Ministry of Higher Education
& Scientific Research
Al Muthanna University
College of Veterinary Medicine
Division of public health

Subject: Genetics
Grade: 2
Lecture : 11

Gene interaction

Gene interactions occur when two or more different genes influence the outcome of a single trait .
Interaction between allelic or non-allelic genes of the same genotype in the production of particular phenotypic characters .

- There may be more than two alleles for a given locus within the population.
- Dominance of one allele over another may not be complete.
- Two or more genes may affect a single trait.
- The expression of a trait may be dependent on the interaction of two or more genes, on the interaction of genes with non genetic factors, or both.

The molecular basis of Dominance

- A character is dominant if it is seen in the homozygous and heterozygous genotypes, and it is called recessive if it is observe in only in a single homozygous genotype .
- The dominance of one allele over an another allele is determined by the activity of protein products of allele by- the manner in which the protein products of allele work to produce the phenotype.
- Wild-type allele are allele that encodes the phenotype most common in a particular natural population .It is often designated, in genetic shorthand, as "+".
- Mutant allele any form of that allele other than the wild type allele

Haplosufficiency: The situation in which an individual who is homozygous or heterozygous is dominant and sufficient to produce wild-type phenotype.

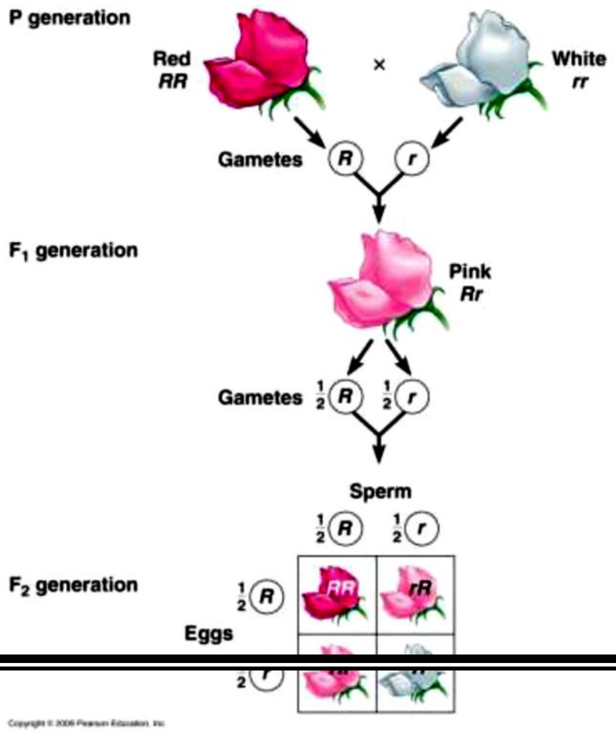
Haploinsufficiency: The situation in which an individual who is heterozygous or hemizygous is incapable of providing sufficient protein production as to assure normal function

Effect of Mutation

- Mutation disrupts normal gene function.
- Wild-type allele, mutant allele can often be placed into either loss-of-function or a gain-of-function category. Effects of Mutation

Incomplete dominance

The Incomplete dominance (partial dominance)where dominance of an allele over other is not complete . • Third phenotype appear which are differ from parent homozygote phenotype but are closer to one homozygous phenotype than the other. • Example Mirabilis Jalapa (4 O’clock plant)



Codominance

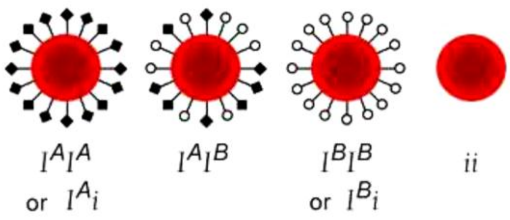
It is like to incomplete dominance, leads to a heterozygous phenotype different from the phenotype of either homozygous parent.

Codominance is characterized by the detectable expression of both alleles in heterozygotes.

Codominance is most clearly identified when the protein products of both alleles are detectable in heterozygous organisms .

