








# Multiple Alleles

- More than 2 alleles for a gene (more than 3 phenotypes)
- Individuals still only have a combination of two alleles
- Often times this inheritance also displays co-dominance
- Blood type has 3 alleles –  $I^A$  ;  $I^B$  ;  $i$  (A, B, o)

• TYPES:

A  $I^A I^A, I^A i$  (AA, Ao)  
 B  $I^B I^B, I^B i$  (BB, Bo)  
 AB  $I^A I^B$  (AB)  
 O  $ii$  (oo)

**The ABO Blood System**

Blood Type (genotype)	Type A (AA, AO)	Type B (BB, BO)	Type AB (AB)	Type O (OO)
Red Blood Cell Surface Proteins (phenotype)	 A agglutinogens only	 B agglutinogens only	 A and B agglutinogens	 No agglutinogens
Plasma Antibodies (phenotype)			NONE.	

# Multiple Allele Problem

- A man heterozygous for blood type B marries a woman heterozygous for blood type A. What is the chance that their first offspring will have type O?

Given and Alleles:

B =  $I^B i$

A =  $I^A i$

Cross: Hetero B x hetero A

$I^B i$  x  $I^A i$

	$I^B$	$i$
$I^A$	$I^A I^B$	$I^A i$
$i$	$I^B i$	$ii$

# Sex-Linked (X-linked traits)

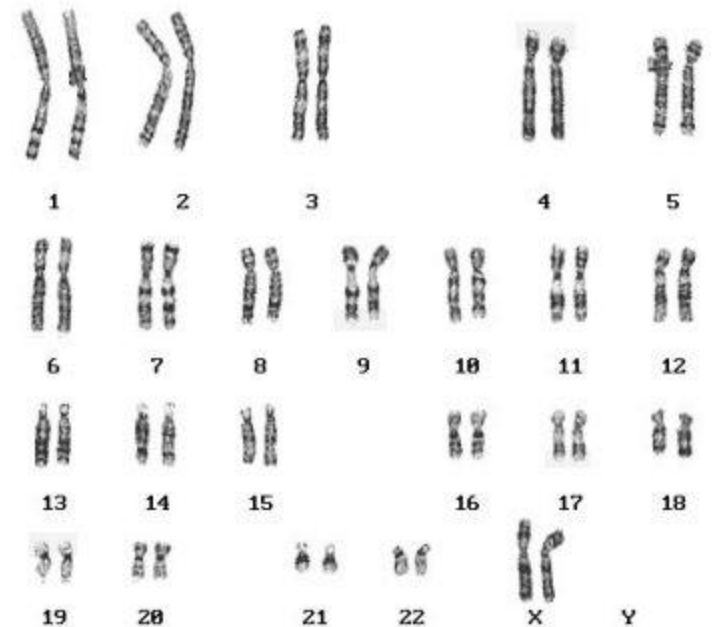
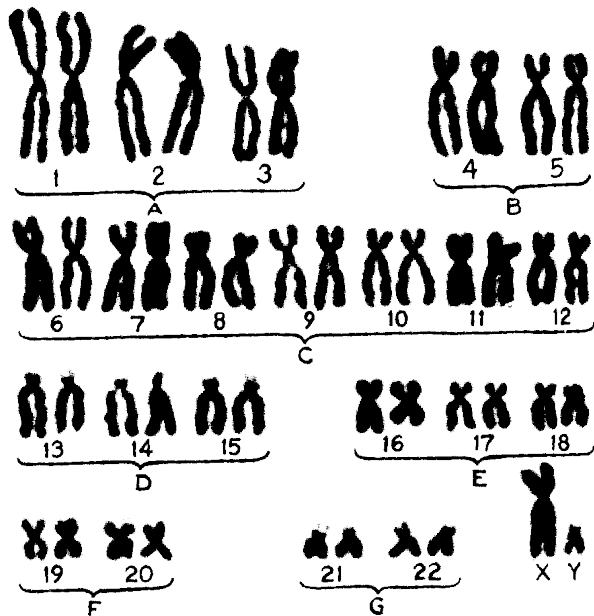
Humans have 23 pairs of chromosomes

Pairs 1-22 are autosomal

Pair 23 determines sex – XX = female XY = male

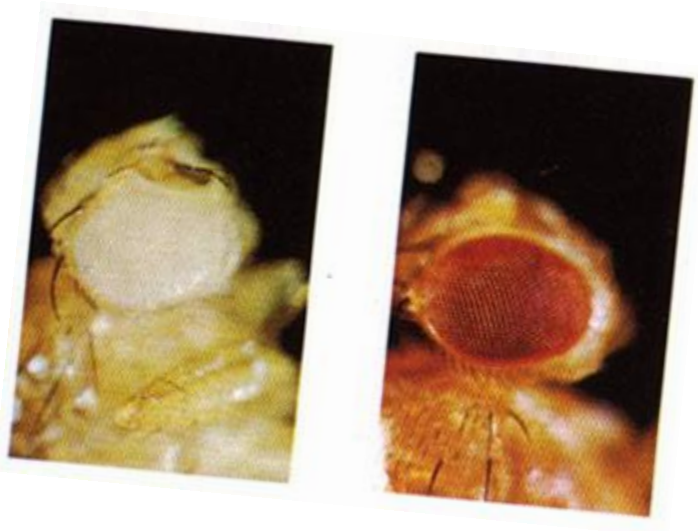
\*\*\*Certain traits are carried only on the X chromosome

The Y chromosome is “blank”



