Interacting genes

http://www.erin.utoronto.ca/~w3bio/bio207/index.htm

February 15

Course Overview

Outline Week	Topic	Chapter
1	Course objectives and Introduction to genetics	Ch. 1 & Ch. 2
2	Human Pedigrees	Ch. 2
3	Patterns of Inheritance: sex-linkage	Ch. 2
4	Chromosomal basis of inheritance	Ch. 3
5	Changes in chromosome number	Ch. 15
6	Gene Mapping	Ch. 4
7	Gene to Phenotype	Ch. 6
8	Modified Mendelian ratios	Ch. 6
9	Model organisms and mutants	Ch. 6 (Ch. 16)
10	Genetics of Plant Development (Arabidopsis)	Ch. 18
11	Genetics of Animal Development (Drosophila)	Ch. 18
12	Behaviour Genetics/Quantitative genetics	Ch. 16 + papers

Complementation

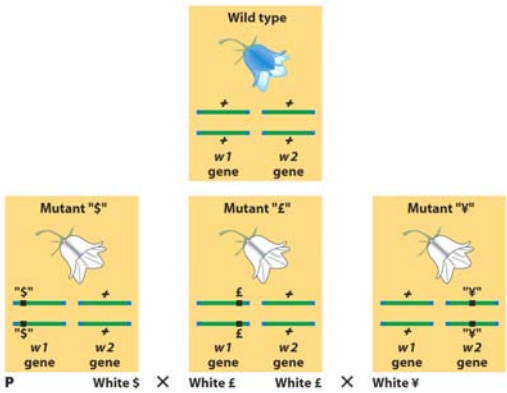
- Complementation: the production of a wildtype phenotype when two haploid genomes bearing different recessive mutations are united in the same cell
- The complementation test: a cross between two individuals that are homozygous recessive for different recessive mutants
  - If the recessive mutations are alleles of the same gene they will not produce wildtype progeny because the progeny are homozygous recessive.

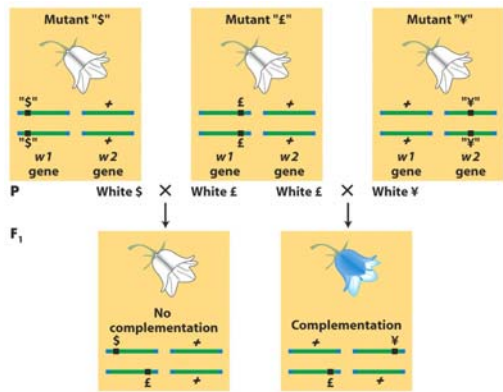
Complementation

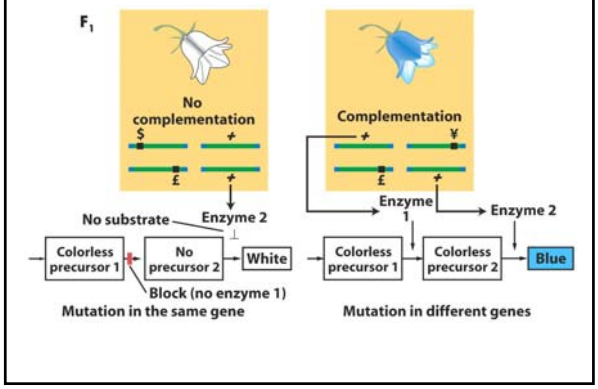
- Three homozygous pure-breeding white flowered harebell plants were crossed to wildtype (blue flowered) harebell plants
- What ratio of progeny do you expect in the F1 and F2 of a selfcross?

- White X blue
- F1 blue
- F2, ¾ blue, ¼ white
- For each of the white plants

- Complementation test:
  - White $ x white £ F_1 = all white
  - White $ x white ¥ F_1 = all blue
  - White £ x white ¥ F_1 = all blue

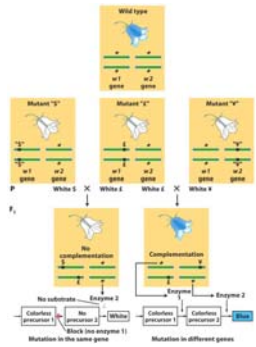






Complementation test

- Complementation test:
  - $ w1/w1 x $w2^+/w2^+$
    F_1 = all white
  - £ w1/w1 x $w2^+/w2^+$
    F_1 = all blue
  - ¥ $w1^+/w1^+$ x w2/w2
    F_1 = all blue

