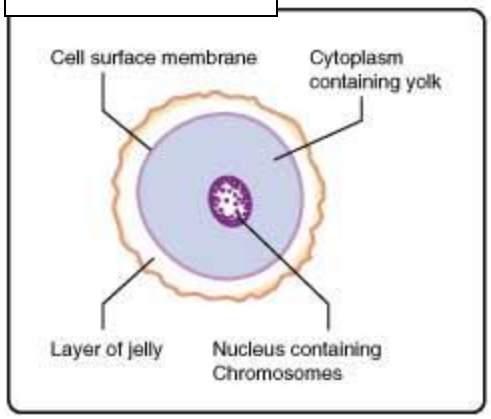
# Meiosis

Section 11-4

- Genes are located on chromosomes in the cell nucleus.
- Each organism MUST inherit a single copy of every gene from both its "parents".
- Each gamete (egg/sperm) contains just ONE set of genes.

## EGG - N

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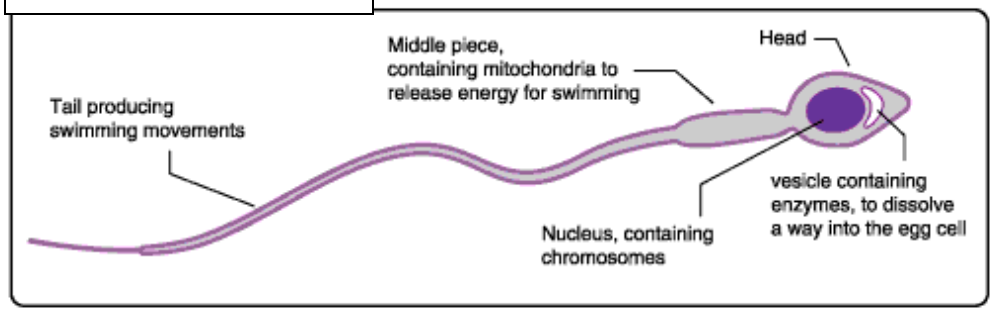
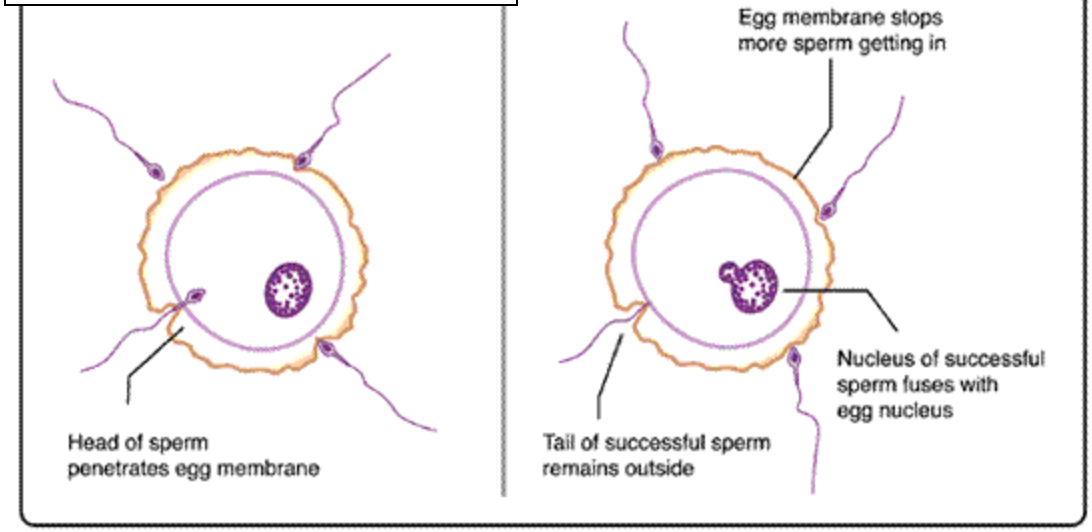
## SPERM - N




=

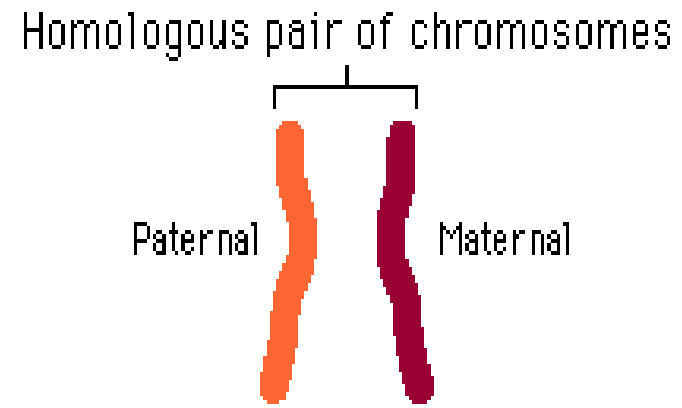
**(Fertilization)**

## ZYGOTE - 2N



# Chromosome Number

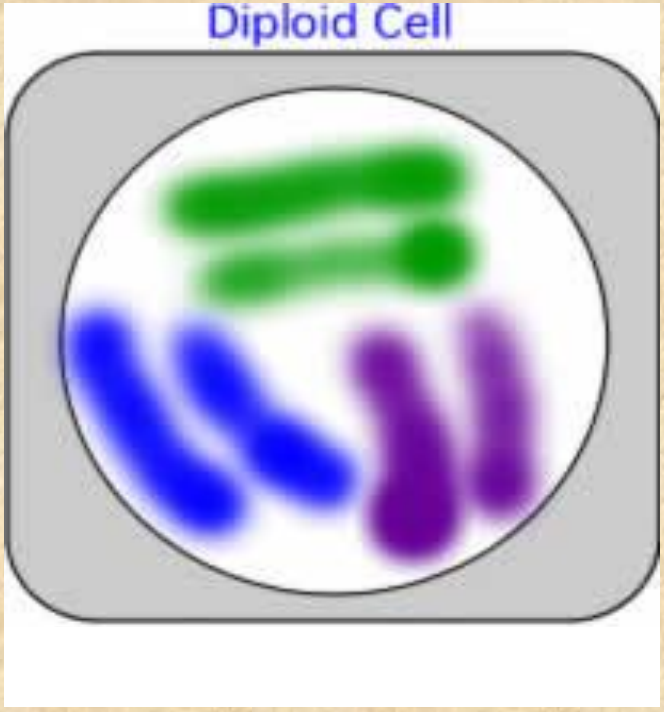
- 1/2 of the total # of chromosomes comes from the male and 1/2 of the total # of chromosomes comes from the female.




These two sets are homologous.

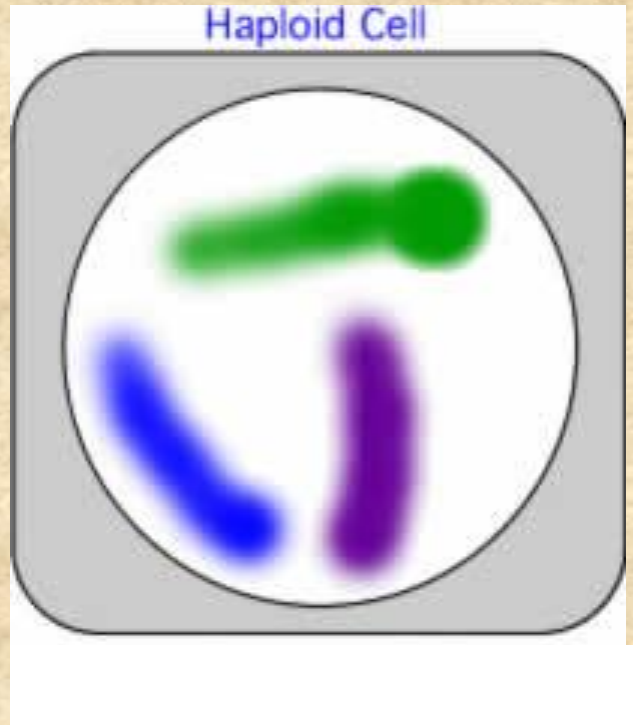
-male set corresponds (matches) the female set.

- A cell, which contains both sets of homologous chromosomes, is diploid.
  - Diploid means "two sets" or 2N
  - In humans, the diploid number is 46 or 2N = 46.



