Unit 1: The Relevance of Science

Teacher Introduction

What's so important about learning science?

"We go about our daily lives knowing almost nothing of the world. We give little thought to the machinery that generates the sunlight that makes life possible, to the gravity that glues us to the Earth that would otherwise send us spinning off into space, or to the atoms of which we are made and on whose stability we fundamentally depend."

Carl Sagan

"…the inspiration of science is wonder, and the reward is discovery. The Hawaiians' voyage across the ocean and the development of their culture are direct results of their unquenchable capacity for wonder and discovery, their greatness being no less than the feats equivalent to flying modern man into the cosmos and colonizing the stars. Their voyaging accomplishments are a direct result of what I call a subjective science. *This form of science maximized the human potential with a minimum of technology. Imagine such a science empowering the objective sciences of today. The possibility opens a new frontier of discovery and understanding."*

Patrick Ka'ano'i. [1]

This initial unit introduces students to relative purposes for scientific study. It shares how it is done, and how it was (is) practiced in Hawai'i and by Hawaiians. The idea is to demystify and place science in the realm of every day life and activities. In this section, students should begin to understand that science is about survival and improving our living conditions; it is also about answering questions, solving mysteries, and having fun.

More specifically, the objectives include:

- Teaching that science is both a set of protocols for developing new information about our world (the "scientific method") and the sum total of information resulting from those protocols. The body of scientific knowledge is alive in the sense that it grows and evolves as new information is added and old theories tested.
- Demystifying science by showing examples of science's role in familiar activities (e.g. the *Science of Sport* videos), and by showing examples of science at work in Hawai'i (videos on Coqui frog, volcano, Keck observatory, and endangered species).
- Introducing the fact that Hawai'i is considered by many scientists to be a very special place with unique opportunities for learning.
- Teaching students how their Hawaiian ancestors practiced the scientific method in voyaging, farming, fishing, and other aspects of day-to-day living necessary for survival.

[1] The Need for Hawaii - a Guide to Hawaiian Cultural and Kahuna Values

What is science?

Science is both a set of protocols for developing new information about our world (the "scientific method") and the sum total of information resulting from those protocols. The body of scientific knowledge is alive in the sense that it grows and evolves as new information is added and old theories tested.

To help students make connections about scientific study, content is focused around developing a better understanding of self and place. The middle school student's natural desire to understand themselves during this time of rapid personal growth and change makes a study of self very interesting. Youngsters also increase their understanding of themselves and find content more relative by learning about where they live and who they are connected to. The following definition of science is used to help youngsters make these connections:

> Science is a way of understanding ourselves, our world, and our place in the world. We do it for survival and for fun. (I.e.: solving puzzles, making predictions.) It involves observing patterns (in the environment or in ourselves), understanding the relationship of those patterns to other things, and using that understanding to increase the probability of success in what we do. -Dr. David Perry 2003

For students, who may equate science with what they read in textbooks, it is important to understand:

"Science is not just facts to be memorized, but a process for building up a picture and explanation of the world from evidence".[2]

The process referred to in the quote is called the ***scientific method.***

The Scientific Method

Physicist Richard Feynman defines the scientific method as "Observation, reason, and experiment,"[3] where "experiment" refers to a test or trial of something**.** Another way of describing the scientific method is: *** Observing *Developing hypotheses to explain observations *Testing those hypotheses** *(The process is ongoing, circular rather than linear. Every test of a hypotheses leads to new observations and hypotheses. There is nothing mysterious about it.)* In his book, What Is Science?[4] Mannoia describes the scientific method as nothing more than common sense:

"The activity of doing science is very much like everyday problem solving. To this extent, the scientific method is just common sense and we are all scientists. The activity of forming scientific ideas is not some kind of mechanical process that proceeds automatically if you only know the secret rules. Rather, it requires both careful attention to precise rules and a vast dimension of creativity."

[2] Stephan Budiansky. The Trouble With Textbooks. *Prism*, Feb. 2001.
[3] Richard Feynman. Six Easy Pieces. p 24. Perseus, Cambridge, MA 1995.
[4] University Press of America. 1980

Values in Science

When asked for guidance from kupuna about what we might teach that would most benefit children in Hawai‘i, consulting elders stressed the importance of teaching about values and protocols. Therefore, these concepts are woven into lessons that extend beyond science and school, which also supports the development of this age student.

