Chapter 5 Topics

- 1. Animal Life Cycles
- 2. Structure of DNA in Eukaryotes and Prokaryotes!
- 3. Replication of DNA (copying of DNA)
- 4. Making proteins!
 - Transcription-going from DNA to mRNA
 - Translation-going from mRNA to protein
- 5. Gene regulation!
- 6. Sizing up the Genome
- 7. Mutations
- 8. Mitosis vs Meiosis (sexual reproduction)
- 9. Mendel and Punnett Squares
- 10. Getting more real....

Chapter 5 Final Topic

Mendel and Punnet Squares

Everyone was interested in inheritance during 2nd half of 1800s

Mostly people believed in blending inheritance.

What is blending inheritance??

Imagine balls are individuals filled with paint and you mimic mating by randomly pulling them out of a bucket two by two....





Fig. 1. Difference between the outcomes from blending and from particulate inheritance. In post-Mendelian terms, we assume a single diallelic locus, and hence three diploid genotypes (AA, blue; Aa, green; aa, yellow). Under particulate inheritance, the population's variability is preserved from generation to generation. In contrast, the conventional wisdom of Darwin's day saw offspring inherit a blend of parents' characteristics, here represented as the average of the two parental shadings. The result is that the variability diminishes in successive generations (the variance is halved each generation if mating is at random) SCIENCE MAGAZINE B. MAY



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Why was Mendel able to deduce the "particulate pattern" while others were struggling?

Imagine you are interested in inheritance.....

What measurements could you make on the people in this class?



Pictorial Press Ltd / Alamy Stock Photo

Box Figure 5.2.1 Gregor Mendel (1822–84) first recognized that inherited traits were made possible by factors (now called genes) passed down from parents to offspring.

Why was Mendel successful?

He was successful because he chose

- flower color is purple or white
- flower position is axil or terminal
- stem length is long or short
- seed shape is round or wrinkled
- seed color is yellow or green
- pod color is yellow or green

He did not choose traits like

- number of seeds per pod
- pod length
- pod width
- seeds per plant
- seed weight
- plant height



To review...

Mendel chose to track only characters that varied in an "either-or" rather than a more or less manner. His plants had either purple or white flowers, there was nothing intermediate between these two varieties.

Had Mendel focused instead on characters that vary in a continuum among individuals-seed weight for example-he would not have discovered the particulate nature of inheritance!

Considering all that can occur in the pathway from genotype to phenotype it is amazing that Mendel could simplify the complexities to reveal the fundamental principles governing transmission of individual genes from parents to offspring! 1865 Mendel publishes his PARTICULATE VIEW of Inheritance ...

Almost completely ignored even though it would have made natural selection work to drive evolution!

Was not until the Modern Synthesis that Mendel's ideas came together with mathematical models of natural selection.

Review of terms... What is a locus? What are alleles? For a diploid organism, how many alleles will there be at each locus? Parent 2 Parent 1 Homozygous? Heterozygous? Dominant? m **Recessive**?

This shows two chromosomes (two copies of chromosome one) in one individual.

The chromosomes are labeled according to which parent they were passed on from.

We have two copies of each chromosome...



The black allele at the gumball locus The white allele at the gumball locus

Shown here are two homologous chromosomes of the 23 pairs of chromosomes you have.



Parent 2

At the gumball locus you are heterozygous... Bb (?)

At the m+m locus you are homozygous... PP (?)

IF the black gumball is DOMINANT to the white gumball, this individual's phenotype would be (what color would the be if the gumball locus affected fur color).....?

We have two copies of each chromosome...



The black allele at the gumball locus The white allele at the gumball locus

There might be other individuals in the population that are homozygous at this locus.

Shown here are two homologous chromosomes of the 23 pairs of chromosomes you have.

C. Which individuals are heterozygous in this **population** at the gumball locus?

How many alleles are there in this **population** of 5 individuals at the gumball locus?

Parent 1 Parent 2 m

1

m

At the gumball locus you are heterozygous...

At the m+m locus you are homozygous...

A. For a diploid organism, how many alleles will there be at each locus?

> B. Image below shows 5 pairs of homologous chromosomes in 5 different individuals.



Lets focus on a **single locus ("gene")** on a **single chromosome** for plants!

In plants we use upper and lower case letters (usually).

Here are three plants with different genotypes at the "lobed" locus.







If each of these individuals were making gametes.....

Punnett Square Example #1

From your text



TADADAT PADATAD

Which is dominant? T or t?



TALE TALE TALE TALE



3:1 lobed/entire



Т Т t Ťt Ťt t Τt Τt

All lobed



3:1 lobed/entire



All entire



tt Entire

Percent of all individuals

Tt/TT Lobed



Perimeter area

Punnett Square Example #2

I'll add another example-Flower color in Mendel's peas

In pea plants P (purple flowers) is **dominant** to (p) white flowers.....

So if a plant's genotype at this locus is PP it will be..what color?

