جامعة ديالى
كلية الزراعة – قسم الثروة الحيوانية
د.خالد حامد حسن
استاذ مساعد – تربية وتحسين طيور داجنة

Diyala University
College of Agriculture
Animal Resources Department

Principles of Genetics

Dr. Khalid Hamid Hassan

Section no. (2)

Dihybrid Crosses

The Principle of independent Assortment

Dihybrid Crosses

- Mendel performed experiments with plants that differed in two traits , he crossed plants that produced Yellow , Round seeds with plants that produced Green , Wrinkled seeds .
- The F1 seeds were all yellow and round , the alleles for the two seed traits were dominant .
- Mendel grew plants from these seeds and allowed them to self-fertilize ,and classified the F2 seeds according to their phenotype , as following : Two Classes , yellow round and green wrinkled resembled the parental strains. The other two Classes , green round and yellow wrinkled showed new combinations of traits .

- Mendel noticed that the four classes appeared in ratio of (9) yellow round (3) green round (3) yellow wrinkled (1) green wrinkled
- These numerical relationships suggested a simple explanation : each trait was controlled by a different genes segregating two alleles, and the two genes were inherited independently .

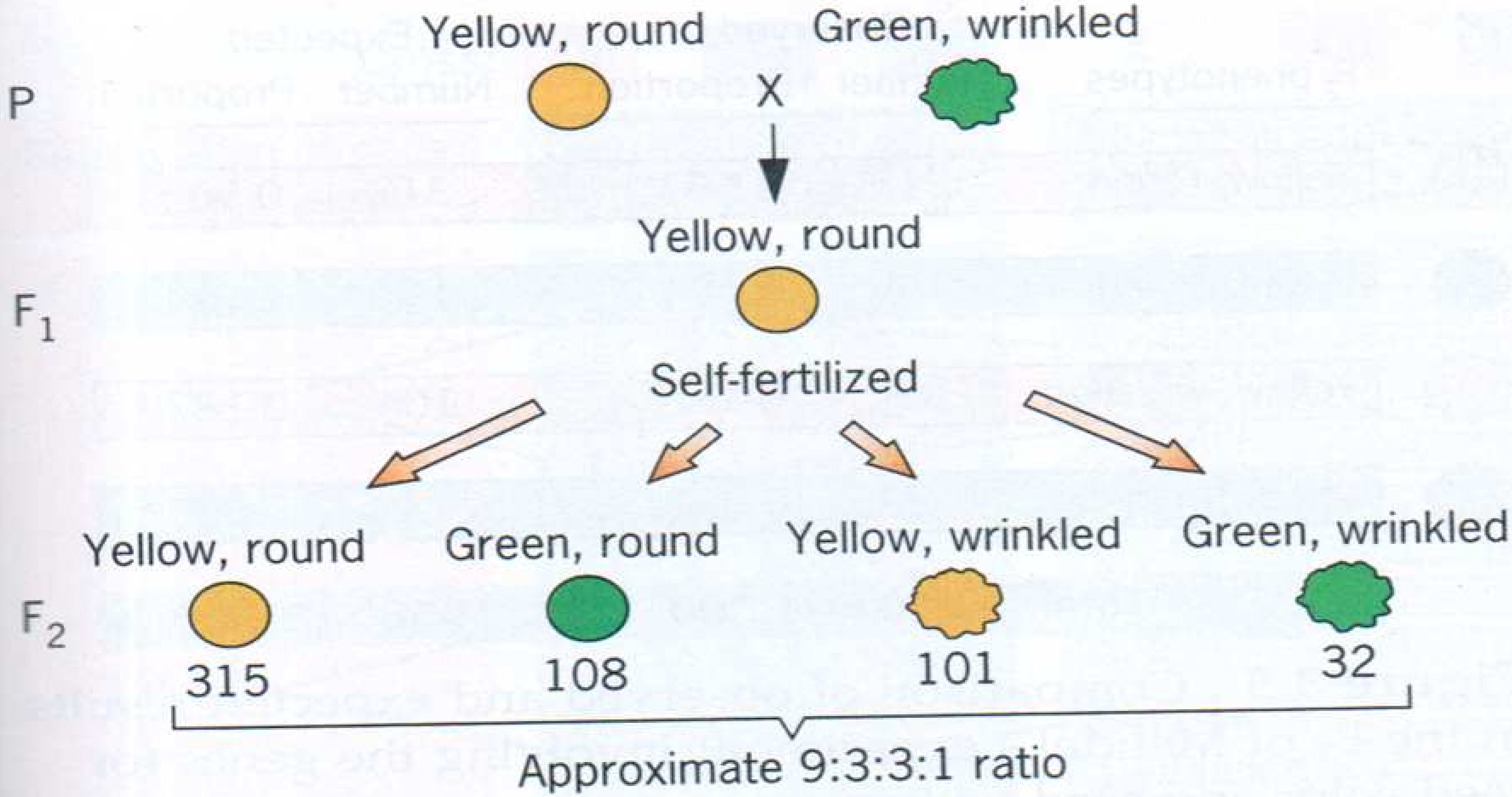
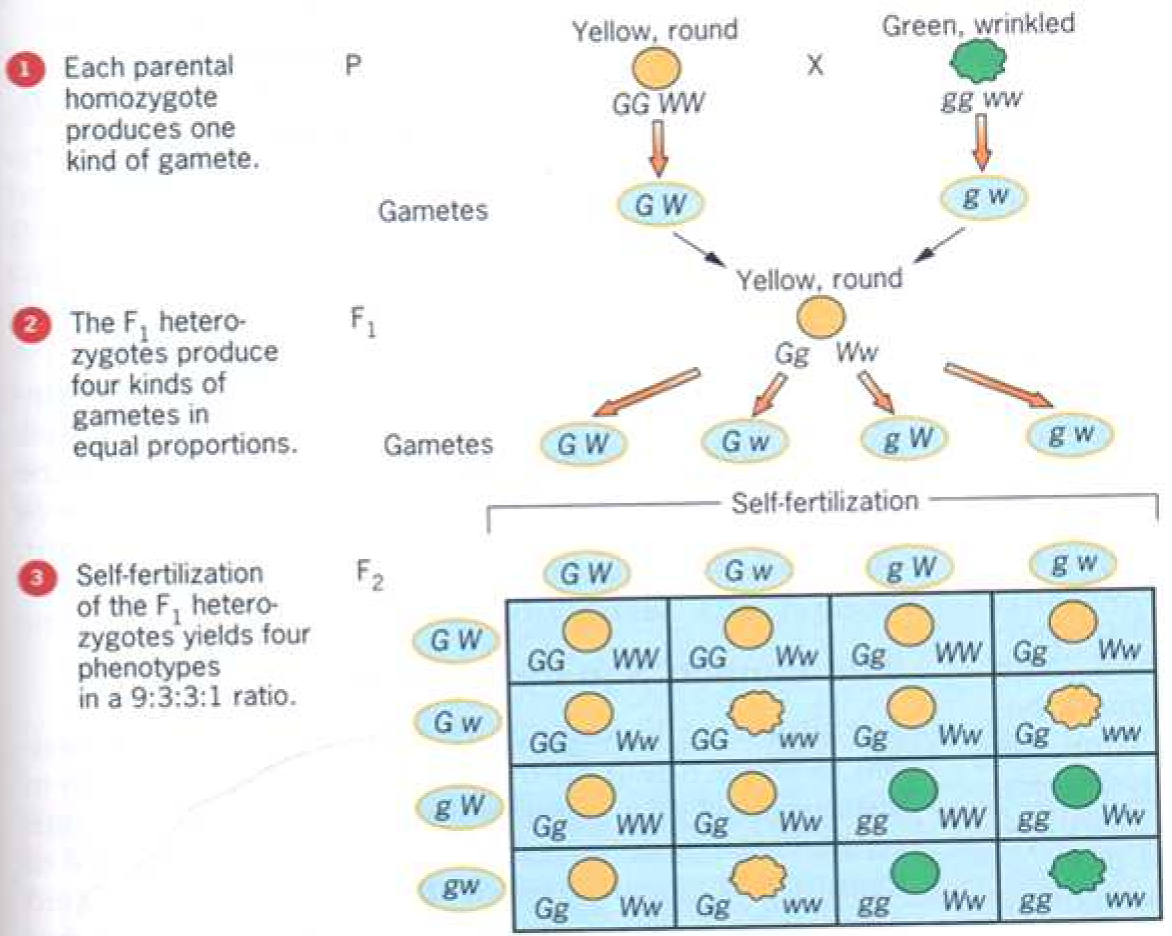


Figure 3.3 Mendel's crosses between peas that produced yellow, round seeds and peas that produced green, wrinkled seeds.



