Curriculum Units by Fellows of the National Initiative
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Using Proportions to compare medicine doses in adults and children

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by Yavet Respes

Introduction and Rationale

Clinical trials are needed to make new medications, devices, and diagnostic tools available and approved for safe human use. Historically, participants in clinical trials often have come from a homogeneous group, white males, and there is a recognized need for increased diversity and representation in these clinical research studies. The shift of clinical trials towards more inclusive and diverse participant pools is critical. The absence of diverse participants in clinical trials makes it difficult for clinicians and researchers to know whether medications and devices are safe and effective for the broader population. This shift in clinical trial design and practice aims to enhance the generalizability and applicability of research findings to a broader range of individuals[1]**.** Because differences among individuals in their genetics or physiology, such as allergies, can affect whether a drug is safe and effective, this is an example of evolutionary medicine: using knowledge of evolution to better understand diseases and their treatments.

The findings from clinical research studies fill knowledge gaps by providing new information about ways to treat, prevent, and diagnose diseases. Studies are needed to advance medicine and health care and optimize outcomes. Volunteers join these studies and contribute to the collected data on drug safety and efficacy. In many of these studies, the diversity of the participants is not representative of the general population, such as across the USA. Some subgroups of the population, including African Americans and Hispanics, were disproportionately under-represented in medical research studies.

Evidence has indicated that poor outcomes following drug administration, such as adverse reactions and reduced efficacy, can differ by patient characteristics, such as gender and ethnicity. Clinical research studies need to consider diversity when the goal is to improve care and outcomes for all patients[2] .

I aim to develop a curriculum unit to teach the meaning of proportional relationships, specifically how the effects of medication errors can affect pediatric patients. Students will examine studies that discuss the importance of correct dosing, how dosages are determined, and why recommended doses may differ between adults and infants/children. My students are often the caretakers of themselves and their younger siblings. They are often responsible for determining how much over the counter (OTC) and prescription medications to give themselves and their younger siblings. By the end of the unit, I hope students see the importance of following dosing guidelines for themselves and their younger siblings.

My goal is to help students understand the concept of a proportional relationship, and how that relationship connects to drug dosages. Students will build on the concept of equivalent ratios learned in 6th grade. In 6th grade, students learned two ways of looking at equivalent ratios. First, if you multiply both values in a ratio **a:b** by the same positive number ***s*** (called the scale factor) you get an equivalent ratio **sa:sb**. Second, two ratios are equivalent if they have the same ***unit rate***. A unit rate is the "amount per 1" in a ratio; the ratio **a:b** is equivalent to **a/b:1**, and **a/b** is a unit rate giving the amount of the first quantity per unit of the second quantity. One can also discuss the amount of the second quantity per unit of the first quantity, which is the unit rate **b/a**, coming from the equivalent ratio **1:b/a**.

Students will describe proportional relationships and constants of proportionality, explain how to determine whether a relationship is proportional and how to compare and represent situations with different constants of proportionality.

Demographics

I am a 7th-grade math teacher at PS DuPont Middle School, a middle school in Wilmington, Delaware. Our school is in the Brandywine School District. We are the northernmost district in Delaware, covering 33 square miles of New Castle County, including a portion of the City of Wilmington, Claymont, Brandywine Hundred, Bellefonte, and Arden. PS DuPont is a Title I school. The Title I program is a funding resource provided by the federal government to help kids in poverty. States receive funding from the federal government and then send the funds to local school districts. Districts earmark money for individual schools with high poverty rates to improve their students' academics and close the achievement gap.

My math classes are an inclusion setting, which includes those with Individualized Education Programs (IEPs) and those without. My primary focus is supporting students who are performing well below grade level, ensuring they receive the tailored instruction and guidance necessary to meet their IEP goals and succeed academically. Despite the challenges, my objective is to help all my students achieve proficiency on our state's SMARTER Balanced assessment and demonstrate measurable growth on the district NWEA MAP test. Through a combination of differentiated instruction, targeted interventions, and fostering a supportive classroom environment, I strive to empower each student to reach their full potential.

