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Curriculum topics:

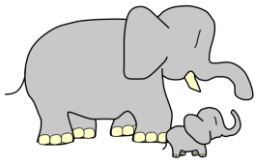
- Biology
- Biotechnology
- DNA
- Forensics
- Genetics
- Inherited traits

Subject:
Life Science

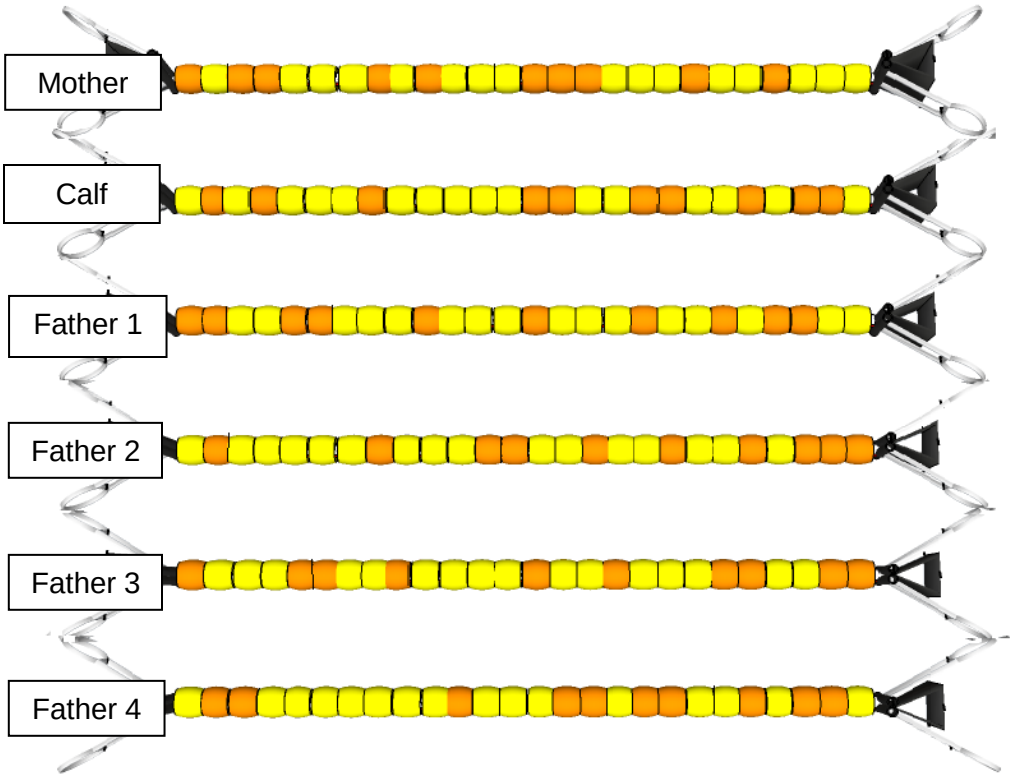
Grade range: 7 – 12

WHO'S THE DADDY?

Test paternity with this simple model



DNA fingerprinting is often seen in today's media. This simplified model helps students visualize the analysis process, understand the underlying concepts and applications of DNA fingerprinting, and develop collaboration skills as young scientists.



Who we are:

Resource Area for Teaching (RAFT) helps educators transform the learning experience through affordable "hands-on" activities that engage students and inspire the joy and discovery of learning.

For more ideas and to see RAFT Locations

www.raft.net/visit-raft-locations

Materials required

For each activity station of two students:

- Pony beads,
  96 Yellow and 60 orange
- Six straws, coffee stirrer size,
  7” (~18 cm) long
- Binder clips, 12
- Labels, 6
- DNA bead patterns – see page 1 or download a full sized pattern at www.raft.net/raft-idea?isid=462

Scenario: A new baby elephant (calf) was born in the city zoo a few weeks ago. A team of zoologists took blood samples from the calf, the mother, and four male elephants (potential fathers). You’ve been asked to lead the team in identifying the calf’s father by isolating and analyzing segments of DNA from the samples.

How to build it (for 2 students)

1 Using the bead pattern as a guide, slide beads onto the straw to represent the DNA fingerprint for the mother elephant. Make sure the bead arrangement matches the graphic and is in the correct order from left-to-right. See figure 1.