F_2

Phenotypes	Genotypes	Genotypic ratio	Phenotypic ratio
Yellow, round	GG WW	1	9
	GG Ww	2	
	Gg WW	2	
	Gg Ww	4	
Yellow, wrinkled	GG ww	1	3
	Gg ww	2	
Green, round	gg WW	1	3
	gg Ww	2	
Green, wrinkled	gg ww	1	1

Figure 3.4 Symbolic representation of the results of a cross between a variety of peas with yellow, round seeds and a variety with green, wrinkled seeds.

- Let us analyze the results of this two factors using Mendel's methods We denote each gene with a letter , for the seed color gene , the two alleles are g (for green) and G (for yellow) and for seed texture gene , they are w (for wrinkled) and W (for round) .
- The parental strains must have doubly homozygous , the yellow round plants were GGWW and the green wrinkled plants were ggww .
- The haploid gametes produced by a diploid plants contain one copy of each gene , gamete from GGWW plants therefore would be GW . And by similar reason , the gametes from ggww plants are written gw .
- Cross fertilization of these two types of gametes produces F1 hybrids that are doubly heterozygous GgWw and their yellow round phenotype indicates that the G and W alleles are dominant .

- The principle of segregation predicts that the F hybrids will produce four different gametic genotypes : GW , Gw , gW , gw
- If each gene segregates its alleles independently each of the four types will be 25 percent of the total .
- Self-fertilization in the F1 will produce an array of 16 equally frequent zygotic genotypes, while the proportion of the four phenotypic classes were :
  9/16 yellow round , 3/16 yellow wrinkled
  3/16 green round , 1/16 green wrinkled .
- The result of these experiments led Mendel to the principle of independent assortment : ((The alleles of different genes segregate independently of each of each other))

Mendel's experiments established Three basic genetic principles :

- 1- Some alleles are dominant , others recessive .
- 2-During gamete formation , different alleles segregate from each other .
- 3- Different genes assort independently .

Practice Problems

- **Q1**; For each of the following genotypes, give all possible gametes , noting the proportion of each for the individual ? 1- dd GG 2- Dd Gg 3- DD Gg 4- Dd GG .
- **Q2**;In horses , B= black coat dominant over b = brown coat and P= trotter dominant over p= pacer . A black pacer mated to a brown trotter produce a black trotter offspring, give all possible genotypes for this offspring ?
- **Q3**; In humans , short fingers and widows peak are dominant over long fingers and continous hairline. A heterozygote reproduces with a heterozygote .what is the chance of any one childs having the same phenotype as the parents ?

Practice Problems

Q ; Choose the correct answer from the following ?

1- In humans , pointed eyebrows are dominant over smooth eyebrows . Marys father has pointed eyebrows , but she and her mother have smooth , what is the genotype of the father ?

1- BB 2- Bb 3- bb 4- Any one of these .

2- In guinea pigs , smooth coat R is dominant over rough coat r and black coat W is dominant over white coat w . In the cross Rr Ww x Rr Ww , how many of the offspring will have a smooth black coat ? 1- 9 only 2- 9/16 3- 1/16 4- 6/16 .

Allelic Variation and Gene Function

Degrees of dominance

Genes interaction

Multiple alleles

- Mendel's experiments established that genes can exist in alternate forms , Mendel identified two alleles : one dominance , the other recessive .
- This discovery suggested a simple function between alleles , as if one allele did nothing and the other did every thing to determine the phenotype , The interaction between alleles in the same locus (of the same gene) present the following gene functions of dominant and recessive :
- 1- Complete dominance . An allele is dominant if it has the same phenotypic effect in heterozygote as in homozygote , that the genotype Aa and AA are the same phenotype .

