Unit III- Principles of inheritance

Course code: SC301

Presented by:
Course instructor: **Dr Rekha Deka**
Dept. of Science and Mathematics
IIITG, Bongora

What is inheritance?

Inheritance refers to the passage of hereditary traits one generation to the next. Children/offspring resemble their parents because they inherit traits passed down from both parents.

The branch of biology that deals with inheritance is called genetics.






Some terminologies in principles of inheritance

1) Homologous chromosomes: The nuclei of all human cells except gametes contain 23 pairs of chromosomes-the diploid number (2n). One chromosome in each pair came from the mother and the other came from the father.

1) **Gene locus**: the location of a gene on a chromosome, or within a DNA molecule, is called gene locus.

e.g, "T" locus ,means **gene T** location on a chromosome. Gene T codes for a functional protein or enzyme.

2) **Alleles**: A DNA sequence at the 'T' locus that has undergone mutation may no longer encode a functional enzyme. Following a mutation, the locus remains same, but the DNA sequence at mutant locus is different. So, different DNA sequences at the same locus are called different alleles of the same gene. Any change in the DNA sequence of gene creates new allele.

3) Genotype: genetic composition of an organism for the particular trait.

4) Phenotype: The external appearance of an organism due to its genetic composition/influence of genes and environmental factors.

5) Homozygous: the individuals having identical alleles in an allelic pair for a character or same alleles of a gene at the gene locus is called homozygous condition. Example : "*PP"* for purple color and "*pp"* for white color.

6) Heterozygous: the individuals having different alleles in an allelic pair for a character or different alleles of a gene at the gene locus is called heterozygous condition. Example : "*Pp"* for purple color.

7) Dominant allele: If out of two different allele of a gene at the locus, one allele is expressed, forms a functional product, and shows its phenotypic effect in every generation, then that allele is known **to be dominant over the other allele.** For example, in previous slide**, genetic make up of plant with *"Pp"* giving purple flower means *"P" allele* is dominant over *"p" allele.***

8) Recessive allele: If out of two different allele of a gene at the locus, one allele is not expressed, or do not form any functional product, then that allele is known **to be recessive over the other allele**

- **Example to understand the concept of alleles:**

Trait : Color of flower

Purple flower (P)

↓

Purple pigmentation due to anthocyanin

↓

This purple color is formed due to a specific functional enzyme

↓

DNA sequence at "P locus" for the functional enzyme for production of anthocyanin

White flower (p)