Content Objectives

This 2-3 week curriculum unit will cover the 7th-grade standards: **7.RP.A.2** Recognize and represent proportional relationships between quantities. **7.RP.A.2.a** Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin. **7.RP.A.2.b** Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships[3] .

The unit is organized into seven lessons concluding with a summative assessment that includes problems related to calculating medicine doses for adults and infants using ratios and proportions. It also includes real-world scenarios where students must apply their knowledge to solve dosage problems accurately. In the first part of the unit, students will learn key, content-specific vocabulary and build background knowledge about ratios and proportions. In the next part, they will begin to understand the concept of medicine dosing as an application of ratios and proportions and begin to understand how to calculate doses for adults and infants using ratios and proportions. Lastly, they will design a dosage chart for a specific medication, considering both adult and pediatric dosing.

For a review of the math concepts in the following sections, a textbook such as Illustrative Mathematics would provide a useful guide.

Ratio

A ratio shows how many times one number contains another. For example, if there are eight oranges and six lemons in a bowl of fruit, then the ratio of oranges to lemons is eight to six (that is, 8:6, which is equivalent to the ratio 4:3). Similarly, the ratio of lemons to oranges is 6:8 (or 3:4) and the ratio of oranges to the total amount of fruit is 8:14 (or 4:7).

The numbers in a ratio may be quantities of any kind, such as counts of people or objects, or such as measurements of lengths, weights, time, etc. In most contexts, both numbers are restricted to be positive.

A ratio may be written as "a to b" or "a:b", or by giving just the value of their quotient a/b. A ratio may be written as an ordered pair of numbers, a fraction with the first number in the numerator and the second in the denominator, or as the value denoted by this fraction. Ratios of counts, given by (non-zero) natural numbers, are rational numbers, and may sometimes be natural numbers[4] .

Notation and terminology

The ratio of numbers A and B can be expressed as:

- the ratio of A to B
- A:B
- A is to B as C is to D
- a fraction with A as numerator and B as denominator that represents the quotient (i.e., A divided by B, or A/B)

This can be expressed as a simple or a decimal fraction, or as a percentage, etc. When a ratio is written in the form A:B, the two-dot character is sometimes the colon punctuation mark. The numbers A and B are sometimes called terms of the ratio, with A being the antecedent and B being the consequent. A statement expressing the equality of two ratios A:B and C:D is called a proportion, written as A:B = C:D or A:B=C:D. This is often expressed as (A is to B) as (C is to D).

Ratios are sometimes used with three or more terms, e.g., the proportion for the edge lengths of a "two by four" that is ten inches long is therefore thickness : width : length = 2:4:10; a good concrete mix (in volume units) is sometimes quoted as cement : sand : gravel = 1:2:4. For a (rather dry) mixture of $^{4}/_{1}$ parts in volume of cement to water, it could be said that the ratio of cement to water is 4:1, that there are 4 times as much cement as water, or that there is a quarter ($^{1}/_{4}$) as much water as cement.

The meaning of such a proportion of ratios with more than two terms is that the ratio of any two terms on the left-hand side is equal to the ratio of the corresponding two terms on the right-hand side.

Number of terms and use of fractions

In general, a comparison of the quantities of a two-entity ratio can be expressed as a fraction derived from the ratio. For example, in a ratio of 2:3, the amount, size, volume, or quantity of the first entity is $2/3$ that of the second entity.

If there are 2 oranges and 3 apples, the ratio of oranges to apples is 2:3, and the ratio of oranges to the total number of pieces of fruit is 2:5. These ratios can also be expressed in fraction form: there are $2/3$ as many oranges as apples, and $2/5$ of the pieces of fruit are oranges. If orange juice concentrate is to be diluted with water in a ratio of 1:4, then one part of the concentrate is mixed with four parts of water, giving five parts total; the amount of orange juice concentrate is $1/4$ the amount of water, while the amount of orange juice concentrate is $1/5$ of the total liquid. In both ratios and fractions, it is important to be clear about what is being compared to what, and beginning learners often make mistakes for this reason.

