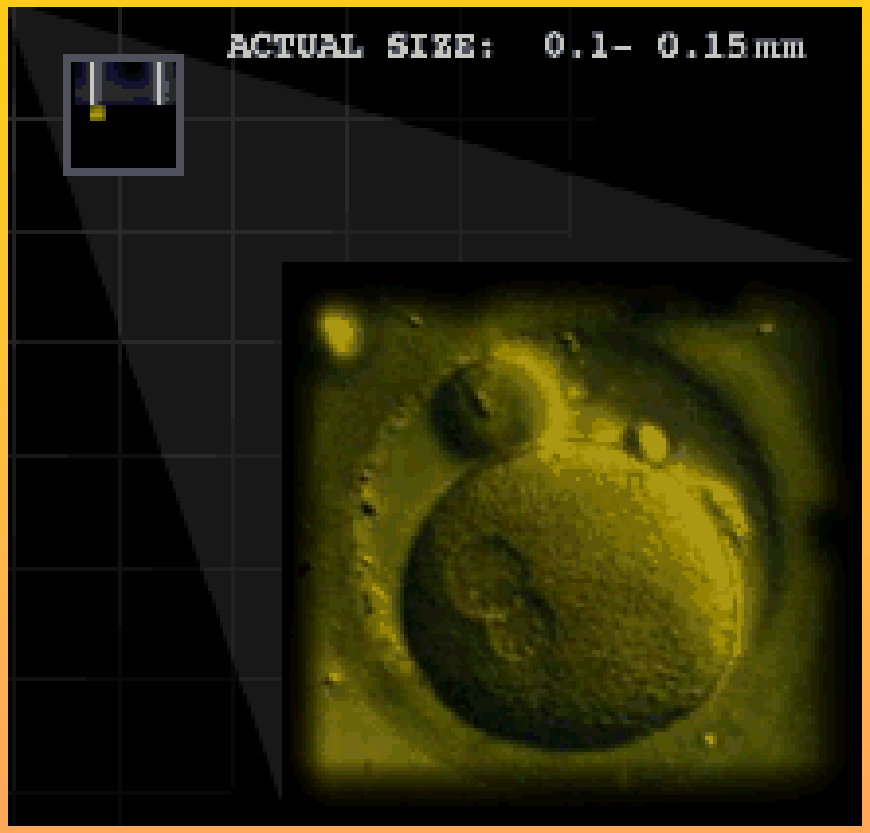
+ 2nd polar body

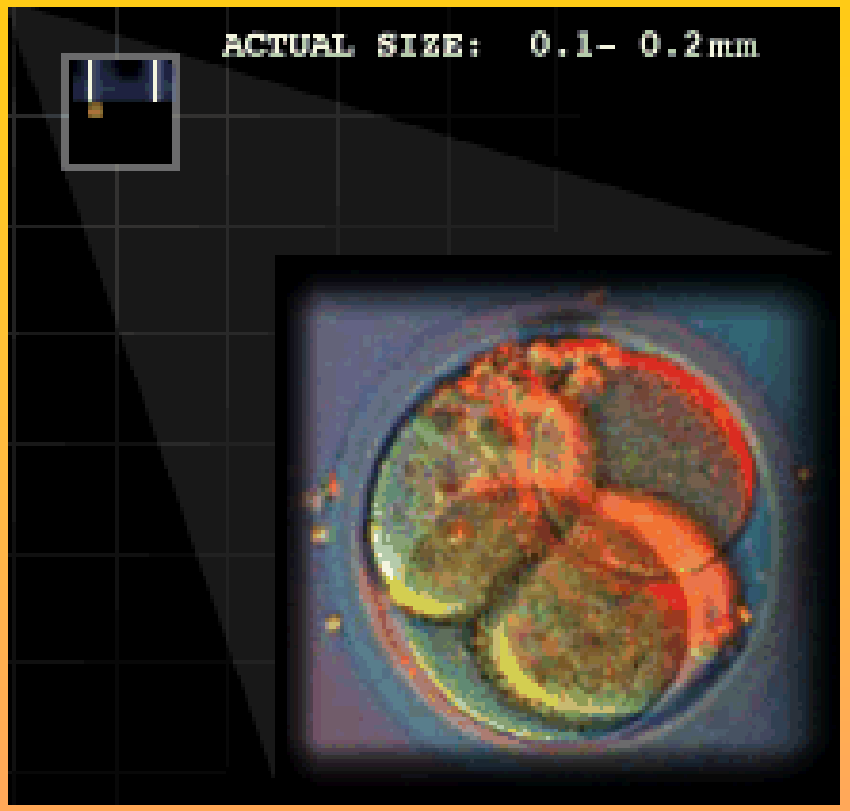
Oogenesis



Oogenesis a fertilization




ACTUAL SIZE: 0.1- 0.15mm


ACTUAL SIZE: 0.1- 0.2mm

Differences in gametogenesis

	Male	Female
Initiation	Puberty	Early embryonic life
Duration	cca 72 days	10-50 years