↓

No pigmentation, absence of anthocyanin

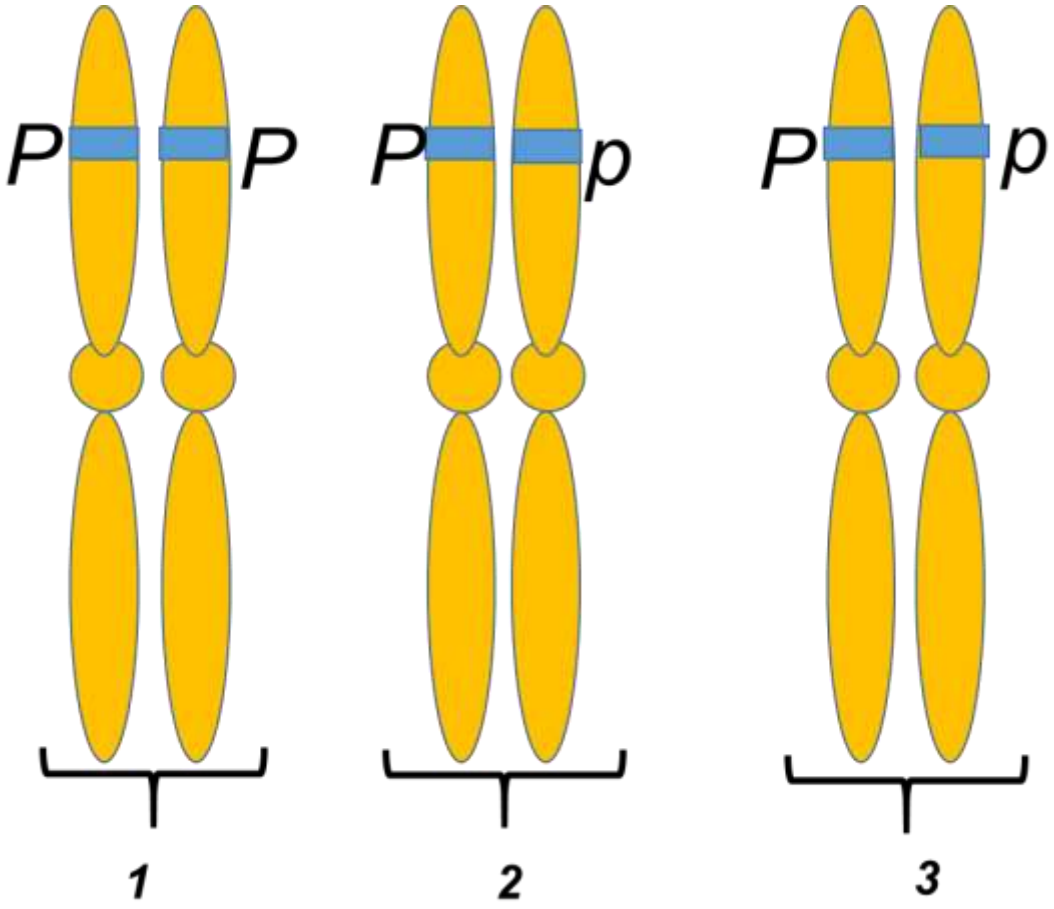
↓

No functional enzyme

↓

DNA sequence at "P locus" mutated for the functional enzyme for production of anthocyanin. **mutated version is now called here as "p" allele.**

Gene locus "P"