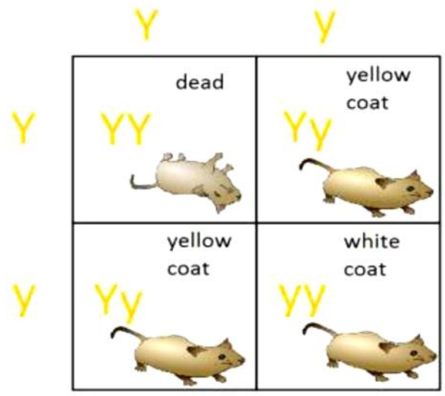
Example

Blood type	Genotype	
A	I^A, I^O	AO
	I^A, I^A	AA
B	I^B, I^O	BO
	I^B, I^B	BB
AB	I^A, I^B	AB
O	I^O I^O	OO



Lethal Mutation

- Alleles that cause an organism to die only when present in homozygous condition are called lethal alleles.
- Lethal alleles are often inherited as recessive mutants, recessive lethal alleles that kill only homozygotes.
- Lethal alleles are often detected as distortions in segregation ratios, where one or more classes of expected progeny are missing.
- Example coat colour gene in mice
- 3:1 (viable : dead)

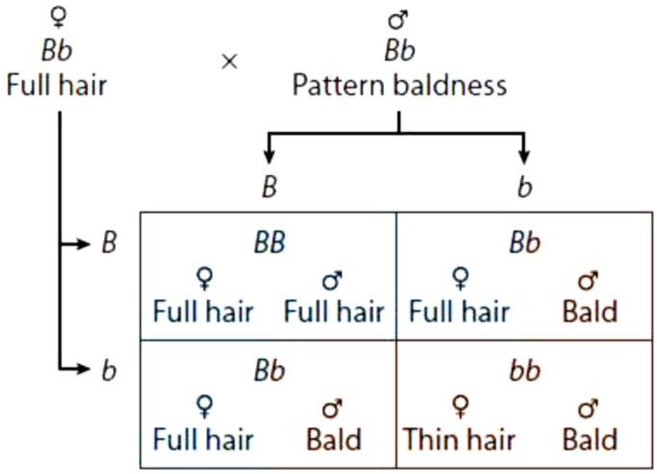


Sex Influenced Traits

- Sex-influenced traits are those in which the phenotype corresponding to a particular genotype .
- Example : BALDNESS
- Male hormones are a principal factor influencing substantial male hair loss whereas in females, the hair thins on top of the head but is not completely lost as males .

BB – Full hair (in both female and male)
Bb - express pattern baldness(male) No baldness in female
bb - express pattern baldness(male) No baldness in female

Thus, the B allele is dominant to the b allele in females, while the opposite is true in males.



Some Genes Produce Variable Phenotype

Incomplete Penetrance : When particular genotype fail to produce the corresponding phenotype . In which organism is non -penetrant for that trait . Example : Polydactyly **Variable Expressivity** : Expressivity is a term used in genetics to refer to variations in a phenotype among individuals carrying a particular genotype. Variable expressivity occurs when a phenotype is expressed to a different character among individuals with the same genotype. Example : waardenburg syndrome Waardenburg syndrome May have any or all of four principal features of the syndrome: (1) hearing loss (2) differently coloured eyes . (3) a white forelock of hair . (4) premature graying of hair.

Gene Enviroment Interaction

It is the result of the influence of environmental factors (i.e., nongenetic factors) on the expression of genes and on the phenotypes of organisms . Example : Phenylketonuria (PKU) is an autosomal recessive disorder

Pleiotropy

- One gene controls many phenotypic character . Example : SICKEL CELL DISEASE (SCD)
- SCD is an autosomal recessive condition caused by mutation of the β- globin gene that, in turn, affects the structure and function of haemoglobin, the main oxygen-carrying molecule in red blood cells.

Epistasis and Its Result

- An allele of one gene masks the expression of alleles of another gene and expresses its own phenotype instead.
- Gene that masks = epistatic gene
- Gene that is masked = hypostatic gene
- Genes that code for enzymes that are upstream in a biochemical pathway usually exert epistasis ("standing on").