Numbers of mitoses in gamete formation	30 - 500	20-30
Gamete production	4 spermatids	1 ovum+3 polar bodies
Gamete production	100-200 million per ejaculate	1 ovum per menstrual cycle

Consequences of meiosis

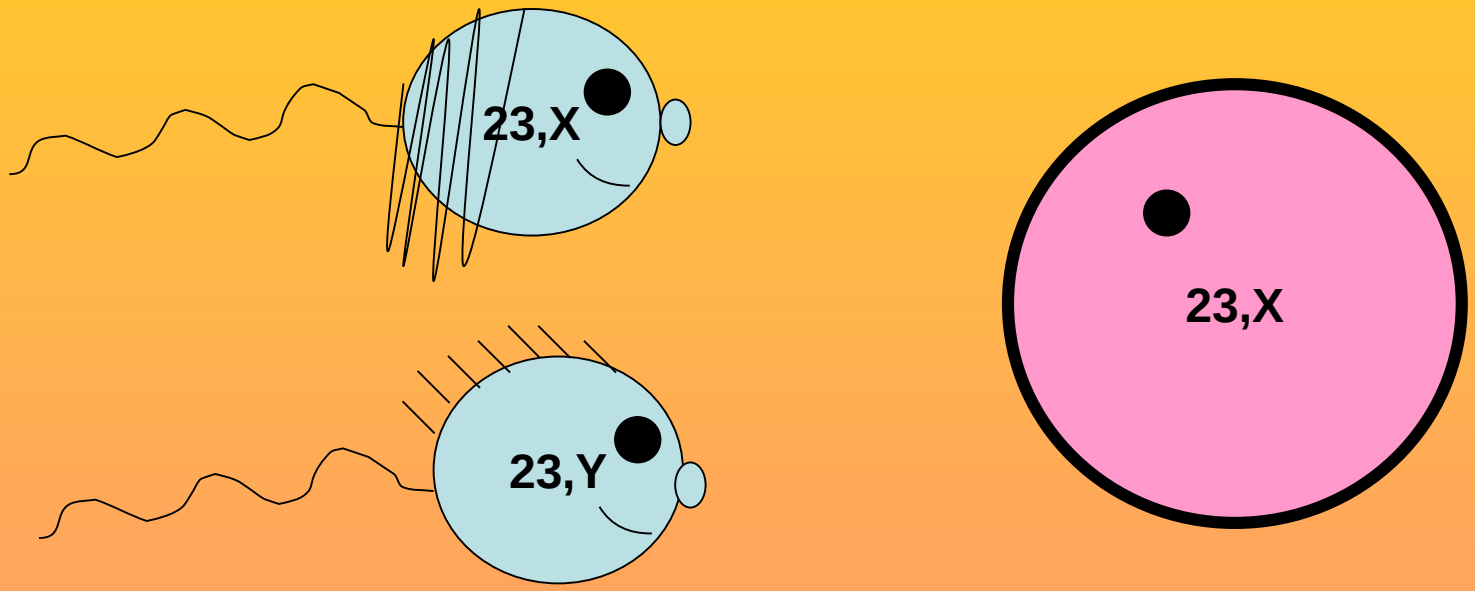
1. **reduction of diploid chromosomal number to haploid**

