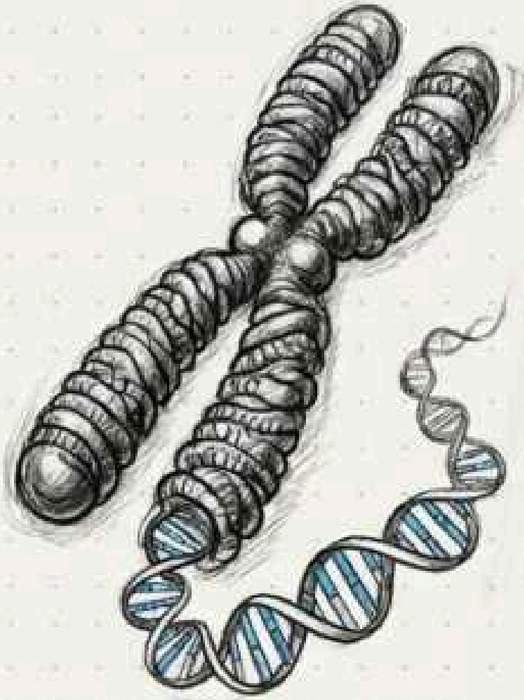
Three Questions That Built Modern Genetics



Pre-Genetics:
How did people explain inheritance, and why was it wrong?



Mendel's Peas:
What rules dictate inheritance?



Chromosomes & Genes:
How are the rules physically anchored?

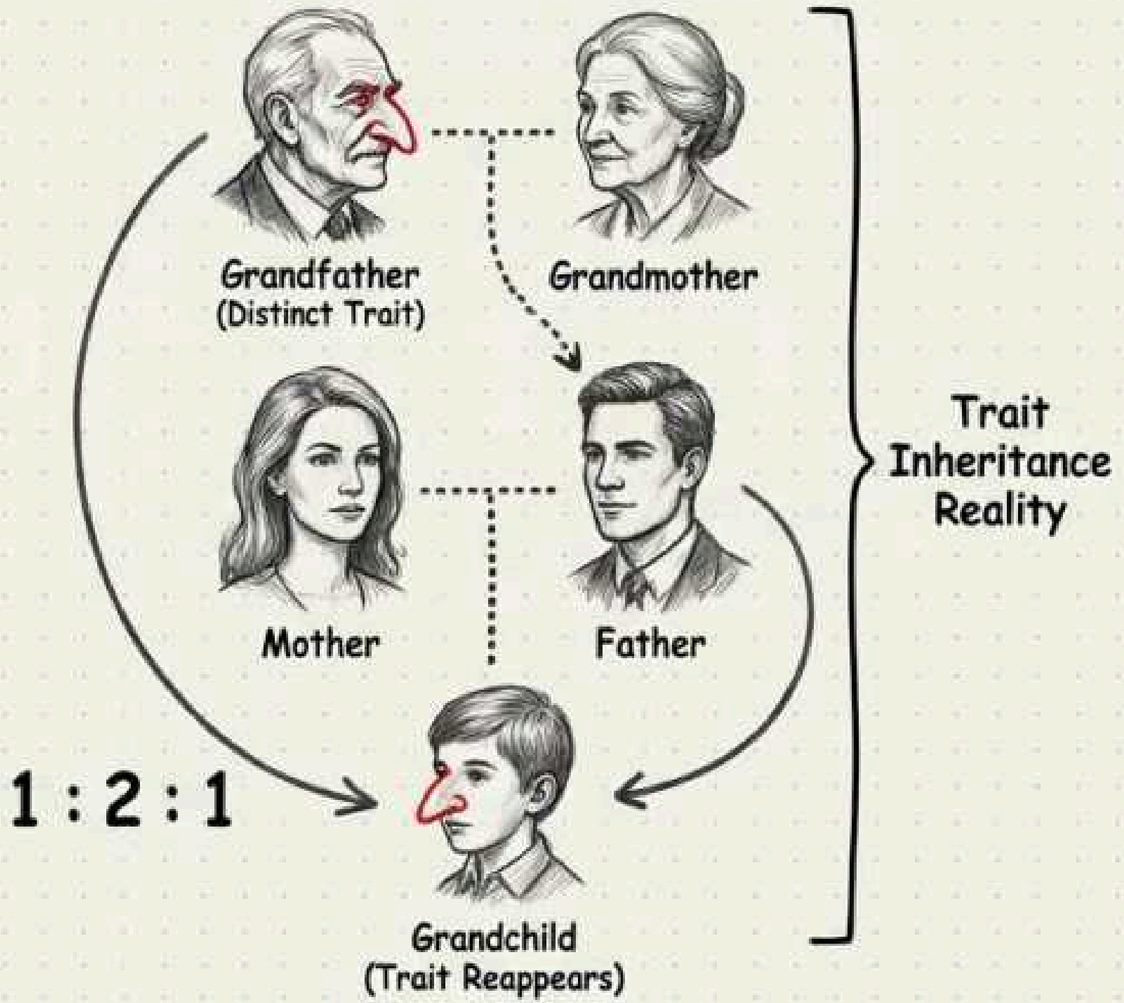
The Mathematical Flaw of Blending Inheritance

