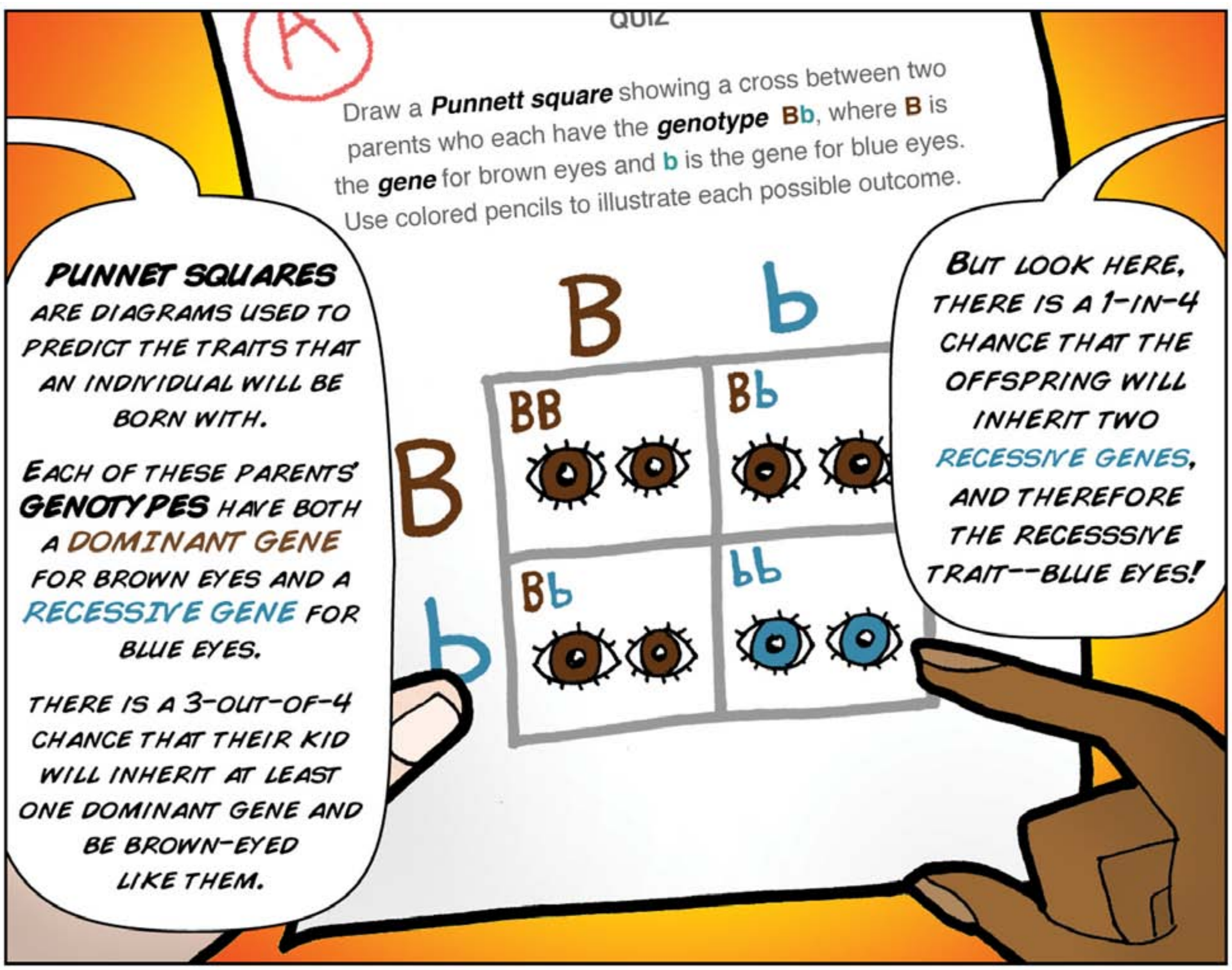
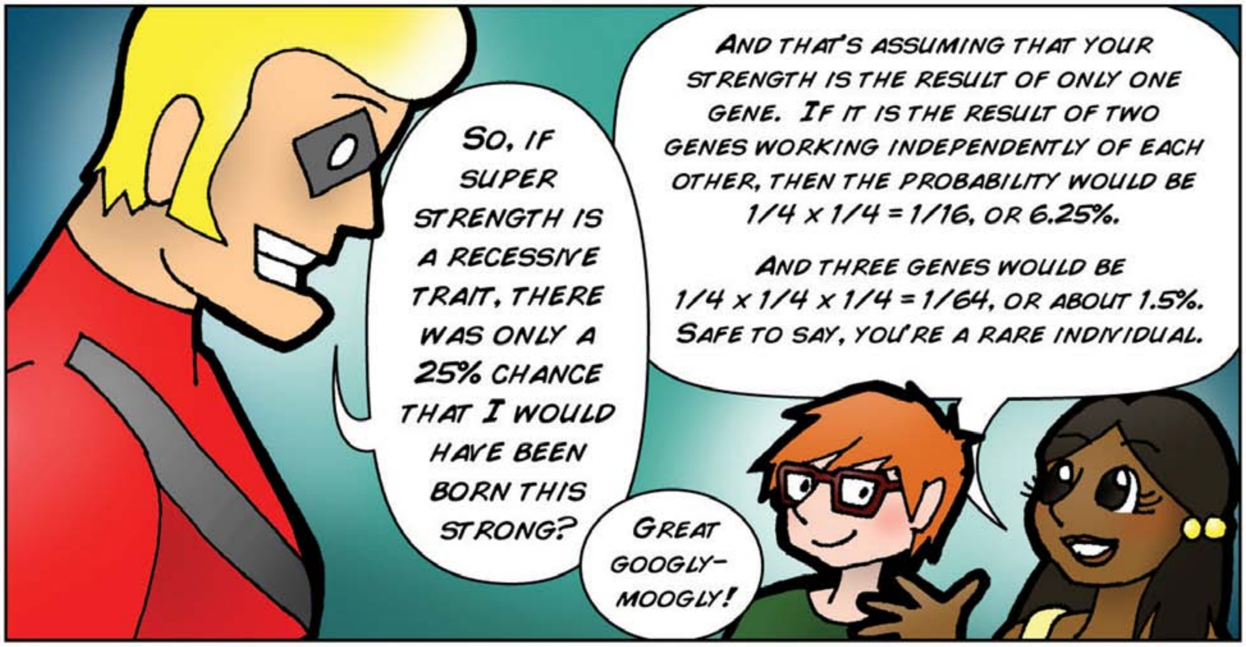
Teacher Supplement
to
Operation Comics, Issue #5

