Lecture 1 **Mendel's laws**

1. Monohybrid crosses
2. Mendel's law I
3. Dihybrid crosses
4. Test cross
5. Mendel's law II

**Mendel's hypothetico-deductive method**:

**1.** he made observations → **2**. formulated hypotheses → **3**. made experimental predictions → **4**. tested predictions → **1.** he made observations

and based on the tests, he **5**. produced new observation and refined the hypotheses.

**1. Monohybrid cross:**

P (parental) ♂ round (R) X ♀ wrinkled (r)

$F_1$ (first **filial** generation) all round (R)

Reciprocal cross:

P ♂ wrinkled (r) X ♀ round (R)

$F_1$ all round (R)

$F_1$ was selfed to produce F2:

$F_2$: 5474 round and 1850 wrinkled

(3/4 round 1/4 wrinkled or 3:1 ratio )

He selfed F2

to obtain F3:

$F_3$: 1/4 all round 2/4 mixture of round and wrinkled 1/4 all wrinkled

So underlying the 3:1 ratio, there was another more fundamental 1:2:1 ratio.

In each cross:

1. The results of reciprocal crosses are the same;
2. $F_1$ progeny resembles one of the parents;
3. In $F_2$, the missing trait reappeared with the frequency of one quarter of the total number of progeny (giving a 3:1 ratio).
4. A less frequent type of $F_2$ always generated a true-breeding line, while a more frequent type split into one quarter true-breeding and two quarters of 'impure' plants. Thus the ratio of F2 was actually 1:2:1.

Mendel's hypotheses:

1. [~~Blending~~ Particulate; Factors = Genes] **Blending** inheritance should be substituted for **particulate** inheritance (there were no blending of shape). Characters are determined by **factors** (we know that they are **genes.**
2. [Alleles – alternative forms of genes; different alleles in $F_1$] Each factor (gene) exists in one of the two alternative forms (**alleles**).
3. [Identical alleles in parents] In this case each parental true-breeding strain should also contain two alleles, but they should contain two **identical** alleles.
4. [Single alleles in gametes] In order to make up two different alleles in $F_1$, each parent should produce **gametes** containing only a **single** allele.
5. [Dominant (R) and recessive (r) alleles] However, since only one trait is seen in $F_1$, one allele is **dominant**, while another is **recessive**.
6. [Fr(R) = Fr(r)] $F_1$ forms both types of gametes (R and r) with equal frequency (1/2), so the number of R-gametes equals that of r-gametes.
7. [Equal chance for R- and r-gametes] When $F_2$ is formed, any R- or r-gamete of one parent has an equal chance to unite with an R- or r-gamete of another parent, thus producing the 1RR:2Rr:1rr ratio.

| | | | | |
|---|---|---|---|---|
| P | RR | x | rr | homozygotes |
| Gametes | R | | r | |
| $F_1$ | | Rr (zygote) | | heterozygote |

| Gametes | | 1/2R | 1/2r | Punnett square |
|---|---|---|---|---|
| | 1/2R | 1/4RR | 1/4Rr | |
| | 1/2r | 1/4Rr | 1/4rr | |

$F_2$ RR, Rr, Rr – round : rr - wrinkled

3 : 1 phenotypically – 2 classes

1 : 2 : 1 genotypically – 3 classes

**Monohybrid test-cross**

P Rr (round) X rr (wrinkled)

↓ ↘ ↓

Gametes 1/2 R 1/2 r all r

F1 1/2 Rr (round) and 1/2 rr (wrinkled)

which is what he obtained (a 1:1 ratio, both phenotypically and genotypically).

## 2. Mendel's law I:

Now we came to formulating **Mendel's Law I: Equal Segregation**:

> **When two alleles segregate from each other into gametes, a half of gametes carries one allele, and a half of gametes carries another allele.**

Or: **Two alleles of the same gene segregate equally**

## 3. Dihybrid cross

If the parents differ in two characters, will these traits be transmitted to the progeny **together** or **independently**?

P: Round, green (R/R;y/y) x Wrinkled, yellow (r/r;Y/Y)

Gametes: R;y r;Y

F1: Round, yellow (R/r;Y/y) (according to dominance of R and Y)

$F_1$ plants were selfed

F2: should give an answer.

Mendel considered two outcomes: a) inherited together; and b) independently.

a. If inherited **together**, the phenotypic and genotypic ratio would be 1:2:1

| | 1/2Ry | 1/2rY |
|---|---|---|
| 1/2Ry | 1/4RRyy | 1/4RrYy |
| 1/2rY | 1/4RrYy | 1/4rrYY |

(according to the Mendel's first law, two types of gametes will be produced with the same frequency, and both are parental type)

