Mendel's Laws and Angelfish Genetics

A presentation for

The Angelfish Society

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Introduction

- This presentation gives an overview of Mendel's laws, what they mean, and how they apply to angelfish genetics to predict the outcome of a cross.
- This presentation also discusses some traits that cannot be predicted with Mendel's laws.

Why another genetics presentation?

My first angelfish were marbles. The first time I bred my marble angelfish, I crossed a veil tail with a standard tail.

I was a brand new member of TAS, and was just starting to learn about angelfish genetics. I predicted that I would get 50% veil and 50% standard tail in the offspring.

I was totally thrilled when I got my predicted result!

Next…

Next, I crossed two of the veil tail offspring. I predicted I would get:

- ¼ super veil
- ½ veil tail
- ¼ standard tail

What do you supposed happened?

Well, I got the predicted results. Now I was super thrilled, and I fell in love with the ability to predict the results of angelfish crosses!

I spent many happy hours dreaming about the types of angelfish I would get and the types of crosses I would do.

It all started with Gregor Mendel

- Mendel was the first person known to make deliberate crosses, document his results, and try to explain why he got his results.

Who was Gregor Mendel?

- Gregor Mendel was born in 1822 to a poor family in a rural area of Austria (now part of Czechoslovakia).
- He entered the monastery to get his education, and focused on math and physics.
- He also had a lifelong interest in biology. He combined his interest in biology with his mathematical training when he performed experiments with pea plants.

Image found on the google images.
Original source: Bettmann Archives

“Blending” versus “Particulate” Inheritance

- Prior to Mendel’s experiments, people knew that offspring often showed signs of traits from both parents. They believed that the traits were somehow blended at conception, but had no idea how.

- Mendel developed the concept of particulate inheritance, meaning that specific genetic units were passed on to the next generation. We now call those units “genes.”

Mendel's experiments

- Mendel first bred pea plants to get pure strains. He then studied one specific trait at a time, such as whether the pea was smooth or wrinkled, or whether it was green or yellow

- Mendel conducted his experiments between 1856 and 1865. He kept records of his crosses and the results.

Image from www.jungleseeds.com/SeedShop/Peas.htm

Mendel discovered the concept of dominance

- He observed that when he crossed a pure (true-breeding) strain of peas with another pure strain with a different trait, all of the progeny looked like one of the parents.
- For example, when he crossed a pure strain of yellow peas with a pure strain of green peas, all of the next generation were yellow.
- He concluded that the yellow trait was <u>dominant</u> to the green trait.

Pure yellow + pure green gives 100% yellow offspring.

The Next Step

- After crossing two pure strains, Mendel then crossed the offspring.

Step 1
P1 cross

P1 x P1 → F1 F1 F1 F1

Pure yellow line x pure green line. All of the F1 offspring are yellow.

Step 2
F1 Cross

F1 x F1 → F2 F2 F2 F2

F1 yellow x F1 yellow: 3/4 of the F2 offspring are yellow and 1/4 are green.

First Law: Law of Segregation

- From his experimental results, Mendel concluded that each parent has two “particles” or genes for a given trait.
- These particles can come in different forms (such as yellow and green). Today we call these different forms “alleles.”
- When the gametes (sperm and ova) are formed, each pair of genes becomes separated or <u>segregated</u> from each other. Each gamete carries just one of each gene pair.
- When the offspring are conceived, each receives one gene from each parent, which unite to make a complete pair again.

Angelfish example: wild x gold

- If you cross a pure wild type (silver) angelfish with a gold angelfish, what will the F1 offspring look like? They will all be wild type (silver).
- If you cross two of the F1 offspring with each other, the F2 offspring will be 3/4 silver and 1/4 gold.

Images from the TAS Phenotype Library

We can show how this happens with a Punnet Square

- The P1 cross between a male wild and a female gold would look like this. The male contributes two alleles, + and +. The female contributes g and g.
  (It doesn't matter which is male and which is female.)

Male Gametes (sperm)

Female gametes (eggs)

	+	+
g	+/g silver	+/g silver
g	+/g silver	+/g silver

All of the F1 offspring are silver.

Now what happens when we cross two of these F1 offspring?

We can predict the results of the F1 cross with a Punnet square

- The F1 cross would look like this. The male contributes two alleles, + and g. The female also contributes + and g.

Male Gametes (sperm)

Female gametes (eggs)

	+	g
+	+/+ silver	+/g silver
g	+/g silver	g/g gold

The result is that 3/4 of the F2 offspring are silver and 1/4 are gold.

Second Law: Law of Independent Assortment

- Mendel studied inheritance of several traits in pea plants.

- He observed that when he made crosses involving two different traits, such as color and texture (wrinkled or smooth), each one still followed the Law of Segregation independently of the other.

- He concluded that when the two paired alleles of a gene pair segregate during formation of the gametes (sperm and eggs), this is completely independent of the segregation of another gene pair for another trait.

Independent Assortment Example

Let's use the previous example of wild x gold, and add a second trait, pearlscale. Assume the silver angelfish does not carry any alleles for pearlscale, and the gold angelfish has two pearlscale alleles.

- The P1 cross is: +/+ - +/+ x g/g – p/p
- The F1 offspring are all: +/g - +/p, silver non-pearlscale.
- Now if we cross two of these, what do we get?