2. **segregation of alleles in M I, M II** (2st Mendel´s law)

3. **random assortment of homologues –** random combination maternal and paternal chromosomes in gametes (3nd Mendel´s law)

4. **increase of genetic variability by crossing-over** (parts of chromatids with segments of maternal and paternal origin)

Genetic determination of sex



If you feel small, low-spirited

and useless, remember:

Thanks to the perfect

Ovum and the fastest Sperm

and their genetic information, YOU ARE

ABSOLUTELY UNIQUE

and NOT REPEATABLE ELEMENT

IN THE WHOLE UNIVERSE

Errors of meiosis

Nondisjunction in M I - failure of homologues to be separated

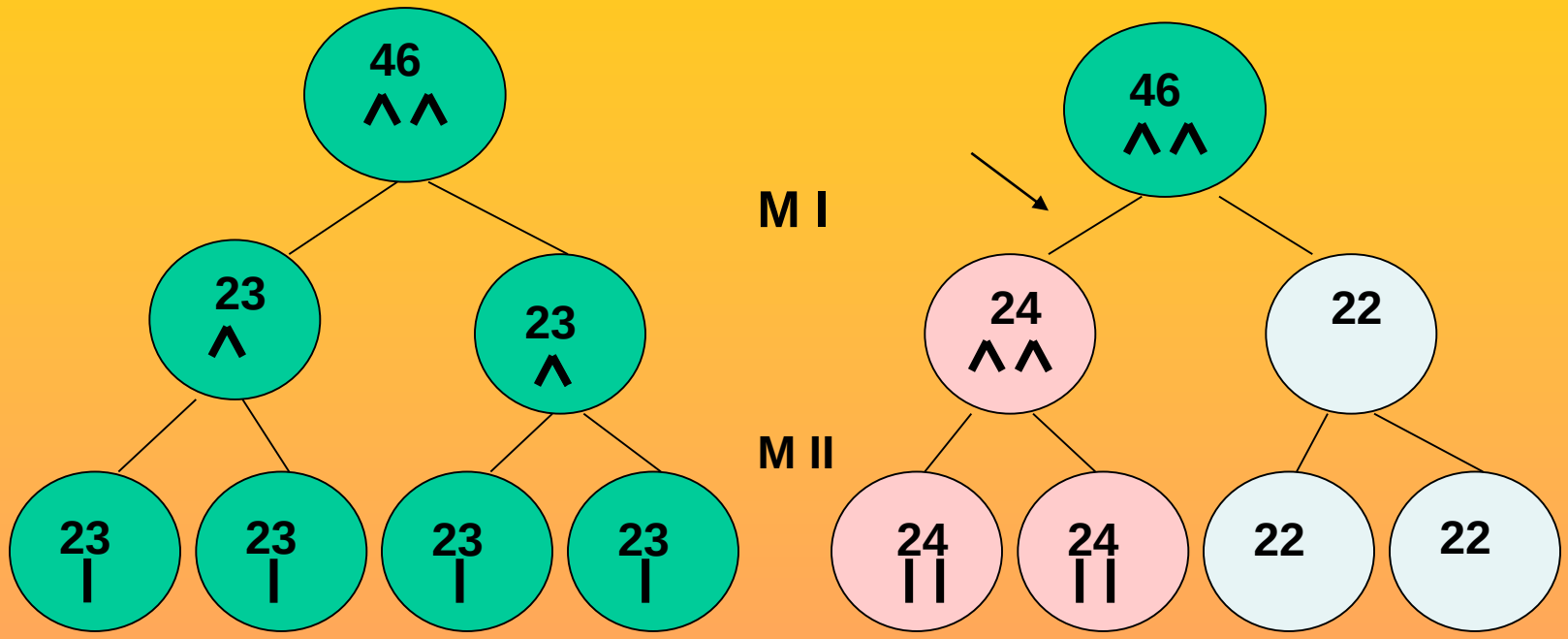
Nondisjunction in M II = failure of chromatids to be separated

