

Non-Mendelian Genetics

Chapter Five

Mendel's Laws

1. Principle of Segregation

Two alleles segregate randomly during formation of gametes

2. Independent Assortment

Two genes will assort independently and randomly from each other



Mendel's Laws Not Perfect:

- Shortly people began to notice that not all traits are “Mendelian”
 - This means, they do NOT follow Mendel's laws
 - Was he just plain wrong?
- Truth is, his laws are correct and did explain how genetics works
 - Real life is just more complicated than peas!

Altering Mendel's Ratios

Two different types of complications:

1. Genotypic ratios follow Mendel's laws, but phenotypes do not
 - Somehow the underlying genotypic ratios are hidden
2. Mendel's laws do not apply
 - Both genotypes and phenotypes are not following Mendel's laws

Type 1 – Laws in effect:

1. Lethal genotypes
2. Allelic Heterogeneity
3. Incomplete dominance
4. Epistasis
5. Penetrance
6. Expressivity
7. Pleiotropy
8. Phenocopies
9. Genetic Heterogeneity

1. Lethal Genotypes

- If a certain genotype (combination of alleles) causes death
 - Every genotype causes death if you wait long enough...
- Usually stillbirth or miscarriage
 - Don't ever see the phenotype

	H	h
H	HH	Hh
h	Hh	hh

Expect to see 3:1 ratio
Instead see 100% dominant

1. Lethal Genotypes

- Mendel's Laws are still correct and still being followed
 - Two alleles; one dominant and one recessive
 - Producing the 1:2:1 genotypic ratio
 - Only the phenotypic ratio that is changed

	H	h
H	HH	Hh
h	Hh	hh

Expect to see 3:1 ratio
Instead see 100% dominant

2. Allelic Heterogeneity

- More than two alleles of the same gene
 - *ex* Cystic Fibrosis has hundreds of alleles possible on the same gene
 - Causes differences in phenotype depending on which two alleles a person inherits
- Still follow Mendel's laws within one cross
 - Individual can only have two alleles (only have two chromosomes)
 - One inherited from mother, one from father

3. Incomplete Dominance

- One allele is not completely dominant over the other
 - Causing the heterozygote to have a third, different phenotype

ex Blending in flowers

- Homo Dominant = red flowers
- Homo recessive = white flowers
- Heterozygotes = pink flowers

3. Incomplete Dominance

ex Blood Types

- Type A = AA or Ao
- Type B = BB or Bo
- Type AB = AB (heterozygote)
- Type O = oo (homozygous recessive)

Still following Mendel's laws:

- Two alleles per cross
- 1:2:1 genotypic ratios
- Just not showing 3:1 phenotypic ratios

4. Epistasis

- Two genes interacting to affect phenotype
 - Therefore Mendel's law about the one gene, is changed by the second gene

ex Gene C controls the color of a person's eyes

- However gene A causes albinism (lack of any pigment anywhere in body)
- Therefore if a person is carrying gene A it will not matter which genotype for gene C is carried (eyes will be red)

4. Epistasis

- One gene effecting or masking another gene
- or
- Two genes controlling same phenotype
 - Mendel's Laws are still working for each individual gene, but phenotype is not determined by that single gene's genotype alone

5. Penetrance

Sometimes the same genotype will not produce the phenotype in all individuals

- Penetrance = the percent of individuals who have a certain genotype and show the expected phenotype
 - Mendel traits penetrance = 100 %
 - Some traits penetrance is less than 100%

5. Penetrance

- Decreased penetrance or “low penetrance” means that some people inherit genotype and yet do not show the phenotype
- Penetrance is calculated as:
$$\frac{\text{Number of individuals who have genotype and expected phenotype}}{\text{Total number of individuals who have genotype (any phenotype)}}$$
- Usually decrease caused by interaction of additional genes or environment

6. Expressivity

Sometimes the same genotype will produce different “degrees” of phenotype in individuals

- Expressivity = the severity or extent of the phenotype an individual shows

ex Hypercholesterolemia

- Some individuals have extremely high cholesterol from birth, others can control with diet and exercise and lead normal lives

Penetrance vs. Expressivity

- Both follow Mendel's laws
 - Genotypic ratio is still 1:2:1
 - Phenotypic ratio is affected
- Both have to do with “amount” phenotype is present
 - Penetrance – is all or none, person is affected with disease or not
 - Expressivity – is the severity of the phenotype

7. Pleiotropy

One gene causes more than one phenotype

- Pleiotropy occurs when one gene controls more than one pathway or is expressed in more than one body part

ex One gene makes connective tissue

- Needed for lens of eye
- Heart Muscle
- Limbs, skin and muscles

Therefore a mutation in this one gene will cause defects in eye sight, heart attacks, and weakness in muscles and limbs

8. Phenocopies

Trait is not genetic at all

- An environmentally caused trait that appears to be genetic/inherited

or

- An environmentally caused phenotype that is the same as an inherited phenotype
- Not breaking any of Mendel's laws because it's not genetic!

9. Genetic Heterogeneity

More than one gene producing the same phenotype

- Phenotype appears not to follow Mendel's laws
- In reality each separate gene to phenotype correlation follows Mendel's laws

ex Retinitis Pigmentosa (RP)

- Can be Autosomal Dominant, recessive, X-linked depending on which gene(s) individual carries

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Type 1 – Laws in effect:

Factors That Alter Mendelian Phenotypic Ratios

Phenomenon	Effect on Phenotype
Lethal alleles	A phenotypic class dies very early in development.
Multiple alleles	Many variants or degrees of a phenotype occur.
Incomplete dominance	A heterozygote's phenotype is intermediate between those of two homozygotes.
Codominance	A heterozygote's phenotype is distinct from and not intermediate between those of the two homozygotes.
Epistasis	One gene masks or otherwise affects another's phenotype.
Penetrance	Some individuals with a particular genotype do not have the associated phenotype.
Expressivity	A genotype is associated with a phenotype of varying intensity.
Pleiotropy	The phenotype includes many symptoms, with different subsets in different individuals.
Phenocopy	An environmentally caused condition has symptoms and a recurrence pattern similar to those of a known inherited trait.
Genetic heterogeneity	Different genotypes are associated with the same phenotype.

Type 2 – Mendel's Laws No Longer Apply

1. Mitochondrial Inheritance

- Mitochondria have their own DNA, which is solely maternally inherited

2. Linkage

- Two genes that are close together physically

3. Linkage Disequilibrium

- Two alleles that are not inherited separately

Questions?

- What are two types of complications that form non-Mendelian phenotype ratios?
- Which are breaking Mendel's Laws?
- Which are actually still following Mendel's laws?
 - How does each of them still follow Mendel's Laws if they are producing non-Mendelian ratios?
- What is Linkage?
- How is genetic distance different than physical distance?
- How is Linkage Analysis/Mapping done?

Next Class:

- Read Chapter Five and Handout
- Homework - Chapter Five Problems;
 - Review: 1,2,3,6,7,9
 - Applied: 1,3,10, 15