Meet a Scientist: Dr. Barbara J. Shaw

Dr. Shaw is a scientist working for CSU Extension 4-H Youth Development on the Western Slope. In addition to her research interests in youth science education, she is also interested in a weird group of mammals, the xenarthrans (living armadillos, tree sloths, anteaters; extinct ground sloths, glyptodons pampatheres) and how they are related to other mammals.

There are several different ways that scientists can examine the relationship of organisms. One method is by evaluating the skeleton (most fossils are the hard parts: skeletons and shells), and another is by analyzing DNA.

Paleontologists generally study fossils. DNA breaks after an organism dies, and eventually scientists cannot analyze it. Almost all DNA work is with living animals. Sometimes, however, DNA is preserved, and scientists can sequence the ancient DNA to compare to their living relatives.

Why does DNA break down? Remember the activity when you built the model of DNA with color marshmallows and licorice? Do you remember that the nucleotides bond A—T and G—C? Those molecules are held together very weakly, that is constantly checked by enzymes to make sure the nucleotides are correct. After an organism dies, the cells stop working. Thymine (T) next to another (T) will often bond together forming a bump instead of the DNA ladder. This stops lab sequencing methods.

4-H Projects:

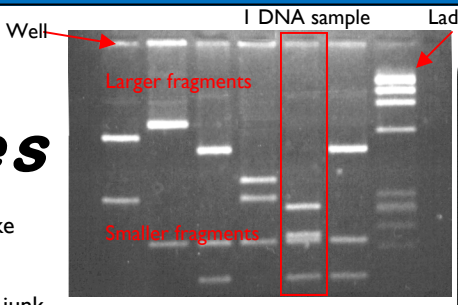
- Any project in 4-H that deals with living organisms;
  - Animals—livestock, pets, entomology, sport fishing, wildlife
  - Plants—forestry, weeds, range management, gardening
  - Food—nutrition, bread project, specialty, preservation, cake decorating

STEM Connections

Colorado State University Extension

Connecting the Science, Technology, Engineering, and Math concepts to our everyday lives. Dr. Barbara J. Shaw

DNA Sequences



http://www.mun.ca/biology/scarr/Gel_Electrophoresis.html

How do scientists use sequences to make DNA fingerprints and solve crimes?

We inherit our parent's DNA, including junk DNA. Junk DNA is free to mutate without harming the individual, because it doesn't code for anything. Identical twins have exactly the same DNA, but over time, their junk DNA will become slightly different. The fewer differences in these regions of DNA, the more closely related two people are, and the more mutations, the more distantly related.

Scientists collect, extract, and isolate the DNA, and then remove the junk DNA discarding the rest. If there is only a single sample (for example a single skin cell) they use process called PCR (Polymerase Chain Reaction) that works like a photocopier making millions of DNA copies. If scientists have enough cells (for example, from a cheek swab), then they do not need to use PCR first.

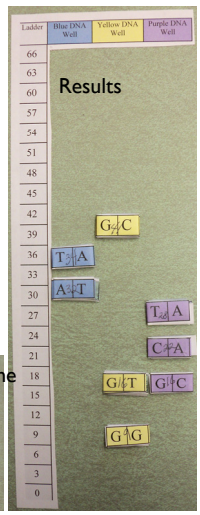
After extracting DNA, scientists add a restriction enzyme. When bacteria are infected with viruses, they make restriction enzymes. These enzymes recognize specific sequence of nucleotides (the DNA molecules ATGC), and cut viral DNA into pieces, protecting the bacteria. Scientists use bacteria restriction enzymes to cut the DNA at specific spots all along the strand.

After the DNA is cut into fragments, scientists load the each sample of DNA into a well on a gel. Using electricity, the different fragments separate. The larger the fragment, the harder it is to move through the gel, and it will remain closer to the well. The smaller fragments of DNA move much more quickly through the gel, and they will be further from the well. (see photo above).

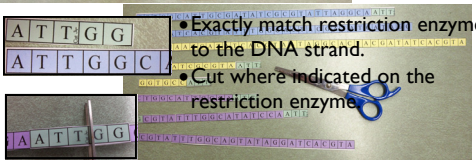
Because each person's junk DNA has a different sequences, the restriction enzymes will cut it differently forming different length fragments. The DNA fingerprint is the pattern those fragments form on the gel.

EXPLORE IT - DESIGN IT - DO IT

DNA is too small to see, but our model describes exactly how scientists make DNA fingerprints. In the top photo, we can see the DNA bands in each column because a dye was added to the DNA to make it visible.



Fragment lengths
Blue: 34, 32
Yellow: 9, 16, 41
Purple: 28, 22, 16



Colorado State University Extension 4-H programs are available to all without discrimination.