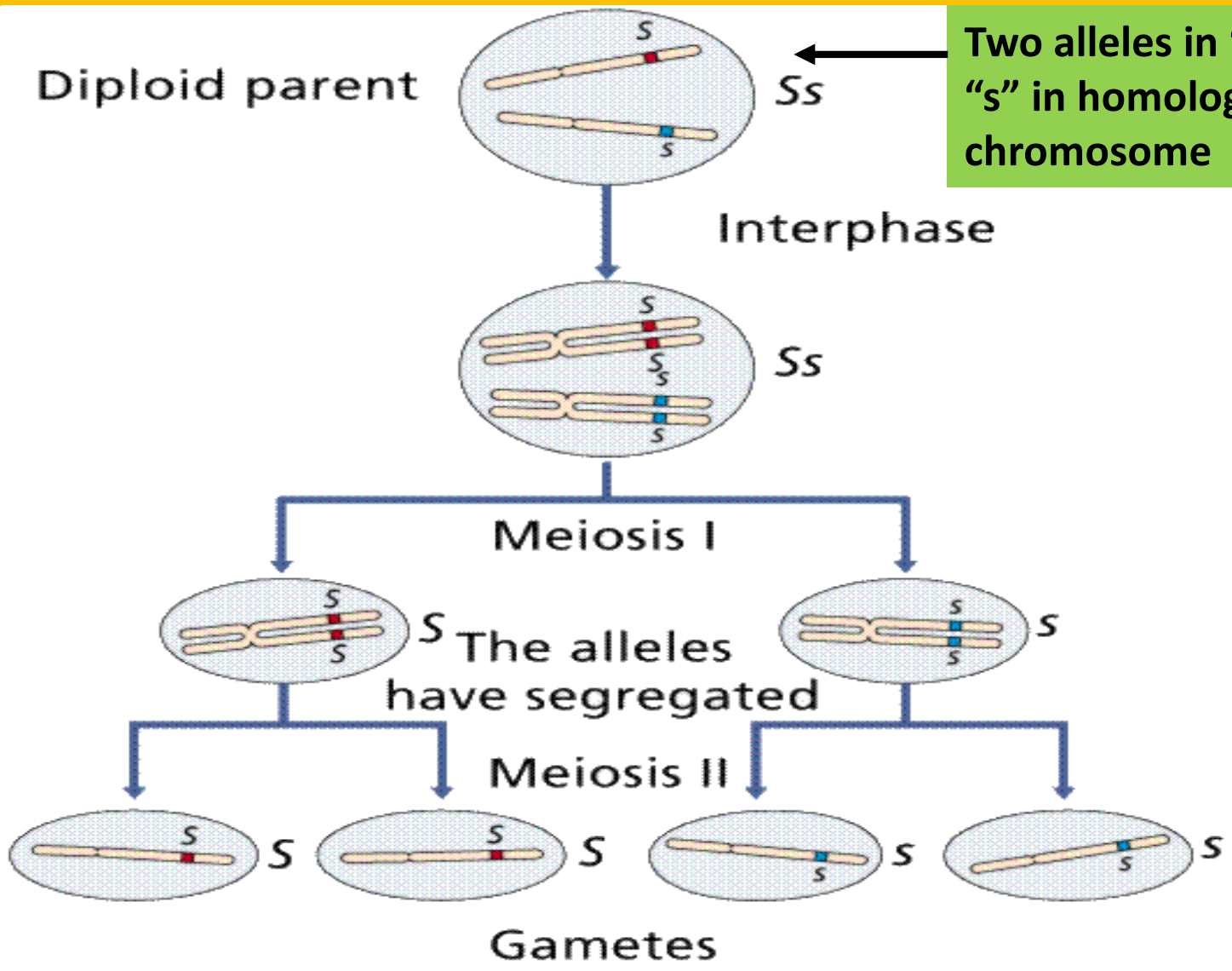


Three pairs of Homologous chromosomes

	1	2	3
Genotype/ Genetic composition	***PP***	***Pp***	***pp***
	Homozygous	***Heterozygous***	***Homozygous***
Phenotype	***Purple flower***	***Purple flower***	***White flower***

Allelic pairs. *There are three allelic pairs for gene "P" at the gene locus*

How alleles separated during gamete formation?