- The gametes of sexually reproducing organisms contain a single set of chromosomes is haploid.
  - Haploid means "one set" or N.
  - In humans, the haploid number is 23 or

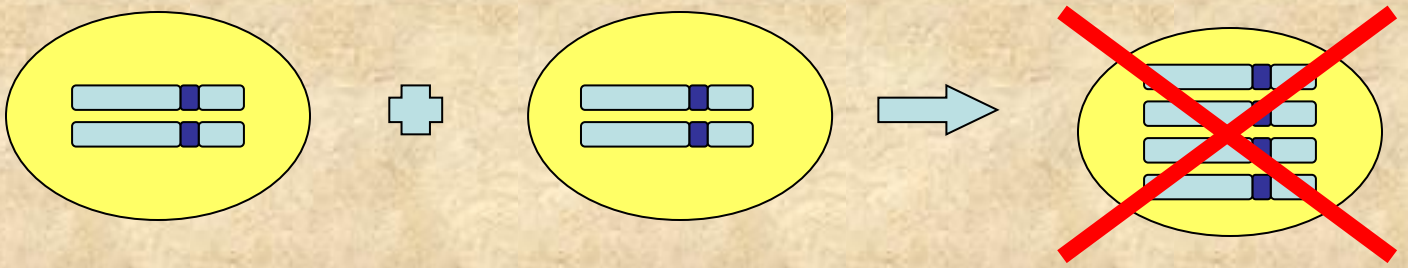
    N = 23



# Meiosis

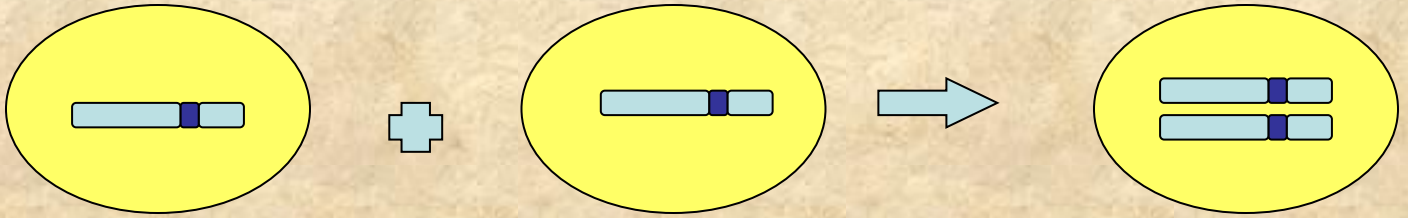
the reduction by division of the number of chromosomes by half in the sex cells (egg/sperm)

**from mom** **from dad** **child**

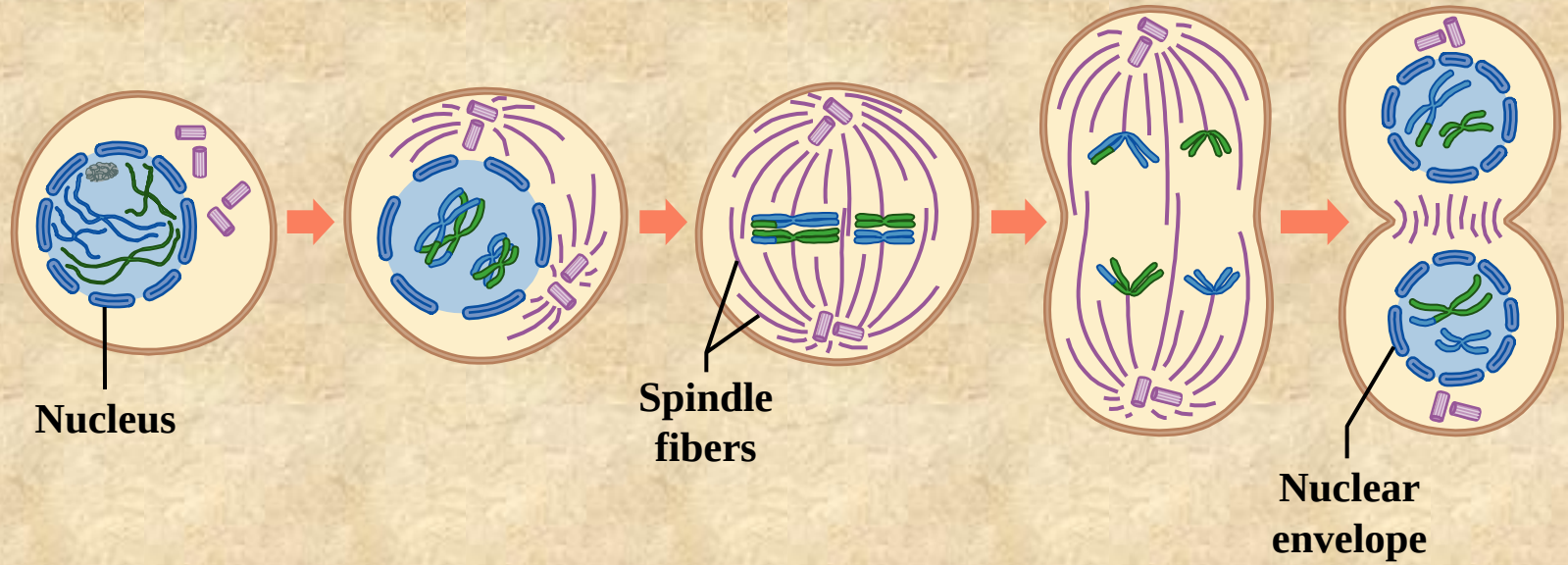


**too much!**

**meiosis reduces genetic content**

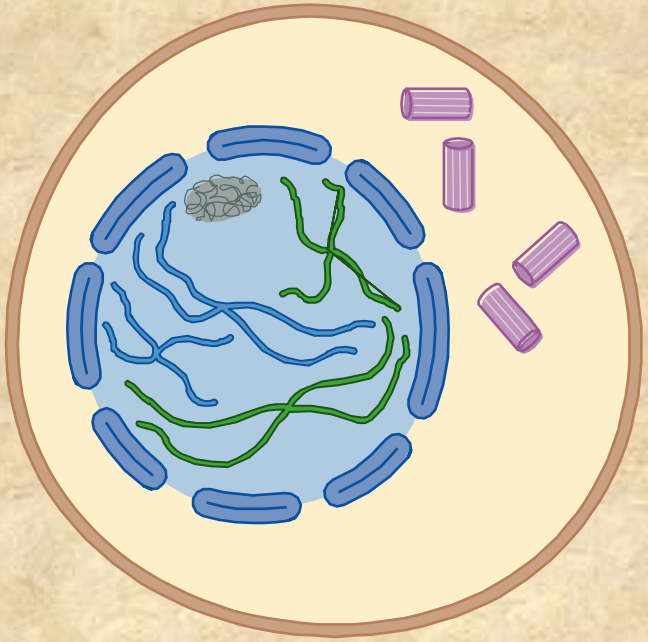


# Meiosis I : The Reduction Division



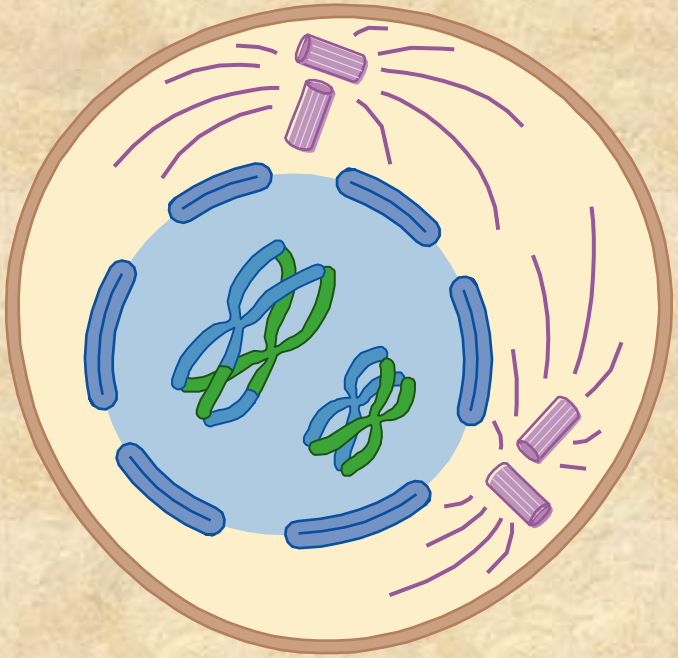

Before Meiosis I, each chromosome is replicated.

