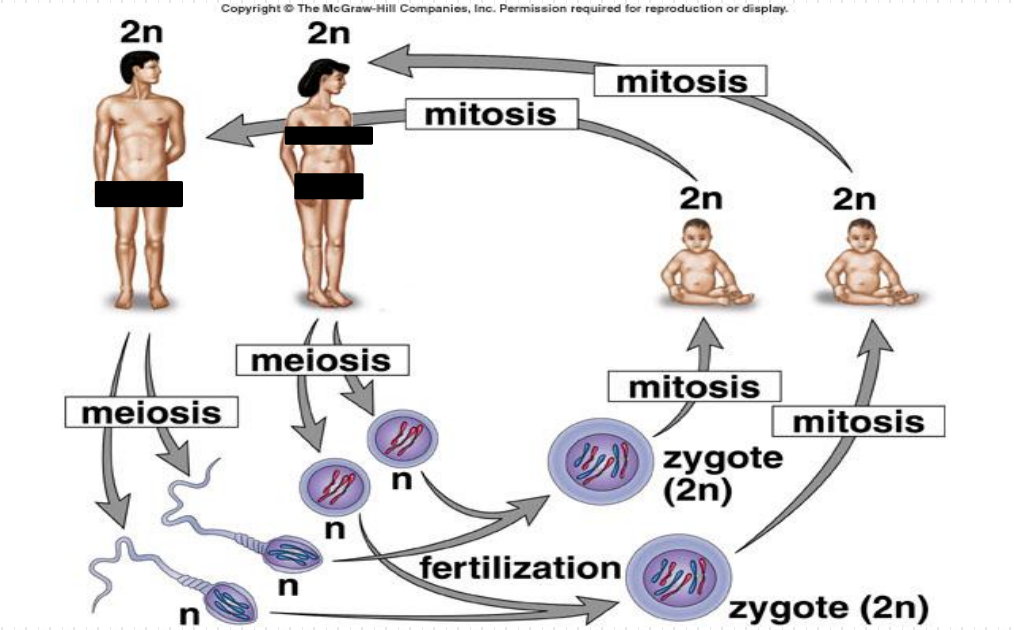
Bellwork

- Many organisms reproduce via asexual and sexual reproduction.
- How would we look if we reproduced mitotically?

SC.912.L.16.17
Meiosis Functions in Sexual Reproduction



Other Standards Addressed:

SC.912.L.16.14

Describe the cell cycle, including the process of mitosis. Explain the role of mitosis in the formation of new cells and its importance in maintaining chromosome number during asexual reproduction

SC.912.L.16.16

Describe the process of meiosis, including independent assortment and crossing over. Explain how reduction division results in the formation of haploid gametes or spores.

The Hook

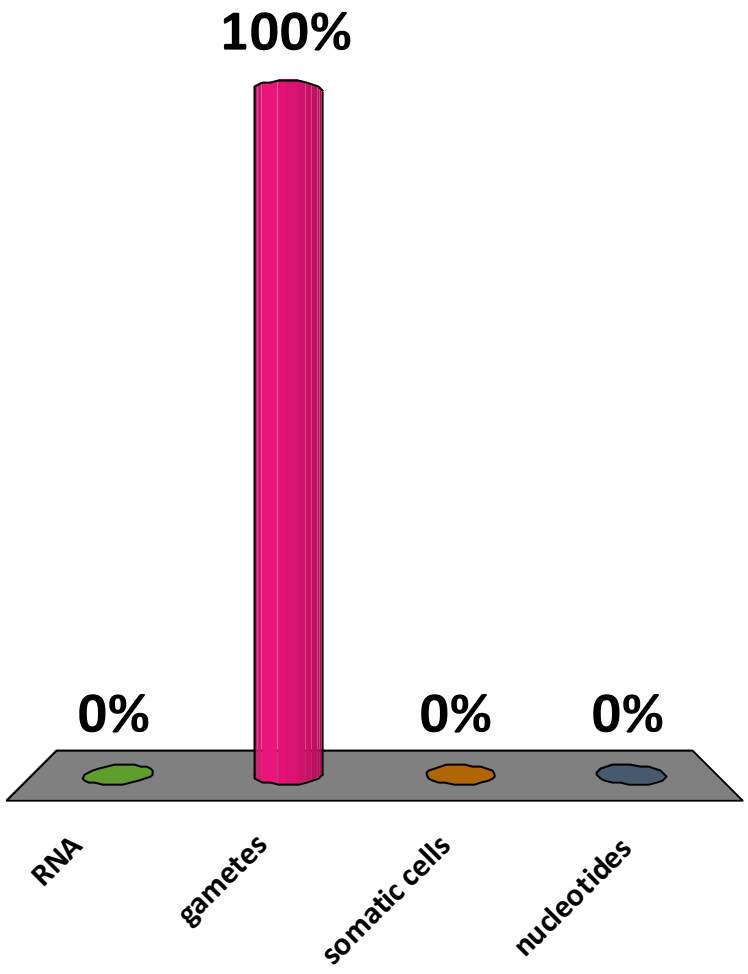
Let's talk about SEX!

Scientifically speaking, of course…

Megan Malone
Becky Waggett
Dan Huber

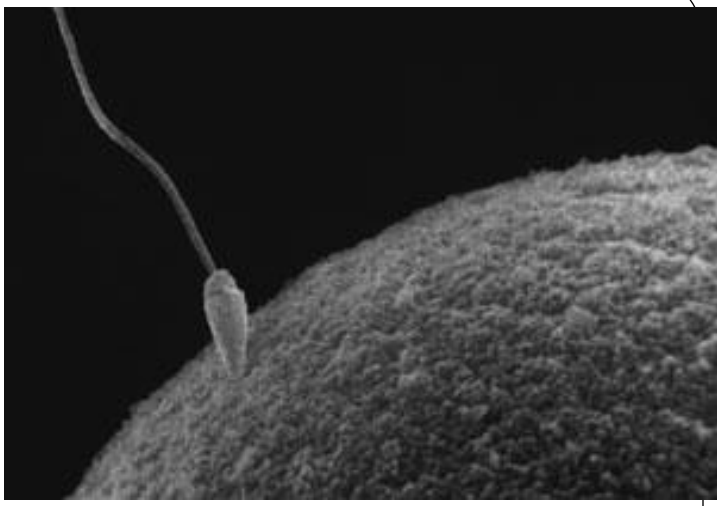
Which of the following transmits genes from one generation of a family to another?

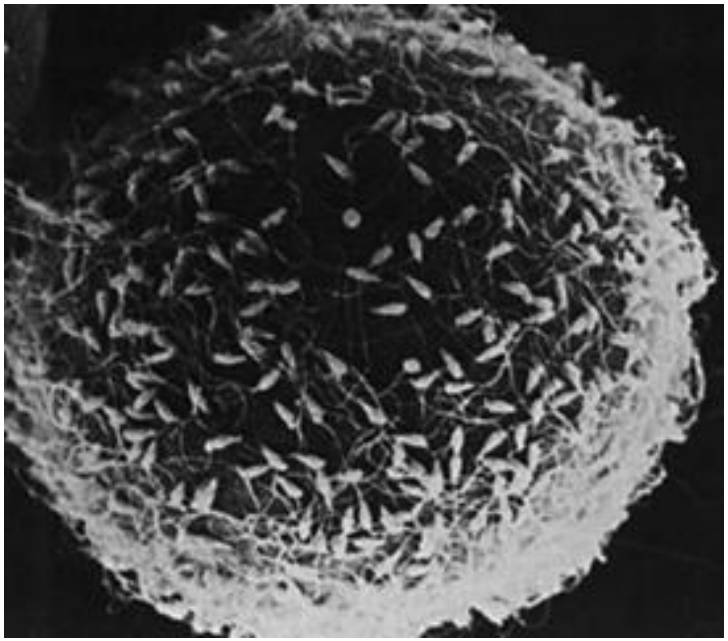
1. RNA
2. gametes
3. somatic cells
4. nucleotides

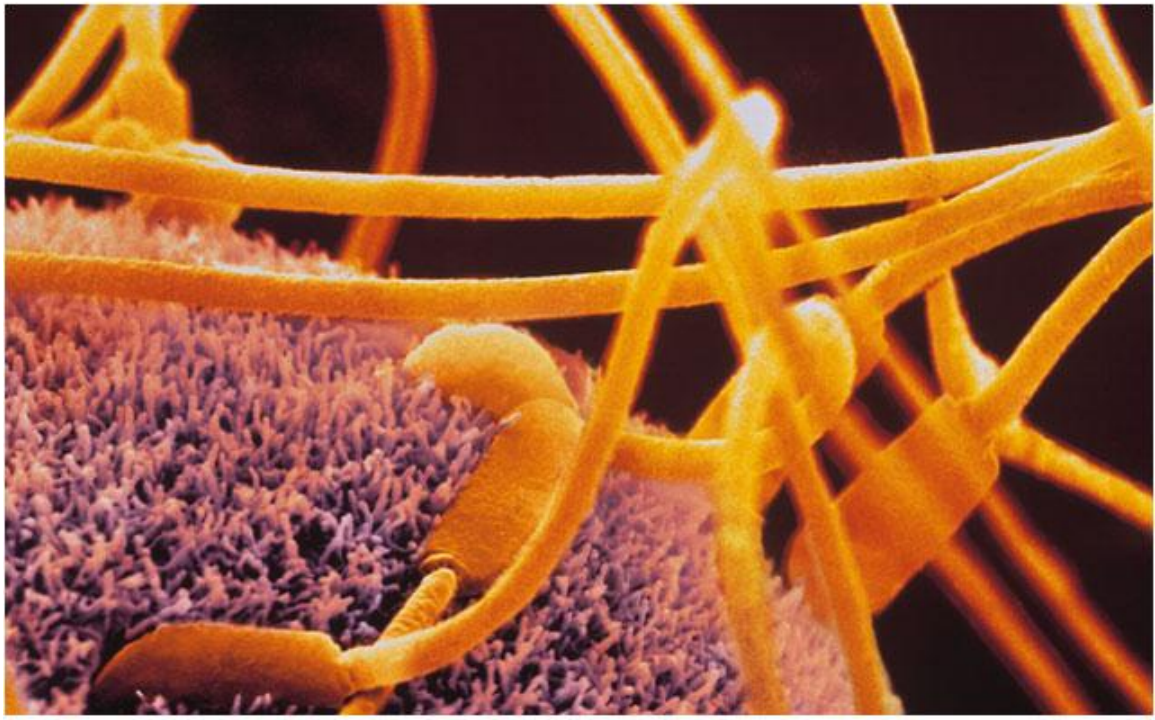


Let's Review...

- Sexual reproduction involves the fusion of male and female gametes –
  - Sex cells, sperm and egg
- The resulting cell is called a zygote-
  - fertilized egg







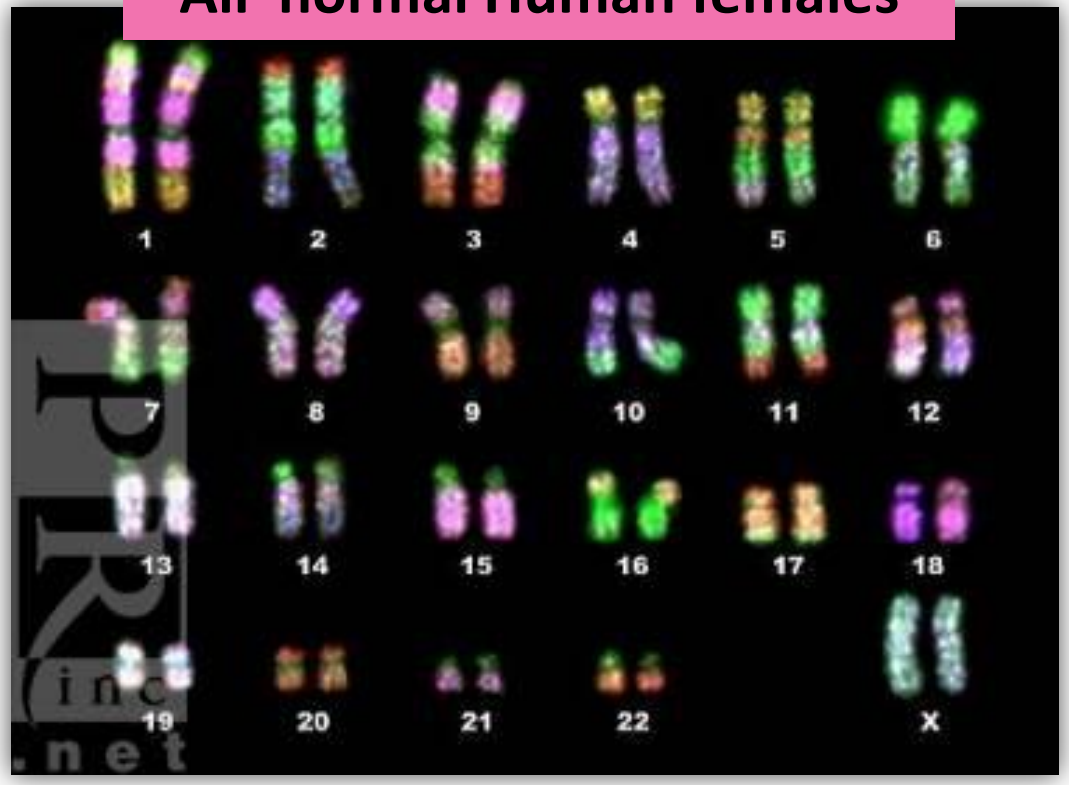
Homologous Chromosomes

- **Sexual reproduction** depends in part on **meiosis**
  - **meiosis** - type of cell division that makes gametes
    - produces four cells,
      - each with half the number of chromosomes as the parent cell.
    - Forms sex cell…sperm and egg
    - occurs in the sex organs—the testes in males and the ovaries in females.