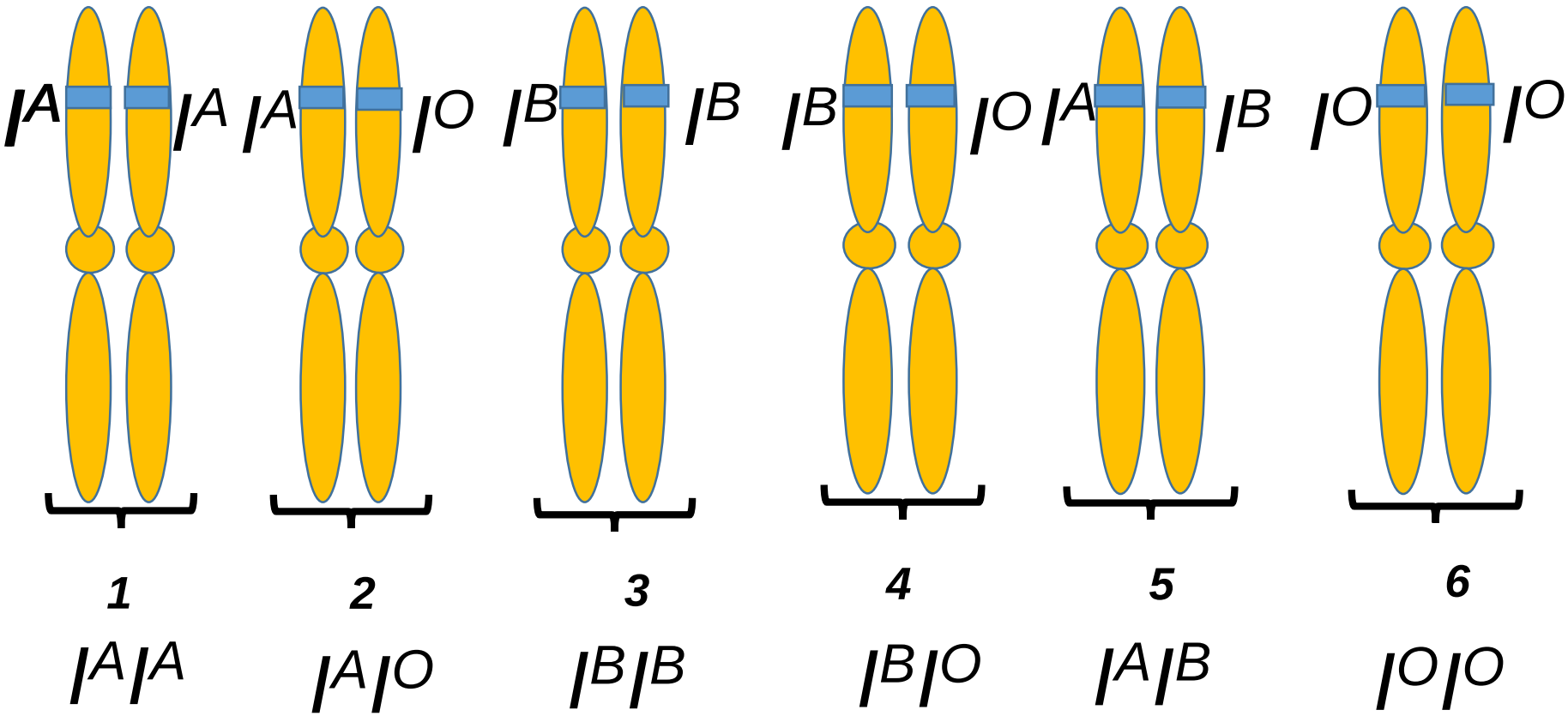
Codominance/multiple-allele inheritance

- **Codominance**: Both the alleles at the gene locus shows its independent affect. "ABO" –locus that determines the blood group of an individual.
- ABO locus has three has three major alleles- ABO*A; ABO*B; ABO*O. Also represented as I^A , I^B , I^O .

At "ABO" gene locus of an individual, two alleles are present and therefore, six genotypes are possible.

Blood group	Six Genotypes	
A	$I^A I^A$	$I^A I^O$
B	$I^B I^B$	$I^B I^O$
AB	$I^A I^B$	
O	$I^O I^O$	

Chromosomal location of ABO blood group alleles



Why blood group alleles are codominant and not dominant?

- Person having blood group A has **“A-antigen”** on its RBC’s surface, blood group B has **“B-antigen” on its surface**, blood group **AB has both “A and B antigens” expressed on RBC** surface, and O has **“no antigens”** on RBC surface. The codominant effect of alleles **is due to the equal expression of A and B antigens on the RBC surface.** No allele is dominant over other or masks the expression of other. Therefore, blood group alleles show the codominance .phenomenon

X-linked inheritance

1) The human X chromosome contains many genes that are required in both sexes, whereas Y chromosome contains only a few genes, primarily genes related to maleness. About 200 traits have been estimated to be X-linked compared to a few, which are Y-linked.

2) **The traits controlled by genes located on X chromosome are often called sex-linked genes, or X-linked traits.**

3) Females have two doses of X-linked genes (because two X-chromosome) and males have only one dose.