If it is Pp it will be...

If it is pp it will be...



Genotypes of all offspring (F1)?

Phenotypes of all offspring?

An organized way to respond to this question of what are the genotypes going to be in the next generation is to use a **Punnett Square**..

PP x **pp** cross...

Practice picturing these as gametes!



What are genotypes and phenotypes of offspring?

An organized way to respond to this question of what are the genotypes going to be in the next generation is to use a Punnett Square..

PP x **pp** cross...



What are genotypes and phenotypes of offspring? Did I even need a 2 x 2 table??



So these are all **Pp**...right?

Now lets cross two of these!

What if you interbred the Pp offspring to get a second generation? **Pp** x **Pp** cross...





What are genotypes and phenotypes of these F2 offspring?

Pp x Pp cross... What colors are the next generation's flowers if you grew them up?

> Р рр РР Рр р Рр рр





Ratio 3:1

Ratio 1:2:1



Was pretty impressive that through these results Mendel was able to infer what was going on!

He figured out that there were true "particles" that retained their identity.

Was not like paint blending!

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10. Getting more real.....

A. Most real loci have many alleles when you look at a population!

- Blood groups... I^A, I^B, and I^O (3 alleles)
- When you have three alleles how many different genotypes can you have?
- Major histocompatibility complex (MHC) genes also known as the human leukocyte antigen (HLA) may have 100 different alleles at a single locus!

Genotype Blood Group



Don't forget about populations!



B. Most genes affect multiple traits - Pleiotropy!

Ex. **Cystic fibrosis** caused by mutations in **CFTR gene** (Which may have over 1900 alleles or different mutations!) affects lungs (get infections) but also affects pancreas and digestive system. (Cool Fact: This mutation may have been selected for in past because may provide resistance to typhoid!)

https://embryo.asu.edu/pages/cystic-fibrosis-transmembrane-conductance-regulator-cftr-gene

Ex. Fruit flies **vg gene** affects wings and the position of bristles on one part of a fly, and decreases the length of a fly's life!



Wikipedia

In some cases...two alleles at a particular locus have unusual relationships!

It may **not** be a simple dominant-recessive relationship.



C. Incomplete dominance!

Is this blending inheritance???

This chicken is heterozygous at a single locus (BW), erminette.

What is going on here? Both alleles are expressed and both traits are "visible"!

D. Codominance



Genotype Blood Group





AB blood type is codominant because the red blood cells have the products of both the A and the B alleles of the ABO gene.

> https://genetics.thetech. org/ask-ageneticist/codominanttraits-people

Plus many genes interact with one another....

Plus many genes interact with one another....



Here are two of the 39 pairs of chromosomes in dogs (#1, #17).

The two genes represented are on different chromosomes.

What are the possible genotypes of the gametes could this dog produce with these two chromosomes?



Haploid= N =39 pairs Diploid= 2N =78



Note these two genes are on two different chromosomes. What are the possible genotypes of the gametes this dog would produce?

Which of the gametes are not possible???





What would be the possible genotypes of the sperm produced by this male lab?







1⁄4 (be)



What is the nature of the relationship between B and b????? What is the nature of the relationship between E and e????

What is going on????

What is the relationship between the two different genes or loci?

Brown lab when homozygous recessive (bb) and either (EE) or (Ee).



Get yellow lab whenever ee!

(ee shuts down color producing gene so doesn't matter whether it would have been black of brown)

What is this called?

E. Epistasis



https://healthtopics.vetmed.ucdavis.edu/health-topics/canine/inheritance-coat-color-labrador-retriever

F. Traits are usually determined by many more than one or even two loci!

With 2 loci what is maximum number of genetically different gametes you could have? **BbEe**

4 different gametes....(BE, Be, bE, be)

Imagine 3 loci or more!

How many genetically different gametes are possible with 3 loci all on separate chromosomes? AaBbCc

ABC Abc ABc aBC abC AbC aBc abc

What will your punnet square look like!!



Ex. Skin color is **Polygenic** (another term for quantitative or multilocus traits)





Do you think having 3 loci is realistic for skin color?



"Human skin color is a polygenic trait, meaning multiple gene loci are involved in its expression. At last count, the International Federation of Pigment Cell Societies...has determined that there are a total of **378 genetic loci** involved in determining skin color in humans and mice."



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The next (26th) International Pigment Cell Conference (IPCC2026) will be organized by the ASPCR and will be held in New Delhi (India) on **April 30 to May 3, 2026**, at the Hotel The Ashok & Samrat Complex.

Remember how we looked at the heritability of height?

"The researchers found **12,111 genetic** variants associated with human height, which clustered into small genomic segments that cover 21% of the genome. This confirms earlier predictions⁹ that a large proportion of the human genome is involved in shaping height."

nature



A combined analysis of 281 genome-wide association studies finds 12,111 common DNA variants associated with a person's height – and shows that larger studies will not yield more variants in populations of European ancestry.