# Prophase I



**Early prophase**

**Homologs pair.**
**Crossing over occurs.**

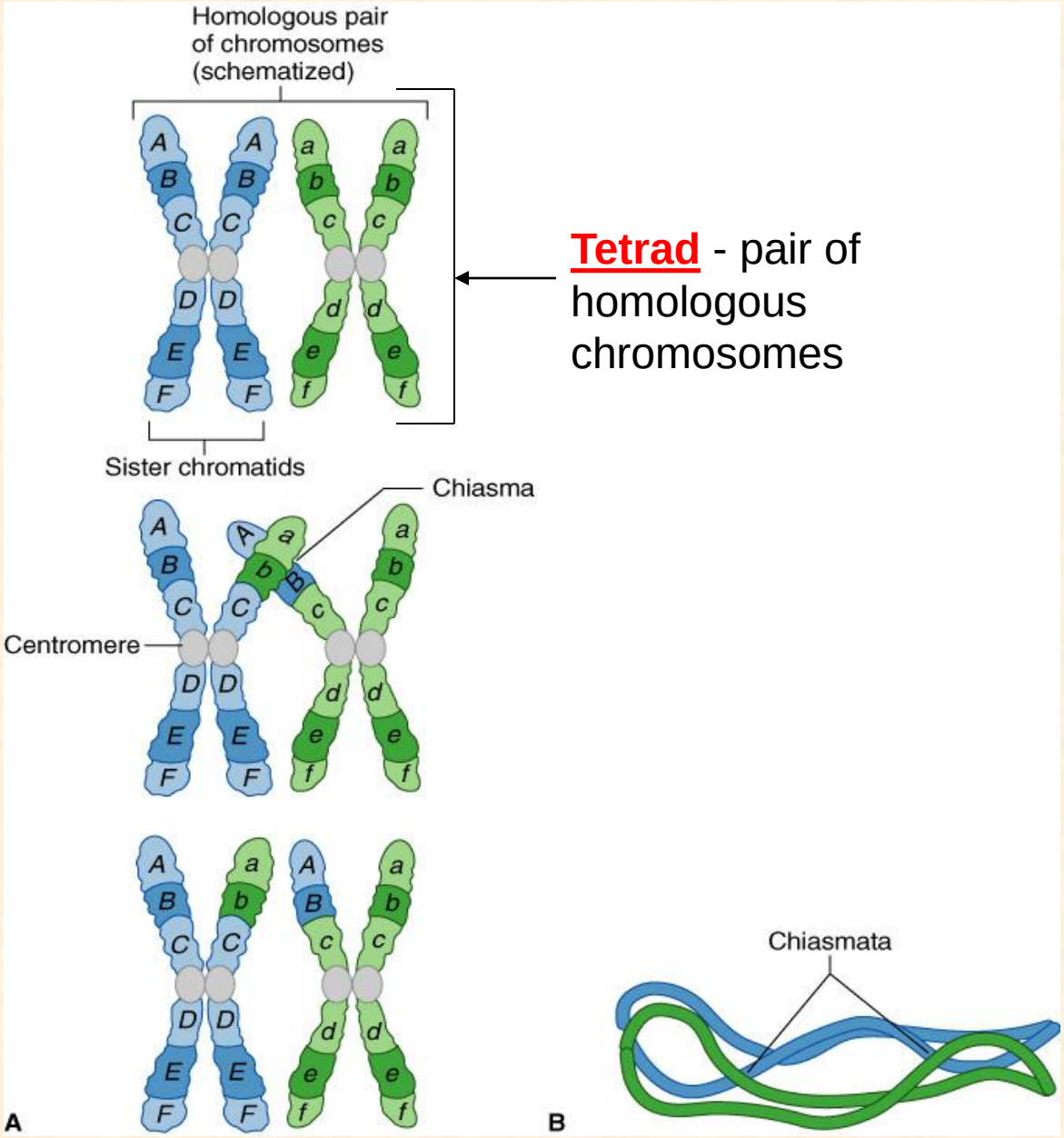


**Late prophase**

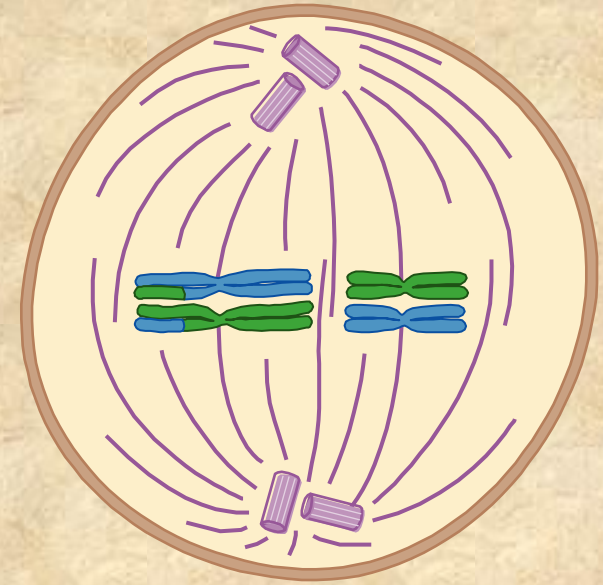
**Chromosomes condense.**
**Spindle forms.**
**Nuclear envelope fragments.**