Examples of Epistasis Pattern

- No Interaction (9:3:3:1 ratio)
- Complementary Gene Interaction (9:7 ratio)
- Duplicate Gene Interaction (15:1 ratio)
- Dominant Gene Interaction (9:6:1 ratio)
- Recessive Epistasis (9:3:4 ratio)
- Dominant Epistasis (12:3:1 ratio)
- Dominant Suppression (13:3 ratio)

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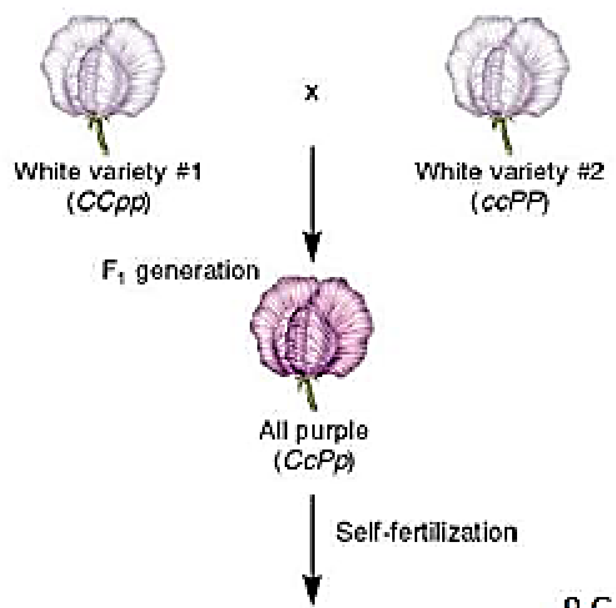
COMPLEMENTARY GENE INTERACTION
9:7 RATIO