# X-Linked Traits

- Ex: Red & white eyes



Female=XX

Add eye trait=

$X^R X^R$  or  $X^R X^r$

$X^r X^r$

Male=XY

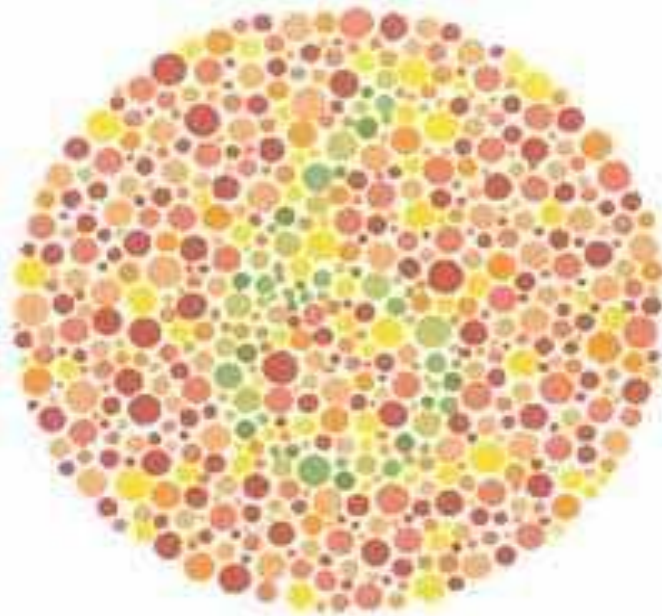
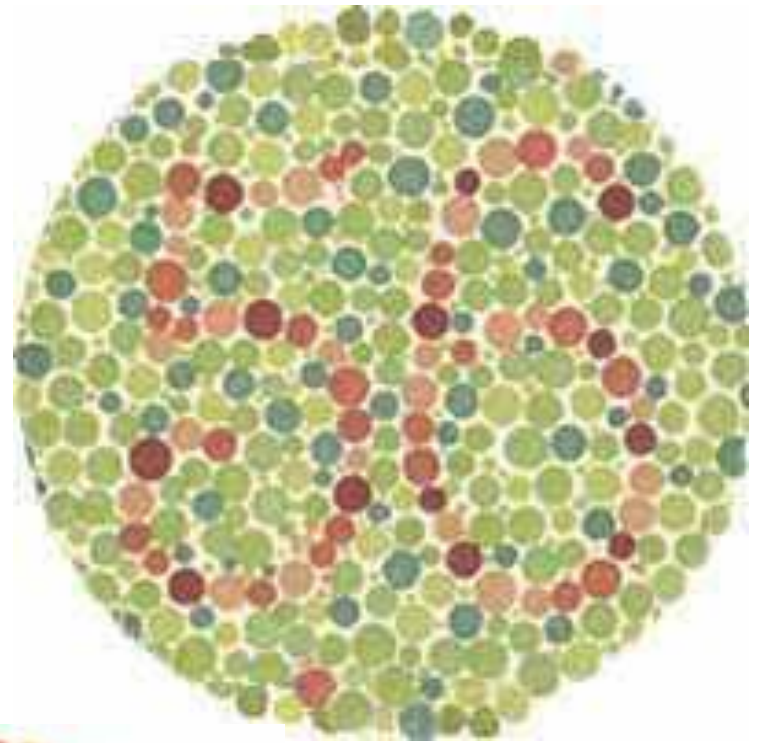
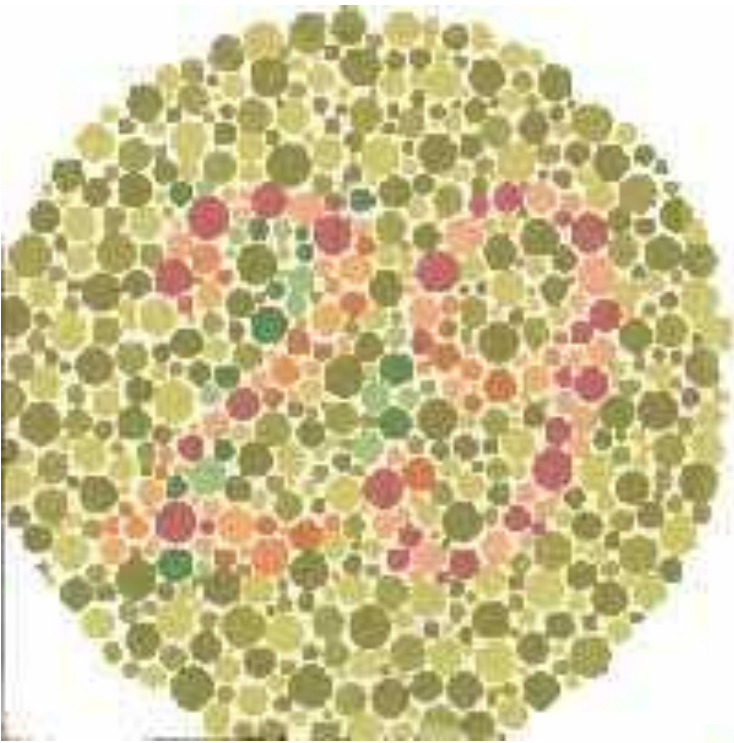
Add eye trait=

$X^R Y$  or  $X^r Y$

“Y” is empty

# Examples of Sex-Linked Traits

- **Red-green colorblindness**
- **Male Pattern Baldness**
- **Hemophilia**
- **Duchenne Muscular Dystrophy**



Ishihara  
test

# Demo Problems

- If a female that has hemophilia mates with a normal blood clotting male what is the likelihood that their son is a hemophiliac? Hemophilia is a recessive sex-linked disorder.
- In humans, red-green colorblindness is a recessive sex-linked trait. What would the phenotypes of offspring be if the father was colorblind and the mother was a carrier?

# Multiple Allele Example Problem

$I^A i$

$I^B i$



A

O

AB

B

$I^A i$

$ii$

$I^A I^B$

$I^B i$