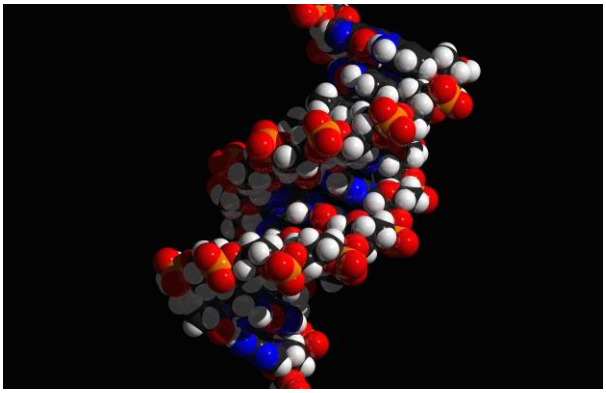
Ke Kumu Welo a me Ka Loli 'Ana: Heredity & Evolution (Extracting DNA from Fruits)



(Photo source: http://commons.wikimedia.org/wiki/File:DNA_Helix_CPK.jpg)

Credit: Kekaha Spencer

Grade Level: 6-8

Learning Time: 2 class periods or 90 minutes

Keywords: chromosomes, DNA, extraction, heredity, *Kumulipo*, meiosis, organelles, replication

Summary & Goals:

- Students will explore the present by examining the past through heredity, relationships, and biological evolution using the *Kumulipo* as an engagement piece. Introducing this concept will show students that all things in the universe are ultimately connected (relationships) and tie into the subject of heredity, or direct connections to ancestors, who pass down traits via genes to descendants through DNA exchange during sexual reproduction (meiosis).
- In the lab activity, DNA will be extracted from strawberries and bananas. Students will learn why DNA extraction from organisms is scientifically important. Students will learn that DNA, as the blueprint for life, is also found in food that they eat.
- Students should already have a basic understanding of cells and organelles, chromosomes, base pairs of DNA, shape and structure of DNA, and DNA replication.

Background | **Standards** | **Resources and Materials** | **Instructions** | **References**

Background:

SCIENTIFIC

To study human migration within the Pacific, DNA is extracted from blood, hair, or mouth swabs of people from each region (Penny & Meyer, 2006, p. 98). Two main types of DNA are analyzed: that from one's mitochondria and that from the male-only Y chromosome (p. 98). Mitochondrial DNA is easy to extract and analyze from a wide variety of samples and evolves very fast and, thus, varies a lot from person to person (i.e., a lot of useful information

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can obtained with relatively little effort), but it is also *maternally* inherited (i.e., passed down the *female* line), only giving information about the migration patterns of female ancestors (p. 98). DNA from the Y chromosome complements the mitochondrial DNA, since it is *paternally* inherited (i.e., passed down the *male* line), but also evolves much more slowly and is relatively uniform, which means that more work is required to obtain useful information from it (p. 98).

CULTURAL

Creation stories explain the origins of all things: the universe, heavens, earth, the gods of nature, all things animate and inanimate in the phenomenological world, male and female forms, and life and death. These mythologies, regarded (by some) as the most sacred of all traditions, reflect deep-seated philosophical, religious, cultural, and social beliefs about the nature of reality and the unknown, being and non-being, and the relationships between all things. The *Kumulipo* is a Hawaiian genealogical chant that tells of the origin of humans but also unintentionally mirrors the concept of biological evolution from a Western science perspective, beginning with the cosmos and ending with humans. *Maiʻa* (banana), *lahi* (a species of banana), and *lahipoko* (short banana) are referenced within the Eleventh Era of Queen Liliʻuokalani's rendition of the Kumulipo.

VOYAGING

Oral traditions that incorporate ideas of creation contain clues about Polynesian origins. Studies of human DNA (together with oral history as well as linguistics and archaeology) also provide new information about the settlement of Polynesia (Penny & Meyer, 2006, p. 98). Based on the DNA of living peoples, the origin of Polynesians was within the islands of southeast Asia, possibly with a degree of interbreeding with other people already living in the area (Irwin, 2006, p. 65) and, before that, Taiwan (Penny & Meyer, 2006, p. 99). The exact order in which Pacific islands were colonized is not entirely known yet but may be determinable with additional analysis and DNA samples (p. 99).

