# Biology 1305
# Modern Concepts in Bioscience (ICB Textbook)

**Hello and welcome to the weekly resources for BIO-1305 - Biology 1**

**This week is <u>Week 6</u> of class, and typically in this week of the semester, your professors are covering the topics below.** If you do not see the topics your particular section of class is learning this week, please take a look at other weekly resources listed on our website for additional topics throughout the semester.

We also invite you **to look at the group tutoring chart on our website to see if this course has a group tutoring session offered this semester.**

If you have any questions about these study guides, group tutoring sessions, private 30 minute tutoring appointments, the Baylor Tutoring YouTube channel, or any tutoring services we offer, please visit our website www.baylor.edu/tutoring  or call our drop in center during open business hours (M-Th 9am8pm on class days at 254-710-4135).

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**KEYWORDS**: Allele, Homozygous, Heterozygous, Dominant, Recessive, Genotype, Phenotype

## TOPIC OF THE WEEK

### Mendelian Genetics

Before we talk about patterns of genetic inheritance, let's make sure we define some important terms!

- **Gene**: a specific sequence of nucleotides (DNA or RNA) which encodes a final protein product; the basic unit of heredity
- **Alleles**: 2 or more variant forms of a gene; alleles of a gene are found at the same chromosomal location (locus) on different chromosomes
- A **diploid** organism has two copies of each chromosome. An allele is called **dominant** when it masks the effect of the other allele on the other chromosome, while the allele which is not expressed is called **recessive.**

Please watch the following video for more background information, including what it means for a trait to be **homozygous** or **heterozygous**, and for an introduction to monohybrid crosses.

https://youtu.be/gjQBVSnycKc

Now that we've looked at some of the important background information relating to basic genetics, it's time to talk about Mendel!

Gregor Mendel was an Austrian monk who studied patterns of inheritance based on his observations of vegetables in his garden. Today, we give him credit for starting the field of **genetics.** During Mendel's time, other prominent biologists had published a study suggesting that when homozygous (or "true-breeding") green pea plants were crossed with homozygous yellow pea plants, the results would produce offspring that either looked like one parents and not the other, or would show a phenotype that was intermediate between the two parents (yellowish-green).

**Does the below image support these ideas?**
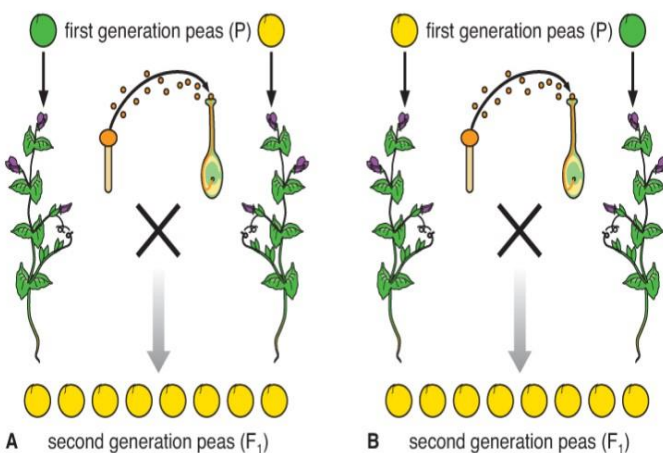


Mendel observed that when he crossed homozygous green plants and homozygous yellow plants, in the first generation of offspring (F1), **all of the offspring were yellow**. After conducting many experiments, he deduced that the allele for a yellow colored phenotype was **dominant** to the allele for green, which was **recessive.** But as we will see in future generations of offspring, the green trait did not disappear!

**Note**: The two crosses shown above are **reciprocal crosses.** Notice that the same parental genotypes were used in each cross, but in one scenario, the female parent was homozygous dominant while the male parent was homozygous recessive, and in the other cross, the genotypes were reversed between the parents. Because the results were the same in both scenarios, this shows us that inheritance of this particular trait in pea plants is **independent** of sex of the parents.

Next, Mendel bred members of the F1 offspring to produce the F2 generation. Based on what we know about alleles and genotypes, what was the genotype of the F1 parents?