Chromosome Number

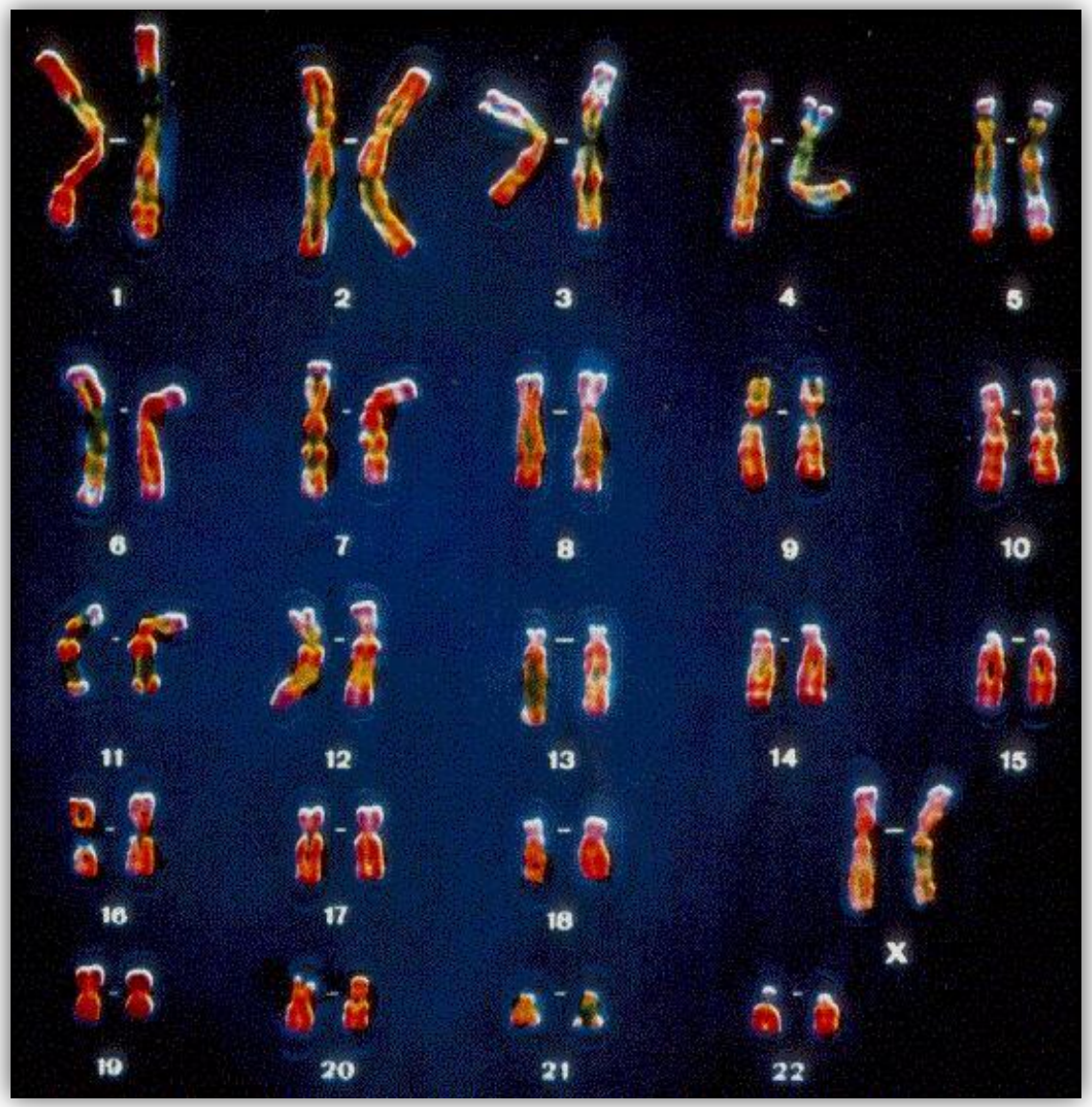
- Chromosome # is the same for
  - all cells of a single organism
  - cells from different male or female individuals of a **single species**

All normal Human females



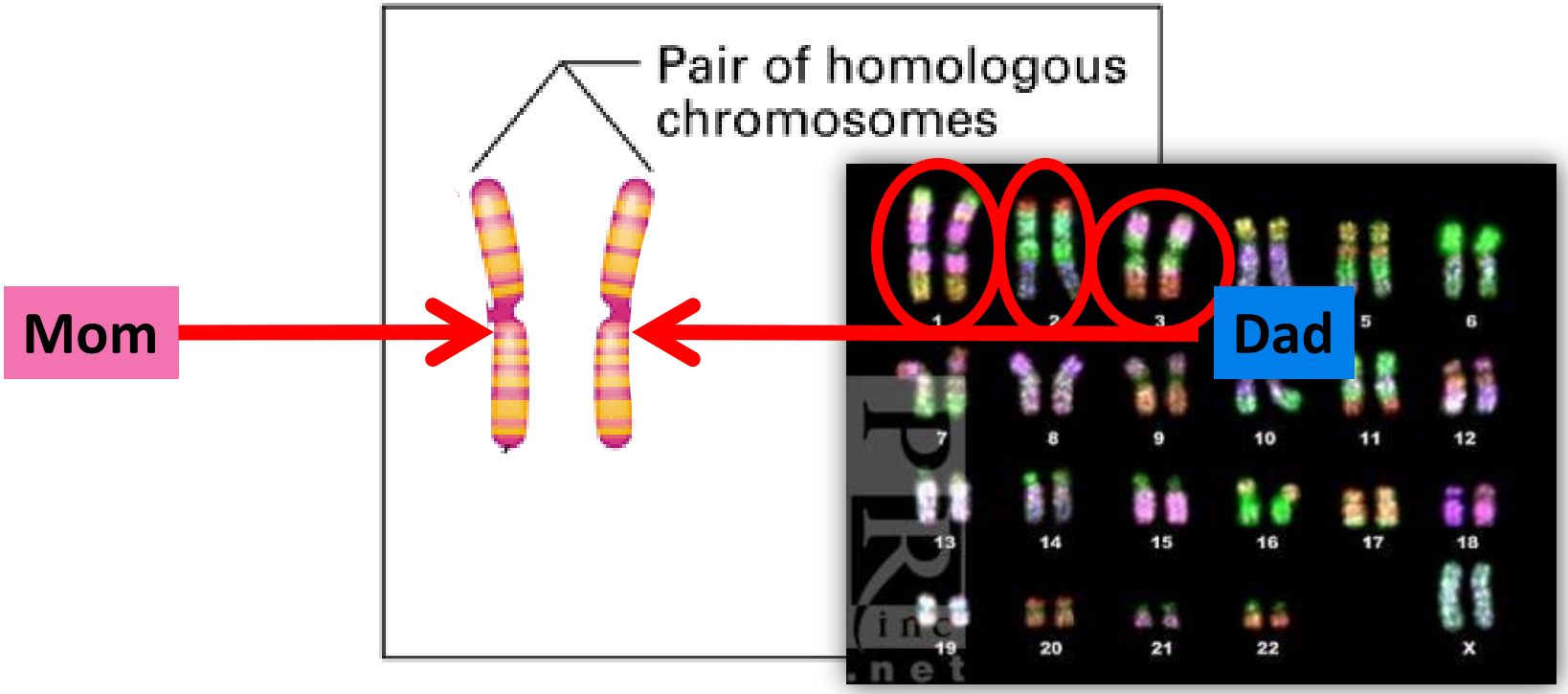
Karyotype

- A display of the 46 human chromosomes of an individual is called a **karyotype**



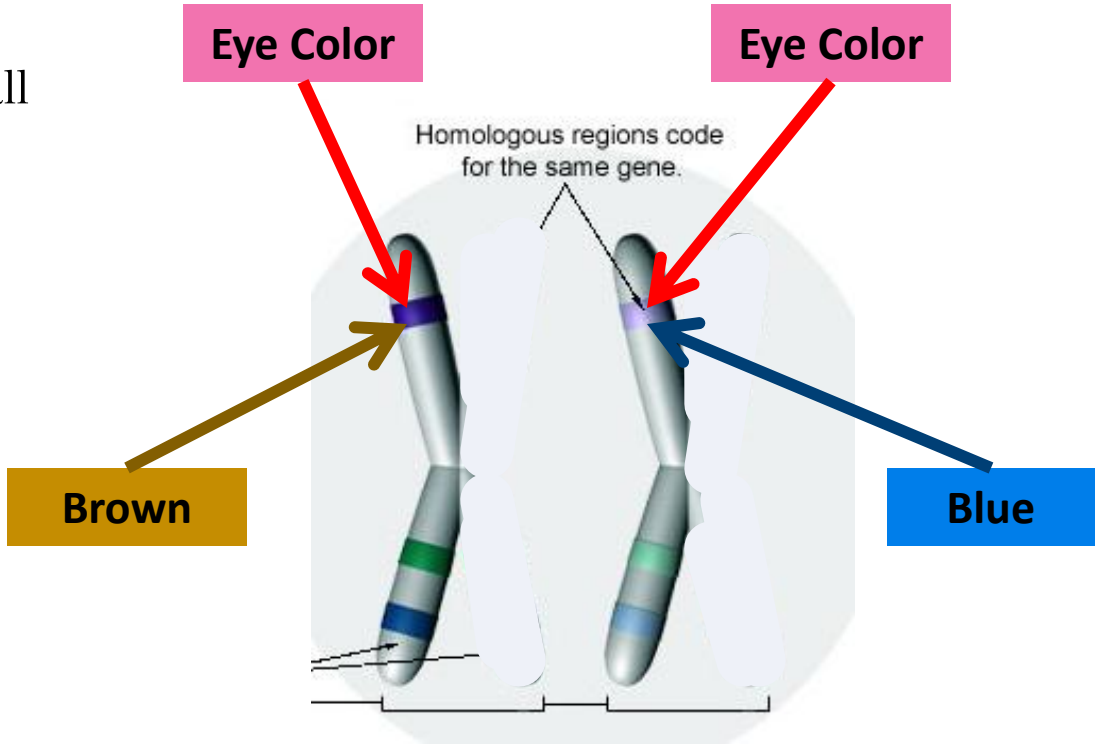
Homologous Chromosomes

- **Homologous chromosomes**: Twins!!!
  - Two chromosomes of each matching pair
  - Identical in size and shape and genes
  - You get one in the pair from mom, and the other from dad