Fractions can also be inferred from ratios with more than two entities; however, a ratio with more than two entities cannot be completely converted into a single fraction, because a fraction can only compare two quantities. A separate fraction can be used to compare the quantities of any two of the entities covered by the ratio: for example, from a ratio of 2:3:7, we can infer that the quantity of the second entity is $3/7$ that of the third entity.

Proportions and percentage ratios

If we multiply all quantities involved in a ratio by the same number, the ratio remains the same. For example, a ratio of 3:2 when multiplied by 4 is the same as 12:8.

If the two or more ratio quantities encompass all of the quantities in a particular situation, it is said that "the whole" contains the sum of the parts: for example, a fruit basket containing two apples and three oranges and no other fruit is made up of two parts apples and three parts oranges. In this case, $2/5$, of the whole is apples and $3/5$, of the whole is oranges. This comparison of a specific quantity to "the whole" is called a proportion[5] .

Proportion

A proportion is a mathematical statement expressing the equality of two ratios. a:b=c:d where ***a and d*** are called extremes, and ***b and c*** are called means. Proportion can be written as a/b=c/d, where ratios are expressed as fractions. This type of proportion is known as geometrical proportion, not to be confused with arithmetical proportion and harmonic proportion[6] .

Fundamental rule of proportion. This rule is sometimes called Means-Extremes Property. If the ratios are expressed as fractions, then the same rule can be phrased in terms of the equality of "cross-products" and is called Cross-Products Property[7] .

- If $\frac{a}{b} = \frac{c}{d}$, then ad = bc

- If $\frac{a}{b} = \frac{c}{d}$, then $\frac{b}{a} = \frac{d}{c}$
- If $\frac{a}{b} = \frac{c}{d}$, then $\frac{a}{c} = \frac{b}{d}, \frac{d}{b} = \frac{c}{a}$.
- If $\frac{a}{b} = \frac{c}{d}$, then $\frac{a+b}{b} = \frac{c+d}{d}, \frac{a-b}{b} = \frac{c-d}{d}$.
- If $\frac{a}{b} = \frac{c}{d}$, then $\frac{a+c}{b+d} = \frac{a}{b} = \frac{c}{d}, \frac{a-c}{b-d} = \frac{a}{b} = \frac{c}{d}$

Dose

A dose is a measured quantity of a medicine, which is delivered as a unit. The greater the quantity delivered, the larger the dose. Doses are most commonly measured for compounds in medicine. The term is usually applied to the quantity of a drug administered for therapeutic purposes but may be used to describe any case where a substance is introduced to the body[8] . Over-the-counter medicines such as Tylenol and Ibuprofen are examples of drugs that require a specific dose that differs for adults and children.

Factors affecting dose

A 'dose' of any chemical or biological agent (active ingredient) has several factors which are critical to its effectiveness. The normalization of the adult dose according to age, body weight, or any other demographic covariate without prior evidence of how these factors contribute to differences in drug exposure may lead to poor and unsafe estimates of the pediatric dose[9] .

In contrast to the use of off-label prescription entrenched in clinical practice, the introduction of pediatric regulation by the European Union and the renewal of the Pediatric Rule by the U.S. Food and Drug Administration on the requirements for pediatric labeling impose special attention on dose selection in pediatric clinical trials.

Dose scaling in pediatric trials remains an important issue, from both a clinical perspective and a drug development standpoint. Given that children may not be subject to dose-finding studies similar to those carried out in the adult population.

Probably, the most common method for dose adjustment in children in pediatric clinical practice is to normalize the adult dose by body weight (i.e., mg kg−1), assuming a linear relationship between weight and dose. This means that the dose doubles with a twofold increase in the weight of a child[10] .