Example: sweet pea (*Lathyrus odoratus*) flower color

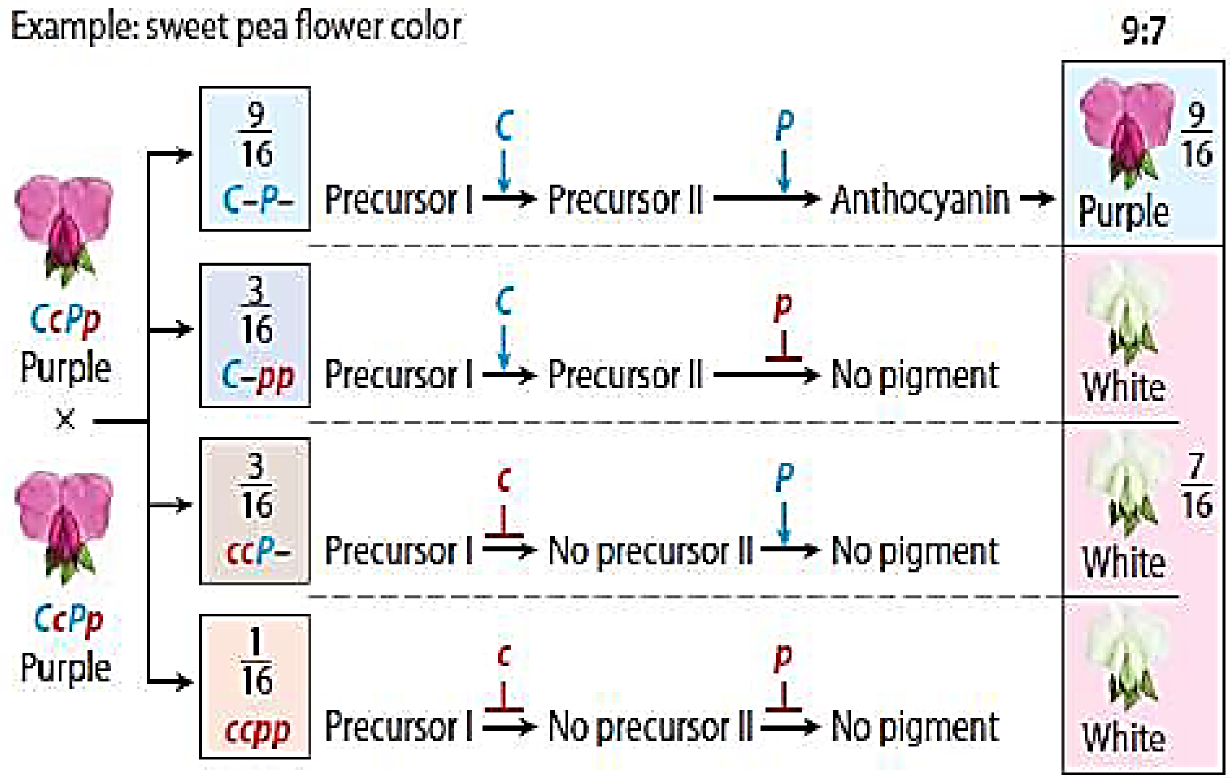
Figure 4.18



	CP	*Cp*	*cP*	*cp*
CP	*CCPP* Purple	*CCPp* Purple	*CcPP* Purple	*CcPp* Purple
Cp	*CCPp* Purple	*CCpp* White	*CcPp* Purple	*Ccpp* White
cP	*CcPP* Purple	*CcPp* Purple	*ccPP* White	*ccPp* White
cp	*CcPp* Purple	*Ccpp* White	*ccPp* White	*ccpp* White

9 C_P_ : 3 C_pp :3 ccP_ : 1 ccpp

purple (9 C_P_) ; white (3 C_pp :3 ccP_ : 1 ccpp)

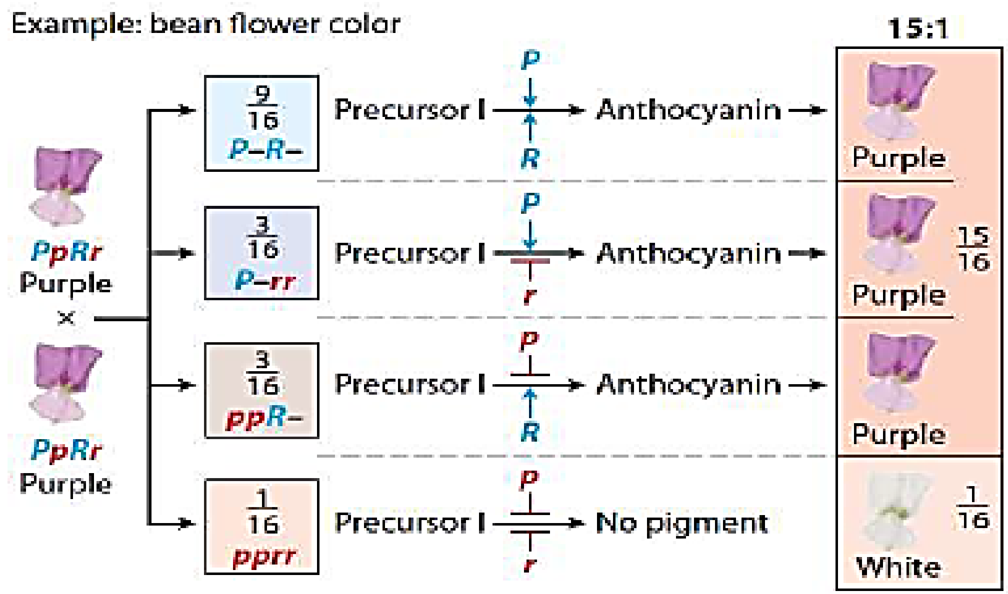


❖ **C** and **P** products controlling different steps of anthocyanin synthesis pathway . Since anthocyanin production requires the action of the product of **C** as well as the product of **P** , both step must be successfully completed for anthocyanin production and deposition in flower petals .

