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iBIO STEM Kits: Biometrics

iBIO STEM Kits welcomes you to a SCIENTIFIC JOURNEY!

Today we will investigate **biometrics,** the use of physical characteristics to digitally identify a person. The purpose of this investigation is to explore how we can use the patterns and measurements of our bodies to create a small database of information that is unique to you! We will even make some secret messages using DNA code! We challenge you to explore these two engineering problems as a scientist would. What does this mean?

Scientific exploration is different than just playing around because it asks you to think about HOW you investigate. This means you need to do your investigation by observing what happens when you change a variable you have carefully chosen. This helps you to understand WHY something happens. Scientific exploration also means that you record WHAT you see or measure and that you record WHY you think it happens. The STEM Kit Notebook you are holding will help to guide your investigation and give you a place to record your observations, measurements and conclusions.

Follow the QR code at the top of the page for additional resources on this activity. There are many resources for you to use on our website. This type of investigation is associated with some very exciting careers! We hope that you will explore these resources while you are doing your investigation!

Let's Get Started!

FIRST, you will need to prepare your workspace. This can be a VERY messy investigation, so make sure that you are using a space that will not be easily damaged. A kitchen table will work nicely. To make your clean up easier, you should protect your surface by laying out some used newspaper or opening up a paper grocery bag.

SECOND, you want to unpack your materials. Use the list below to identify which materials are used in each part and organize them in your workspace.

Materials for Part A:
Carbon fingerprint powder
Paintbrush
2 Glass slides
Four small index cards
Plastic gloves
Pencil

Materials from Welcome Kit:
Scotch Tape

General Supplies:
Paper to cover your workspace

Materials for Part B:

Materials from Welcome Kit:
Ruler

General Supplies:
Your hands!

Materials for Part C:
Foam paper plate
Acetate square

Materials from Welcome Kit:
Sharpie

Materials for Part D:

General Supplies:
Access to the internet

LAST, you need to be prepared for experimenting safely. The carbon fingerprint powder is a loose powder that sticks to EVERYTHING. You need to make sure that you use the gloves. Do not taste the carbon powder. When using the foam plate, do not chew or swallow any foam pieces.

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Biometrics-Computational Thinking

Part A: How can we encode the pattern of 10 fingerprints into a Henry Classification?

What is a biometric identifier?

A biometric identifier is a characteristic that is a natural human characteristic. Most physical identifiers do not change over time which makes them the perfect way to identify you for any type of security measure, like door locks and passkeys.

Computer memory and software is able to use the patterns that exist as a part of our bodies and digitize them into a numerical or alphabetical system that can be used to identify us more accurately than ever before. People cannot steal your fingerprints, so it makes these systems much more secure.

What's so special about fingerprints?

Your fingerprints are unique! Fingerprints are made out of friction ridges, which are raised strips of skin that produce small amounts of sweat and oil. These strips help us to grip things. When you touch something, these oily liquids are left behind in the pattern of your fingerprint ridges. Your fingerprint ridges are formed before you are born and NEVER change. Everyone's fingerprints are so unique (even identical twins' prints are different) that a single print can be used as direct evidence to prove that a person was present at a crime scene.

The oil that is left behind when you touch a surface is difficult to see, but can be made more visible if we cover it with a thin layer of particles. Scientists have determined that the best particle to use is carbon powder and you will be using carbon powder to make your prints visible so that you can examine the patterns of your friction ridges!