¶ 1.2

Industrial Paint Buckets



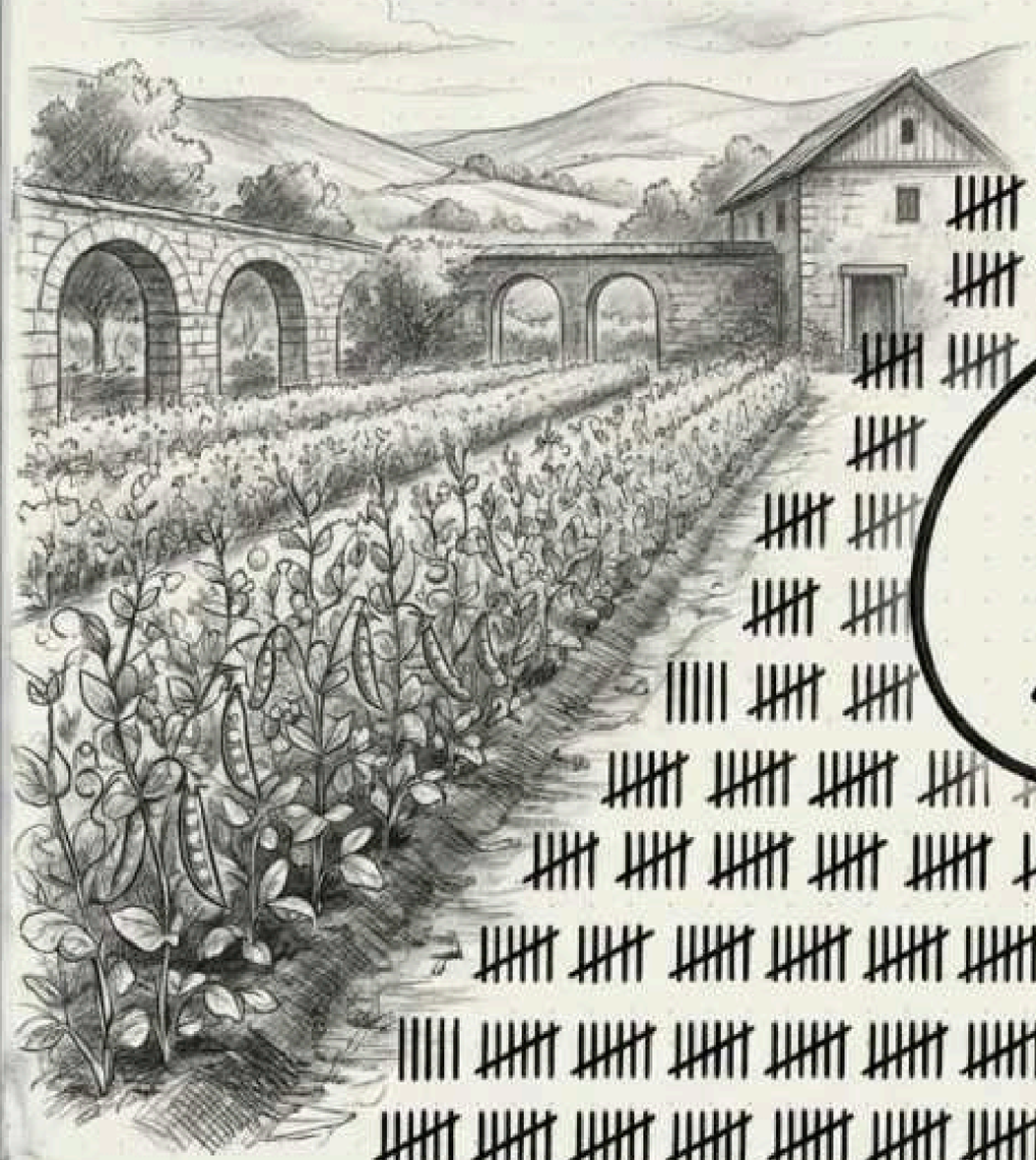
Multi-Generational Traits



If blending were true, differences would fade away in every generation. In reality, traits reappear unchanged.

Gregor Mendel and the Power of Scale

¶ 1.3



$\sum$

Tens of thousands of plants grown and counted over 8 years (1856+)

An Augustinian friar trained in rigorous science and mathematics.

The Ideal Biological Machine

¶ 1.4

Grows quickly

Produces many seeds

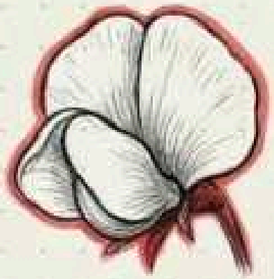




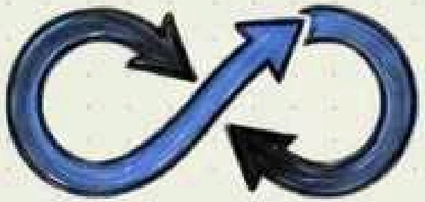


Round vs. Wrinkled





Purple vs. White



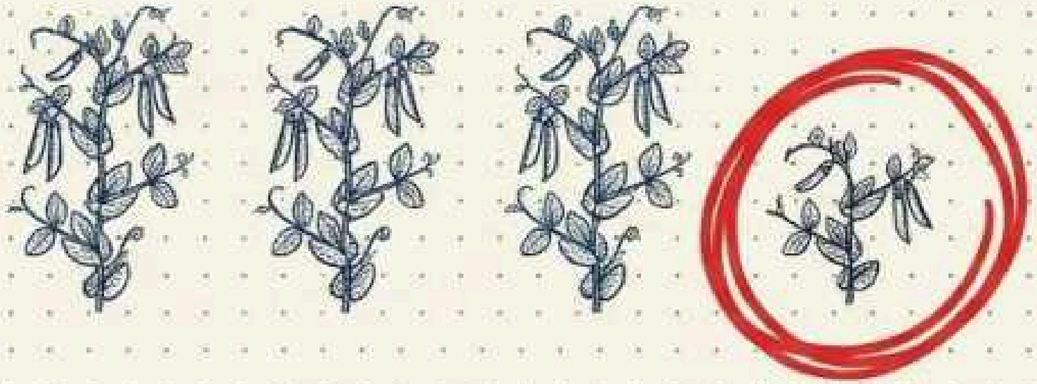
True-Breeding Lines: Always produces the same trait when bred among themselves (e.g., always tall).