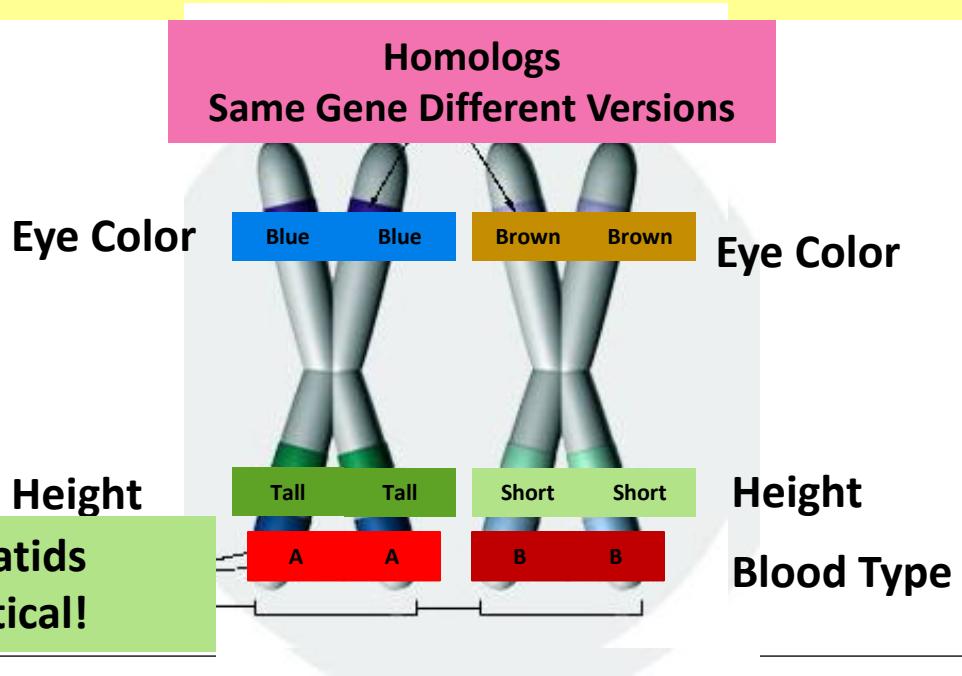
Genes on Homologous Chromosomes

- Each homologous chromosome in a pair carries the **same sequence of genes** controlling the same inherited characteristics (height, eye color).
  - However, the two genes may be different versions.
    - Ex. Gene = eye color,
      - versions of eye color = blue, brown, green…
    - Ex. Gene = height,
      - versions = short, tall



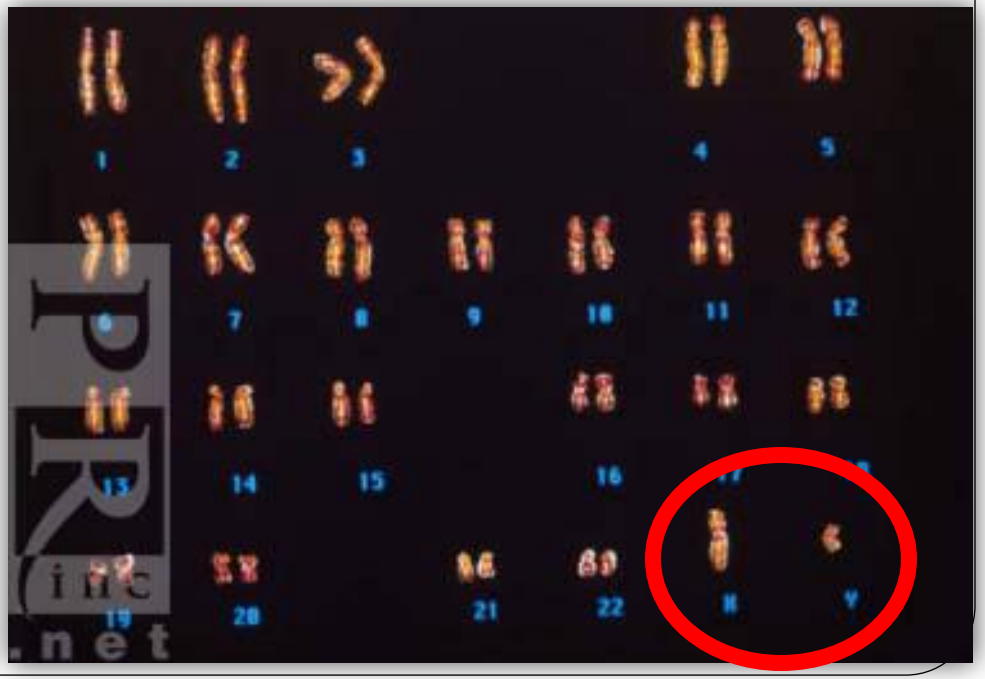
Homologous Chromosome vs. Sister Chromatid

- *Homologous chromosomes are different from sister chromatids*
- **Homologous Chromosomes**
  - Have the same sequence of genes on each chromosome in the pair
  - But may carry different versions of the same gene
- **Sister chromatids**
  - are copies of a single chromosome that are attached to each other and are **identical**
  - Both chromatids contain ***EXACTLY*** the same forms of each gene.



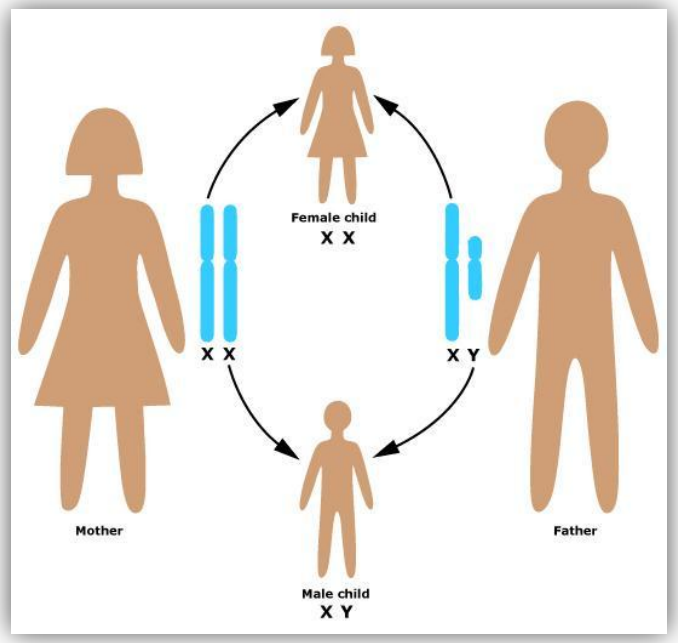
Sex Chromosomes

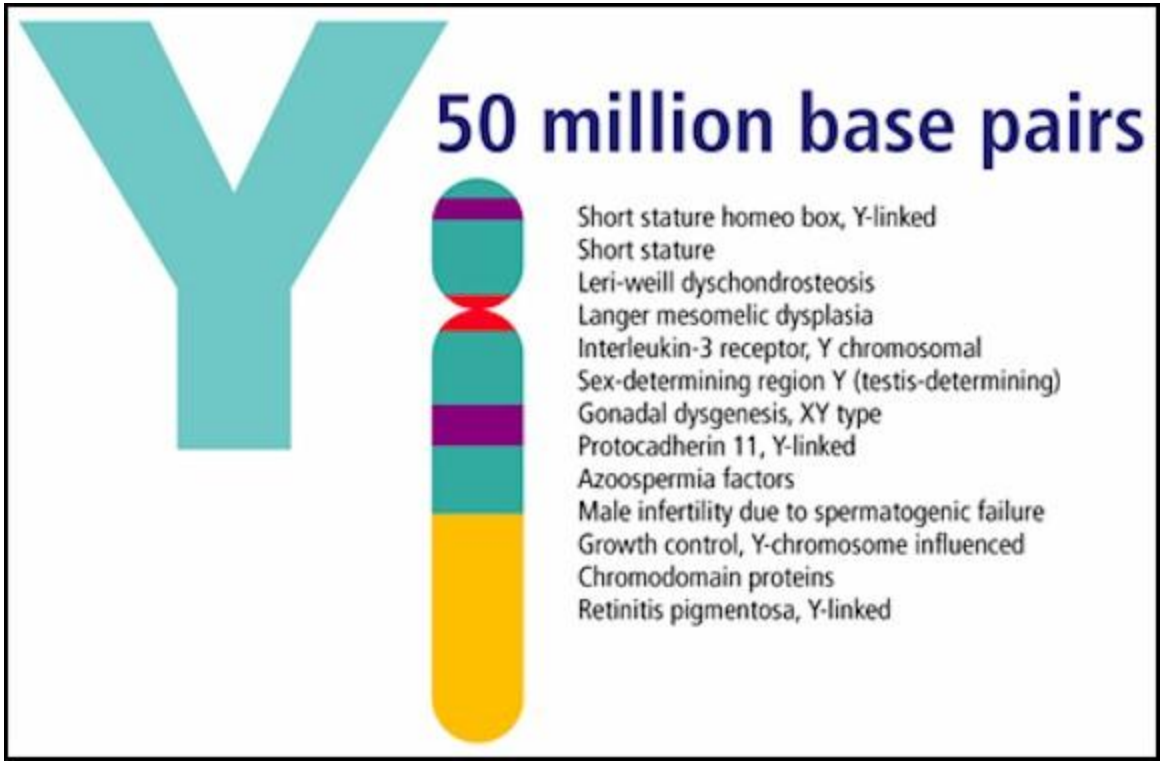
- Humans have 23 homologous pairs of chromosomes.
  - #23 determine sex → **<u>sex chromosomes</u>**
    - Females have 23 homologous chromosomes
    - Males have 22 homologous chromosomes

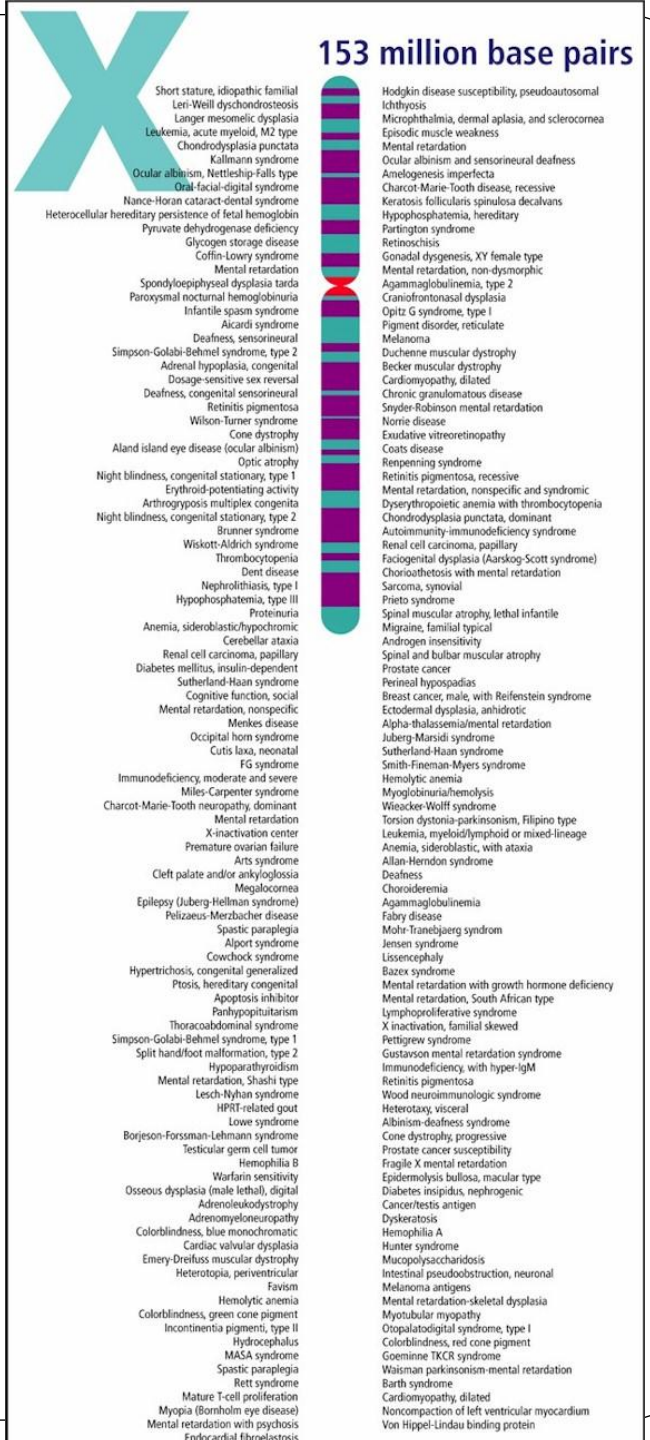


Sex Chromosomes

- 2 forms of the sex chromosome → X & Y
  - Males have 1 X chromosome and 1 Y chromosome (XY at #23)
  - Females have 2 X chromosomes (XX at #23)
- Most genes carried on the X chromosome do not have counterparts on the Y
- Y has genes that are not on the X