1 RRyy : 2 RrYy : 1 rrYY (both parental and hybrid phenotypes are produced)

b. If these characters are inherited **independently**, the result will be different. If assortments of Y and y alleles into gametes happens independently of assortment of R and r alleles, we can use the mathematical probability rules (**product rule**) to calculate the frequency of gametes carrying each combination of these alleles:

p(RY) = p(R) x p(Y) = 1/2 x 1/2 = 1/4

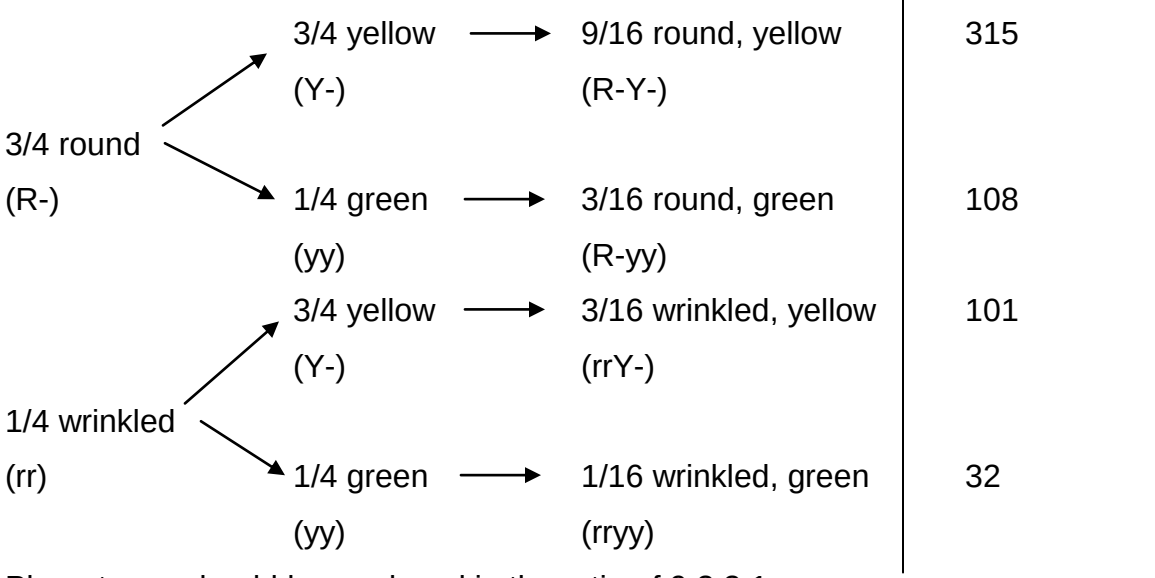
p(Ry) = 1/2 x 1/2 = 1/4

p(rY) = 1/2 x 1/2 = 1/4

p(ry) = 1/2 x 1/2 = 1/4

Therefore, each $F_1$ pant will produce four types of gametes with equal probability, and actual frequencies of these gametes will also be a more or less equal.

**Branch diagram to calculate the phenotypic ratio**




Phenotypes should be produced in the ratio of 9:3:3:1.

**4. Dihybrid test-cross**

| P: | R/r;Y/y | x | r/r;y/y | | |
|---|---|---|---|---|---|
| Gametes | | genotype (phenotype) | | Mendel's data | Ratio |
| ¼ RY | ry | RrYy (round, yellow) | | 56 | 1 |
| ¼ Ry | | Rryy (round, green) | | 49 | 1 |
| ¼ rY | | rrYy (wrinkled, yellow) | | 51 | 1 |
| ¼ ry | | rryy (wrinkled, green) | | 53 | 1 |

Observed 1:1:1:1 ratio was possible if all gametes were produced with the same frequency (1/4), which was due to independent assortment of R/r and Y/y alleles.

**5. Mendel's Law II: Independent Assortment**

**During gamete formation assortment of alleles of one gene is independent of assortment of alleles of another gene.**

Or: **Different pairs of alleles assort independently**

Branch diagram to calculate the genotypic ratio in the dihybrid cross:

| 1:2:1 | 1:2:1 | $F_2$ genotype | $F_2$ phenotype |
|---|---|---|---|
| 1/4 RR | 1/4 YY | 1/16 RRYY | round, yellow |
| | 2/4 Yy | 2/16 RRYy | round, yellow |
| | 1/4 yy | 1/16 RRyy | round, green |
| 2/4 Rr | 1/4 YY | 2/16 RrYY | round, yellow |
| | 2/4 Yy | 4/16 RrYy | round, yellow |
| | 1/4 yy | 2/16 Rryy | round, green |
| 1/4 rr | 1/4 YY | 1/16 rrYY | wrinkled, yellow |
| | 2/4 Yy | 2/16 rrYy | wrinkled, yellow |
| | 1/4 yy | 1/16 rryy | wrinkled, green |
| | | **9 classes** | **4 classes** |

In a trihybrid cross there will be 8 phenotypic classes and 27 genotypic classes. $2^n$ and $3^n$ classes, respectively, for a cross with *n* segregating pairs of alleles:

| # of allelic pairs | Phenotypes | Genotypes |
|---|---|---|
| 1 | 2 | 3 |
| 2 | 4 | 9 |
| 3 | 8 | 27 |
| n | $2^n$ | $3^n$ |