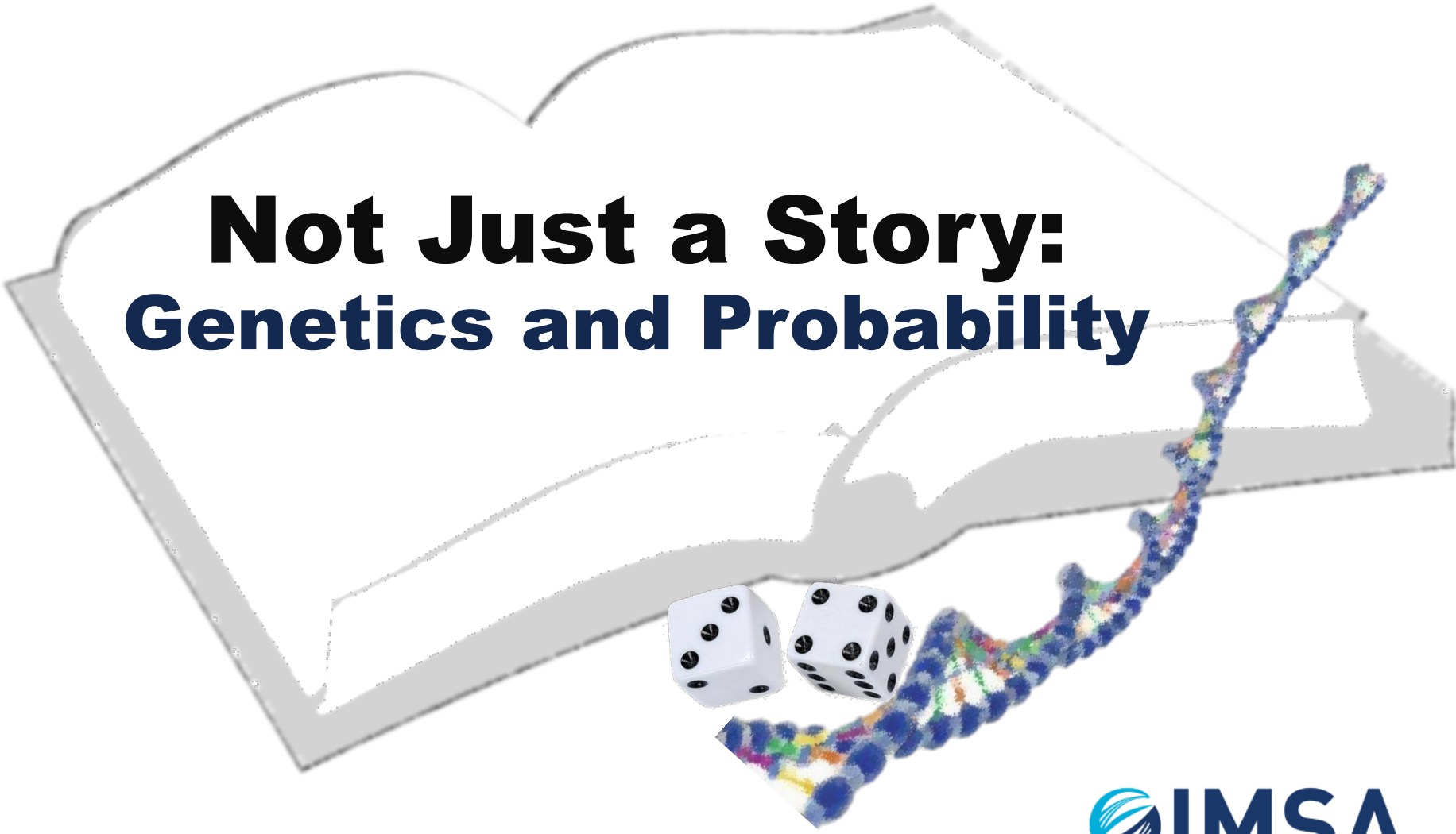
Not Just a Story:
Genetics and Probability



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Objectives

- Experience integrative techniques used in a model activity.
- Identify characteristics of integrative instruction.
- Consider tips or opportunities for integrative teaching in your current curricula.