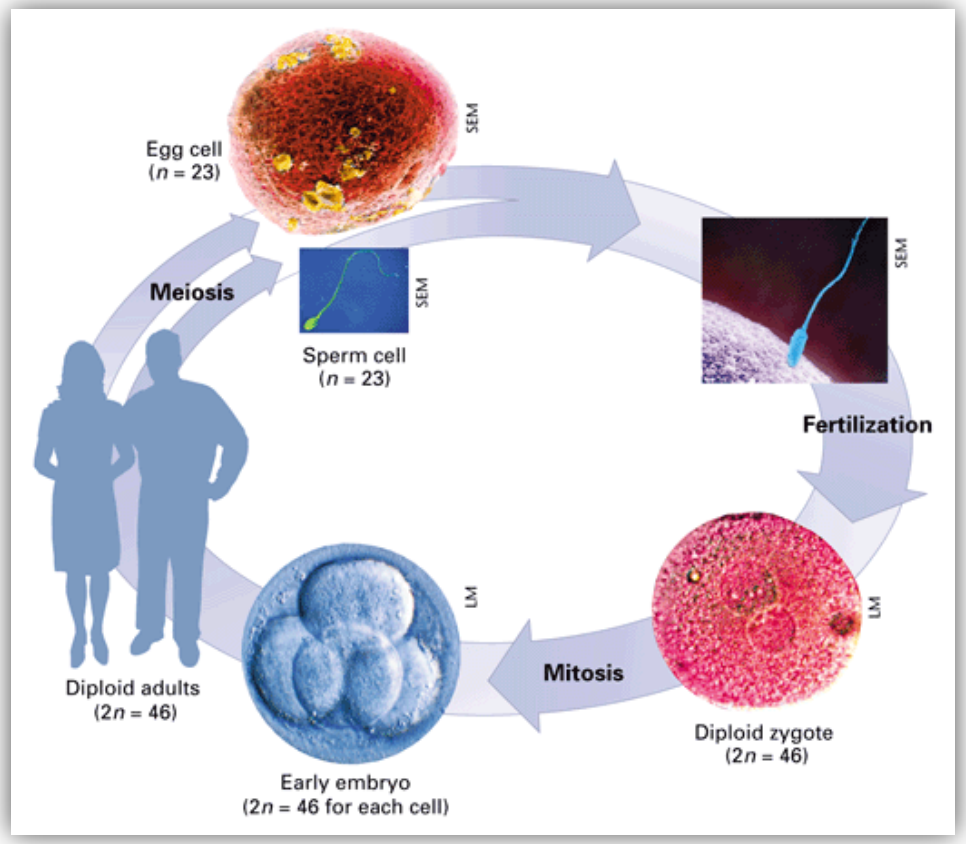



50 million base pairs
Short stature homeo box, Y-linked
Short stature
Leri-weill dyschondrosteosis
Langer mesomelic dysplasia
Interleukin-3 receptor, Y chromosomal
Sex-determining region Y (testis-determining)
Gonadal dysgenesis, XY type
Protocadherin 11, Y-linked
Azoospermia factors
Male infertility due to spermatogenic failure
Growth control, Y-chromosome influenced
Chromodomain proteins
Retinitis pigmentosa, Y-linked


153 million base pairs
Short stature, idiopathic familial
Leri-Weill dyschondrosteosis
Langer mesomelic dysplasia
Leukemia, acute myeloid, M2 type
Chondrodysplasia punctata
Kallmann syndrome
Ocular albinism, Nettleship-Falls type
Oral-facial-digital syndrome
Nance-Horan cataract-dental syndrome
Heterocellular hereditary persistence of fetal hemoglobin
Pyruvate dehydrogenase deficiency
Glycogen storage disease
Coffin-Lowry syndrome
Mental retardation
Spondyloepiphyseal dysplasia tarda
Paroxysmal nocturnal hemoglobinuria
Infantile spasm syndrome
Aicardi syndrome
Deafness, sensorineural
Simpson-Golabi-Behmel syndrome, type 2
Adrenal hypoplasia, congenital
Dosage-sensitive sex reversal
Deafness, congenital sensorineural
Retinitis pigmentosa
Wilson-Turner syndrome
Cone dystrophy
Aland island eye disease (ocular albinism)
Optic atrophy
Night blindness, congenital stationary, type 1
Erythroid-potentiating activity
Arthrogryposis multiplex congenita
Night blindness, congenital stationary, type 2
Brunner syndrome
Wiskott-Aldrich syndrome
Thrombocytopenia
Dent disease
Nephrolithiasis, type I
Hypophosphatemia, type III
Proteinuria
Anemia, sideroblastic/hypochromic
Cerebellar ataxia
Renal cell carcinoma, papillary
Diabetes mellitus, insulin-dependent
Sutherland-Haan syndrome
Cognitive function, social
Mental retardation, nonspecific
Menkes disease
Occipital horn syndrome
Cutis laxa, neonatal
FG syndrome
Immunodeficiency, moderate and severe
Miles-Carpenter syndrome
Charcot-Marie-Tooth neuropathy, dominant
Mental retardation
X-inactivation center
Premature ovarian failure
Arts syndrome
Cleft palate and/or ankyloglossia
Megalocornea
Epilepsy (Juberg-Hellman syndrome)
Pelizaeus-Merzbacher disease
Spastic paraplegia
Alport syndrome
Cowchock syndrome
Hypertrichosis, congenital generalized
Ptosis, hereditary congenital
Apoptosis inhibitor
Panhypopituitarism
Thoracoabdominal syndrome
Simpson-Golabi-Behmel syndrome, type 1
Split hand/foot malformation, type 2
Hypoparathyroidism
Mental retardation, Shashi type
Lesch-Nyhan syndrome
HPRT-related gout
Lowe syndrome
Borjeson-Forssman-Lehmann syndrome
Testicular germ cell tumor
Hemophilia B
Warfarin sensitivity
Osseous dysplasia (male lethal), digital
Adrenoleukodystrophy
Adrenomyeloneuropathy
Colorblindness, blue monochromatic
Cardiac valvular dysplasia
Emery-Dreifuss muscular dystrophy
Heterotopia, periventricular
Favism
Hemolytic anemia
Colorblindness, green cone pigment
Incontinentia pigmenti, type II
Hydrocephalus
MASA syndrome
Spastic paraplegia
Rett syndrome
Mature T-cell proliferation
Myopia (Bornholm eye disease)
Mental retardation with psychosis
Endocardial fibroelastosis
Hodgkin disease susceptibility, pseudoautosomal
Ichthyosis
Microphthalmia, dermal aplasia, and sclerocornea
Episodic muscle weakness
Mental retardation
Ocular albinism and sensorineural deafness
Amelogenesis imperfecta
Charcot-Marie-Tooth disease, recessive
Keratosis follicularis spinulosa decalvans
Hypophosphatemia, hereditary
Partington syndrome
Retinoschisis
Gonadal dysgenesis, XY female type
Mental retardation, non-dysmorphic
Agammaglobulinemia, type 2
Craniofrontonasal dysplasia
Opitz G syndrome, type I
Pigment disorder, reticulate
Melanoma
Duchenne muscular dystrophy
Becker muscular dystrophy
Cardiomyopathy, dilated
Chronic granulomatous disease
Snyder-Robinson mental retardation
Norrie disease
Exudative vitreoretinopathy
Coats disease
Renpenning syndrome
Retinitis pigmentosa, recessive
Mental retardation, nonspecific and syndromic
Dyserythropoietic anemia with thrombocytopenia
Chondrodysplasia punctata, dominant
Autoimmunity-immunodeficiency syndrome
Renal cell carcinoma, papillary
Faciogenital dysplasia (Aarskog-Scott syndrome)
Choreoathetosis with mental retardation
Sarcoma, synovial
Prieto syndrome
Spinal muscular atrophy, lethal infantile
Migraine, familial typical
Androgen insensitivity
Spinal and bulbar muscular atrophy
Prostate cancer
Perineal hypospadias
Breast cancer, male, with Reifenstein syndrome
Ectodermal dysplasia, anhidrotic
Alpha-thalassemia/mental retardation
Juberg-Marsidi syndrome
Sutherland-Haan syndrome
Smith-Fineman-Myers syndrome
Hemolytic anemia
Myoglobinuria/hemolysis
Wieacker-Wolff syndrome
Torsion dystonia-parkinsonism, Filipino type
Leukemia, myeloid/lymphoid or mixed-lineage
Anemia, sideroblastic, with ataxia
Allan-Herndon syndrome
Deafness
Choroideremia
Agammaglobulinemia
Fabry disease
Mohr-Tranebjaerg syndrom
Jensen syndrome
Lissencephaly
Bazex syndrome
Mental retardation with growth hormone deficiency
Mental retardation, South African type
Lymphoproliferative syndrome
X inactivation, familial skewed
Pettigrew syndrome
Gustavson mental retardation syndrome
Immunodeficiency, with hyper-IgM
Retinitis pigmentosa
Wood neuroimmunologic syndrome
Heterotaxy, visceral
Albinism-deafness syndrome
Cone dystrophy, progressive
Prostate cancer susceptibility
Fragile X mental retardation
Epidermolysis bullosa, macular type
Diabetes insipidus, nephrogenic
Cancer/testis antigen
Dyskeratosis
Hemophilia A
Hunter syndrome
Mucopolysaccharidosis
Intestinal pseudoobstruction, neuronal
Melanoma antigens
Mental retardation-skeletal dysplasia
Myotubular myopathy
Otopalatodigital syndrome, type I
Colorblindness, red cone pigment
Goeminne TKCR syndrome
Waisman parkinsonism-mental retardation
Barth syndrome
Cardiomyopathy, dilated
Noncompaction of left ventricular myocardium
Von Hippel-Lindau binding protein

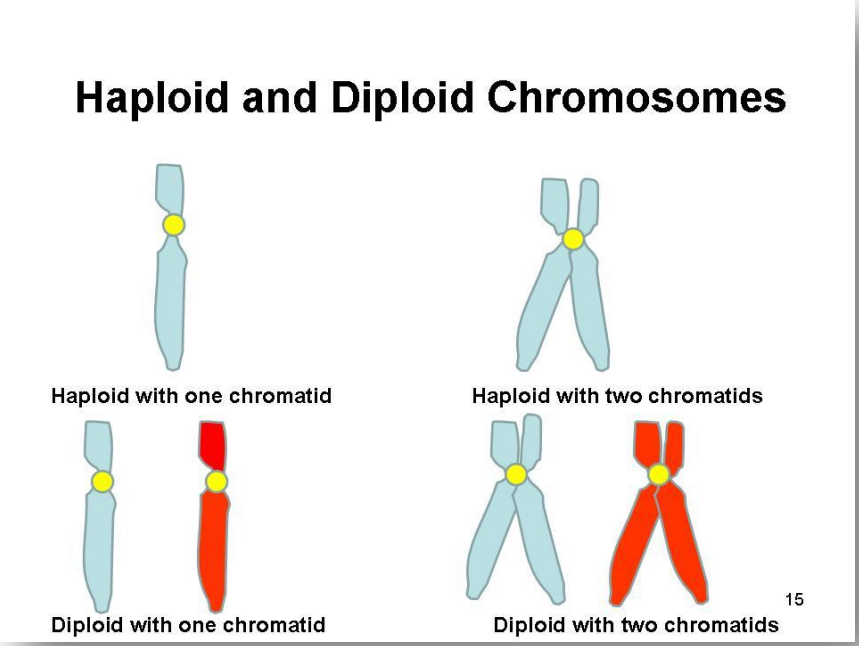
Diploid and Haploid Cells

- 2 sets of chromosomes
  - 1 inherited from each parent
  - ***key factor in the life cycles of all sexually reproducing organisms.



