Grade 6-9 iGEM presentation

Part I: DNA encodes information

DNA, deoxyribonucleic acid, is a chemical in all living things that encodes information about how to make all the proteins an organism needs to survive, like an instruction manual for how to build one's self. Your DNA has the instructions to make your hair and eyes the colour they are, to give you the right number of fingers and toes, and to make many other aspects of your body. The information in DNA differs slightly between people, which is part of the reason why people are different from each other. Information in DNA can be passed from parents to their children, which is part of the reason why you may be like your parents. As DNA can be used to identify people and their relatives, DNA is samples are often useful in criminal investigations.

Materials: all supplied in the SF office

- PTC paper
- Hard candies

Procedure:
Have the students see which ones of the following DNA encoded traits they have. Describe each trait and give the students a moment to determine which traits they have (they may need to ask each other what their hairlines look like or if they get dimples). Then call out each trait and have students raise their hands if they have it. Are there many differences between students?

- Dimples or no dimples (smile – if there are indents in your cheeks these are dimples)
- Unattached or attached ear lobe
- Peaked or flat hairline
- Six fingers or five
- Can roll tongue or can't

(Each of the following traits may be due to a single gene, though there is disagreement between scientists about many of them. The dominant trait of the pair is listed first, though you probably don't want to explain that).

Some people's DNA has information that lets them taste a chemical called PTC (phenylthipcarbamide), while other people can't. (See http://faculty.washington.edu/chudler/bitter.html for some interesting background).

Each student will have a chance to taste a strip of paper with PTC on it. If they can taste something bitter, they can taste PTC. While PTC taste testing is widely done in schools, university classes and research, some people find the taste of PTC very strong. Save the PTC taste test to the end of your presentation and give each student a sucker afterward to take away any bad taste. Warn the students to just lightly touch the tip of the paper to the edge of their tongue – putting too much of the paper in your mouth may make the taste overwhelming!

Chemicals like PTC are found in broccoli, brussels sprouts and cabbage. People who taste PTC often dislike these vegetable because they taste bitter to them – a convenient excuse not to eat your vegetables? PTC tasters are also less likely to smoke because the nicotine tastes bitter to them. Testing of huge numbers of people for PTC tasting has actually helped suggest what part of the world humans first evolved in.

Is everything about you coded in DNA? Definitely not! For instance, being good at a computer game has a lot to do with practice, not what your DNA says. As another example, the gene that makes Siamese cats have black paws and faces is activated by cold temperatures. Thus, if you tied an ice pack to a Siamese kitten, it would develop a patch of black fur where the ice pack was. Just about every trait is influenced by the environment to some degree.

Part II: DNA structure

Each DNA particle is a very long thread of two strands coiled around each other. Information is coded as the pattern of different components in each strand, like a pattern of beads on a string. Humans would need a DNA strand about 6.5 feet long to code all the information we need. However, since the DNA strands are very narrow, this much DNA can be folded up into each cell of your body. Overall, there are 16-32 billion kilometers of DNA in your body – enough to reach to the sun and back over fifty times! (DuPraw, E. J. *DNA and Chromosomes,* p. v; McGrayne, Sharon Bertsch.365 *Surprising Scientific Facts, Breakthroughs, and Discoveries,* p. 116.)

Wonder what DNA actually looks like? Do you think you could touch it? You have actually had lots of contact with DNA before – you eat it every time you eat a plant or animal (or yogurt). Strawberries have actually been bred to have lots of DNA (they are actually octaploid), because this allows them to make more protein and be larger than wild strawberries. You are going to extract a glob of DNA from a strawberry!

Materials:

2 bottles of extraction buffer (50 ml liquid dishwashing detergent, 15 g NaCl and 950 ml water, pre-made for you)

- Isopropyl alcohol (This should be cold. If possible, put some snow in a bucket with the alcohol on the way to your demo, or make sure to bring ice with you. The demo still works if its warm, just not as much DNA precipitates.)
- Two Pasteur Pipettes, with bulbs, for dispensing the alcohol
- 15 strawberries, thawed, each in a Ziploc bag
- 15 funnels
- 15 coffee filters
- 30 plastic cups
- toothpicks

- napkins for wiping up drips

Procedure:

1. Have the class split into pairs. If you have a huge class and will have more than 15 pairs, let us know and we'll get you more than 15 strawberries.
2. Give each group: a strawberry in a Ziploc bag, two plastic cups, a funnel, four toothpicks and a coffee filter
3. Have each group smash their strawberry for 1 minute (without breaking the bag!) This breaks apart the strawberry cells.
4. Bring around bottles of extraction buffer and have each group add about 10mL (2 tablespoons) of extraction buffer into their bag. Have them push as much air as possible out of the bag, and securely reseal the bag.