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Framing the activity

- Book: *Wonder*, RJ Palacio

- Summary:
  - August starts at a new school
  - Has severe facial deformities: *"won the jackpot"*
  - Family, sister and friends play important roles in story
  - "chapters" in individual the voice of individual characters

Begins with a quote

"so doesn't that make the universe a giant lottery, then? You purchase a ticket when you're born. And it's all just random whether you get a good ticket or a bad ticket. It's all just luck," - Justin

Questions:

- **How do you define random?**
- **What are some events you consider to be random?**

Flipping coins

How might you devise a test to determine if the results of a coin flip are random?

- Consider how you will collect, organize and analyze the data
- What's the predicted value? How do we determine?

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Flipping coins

$$p(\text{tails}) = \frac{\#\text{ favorable outcome (flipping tails)}}{\text{total \# possible outcomes}}$$

$$p(\text{tails}) = \frac{1}{2}$$

50%

Flip for tails… flip 4 separate times, record your data. What is the outcome?

- **Combine data across groups. Do these values approach predicted value?**
- **What does this indicate about "sample size" in an experiment?**

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Standards (Common Core Math)

CCSS.MATH.CONTENT.6.RP.A.3.C
Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, given a part and the percent.

CCSS.MATH.CONTENT.7.SP.C.6
Approximate the probability of a chance event by collecting data on the chance process that produces it and observing its long-run relative frequency, and predict the approximate relative frequency given the probability. *For example, when rolling a number cube 600 times, predict that a 3 or 6 would be rolled roughly 200 times, but probably not exactly 200 times*.
CCSS.MATH.CONTENT.7.SP.C.7
Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy.

High School Common Core Standards,
http://www.corestandards.org/Math/Content/HSS/CP/

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Importance to the story?

"so doesn't that make the universe a giant lottery, then? You purchase a ticket when you're born. And it's all just random whether you get a good ticket or a bad ticket. It's all just luck," - Justin

Is Auggie's genetic condition a random event?

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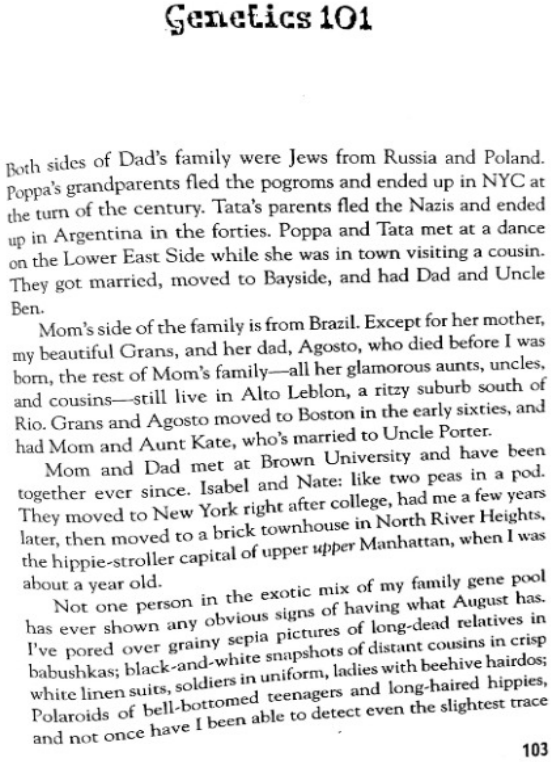
So… the genes in the story.



Genetics 101

Both sides of Dad's family were Jews from Russia and Poland. Poppa's grandparents fled the pogroms and ended up in NYC at the turn of the century. Tata's parents fled the Nazis and ended up in Argentina in the forties. Poppa and Tata met at a dance on the Lower East Side while she was in town visiting a cousin. They got married, moved to Bayside, and had Dad and Uncle Ben.