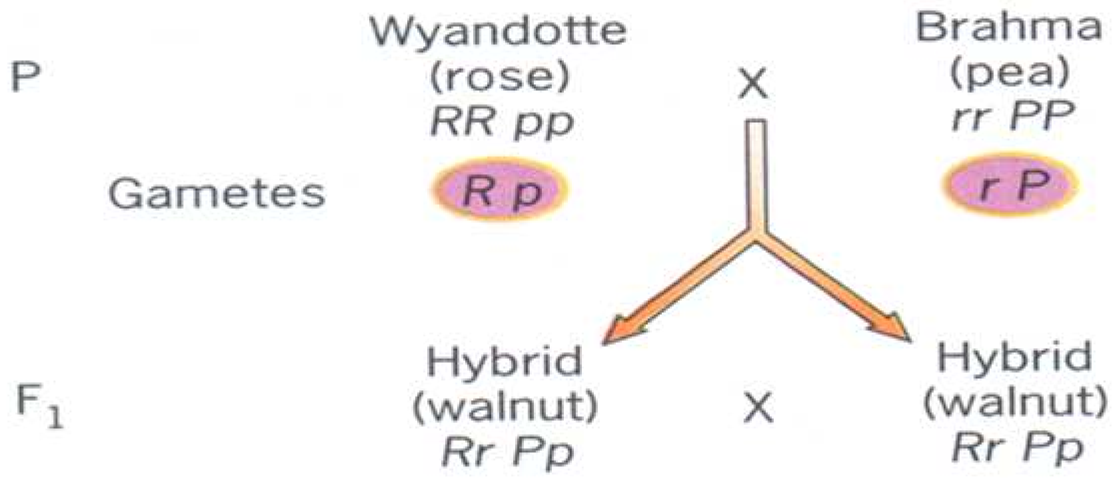
- 2-Incomplete dominance (partial dominance) When a heterozygote has a phenotype different from that of either of its associated homozygotes .
- Flower colors in the snapdragon are white and red varieties are homozygous for different alleles of a color gene , when crossed ,they produced heterozygotes that have Pink flowers, the allele for red color (W) is therefore said to be incompletely dominant over the allele for white color (w) .

- 3-Codominant . In this case there is an independence of allele function , neither allele is dominant or even partial dominant over the other .

Gene interaction

- Some of the first evidences that a trait can be influenced by more than one gene was obtained by Bateson and Punnett from breeding experiments with chickens .
- Domestic breeds of chickens have :
  Rose comb (Wyandotte chickens)
  Pea comb (Brahmas chickens)
  Single comb (Leghorn chickens)
- Crosses between Wyandottes and Brahmas produce chickens that have another type of comb called Walnut comb .

- Bateson and punnett discovered that comb type is controlled by two independently assorting genes R and P each with two allele ,and the interaction between their product result different phenotype.



Male gametes

F_2	R P	R p	r P	r p
R P (Female gametes)	RR PP walnut	RR Pp walnut	Rr PP walnut	Rr Pp walnut
R p (Female gametes)	RR Pp walnut	RR pp rose	Rr Pp walnut	Rr pp rose
r P (Female gametes)	Rr PP walnut	Rr Pp walnut	rr PP pea	rr Pp pea
r p (Female gametes)	Rr Pp walnut	Rr pp rose	rr Pp pea	rr pp single

Summary: 9/16 walnut, 3/16 rose, 3/16 pea, 1/16 singl

Figure 4.14 Bateson and Punnett's experiment on comb shape in chickens. The intercross in the F_1 produces four phenotypes, each highlighted by a different color in the Punnett Square, in a 9:3:3:1 ratio.

- Wyandottes (with rose combs) have the genotype RRpp and Brahmas (with Pea combs) have the genotype rrPP
- The F1 hybrids between these two varieties are therefore RrPp and the phenotypes are walnut combs .
- If these hybrids are intercrossed with each other, all four types of combs appear in the progeny :

9/16 walnut (R- P-)
3/16 rose (R- pp)
3/16 pea (rr P-)
1/16 single (rr pp)

The Leghorn breed ,which has the single comb type must be homozygous for both of the recessive alleles .