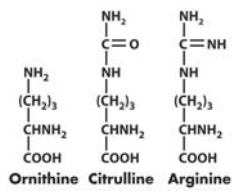


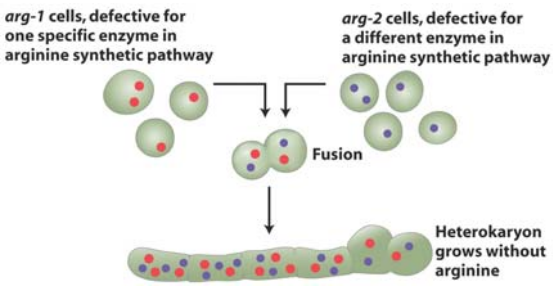
Complementary gene action

- A type of epistasis which involves the cooperative interaction of the wildtype alleles of two genes

One-gene-one-enzyme

- The arg- mutants are auxotrophs for arginine and mapped to 3 loci on different chromosomes
- Each of the *arg* loci differed in their response to structurally related compounds:





One-gene-one-enzyme

- All the arg mutants require addition of arginine for growth each encodes for a different enzyme in a pathway for the conversion of these precursor compounds into arginine:
  - Precursor → ornithine → citrulline → arginine

Enzyme X (*arg-1*$^+$) Enzyme Y (*arg-2*$^+$) Enzyme Z (*arg-3*$^+$)

Table 6-1 Growth of *arg* Mutants in Response to Supplements

	Supplement		
Mutant	Ornithine	Citrulline	Arginine
arg-1	+	+	+
arg-2	−	+	+
arg-3	−	−	+

Note: A plus sign means growth; a minus sign means no growth.

Complementary gene action

- Bateson and Punnet (who suggested using the Punnet square to calculate ratios) crosses two white flowered plants
  - white X white
- The F1 bore purple flowers
- F1 x F1 gave purple and white flowers
  - Let c = white in one plant and p = white in another plant
  - So the parental cross was ccPP X CCpp which gave CcPp F1

Complementary gene action

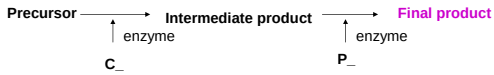
	Cc; Pp X Cc ; Pp			
	¼ CP	¼ Cp	¼ cP	¼ cp
¼ CP	CC;PP	CC;Pp	cC;PP	Cc;Pp
¼ Cp	CC;Pp	CC;pp	Cc;Pp	Cc;pp
¼ cP	cC;PP	cC;Pp	cc;Pp	cc;Pp
¼ cp	cC;pP	cC;pp	cc;Pp	cc;pp

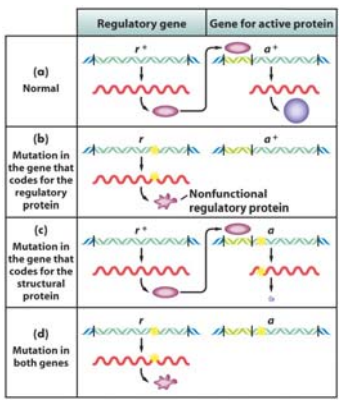
9/16 are C_P_ 7/16 are C_pp, ccP_, ccpp

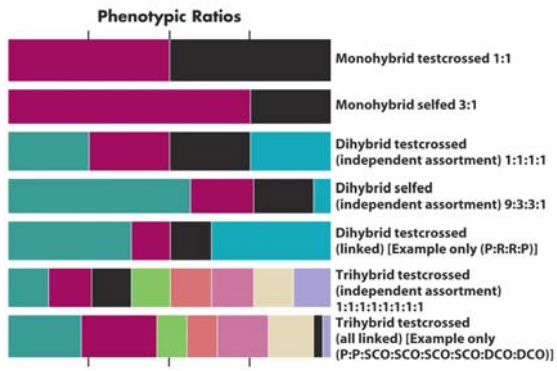
9 purple : 7 white

Two genes, same pathway

- A type of epistasis which involves the cooperative interaction of the wildtype alleles of two genes
  - In this example pigmentation of the flowers of sweet peas is a result of the pathway for the production of anthocyanins
  - Whenever a step of this process is blocked by the absence of a functional enzyme no pigmentation results
- Notice the pattern:







Complementary gene action

- Corn snake skin colouration :
- Wildtype is camouflage= o^+ /_ ; b^+ /_
- Orange pigment o^+
- Absence of orange pigment = o
- Black pigment b^+
- Absence of black pigment= b

Two genes, different pathways

- A female homozygous orange corn snake is crossed to a male homozygous black corn snake
- The F1 are wildtype i.e. camouflage
- How would you write the cross?