The Disappearing Trait

¶ 1.5

P:  x 

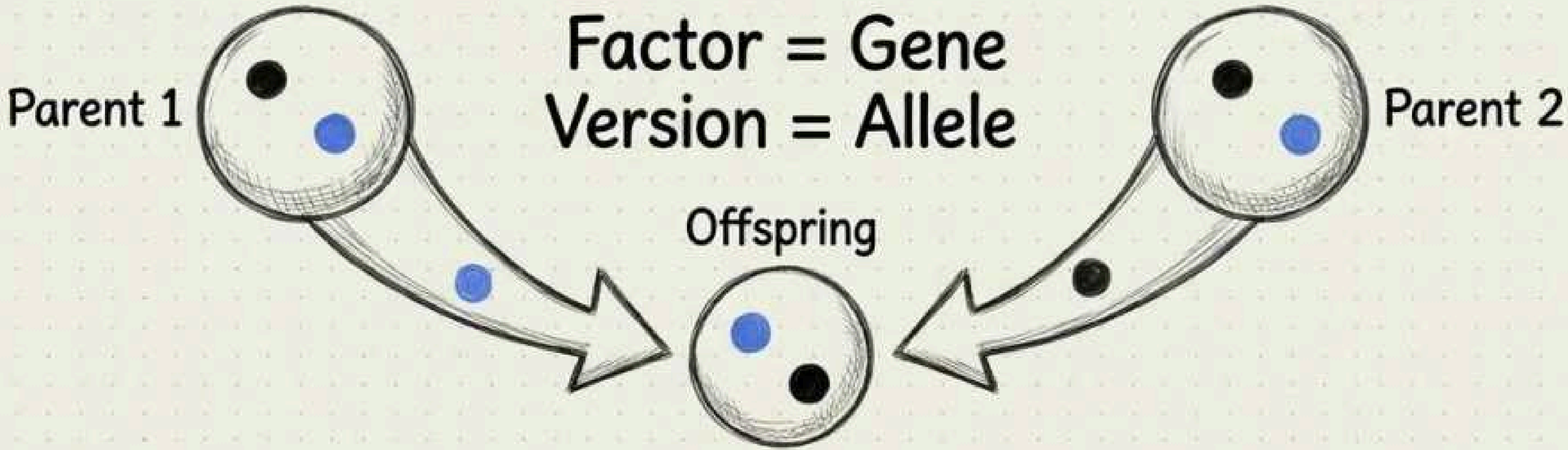
F1: 100% Tall  

F2: 

Extracting the Rule from the Ratios

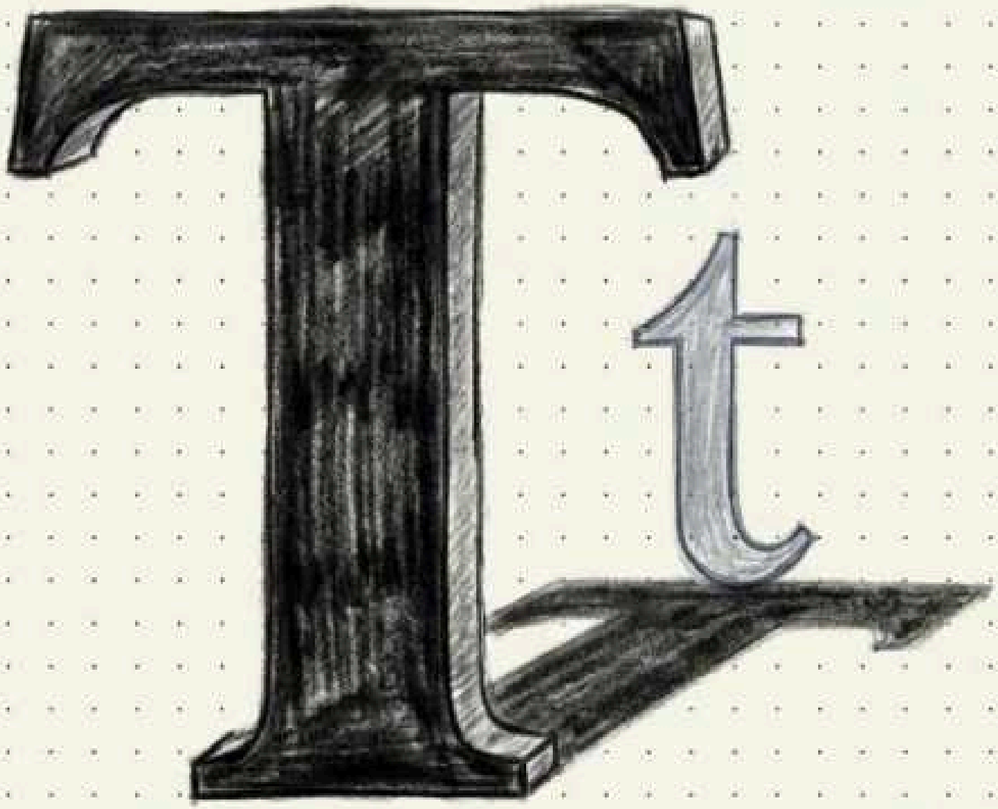
3:1

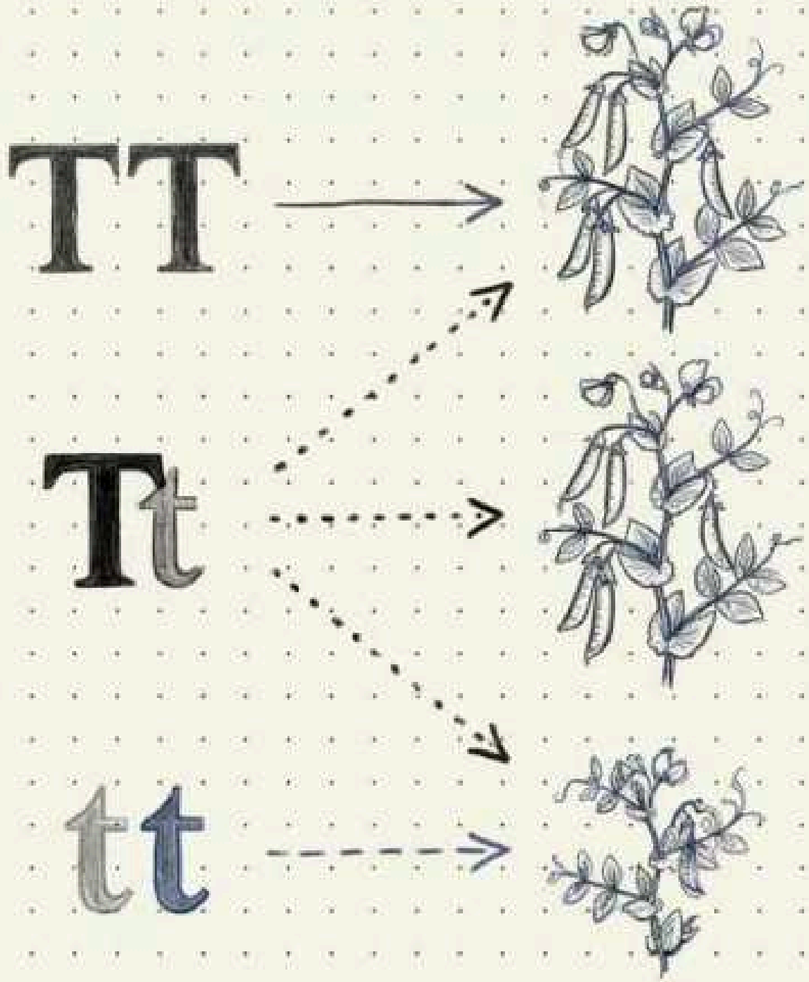
Factor = Gene
Version = Allele



Each plant carries two copies of every factor, receiving one from each parent.