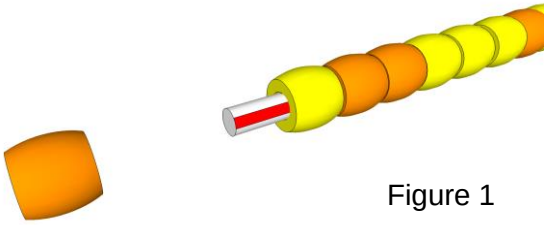
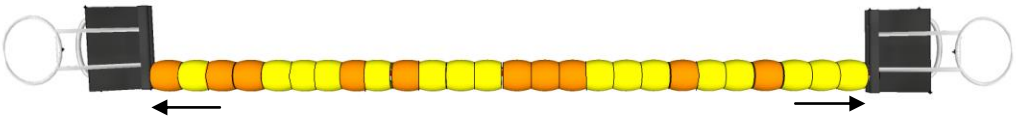


Figure 1

Note: A common mistake is to put beads on the straws in the wrong order. Writing the bead sequence with letter abbreviations for the colors helps students with the order. For example, if the sequence from left to right is yellow, yellow, orange, yellow in the graphic, students can write down YYOY and string the beads in that order, then cross them out of the written sequence. This also helps to avoid erroneous repeats.

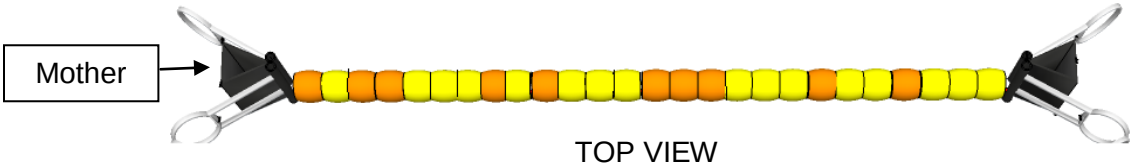
2 Attach a binder clip to both ends of the straw, making sure beads are held tightly in position. To prevent the straw from falling out, adjust the straw so it is clamped securely at the ends of each binder clip rather than in the middle of the binder clips. See figure 2.



SIDE VIEW

Figure 2

3 Label the binder clip on the left side of the DNA fingerprint model as “Mother”. See figure 3.



TOP VIEW

Figure 3

4 Repeat steps 1-3 for the calf and four potential father elephants (see graphic on title page).

To do and notice

1 The orange beads represent specific non-coding regions along the DNA fingerprint that are inherited by the elephant calf.
The mother strand: Numbering the beads from left to right, observe the mother strand and note that there are orange beads in places 1, 3, 4, 8, 10, 14, 15, 16, 20, and 23 (see Figure 4).

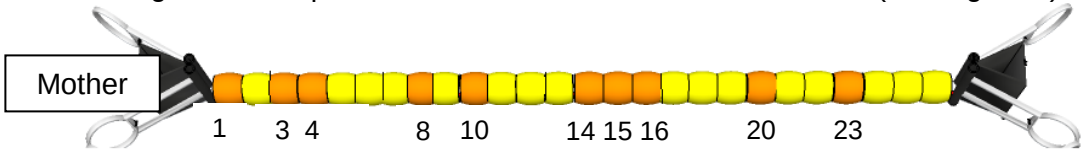


Figure 4

2 Calf & mother: Line up the calf's DNA fingerprint model with the mother's DNA fingerprint model and note that a number of orange beads are in the same location for both the mother and the calf: places 4, 8, 14, and 15 (see Figure 5).

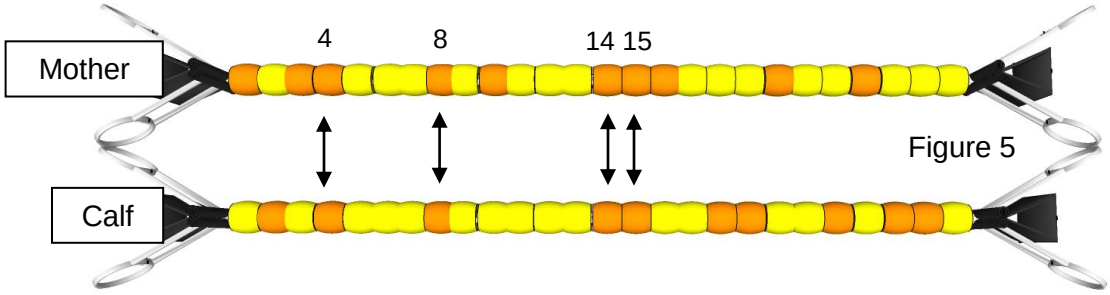


Figure 5

3 Calf, mother, & father 1: Place the calf's DNA fingerprint model between the DNA fingerprints of the mother and father 1. For each orange bead position on the calf's fingerprint, check the mother fingerprint and the father 1 fingerprint to see if there is an orange bead in the same position. Since the mother is known, any orange bead on the calf DNA fingerprint that is not present on the mother fingerprint must be present on the father's fingerprint in that position. Potential fathers can be ruled out if this is not the case (see Figure 6).