Two genes, different pathways

- A female homozygous orange corn snake is crossed to a male homozygous black corn snake
- The F1 are wildtype i.e. camouflage
- How would you write the cross?
  - o^+ /o^+ ; b / b X o /o ; b^+ / b^+
  - o^+ /o; b^+ /b camouflage

Two genes, different pathways

- The two genes act independently
- The F1 X F1 cross gives a 9:3:3:1 ratio
  - 9 o^+ /_ ; b^+ /_
  - 3 o^+ /_ ; b / b
  - 3 o / o ; b^+ /_
  - 1 o / o ; b / b

Two genes, different pathways

- Precursor $\xrightarrow{b^+}$ black pigment
- Precursor $\xrightarrow{o^+}$ orange pigment

} camouflaged

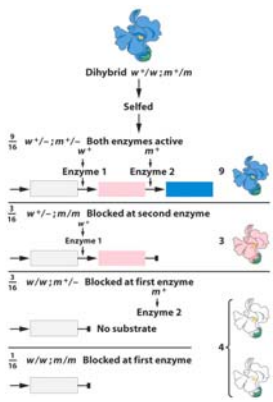
The F1 X F1 cross gives a 9:3:3:1 ratio

9	o+ /_ ; b+ /_	camouflaged
3	o+ /_ ; b / b	orange
3	o / o ; b+ /_	black
1	o / o ; b / b	albino

Epistasis

- Epistasis: two or more genes interact to influence a trait
  - E.g. P: ww;++ X ++;mm white (w) X magenta (m)
  - F1: w+;m+ blue flowers

Genotype	Phenotype	Ratio
+ / _ ; + / _	Blue	9
+/ _ ; m / m	Magenta	3
w/ w ; +/ +	White	4
w/w ; m/m	White	



Suppressors

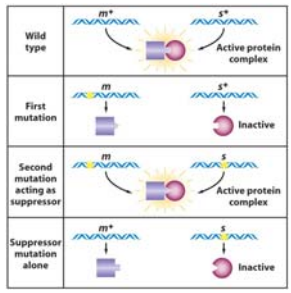
- Suppressors cancel the expression of the mutant allele of another gene, resulting in normal wildtype phenotype
- The recessive allele that confers purple eye colour (***pd***) in Drosophila
- Suppressed by a recessive allele ***su***.
  - pd /pd ; su^+ / su^+ X pd^+/ pd^+ ; su / su
- Gives all red eyed (wildtype) F1:
  - pd^+ /pd; su^+ / su

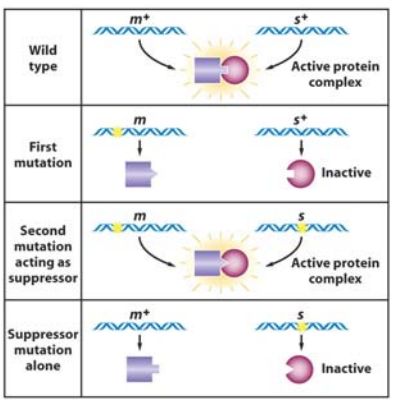
Suppressors

- F_1 X F_1 red eyed (wildtype) :
  - pd^+ /pd; su^+ / su X pd^+ /pd; su^+ / su
    - 9 pd^+ /_; su^+ / _
    - 3 pd^+ /_; su / su
    - 1 pd /pd; su / su
    - 3 pd /pd; su $^+$/ _
- F_2 phenotypes:
  - 9 red
  - 3 red
  - 1 red
  - 3 purple
- ie a 13:3 F_2 ratio red to purple

Suppressors

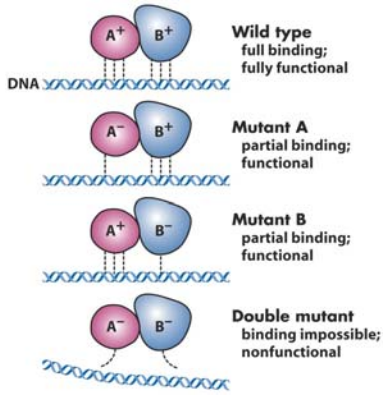
- F_1 X F_1 red eyed (wildtype) :
  - pd^+ /pd; su^+ / su X pd^+ /pd; su^+ / su
    - 9 pd^+ /_; su^+ / _
    - 3 pd^+ /_; su / su
    - 1 pd /pd; su / su
    - 3 pd /pd; su $^+$/ _