Other sources of DNA samples are plants, such as the *maiʻa* (banana) and *ʻōhelo papa* (strawberry). *Maiʻa* grew on many Pacific islands and served as an important food-producing tree (Oliver, 2002, pp. 75-76). The species *Musa paradisiaca* likely originated in southern and southeast Asia whereas *Musa troglodytarum* possibly came from Melanesia, but both were introduced to Polynesia by humans aboard voyaging canoes (p. 76). *Maiʻa* is also a *kino lau* (incarnate form) of Kanaloa, the god of the ocean (Bishop Museum, 2013a). The native Hawaiian *ʻōhelo papa* or *Fragaria chiloensis* (Carr, 2009) voyaged via migratory birds during prehistoric times from the western coast of North America (Robertson, 2011).

BISHOP MUSEUM

Carl F. K. Pao, a contemporary Hawaiian artist, created a 16-panel visual interpretation of the Kumulipo (on display within Hawaiian Hall) based on various translations but largely on the work of King Kalākaua (in the 1880s) and the more recent translation by Martha Beckwith (in 1951) (Gobetz, 2010).

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(Photo source: http://apps.ksbe.edu/kaiwakiloumoku/sites/apps.ksbe.edu.kaiwakiloumoku/files/images/03%20kumulipo216.jpg)

(Photo source: http://foter.com/f/photo/4827161876/822497f2cc/)

The Origins Tunnel (within the Science Adventure Center) showcases papier-mâché plants and animals created by students from Jarrett Middle School, Dole Middle School, Hakipu'u Learning Center, Hālau Lōkahi Public Charter School, and 'Aiea Intermediate School and features chanting (by Sam Gon and Hālau Lōkahi students) of the Kumulipo (Keany, 2005).

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(Photo source: http://farm2.staticflickr.com/1015/1338259227_1ab05b23d0_o.jpg)

The Pacific Center for Molecular Biodiversity (PCMB) is an integral component of the Bishop Museum Natural Sciences biological collections, housing genetic material at ultra-cold temperatures for long term preservation in hopes of expanding the knowledge and understanding of the natural and cultural history of Hawai‘i and the Pacific region through molecular research. PCMB staff members collaborate with scientific, educational, and cultural partners and programs, and the use of the facilities at the PCMB by researchers and students is encouraged.

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Standards:

Na Honua Mauli Ola

- ‘Ike Pilina (Relationship Pathway)
- ‘Ike Mauli Lāhui (Cultural Identity Pathway)
- ‘Ike Na‘auao (Intellectual Pathway)
- ‘Ike Honua (Sense of Place Pathway)

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- ʻIke Kuanaʻike (Worldview Pathway)

GLOs

- GLO 3 Complex Thinker

HCPS III

Grade 6 Science

- SC.6.1.2: Use appropriate tools, equipment, and techniques safely to collect, display, and analyze data

Grade 7 Science

- SC.7.5.2: Describe how an inherited trait can be determined by one or more genes

Common Core

Grades 6-8 Reading: Science and Technical

- 6-8.RST.3: Follow precisely a multistep procedure when carrying out experiments or tasks

Grades 6-8 Writing

- 6-8.W.1: Write arguments to support claims with clear reasons and relevant evidence

NGSS

Middle School Biological Evolution: Unity and Diversity—Students will understand the following DCI:

- LS3.A: Inheritance of Traits—How are the characteristics of one generation related to the previous generation?
- LS4.A: Evidence of Common Ancestry and Diversity—What evidence shows that different species are related?
- LS4.D: Biodiversity and Humans—What is biodiversity, how do humans affect it, and how does it affect humans?

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Resources and Materials:

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Books:

- Beckwith, M. W. (1972, c1951). *Kumulipo, a Hawaiian creation chant.* Honolulu, HI: University Press of Hawaii.
- Johnson, R. K. (1981). *Kumulipo, the Hawaiian hymn of creation.* Topgallant Pub. Co.