Mom's side of the family is from Brazil. Except for her mother, my beautiful Grans, and her dad, Agosto, who died before I was born, the rest of Mom's family—all her glamorous aunts, uncles, and cousins—still live in Alto Leblon, a ritzy suburb south of Rio. Grans and Agosto moved to Boston in the early sixties, and had Mom and Aunt Kate, who's married to Uncle Porter.

Mom and Dad met at Brown University and have been together ever since. Isabel and Nate: like two peas in a pod. They moved to New York right after college, had me a few years later, then moved to a brick townhouse in North River Heights, the hippie-stroller capital of upper *upper* Manhattan, when I was about a year old.

Not one person in the exotic mix of my family gene pool has ever shown any obvious signs of having what August has. I've pored over grainy sepia pictures of long-dead relatives in babushkas; black-and-white snapshots of distant cousins in crisp white linen suits, soldiers in uniform, ladies with beehive hairdos; Polaroids of bell-bottomed teenagers and long-haired hippies, and not once have I been able to detect even the slightest trace

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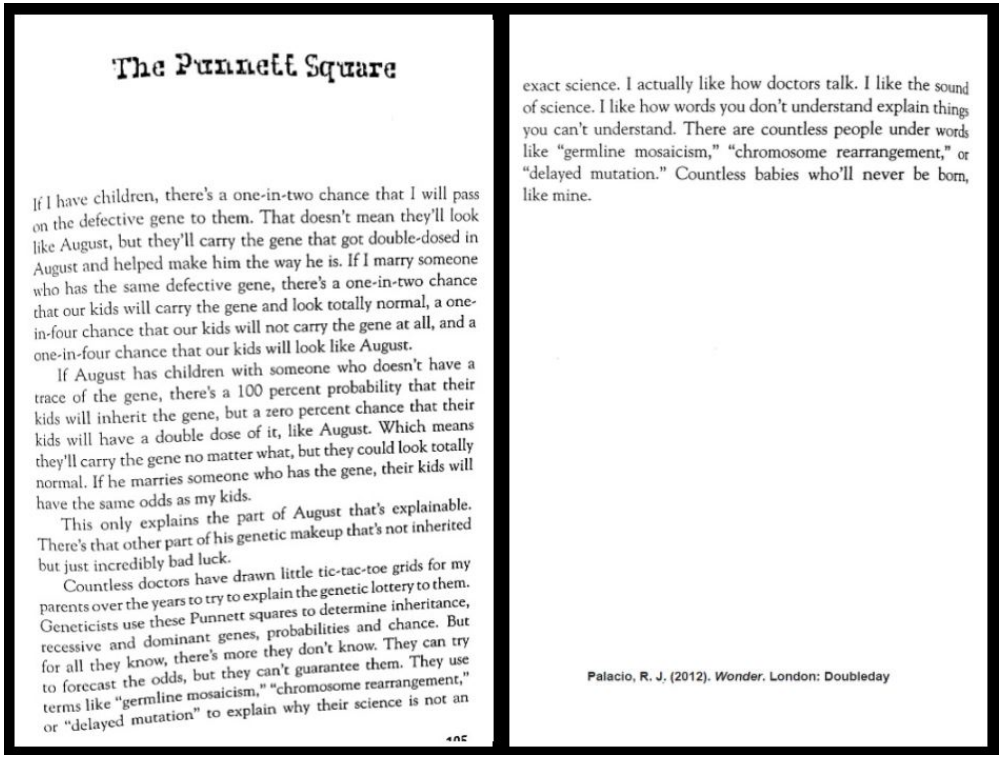

The Punnett Square

If I have children, there's a one-in-two chance that I will pass on the defective gene to them. That doesn't mean they'll look like August, but they'll carry the gene that got double-dosed in August and helped make him the way he is. If I marry someone who has the same defective gene, there's a one-in-two chance that our kids will carry the gene and look totally normal, a one-in-four chance that our kids will not carry the gene at all, and a one-in-four chance that our kids will look like August.

If August has children with someone who doesn't have a trace of the gene, there's a 100 percent probability that their kids will inherit the gene, but a zero percent chance that their kids will have a double dose of it, like August. Which means they'll carry the gene no matter what, but they could look totally normal. If he marries someone who has the gene, their kids will have the same odds as my kids.

