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 homozygous 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?

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

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 = 17
    – 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 products 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

Substrate 1 → A → Product
Substrate 2 → B

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

Two genes are sequential in a pathway

Substrate 1 → A → Product
Substrate 2 → B

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

What offspring phenotypes would you expect if you give them an external source of Substrate 2?

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

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"+" means the mutant can grow

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

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

Now try this one:

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

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