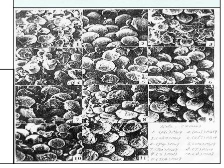
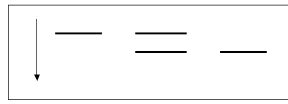
Lecture Outline 10/4

From Gene to Phenotype
- Degrees of dominance
- Multiple alleles
- Gene interactions
  - Altered Mendelian ratios
  - Lethal alleles
  - Analysis of biochemical pathways

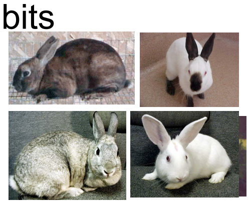
Smooth/Wrinkled peas is a result of starch content

- Whole plant level: recessive
- Physiological level: Incomplete dominance
  - Heterozygous plants have less starch than homozogous smooth
- Molecular level: co-dominant

Several alleles for coat color in rabbits

- 4 alleles at a single locus
  - Different defects in the pigment gene
- What kinds of offspring would you expect from these crosses:
  - Normal x albino?
  - Chinchilla x Himalayan?



$C>c^{ch}>c^{h}>c$

Normal > chinchilla > Himalayan > albino

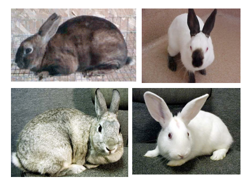
Composite cross:

Make two F1s:

Normal x Himalayan

and

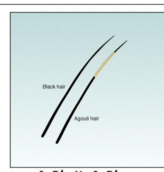
Chinchilla x albino



- Now cross the two *different* F1s
  - What are the phenotypic ratios in the F2?

See http://home.pacbell.net/bettychu/genetics.html for more about rabbit color genes

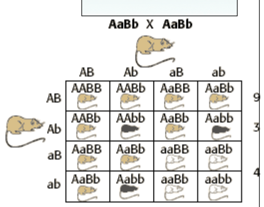
Epistasis



Gene interactions may modify the phenotypic ratios

- Example:
  Agouti, albino and black mice:
  - two genes give only three F2 phenotypes

A locus controls deposition pattern
B locus controls pigment production



There is also a third interacting gene. Black coat color (C) is dominant to brown (c). What would you expect from the trihybrid cross AaBbCc x AaBbCc?

Another example

- Black Lab x Yellow Lab
  - Two genes:
    - B determines types of pigment (B=black, b=brown or chocolate)
    - E determines deposition of pigment on hair (E = pigment on hairs, e = none)
  - Cross BBEE x bbee
    - F1 = ??
    - F2 = 9:4:3 (black:yellow:brown)

e is epistatic to B and b

Redundant genes

- Fruit shape in Shepherd's Purse
  - Most plants have triangular fruits; occasionally you find a plant with round fruits.
- Cross Round x Triangular
  - F1: all Triangular
  - F2: 1/16 round, all the rest are triangular
- *Propose a mechanism to explain those results*

Epistasis: things to remember:

- The alleles are inherited just as before, and the genotypic ratios in the F1 and F2 are just the same.
- The interaction of gene <u>products</u> can affect the phenotypes, but the genes are still genes, following the same rules.
- Don't try to memorize all of the different ratios (12:3:1, 9:6, etc). Instead, relate them back to combinations of the familiar 9:3:3:1

Dominant Epistasis

- White squash x green squash
- F2 gives 12:3:1 white, yellow, green
  - Why?

Duplicate recessive epistasis

- White flowers can arise from defects in in several different genes (e.g. DFR and ANS)
- Cross two purple morning glories and see 9:7 purple:white offspring- WHY?

