**MAJOR** **CATEGORIES OF DISCOVERY ACTIVITIES**

Where do textbook writers come up with lists of symptoms of a disease? The steps in a process? The structure of an atom? The characteristics of a genus of organisms? The formula for acceleration? From scientists who examined real experimental or observational data! In Concept Discovery learning experiences, students use the thinking skills of scientists to “discover” scientific understandings in authentically scientific ways.

**INVESTIGATE A HYPOTHESIS IN A LABORATORY**

Students are capable of making and testing hypotheses for a wide variety of phenomena; in many cases, they are also able to design ways to test those hypotheses.

\* BIOLOGY: Factors affecting seed germination

To find out what factors affect seed germination rate, students each choose two conditions to test. At the end of a week, the class shares data and comes to a conclusion about what factors affect germination rate.

\* CHEMISTRY: Chemical properties (of metals)

Students learn what color each metal creates (in fireworks, for example) by burning metal samples at prescribed temperatures and observing the light given off.

\* PHYSICS: Relationship between mass and acceleration

Given a variety of equipment—including speed indicators—students design and carry out an experiment to see how mass affects acceleration.

**FIND PATTERNS IN EXTANT DATA SETS**

When time, resources, safety, or environmental conditions prohibit students collecting their own data, the teacher can supply the data for analysis.

\* BIOLOGY: Predator-Prey population cycles

Students are given population data for a predator and prey population. They graph the results and draw a conclusion about how predator and prey population changes affect each other.

\* CHEMISTRY: Heat of vaporization and temperature

Students are given data on the heat of vaporization for several compounds at different temperatures and asked to graph them in order to determine the general shape of the relationship between temperature and heat of vaporization.

\*PHYSICS: Gravitational force

Students are provided with data about several objects in space and their attraction to each other in order to determine the qualitative relationships between mass and attraction and between distance and attraction.

**EXPERIENCE THE PHENOMENON**

This strategy works well for helping students conceptualize phenomena that a) involve a social component or b) happen at a scale, location, or set of environmental conditions that make it impossible for real data collection. Students experience the phenomenon through kinesthetic, manipulative, or digital simulation.

\* BIOLOGY/ CHEMISTRY/ENVIRONMENTAL SCIENCE: Tragedy of the Commons

Students play the role of commercial fishers fishing a limited population of “taf-fish” (wrapped candy taffies) over two seasons, experiencing the psychology and economics (“If I don’t take it, someone else will”) behind depletion/degradation of resources held in common. Students are then able to suggest and try out strategies for sustained resource management.

\* CHEMISTRY: Effect of temperature and pressure on atomic/molecular movement

Students play the part of atoms in different temperature and pressure conditions, as directed by their teacher. Afterwards, they draw and describe the differences in atomic motion in their notes.

**GROUP, ORDER, SORT, and CATEGORIZE**

This approach works for learning events in a series, parts of a system, or categorization schemes. Often, students are looking at data that scientists have already decided how to order and name. Through analysis, students come to similar—though not identical—patterns and form a strong basis for then understanding the reasoning for the scientific convention. The scientific conception and any associated conventions or names are introduced in the Concept Clarification phase.

BIOLOGY: Mitotic stages

After students discuss what cells might be doing in a root or twig tip compared to most cells in a plant (dividing for growth), students examine root tip tissue under a microscope. They are asked to identify 4-6 distinctly different-appearing cells and draw each. They are then asked to put the pictures in an order that they think represents cell division and invent a name for each step.

CHEMISTRY: Periodic table organization and trends

Students are given a set of cards of the elements. Using the information on the cards—atomic mass, number of valence electrons, diameter, reactivity, etc.—students arrange the cards into a cohesive pattern as a means to understanding the rationale for the organization of the periodic table.

PHYSICS/ASTRONOMY/EARTH SCIENCE: Categorization schemes of objects in space

Students are given descriptions and scale drawings (but no names) of objects in space and asked to group them according to characteristics.

**MIMICK THE HISTORICAL DISCOVERY OF A RELATIONSHIP OR PHEONOMENON^**

When possible, this strategy is an excellent means of helping students grasp a concept while also learning about the history of the development of a scientific idea.

\* BIOLOGY: Life come from other life (Redi)

Students set up meat and jars with and without cheesecloth (or screen) coverings as a way to test the hypothesis that flies come from other flies (rather than “life-giving-forces” like “ethers”).

\* CHEMISTRY: Atomic Structure (Rutherford)

Students mimic Rutherford’s investigation of his hypothesis of a central, dense nucleus. Students aim a laser beam through a mailing tube into which is inserted—about ¾ of the way down the tube—a clear pane of glass that is dotted infrequently with small stickers or paint dots. Students point the laser from different positions and record whether the beam is always visible on the thin paper cover at the far end of the tube (the paper cover prevents students from holding the tube to the light to view the glass pane).

\* PHYSICS: Acceleration (Galileo/ Stevin and de Groot)

Students (or teacher) drop balls of different masses from a (safe) balcony (or other accessible structure of sufficient height) and observe objects as they land in order to test Aristotle’s assertion that heavier objects fall faster than light objects.

**DEDUCE CHARACTERISTICS, CONVENTIONS, OR DEFNITIONS FROM EXAMPLES**

This approach works for learning human-determined conventions of science rather than particular observable phenomena or relationships.

BIOLOGY: Punnet squares

Students are given 5 samples of completed Punnet squares. Using what they see, they construct a list of steps for completing a Punnet square.

CHEMISTRY: Empirical formulas

Students are given cards with one drawing of a molecule along with its empirical formula. Students write the molecular formula for the molecule and determine the relationship between the molecular and empirical formula.

PHYSICS/MATH: Slope

Students are given examples of five graphed lines and their calculated slopes (all positive slope). Students figure out the generic formula for slope, then test and revise it given five new examples, some of which have positive and some of which have negative slopes.

***For definitions and characteristics, it is usually helpful to provide students with non-examples as well. This helps them better delineate what specific qualities are important in the examples.***

\* BIOLOGY: Mollusk characteristics

Students are given two sets of specimens (or pictures). One set is labeled “mollusks” and the other set is made up of other invertebrates and labeled “not mollusks.” Students must determine the characteristics of mollusks from the specimens.

\* CHEMISTRY: Molecular structure and smell

Students are given two sets of cards. One set has diagrams of compounds that smell minty, the other has diagrams of compounds that do not smell minty (or, alternatively, that smell “sweet”). Students determine what chemical structure makes a compound smell minty.

\* PHYSICS/MATH: Functions

Students are given one handout labeled “Functions: Examples” that has 4-5 graphs of functions. A second handout is labeled “Functions: Non-Examples” (Or “NOT Functions”) and has graphs on it that do not represent functions. Students figure out the definition of a function. (*Recognize how hard it would be to deduce the definition of functions if you were only given positive examples*)

^ This category necessarily overlaps with “investigating a hypothesis in a lab,” “finding patterns in extant data sets,” and “Group, order, sort, and organize” because, really, those are the intellectual activities of scientists. However, because use of original discoveries is so ripe for the picking in terms of generating ideas for teaching, I believe it is worth listing alone.