The purpose of this supplement is to provide content support for the mathematics embedded into the fifth issue of Operation Comics, and to show how the mathematics addresses the content standards provided by the National Council of Teachers of Mathematics (NCTM) for grades 3–5 and 6–8. The mathematics in this issue is a little light in comparison to the other issues, as the main purpose of the issue is to explain the origin of Wonderguy. However, in the course of explaining his origins, we are able to involve some science, specifically genetics and Punnett squares, and some probability. The mathematics used in this issue addresses both the NCTM standard for problem solving and the NCTM standard for reasoning and proof, for both grade ranges, in addition to the standards addressed below.

Punnett Squares and Probability

The explanation we give for Wonderguy's immense strength is that both of his parents had their genetics altered slightly to where they each carried at least one recessive gene for super-strength. Claire and Dillon, having just recently used Punnett squares in their science class, demonstrate how that meant that there was at best only a 1-in-4 chance (25%) that his parents had an offspring with super-strength, as shown in the figure.





We are able to illustrate that the probability of multiple independent events is the product of the individual probabilities by considering the possibility that having super-strength relies on having more than one recessive gene in place. The student worksheets will reinforce this idea by having students construct Punnett squares for multiple situations.

Using Punnett Squares

The first student supplement that accompanies this issue has the students constructing their own Punnett squares and reading probabilities from the results. Note that the results only hold if the genes are equally-likely to be passed on to their offspring. Solutions are given below.

1) The Punnett square in this case would look like the following.

1) Suppose one parent is super-strong (tt) and the other does not carry the recessive gene (TT).

	t	t
T	Tt	Tt
T	Tt	Tt

The probability that their offspring has super-strength is 0.

2) The Punnett square in this case would look like the following.

2) SUPPOSE ONE PARENT IS SUPER-STRONG (tt) AND THE OTHER DOES CARRY THE RECESSIVE GENE (Tt).

	t	t
T	Tt	Tt
t	tt	tt

The probability that their offspring has super-strength is $\frac{1}{2}$.

3) The Punnett square in this case would look like the following.

3) SUPPOSE ONE PARENT CARRIES THE RECESSIVE GENE (Tt) AND THE OTHER DOES NOT (TT).

