Gene Interactions

Interactions of genotype and environment and their effect on phenotype

Gene Interactions

- Soon after Mendels's discovery, experimentation revealed that phenotypic characters were often under the control of more than one gene pair.
- It became clear that each phenotypic character is influenced by many gene products.

Gene Interactions

- The concept of gene interaction does not necessarily mean that two or more genes, or their products interact directly to influence a particular phenotype.
- Instead, it is the total cellular function of numerous gene products that come together and contribute to the development of a common phenotype.

Assumptions

- In studying gene interactions, several assumptions and certain conventions are made and adopted.

(i) the genes considered in each cross are **unlinked** and therefore assort independently of one another during gamete formation.

Assumptions

(ii) if complete dominance exists between the alleles of any gene pair, such that AA and Aa or BB and Bb are equivalent in their genetic effects, the designation A- or B- will be used for both combinations.

This means (-) indicates that either allele may be present without consequence.

Assumptions

(iii) all P_1 crosses will involve homozygous individuals:

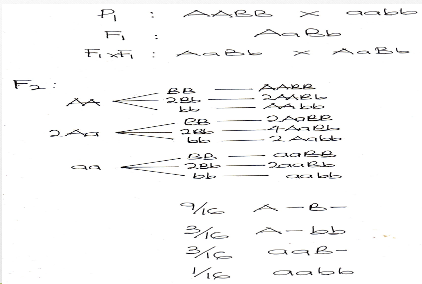
(e.g. AABB x aabb or AAbb x aaBB)

Therefore, each F_1 generation will consist of only heterozygotes of genotype AaBb.

Assumptions

(iv) In each example, the F_2 generation produced from the heterozygous parents will be the **main focus of analysis**.

Example



Gene Interactions

When two genes are involved, the F_2 genotypes will fall into FOUR categories:

9/16 A-B-, 3/16 A-bb, 3/16 aaB-, and 1/16 aabb

Gene Interactions

- The study of gene interaction has revealed inheritance patterns where these four categories are grouped together in various ways, such that each grouping yields a different phenotype.
- i.e., the classical Mendelian dihybrid ratio of 9:3:3:1 can be modified in several ways and are referred to as **modified dihybrid ratios**.

Epistasis

- One important type of functional interaction between different genes occurs ***when an allele or genotype at one locus "masks" or inhibits the expression of a nonallele or genotype at a different or distinct locus.***
- Such an interaction is called **Epistasis**.

Epistasis

- This means, any gene that masks the expression of another nonallelic gene is epistatic to that gene.
- The gene whose expression is suppressed is the hypostatic gene.

Epistasis

- Epistasis should not be confused with dominance.
- It is the interaction between different genes (nonalleles).
- Dominance, on the other hand, is the interaction between different alleles of the **same** gene.

Epistasis is manifested in numerous ways

- The homozygous condition of a recessive allele may prevent the expression of a different gene.
- The presence of a dominant allele of one gene may mask the expression of a dominant or recessive allele of another gene.

Epistatic Interactions

- When epistasis is operative between two loci, the number of phenotypes appearing in the offspring from dihybrid parents will be less than four.
- There are six types of epistatic ratios commonly recognized.
- Three of them have three phenotypes and the other three have only two phenotypes.

Summary of Epistatic Ratios

GENOTYPES	A-B-	A-bb	aaB-	aabb
Classical ratio	9	3	3	1
Dominant epistasis	12		3	1
Recessive epistasis	9	3	4	
Duplicate genes with cumulative effect	9	6		1
Duplicate dominant genes	15			1
Duplicate recessive genes	9	7		
Dominant and recessive interaction	13		3	

Dominant epistasis (12:3:1)

- When the dominant allele at one locus, e.g., the A allele, produces a certain phenotype regardless of the allelic condition of the other locus, then, the A-locus is said to be epistatic to the B-locus.

GENOTYPES	A-B-	A-bb	aaB-	aabb
Classical ratio	9	3	3	1
Dominant epistasis	12		3	1

Dominant epistasis

- The situation where the dominant allele A is able to express itself even in the presence of either B or b, is called **dominant epistasis**.
- Only when the genotype of the individual is homozygous recessive at the epistatic locus (aa) can the alleles of the hypostatic locus (B and b) be expressed.

Dominant epistasis

- Thus, the genotypes **A-B-** and **A-bb** produce the same phenotype, whereas **aaB-** and **aabb** produce two additional phenotypes.
- The classical 9:3:3:1 ratio becomes modified into a 12:3:1.