Indicated position shows no orange match for mother AND no orange match for father. Father is ruled out

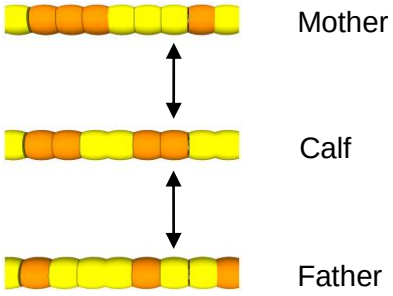


Figure 6

4 Remove father 1 fingerprint and replace with father 2 fingerprint. Repeat step 3.

5 Remove father 2 fingerprint and replace with father 3 fingerprint. Repeat step 3.

6 Remove father 3 fingerprint and replace with father 4 fingerprint. Repeat step 3.

7 For the DNA fingerprint that cannot be ruled out, notice the number of orange bead father-calf matches not shared with the mother elephant. Did you find the daddy?

Note: Students can count the number of father-calf orange bead matches for the ruled out samples and compare numbers to that of the actual father elephant, then explain reasons for any differences in the context of inherited traits.

Curriculum Standards:

Genes and DNA (Next Generation Science Standards: Middle School, Life Science 3-2; High School, Life Science 3-1)

Additional standards at: http://www.raft.net/raft-idea?isid=462

Learn more

- Create your own set of DNA: Mom, baby, and possible fathers. See if another person can solve the set.
- Create longer DNA fingerprints using 10-12" skewers (points removed).
- Make each of the six DNA fingerprints a different length to model size variances seen in real cleaved DNA fragments.
- Use UV beads or glow-in-the-dark beads for genetic material.

Extend this activity with the following suggestions:

- Create a fictional crime scene with several types of evidence, including simulated blood or hair from 5 or more suspects.
- Develop clues describing the results of restriction enzyme applications and the resulting fragments. Have students model fragments using clues and enzyme results to build the models.
- Assign a research team to analyze the models and compare to other evidence to develop a plausible scenario.

Related activities: See RAFT Idea Sheets:

Codon Necklaces -
http://www.raft.net/ideas/Codon Necklaces.pdf

Modeling DNA -
http://www.raft.net/ideas/Modeling DNA.pdf

Who's Your Mummy? -
http://www.raft.net/ideas/Who is Your Mummy.pdf

Resources

Visit www.raft.net/raft-idea?isid=462 for "how-to" video demos & more ideas!

See these websites for more information on the following topics:

- **Detailed information about how DNA fingerprints are made and used in legal situations** – http://www.howstuffworks.com/dna-evidence.htm
- **Using DNA fingerprinting in criminal cases** – http://education.llnl.gov/bep/socsci/11/tEvi.html
- **Video on DNA from the Khan Academy** – https://www.khanacademy.org/science/biology/evolution-and-natural-selection/v/dna

The science behind the activity

The human genome consists of more than three billion nucleotides in its DNA molecules that form the rungs in the double-helical structure. In cell nuclei DNA is wrapped around proteins called histones to form complexes called nucleosomes. The nucleosomes coil around themselves to form solenoids, which coil further to form chromatin loops. Chromosomes are composed of several layers of chromatin loops. Chromosomes are the genetic units passed on from parent cells to offspring. Human body cell nuclei contain 46 chromosomes, 23 from each parent. Along the length of a chromosome are DNA-protein subunits called genes that code for specific proteins and determine the traits of an individual.

The human cell has 21,000 protein-coding genes. There are large quantities of DNA that do not code for proteins called noncoding, or "junk", DNA that appear to be non-functional. The importance of this DNA becomes apparent when trying to establish paternity because although the material is noncoding it is still passed on to offspring on the chromosomes. Since 50% of the genetic material in most organisms comes from each parent it is possible to analyze the noncoding sequences and characterize an individual, a process called DNA Fingerprinting.

DNA fingerprinting uses proteins called restriction enzymes that cut, or cleave, the noncoding DNA at specific places called recognition sites. The bead strands in this activity represent the cleaved portions of DNA from the mother elephant, the elephant calf, and potential father elephants. The lengths of the cleaved portions of DNA in the activity are the same but in reality the fragments are usually different sizes. DNA from different individuals rarely has exactly the same array of restriction sites and distances between sites, so the restriction fragment patterns for different individuals will be different. The fragments are separated and analyzed using a technique called gel electrophoresis.

The beads in the activity represent genetic material along the cleaved fragments, the orange beads being the material of interest. Paternity can be established by comparing the mother, calf, and father strands and moving along the calf strand from left to right and noting the positions of the orange beads. This information is used to rule out potential fathers much the same way it is used in the laboratory to rule out suspects in DNA probes. DNA researchers and forensic scientists spend much time trying to narrow a list of candidates/suspects down to identify specific individuals of interest rather than determine the genetic attributes of every suspect.

Field biologists use DNA Fingerprinting on specimens to provide evidence of evolutionary relationships between organisms. Although evolutionary theory depends on many sources and types of evidence for support, applied genetics and modern biotechnology have allowed scientists to confirm or modify findings of previous scientists and enhance our understanding of the biosphere.