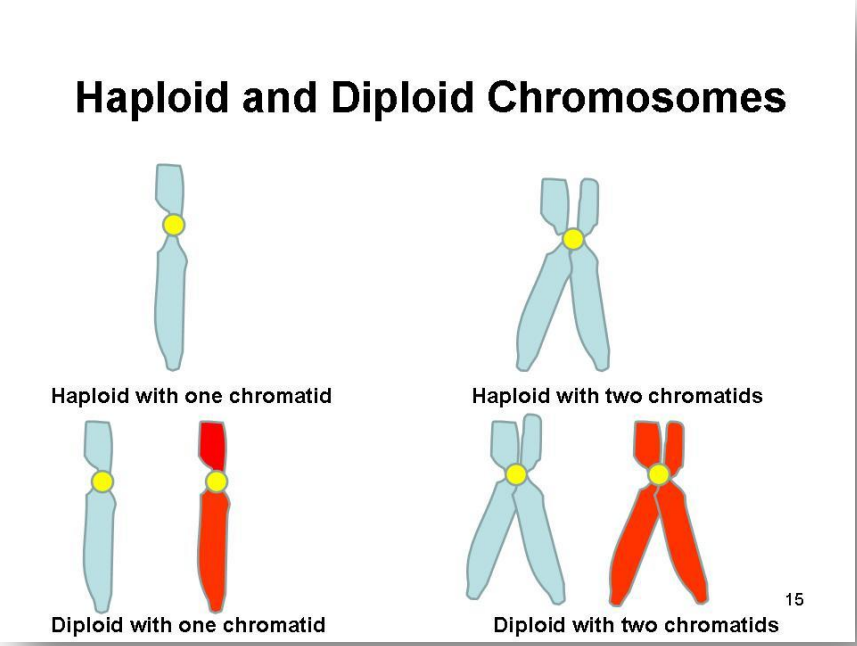
Diploid

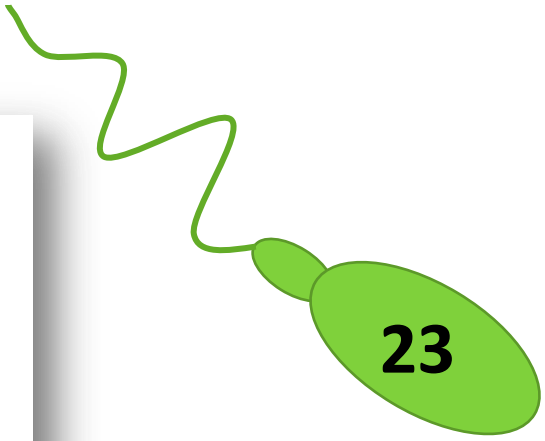
- Almost all human cells are **diploid**
  - **diploid** : they contain two homologous sets of chromosomes.
- *Diploid number*
  - total number of chromosomes (46 in humans)
  - (abbreviated $2n$, as in $2n = 46$).

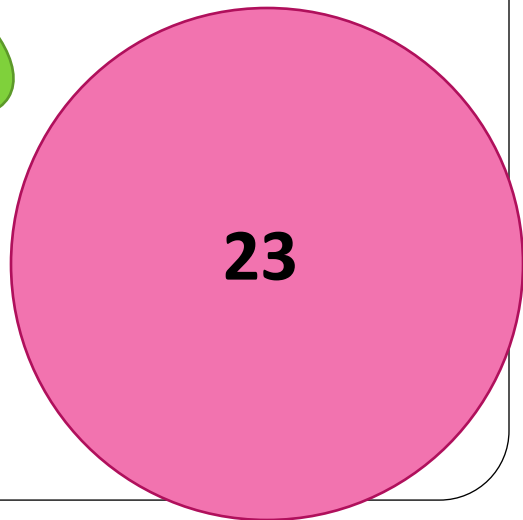


Haploid Cells

- **haploid** (half): cell with a single set of chromosomes, gametes
  - produced through the process of *meiosis*
    - Each gamete has a single set of chromosomes, one from each homologous pair.
      - **gametes** : sex cells , or egg and sperm cells
- *haploid number*
  - humans, (abbreviated *n*) is 23.

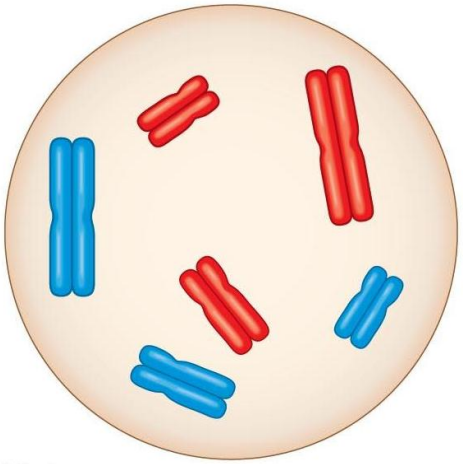






Based on the figure, which of the following statements is true?

1. This cell is haploid
2. This cell is diploid

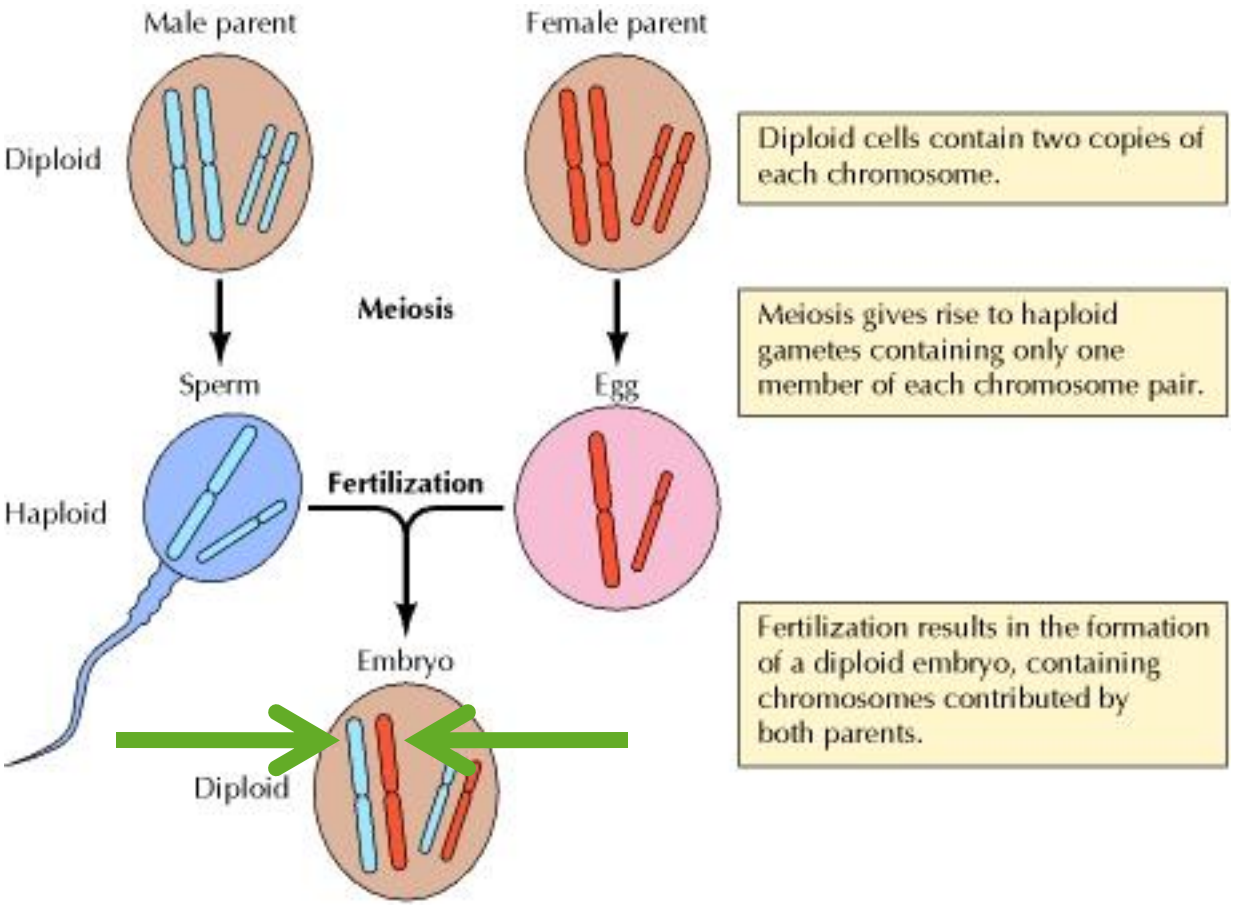


The best explanation for your answer in the previous question is

1. Each chromosome consists of two chromatids.
2. The cell contains two sets of chromosomes

Haploid and Diploid cells

- **Fertilization**
  - the nucleus/chromosomes of a haploid sperm cell from the father fuses with the nucleus/chromosomes of a haploid egg cell from the mother

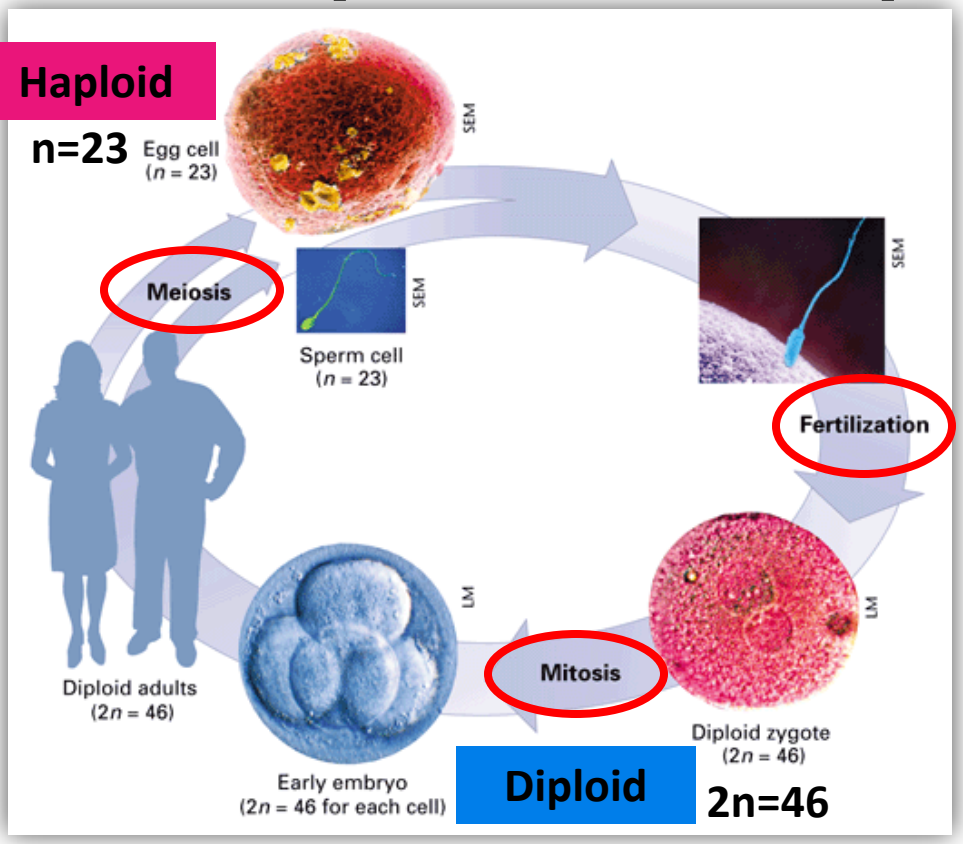


Homologous Chromosomes!!!

Haploid and Diploid cells

- zygote: fertilized egg, diploid
  - has **two homologous sets of chromosomes**, one set from each parent.
  - develops into a sexually mature adult with trillions of cells produced by mitosis.
- Fertilization restores the diploid chromosome number
- Zygote's 46 chromosomes are passed on to all other diploid body cells.