Recessive Epistasis (9:3:4)

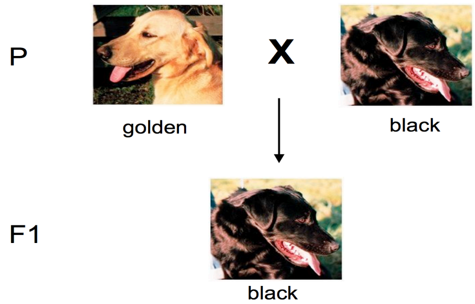
- If the recessive genotype at one locus (e.g. aa) suppresses the expression of the alleles at the B-locus, then the A- locus is said to exhibit recessive epistasis over the B-locus.
- It is only when the dominant allele is present at the A-locus can the alleles of the hypostatic B-locus be expressed.

Recessive epistasis

- The genotypes **A-B-** and **A-bb** produce two additional phenotypes.
- Thus, the 9:3:3:1 ratio becomes a 9:3:4 ratio.

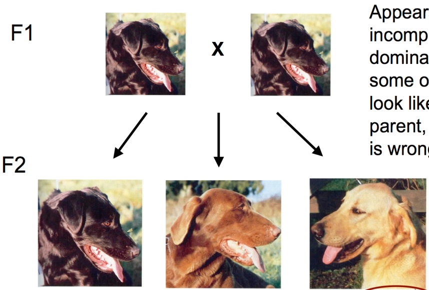
GENOTYPES	*A-B-*	*A-bb*	*aaB-*	*aabb*
Classical ratio	9	3	3	1
Recessive epistasis	9	3	4	

Coat-Color Inheritance in Labrador Retrievers



Recessive Epistasis:

a recessive mutation in one gene masks the phenotypic effects of another



Appears like incomplete dominance because some of the progeny look like neither parent, but the ratio is wrong.

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Dihybrid Cross:

F2

	BE	Be	bE	be
BE	BBEE	BBEe	BbEE	BbEe
Be	BBEe	BBee	BbEe	Bbee
bE	BbEE	BbEe	bbEE	bbEe
be	BbEe	Bbee	bbEe	bbee

9 black: 3 brown: 4 golden

(9 B-E-: 3 bbE-: 3 B-ee: 1 bbee)

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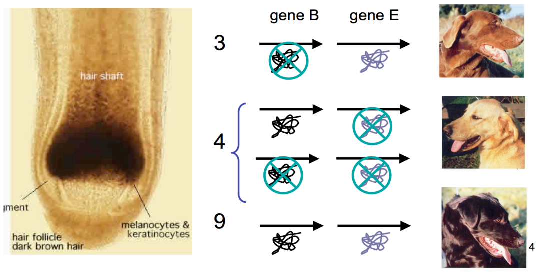
Molecular Explanation

Pigment production (B) and subsequent incorporation (E) into the hair shaft are controlled by two separate genes. To be black, both genes must function. Mutations in B (b) lead to brown pigment. Mutations in E (e) lead to no pigment in coat.



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Duplicative Recessive Genes (9:7)

- In the case where identical phenotypes are produced by both homozygous recessive genotypes, the F_2 ratio becomes 9:7.
- The genotypes **aaB-**, **A-bb**, and **aabb** produce one phenotype. Both dominant alleles, when present together, complement each other and produce a different phenotype.

GENOTYPES	*A-B-*	*A-bb*	*aaB-*	*aabb*
Classical ratio	9	3	3	1
Duplicate genes with cumulative effect	9	6		1

Solved Problem

Two white-flowered strains of the sweet pea (*Lathyrus odoratus*) were crossed, producing an F_1 with only purple flowers. Random crossing among the F_1 produced 96 progeny plants, 53 exhibiting purple flowers, and 43 with white flowers.

(a) What phenotypic ratio is approximated by the F_2?

Solved problem

- (b) What type of interaction is involved?
- (c) What were the probable genotypes of the parental strain?

Solution

(a) To determine the phenotypic ratio in terms of the familiar sixteenth, then, the following proportion for white flowers may be made:

43/96 = x/16, this means x = 7.2 (white)

53/96 = x/16, this means x = 8.8 (purple)

The approximated phenotypic ratio is 7:9

Solution

- (b) A 7:9 ratio is characteristic of duplicative recessive genes where the recessive genotype at either or both of the loci produces the same phenotype.

GENOTYPES	*A-B-*	*A-bb*	*aaB-*	*aabb*
Classical ratio	9	3	3	1
Duplicate recessive genes	9	7		

Solution

- (c) If ***aa*** or *bb* or both could produce white flowers, then only the genotype ***A-B-*** could produce purple.
- For two white parental strains (pure lines) to be able to produce an all-purple F_1, they must be homozygous for different dominant-recessive combinations.

Solution

P: aaBB x AAbb
(white) (white)
F_1: AaBb (purple)
F_2: 9/16 A-B- = 9/16 purple
3/16 A-bb
3/16 aaB-
1/16 aabb