Over-the-counter medications

In over-the-counter medicines, dosage is based on age. Typically, different doses are recommended for children 6 years and under, children aged 6 to 12 years, and persons 12 years and older, but guidance aside from these ranges is slim. This can lead to serial under or overdosing, as relatively smaller people (compared to average size) take more than they should, and larger people take less. Over-the-counter medications are typically accompanied by a set of instructions directing the patient to take a certain small dose, followed by another small dose if their symptoms don't subside. Under-dosing is a common problem in pharmacy, as predicting an average dose that is effective for all individuals is extremely challenging because body weight and size impact how the dose acts within the body.

Prescription drugs

Prescription drug dosage is based typically on body weight. Drugs come with a recommended dose in milligrams or micrograms per kilogram of body weight, and that is used in conjunction with the patient's body weight to determine a safe dosage. In single-dosage scenarios, the patient's body weight and the drug's recommended dose per kilogram are used to determine a safe one-time dose.[1] Medication under-dosing occurs commonly when physicians write prescriptions for a dosage that is correct for a certain time but fail to increase the dosage as the patient needs (i.e. weight-based dosing in children or increasing dosages of chemotherapy drugs if a patient's condition worsens).

History of dosing

Dose and time considerations in the development and use of a drug are important for assessing actions and side effects, and predictions of safety and toxicity. The importance of dose – the amount of anything – is apparent in everything biological, and in all other matters.

To understand drug actions, the locations and identities of specific targets need to be known. Questions of drug logistics that require consideration and answers include whether the target is reached, what amount is available and acting at the target over time, and how receptor-binding, metabolism, and excretion occur.

Developing a pharmaceutical product from the discovery phase to market introduction can take 15 years. For instance, starting from a screening of 10,000 discovery compounds, 250 compounds will be selected for further preclinical evaluation. Of these 250 compounds, only five will be considered drug candidates that will enter human clinical trials, of which one will finally be introduced into the market[11] (See Table 1 for examples)

	Discovery	*Pre-clinical*	*phase I*	*phase II*	*phase III*	*Pre-registration*	*Phase IV*
Time lines	6.5 years		7 years			1.5 years	10 years
Compounds	**10.000**	**250**	**5**			**1**	
Investments [mio USD]	350		100	170	370	70	240
Major milestones		CAN	FIH	cPoC		SPC	
				Final product		Final Approval	

Table 1- Example development of a pharmaceutical product from the discovery phase to market introduction.

Historically mouse studies are used to help determine how much and how often a drug should be taken. Robert Gatenby, M.D., is a radiologist who directs the Cancer Biology and Evolution Program at the Moffitt Cancer Center in Tampa, Fla. Gatenby and colleagues published results in *Science Translational Medicine* showing that mouse models of aggressive human breast cancer live longer with fewer side effects if they get successively lower doses of chemotherapy instead of standard high dose treatment[12] .

Randomized clinical trials with human volunteers are another way to test a new medicine. Randomized clinical trials deal with issues in a cumbersome and heavy, handed manner, by requiring many patients to balance the heterogeneous distribution of patients into the different groups. By observing known characteristics of patients, such as age and sex, and distributing them equally between groups, it is thought that unknown factors important in determining outcomes will also be distributed equally[13] .

Trade-off/Evolutionary Medicine

It is estimated that more than 50 million animals are used in experiments each year in the United States.[14]

Dogs have their hearts, lungs, or kidneys deliberately damaged or removed to study how experimental substances might affect human organ function.

Monkeys are taken from their mothers as infants to study how extreme stress might affect human behavior.

Mice are force-fed daily doses of a chemical for two years to see if it might cause cancer in humans.

It is unclear whether these studies are ideally suited to usefully testing the equivalent biology in humans.