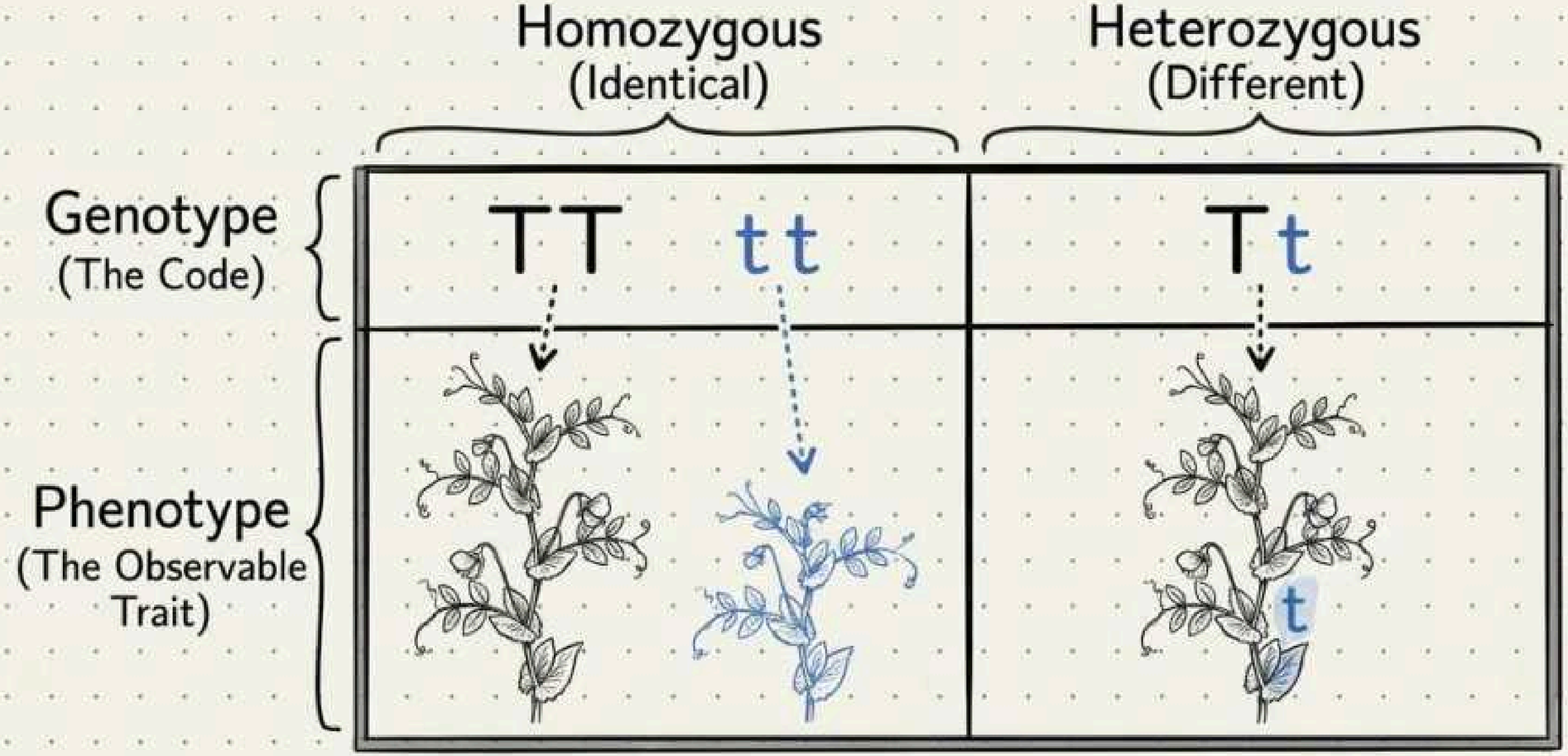
Dominant vs. Recessive Mechanics





A dominant allele shows its effect with only one copy.
A recessive allele shows only when both copies are recessive.

The Language of Heredity



Two plants can share a phenotype while carrying entirely different genotypes.

The Predictive Grid

	T	t
T	TT	Tt
t	Tt	tt

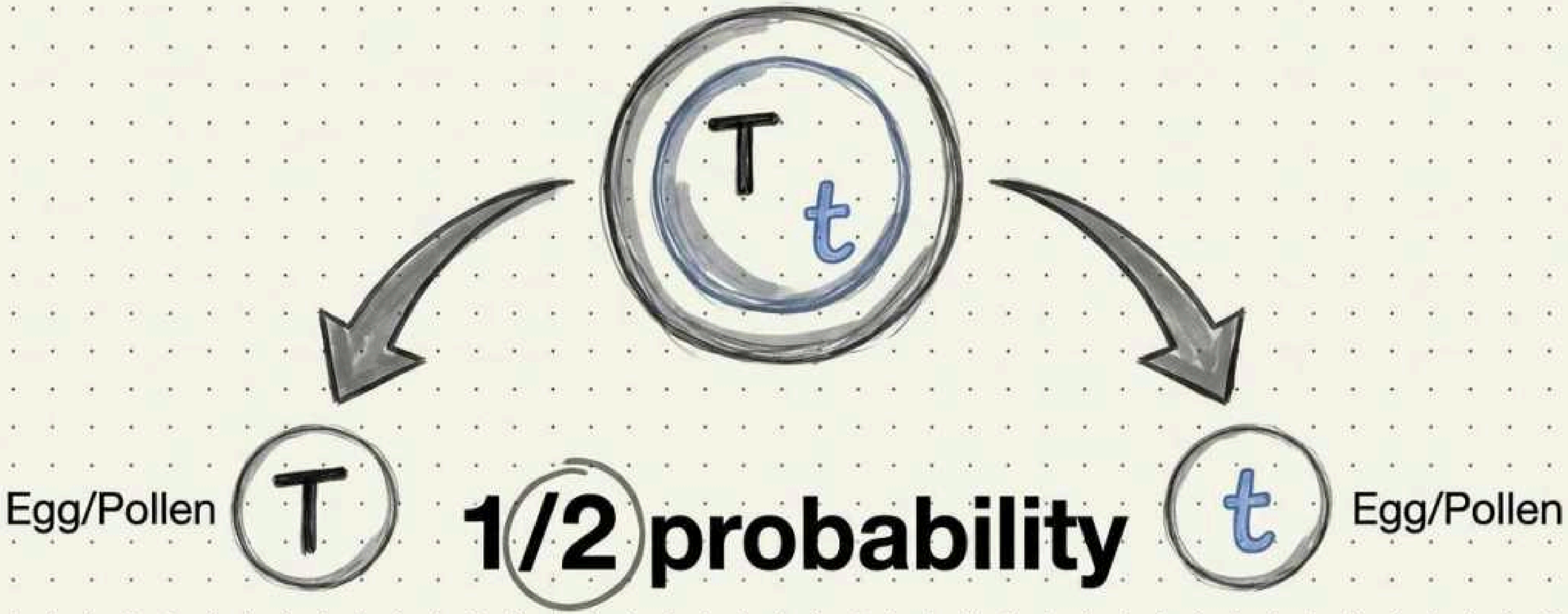
Genotype Ratio –> **1:2:1**
(1 pure tall, 2 hybrid tall, 1 short)