# Crossing-over

**Crossing-over is an exchange of alleles between homologous chromosomes and produces a new combination of alleles.**

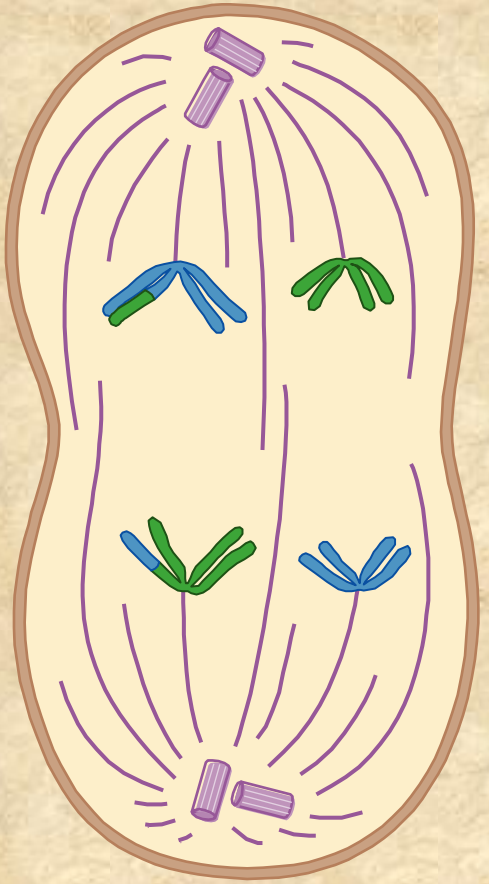


# Metaphase I



**Homolog pairs align along the equator of the cell.**

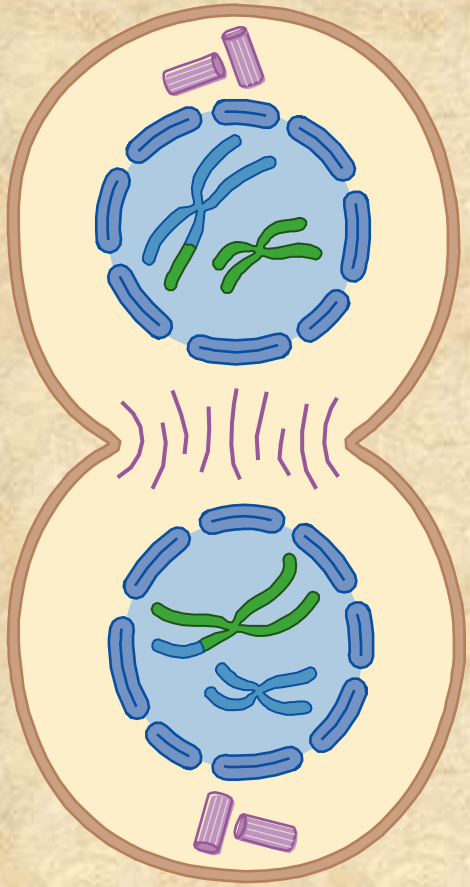
# Anaphase I



**Homologs separate and move to opposite poles.**

**Sister chromatids remain Attached at their centromeres.**

# Telophase I

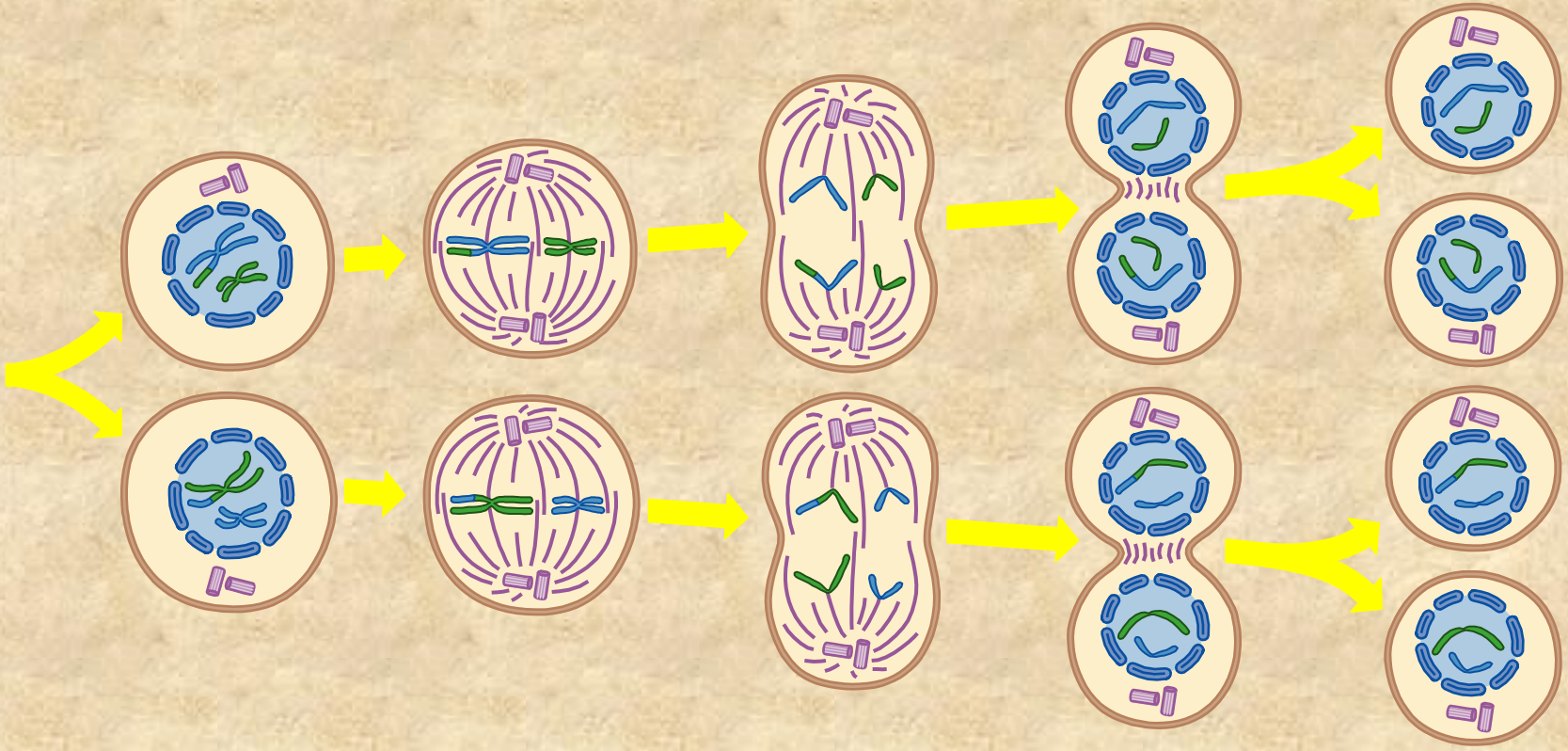


**Nuclear envelopes reassemble.**

**Spindle disappears.**

**Cytokinesis divides cell into two.**

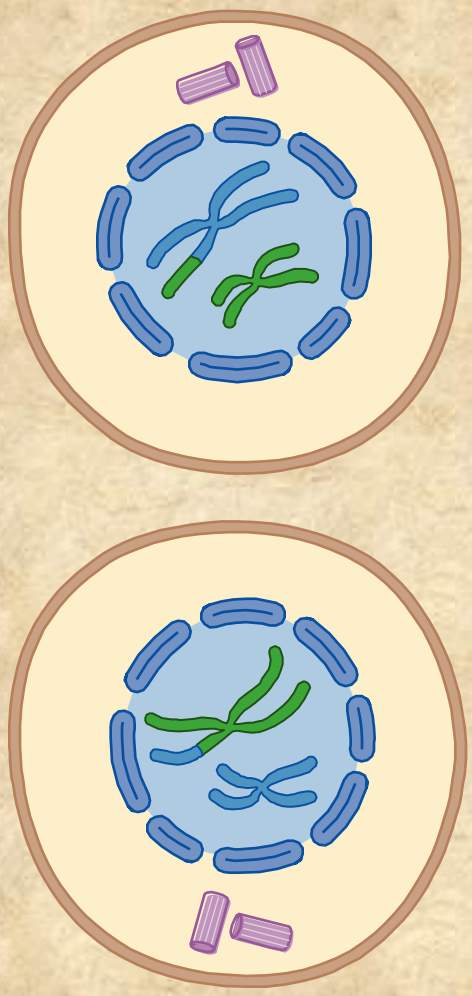
# Meiosis II : The Equational Division



**Prophase II (haploid)** | **Metaphase II (haploid)** | **Anaphase II (haploid)** | **Telophase II (haploid)** | **Four nonidentical haploid daughter cells**

**NEITHER CELL GOES THROUGH REPLICATION BEFORE MEIOSIS II**

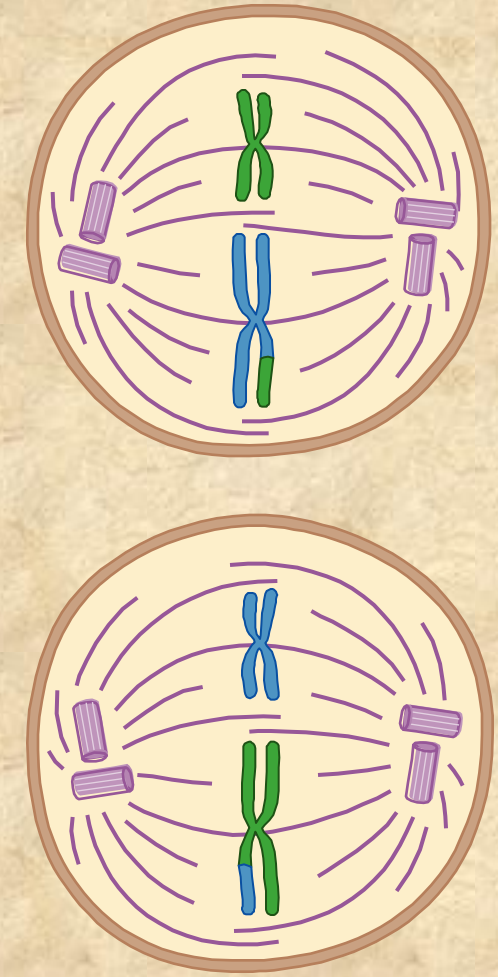
# Prophase II



**Nuclear envelope fragments.**

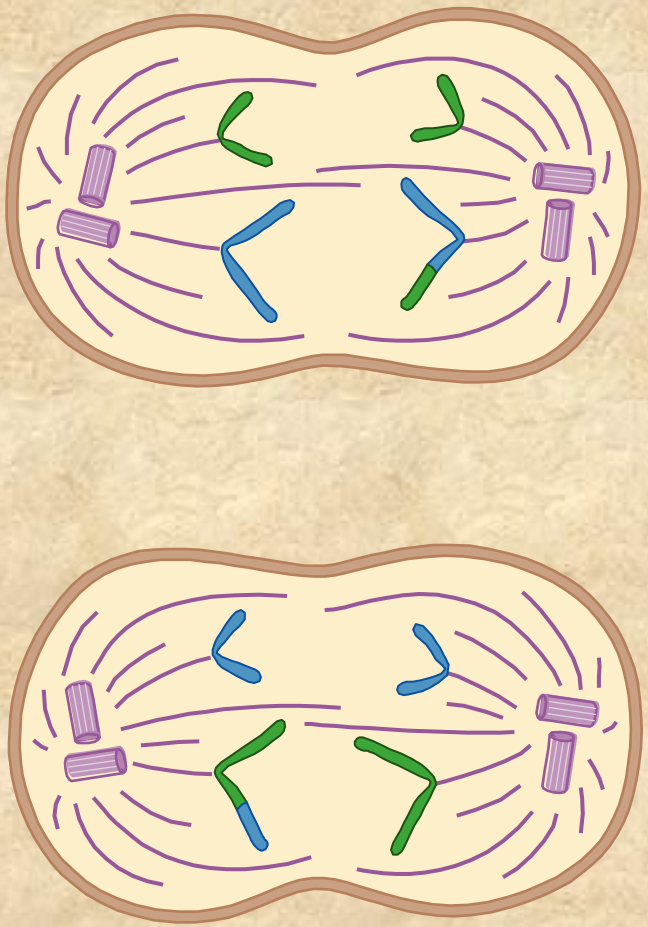
**Spindle forms.**

# Metaphase II



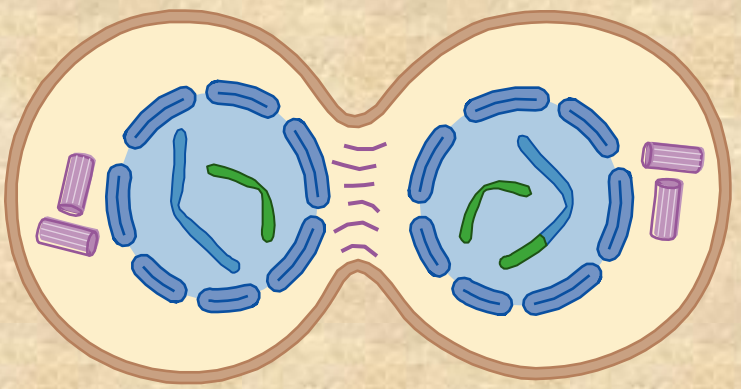
**Chromosomes align along equator of cell.**