The animals most commonly used in experiments—are "purpose-bred" mice and rats (mice and rats bred specifically to be used in experiments). Chimpanzees have not been subjected to invasive experiments in the U.S. since 2015 when federal decisions were made to prevent their use. Many believe that animal experiments are time-consuming and expensive. Animal experiments do not accurately mimic how the human body and human diseases respond to drugs, chemicals, or treatments[15] .

In the United States and European Union countries, approximately 15 and 7 million laboratory rodents, respectively, are used annually for research and testing. Given the surprising and controversial nature of the data concerning mouse-to-human (in) compatibilities in tested inflammatory disease models, the findings of the *PNAS* paper, (The Proceedings of the National Academy of Sciences) were quickly publicized in the lay press. The initial account of the research in the *New York Times* entitled, "Mice Fall Short as Test Subjects for Some of Humans' Deadly Ills", led to a subsequent ripple effect in the form of several alarming follow-up editorials, posts, and/or blog. Their collective conclusion was clear and implied that decades of mouse-based research culminated in few scientific advances wasted precious research opportunities and were a poor use of taxpayers' money[16] .

For decades, mice have been the species of choice in studying human diseases. As a result, years and billions of dollars have been wasted following false leads, they say.

The study's findings do not mean that mice are useless models for all human diseases. But, the authors emphasized they do raise troubling questions about diseases like the ones in the study that involve the immune system, including cancer and heart disease[17] .

Teaching Strategies

I decided to move away from the traditional learning style in many classrooms. As a teacher for over 25 years, I have been used to the "I do, we do, you do" method. I show the students how, we practice together, and then they complete the task on their own. I moved away from this approach because the students were sitting at their desks, copying work off the board to students working in randomly selected groups of three on thinking tasks from the curriculum. I adopted a new approach called Building Thinking Classrooms.

Building Thinking Classrooms

Building thinking classrooms (BTC) is a teaching strategy in which students receive a task and decide what mathematical strategy will best solve it. Students stand at wall-mounted whiteboards, in groups of no more than three, while they work through their thinking tasks. Each group has one marker and the person with the marker must write their group members' ideas and not their ideas. I set a timer for 2 minutes and the students know that when the timer goes off the students pass the marker to another group member. This allows the work to be equally distributed amongst the students throughout the tasks. The students must discuss their strategy together as they are working through each task. This allows the students to share their ideas as well as allowing them to see different strategies that can be used to solve the same problem. The boards are visible to every group, and they are allowed to borrow ideas from other groups if they are stuck.

Problem-Based Learning

In a problem-based curriculum, students spend most of their time in class working on carefully crafted and sequenced problems. Teachers help students understand the problems; ask questions to push their thinking, and orchestrate discussions to be sure that the mathematical takeaways are clear[18] . Students gain a lasting understanding of math concepts and procedures and experience applying this knowledge to new situations. Students frequently collaborate with their classmates—they talk about math, listen to each other's ideas, justify their thinking, and critique the reasoning of others. They gain experience communicating their ideas both verbally and in writing, developing skills that will serve them well throughout their lives.

Problem-based learning may look different from what their parents experienced in their math education. Current research says that students need to be able to think flexibly to use mathematical skills in their lives[19] . Flexible thinking relies on understanding concepts and making connections between them. Over time, students gain the skills and the confidence to independently solve problems that they've never seen before.

Three Reads (MLR6 Three Reads)

The Three Reads strategy is used to support reading comprehension of the problem, without solving it for students[20] . The first read focuses on the situation, context, or main idea of the text. After a shared reading, I ask students "What is this situation about?" This is the time to identify and resolve any challenges with any non-mathematical vocabulary. After the second read, students list any quantities that can be counted or measured. They should not focus on specific values; instead, they focus on naming what is countable or measurable in the situation. It is not necessary to discuss the relevance of the quantities, just to be specific about them (examples: "number of people in her family" rather than "people," "number of markers after" instead of "markers"). They should record the quantities to use as a reference after the third read. During the third read, the final question or prompt is revealed and students should discuss possible solution strategies, referencing the relevant quantities recorded after the second read. It may be helpful for students to create diagrams to represent the relationships among quantities identified in the second read or to represent the situation with a picture.

