Science Unit: *DNA*
Lesson 1: *Extracting Human DNA*

School Year:	2012/2013
Developed for:	Sir Wilfrid Laurier Elementary School, Vancouver School District
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Grade level:	Presented to grades 1-3; appropriate for grades K – 7 with age appropriate modifications
Duration of lesson:	1 hour and 30 minutes

Objectives

1. Experience a simple version of a common lab procedure: DNA extraction.
2. Visualize human DNA, connecting an often-referenced theoretical substance (in the news etc) to experience with the real thing.
3. Reinforce/introduce an understanding of cells and their function in our body, by using them in an experiment.
4. Start to understand the central role of DNA in the formation and growth of all living things.
5. Start to understand the DNA code (the "instructions for life"): how it generates the enormous diversity of living things, and accounts for the similarities between living things.

Background Information

DNA (an abbreviation for deoxyribonucleic acid) is a key molecule in the cells of every living thing. It is made up of molecular units (A, C, G and T) strung together in a long chain, and wound into a double helix shape. DNA carries the instructions for the development and functioning of living things, the unique instructions for each living thing being encoded in their unique order of units. From the beginning of the life of a living thing from a single cell, DNA is used to make many molecules that chemically react and give rise to new molecules and more chemical reactions. The resulting immense number of chemical reactions allows an organism to grow and interact with its surroundings. See ref. 1 for an illustrated book on DNA and its function, and ref. 2 for an animated video.

DNA is a familiar word to most students, and many will have seen images of DNA, but few if any will have seen the real thing. Medical and forensic news articles often include references to DNA, but with the complexity of the issues discussed, students may not be familiar with the basic function of DNA. DNA extraction is a relatively simple process. Access to some basic laboratory materials makes the process easier, but it can be done with household materials.

Vocabulary

DNA:	(An abbreviation for deoxyribonucleic acid.) A molecule in all living things that instructs cells how to grow. It is passed from generation to generation and determines how things look, and to some extent, how they behave.
Molecule:	A tiny particle that makes up everything around us. Molecules are too small to see individually, but when enough are clumped together we can see them.
Cell:	A bag of chemicals that function as a unit. Living things are made up of cells. Some living things are just one cell (e.g. bacteria), and others are groups of different kinds of cells working together (e.g. humans). Inside cells, molecules interact, break down and build together to perform the functions of the cell.
SDS:	A detergent, often used in laboratories.

Cell membrane:	The skin around a cell, composed of fatty molecules.
Nucleus:	A compartment within a cell that houses the DNA.
Ethanol:	A kind of alcohol, often used in laboratories.
Precipitate:	To come out of solution, so it can be seen and collected.

Materials

- Dixie cups, one per student, containing 5ml drinking water.
- 95% ethanol, 5ml per student in a tube. (Purchase as “denatured ethanol/alcohol”, available at ref. 3, or from a hardware store.)
- Small tubes to put each students’ DNA in, filled with 95% ethanol. Alternatively, tiny spice jars or other small vials can be used.
- 50ml tubes and caps, one per student. (Available at ref. 3 - wash and reuse. Alternatively, use small glass jars e.g. baby food jars).
- Test tube rack (available at ref. 3), deep tubs, or balls of modeling clay, to hold all tubes upright at each table.
- Optional: necklace string, or strong thread, to hang students’ DNA tubes on.
- 6% salt water, 1ml per person in their 50ml tube. Make 6% salt water with 1/2 teaspoon salt in 4 tablespoons water.
- Small funnel with a bend in the spout. Alternatively, the spout of a straight funnel can be held against the side of the tube while pouring into it.
- Images of DNA (e.g. from a Google image search for “DNA structure”). See ref. 4 for an example.
- Detergent, 1ml per student. 7% SDS in water works best (available from biology laboratories). 50% dish soap works too, though less well.
- Black acrylic sticks, or other dark-coloured hard-plastic sticks, 1-2mm diameter. Test out available sticks before using in class.
- Code worksheet (following this lesson; half a sheet per worksheet). Distribute one per student, so that the same codes are not next to each other.
- Small tubes to contain each students’ detergent (alternatively, pipettes for delivery of detergent).
- Pipette, or eye dropper, to recover DNA that will not stick to the plastic sticks
- Pencil and eraser for filling out the code sheet.