Electronics:

- Laptop connected to a Smart Board or projector

Materials (per student):

- DNA Extraction Lab worksheets
- heavy duty storage or freezer bag (quart size);
- 1 strawberry or 1 chunk of banana;
- DNA extraction buffer (see recipe for directions): requires 900 mL water, 50 mL dishwashing soap, and 2 tsp. salt);
- small plastic container/cup to hold extraction buffer;
- coffee filter; small funnel (4" x 4" should be fine);
- 50 mL container;
- coffee stirrer/popsicle stick/chopstick;
- cold ethanol or isopropyl alcohol;
- ice

Photographs:

- *Kumulipo* in Bishop Museum's Hawaiian Hall
- Origins Tunnel in Bishop Museum's Science Adventure Center (SAC)
- [Dr. Tianlong Jiao's PowerPoint slide of the map of migration dates and locations throughout Austronesia]
- [BM Anthropology Dept. artifacts/tools to show links of cultures across Austronesia]
- [Archival photographs of archaeological sites and evidence across Austronesia]

Websites:

- Beckwith's *Kumulipo*: http://www.sacred-texts.com/pac/ku/index.htm
- Queen Liliūokalani's *Kumulipo*: http://www.sacred-texts.com/pac/lku/index.htm

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Instructional Procedures:

1. **ENGAGE:**
    - As students enter the classroom, have a slideshow of pictures of the Kumulipo artwork in Hawaiian Hall and SAC, archived photos of Austronesian/Polynesian people, archaeological sites, and tools/artifacts playing on a computer hooked up to a projector or Smart Board.

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- Use the summary information to guide discussion and connections between the topic of genetics, heredity, and relationships between ancestors and the generations of descendants.

2. EXPLORE:

- Introduce the Fruit DNA Extraction Lab. Half of the students will use strawberries and half of the teams will use bananas to extract DNA. Students will learn the lab procedure used to extract DNA from organisms, collect a DNA sample, and observe the physical characteristics of DNA. Students will crush the banana or strawberry to break open the cells, then add a lysis buffer to separate the DNA from other cell parts by dissolving cell and nuclear membranes. DNA will be filtered from the fruit and other material using a coffee filter and collected in a container. Cold isopropyl alcohol is then slowly added to the liquid collected in the container and observed for any changes.
- Procedure:
    i. Place one strawberry or banana chunk in a Ziploc bag.
    ii. Smash the fruit up using your fist or fingers for 3 minutes. BE CAREFUL NOT TO DAMAGE THE BAG!
    iii. Add 10 mL of the pre-made extraction buffer (salt and soap solution) to the bag.
    iv. Massage the fruit in the bag again for 2 minutes. Avoid making bubbles in your bag.
    v. Set up the filtration apparatus by putting the coffee filter inside the funnel. Place the funnel inside of a sturdy container to catch the liquid.
    vi. Pour the mixture from inside the Ziploc bag into the coffee filter in the funnel and let it drip directly into the container.
    vii. Slowly pour 10 mL of ice cold isopropyl alcohol down the inside the container. DO NOT MIX!
    viii. WAIT AND OBSERVE. You'll see the DNA start to collect as a glob or blob and you can pull it out using the tip of a coffee stirrer/popsicle stick/chopstick.

3. EXPLAIN:

- Explain the function of each procedure and then have students match them:
    - Initial smashing of the fruit helps to break open the cells and break up tissues;
    - Mashing the fruit with the lysis buffer (salt/soap solution) breaks up proteins and dissolves cell membranes;
    - Filtering fruit through the coffee filter separates the DNA components from the cell; and
    - Addition of isopropyl alcohol to the filtered extract precipitates the DNA from the solution.
- Ask the students to discuss and explain the links between DNA extraction and research and understanding their own origins and human migratory patterns.

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4. **ELABORATE/EXTEND:**
    - Have the class compare observations between banana DNA and strawberry DNA (yield, thickness, etc);
    - Create a dilemma problem:
        - Should scientists conduct research using DNA to change human genes? Why or why not?
        - Should DNA be used to provide personalized medical care and treatment of disease with medicines specific to individuals? Why or why not?

5. **EVALUATE:**
    - Students will answer conclusion and analysis questions at the end of their lab worksheet, and discuss with their classmates. The class will reflect on and assess what they have learned and identify questions that they would like to pursue further.
        - Analysis Questions:
            1. What did the DNA look like? Relate the structure of DNA to what you observed today.
            2. Explain what happened in the final step when you added ethanol to your fruit extract. (*Hint: DNA is soluble in water, but not in isopropyl alcohol).*
            3. Why is it important for scientists to be able to remove DNA from an organism? List two reasons.
            4. Is there DNA in your food? How do you know?

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