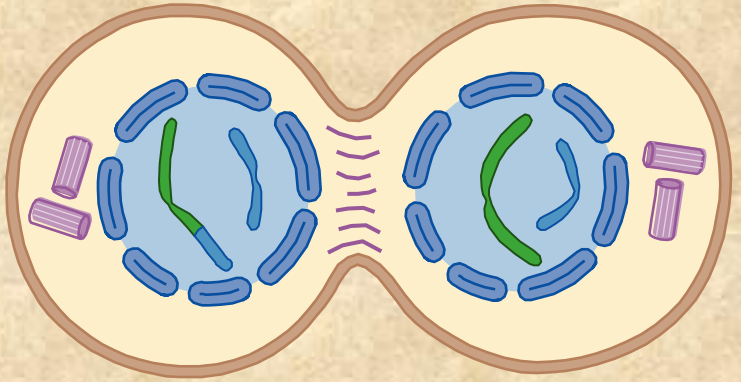
# Anaphase II



**Sister chromatids separate and move to opposite poles.**

# Telophase II





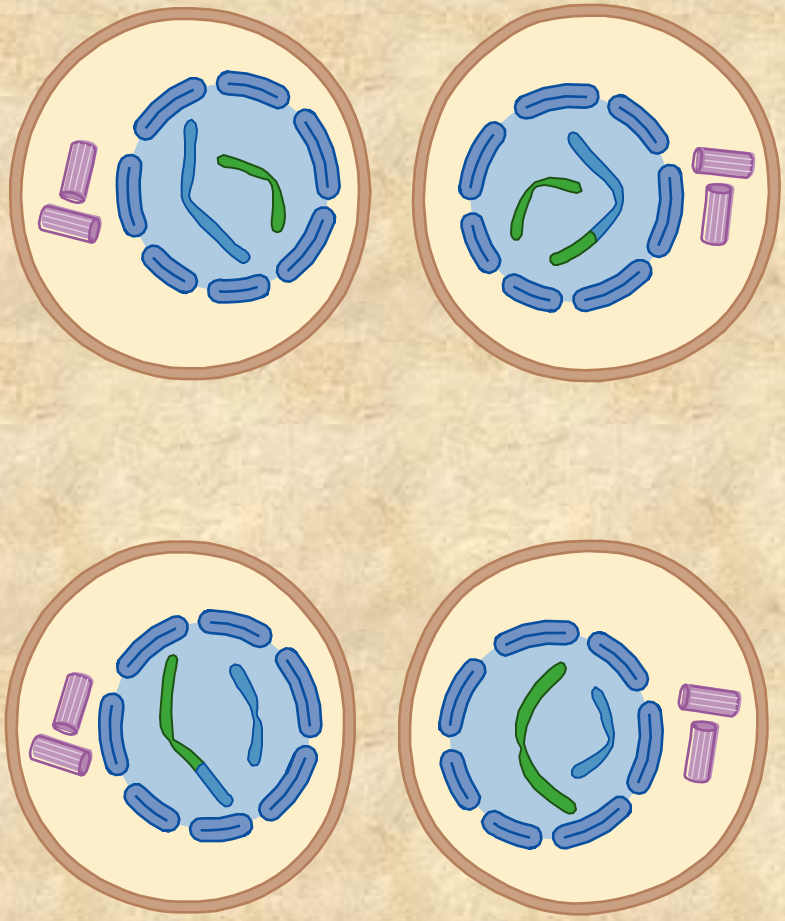
**Nuclear envelope assembles.**

**Chromosomes decondense.**

**Spindle disappears.**

**Cytokinesis divides cell into two.**

# Results of meiosis



**Gametes**

**Four haploid cells**

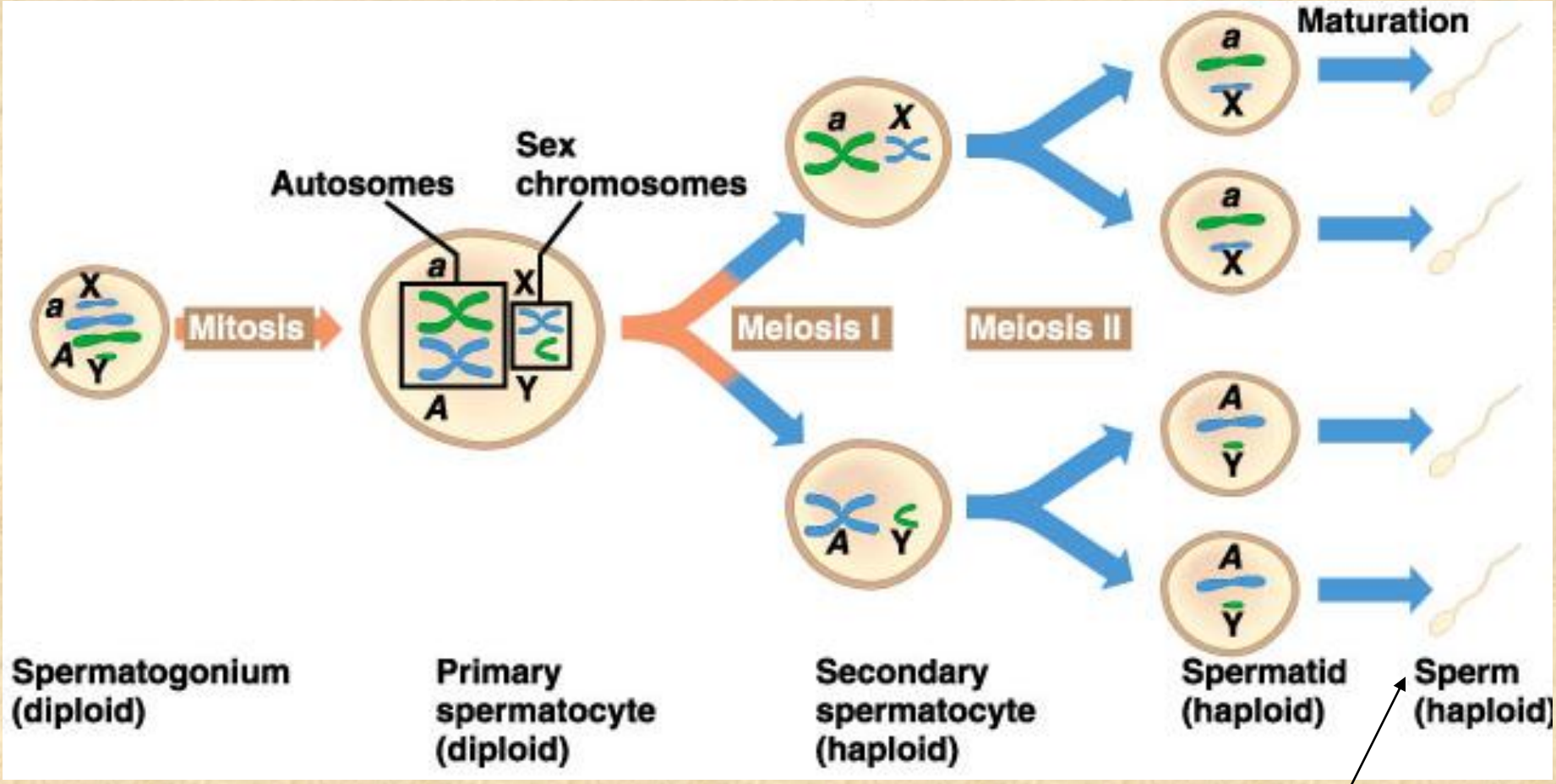
**One copy of each chromosome**

**One allele of each gene**

**Different combinations of alleles for different genes along the chromosome**

| | Mitosis | Meiosis |
|---|---|---|
| **Number of divisions** | 1 | 2 |
| **Number of daughter cells** | 2 | 4 |
| **Genetically identical?** | Yes | No |
| **Chromosome #** | Same as parent | Half of parent |
| **Where** | Somatic cells | Germline cells |
| **When** | Throughout life | At sexual maturity |
| **Role** | Growth and repair | Sexual reproduction |