In the Classroom

Introductory Discussion

Ask students if they have heard of DNA, and if so, what they recall about it. Allow students to bring up anything they have heard about the topic (including references to movies such as Spiderman) so that their knowledge can be tied to the lesson as it progresses. Use images of DNA to refer to as discussion unfolds e.g. ref. 4.

Tell students that we will extract DNA from their own bodies. We could use almost any cells from our bodies to obtain DNA, but the quickest and easiest is cheek cells.

Brief description of science activities:

- Extraction of DNA from students’ cheek cells.
- Code activity.

Brief description of the processes of science that the students will focus on: technical manipulation, measuring, close observation, comparison.

Safety guidelines

Ethanol is used in the final step of DNA extraction and should be used with care. Ethanol is flammable and should be kept away from any open flame. Ethanol is poisonous, so although the amounts used are not toxic, students should avoid inhaling the fumes.

Science Activities

(1) Activity Title: DNA extraction from human cheek cells

Purpose of Activity: Collect DNA from human cheek cells, for students to observe, and take home.

Methods and Instructions:
Set-up prior to experiment: for smooth running of the activity in the classroom, pre-measure out all the materials, as listed in the materials section.

Students work individually and can pour and mix their own materials until the last step. The last step (DNA precipitation), should be done by the teacher (who should practice this step before the lesson).

1. Collect cheek cells: ask students to tip the 5ml water from the Dixie cup into their mouth, swish the water in their mouth for 30 seconds (like a mouthwash) and then spit it back into the Dixie up. This is best done simultaneously as a class. The swishing washes the cells from the inside of their cheeks into the water. More vigorous swishing yields more cells - hundreds of thousands of cheek cells are collected from one mouth wash.
2. Students then pour this mouthwash (now cloudy with cells) from the Dixie cup into their 50ml tube. (The 50ml tube should already contain 1ml salt water, which is needed for the precipitation step later.) Bacterial cells from their mouth, and maybe food particle cells too, will also be mixed in with the cheek cells - DNA from these other cell types will be extracted too.
3. Break open the cheek cells: students add 1ml detergent to their 50ml tube, cap the tube, then gently mix by inverting several times. The detergent removes the greasy cell membranes from around the cheek cells, as well as the membrane around the nucleus. All the cell molecules - DNA, proteins, sugars etc - are released into the salt water.
4. Precipitate the DNA: this step onwards is best done table by table. While they are waiting, students at other tables can draw the activity materials and describe what they have done so far.

   Remove the cap from a 50ml tube and rest the bent funnel in the tube so that the end of the spout touches the side of the tube. If a straight funnel is used, hold the end of the funnel spout against the wall of the tube above the level of the liquid. The student pours 5ml ethanol into the funnel - it will run down the side of the tube and make a layer on top of the salt water layer already in the tube. Keep the tube still for 30 seconds.

   The ethanol and salt together precipitate the DNA, while most other cell molecules remain in solution. Look for an almost invisible cloud of white, cottony strands of DNA forming in the lower half of the ethanol layer. There will be bubbles stuck among the strands, so if you do not see any DNA, first look for the bubbles. After a couple of minutes the DNA clump may float to the top of the ethanol layer. (The bubbles form as dissolved gas in the salt water layer are forced out of solution by the ethanol.) Single DNA molecules are way too small to see - a strand seen here is a clump of thousands of DNA molecules.
5. Collect the DNA: this is the trickiest step and should be done by the teacher, or in small groups with close assistance.

Pick up the 50ml tube and hold it close to your face in good light, to see the DNA. Then lower an acrylic stick into the tube, pushing it through the DNA clump, until it rests on the bottom of the tube. Keep the stick resting on the bottom of the tube, and roll it between the fingers so that it spins in one direction. Do not spin it in both directions. Do not stir the rod in the tube like you would stir a drink. Keep spinning the rod in one direction until all the long strands of white DNA have wrapped around it. If the DNA does not catch right away, start again with a new stick (the DNA will not grab onto reused sticks). The white DNA should be just visible on a black stick - it will look like white goop when the stick is pulled out.

Shake the DNA off into a small tube filled with ethanol, scraping the rod on the side of the tube if necessary.