Phenotype Ratio –> **3:1**
(3 tall looking, 1 short looking)



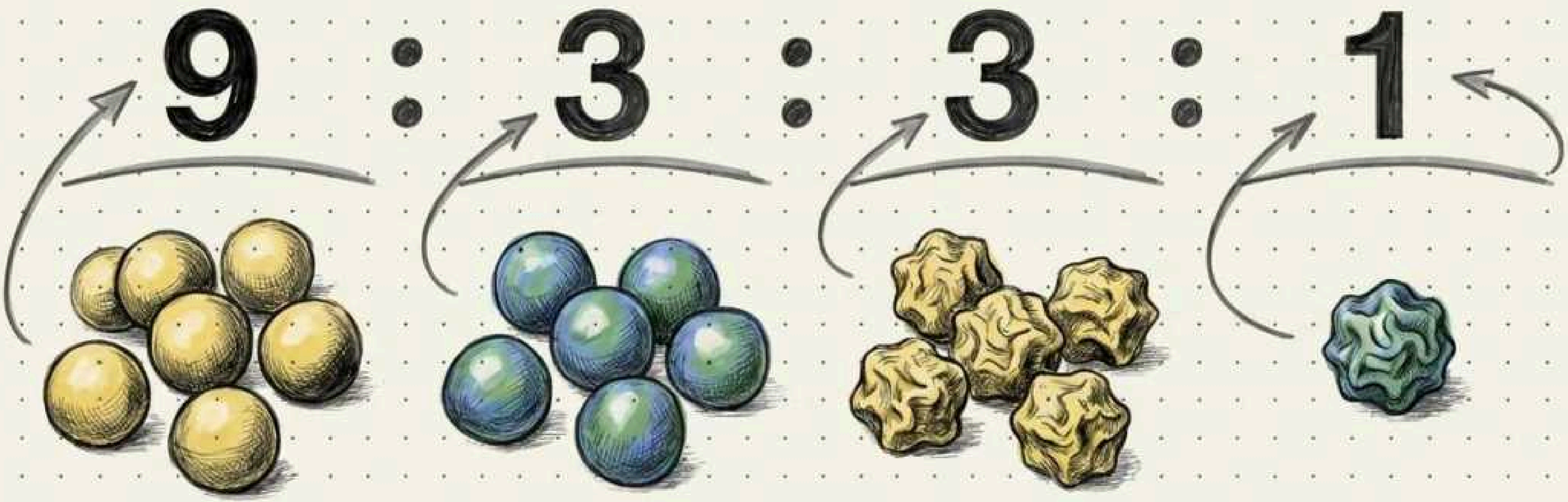
Reginald Punnett, early 1900s

Mendel's First Rule: The Law of Segregation



Alleles separate during sex cell formation. The recessive version is never lost—only hidden for a generation.

Tracking Complexity: Independent Assortment



Alleles for one trait are sorted into sex cells completely independently of alleles for another trait.

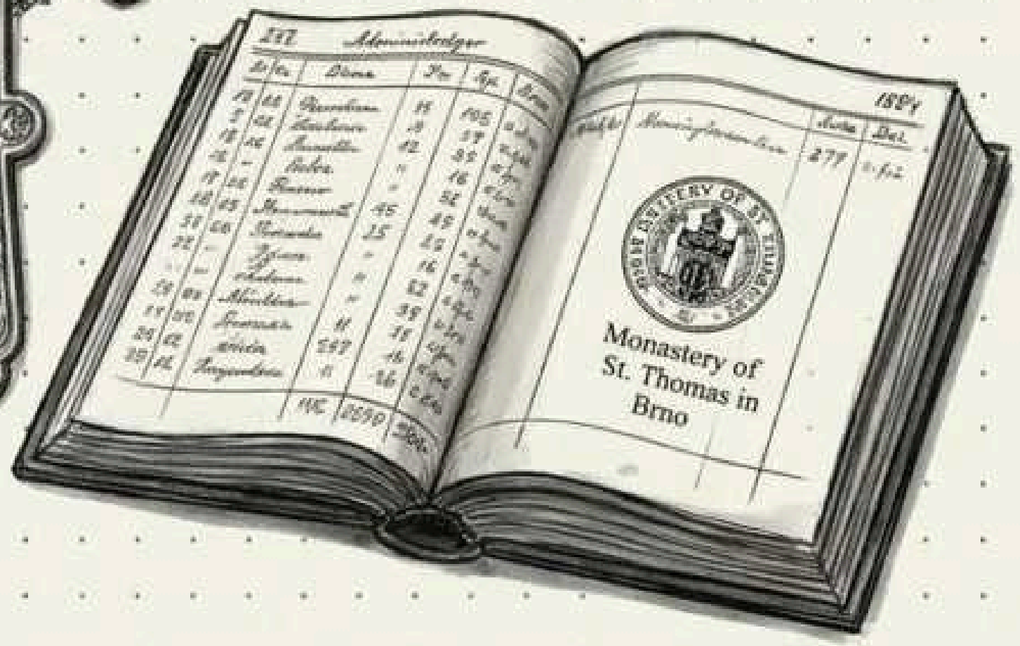
Lost in the Archives

1865 — 1884





Scientific duties replaced by administrative ones. Died in 1884, never knowing how famous his peas would become.