consequences for 1 chromosomal pair:

disomic + nullisomic gametes

after fertilization: trisomic or monosomic zygote

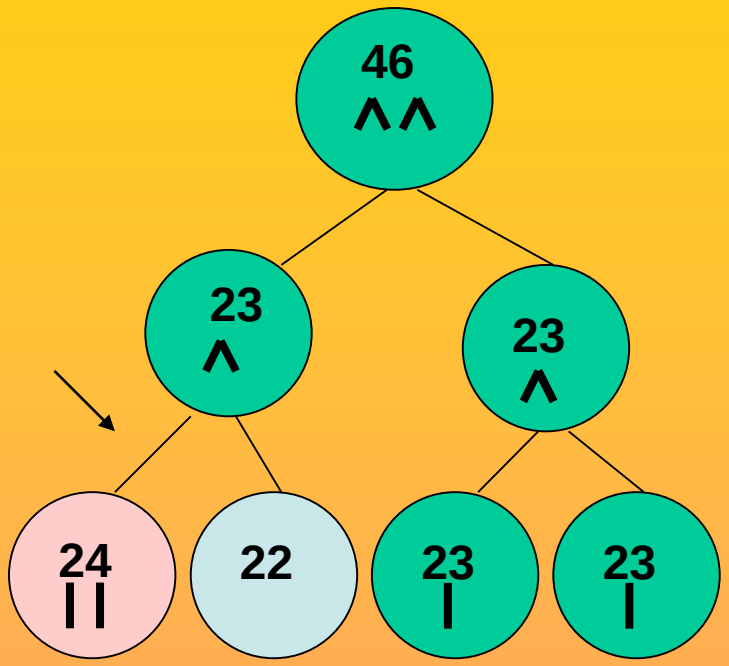
Error in meiosis for 1 chromosomal pair



Normal meiosis

Nondisjunction in M I

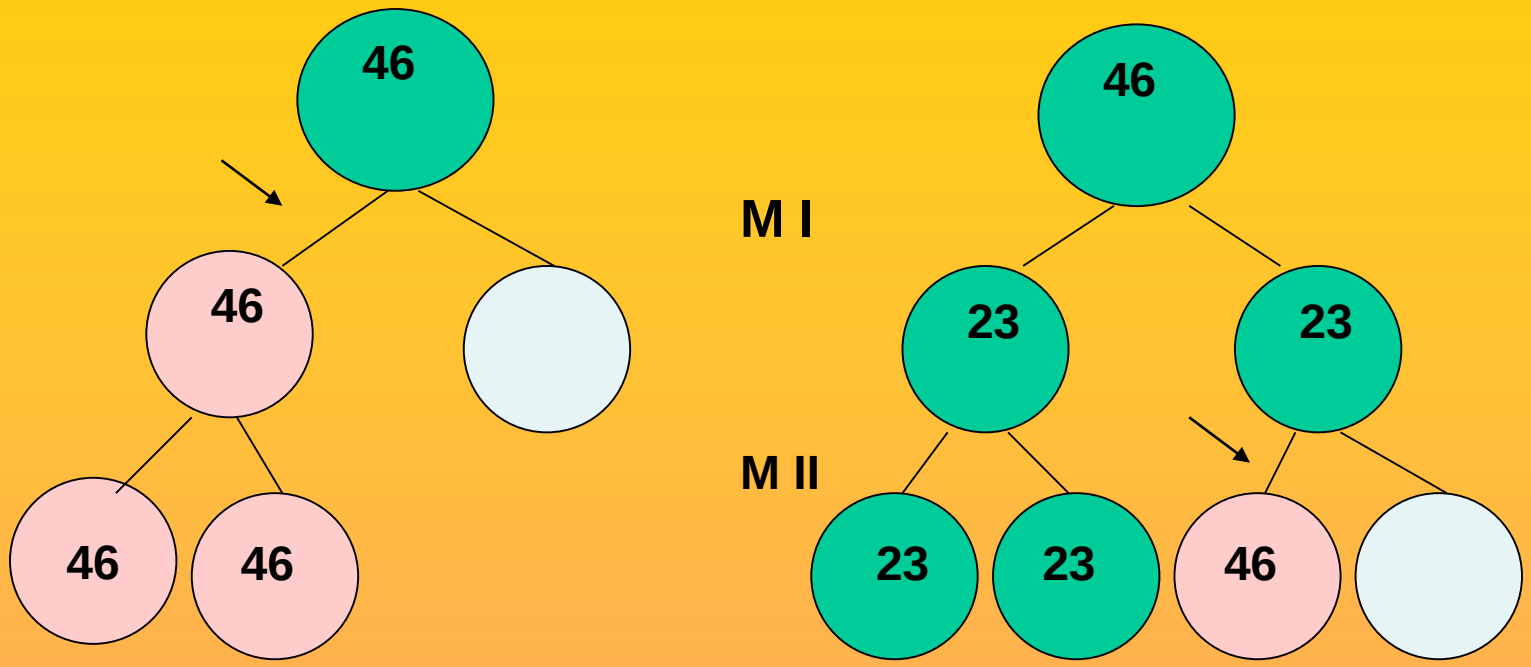
Consequences: trisomy/monosomy after fertilization