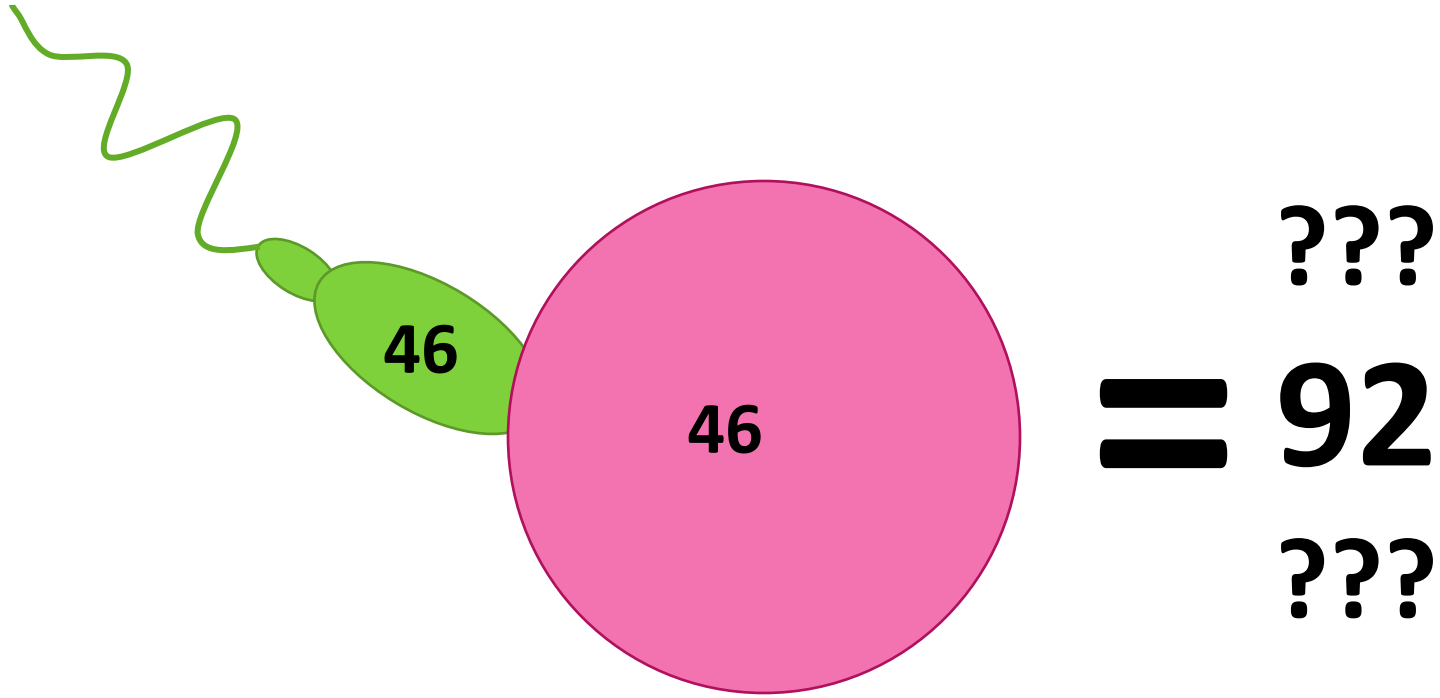
Diploid
2n=46

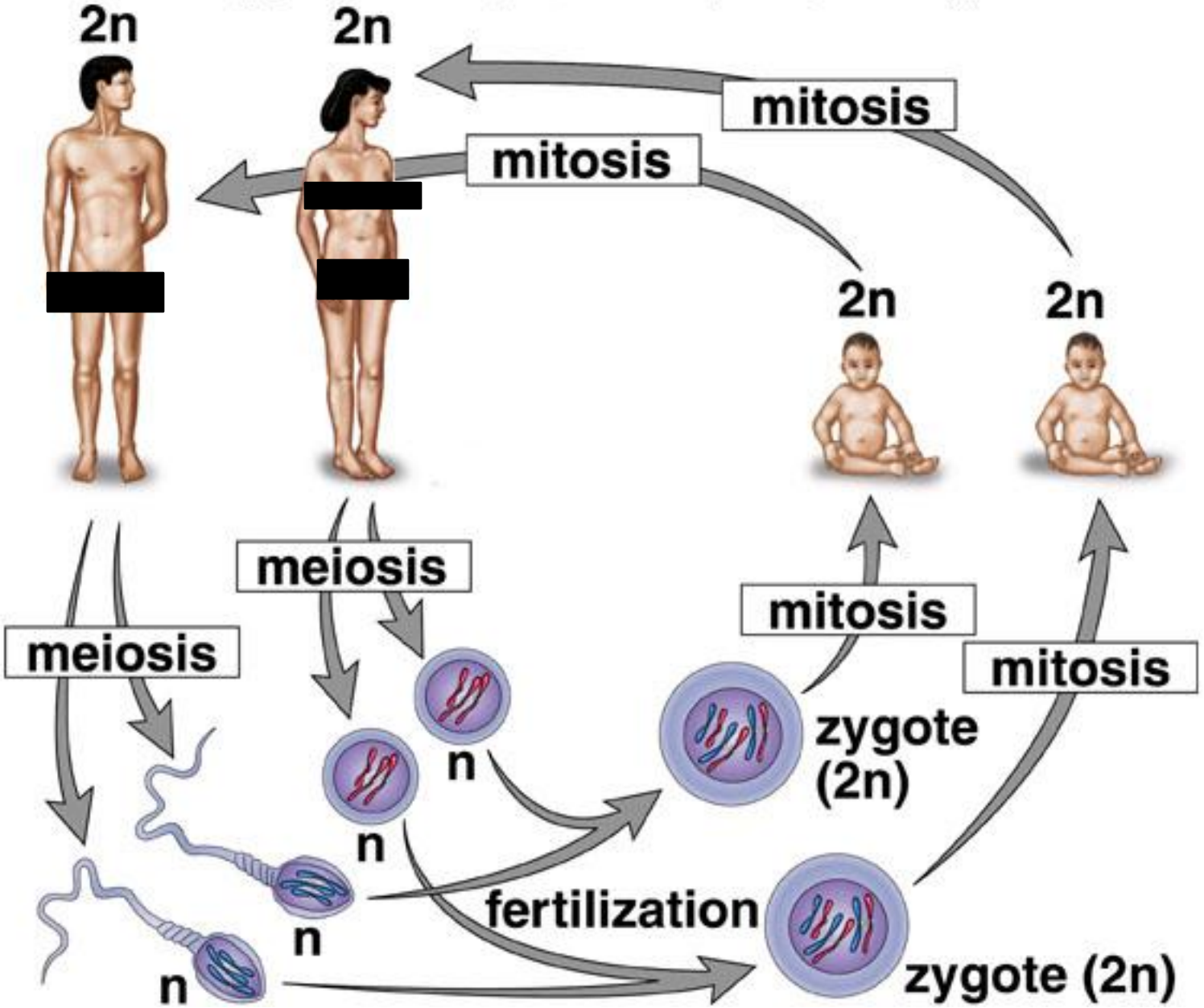


Diploid
2n=46

The Importance of Meiosis

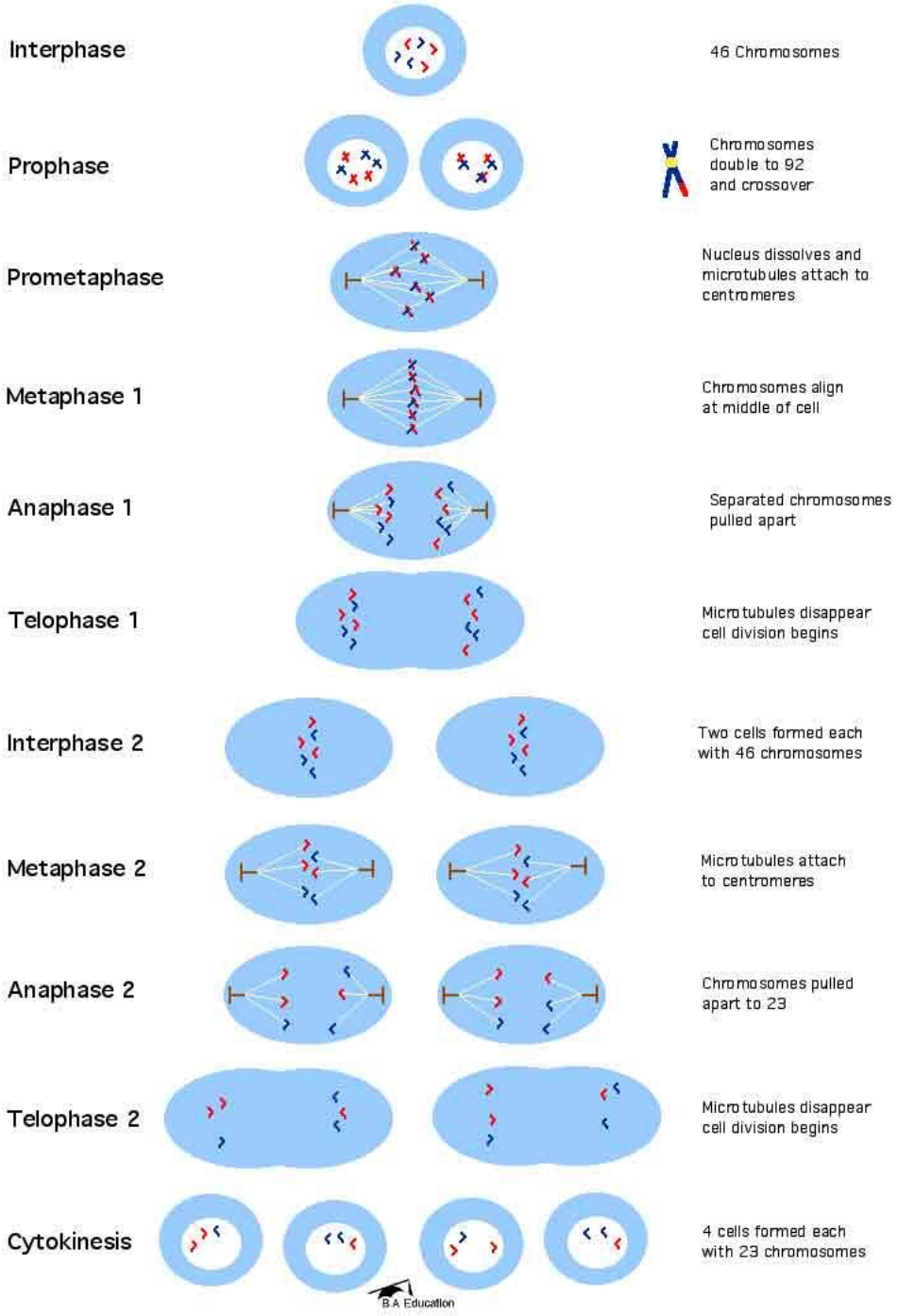
- Producing haploid gametes by meiosis keeps the chromosome number from doubling in every generation.
  - If meiosis did not occur, cells involved in fertilization would produce new organisms having twice the number of chromosomes as those in the previous generation.
  - The alternation of meiosis and fertilization keeps the number of chromosomes in a species the same from generation to generation.





Meiosis:

The Process




BioFlix
Meiosis
PEARSON
Benjamin
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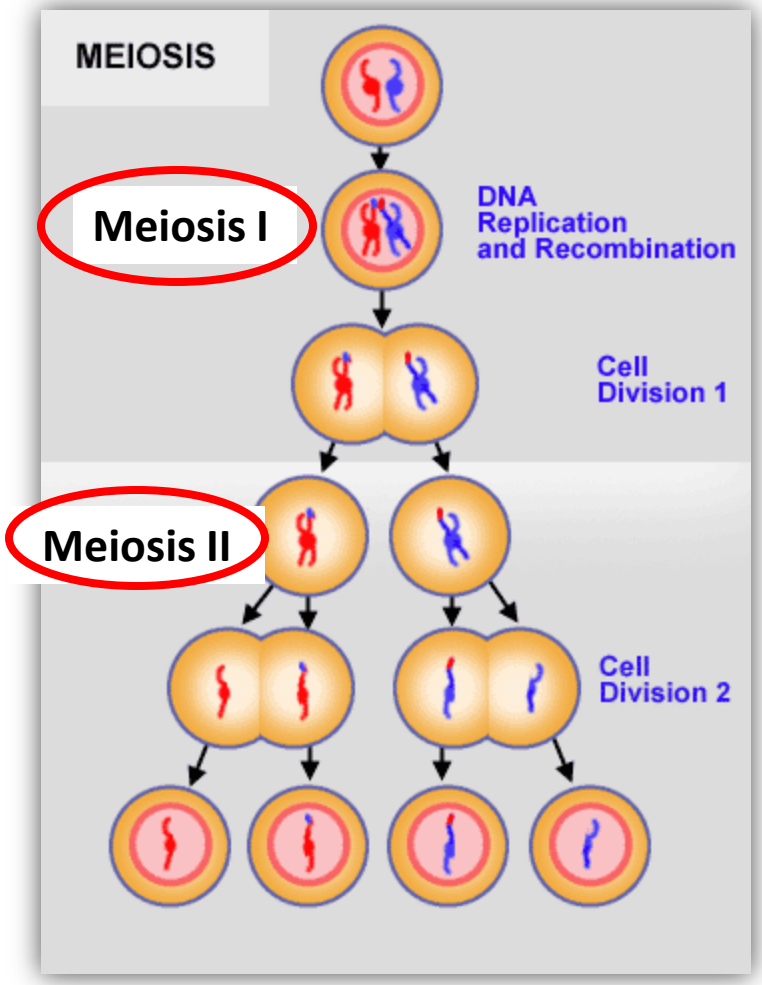
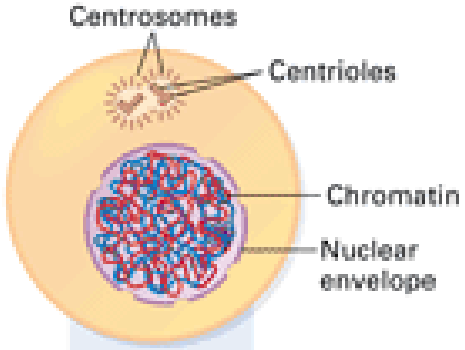
Meiosis Versus Mitosis

- 2 major Differences
  - 1st major difference
    - **Meiosis** produces **4 new offspring cells**,
      - each with **1 set of chromosomes**
        - *1/2 the # of chromosomes as parent cell*
    - **Mitosis** produces **2 offspring cells**,
      - each with the **same number of chromosomes** as the parent cell.
  - 2nd major difference
    - **Meiosis** involves the swapping of genetic material between homologous chromosomes-
      - *crossing over*

The Two Meiotic Divisions

- Meiosis consists of two distinct parts—
  - **Meiosis I**
    - Homologous chromosomes with sister chromatids, separate from one another
  - **Meiosis II**
    - Sister chromatids are separated much as they are in mitosis.
    - However, the resulting cells are **haploid**, NOT diploid.