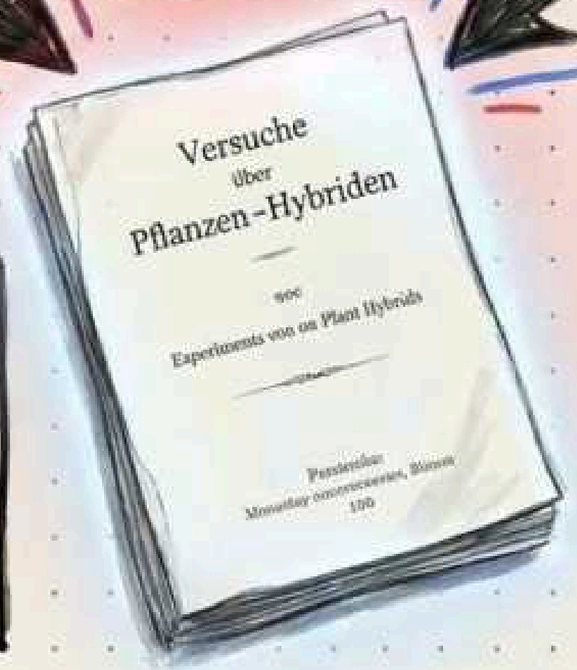
The 1900 Rediscovery

Carl Correns

Hugo de Vries

1900

Erich von Tschermak



1909

Danish scientist Wilhelm Johannsen coins the foundational units: Gene, Genotype, Phenotype.

The Chromosome Theory of Inheritance

Mendel's Math (1865)

- Factors come in pairs

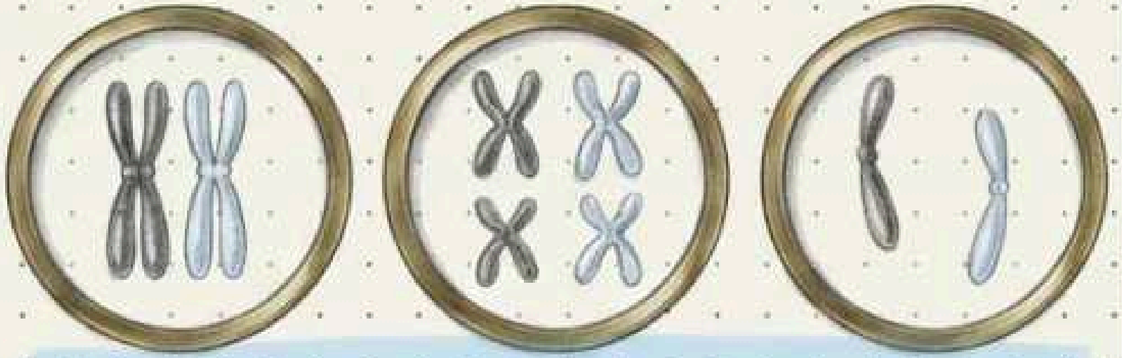
→ They separate

→ Inherit one from each parent.



=

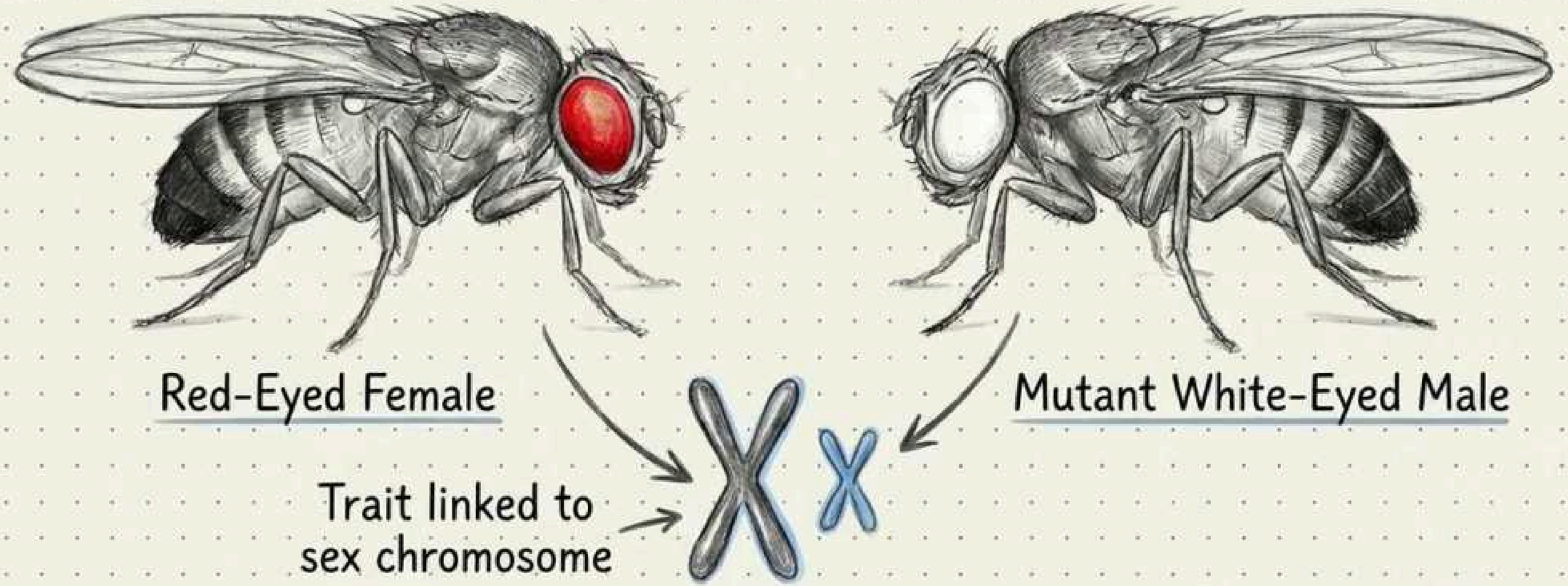
Sutton & Boveri's Microscopes (1902–1903)



Chromosomes come in pairs → They separate during cell formation → Inherit one from each parent.