Female genotype : XX; males genotype : XY

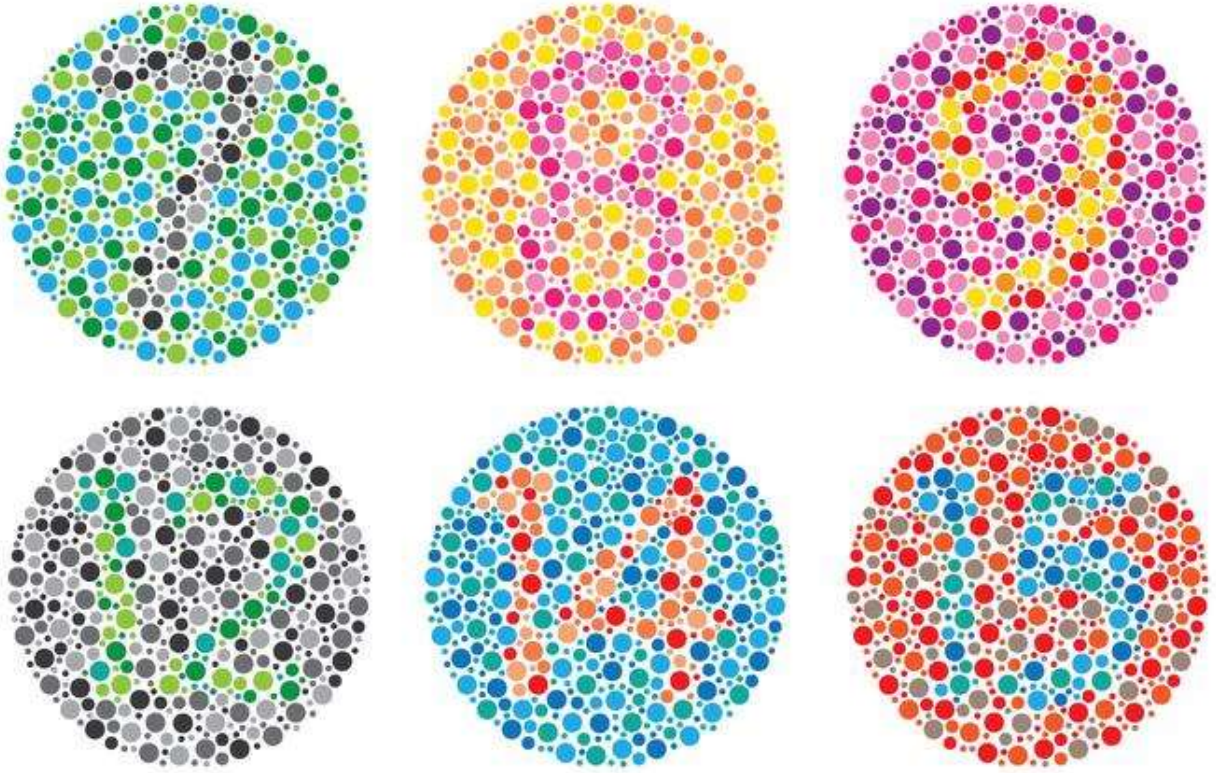
4) One dose of **X-linked dominant allele** produces its effects in males as well as females

for example: X^HX X^HY; where "H" is the dominant allele and will show its effect on both males and females.

5) **If the allele is X-linked recessive**, then female will show the phenotypic effect only when both X-chromosome has the allele, while males will show the phenotypic effect due to presence of only one X-chromosome

for example: X^hX X^hY; where "h" is the recessive allele and will show its phenotypic effect only in males and females will be the carrier of recessive allele. Females will show its effect when both the X-chromosome carries the recessive allele.

Colorblindness test chart



Inheritance pattern of X and Y

Parental generation **44+XX** **44+XY**

Gametes: ova in female and sperm in males

22+X **22+X** **22+X** **22+Y**

Fertilization of Ova and Sperm

44+XX **44+XY** **44+XX** **44+XY**

Female gamete → / Male gamete ↓	X	X
X	XX	XX
Y	XY	XY

Red-green color blindness and haemophilia is an example of X-linked recessive inheritance