If the DNA will not catch onto the stick, use a pipette to suck up the blob of white DNA and transfer it to the small tube of ethanol. Avoid sucking up any of the salt water layer, as this will make the DNA go back into solution.

Different people get different amounts of DNA because some people's cheek cells fall off more easily than others. If you get no DNA, make sure you swish really well when you try again.

6. Hang your DNA on a necklace: thread the DNA tube onto a necklace string and tie securely. Students might instead make bracelets or a backpack momento.

   The DNA should keep indefinitely in the small tube of ethanol. If the level of ethanol falls, top it up with some more. Most students will just have tiny white specks of DNA in their tube. This is still hundreds of thousands of copies of their DNA.

   Note: the DNA you get is not pure DNA - there is also some protein mixed in. The long strands you see are clumps of DNA molecules. The protein is stuck to the DNA strands and makes them whiter and more bulky than pure DNA.

Closure Discussion for DNA extraction activity

Once all the students have their DNA in a small tube, make sure they can all see it, then reiterate what DNA does: the DNA in your tube carries the instructions to make you. Each of your DNA samples is slightly different, it has slightly different instructions, so that we all look a bit different e.g. eye colour, hair colour, skin colour. (Identical twins have the exact same instructions, so they look exactly the same.)

Introductory Discussion for Code activity

The following activity will help understand how the DNA code can make us look different.

(2) Activity Title: Code activity

Purpose of Activity: To demonstrate how changing the order of the characters in a code can generate a variety of end products.

Methods and Instructions:
Set-up prior to experiment: none
Students work individually.

1. Distribute the code worksheets (attached at the end of this lesson, half a sheet for each code). Make sure that students sitting near to each other do not have the same code.
2. Explain how to fill in the code sheets: find the lines of code at the bottom of your sheet, made up of Ws and Ps. You will use these to fill in the boxes of the grid. If you read a P you will fill in the square with pencil; if you read a W you will leave the square white. The first block of code letters (9 of them in a block) is for the top row of the grid - pencil in/leave white the grid boxes left to right as you read off each letter. The second block of code letters is for the second row of the grid, and so on, continuing until the last (8th) block of code letters for the last (8th) row of the grid. Cross off each letter and block as you use them so you don't make mistakes.
3. As students complete their grids, they will see a shape of a living thing. Students will discover that sometimes they get the same shape as someone else. Once all students have filled in their grid, ask

what shapes they made. The last sheet of the code worksheet informs the teacher of the shapes that the students should make with each code. (Sometimes a student will make an error - this can also be used for discussion on what happens when there is an error in a DNA sequence - see Closure Discussion following).

Closure Discussion on Code activity

1. Just as the letters of the code in our activity could make many different living things, the DNA code in all living things can give rise to the variety of living things.
2. The code in our activity had just two letters and was only 70 units long. We were able to make several different shapes from it and you can imagine many more shapes that could be make with these letters and this grid. DNA has 4 letters and in people is 3 billion units long, so there are many, many more ways that the letters can be arranged, making many, many different kinds of instructions possible, so giving rise to a huge variety of living things.
3. If a student made an error in their code and did not get a recognizable picture, use this to discuss what happens with DNA: when DNA is copied, sometimes an error is made, and the wrong letter appears in the DNA sequence. When this happens the instructions are changed, and the living thing may not survive, or may have a disorder.
4. If students are keen and able, information on DNA code can become more detailed: the four different units in DNA are called A, C, G and T (they may be familiar to some students). The units are joined together in a long string, for example AATTCGTCGTTAATCTGATC, and so on, 3 billion of them in people.
5. Each of us has a slightly different order of these four units, so our instructions are a little different, so we look a little different from each other: our hair colour, whether we are a boy or a girl etc. But, all of our instructions are similar enough that we are all people.
6. Other living things have the same 4 letters, but in another order, so the instructions are different enough to make a different living thing.
7. Our instructions are quite similar to apes, so we are fairly similar to the apes. Our instructions are very different from a tree, so we look quite different from a tree. However, we do have some internal chemistry in common with a tree, so some of our instructions are even the same as a tree!
8. Scientists study the order of the As, Cs, Gs and Ts in different living things to understand how they are related to each other and how living things evolved.