Explain that the buffer contains soap, which dissolves the tiny packages called cells that the DNA is in. The mechanical mixing also helps to break open the cells.

5. Mush together the strawberry and buffer for 1 minute.
6. Show the students how to fold their filter to sit in the funnel: fold it in half, then half again, then half again and half again, so that it looks like smaller and smaller pieces of a pie. Put the folded filter in the funnel and open out a couple of folds so the strawberry pulp can be poured in.
7. Ensure each group has two plastic cups separated and ready. Have the students place the funnel in one of the cups and pour half of the strawberry pulp into the filter. Remind students not to overflow the funnel! Move the funnel to the second cup and pour the rest of the bag's contents into the funnel.

The DNA has been released into the liquid. The solid parts are now removed, as they won't be able to pass through the filter. This is called filtration.

8. Add a few millilitres of ice cold isopropyl alcohol to each cup. Remind everyone that isopropyl alcohol (though it is just rubbing alcohol) is poisonous. Students should wash their hands if they touch it and avoid getting any in their mouth or eyes.
9. The DNA should precipitate out of solution at the interface between the extract and alcohol. It looks like thin white fibers, and may float upwards through the alcohol.

Remember how oil clusters together into droplets if you try to mix it with water? That's because oil is not soluble in water. DNA is not soluble in alcohol, and thus it clumps together. Enough strands clump together that they become visible. This is called precipitation.

10. Each student can fish out some DNA from one of cups using a toothpick. Just stab the goo at the bottom of the clear alcohol layer and pull it out of

the test tube. Long, thin filaments of DNA should be hanging off it. Rotate the DNA to wrap it around the toothpick. Use a second toothpick to pull this glob apart and show the strands. There is a lot of DNA in a strawberry!

11. In a laboratory, the spooled DNA would be rinsed off into a little container and stored in the freezer. Students can just leave their spools in their cups for us to clean up (You will need to rinse off the cups, and funnels for reuse).

Scientists extract DNA using similar steps. Extracting DNA is a very important technique because the isolated DNA can then be analyzed or changed to create something new. We're now going to talk about how we can manipulate it for genetic engineering.

Part III: Building with DNA

Once you have pieces of DNA and you want to build something out of them, its very important to be able to connect them together – can you figure out how?

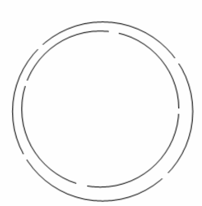
Materials:
2ft of velcro, cut into 5 pieces of variable length (three sets)
Picture of Ecoli
Agarose gel
Plate of Ecoli

Divide the class into three groups, and give each group a bag of Velcro pieces, with the two halves of each piece already separated. Challenge them to do the following:

The goal: to connect all the Velcro pieces together into one shape.

The only rules: there must be no single stranded Velcro remaining when you're done – all the hooks and loops must be in contact with other Velcro.
No use of other materials

The solution: Make a double stranded circle, staggering the end of pieces so they overlap



How this relates to DNA: DNA is made of two strands that like to stick to each other. Each side of the velcro is like a single strand of DNA. When scientists connect DNA they use single stranded sticky ends to stick the pieces together.

You can't leave single stranded gaps because that makes the construct more prone to falling apart. Making the DNA circular is also useful for allowing it to replicate.

The next thing we need to be able to do with the DNA is purify the construct we want. This is done by 'gel electrophoresis'. If possible, bring an agarose gel in a plastic bag to pass around. Make sure the agarose never contacted anything that's been in contact with ethidium bromide.

You can add DNA to one side of the gel and pull it through with electricity. The larger DNA takes longer to move around all the gel molecules, and so doesn't move as far in the gel. Thus, you can separate DNA by size.

To demonstrate this: have the class all stand up. Together, they represent a gel, and each person is a molecule in the gel that DNA would have to go around. The presenter then pretends to be the DNA and tries to walk through the gel of kids. Hold your arms close to your body and move through quickly, then try again with your arms held out or with a hula hoop around your waste, so show its more difficult for you to get through when you're larger.

So what do we do with the DNA we've connected together and purified? I'll give an example from my own work, for the U of A iGEM team, REcoli – were competing in something like a science fair for university kids. We're building a circle of DNA just like you did with Velcro, and we think the DNA we're putting in that circle has all the information needed for life. We're trying to figure out what's the least amount of information you need in your DNA.

