

STUDENT VERSION

Drug Model for Aspirin Absorption

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Abstract: We model the amount of aspirin absorbed by the human body at a constant rate. This is a “zero-order reaction” in the language of pharmacokinetics – the study of how drugs move in the body. This simple activity can be used to introduce differential equations and it can be used to introduce the study of drugs in the body to students who know some differential equations.

SCENARIO DESCRIPTION

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

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.

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

(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

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

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].

$$A(t) = 0.86t - 0.04 \quad (3)$$

(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”?

REFERENCES

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