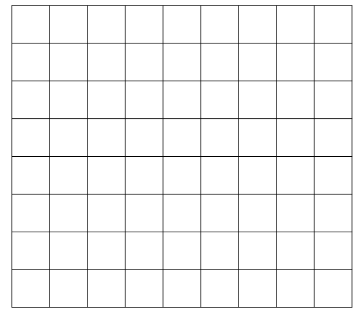
References

1. Balkwill, Fran and Rolph, Mic. 1993. DNA Is Here to Stay. Carolrhoda Books Ltd. [One of many books available explaining how DNA makes us all look different.]
2. <www.statedclearly.com/what-is-dna-and-how-does-it-work-2/> What is DNA? on the Stated Clearly website. [Animated video explaining DNA structure and function.] Also posted on You tube at <www.youtube.com/watch?v=zwibgNGe4aY> Both accessed June 13, 2013.
3. <www.newhorizonsscientific.ca> New Horizons Scientific Supply company in Surrey, BC for some specialist equipment e.g. 50ml tubes (at <http://www.newhorizonsscientific.ca/microscopes/accessories/centrifuge-tubes-50.html>) Accessed May 24, 2013.
4. <www.accessexcellence.org/RC/VL/GG/structure.php> Image of the Structure of DNA from the Access Excellence website. Accessed June 13, 2013.

Code A

P: fill the square with pencil

W: leave the square white



Code:

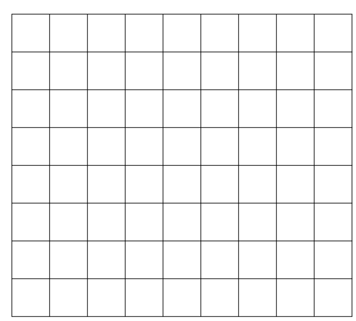
W W P P P P P W W   W P P P P P P P W   P P W P P P W P P   P P P P W P P P P

W P P P P P P P W   W P P W W W P P W   W W P P P P P W W   W W W P P P W W W

Code B

P: fill the square with pencil

W: leave the square white



Code:

W P P W W W P P W   P P P W P W P P P   P P P P P P P P P   P P P P P P P P P

W W P P P P P W W   W P P P P P P P W   W P P W P W P P W   P W W W W W W W P

Code C

P: fill the square with pencil
W: leave the square white

Code:

W W W W P W W W W   W W W P P P W W W   W W W P P P W W W   W W P P P P P W W

W W P P P P P W W   W P P P P P P P W   W P P W P W P P W   W W W W P W W W W

Code D

P: fill the square with pencil
W: leave the square white

Code:

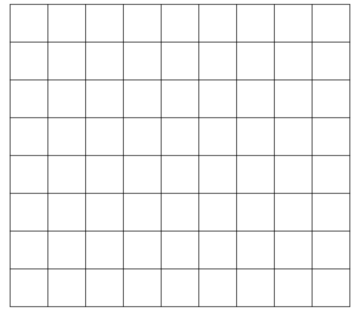
W W W P W W W W W   W P P P W W W W W   P P P P W W W W P   W W P P P P P P W

W W P P P P P P W   W W P P P P P P W   P P P W W W W P P   P W W W W W W W P

Code E

P: fill the square with pencil

W: leave the square white



Code:

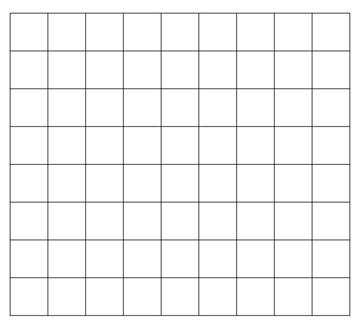
W W W W W W W W W   W W W W W P W W W   W W W W P P P W W   W W W P P P P P W

P P W P P P P P W   P P P P P P P P P   W W P P W W P P W   W P P W W W W P P

Code F

P: fill the square with pencil

W: leave the square white



Code:

W W W P W W W W W   W W W P P W W W P   W W P P P P P W P   W P W P P P P P P

P P P P P P P P   P P P P P P P P W P   W W W P P P W W P   W W W W W W W W W

Teacher's Key

A: human
B: butterfly
C: conifer tree
D: dog
E: turtle
F: fish