DUPLICATE GENE INTERACTION

15:1 RATIO

Example: bean flower color

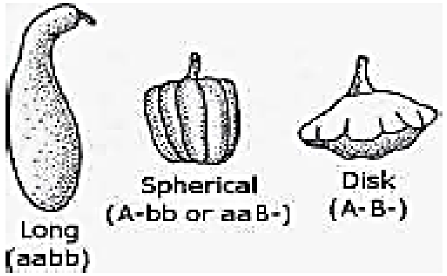


- Dominant allele at either locus is capable of catalyzing the conversion of precursor of anthocyanin and producing dominant phenotypes. Conversely if recessive homozygous allele are present at both loci no functional gene product is produced and synthesis pathway does not completed

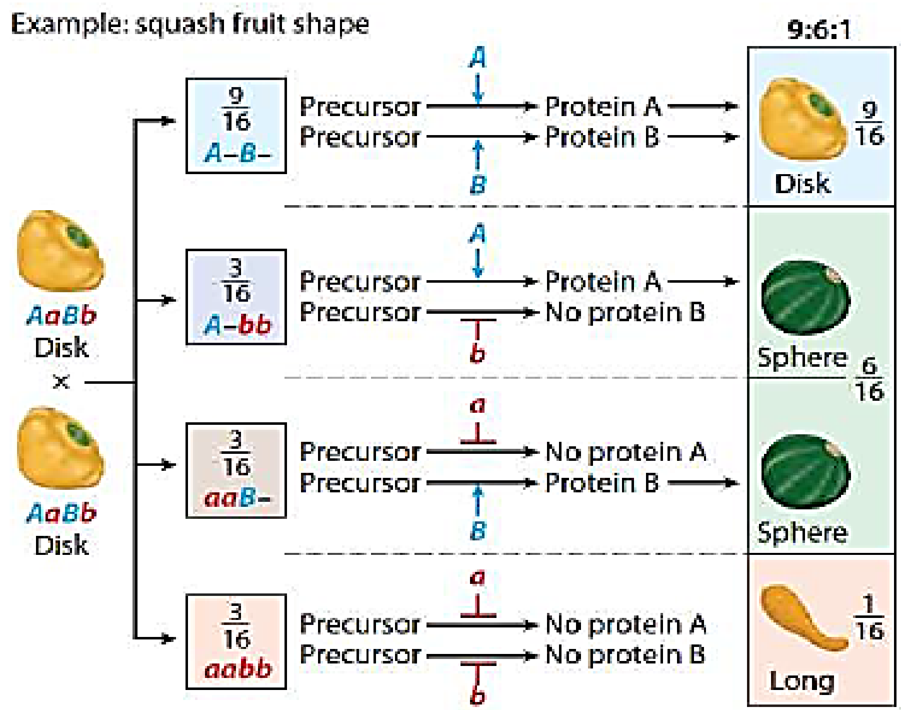
DOMINANT GENE INTERACTION

9:6:1 RATIO

Example: squash fruit shape

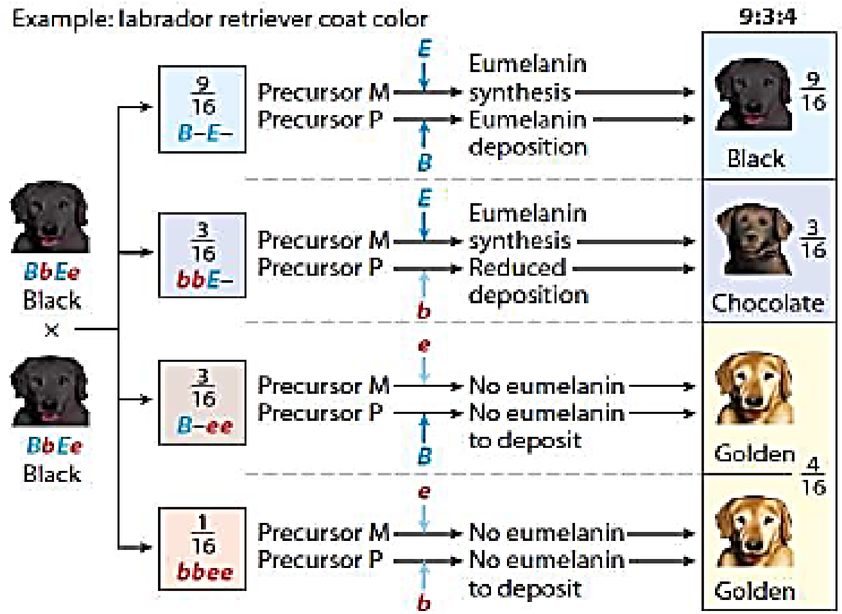


F2 ratio for A/a × A/a	F2 ratio for B/b × B/b	Combined F2 ratio	F2 phenotypic proportions	
$\frac{3}{4}$ A/_	$\frac{3}{4}$ B/_	$\frac{9}{16}$ A/_ B/_	$\frac{9}{16}$ disk-shaped	
	$\frac{1}{4}$ b/b	$\frac{3}{16}$ A/_ b/b	$\frac{3}{16}$ sphere-shaped	$\frac{1}{16}$ sphere- shaped
