Mendelian Genetics:

Review of problems with Darwinian theory of NS:

blending inheritance

mechanism of heredity

Proportion of total biological information in offspring expected to be provided by parent(s):

Asexual organisms (clonal or parthenogenic)

Sexual organisms

each of two sexes?

each of three sexes (hypothetically speaking)?

Terms:

Trait or **Character**: morphological of functional feature of an organism (may include behavior).

Value of a trait or **character**, or **Phenotype**: possible observable variants of a trait

Example:

Trait	Values or Phenotypes	
Flower Color	***Purple***	***White***
Hygiene	***Uncap, Remove***	***Neither Uncap Nor Remove***

Prior ideas of heredity

gender bias: humunculus

non-particulate: organs contribute various essences to gametes; combinations, proportions, and states of essenses created variations between offspring explaining why siblings are similar to one another and to parents, but not identical.

Gregor Mendel (background)

More Terms:

Parental generation:

Hybrid:

First filial generation (F1):

Second filial generation (F2):

Mendel's experimental design: garden pea plants for study of heredity of specific traits

True-breeding pea strains exhibiting different forms of the same trait (Fig. 3-1)

Peas are self-fertilizing, thus no exchange of hereditary material between plants unless manipulated.

Why is self-fertilization useful?

Why true-breeding important?

Why only two possible forms for each trait?

Experiment (first level): Cross strains that differ in form for a single trait.

Example: Tall plants X Dwarf plants ÷

What is predicted form of offspring IF blending inheritance hypothesis is true?

Example: Tall%% X Dwarf&& ÷

What is predicted form of offspring IF "humunculus" (or "legumunculus"?) hypothesis is correct?

RESULT: Tall X Dwarf ÷ Tall offspring (F1)

[Tall%% X Dwarf&& ÷ Tall offspring, **AND**
Tall&& X Dwarf%% ÷ Tall offspring]

Observation: Only one form is passed to the offspring.

Conclusion: One form is **dominant** to the other.

Question: How is the other form 'dominated' in the F1 generation?

Hypotheses: 1. The other form is hidden, just not visible.

2. The other form is completely lost, not just rendered invisible.

Experiment (second level): Cross members of the F1 generation that appear all tall but which all had one dwarf parent.

Example: Tall X Tall ÷

Prediction under Hypothesis 1, above:

Prediction under Hypothesis 2, above:

RESULT: Dwarf form appeared in the ratio 3 tall plants for every 1 dwarf plant. The non-dominant trait was preserved through the ALL tall F1 generation.

Conclusion: One form is hidden in the F1 generation. Thus one form of the trait is dominant, while the other is present but **recessive**. In addition, hereditary traits themselves must be controlled by physical, unchanging units or "factors" that are passed through the sperm and egg. If these "**unit factors**" where not passed unchanged through the F1 generation, they would not have reappeared in the F2.

Mendel and the math:

1. **Mendel's first principle: Traits are determined by paired unit factors.** [Mendel determined that the observed pattern of inheritance (3:1) could be explained by a pair of these unit factors in each individual (one member of each pair coming from the female parent and one from the male parent)].

2. **Principle of dominance:** If two different unit factors (e.g. Tall vs. Dwarf) for a single trait, then one factor is **dominant** to the other which is said to be **recessive**.

If a pea plant must have a pair of factors for this trait, what are the possible pairs that could exist?

Which of these possible pair types would constitute a:

True-breeding tall individual?

True-breeding dwarf individual?

An F1 individual?

Modern terminology:

Traits are determined by GENES

Unit factors, or different forms of the same gene, are ALLELES

Genotype, the alleles an individual possesses constitutes his genotype: TT, tt, Tt

How the genotype is expressed is the individuals phenotype: Tall or Dwarf

An individual with *two like alleles* for a trait = **homozygote**

An individual with *two different alleles* for a trait = **heterozygote**

So in Mendel's first level experiment, he bred

(Parents) (F1)

Phenotypes: Tall X Dwarf ÷ Tall

Genotypes: TT X tt ÷ Tt

Thus, the white "unit factor" would be preserved (and unexpressed) through the F1 generation to be passed onto the F2 generation. Reappearance of the white form would be explained.

<u>Mendel and the math, again:</u>

Mendel surmised that the consistent ratio of tall to dwarf offspring in the F2 generation could be explained ONLY if each allele were equally likely to be passed on to each offspring.

Punnett squares: (gametes first!)

3. **Law of independent segregation:** each allele has a fifty-fifty chance of being passed on to any particular offspring.

Practice with **monohybrid crosses** and Punnett squares:

[include round (R) vs. wrinkled (r) seeds as an example in preparation for dihybrid]

Mendel's fourth law:

If a true breeding round-seeded, tall plant were crossed with a wrinkled-seeded, dwarf plant -

What are the genotypes of each parent of the cross?

What is/are the expected genotype(s) and phenotype(s) of the F1 generation of this **dihybrid cross**?

F1 cross:

RESULT: 9 round-seeded, tall plants

3 round-seeded, dwarf plants

3 wrinkled-seeded, tall plants

1 wrinkled-seeded, dwarf plants

Mathematically, the results indicated Mendel's fourth law.

4. **Law of independent assortment:** unit factors (alleles) for any one trait are passed on to offspring independently of factors (alleles) determining other traits OR alleles for one trait are passed on to gametes independently of alleles for other traits.

Punnett squares and dihybrid crosses: (*definitely* gametes first!)

- genotypic ratios

- phenotypic ratios

You and the math: Probability

Sum Rule of Probability: the probability that one of several independent events will happen is the sum of each of their independent probabilities of occurrence.

Card example: Probability of drawing a Heart?

Probability of drawing a Spade?

Probability of drawing a Heart OR a Spade?

Product Rule of Probability: the probability that two (or more) independent events *will occur simultaneously* is the product of each of their independent probabilities of occurrence.

Card example: Probability of drawing a the King of Hearts?

Probability of drawing a Heart?

Probability of drawing a King?

Probability of drawing a Heart that is simultaneously a King?

The product rule and the results of dihybrid crosses:

Rr X Rr:

Probability of being Round-seeded in the F2?

Probability of being Wrinkled-seeded in the F2?

Tt X Tt:

Probability of being Tall in the F2?

Probability of being Dwarf in the F2?

RrTt X RrTt:

Probability of being: Round-seeded and Tall?

Wrinkled-seeded and Tall?

Round-seeded and Dwarf?

Wrinkled-seeded and Dwarf?

Forked Line Method of Determining (Genotypic and) Phenotypic Probabilities