The dictionary defines *values* as, “the social principles, goals, or standards held or accepted by an individual, class, society, etc.” (Webster’s New World Dictionary). In other words, our values guide our behavior.

As in all of life, values are important in science, particularly:

1. **Honesty.** The objective of science is to learn how nature works, not to prove some favorite hypothesis. Therefore, when we do an experiment or make an observation, it is essential to be totally honest about the results, even when they don’t turn out as expected.

2. **Lack of bias.** Experiments and observations are done so that no one outcome is favored by the way we experiment or observe. Science has important protocols for ensuring that hypotheses are tested in an unbiased away.

3. **Rigor**. To be rigorous in work is to be thoroughly accurate and precise in what you do. Scientists value this very highly.

4. **Cooperation and sharing.** Scientists place high value on working together and openly sharing knowledge.

5. **Unselfish service.** Scientists don’t do science to get rich. Most scientists value their work because it serves the needs of society or nature.

Ka ‘Upena o ke Ola (The Net of Life)

What is it?

‘Upena is the Hawaiian word for net, an object made by weaving strands into an interconnected whole that is a valuable tool for catching things. We use ‘upena to symbolize the weaving together of the individual pieces of our world to make an interdependent, interactive whole. We hope our ‘upena will help students “catch” ideas and concepts about the ties that bind us to each other and to our environment, and lead to the realization that we are all part of a great chain of being, each of us utterly dependent upon a larger whole. At the same time, the whole depends on each of us. Such reciprocity, which is fundamental to the Hawaiian world view, is the foundation of *pono* (righteous or proper), *Ola kino* (health), and *mālama ‘aina* (caring for the land). When we see what we are in relation with, we can begin to understand how our actions influence our family, community, and both our immediate environment and the Earth as a whole.

From the standpoint of the physical sciences, the connecting strands within the ‘upena represent transformations and exchanges of energy and matter, without which we would not survive. (Hence it is an ‘upena of life).

Why in this curriculum?

The idea that each individual is embedded within a network of relationships is central to Hawaiian culture. Family and community are a part of this network, but the most widely known of the origin chants, the Kumulipo, makes clear that the relational network extends to all creation. Similarly, modern science is coming to the realization that, as the physicist Paul Davies puts it, “the universe is not a collection of objects, but a network of relationships”. The concept of the upena of life provides a culturally appropriate framework for understanding many aspects of modern science, not only the traditional divisions of physical, chemical, and biological, but the newly emerging integration of these into a systems view of our world that would have been very familiar to Hawaiians of old.

In terms of 6th grade science standards, the upena is a tool for teaching how fundamental relationships in our world are mediated by basic physical principles such as energy transformations, forces, and change of state in matter. The upena teaches about unifying concepts and themes, and the vital importance of reciprocity, or giving as well as taking.

What is it made of?

The ‘upena presented here is only one of many possible representations of the interconnections that influence and shape our lives, all of which are equally valid and tell different aspects of an overall story. In our ‘upena we have the following pieces:

- **People; individuals, families, communities, and ancestry**. Your ancestry tells you where you come from, and plays an important role in making you who you are. The elders tell us, and modern science confirms, that ancestry includes not only grandparents and great-grandparents and so on, but stretches back to the creation of all things. In other words, all of creation is tied together by bonds of relationship. Each of us, and all the world around us, is made of stuff that was formed at the beginning of time.

Now consider what surrounds you and your family and friends in your daily life, and what we all depend upon to sustain our lives.

- **Nā Mea kanu, the plants**. Living in both the sea and on land, ka la’au perform a kind of magic that no other thing on earth can do. They build their bodies using only the air, the rain, the minerals of the earth, and the energy from the sun. Their bodies feed animals (including humans) and

microbes, creating what scientists call food webs. Food webs distribute the sun's energy and the earth's minerals so all living things can build bodies and live healthy lives. Nā Mea kanu give us not only food, but medicines and materials to make homes, canoes, clothes, and many other things. Nā Mea kanu also feed animals of the land and ocean, and release oxygen to the air so we can breath.