Materials:

- Paper DNA (next page)
- Scissors
- Tape
- Marker

Directions:

- Cut the strips of paper that represent DNA sequences blue, yellow, and purple.
- Tape the same color strips together, being sure to match the ends together correctly. These represent the same junk DNA for 3 people.
- Cut out restriction enzymes.
- Match a restriction enzyme **EXACTLY** to the junk DNA strand and tape the restriction enzyme on top of the matching sequence. For example, the yellow strand sequence begins with GGTGCCATTGGG. The restriction enzyme ATTGG matches the underlined portion of that sequence. Tape the restriction enzyme over the ATTGG on the yellow DNA strand. Cut where indicated on the restriction enzyme between the T and G. The first yellow fragment is 9 nucleotides.
- Continue to tape the restriction enzymes over the rest of the yellow, blue, and purple DNA strands.
- Cut the restriction enzyme (and the DNA) between the T and G (ATT cut GG).
- Count the number of nucleotides you have on each fragment and record the number on each fragment.
- Fold the fragments into packages (picture labeled "results" on the left) and tape closed.
- DNA is loaded on a gel in wells at the top. The paper gel has the ladder on the left and the three wells (blue, yellow, and purple) on top.
- DNA travels from the well down toward the bottom of the gel, depending on the number of nucleotides in each fragment. The ladder indicates how far fragments will travel. Blue fragments will be in the blue column, yellow fragments in the yellow column, and purple fragments in the purple column. Each fragment travels down its column, and ends where indicated on the ladder. Notice the 9 nucleotide yellow fragment aligns to the 9 on the ladder.

G	C	T	G	G	C	A	T	T	G	C	G	A	T	A	T	C	G	C	G	T	A	1st tape
T	T	A	G	G	C	A	A	T	T	G	G	A	T	A	T	C	A	C	G	T	A	2nd tape 3
T	T	T	G	G	C	A	C	T	A	C	G	A	T	A	T	C	A	T	A	G	G	3rd cut
G	G	T	G	C	C	A	T	T	G	G	G	A	T	A	T	C	G	C	G	T	A	1st tape
A	T	T	G	G	C	A	T	A	A	G	C	A	T	A	T	C	A	C	G	T	A	2nd tape 3
A	T	A	G	G	C	A	C	T	A	C	G	A	T	A	T	C	A	C	G	T	A	3rd cut
C	C	T	G	G	C	A	T	T	G	C	G	A	A	T	T	G	G	C	G	T	A	1st tape
T	T	T	G	G	C	A	T	A	T	C	C	A	A	T	T	G	G	C	G	T	A	2nd tape 3
T	T	T	G	G	C	A	G	T	A	T	A	G	G	A	T	C	A	C	G	T	A	3rd cut

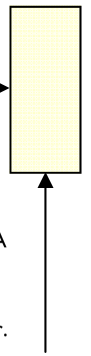
Purple DNA Well

A	T	T	Cut ✂	G	G	A	T	T	Cut ✂	G	G	A	T	T	Cut ✂	G	G	A	T	T	Cut ✂	G	G	A	T	T	Cut ✂	G	G
A	T	T	Cut ✂	G	G	A	T	T	Cut ✂	G	G	A	T	T	Cut ✂	G	G	A	T	T	Cut ✂	G	G	A	T	T	Cut ✂	G	G

Yellow DNA Well

Blue DNA

- Cut out the blue, yellow, and purple DNA strands. For each color, tape the 1st square of the 2nd strip on top of the last square "1st tape 2 here" square. Tape the 3rd strip of each color on top of "2nd tape 3 here" square to form one strand of DNA that is 66 nucleotides long.
- After you have taped all of the restriction enzymes over the matching nucleotides of your three strands of DNA (blue, yellow, and purple), cut where indicated, between the "T" and "G" on the restriction enzyme.
- Count the number of nucleotides (ATGC) in each fragment and write that number on the fragment. The answer is on the fragment.
- The image to the left and bottom of this page represents the gel (the machine that holds the gel and DNA while it is separating is the rig). To the left is the well for each DNA strand (blue, yellow, and purple). Below is the ladder that indicates the number of nucleotides (ATGCs) in each fragment.
- Cut out the rig. The wells are on top, and the ladder is on the left. Fold the fragment into a tiny package with the number of nucleotides showing. Tape it to keep it together.



Restriction Enzymes

Do not "cut ✂ until after you have taped the restriction enzyme over the matching sequence on the blue, yellow, and purple DNA.

Ladder	66	63	60	57	54	51	48	45	42	39	36	33	30	27	24	21	18	15	12	9	6	3	0