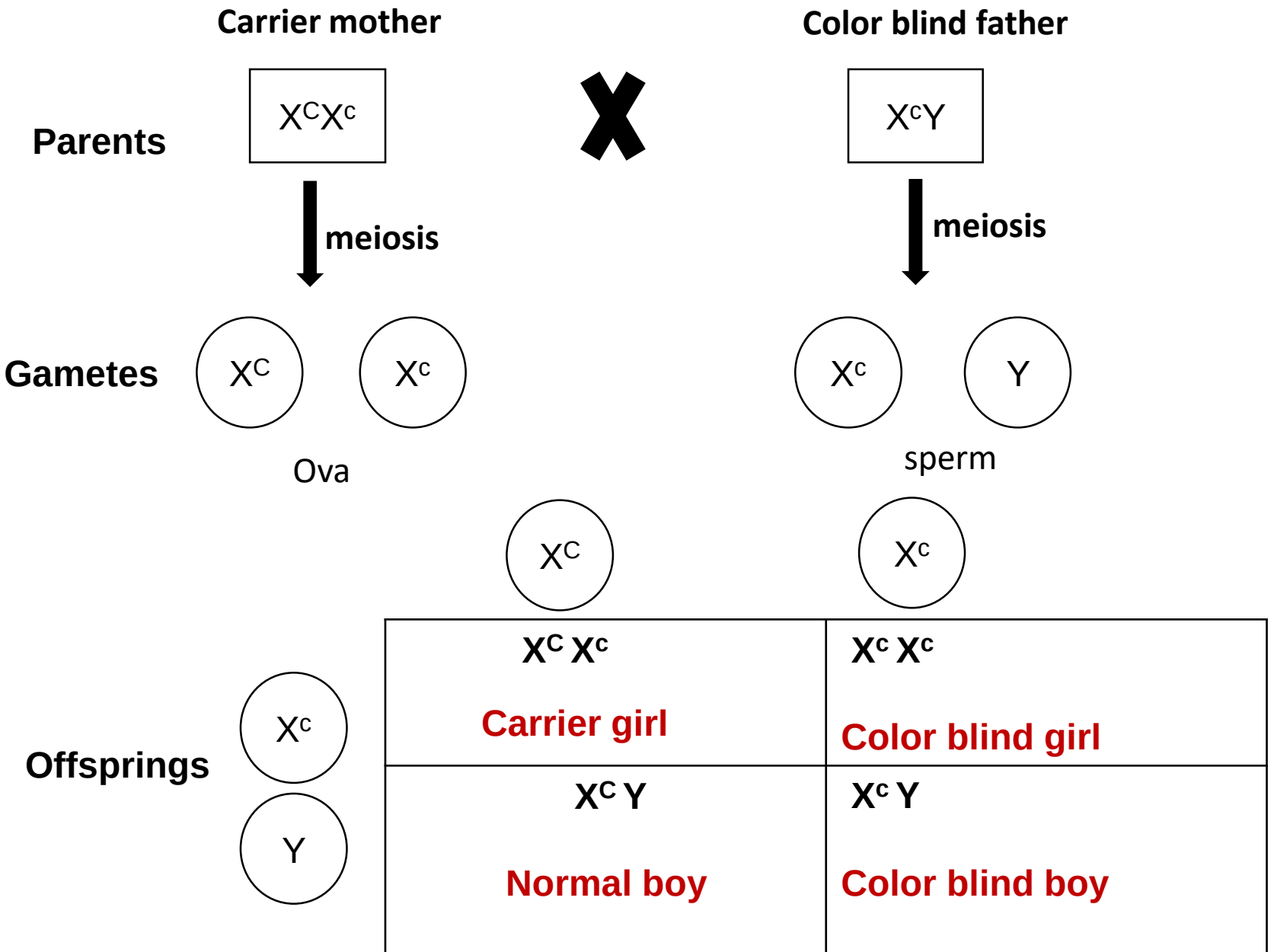
1) Red-green color blindness condition is characterized by a deficiency in either red-or-green-sensitive cones. So red and green are seen as same color (either red or green, depending on which cone is present). The gene for red-green color blindness is a recessive one designated as “c”. Normal color vision , designated as “C” dominates. The C/c genes are located on X-chromosomes and thus the ability to see colors depends entirely on the X-chromosome. The possible combinations are as follows:

Genotype	Phenotype
X^CX^C	Normal female
X^CX^c	Normal female but carrier of recessive gene
X^cX^c	Red-green color blind female
X^CY	Normal male
X^cY	Red-green color blind male

