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STUDENT VERSION
Drug Model for Aspirin Absorption with Metacognition

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STATEMENT

How does the human body absorb some drugs, particularly aspirin? That is the question for our study.

General Activity Guidelines

Rationale: This activity is designed to enhance your understanding of several fundamental concepts needed in mathematical modeling and to engage you in an interdisciplinary topic. In your answers to questions, use modeling terms, although you may mix them with general English sentences.

This activity is designed to be student centered, active, and inquiry-oriented. You will reflect upon both content skills (what you learn) and process skills (how you acquire, interpret, and apply knowledge). This is designed to help you become a lifelong learner and prepare you to be more competitive in a global market.

If appropriate, as you progress through this module, you may wish to revisit a portion and modify your response. Do not erase previous efforts, but add to your response. Indicate what you changed and why. Attach paper as needed.

Primary Content Learning Objective

Students will explore some mathematical aspects of molecular biology dealing with the body's method of processing various molecules. Specifically, we will consider the pharmacokinetics of zero-order processes in drug absorption. The activities are designed to enhance both *mathematical content* and *thought process* of learning.

Student Learning Outcomes

Upon successful completion of the activity, the student should be able to:

- apply mathematical expertise to deal with an interdisciplinary topic (content and process);
- enhance science and technology literacy for students in all disciplines (content and process);
- practice in modeling and growth in the mathematics necessary to model and analyze these situations (content);
- interpret and process information (process);
- communicate mathematical modeling effectively orally and in writing (content and process);
- deal with multiple representations of a concept, including verbal/written, graphical, and symbolic (content and process); and
- realize that "mistakes" can be as valuable as an initially correct answer (process).

1 ASPIRIN ABSORPTION

Activity 1: First Thoughts on Modeling Drug Absorption

(1.1) Typically when a drug is administered to an individual, the amount of the drug in mg, A(t), in the body changes over time in minutes. *Pharmacokinetics* is "the science of the kinetics of drug absorption, distribution, and elimination (i.e. metabolism and excretion.)" [1, p. 4] Write an equation that corresponds to a **constant release** of the drug from an ingested tablet into the body over time.

$$\frac{dA}{dt} = \qquad (1)$$

(1.2) Identify the following for your equation, or write "none": independent variable(s); dependent variable(s); constant(s); parameter(s).

(1.3) For a drug that is released into the body at a constant rate, would you expect the amount of drug in the body to increase, stay the same, or decrease with time, at least for a while? What value would you expect for the initial amount of drug in the body?

Activity 2: A General Model

(2.1) One general model of drug amount in the body is given by

$$\frac{dA}{dt} = k. \qquad (2)$$

Use your mathematical background: $\frac{dA}{dt}$ represents the ____ __ ____ of the amount of drug in the body over time, in units of _____ .

(2.2) A "zero-order reaction" in pharmacokinetics is exemplified by (2). Classify this differential equation using mathematical terms. Determine a general solution.

Activity 3: ASA Model and Specific ASA Situation.

ASA stands for *acetylsalicylic acid*, which can be used to treat pain and other conditions. It is the primary ingredient in Bayer®Aspirin™. Note that Aspirin is trademarked in some countries. Other ASA variants include BC®Powder and Excedrin®.)

A patient swallows a tablet that contains 325 mg of ASA. A specific model of drug amount in this case is given below from [1].

$$A(t) = 0.86t - 0.04 \tag{3}$$

(3.1) Is this a zero-order reaction?

(3.2) The tablet takes a while to dissolve. What are the smallest and largest amounts of ASA in the body? At what times do these occur? Determine a realistic time interval for (3) to be in effect and graph the resulting realistic $A(t)$.

(3.3) Give the differential equation form of (3) and provide a realistic initial condition.

(3.4) Create a "phase plane", which in the context of our differential equation, is a graph with $A(t)$ on the horizontal axis and the rate of change of the drug amount $\frac{dA}{dt}$ on the vertical axis.

(3.5) What about the phase plane might indicate that the reaction is "zero-order"?

Learning Reflection

Part of learning can include a self assessment. A *good* response indicates honest evaluation rather than flowery speech which may overstate what you got out of the activity because you may think that's what you think the instructor wants to hear. A *good* response also shows clearly that you have actually *read* and *thought about* the Student Learning Outcomes.

You should discuss strengths and areas for improvement. This segment is to provide some closure for you and to have you engage in *metacognition*, awareness of your own learning.

- Summarize the content objectives of this assignment. Assess how well you mastered the objectives.
- Do you know more about molecular biology than you did prior to this assignment? Briefly provide evidence. Indicate any questions regarding the content or the rationale for the activity that you may have.
- Did you work effectively to do this assignment? If so, explain how. If not, identify what needs to happen to enhance active and positive participation on your part.

For each question, on a scale of 1 for "Strongly Disagree" to 5 for "Strongly Agree", indicate your agreement.

- The activity added to my understanding of
  - a real-world context for a differential equation,
  - the derivation of a differential equation model,
  - initial value or boundary value conditions.
- The activity added to my appreciation of applied mathematics and mathematical modeling.
- The model and analysis enhanced my educational experience in this class.

REFERENCES

[1] Shargel, L. and A. Yu 2016. *Applied Biopharmaceutics and Pharmacokinetics. 7th ed.* New York: McGraw Hill.