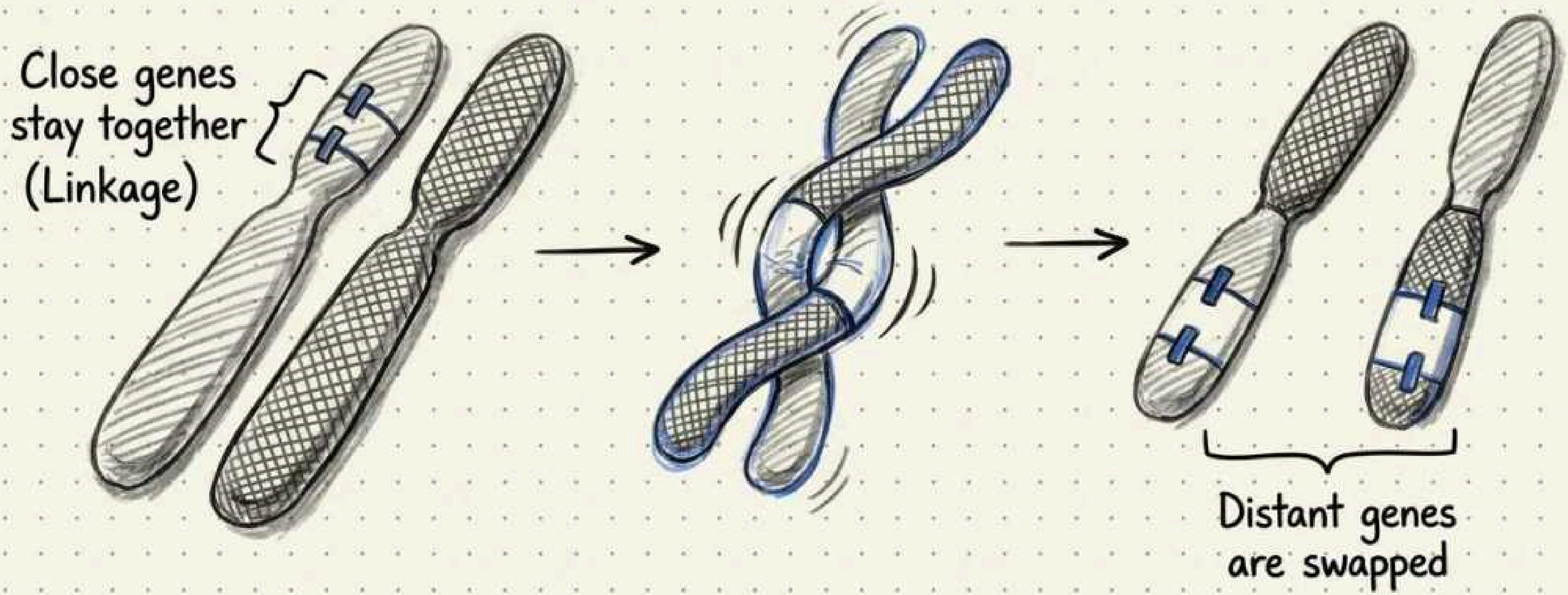
Microscopic observations prove chromosomes behave exactly as Mendel's mathematical factors do. Genes live on chromosomes.

The White-Eyed Fly (Morgan, 1910)



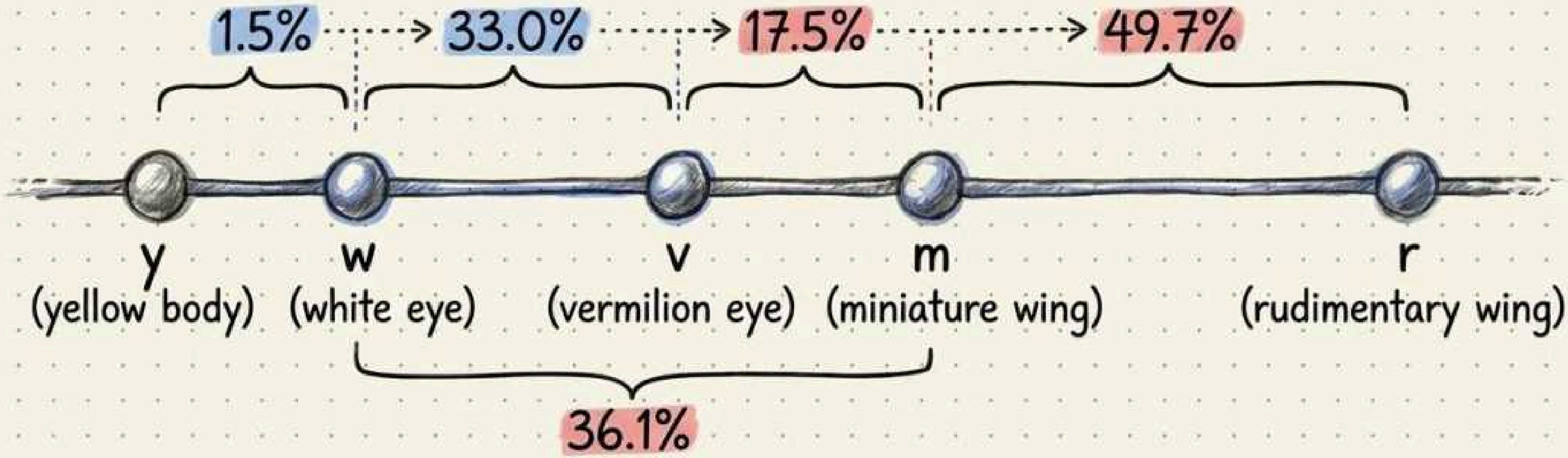
Columbia University's Thomas Hunt Morgan links a single gene to a single chromosome for the first time. (Nobel Prize, 1933).

The Exception: Linkage & Crossing Over



Genes on the same chromosome don't always assort independently, but linkage isn't perfect because chromosomes swap segments.