Epistasis

- When two or more genes influence a trait ,an allele of one of them may have an overriding effect on the phenotype, when an allele has such effect it said to be epistatic to the other genes that are involved .And the other gene called hypostatic .
- Example : Most meat type male lines of broiler breeder parents are dominant white because they have an autosomal gene that inhibits the production of color in the feathers .The White Leghorn is the only pure colored birds with inhibitor gene that prevent expression of the genes for colored feathers .

- The inhibitor gene is dominant and symbolized as I and its recessive allele enable genes for colored feathers to produce their effects and symbolized as i .
- If a dominant white male II CC crossed with a colored female ii CC all offspring would be white feathers , as following :

parents (P)	II CC	×	ii CC
gametes	I C	↓	i C
F1		Ii CC	

- The epistasis cause deviation from mendelians proportion in the F2 progeny of the following cross :
- When White Leghorn II CC crossed with White Silkie ii cc the results would be :
- Parent (P) II CC × ii cc

gametes I C ↓ i c

F1 (intercrossed) Ii Cc × Ii Cc

gametes I C , I c ,I C,I c ↓

F2 9/16 (I- C-), 3/16 (ii C-) ,3/16(I- cc) ,1/16(ii cc)

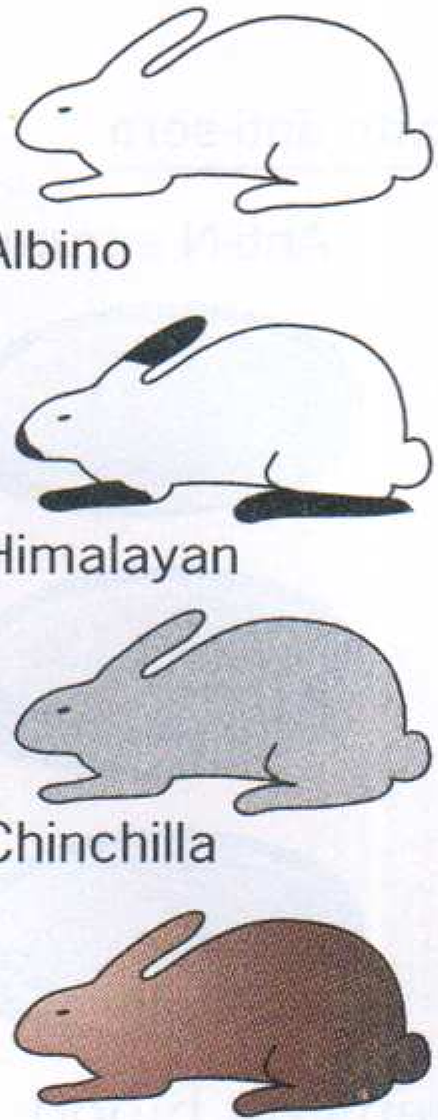
The phenotypic ratio would be : 13 white : 3 colored

Pleiotropy

- Not only is it true that a phenotype can be influenced by many genes , but also true that a gene can influence many phenotypes , it is said Pleiotropic
- For example ; from the study of mutations affecting the formation of bristles in Drosophila, wild type flies have long ,smooth curved bristles on the head and thorax . Flies homozygous for singed bristles mutation have short, twisted bristles on these body parts . This gene also needed for the production of healthy , fertile eggs , we know this fact because females that are homozygous for singed mutation are completely sterile , they lay flimsy ,ill formed eggs that never hatch. However these mutation no adverse effect on male fertility .Thus , the singed gene pleiotropically controls the formation of both bristles and eggs in females and formation of bristles in males .

Multiple Alleles

- Sometimes there are more than two alleles for a given chromosome locus in which case a trait is controlled by multiple alleles . each individual has only two of all the available alleles .
- The classical example for this case is ,In rabbits there are 4 alleles for coat color, and there is a dominance sequence as follow : $c^{+} > c^{ch} > c^{h} > c.$



	Genotype	Phenotype
Albino	cc	White hairs over the entire body
Himalayan	$c^h c^h$	Black hairs on the extremities; white hairs everywhere else
Chinchilla	$c^{ch} c^{ch}$	White hair with black tips on the body
Wild-type	$c^+ c^+$	Colored hairs over the entire body

Figure 4.3 Coat colors in rabbits. The different phenotypes are caused by four different alleles of the *c* gene.