$\frac{1}{4}$ a/a	$\frac{3}{4}$ B/_	$\frac{3}{16}$ a/a B/_	$\frac{3}{16}$ sphere-shaped	
	$\frac{1}{4}$ b/b	$\frac{1}{16}$ a/a b/b	$\frac{1}{16}$ long-shaped	



❖ Plant at least one dominant at each locus (**A-b-**) have disc shaped fruit m plant with recessive allele at each locus (**aabb**) produces long fruit and plant are homozygous recessive at either of the loci (**A-bb or aaB-**) produce spherical fruit **.**

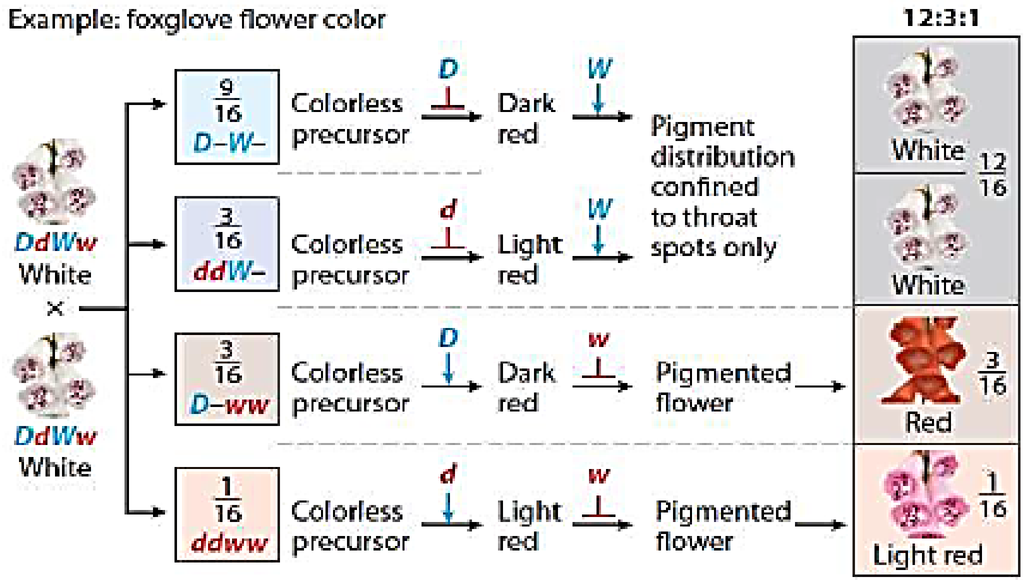
RECESSIVE EPISTASIS
9:3:4 RATIO



- **B gene is TYRP1** gene that controls melanin distribution . The wild-type allele **B** produces full **melanin distribution** , mutant allele b reduced distribution .**Gene E IS MCIR** that controls eumelanin synthesis. **Gene E** permit synthesis but **mutant allele** e does not .