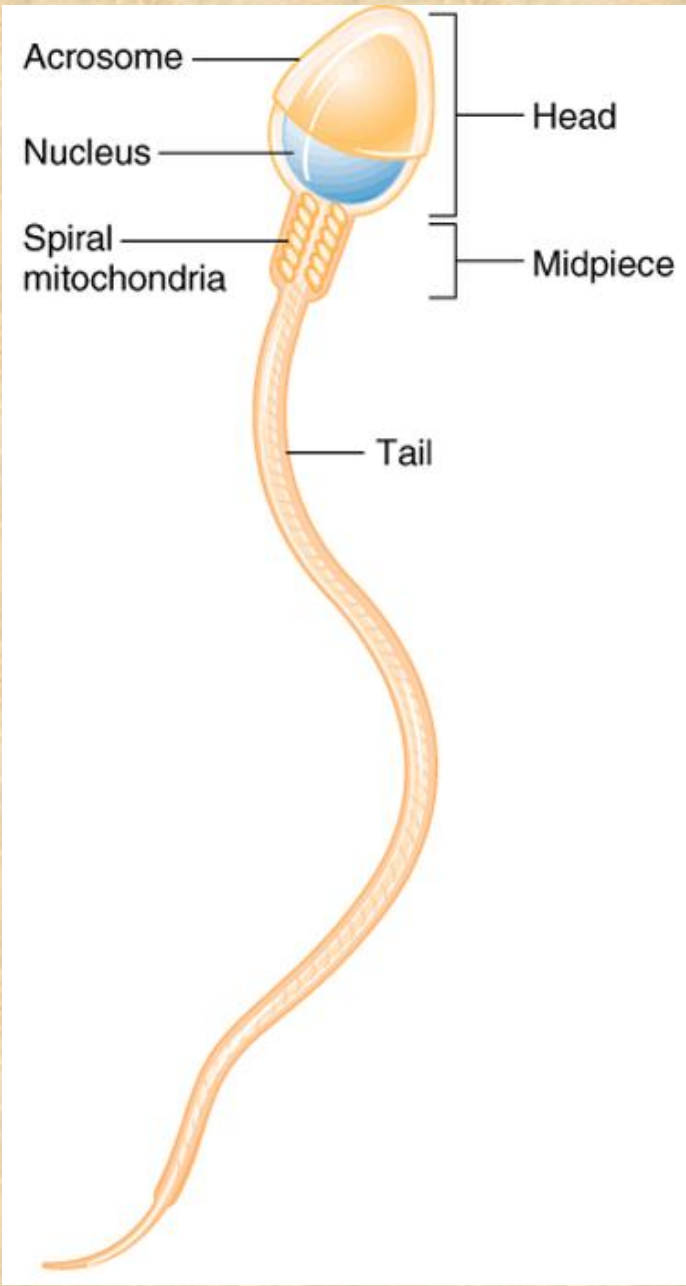
# Spermatogenesis: sperm formation



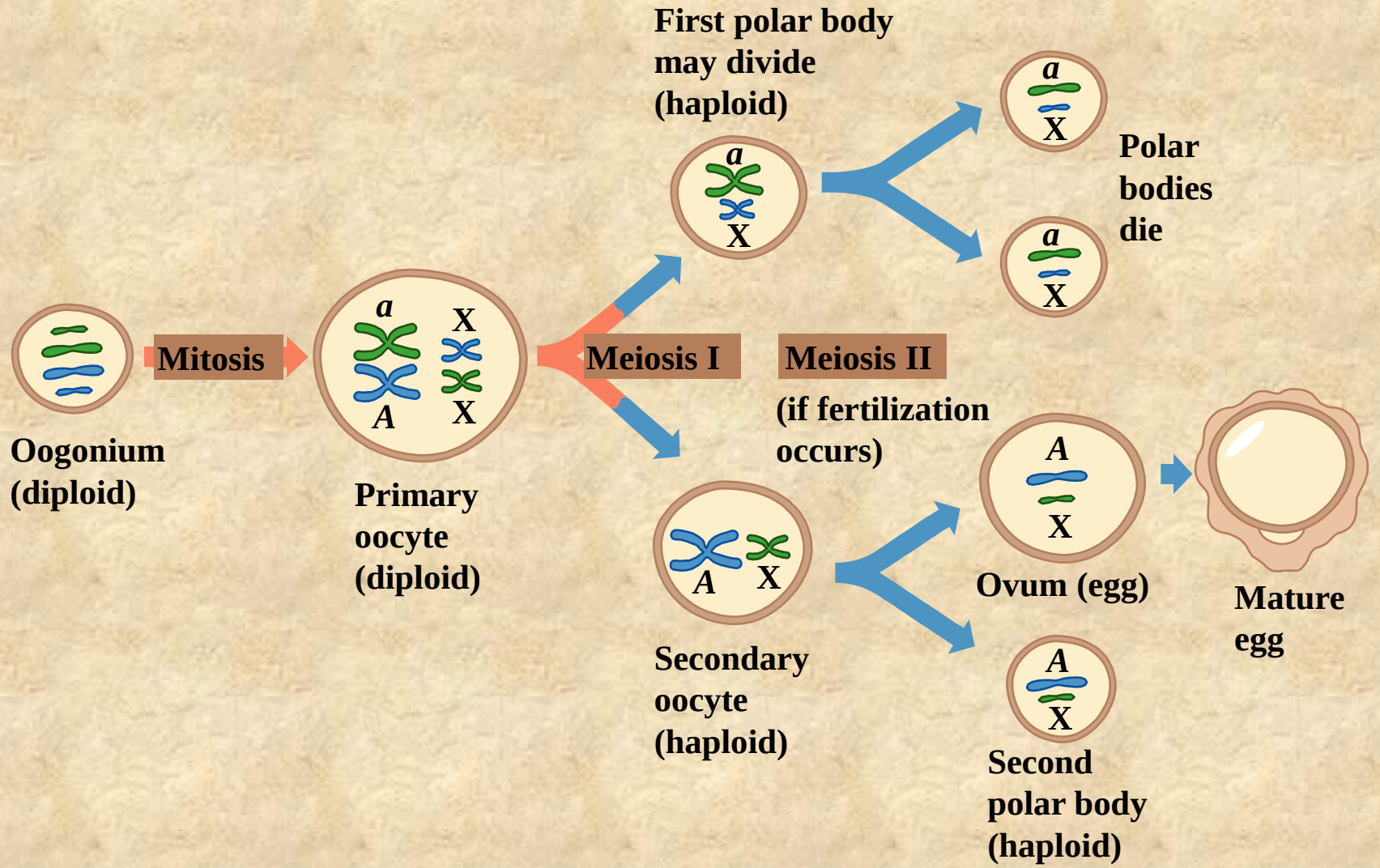

4 Sperm Cells Result

# Spermatogeneis

- Stem cells in testes divide mitotically to create a pool of spermatocytes.
- Meiosis produces four spermatids.



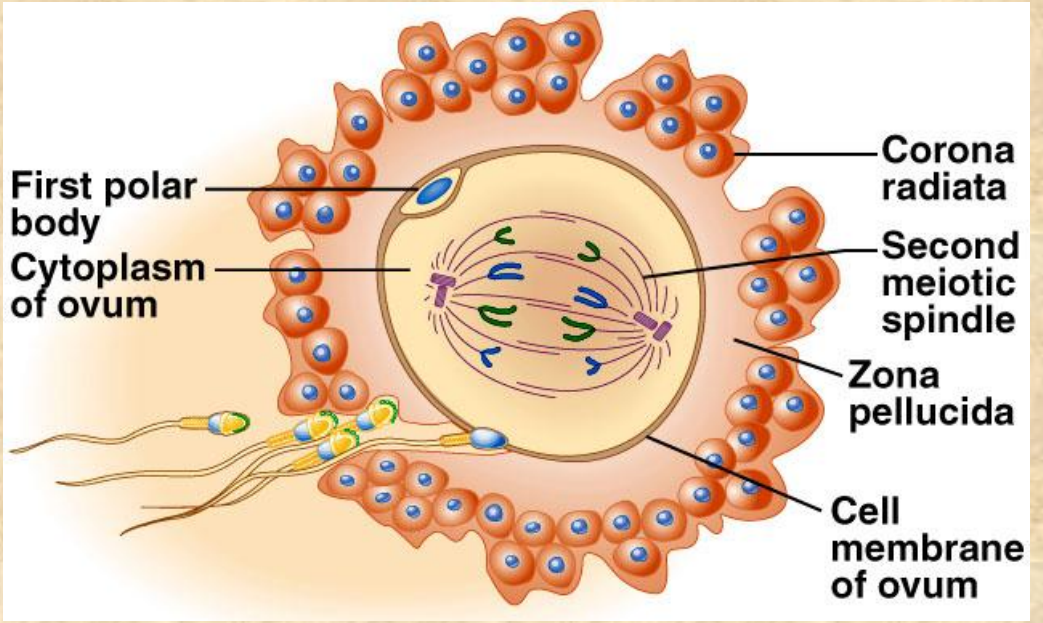
# Oogenesis


Oogonium
(diploid)
Mitosis
a
X
A
X
Primary
oocyte
(diploid)
Meiosis I
First polar body
may divide
(haploid)
a
X
a
X
Polar
bodies
die
Meiosis II
(if fertilization
occurs)
A
X
Secondary
oocyte
(haploid)
A
X
Ovum (egg)
Mature
egg
A
X
Second
polar body
(haploid)

# Oogenesis: Ovum (Egg) Formation

- One of four meiotic products becomes an ovum.
- The three remaining meiotic products are polar bodies.
- Occurs in the ovaries
- The mature egg has a rich storehouse of nutrients to nourish the young organism that develops after it is fertilized.