Nondisjunction in M II

Consequences: trisomy/monosomy

after fertilization



Errors in meiosis – nondisjunction of all chromosomes (M I or M II)

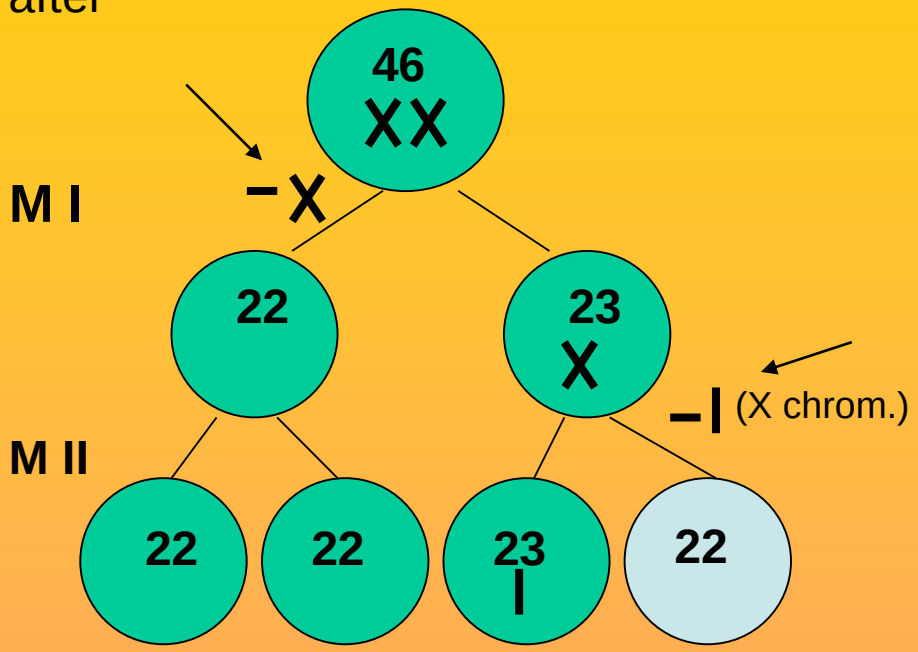
Consequence: non-reduced gamete,

Triploidy after fertilization

Anaphase lag of 1 chromosome

consequence: **nullisomic** gamete after

fertilization: **monosomic** zygote



Anaphase lag in M I or M II

Consequence: monosomy

after fertilization

Thank you for your attention

Campbell, Neil A., Reece, Jane B., Cain Michael L., Jackson, Robert B., Minorsky, Peter V.**,** **Biology**, Benjamin-Cummings Publishing Company, 1996 – 2010.