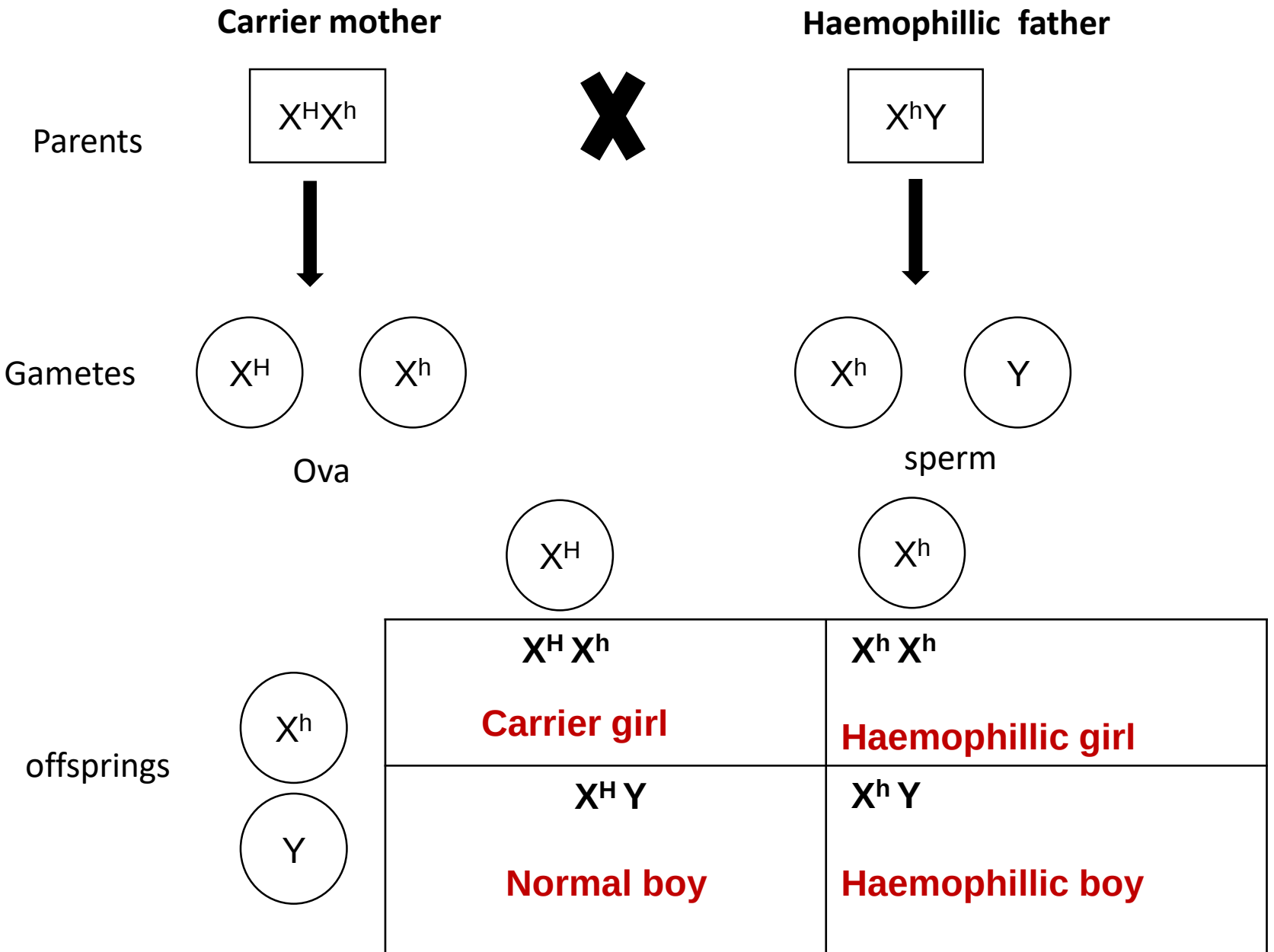
2) Haemophilia is also a sex-linked trait, in which the blood fails to clot or clots very slowly after an injury.

Genotype	Phenotype
X^HX^H	Normal female
X^HX^h	Normal female but carrier of recessive gene
X^hX^h	Haemophillic female
X^HY	Normal male
X^hY	Haemophillic male

Inheritance pattern of red-green color blindness



Inheritance pattern of haemophilia



Sample questions

Q.1) A woman with two genes for haemophilia marries a normal man. What will be the phenotypes of progeny?

Choose from Options:

A). All sons and daughters are haemophillic. .

B) All normal sons

C) !00% chances of sons to be hemophilic and all daughters will be the carrier.

Q.2) If a woman is a carrier of color blind gene, marries a color blind man, and have daughter, what is the percent chance that she will have color blind?

Q.3) A mother with blood type A has a child with blood type A. Give all possible blood types for the father of this child from the options below.

a) O

b) B, AB

c) A, AB

d) A, B, O

e) A, B, AB,O

Q.4) A mother of blood type A gives birth to a child with blood type O. Which of the following could NOT be the blood type of the father?

a) A

b) B

c) O

d) AB

e) Any of the above is a possible blood type of the father

Thank you