Scaffolding

Scaffolding provides temporary supports that foster student autonomy**.** Learners with emerging language—at any level—can engage deeply with central mathematical ideas under specific instructional conditions. Mathematical language development occurs when students use their developing language to make meaning and engage with challenging problems that are beyond students' mathematical ability to solve independently and therefore require interaction with peers. However, these interactions should be structured with temporary access supports that students can use to make sense of what is being asked of them, to help organize their thinking, and to give and receive feedback.

Activating Previous Learning

In each of my lessons, it is essential to activate previous learning so that students are more successful and fluent when completing group tasks. The first event in every lesson is a warm-up. Either a warm-up will help the student get ready for the day's lesson, or it will allow the students to strengthen their number sense or procedural fluency.

A warm-up that helps students get ready for today's lesson might serve to remind them of a context they have seen before, get them thinking about where the previous lesson left off, or preview a calculation that will happen in the lesson so that the calculation doesn't get in the way of learning new mathematics. This is a great way to review skills necessary for the upcoming lesson without having to reach the skill.

A warm-up that is meant to strengthen number sense or procedural fluency asks students to do mental arithmetic or reason numerically or algebraically. It gives them a chance to make deeper connections or become more flexible in their thinking.

A sample task could be to have the students fill in the missing values. The students will copy the table onto their whiteboards and work together to fill in the missing values:

Classroom Activities

Day 1

Introduce the concept of a proportional relationship by using the following structure.

Warm-up: Have students look at tables of equivalent ratios. (the students should be familiar with the concept of equivalent ratios from 6th grade) The students will learn that all values in one column can be obtained by multiplying values in the other column by the same number. They will identify this number as the constant of proportionality.

Activities: The students will begin to understand proportional relationships by exploring real-world examples of ratios and proportions (e.g., recipes, maps). They will have two or more tasks to read and complete within their groups.

Sample tasks:

1. A recipe says that 2 cups of dry rice will serve six people. Complete the table as you answer the questions.

Reflection and Extension

Reflection: Students write a brief reflection on the importance of accurate dosing in healthcare and how math skills are applied in real-world settings.

Extension: Explore careers in healthcare where dosage calculations are critical, and invite a guest speaker (e.g., a pharmacist) to discuss the role of math in their profession.

Resources and Materials needed for activities

Tables of equivalent ratios

Standard dosing charts for adults and pediatrics

Calculators for dosage calculations

Worksheets and practice problems

Real-world scenario examples

Resources

American Career College. “The Medical Side of Math: How Is Math Used in the Medical Field?” *American Career College* (blog), October 3, 2023, https://americancareercollege.edu/blog/the-medical-side-of-math-how-is-math-used-in-the-medical-field#. This article provides examples of how math is used in different occupations.

Ben-Chaim, David, Keret, Yaffa and Ilany, Bat-Sheva. *Ratio and Proportion: Research and Teaching in Mathematics Teachers’ Education (Pre- and In-Service Mathematics Teachers of Elementary and Middle School Classes).* Rotterdam: SensePublishers, 2012. This article provides in depth examples of ratios and proportion.

Brown, Shannon V., Patterson, Richard, Davidson, Tamara, and Rozette, Nicole A. “Evaluation of a Pharmacist-Driven Pediatric Dose Rounding Protocol*.” J Pediatr Pharmacol Ther*. 2022; 27(7): 636–640. Published online 2022 Sep 26. doi: 10.5863/1551-6776-27.7.636. This article provides an overview of pediatric drug dosing principles and considerations, including the importance of weight-based dosing and the differences between pediatric and adult dosing.

Charlie Schmidt, Dose Schedules Inspired by Evolutionary Concepts Lengthen Progression-Free Survival in Mice, *JNCI: Journal of the National Cancer Institute*, Volume 108, Issue 6, June 2016, djw157, https://doi.org/10.1093/jnci/djw157 This article provides an example of a clinical trial done on mice.