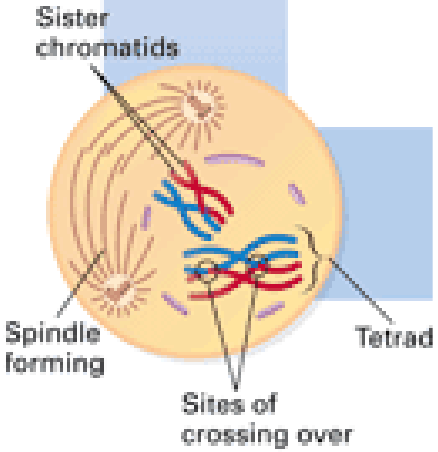


Interphase

Just as in mitosis, the cell duplicates its DNA. Each chromosome then consists of two identical sister chromatids that can be seen more clearly in prophase.

Meiosis I:

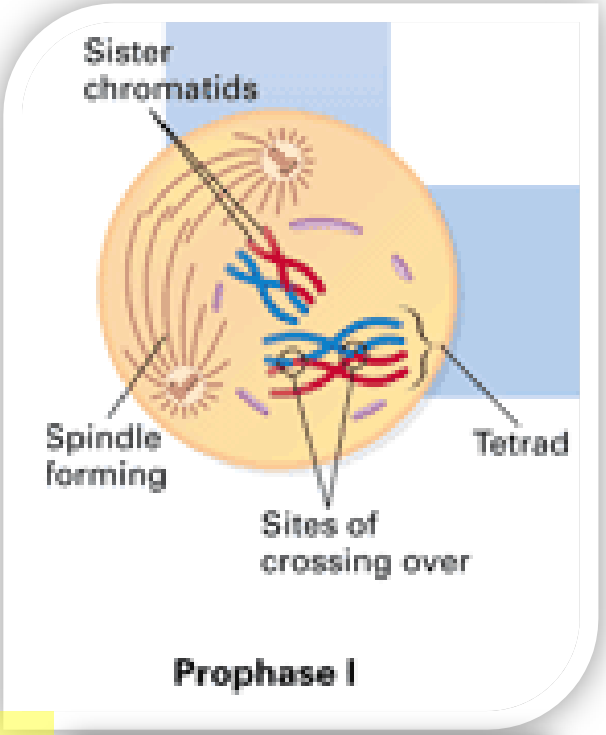
In contrast to mitosis, meiosis involves two divisions. The first division is called meiosis I. It consists of four stages: prophase I, metaphase I, anaphase I, and telophase I.

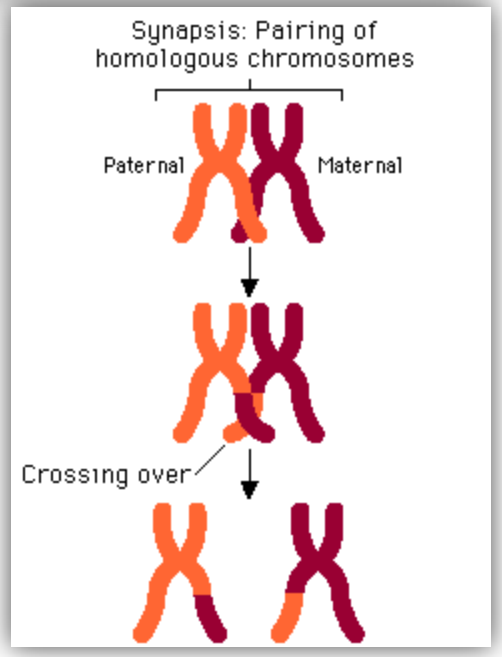


Prophase I

Prophase I

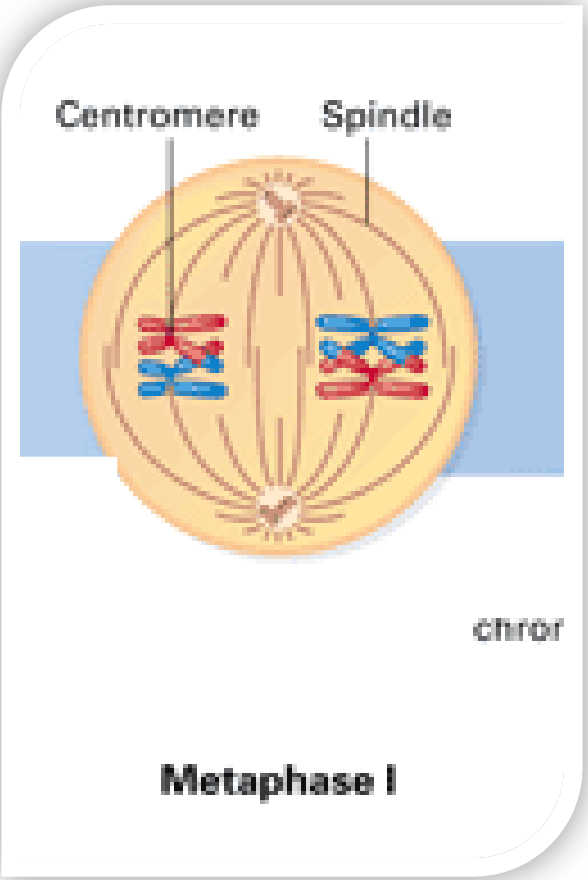
- Meiosis adds 2 new steps to the mitosis routine.
  - 1) Tetrads:
    - Homologous chromosomes to stick together along their length.
    - Homologous chromosomes are paired, and consist of four chromatids
      - Referred to as tetrads.
      - Attach to the spindle.
  - 2) Crossing Over:
    - Sister chromatids in the tetrads exchange some genetic material





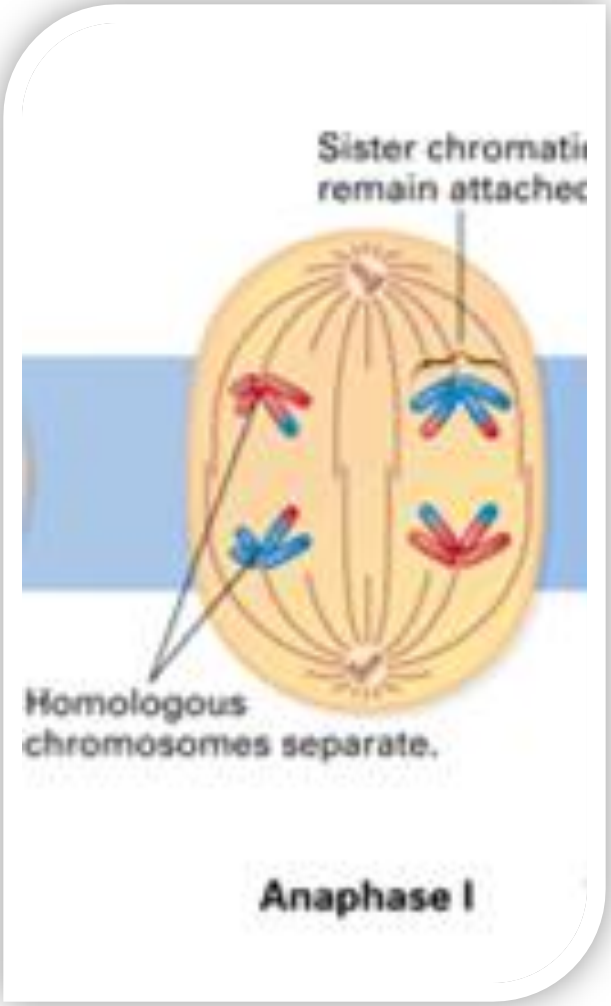
Metaphase I

- Tetrads move to the middle of the cell
- Line up across the spindle



Anaphase I

- Homologous chromosomes separate and migrate to opposite poles of the spindle.
- Sister chromatids migrate together
- Genes split in half.
  - This cell started with 4 chromosomes
  - There are only 2 chromosomes (each with 2 copies) moving to each pole.

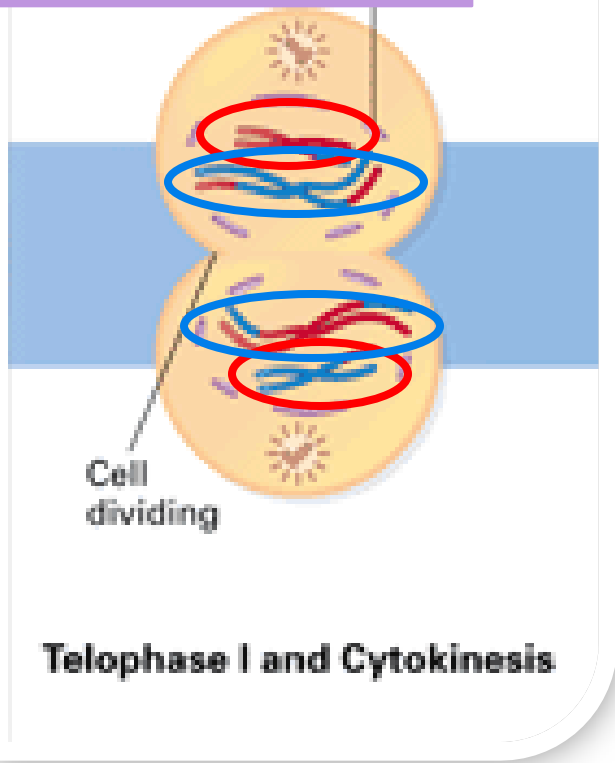


Telophase I and Cytokinesis

- Chromosomes arrive at the poles forming *Haploid* daughter nuclei
  - Each has only 1set of chromosomes
    - Each chromosome consists of 2 sister chromatids
- Cytokinesis occurs with Telophase I
  - Forming 2 haploid daughter cells
- **Chromosomes in each daughter cell are still duplicated.**

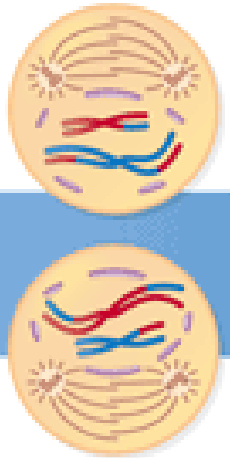
Homologous Chromosome Partners Separate,

Genes are split 50:50



Meiosis II:

The steps of meiosis II are very similar to the steps of mitosis. The difference is that instead of starting with a diploid cell, meiosis II starts with a haploid cell.

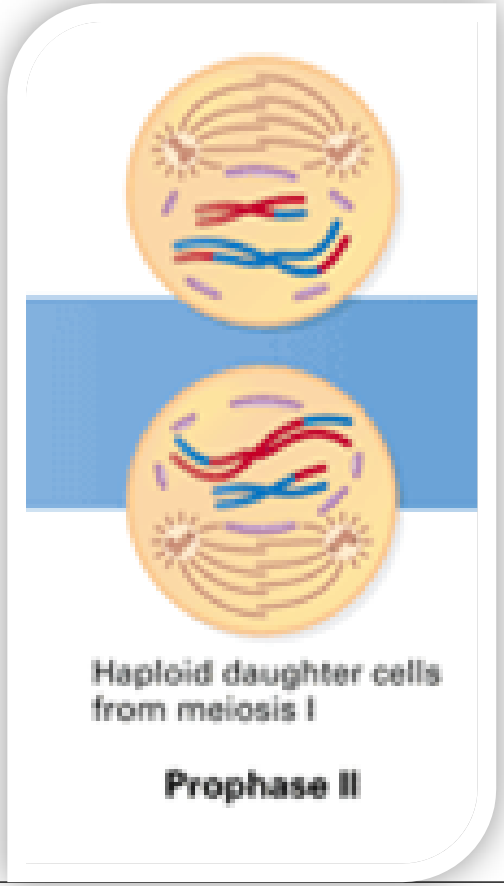


Haploid daughter cells from meiosis I

Prophase II

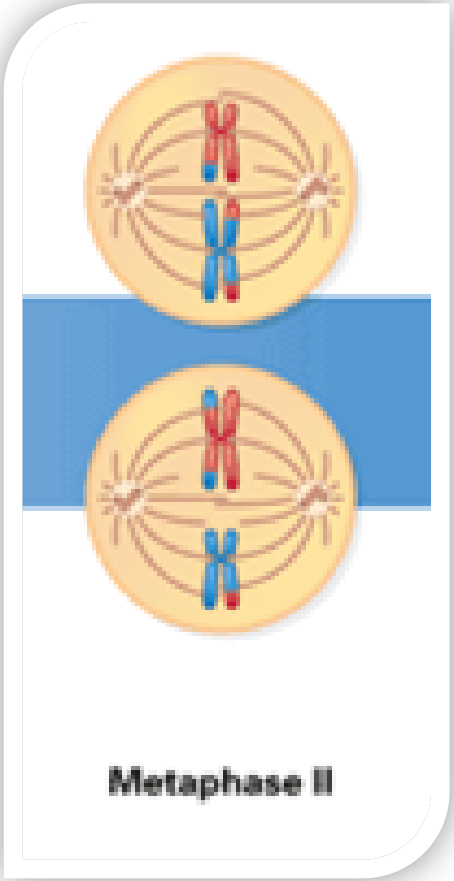
Prophase II:

- In each haploid daughter cell:
  - Spindle forms, attaches to centromeres, and moves individual chromosomes to the middle of the cell.