# Fertilization




- **Fertilization is the joining of sperm and ovum.**
- **Meiosis II in the ovum is completed at the time of fertilization forming one ovum and one polar body.**
- **Following fertilization, chemical reactions occur preventing additional sperm from entering the ovum.**

- All animals have a characteristic number of chromosomes in the somatic or body cells called the diploid (or 2n) number.
- The gametes or sex cells (egg & sperm) contain half the number of chromosomes as a body cell; known as the haploid number (n) of chromosomes.

| Organism | (2n) Diploid | (n) Haploid |
|---|---|---|
| Man | 46 | 23 |
| Dog | 78 | 39 |
| Fruitfly | 8 | 4 |
| Crayfish | 200 | 100 |
| Corn | 20 | 10 |

# Human Heredity

## Section 14-1

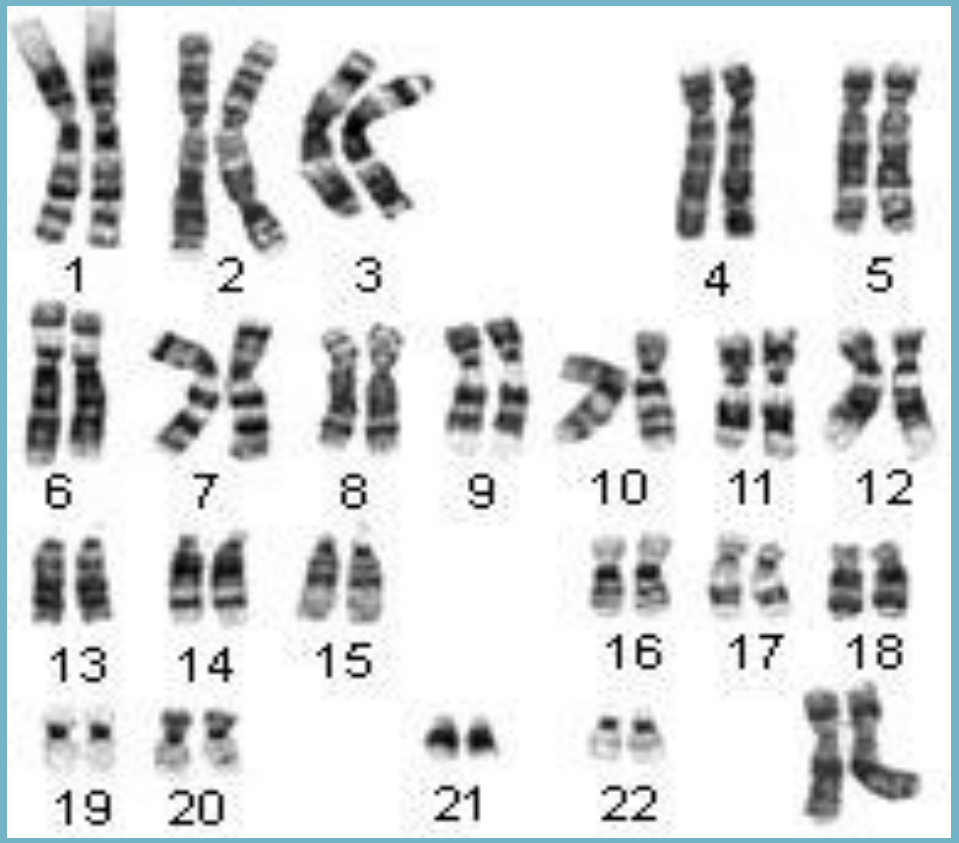
# Human Chromosomes

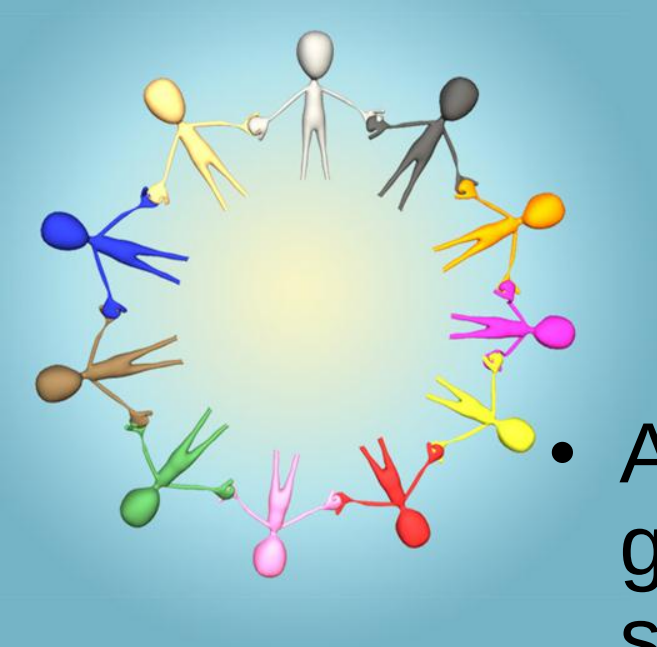
- Each chromosome is composed of a single, tightly coiled DNA molecule.
- The two DNA strands are homologus (duplicates) and are held together by the centromere.
- While they are still attached, the duplicated chromosomes are called sister chromatids.

- Chromosomes can be categorized as two types:
  - Autosomes which are non-sex chromosomes that are the same number and kind between sexes.
  - Sex chromosomes which determine if the individual is male or female.

- Sex chromosomes in the human female are XX and those of the male are XY.
- Males produce X-containing and Y-containing gametes; therefore males determine the sex of the offspring.

A karyotype is a picture of chromosomes which are grouped together in pairs.





# Pedigree Charts

- A pedigree is a chart of the genetic history of family over several generations.

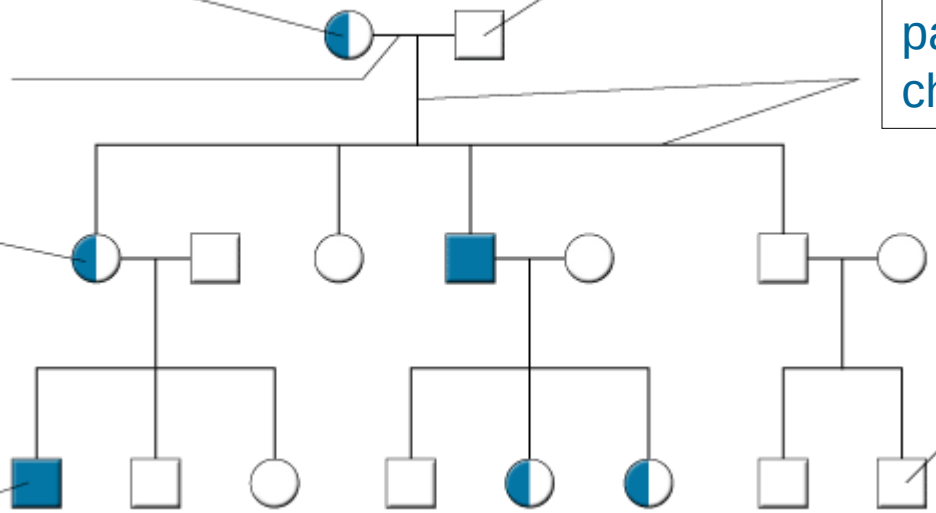
- Scientists or a genetic counselor would find out about your family history and make this chart to analyze.

A horizontal line connecting a male and female represents a marriage.

A circle represents a female.

A square represents a male.

A vertical line and a bracket connect the parents to their children.