Hellman, Samuel and Hellman, Deborah S. *Of Mice But Not Men Problems of the Randomized Clinical Trial*. London, U.K.: Routledge, 2008. This book provides information about a clinical trial done on mice.

Illustrative Mathematics (Dubuque, IA: Kendall Hunt, 2019), “What is a "Problem-Based" Curriculum?”. This website provides lessons on ratios and proportions.

Kuter, Barbara J., Offit, Paul A. and Poland, Gregory A. “The development of COVID-19 vaccines in the United States: Why and how so fast?” *Vaccine*. 2021 Apr 28; 39(18): 2491–2495. Published online 2021 Mar 26. doi: 10.1016/j.vaccine.2021.03.077. This article gives background information on the COVID-19 vaccine.

Losos, Jonathan B. and Lenski, Richard E.. *How Evolution Shapes Our Lives: Essays on Biology and Society*. Princeton: Princeton University Press, 2016. https://doi.org/10.1515/9781400881383 This article gives information on evolution.

Nunn, Tony and Williams, Julie. “Formulation of medicines for children.” *Br J Clin Pharmacol*. 2005 Jun; 59(6): 674–676. doi: 10.1111/j.1365-2125.2005.02410.x

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1884856/#:~:text=An%20ideal%20formulation%20for%20children,convenient%2C%20easy%2C%20reliable%20administration

This article gives information about the formulation of medications for children.

Stegemann, S. Challenges and opportunities in the design of age-appropriate drug products. *Z Gerontol Geriat* **45**, 479–484 (2012). https://doi.org/10.1007/s00391-012-0361-z. This website shows a table explaining the development of a pharmaceutical product from the discovery phase to market.

The Humane Society of the United States. “Using Animals in Experiments.” *The Humane Society of the United States*, 2024. Accessed July 29, 2024, https://www.humanesociety.org/resources/animals-used-experiments-faq. Accessed 29 July 2024. This website gives background information on why clinical trials are used.

Wikipedia, s.v. “Dose (biochemistry),” last modified July 6, 2024, 16:27 (UTC), https://en.wikipedia.org/wiki/Dose_(biochemistry). This website gives an in depth definition of a dose.

Wikipedia, s.v. “Proportion (mathematics),” last modified March 19, 2023 18:06 (UTC), https://en.wikipedia.org/wiki/Proportion (mathematics). This website gives an in depth definition of a proportion.

Appendix on Implementing District Standards

This unit is based on three Common Core State Standards:

7.RP.A.2 Recognize and represent proportional relationships between quantities.

7.RP.A.2.a Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin.

7.RP.A.2.b Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships.

Notes

1. The Humane Society of the United States. "Using Animals in Experiments"
2. Ibid.
3. *Illustrative Mathematics* (Dubuque, IA: Kendall Hunt, 2019)
4. Ben-Chaim, David, Keret, Yaffa and Ilany, Bat-Sheva. *Ratio and Proportion: Research and Teaching in Mathematics Teachers' Education*
5. Wikipedia, s.v. "Proportion (mathematics)
6. Ibid.
7. Ibid.
8. Wikipedia, s.v. "Dose (biochemistry)
9. Ibid.
10. Ibid.
11. Ibid.
12. Charlie Schmidt, Dose Schedules Inspired by Evolutionary Concepts Lengthen Progression-Free Survival in Mice
13. Hellman, Samuel and Hellman, Deborah S. *Of Mice But Not Men Problems of the Randomized Clinical Trial*
14. The Humane Society of the United States. "Using Animals in Experiments*."*
15. Ibid.
16. Ibid.
17. Ibid.
18. *Illustrative Mathematics* (Dubuque, IA: Kendall Hunt, 2019)
19. Ibid.
20. Ibid.
21. Ibid.