When we say 'for life' we mean for a very simple organism – we're working with a microorganism, one that is too small to even see, called *E.coli*. Pass around a picture of it. They're pretty simple, but we call them alive because they can grow and divide, use energy, and respond to their environment. You may want to brainstorm with the kids what they think defines a living organism before telling them this.

E.coli are too small to see just one of them, but If there are billions of *E.coli* all clumped together we can actually see them. What do you think they'd look like? Have a picture printed out of a plate of E.coli, and pass it around.

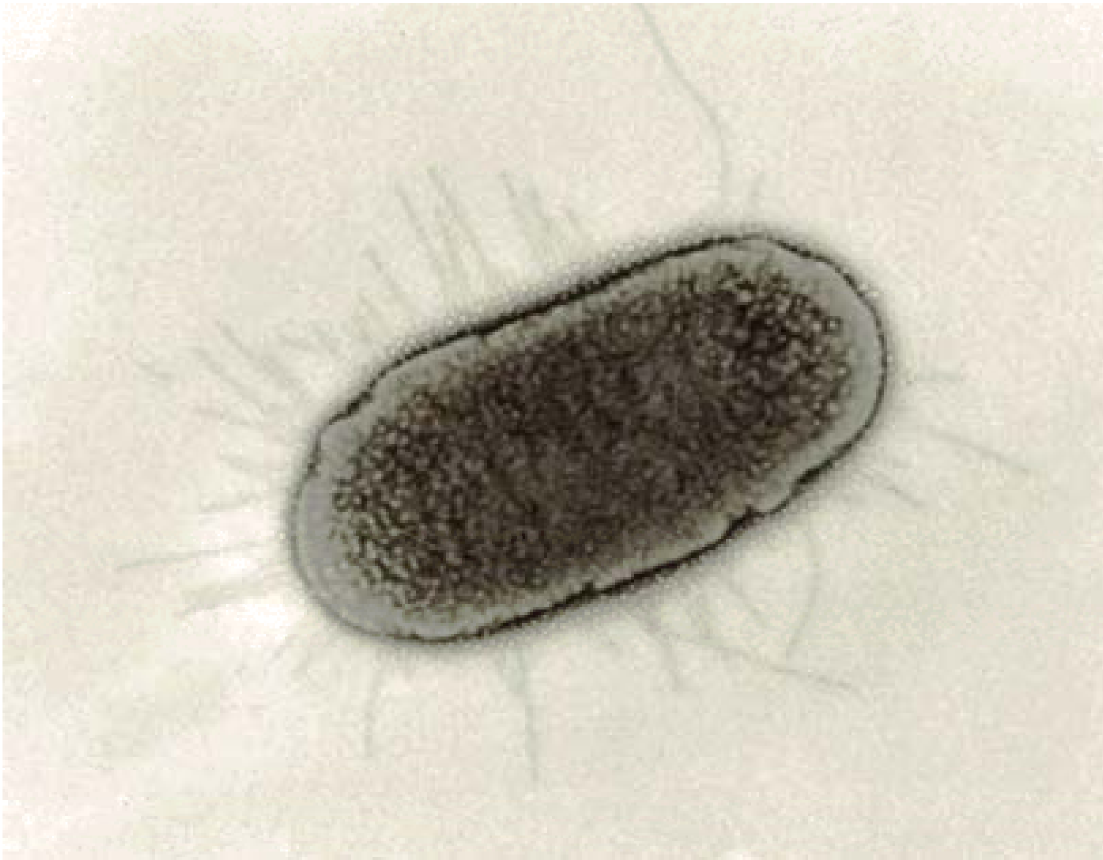
It's possible to insert DNA into almost any organism, and you can make DNA that has instructions for a lot of different traits. What would you like to make with DNA? What advantages and disadvantages could there be?

How this relates to the curriculum:

It really doesn't. There are units on plants in Grade 4 and Grade 7, and cells are studied in Grade 8. The use of DNA for forensics could tie into the Grade 6 evidence and investigations unit. The terms "atom", "molecule" or "cell" until junior high.

Sources:

http://awis.npaci.edu/committees/traits_compairing.pdf
http://www.btanj.org/demo/2004/berry_lesson.pdf
http://chsweb.lr.k12.nj.us/psidelsky/Strawberry%20DNA%20Lab%20Protocol..doc (this site has a good picture of the DNA precipitating)



E. coli