- **Animals**. Some animals provide food for humans. All influence the energy flows through nature by eating plants or other animals and cycling nutrients. Scientists call plants and animals that are connected to one another through feeding relationships a **food web** or a **food chain.**
- **Ka Lā, the sun**. Ka Lā is our star. It is the ultimate source of energy that feeds and warms us. By warming the oceans and moving the air and water in great global cycles, Ka Lā creates the winds that cool us and the rains that fill our streams and feed our crops. The electromagnetic radiation emitted by Ka Lā comes in many forms, some of which make life possible, and some of which can be harmful if we are not shielded from it.
- **Ka Papa Honua, the foundation of the Earth and ka lua'i pele, the lava**. The lava that forms the Hawaiian islands comes from deep within the Earth. Physical processes cause it to heat, rise to the surface, and erupt, bringing to us from ka Papa Honua not only land, but nutrients vital to life (a nutrient is any element or molecule that nourishes). Energy transferred to lava by plants and rain releases nutrients from the rock. The rock-nutrients are taken up by plants, where they combine with water, nutrients from the air, and energy from the sun to support life. Eventually, as each island grows old, the mountains built by lava erode back into the ocean, which is why the mountains are shorter and the canyons deeper on the older Hawaiian Islands. Perhaps one day in the far distant future, the rocks eroded from an old island will rise again to form a new island.
- **Ka lepo, the soil**. As rocks are broken down by the energy of plants and rain (a process called "weathering") small pieces of rock combine with the remains of plants and tiny animals to form ka lepo, the soil. The soil is important to us because it serves as a storehouse of nutrients and water. Plants use the soil as a kind of bank account from which they can draw water between rains, and the soil holds onto nutrients to keep them from washing away during rains.
- **Ke Kai, the ocean**. For Hawaiians, Ke Kai is both a playground and a grocery store. For millennia, the ocean has been a major highway for Polynesians, who are the world's most accomplished sailors. The climate of Hawai'i, one of those most benevolent in the world, is due largely to the strong influence of the ocean in moderating extremes of heat and cold.
- **Ka Lewa, the atmosphere**. Everyone knows that without air to give us oxygen we can't live, but do you know that without plants to replenish it, the oxygen in the atmosphere would eventually

disappear? Without air to give the plants carbon dioxide, they couldn't live (therefore nothing else could). The atmosphere regulates temperatures on the Earth, and protects us from those parts of the sun's radiation that are harmful. The composition of the atmosphere is regulated by the breathing of plants and bacteria, and by the activities of people, such as burning oil.

- **Ke Ao, the clouds and Ka Ua, the rain**. For scientists who study the climate ("climatology"), the Earth is a great heat engine. A heat engine is anything that converts heat energy into other kinds of energy, which covers a lot of things (including you!). How is the Earth a heat engine, and what does it have to do with clouds and rain? We will cover this in some detail during the course, but, briefly, it goes like this. When the sun's energy heats water at the Earth's surface (land and ocean, but especially ocean), some of the water changes from a liquid to a gas (water vapor) and rises. In rising, the water vapor loses energy and changes once again, this time back into water (or even tiny ice crystals). When enough water droplets and ice crystals get together, they begin to reflect sunlight, and we see them as clouds. In lots of clouds the droplets are small and light enough to float, but in some clouds enough droplets get together to form drops, which are too heavy to float and so fall under the force of gravity. That's what we call ka ua, the life-giving rain. It is produced by the heat of the sun and the force of gravity.
- **Ka Mahina, the moon**. Scientists believe the moon was once part of the earth. According to this theory, during the early days of the formation of our solar system another planet came close to the Earth, and the force of its gravity pulled away the piece of earth that became the moon. (What evidence might scientists have to make them believe this?) Through its gravitational energy, the moon has profound influences on the earth. The most obvious for those living near an ocean is the creation of tides, however Hawaiians believed that the moon also influenced the growth of crops and the success of fishing. The moon may have many influences that we don't yet understand. For example, scientists learned recently that the moon influences both the types of leaves that plants grow and also the quality of near-shore ocean water. There is also strong evidence that the moon influences the moods and behavior of people.

Energy movements and transformations within Ka 'Upena o ke Ola are explored later in the curriculum.