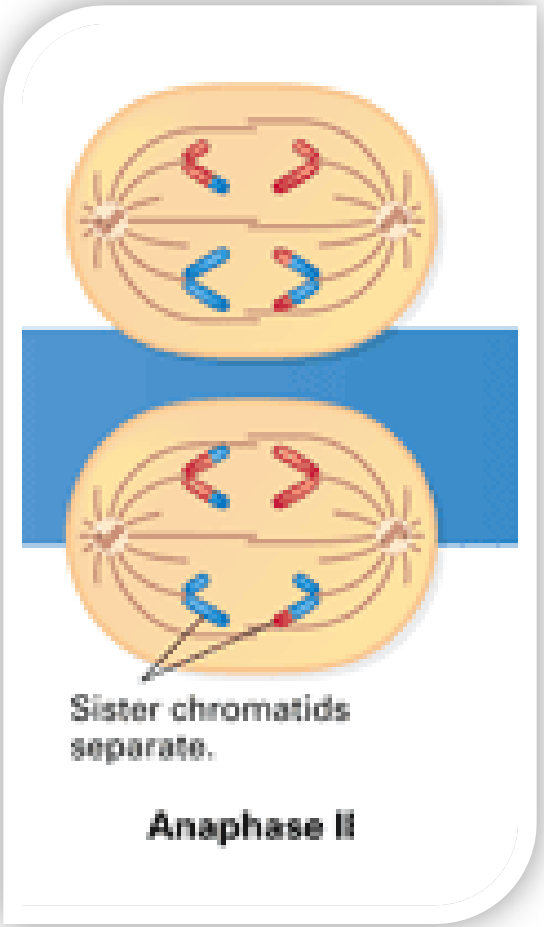
Metaphase II:

- The chromosomes line up in the middle of the cell
- Spindle microtubules attached to each sister chromatid



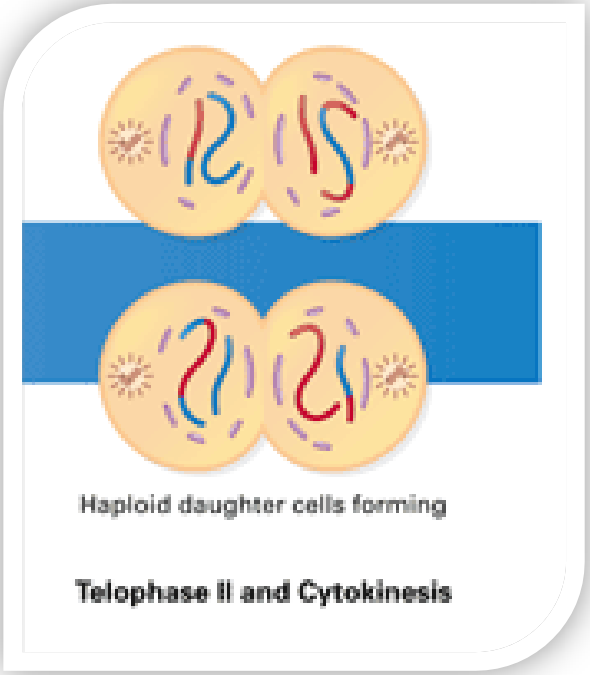
Anaphase II:

- The sister chromatids separate and move to opposite poles.



Telophase II and Cytokinesis:

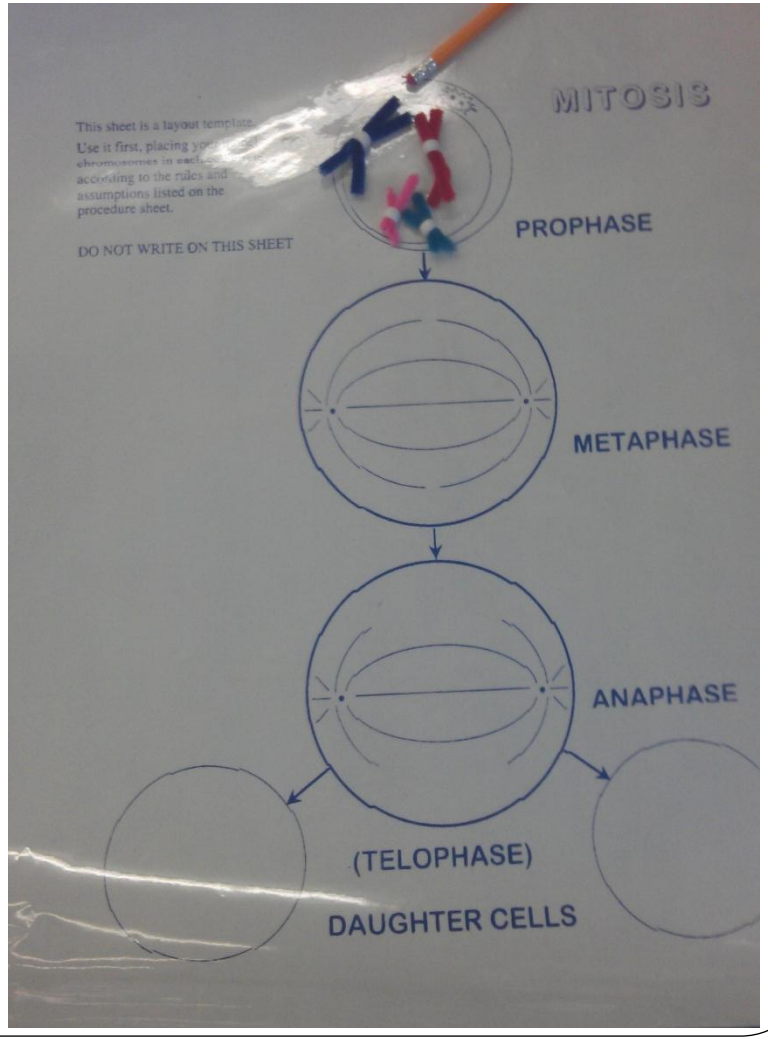
- Chromatids arrive at the poles
  - Now considered individual chromosomes
- Cytokinesis splits the cells
- The process of meiosis is completed
- Final result:
  - 4 haploid daughter cells



Doing it on the table: Mitosis and Meiosis comparison

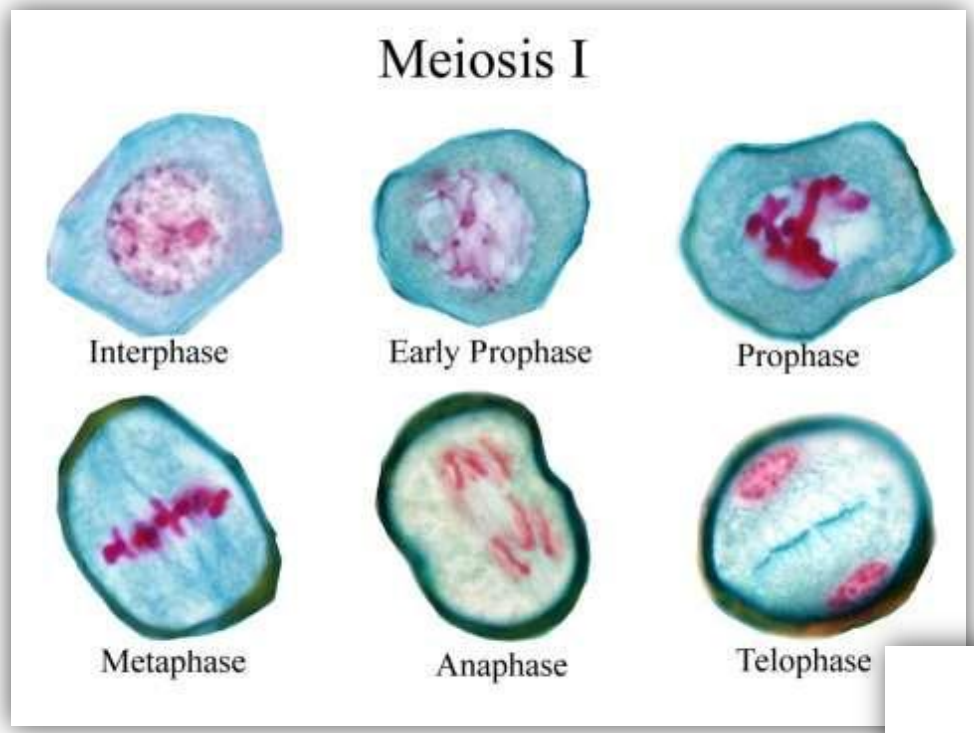
Doing it on the table: Mitosis and Meiosis comparison

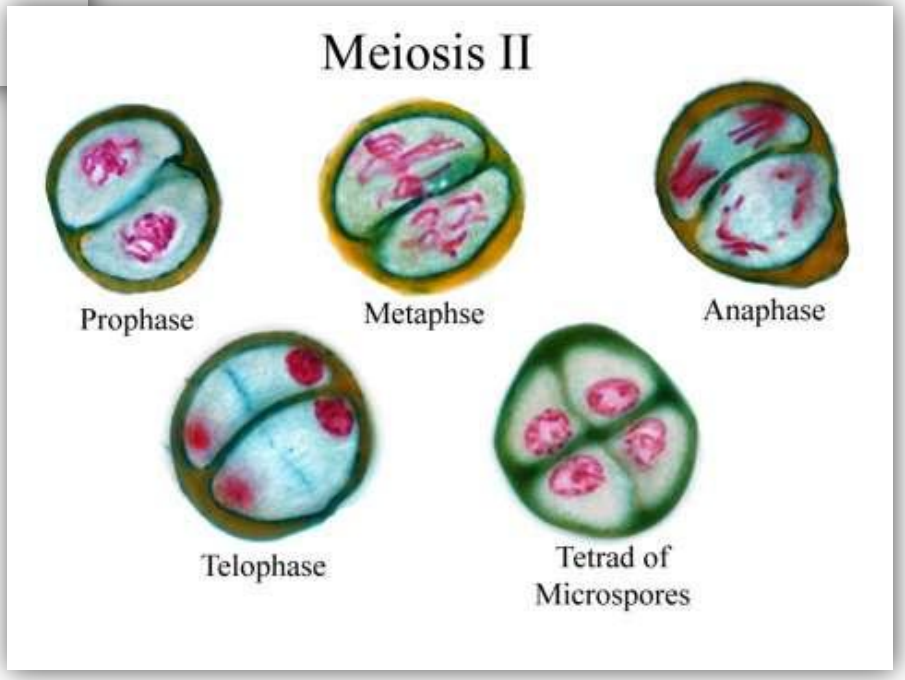
- Read your Assumptions and Procedure
- 3 posters
  - Mitosis
  - Meiosis I
  - Meiosis II
- Pipe cleaner chromosomes
  - 2 sets of Homologous chromosomes
    - Pink and red
    - Dark blue and light blue
  - Sister chromatids
    - Held together at centromere



Doing it on the table: Mitosis and Meiosis comparison

- Walk your pipe-cleaner chromosomes through:
  - Mitosis
- When you have the process down, show your teacher
- Your teacher will check you off
  - You will record the correct process on your Summary Sheet
- Repeat for:
  - Meiosis I &
  - Meiosis II
- Complete the Worksheet questions


Meiosis I
Interphase
Early Prophase
Prophase
Metaphase
Anaphase
Telophase


Meiosis II
Prophase
Metaphse
Anaphase
Telophase
Tetrad of
Microspores

Meiosis vs. Mitosis