Of Mice and Mendel

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> **"My scientific studies have afforded me great gratification; and I am convinced that it will not be long before the whole world acknowledges the results of my works."**
> ***Gregor Mendel***

There are those few and fearsome teachers who are determined that their lessons will not be forgotten. Instead of teaching their students to become monkeys that spit information back to them, they endeavor to teach their students to think, a really quite tricky business if you think about it.

In science there are the discoverers, and also the sadly-overlooked keepers of the flame, who laboriously make sure information from past generations is not lost, and that the new generation rising up is building upon what has already been found so that science can progress instead of running in a continual loop of starting from nothing.

My Biology professor sought to do just that. Genetics was our topic of the day and Gregor Mendel was the man of the hour. That great scientist who had predicted so many years ago that his findings would be acknowledged by the world was right, but on the fateful Tuesday morning Biology lab that I stumbled into bleary eyed and deodorantless, my professor was determined to make sure it would also be understood. At least by the twenty students of his class. So he started from the beginning.

Gregor Mendel was a monk, an Augustinian monk if you're interested in that sort of thing, but he is more commonly known as the Father of Modern Genetics, because between the ages of 34-41 he watched peas reproduce. Why peas? Well actually, good old Gregor did not start with peas, but rather studied heredity in mice, but his bishop thought it wouldn't be fitting for him to watch Mickey and Minnie copulate, so pea plants it was. His findings laid the foundation for tons of important sciency stuff, but all of that is entirely over most of our heads. In fact, most of it would probably have been over Gregor's head too, because while he was able to draw correlations between his findings, he could not determine their causes. It was 1865, genetics was just beginning, give the man a break.

Now genetics, as you can probably guess, has a great deal to do with genes. What is a gene? The simplest answer is a strand of DNA. These genes, these strands of DNA which are found in the nuclei of your cells, do not determine what traits you have. DNA has one function and one function only, and that is to be a code for

proteins, and the proteins determine what traits you have. Same difference? So it would seem, but it's really not.

Proteins are crazy little molecules, and can be or do whatever the heck they want basically. Proteins can be enzymes, which help break apart and bring together other molecules. Proteins can be pigments and decide whether or not a girl is hazel-eyed and merely pretty, or whether she has blue eyes and now meets the requirement for becoming a Miss America. Proteins determine your traits, and genes determine your proteins. Hold on to that fact, you'll need it later. So my professor assured us all.

To ensure that we did hold on to this fact, our professor gave us a proposition. If we scored 20 out of 20 points on this lab, he would bump our midterms up to an A. This wasn't much of an incentive for me since I already got an A on my midterm. So he made the deal a little sweeter. If someone who got the lowest grade on the midterm needed 50 points to get an A, 50 points would be given to everyone who got a perfect score on this lab, and the extra points would be tacked on to the next test. Considering his tests are about 60 points, I would be sitting happy with an A on the next test even if I only got a 5 point question right. Considering there were people who only got in the teens on the midterm, many eyes widened with hope. He smiled at us, said he would make the deal even sweeter later, and then returned to conducting the lab as usual.

To start at the beginning with our dear friend Gregor, you're going to need to know about Punnett squares. Punnett squares are—you guessed it—squares. From dominate and recessive alleles you can determine the likelihood of pea plants being green or yellow with remarkable precision and only a two by two graph.

A thing of beauty if there ever was one.

This is the basic Punnett square scenario you will see in any basic biology class or textbook, and while it is important, my professor was not content with stopping there. After all, it is perfectly reasonable to go through the basic Punnett square without realizing that proteins come into play at all. Realizing the role of proteins is crucial for understanding genetics, but thinking the through the process is more than what any non-biology major would want to do in an 8:00 AM lab.

So my professor decided to give us a carrot. If we were able to explain the last scenario he was about to give us with Punnett squares without any help from him, he would give us an A for the whole course, and we would never have to show up for that 8:00 AM class ever again.

"This scenario I have crafted is a thing of beauty. I know what areas all of you have weaknesses in, and I am targeting them with this question. You will have to draw upon all your knowledge from the course up to this point to answer it. The answer is very simple, it will be staring you straight in the face, but you will not see it. Isn't it scary I know you all that well? But if any of you can adequately explain the scenario I am about to give you with no help from me, you will never have to see my face again."

This isn't just some game anymore, is it?

This isn't just some crazy monk watching peas, this isn't just some useless information about Punnett squares that you will never use again for the rest of your life.

This is important.

This is getting to sleep in Monday, Tuesday, Wednesday, and Friday again.

This is life and death.

This is war.

The last, fateful scenario he gave us had to do with mice, ironically enough. The last scenario was given to us as follows:

There are two types of mice, agouti and albino. Agouti is a type of brown mouse. A purebred male agouti is bred with a purebred female albino mouse, resulting in 12 agouti offspring, half male and half female. These mice are left to breed with themselves in an incestual paradise for a year (no wonder the bishop had reservations about his minks performing experiments with mice!) resulting in 384 mice total: 219 agouti, 96 albino, and 69 black. Explain this without using the internet.