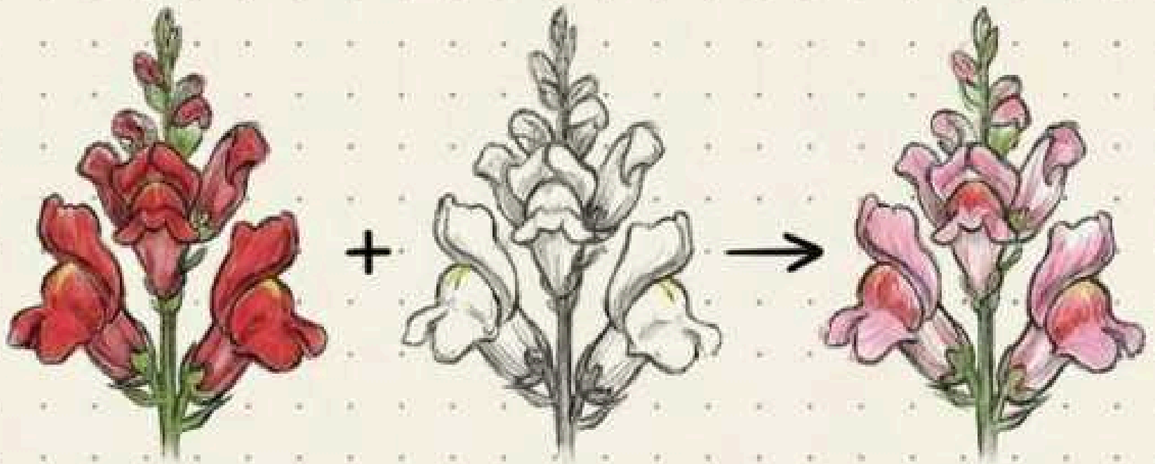
The First Genetic Map (Sturtevant, 1913)



Morgan's student, Alfred Sturtevant, realized that the closer two genes sit, the less often they are separated. Crossing-over rates became the first unit of physical distance.

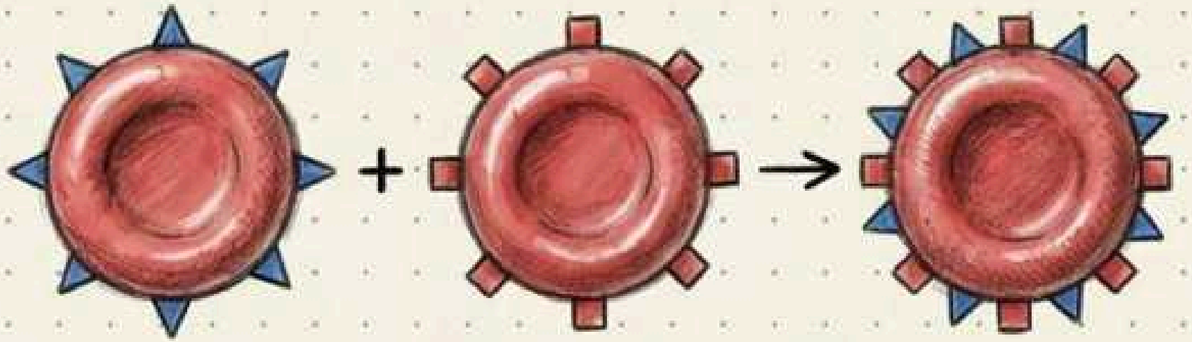
Beyond Strict Dominance

Incomplete Dominance



Red (C^RC^R) + White (C^WC^W) → Pink Intermediate (C^RC^W)

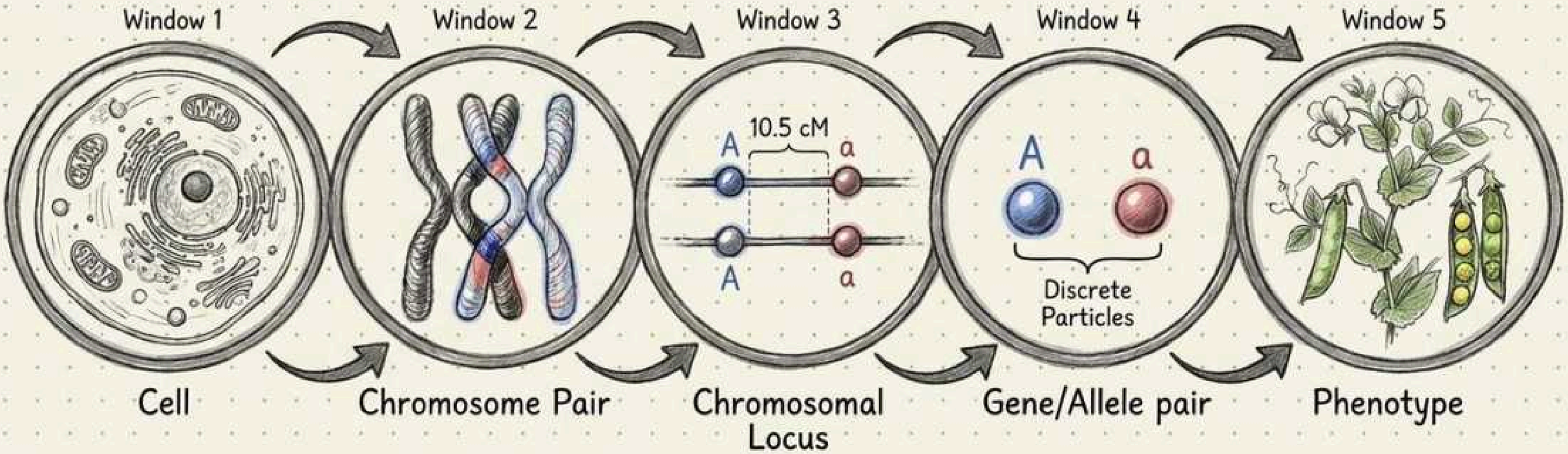
Codominance



A blood type (I^AI^A or I^Ai) + B blood type (I^BI^B or IBi) → AB blood type (I^AI^B)

Despite intermediate appearances, Mendel's logic holds:
The underlying alleles remain separate and are passed on unchanged.

The Grand Synthesis of Heredity



Heredity works by particles, housed on chromosomes, shuffled by sorting, and mathematically predictable. Mendel's ratios remain the first law of genetics. "P = G + E"

The Final Challenge: Probability vs. Reality

Cross: Heterozygous Tall (Tt) x
Heterozygous Tall (Tt)

Expected Short: 1/4

Observed: 5 short out of 16 grown.

Does this contradict Mendel's rule? Why not?