Allelic series

- The functional relationships among the membersof series of multiple alleles can be studied by making heterozygous .
- For example; the four alleles of the c gene in rabbits can be combined with each other to make six different kinds of heterozygotes

$$c\,c^{h};\ c\,c^{ch};\ c\,c^{+};\ c^{h}c^{ch};\ c^{h}c^{+};\ c^{ch}c^{+}$$

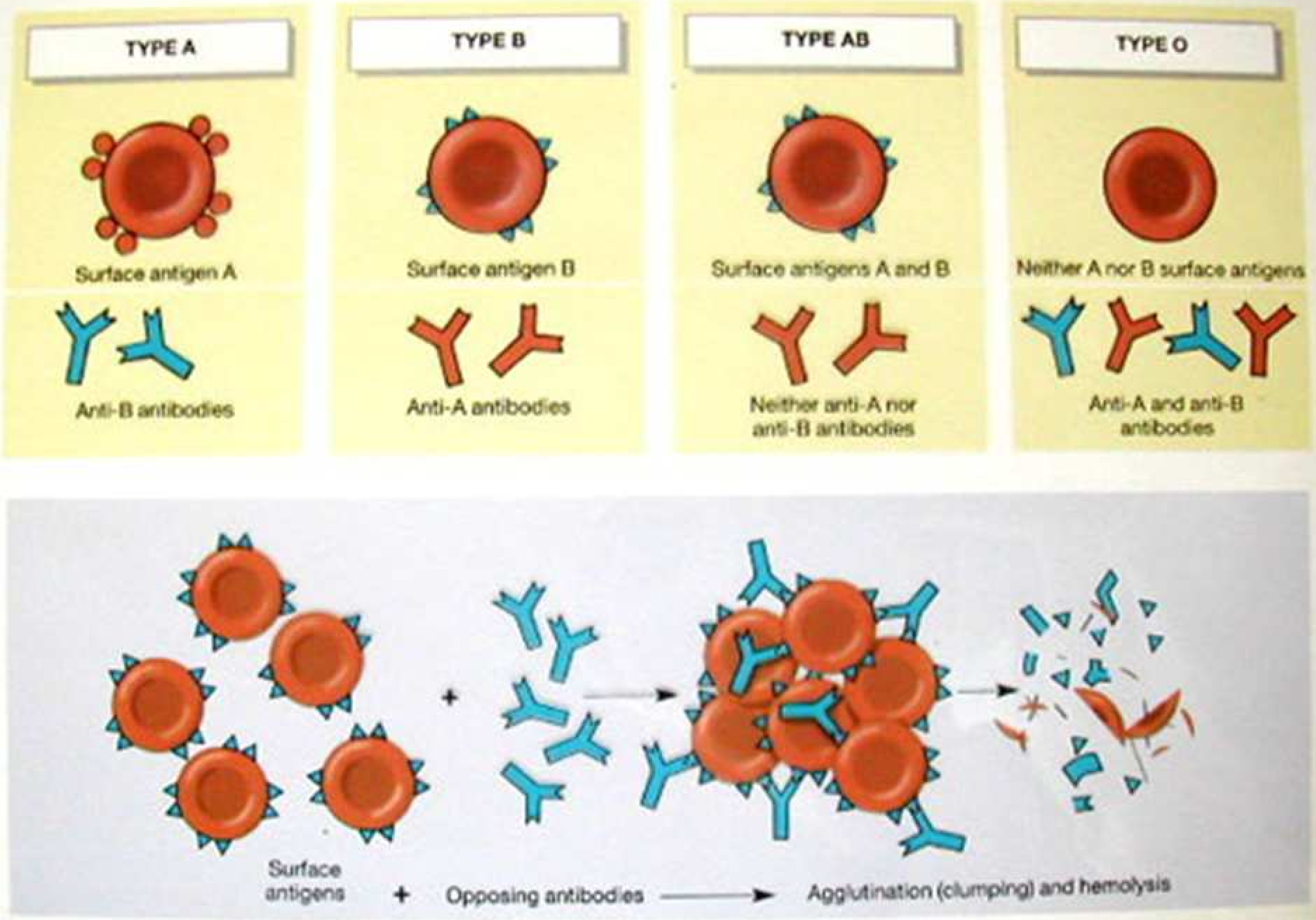
ABO Blood groups iheritance

- Another example of multiple alleles comes from the study of human blood types, the A , B , AB , and O blood types are identified by testing a blood sample with different sera , one serum detects the A antigen another the B antigen .
- When only the A antigen is present on the cells, the blood is type A .
When only the B antigen is present on the cells, the blood is type B .
- When both antigens are present, the blood is type AB .and when neither antigen is present ,it is type O .

- The blood typing for A and B antigens is completely independent of blood typing for M and N antigen .
- The A allele and B allele are codominant scince each is expressed equally in the heterozygous AB , and O allele is recessive to both the A and B alleles .

Fig. 11-6

Blood Typing and Cross Reactions



Genotypes, Phenotypes, and Frequencies in the ABO Blood-Typing System

Genotype	*Blood Type*	*A Antigen Present*	*B Antigen Present*	*Frequency in U.S. White Population (%)*
I^AI^A or I^AI^O	A	+	–	41
I^BI^B or I^BI^O	B	–	+	11
I^AI^B	AB	+	+	4
I^OI^O	O	–	–	44

The inheritance of blood groups in human

I^AI^A I^AI^O	A
I^BI^B or I^BI^O	B
I^AI^B	AB
I^OI^O	O