I immediately whipped out my calculator to find the percentages for the third generation. 57% agouti, 25% albino, 18% black, so by that point it definitely wouldn't be a 2x2 Punnett square in the end. But a 4x4 Punnett square usually resulted in four different outcomes, with the ratio of 9-3-3-1, and we only needed three outcomes.

"Hey, Kristine." I turn around to see a classmate, Mike. "Do you want to come work with us?" I look around, everyone has divided back into groups around the tables in the back.

"Sure!" I said, gathering my stuff and moving to a table. A few other guys join, including Mr. Baseball. I don't remember his actual name, but he misses class a lot and was one of the ones in need of the extra points. I start spitballing Punnett squares right and left. The black didn't make sense; the scenario clearly stated there had been no mutations, and unfortunately it wouldn't make sense to claim black was a combination of agouti and albino. Albinism was the lack of pigments, and I knew Melanism was when there was pigment overkill, resulting in entirely black animals, but if there were no mutation would melanism even be possible…

"What are you saying there Miss Wagner?" My professor asked, coming back to our table in his rounds around the class.

"Just how albinism is the lack of pigments and melanism is the…"

"Yes! Yes!" My professor affirmed enthusiastically. "And what are pigments?"

I stared at him blankly. "Proteins."

"And what else are proteins?"

“Enzymes.”

“Yes! And what do proteins do?”

“Everything basically.” He grinned at me.

“Exactly Miss Wagner. You’re on the right track! You have all of the pieces, you just need to put them together!”

“But what track am I on? How do I know where to go from here?”

“Think! Proteins!” The professor gave me a wide, evil smile and resumed his rounds about the classroom. I returned to the scenario, even more confused than before.

The first generation seems fairly straightforward. Two agouti genes (G,G) across the top with two albino genes (a,a) down the side, creating all agouti offspring (G,a) assuming that agouti was the dominant gene. However, somehow, somewhere, they started reproducing black mice. Black couldn’t be a recessive gene because the original two mice were purebred. Where did the black come from?

Mr. Baseball hunched over his phone, trying to hide the fact he was googling for the answer. I knew it would do no good. The question was beautiful, the professor said, the answer was simple, he said. He smiled as he watched us all. He knew exactly what he was doing, making us all go out of our minds fighting for an A in the class. He was a bit of a sociopath. We got along really well actually.

It was nearly four hours into the lab. My lack of deodorant was beginning to become obvious. Our professor had not only succeeded in making us think with his little A for the whole course stunt, but he had driven many of us to skip classes and work in learn in pursuit of the ever elusive answer. Many flawless Punnett squares were drawn up, the roles of proteins were gone over again and again, DNA replication and translation into the amino acids was even well understood by all of the students. The professor merely smiled at us and told us we had all of the pieces we needed. But I did not have the time I needed.

It was 11:30. I gathered my papers.

“I’m giving up. I’m asking for the second hint.”

“No!” Mr. Baseball wailed. “You’re the smart one here! You’re our only hope!”

“Find a new Obi Wan,” I quipped back, and went up to the teacher. “I want the second hint.”

“You will want to hit yourself when you see how simple and logical this answer is, Miss Wagner.” My professor told me, leading me to his computer. I already wanted to beat my head against the wall, so I was not worried about sinking any lower at that point. And then he revealed to me the answer, which was in our eyes, truly a thing of beauty.

Reach back into your memories about how traits are determined. Do the genes determine the traits? No. What determines the traits? The proteins. In this case, there were two different types of proteins: pigments and enzymes. There was a pigment for black, and an enzyme that broke it down into smaller brown pigments. If you have a dominant black pigment, you get a black mouse, *unless* you also have a dominant enzyme, whereupon you have a brown mouse. If you have a recessive black pigment, you get an albino mouse no matter if the enzyme is recessive or not. If you have a dominant black pigment and a recessive enzyme, then you get a black mouse. All three colors factored for with only two genes, one gene that codes for the pigment and one that codes for the enzyme.

I returned to graph out a four by four Punnett square and write up my paper to turn in. Everything was explained perfectly; everything made sense. The logic of it all, the streamlined functionality, it made so much sense. The crazy professor was right, it was even rather beautiful how everything fell into place. Gregor Mendel became acknowledged worldwide years ago, but in that single lab another goal was met; a professor had all his students think through and understand the basics of genetics. The very, very basics, but any step forward in understanding is a moment to be rejoiced in, even if the motivation for it came from shameless bribery.

"Did I miss anything?" I asked, holding out my completed answer. He didn't even look at the paper as he accepted it.

"I'm sure you have everything." I thanked him and left, feeling like I had just exited some sort of psychology experiment. It was noon. The other students who held out for the extra points for the midterm got them, but it took 5 hours total. Not a single student was able to get an A for the rest of the course. But none of us will forget what we learned in that lab anytime soon.