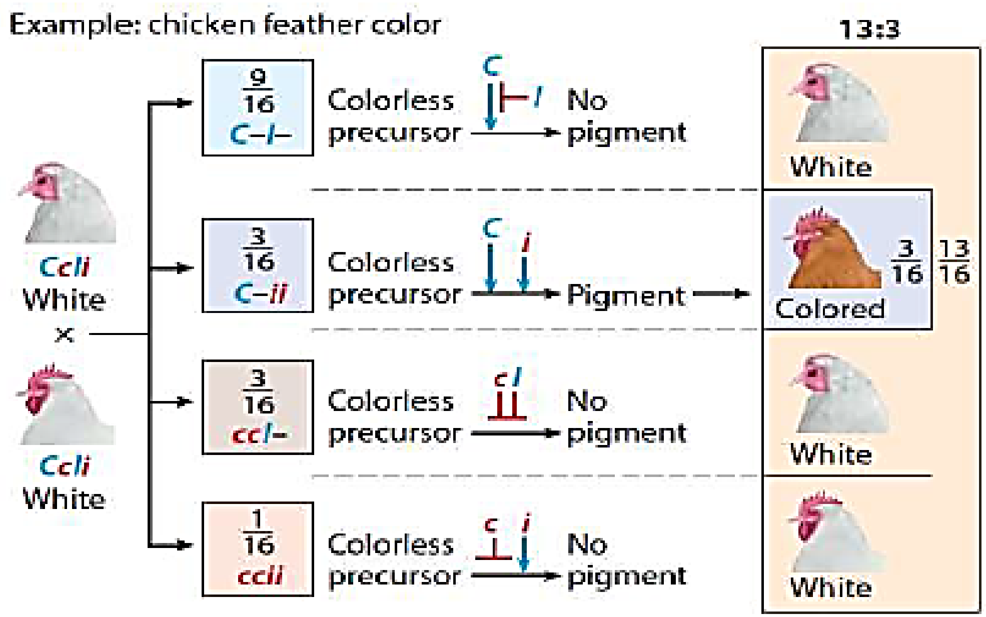
DOMINANT EPISTASIS
12:3:1 RATIO

Example: foxglove flower color



- Wild-type allele **d** produces a light red pigment seen in flowers and a mutant allele **D** produces a dark red flower pigment . At another gene allele **w** is wild type allele that distribute pigment throughout the flower . A mutant allele **W** restrict the pigment to the flower .

DOMINANT SUPPRESSION
13:3 RATIO



- Product of allele **C** converts colorless precursors into pigment , whereas the allele c product is inactive and fails to convert to the precursors , resulting in white feather color for **cc** genotype . Dominant suppression of **C** by the product of **I** prevent the pigment production in chicken with ***C-I-*** genotype.

SUMMARY OF EPISTASIS

Gene interaction:	None	Complementary	Duplicate	Dominant	Recessive epistasis	Dominant epistasis	Dominant supression
Phenotype ratio:	9:3:3:1	9:7	15:1	9:6:1	9:3:4	12:3:1	13:3
Genotype ratio $\frac{1}{16}$ *AABB*, $\frac{2}{16}$ *AaBB*, $\frac{2}{16}$ *AABb*, $\frac{4}{16}$ *AaBb*	$\frac{9}{16}$ *A–B–*	$\frac{9}{16}$ *A–B–*	*A–B–*	$\frac{9}{16}$ *A–B–*	$\frac{9}{16}$ *A–B–*	*A–B–*	$\frac{9}{16}$ *A–B–*
$\frac{1}{16}$ *AAbb*, $\frac{2}{16}$ *Aabb*	$\frac{3}{16}$ *A–bb*	*A–bb*	$\frac{15}{16}$ *A–bb*	*A–bb*	$\frac{3}{16}$ *A–bb*	$\frac{12}{16}$ *A–bb*	$\frac{3}{16}$ *A–bb*
$\frac{1}{16}$ *aaBB*, $\frac{2}{16}$ *aaBb*	$\frac{3}{16}$ *aaB–*	$\frac{7}{16}$ *aaB–*	*aaB–*	$\frac{6}{16}$ *aaB–*	*aaB–*	$\frac{3}{16}$ *aaB–*	*aaB–*
$\frac{1}{16}$ *aabb*	$\frac{1}{16}$ *aabb*	*aabb*	$\frac{1}{16}$ *aabb*	$\frac{1}{16}$ *aabb*	$\frac{4}{16}$ *aabb*	$\frac{1}{16}$ *aabb*	$\frac{4}{16}$ *aabb*