This only explains the part of August that's explainable. There's that other part of his genetic makeup that's not inherited but just incredibly bad luck.

Countless doctors have drawn little tic-tac-toe grids for my parents over the years to try to explain the genetic lottery to them. Geneticists use these Punnett squares to determine inheritance, recessive and dominant genes, probabilities and chance. But for all they know, there's more they don't know. They can try to forecast the odds, but they can't guarantee them. They use terms like "germline mosaicism," "chromosome rearrangement," or "delayed mutation" to explain why their science is not an

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exact science. I actually like how doctors talk. I like the sound of science. I like how words you don't understand explain things you can't understand. There are countless people under words like "germline mosaicism," "chromosome rearrangement," or "delayed mutation." Countless babies who'll never be born, like mine.

Palacio, R. J. (2012). *Wonder*. London: Doubleday

- **Mom and Dad both have one defective gene**
- **Nobody else in the family has symptoms**
- **Autosomal Recessive**

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How do we test for randomness?

- Use knowledge from coin flip experiments
- Find predicted value
- Devise test and tables
- Review experimental design… *introduce Punnett Square?*

    - Label both coins, 1 side Big T, 1 side Little t
    - 4 trials/flips
    - Results as predicted?
    - Importance of sample size… *population?*

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Vocab/Content

One possible assessment question: Via, Auggie's sister: if she were to have children with a partner who also carries one of the same mutations, there is a 1/4 chance of having either a child with no mutations or a child who looks like Auggie. She also states that there is a 1/2 chance of producing a child who does not visual express the disorder, but still carries the mutation.
a) Looking at the Punnett Square, are her assertions correct?

Introducing terms like phenotype and genotype, point mutation...

Fun fact: the book gets it wrong in places… the TCOF1 point mutation in the assumed disorder is autosomal dominant. What does that mean with regards to the randomness of this genetic event? Why did the author choose to highlight the gene but refer to it as autosomal recessive?

More standards (NGSS)

MS-LS3-1. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] [Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.]

HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution
Scale, Proportion, and Quantity . Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).
of expressed traits in a population.

https://www.nextgenscience.org/

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Even More standards (ELA)

CCSS.ELA-LITERACY.RL.9-10.1
Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

CCSS.ELA-LITERACY.RL.9-10.4
Determine the meaning of words and phrases as they are used in the text, including figurative and connotative meanings; analyze the cumulative impact of specific word choices on meaning and tone (e.g., how the language evokes a sense of time and place; how it sets a formal or informal tone).

CCSS.ELA-LITERACY.RL.9-10.5
Analyze how an author's choices concerning how to structure a text, order events within it (e.g., parallel plots), and manipulate time (e.g., pacing, flashbacks) create such effects as mystery, tension, or surprise.

CCSS.ELA-LITERACY.RL.9-10.6
Analyze a particular point of view or cultural experience reflected in a work of literature from outside the United States, drawing on a wide reading of world literature.

http://www.corestandards.org/ELA-Literacy/RL/9-10/

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Integrative

Integrative, defined:

Integrative learning experiences are those which forge meaningful connections of concepts, constructs, and principles within and across academic subjects and real-world situations

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Multidisciplinary

- *Based on standards*
- *Theme focused*
- *Parallel Disciplines – Learning Centers*

Intradisciplinary

- *Within Disciplines*
- *Skills focused*

Interdisciplinary

- *Organized around common concepts*
- *"interdisciplinary"*
- *Themes/Skills*
- *Disciplines identifiable but less focused upon*

Transdisciplinary

- *Student-lead*
- *Problem-Centered*
- *Open-ended*

"Quick Tips"

- *Dip your feet in first: "Multidisciplinary" is integrative*
- *Focus on real-world application of the content*
  - *Problems*
  - *Issues*
  - *Questions*
- *Allow students to develop questions – they often lead to other content areas*
- *Note the standards from other content areas that align with your focus:*

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http://www.imagefully.com/cute-dog-thank-you-picture/

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