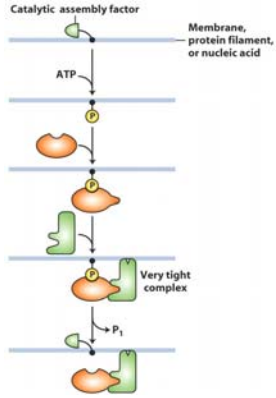




Synthetic lethals

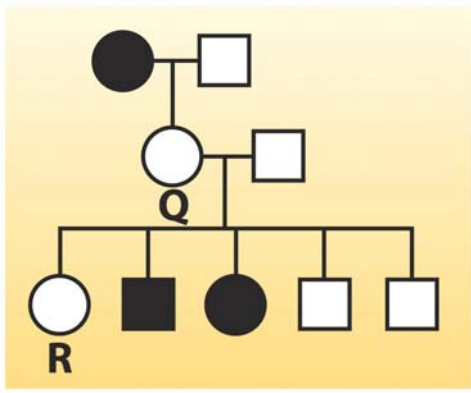
- Synthetic lethals are formed when two viable single mutants are intercrossed and the resulting double mutant is lethal





Penetrance

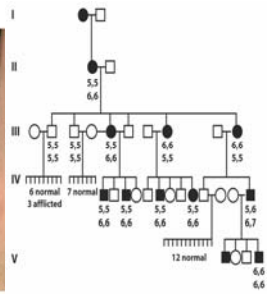
- For some genes a given genotype may or may not show the phenotype this phenomenon is called penetrance.
- Penetrance is expressed as the percentage of individuals of with a given allele that exhibit the phenotype associated with that allele

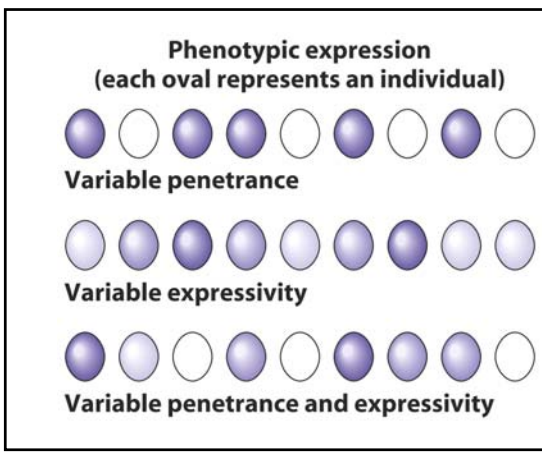


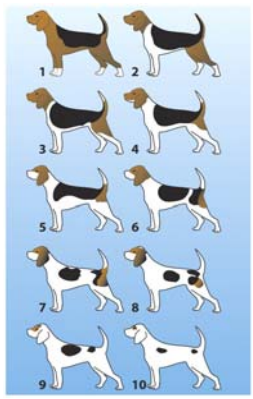
Variable expressivity

- Expressivity measures the degree to which an allele is expressed at the phenotypic level

Pedigree of an autosomal dominant condition







Introduction to genetic analysis

Griffiths, A., Wessler, S.R., Lewontin,R.C., Gelbart, W.M.,Suzuki, D.T. and Miller, J.H.
Eighth Edition, W.H. Freeman and Company NY

- Part I Transmission genetic analysis
  - Chapter 1: all questions p. 24-26
  - Chapter 2: all the questions p. 62-72
  - Chapter 3: questions #1-12,18,19, 22, 25-27, 29, 30, 32, 40-42.
  - Chapter 4: sections 4.1- 4.4 and 4.6, questions # 1-4, 6-13,15-22,24-43.
- Part II The relationship of DNA and phenotype
  - Chapter 6: questions# 1,3-5,7,9,11,14,18,19,21,23,24, 26,29,32,33,35,39,41,44,45,47,49,51,53,55,63-66.
- Part IV The nature of heritable change
  - Chapter 15: sections 15.1 and 15.3; questions #1-3,11-13,19,21,22, 32, 38, 52.
- TERM TEST 2: Feb 27th covers chapters 4 and 15.

Feb 27 Term test

- TERM TEST 2: Feb 27th covers chapters 4 and 15.
- Multiple choice and short answer