**(For more help with this concept and information about Mendel's experiments, monohybrid crosses, and dihybrid crosses, check out this video!**

**https://youtu.be/3f_eisNPpnc)**
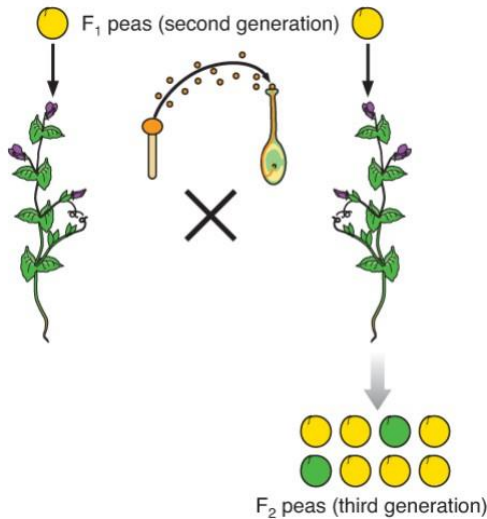
When we breed a **homozygous dominant** parent with a **homozygous recessive** parent, all of the offspring will have the **phenotype** of the dominant parent and the **heterozygous** genotype. Therefore, the entire F1 generation was **heterozygous.**

Based on these results, we see that ¼ of the F2 generation is green. Because green is the recessive trait, we know that the genotype of these green peas is yy, or homozygous recessive. **Of the remaining yellow pea plants, ⅓ of the yellow are YY, and the other ⅔ are Yy, or heterozygous. This means that of the TOTAL F2 offspring, ¼ were YY (homozygous dominant), ¼ were yy (recessive), and ½ were Yy (heterozygous).** **Based on this, we can say that the genotypic ratio for this generation is 1:2:1, and the phenotypic ratio is 3:1.** Make sure you understand how we got these numbers!

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<span style="background-color:cyan">HIGHLIGHT #1</span>: Probability Rules

In order to understand how to calculate probabilities in this chapter, we need to review two basic rules of probability:

1)  The **multiplication rule** tells us that to find the probability of two **independent** events A and B occuring, we need to multiply the probability of A occurring by the probability of B occurring   **(HINT: the word AND can be used to describe these situations)**

What does it mean for two events to be independent?

We say two events are independent when the probability of one occurring is not influenced by whether or not the other event occurs. For example, if we are trying to calculate the probability of producing a YY F2 pea (probability of inheriting one Y allele from male parent AND inheriting one Y from female parent), we would multiply the probability of inheriting Y from the

male parent times the probability of inheriting Y from the female parents. This is an independent event because the probability of inheriting a Y allele from each parent is an independent event, and whether or not a Y allele is inherited from one parent does not affect the probability of inheriting a Y allele from the other parents. We would solve this using the multiplication rule: **½ * ½ = ¼, or 25%.**

2) The **addition rule** is used when you are finding the probability of any one of multiple events happening when the events are mutually exclusive. **(HINT: the word OR can be used to describe these situations)**

**Mutually Exclusive** events cannot occur simultaneously.

In order to find the probability of a pea plant being homozygous, we have to find the probability of it being YY OR yy. These two events are mutually exclusive because a plant can only be one or the other, and not both. To do this, we **ADD** the probability of each event happening: **¼ + ¼ = ½.**

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**HIGHLIGHT #2: Dihybrid Crosses**

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Since we already looked at monohybrid (single trait) crosses, let's make sure we understand how dihybrid crosses work! We use the same principles that we discussed above, but now, our cross is much larger.



Notice that because we have two separate tracks to keep track of, there are **four** different possible combinations of alleles for each parent. If a parent is YySs, with S being smooth and s being wrinkled, the possible allele combinations we can get are **Ys, YS, yS, and ys.** Notice that these are listed at the top of our cross, while the combinations for the other parent's genotype are listed on the left side of the cross. Once we set up the cross in this way, we solve the cross in the exact same way that we did for monohybrid crosses.

Remember that when we crossed two heterozygous parents, our phenotypic ratio was 3:1. What ratio do we observe when we cross two parent plants that are both heterozygous for TWO traits?

This cross results in 9 offspring which are yellow and smooth, 3 which are green and smooth, 3 which are yellow and wrinkled and 1 which is green and wrinkled. This gives us the famous ratio 9:3:3:1.