	T	t
T	TT	Tt
T	TT	Tt

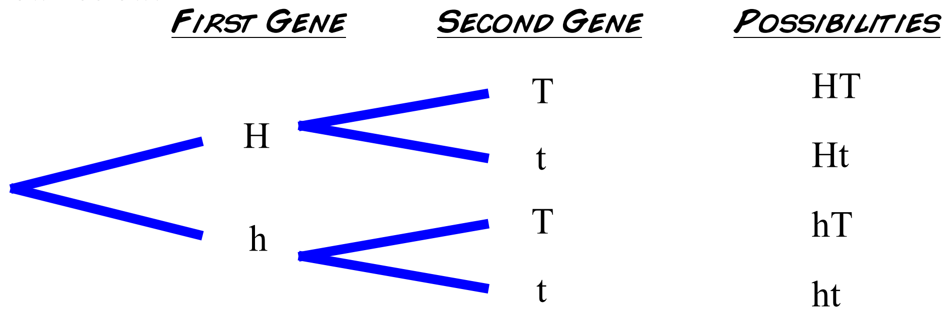
The probability that their offspring has super-strength is 0.

Super-Tricky! The probabilities that the offspring does not have super-strength in each of the problems is 1) 1, 2) $\frac{1}{2}$, and 3) 1. In each case, the probabilities that the offspring does have super-strength and does not sum to 1.

Two Independent Genes for Super-Strength #1

The second student supplement that accompanies this issue has the students constructing their own Punnett squares where more than one genotype is involved, and reading probabilities from the results. Note that the results only hold if the genes are equally-likely to be passed on to their offspring. Solutions are given below.

Step 1: The tree diagram showing the possible gene combinations sent to an offspring from one parent is shown below.



Step 2: The Punnett square in this case would look like the following.

	HT	Ht	hT	ht
HT	HHTT	HHTt	HhTT	HhTt
Ht	HHTt	HHtt	HhTt	Hhtt
hT	HhTT	HhTt	hhTT	hhTt
ht	HhTt	Hhtt	hhTt	hhtt

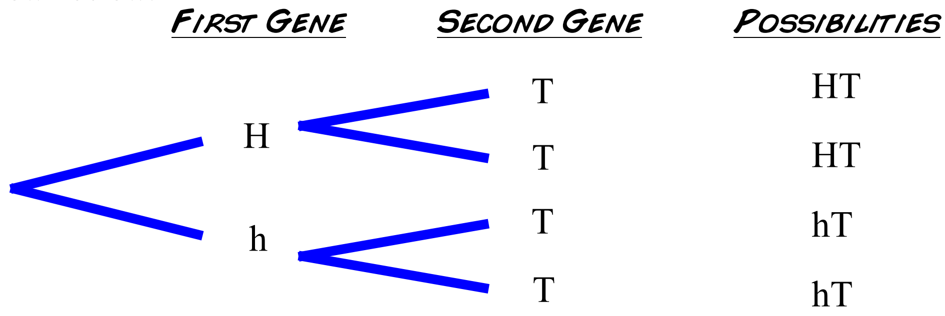
Only the "hhtt" genotype would have super-strength, so the probability is $\frac{1}{16}$. Notice that this is the product of the probabilities for each genotype, $\frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$.

Super-Tricky! The probability that their offspring will carry at least one recessive gene, but not have super-strength, is $\frac{14}{16} = \frac{7}{8}$. The probability that their offspring will not have a recessive gene is $\frac{1}{16}$. The sum of the probabilities is 1.

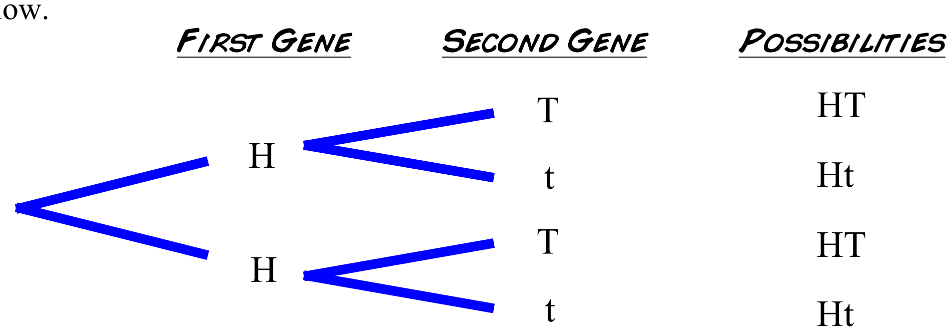
Two Independent Genes for Super-Strength #2

The third student supplement that accompanies this issue has the students constructing their own Punnett squares where more than one genotype is involved, and reading probabilities from the results. Note that the results only hold if the genes are equally-likely to be passed on to their offspring. Solutions are given below.