Genotypes of Crosses		progeny		phenotype
$I^AI^A \times I^AI^A$	=	I^AI^A	=	A
$I^AI^A \times I^OI^O$	=	I^AI^O	=	A
I^BI^B or $I^BI^O \times I^BI^B$	=	I^BI^B or I^BI^O	=	B
$I^BI^B \times I^AI^A$	=	I^AI^B	=	AB
$I^AI^B \times I^OI^O$	=	I^AI^O or I^BI^O	=	A or B

Practice problem

- Q ; A person with type A blood reproduces with a person with type B blood and produce child with type O blood , what the genotype of the parents ?
- Q ; From the following blood types , determine which baby belongs to which parents ?

Parents		Progeny	
Mrs. Doe	Type A	Baby 1	Type O
Mr. Doe	Type A	Baby 2	Type A
Mrs. Jones	Type AB		
Mr. Jones	Type A		

The inheritance of M and N blood Types

- There are two kinds of serum , one serum called anti-M , which recognizes only the M antigen on human blood cells . Another serum , called anti-N , recognizes only the N antigen on the cells. When one of these sera detects its specific antigen in blood – typing test , the cell clump together causing a reaction called agglutination .
- The ability to produce the M and N antigens is determined by a gene with two alleles . One allele allows the M antigen to be produced , the other allows the N antigen to be produced . Homozygotes for the M allele produce only the M antigen .and homozygotes for the N allele produce only the N antigen .

- The heterozygotes for these two alleles produce both kinds of antigens because the two alleles appear to contribute equally to the phenotype of the heterozygotes . So they are said to be Codominant .
- The different genotypes shown in the following :