*(Can you answer this question using the probability rules we discussed above without drawing a Punnett square? HINT: you can try dividing the problem into two separate monohybrid crosses, calculating probabilities separately, and multiplying or adding at the end!)*

## HIGHLIGHT #3: Binary Fission

Finally, let's briefly discuss binary fission. **Binary fission** is an asexual form of reproduction that is observed in bacteria in which an adult cell divides into two identical cells which will each eventually grow to the size of the original parent cell. Scientists knew that there must be a genetic component to bacterial reproduction, and they designed an experiment that would allow them to observe this effect. Microbiologists measured the average volume of mutant *E. coli* cells which were grown either in the presence or absence of the DNA base thymidine. The bacterial cells were mutated so that they could not produce their own thymidine base. Therefore, these cells which did not have Thymidine could not replicate their DNA.
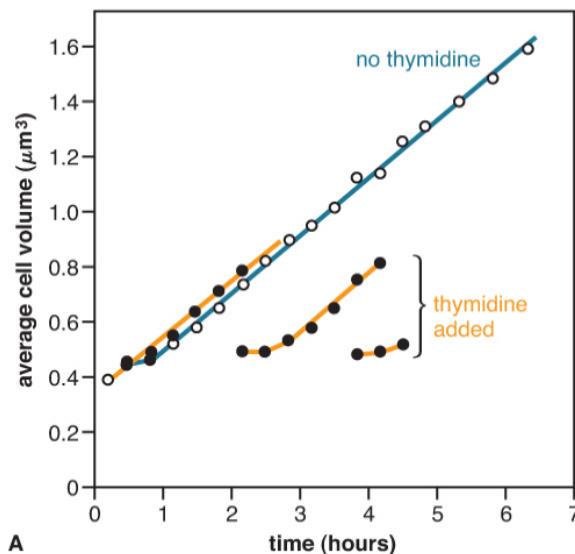


This graph represents the effect of DNA replication on cell size. Findings suggested that cells that are unable to replicate DNA (no thymidine) will continue to grow over time (blue line) and do not divide. Contrarily, cells that have thymidine available will cease to grow because they will divide. Notice how the orange lines start at approximately 0.4 um^3, grow to about 0.8 um^3 and then go back to 0.4 um^3. This suggests that the volume of the cells is being "cut in half," which is the evidence of cell division.

These results led the researchers to hypothesize that **cells divide into two equal-sized daughter cells only once the parental cell has reached a certain volume AND has replicated its DNA,** suggesting that the cell has mechanisms which allow it to "check" for each of these things before allowing division to happen.

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==**CHECK YOUR LEARNING**==

**(Answers below)**

1) What made Mendel such an effective researcher, and why did his experiments work as well as they did?
2) What is the difference between two events being independent and mutually exclusive? Can two events be BOTH independent and mutually exclusive?
3) What is the probability of producing an F2 pea plant which is heterozygous (Yy)?

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==**THINGS YOU MAY STRUGGLE WITH**==

- Thymidine is a nucleoside that E. coli needed to make DNA in the above experiment. It is similar to the nucleotide Thymine.
- Remember that the genetic ratios we discussed are based purely on theoretical probability; Mendel's data did not follow this exact ratio in every experiment. However, the more experiments we do and the greater numbers of organisms we use, the closer the obtained data will be to the theoretical ratios. (Think of it like flipping a coin: We know that the probability of getting heads is ½, but if we flip a coin 10 times, we might not get exactly 5 out of 10 heads. However, the more times we flip it, the more likely we are to get close to 50 % heads and 50 % tails)
- Remember that the same rules apply for monohybrid and dihybrid crosses! If you need more help with this concept, check out this video for more explanations of dihybrid crosses and their ratios: https://youtu.be/fe5kSSs83qc

1) Mendel chose pea plants, which can produce large numbers of offspring, have many traits which are easy to observe and study, and which offered him a controlled experimental system because all reproductive parts of this plant are enclosed within the same flower, making fertilization less subject to chance. He also kept very careful and detailed records and conducted many experiments using very large numbers of pea plants, which allowed him to observe important ratios relating to basic patterns of genetic inheritance.

2) Independent events mean that one event does not affect the probability of the other event; the two probabilities of each event occurring are completely independent. Mutually exclusive events cannot both occur together; if one happens, then the other cannot happen. Therefore, we know that mutually exclusive events are NOT independent! The occurrence of one event prevents the other one from happening, which means it is definitely affecting the probability of it occurring, and the two events can never be independent.

3) The probability of getting a Yy plant is the probability of getting a Y allele from the female parent **and** a y allene from the male parent, **OR** vice versa. Remember that all of the F1 parents are heterozygous. Therefore, the probability is: **¼ + ¼ = ½ (We have to first use the multiplication rule and then the addition rule).**

Thanks for checking out these weekly resources! Don't forget to check out our website for group tutoring times, video tutorials and lots of other resources: www.baylor.edu/tutoring! Answers to Check your Learning questions are below!