Step 1: The tree diagram showing the possible gene combinations sent to an offspring from the father is shown below.



The tree diagram showing the possible gene combinations sent to an offspring from the mother is shown below.



Step 2: The Punnett square in this case would look like the following.

	HT	HT	hT	hT
HT	HHTT	HHTT	HhTT	HhTT
Ht	HHTt	HHTt	HhTt	HhTt
HT	HHTT	HHTT	HhTT	HhTT
Ht	HHTt	HHTt	HhTt	HhTt

Only the "hhtt" genotype would have super-strength, so the probability is 0.

Super-Tricky! If three doubly-recessive gene pairs were needed to produce an offspring with super-strength, and each parent had the genotype "HhRrTt", then each parent could potentially send their offspring the gene combinations "HRT", "HRt", "HrT", "Hrt", "hRT", "hRt", "hrT", and "hrt". Thus, the Punnett square for this scenario would be as follows.

	HRT	HRt	HrT	Hrt	hRT	hRt	hrT	hrt
HRT	HHRRTT	HHRRTt	HHRrTT	HHRrTt	HhRRTT	HhRRTt	HhRrTT	HhRrTt
HRt	HHRRTt	HHRRtt	HHRrTt	HHRrtt	HhRRTt	HhRRtt	HhRrTt	HhRrtt
HrT	HHRrTT	HHRrTt	HHrrTT	HHrrTt	HhRrTT	HhRrTt	HhrrTT	HhrrTt
Hrt	HHRrTt	HHRrtt	HHrrTt	HHrrtt	HhRrTt	HhRRtt	HhrrTt	Hhrrtt
hRT	HhRRTT	HhRRTt	HhRrTT	HhRrTt	hhRRTT	hhRRTt	hhRrTT	hhRrTt
hRt	HhRRTt	HhRRtt	HhRrTt	HhRrtt	hhRRTt	hhRRtt	hhRrTt	hhRrtt
hrT	HhRrTT	HhRrTt	HhrrTT	HhrrTt	hhRrTT	hhRrTt	hhrrTT	hhrrTt
hrt	HhRrTt	HhRrtt	HhrrTt	Hhrrtt	hhRrTt	hhRrtt	hhrrTt	hhrrtt

Only the "hhrrtt" genotype would have super-strength, so the probability is $\frac{1}{64}$. Notice that this is the product of the probabilities for three separate genotypes, $\frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} = \frac{1}{64}$.

<u>NCTM Standards</u>

The counting of outcomes to find probabilities addresses the NCTM standard for data analysis and probability for grades 3–5, which says that "in grades 3–5, all students should propose and justify conclusions and predictions that are based on data and design studies to further investigate the conclusions or predictions," "describe events as likely or unlikely and discuss the degree of likelihood using such terms as *certain*, *equally likely*, and *impossible*," "predict the probability of outcomes of simple experiments and test the predictions," and "understand that the measure of the likelihood of an event can be represented by a number from 0 to 1." It also addresses the NCTM standard for data analysis and probability for grades 6–8, which says that "in grades 6–8, all students should compute probabilities for simple compound events, using such methods as organized lists, tree diagrams, and area models."

In addition to the NCTM standards, the construction of Punnett squares helps meet core standards in the science curriculum, but we will restrict our comments to just the math standards.

One last note . . .

While my purpose here is to produce a comic book with embedded mathematical content, and mathematics is my background, I did endeavor to write a good story, and hopefully, the comics can be used for their literary elements as well. The following are a few examples of subtle things at work in the story.

- The story references a "super-soldier" program, which was previously referenced in another issue, Operation Comics #3: Not Your Average Cat, with the villain The Cheetah, who was also a scientist wanting to "improve" upon standard human abilities. The notion of having such a program could lead to a philosophical discussion regarding the ethics of having such a program.

- We get to see Wonderguy as a child in this issue, and learn that he was born with his great strength. This could lead to a discussion of whether always being extra strong had any affect on how hard the younger Wonderguy actually pursued academics while he was in school.
- What would have been the ramifications if Wonderguy's parents had not hidden the fact that he was super-strong as a child?

This document, as with the student supplements, is a work in progress. Please contact me with corrections or suggestions, and I will make the needed changes. Thanks for inviting Wonderguy into your classrooms, and please encourage your students to contact me with their comments and suggestions for future episodes.