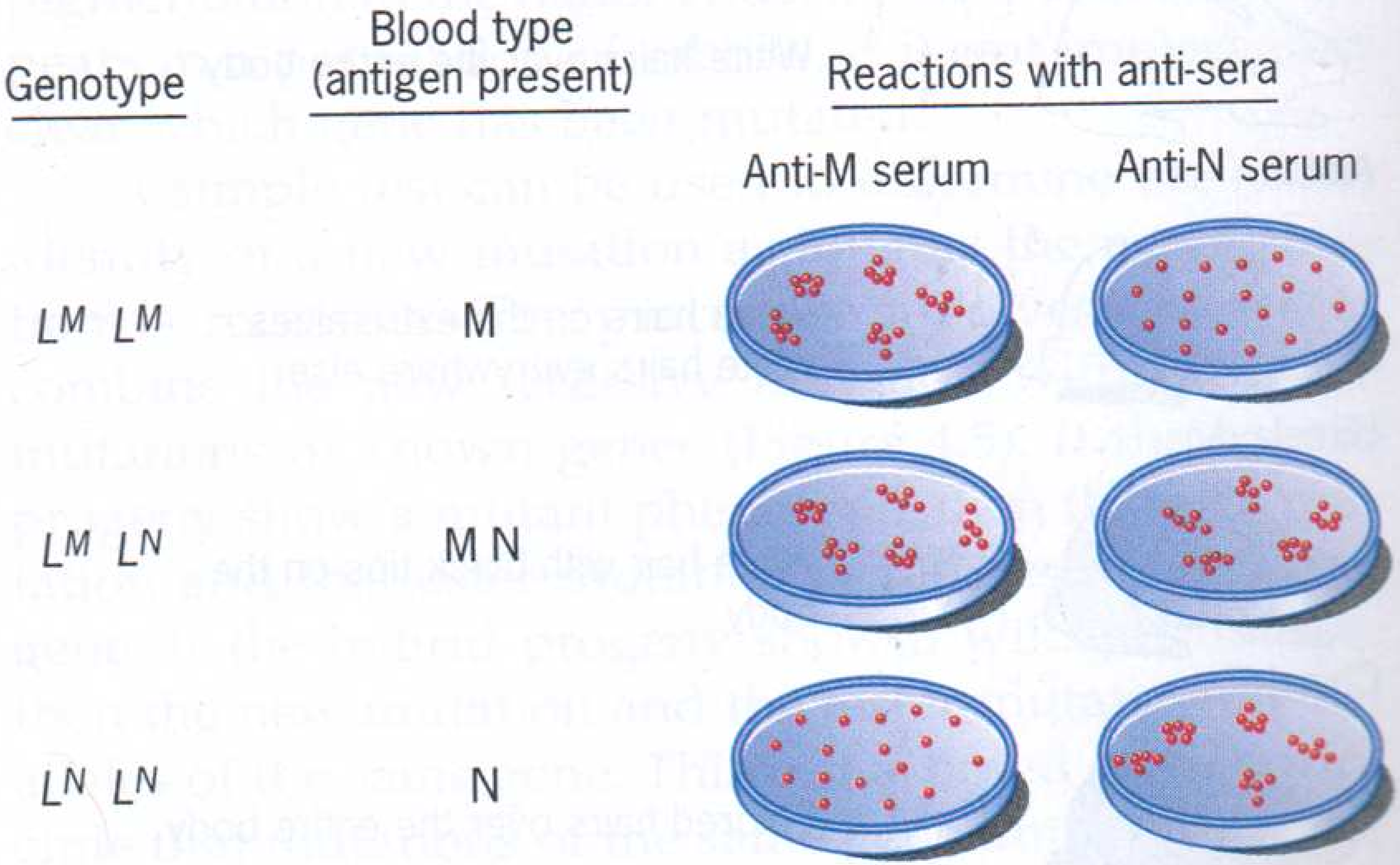


Figure 4.2 Detection of the M and N antigens on blood cells by agglutination with specific anti-sera. With the anti-M and anti-N sera, three blood types can be identified.

The Rh Blood Factor

- Rh Factor ; Antigen in the red blood corpuscles of certain people . A pregnant Rh negative woman carrying an Rh positive child may develop antibodies , causing the child to develop a hemolytic disease .
- The Rh blood factor is inherited separately from types A , B , AB , or O type blood , in each instance, it is possible to be Rh positive or Rh negative.

- When you are Rh positive ,there is a particular antigen on the red blood cells, and when you are Rh negative, it is absent . It can be assumed that the inheritance of this antigen is controlled by a single allele pair in which simple dominance prevails.
- The Rh positive allele is dominant over the Rh negative allele , complications a rise when an Rh negative woman reproduces with an Rh positive man and the child in the womb isRh positive , the woman may begin to produce antibodies that will attack the red blood cells of this baby or of a future Rh positive baby .