F1 Cross

- Each F1 parent is +/g - +/p and contributes the following combinations of alleles in the gametes (eggs and sperm):
  - + - +
  - + - p
  - g - +
  - g - p

- If we put these in a Punnet square, what do we get?

F2 Results

Male gametes

Female gametes

	+ - +	+ - p	g - +	g - p
+ - +	+/+ - +/+ silver	+/+ - +/p silver	+/g - +/+ silver	+/g - +/p silver
+ - p	+/+ - +/p silver	+/+ - p/p silver pearlscale	+/g - +/p silver	+/g – p/p silver pearlscale
g - +	+/g - +/+ silver	+/g - +/p silver	g/g - +/+ gold	g/g - +/p gold
g - p	+/g - +/p silver	+/g – p/p silver pearlscale	g/g - +/p gold	g/g – p/p gold pearlscale

F2 Results continues

- Look at the Punnet square on the previous slide.
  - How many combinations of alleles are possible? (Answer: 16)
  - How many are silver? (answer: 12)
  - How many are gold? (answer: 4)
  - What are the ratios?
    - 12/16 silver = 3/4 silver
    - 4/16 gold = 1/4 gold
  - These are ratios we would expect for a single gene with one dominant and one recessive allele.
  - What are the ratios for wild type scales versus pearlscales? (see next slide)

F2 results continued

- From the Punnet square you can see that there are 12 with the wild type scales and 4 with pearlscale. Thus:
  - 12/16 = 3/4 are wild type scales
  - 4/16 = 1/4 are pearlscale
- Now look at just the 12 silver offspring.
  - 9/12 = 3/4 are wild type scale
  - 3/12 = 1/4 are pearlscale
- Now look just at the 4 gold offspring.
  - 3/4 are wild type scales
  - 1/4 are pearlscale
- What does it all mean?
  - It means that the silver/gold gene does not affect the ratio of wild:pearlscale, and
  - the wild/pearlscale gene does not affect the ratio of silver:gold

This means that the genes independently assort, as per Mendel's 2nd law!

How did Mendel derive his laws?

- Mendel did numerous crosses and carefully counted the number of offspring with each trait. He formed the laws based on his results.

- Every time we predict the results of a cross, then do the cross and count the offspring, we are testing this hypothesis.

Additions to Mendel’s Laws

- Mendel was very lucky with pea plants. All of the traits he examined just happened to have a dominant and a recessive gene. These resulted in very clear and predictable ratios.
- Since that time, we have discovered variations on these laws.
- We have also discovered that some traits do not follow these laws.

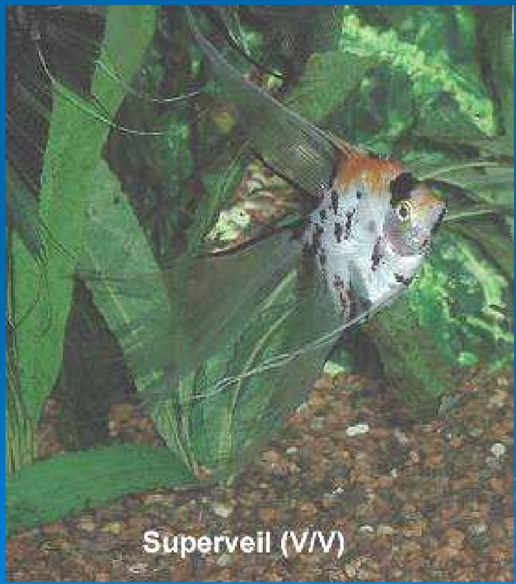
Variations on Mendel's Laws

- Some of the variations we have found include the following:
  - Some alleles are incompletely dominant. (We see this with a number of angelfish traits.)
  - Some genes are sex-linked. (We have not identified any sex-linked angelfish traits.)
  - Some pairs of genes do not assort independently because they are physically linked on a chromosome. (We do not identified any documented example of linked genes.)

Example of incomplete dominance

- Incomplete dominance means that the trait is partially expressed when there is one allele for the trait, and fully expressed when there are two alleles for the trait.
- The veil tail trait is an example of incomplete dominance.

A single dose of the veil allele (V/+) makes the tail and fins longer.



A double dose (V/V) makes the tail and fins even longer.

Another example: Smokey

Smokey Sm/+

Chocolate Sm/Sm

A single dose of smokey partially covers the body with the smokey coloration. A double dose results in much more coverage of the body with the smokey coloration. So Sm is partially dominant.

Non-Mendelian Genetics

- The inheritance of some traits cannot be explained by Mendel’s Laws.
- These traits are multigenic: governed by multiple gene pairs.
- Multigenic traits can be identified because there will be many gradations of expression, instead of clear cut distinctions.

Examples

- Size is multigenic in both angelfish and people. You don’t see clear cut distinctions in the ratios of large to small. You see a wide distribution of sizes, not distinct steps between sizes.

- Expression of orange in koi angelfish is multigenic. By selective breeding, you can develop a line that selects for the genes that increase expression of orange, but you will see many variations on the amount of orange expressed. See photo on next slide.

Orange in koi angelfish is multigenic

This stunningly orange koi angelfish was the winner of the TAS photo contest in August 2008. It was bred by Mario Toromanovic.

The End

Now join is back in the chat room for discussion.