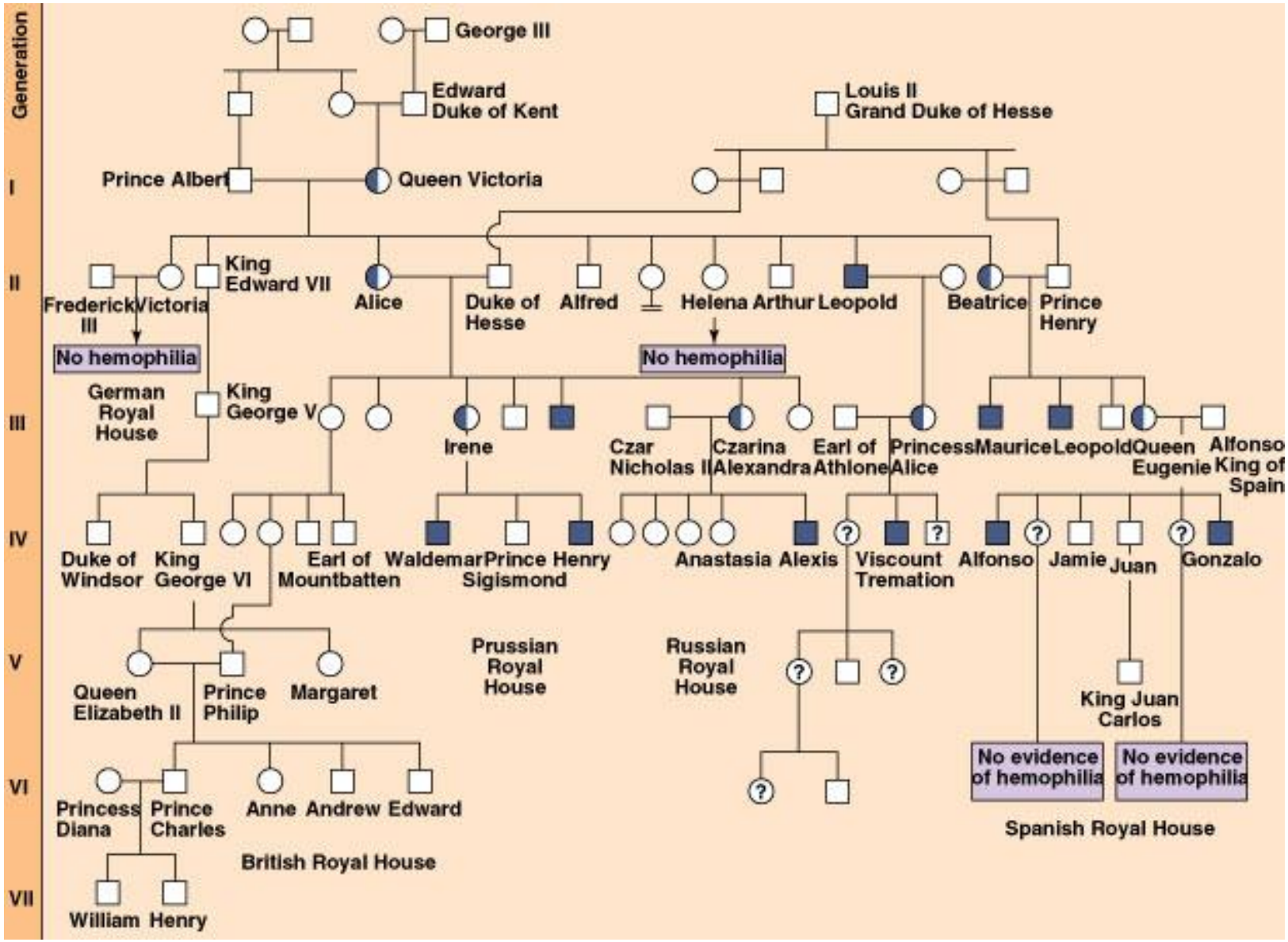


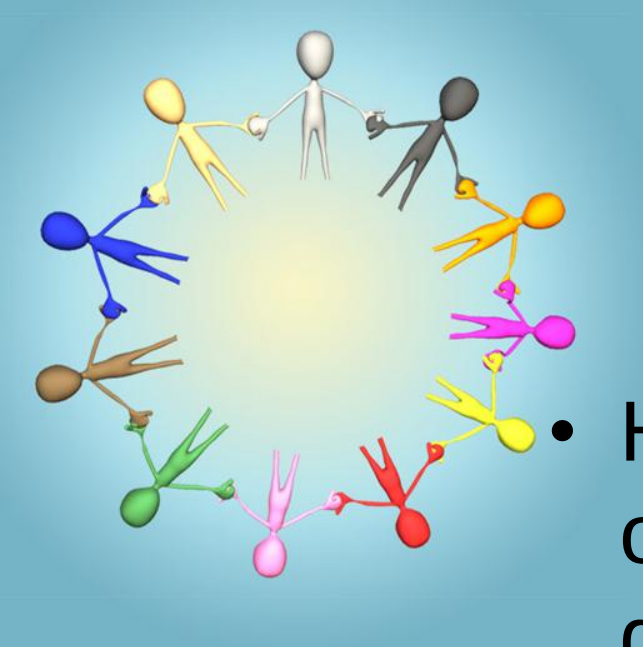
A half-shaded circle or square indicates that a person is a carrier of the trait.

A completely shaded circle or square indicates that a person expresses the trait.

A circle or square that is not shaded indicates that a person neither expresses the trait nor is a carrier of the trait.

# Royal Hemophilia Pedigree





# Blood Type Genes

- Human blood comes in a variety of genetically determined blood groups.
- The best known genes for determining blood types are:
  - ABO group
  - Rh blood group (two alleles - positive and negative)
    - $Rh^+$ is dominant/$Rh^-$ is recessive



# Blood Groups



| Phenotype (Blood Type) | Genotype | Antigen on Red Blood Cell | From<br>Safe Transfusions | To |
|---|---|---|---|---|
| **A** | $I^AI^A$ or $I^Ai$ | A | A,O | A,AB |
| **B** | $I^BI^B$ or $I^Bi$ | B | B,O | B,AB |
| **AB**<br>Universal Recipient | $I^AI^B$ | A and B | A,B,AB,O | AB |
| **O**<br>Universal Donor | ii | none | O | A,B,AB,O |

# Question #1

In humans the blood groups are produced by various combinations of three alleles $I^A$, $I^B$, and i. Suppose a child is of blood type A and the mother is of type O. What type or types may the father belong to?

Since the mother can only provide for O type blood (i), the father must provide the allele for blood type A ($I^A$). Three genotypes can provide the $I^A$ allele:

$I^AI^A$ (blood type A)

$I^Ai$ (blood type A)

$I^AI^B$ (blood type AB)

# Question #2

Suppose a father of blood type A and a mother of blood type B have a child of type O. What blood types are possible in their subsequent children?

Type O must be ii. Since the father has blood type A, he must be heterozygous ($I^Ai$). Since the mother has blood type B, she must be heterozygous as well, but with B and O alleles ($I^Bi$).

| | $I^B$ | i |
|---|---|---|
| $I^A$ | $I^AI^B$ | $I^Ai$ |
| i | $I^Bi$ | ii |

**Possible Offspring**

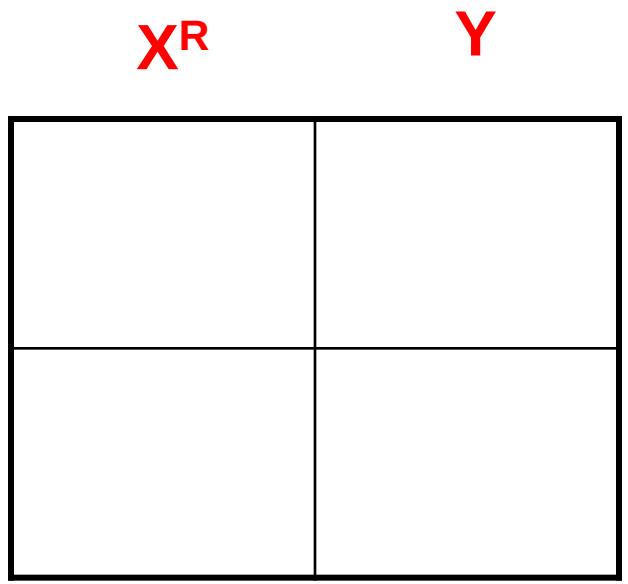
# Sex-linked Traits

- Traits (genes) located on the sex chromosomes
- Sex chromosomes are X and Y
- XX genotype for females
- XY genotype for males
- Most sex-linked traits carried on X chromosome

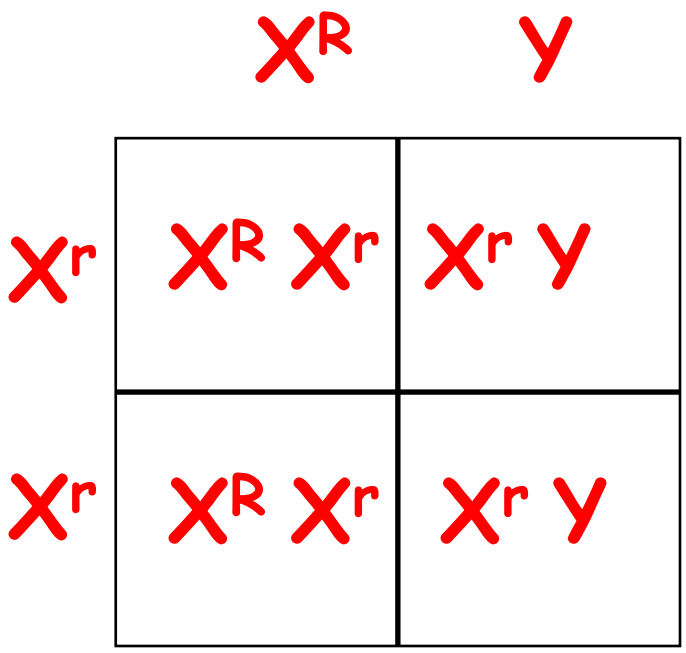
# Sex-linked Trait Problem

- Example: Eye color in fruit flies
- (red-eyed male) x (white-eyed female)

  $X^RY$ x $X^rX^r$
- Remember: the Y chromosome in males does not carry traits.
- RR = red eyed
- Rr = red eyed
- rr = white eyed
- XY = male
- XX = female



# Sex-linked Trait Solution:




50% red eyed female

50% white eyed male

# Female Carriers

In a sex-linked trait (like hemophilia), women are carriers, and men have the phenotype more often.