Name Period Date

DESIGNING EXPERIMENTS

Defining Variables Operationally

Before starting an experiment, you must define how you will measure the dependent variable. An **operational definition** is a description of the one particular way in which you will measure the dependent variable. Operational definitions are necessary so that other scientists will know exactly what the dependent variable is and how it was measured. For example, if you are investigating the amount of time it takes for steel wool to rust at different temperatures, you must specify how you will measure the rate of rusting. Different measurements can provide useful information, such as the time to start rusting, the time to completely rust, and the time between these two time points. Before you begin the investigation you must know what you will measure and how you will measure it.

Operational definitions can be qualitative or quantitative. Think again about the following hypothesis: "If the temperature is increased, then the steel wool will rust faster, because higher temperatures increase the rate of chemical reactions."

- A **qualitative** operational definition for the hypothesis above could be "Rust forms." A qualitative operational definition requires a simple "yes" or "no" answer. Recording data this way can be useful, but provides a limited amount of detail.
- A **quantitative** operational definition could be "Time from moistening steel wool until first rust appears (in minutes)." This measurement is more difficult to make but provides much more information.

For each hypothesis below, write the dependent variable and two quantitative operational definitions that could be used for measuring the dependent variable.

1. Hypothesis: If particles in a tube are small, then water will pass through the tube more slowly than if particles are large, because there is less space between small particles.

Dependent variable: _____

Operational definition 1: _____

Operational definition 2: _____

2. Hypothesis: If you roll a heavier steel ball off an inclined ramp, then it will travel faster than a lighter steel ball, because the heavier ball has more momentum.

Dependent variable: _____

Operational definition 1: _____

Operational definition 2: _____

3. Hypothesis: If you increase the size of an agar cube, then it will absorb more liquid, because the cube has more surface area.

   Dependent variable: _____

   Operational definition 1: _____

   Operational definition 2: _____

Now write a qualitative operational definition for each of the hypotheses.

4. Hypothesis: If particles in a tube are small, then water will pass through the tube more slowly than if particles are large, because there is less space between particles.

   Qualitative operational definition: _____

5. Hypothesis: If you roll a heavier steel ball off an inclined ramp, then it will travel faster than a lighter steel ball, because it has more momentum.

   Qualitative operational definition: _____

6. Hypothesis: If you increase the size of an agar cube, then it will absorb more liquid, because it has more surface area.

   Qualitative operational definition: _____

Challenge Write a hypothesis that would lend itself to a qualitative operational definition for the dependent variable. Explain why this hypothesis is appropriate for a qualitative operational definition.

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