Gene interactions

- Sometimes two genes interact to produce novel phenotypes:
  - Comb type in chickens
    - » R-P- = walnut; R-pp: rose; rrPP=pea; rrpp=single
    - » Crosses fit Mendelian expectations (9:3:3:1), but instead of combinations of two characters, they produce four types of a single character
  - Colors of bell peppers
    - 9:3:3:1
    - R:Y:Br:G

Lethal Alleles

- Sometimes one genotypic class is missing, so you can get 2/3: 1/3 ratios
- Lethal alleles are commonly recessive.
  - Example from book: Yellow mice
  - You can get this from a loss of function mutation in any *essential* gene

Yellow mice

- Yellow is an allele at the agouti locus
- Cross yellow x yellow
  - Observe 2:1 yellow vs black
  - Why? Yellow homozygotes die
- The same allele has two phenotypes: color and survival
  - Is it dominant for color?
  - Is it dominant for survival?

Temperature sensitive genes

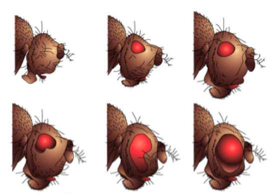
- Himalayan rabbits and Siamese cats have light-colored bodies with dark fur on their paws, nose, ears, and tail
  - All cells of these animals carry the same genes for pigment production, but the environment determines phenotypic pattern of expression

Variation in Gene Expression

- Expressivity
  - Means that the expression is variable
    - Lobe eyes in Drosophila may be pronounced or weak
- Incomplete Penetrance
  - Means the trait is not expressed in 100% of the individuals
    - BRCA1 is well known gene for breast cancer, but inheriting the gene does not mean you will necessarily get cancer.

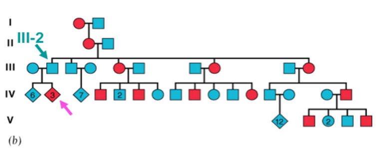
Expressivity

- Heterozygotes for *lobe* eyes in Drosophila show variable expressivity.
  - All have the same genotype, but different expression of the trait.

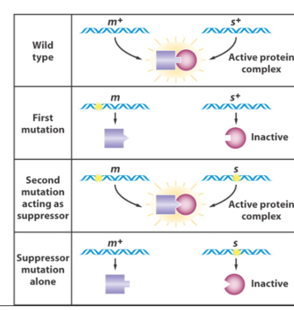


Incomplete Penetrance

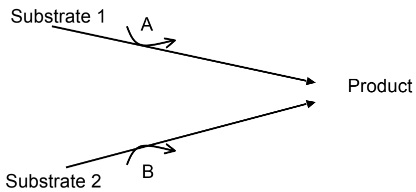
- Polydactyly:
  - Here a dominant trait skips a generation in the pedigree.



Suppressors can restore normal phenotype

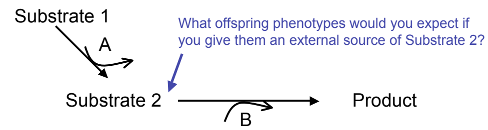


Two genes are both required to make a product



Cross A/a B/b x A/a B/b
What offspring do you expect?

Two genes are sequential in a pathway



Cross A/a B/b x A/a B/b
What offspring do you expect?

Deducing the order of biochemical pathways

- Assume substrates A, B, C, D are all in the same pathway.
- Collect several mutants that cannot grow on minimal medium, but can grow if those substrates are added.
- Assume mutants each block an (unknown) step of the pathway

Deducing the order of biochemical pathways

"+" means the mutant can grow

Mutant	Substrate added			
	A	B	C	D
1	+	+	+	+
2		+	+	+
3			+	+
4				+

A → B → C → D → product

Deducing the order of biochemical pathways

"+" means the mutant can grow

Mutant	Substrate added			
	A	B	C	D
1	+	+	+	+
2		+	+	+
3			+	+
4				+

Mutant 3 must act somewhere before C, because adding substrate C restores growth

1 A 2→ B 3→ C 4→ D → product

Mutations early in the pathway are "rescued" by more different substrates

Now try this one:

What is the order of A-D in the pathway?
Which step does each mutant block?

Mutant	Substrate added			
	A	B	C	D
1	+	+	+	+
2	+	0	+	0
3	+	0	+	+
4	0	0	+	0