Here's what you will need to record your fingerprints:

- Clear adhesive tape
- Sharpened Pencil
- Piece of paper
- My Biometrics card

Making Prints:

1. Using the side of the carbon "lead" of the pencil, scribble an area of carbon graphite on your piece of paper. This is going to be your "stamp pad" so make it big and dark.
2. Start with your left pinky finger. Rub your finger in the pencil graphite. Make sure to get the sides of your finger. You kind of have to roll your finger around to get enough coverage to have a good fingerprint.
3. Take a small piece of adhesive tape. Stick a small piece of adhesive tape to the blackened part of your finger. The sticky side of the tape will pick up the fingerprint. Make sure that you press the tape into all of the areas of your print.
4. Carefully peel the tape off of your finger. You should see the print on the tape. Tape this piece to your Fingerprint Practice page. How does it look? Did you get the whole print?
5. You will want to do a few practice prints to make sure that you are able to see all of the features of the prints. When you feel confident, you can start putting the prints for each of your fingers on your "My Biometrics Card."
6. You will need prints for each one of your fingers.
7. When you finish, compare the patterns of your prints to the "Identifying Fingerprint Patterns" and determine the patterns for each of your fingers!

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Fingerprint Practice Page- Tape your practice prints here!

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Identifying Fingerprint Patterns

Look at the patterns of the prints you made and classify their type.
Record it on the "My Biometrics" Card.

PLAIN ARCH - a smooth, slightly raised arch

TENTED ARCH - a spike like a tent pole looks like it is holding up a tent)

LOOP PATTERNS - Several ridges ender from one side of the fingerprint then fold or curve over and exit from the same side forming a loop. There are two kinds of loops.

DOUBLE LOOP - Ridges form two loops turning around each other.

PLAIN WHORL - Ridges form a series of circular rings in the center of the print.

CENTRAL POCKET WHORL - Ridges form a loop pattern, however, the ridges form a small complete circle in the center of the loop.

ACCIDENTAL WHORL - Ridges form a combination of several patterns. The most common is a double loop with a circle of ridges inside one loop.

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Here's what you will need to lift your fingerprints:

- Four small index cards
- 2 glass microscope slides
- Clear adhesive tape
- Plastic gloves
- Carbon Powder
- Camel hair paint brush
- My Biometrics Card

The carbon-black powder you will be dusting with is VERY messy. Please be neat while completing the following steps!!

If you get carbon powder on your hands, you will need to use soap as you wash to remove it.

Wearing your gloves while you are dusting will help to keep your hands clean!

Lifting Prints:

1. Make sure that you have covered your workspace with newspaper or a garbage bag to make clean-up easier.
2. Pick up a glass slide. Make sure the slide is clean and dry and touch the slide by its edges only.
3. Your goal is to leave a good RIGHT THUMBPRINT in the center of the glass slide. You will leave a better print on the slide if you first touch your thumb to your face to pick up extra oils. Press your thumb directly on the flat slide. Don't press too hard or roll your thumb or your print will smear. You can always clean your slide and try another print if needed.
4. Use a dusting brush to pick up a little carbon-black powder and LIGHTLY dust it over the print. The carbon-black powder should stick to the oils in the print and make the print easily visible. It takes practice and a good touch to be able to dust a print perfectly.

   PROBLEMS:

   - Dusting too hard with the brush will smear the print - the fewer brush strokes the better!
   - Too much powder will make it difficult to see the details of the print.
   - Too little powder will make the entire print difficult to see.

   ***NOTE**: Some people find it easier to sprinkle the dust on the slide and tap the slide around until the powder covers the print on the slide. If you have trouble with the brush. Try that instead!*

5. Time to lift the print!! First, remove all excess powder from the slide by lightly tapping it on its side. Get a piece of tape that is slightly shorter than the length of the glass slide. Stick one end of the tape on the slide near the print, then use your thumb to smooth the rest of the tape over the print. Make sure the tape has stuck tightly to the slide and print.
6. Slowly peel the tape from the glass slide (the print should lift with the tape). Place this lifted print in a random "Lifted Print" space on your "My Biometrics" card.
7. Clean your slide and repeat steps #1 - #6 with a DIFFERENT FINGER. This time place your lifted print in another random "Lifted Print" space.
8. When you have all of your "Lifted Print" spaces filled, take a look at all of them and see if you can identify which finger each one came from. This is what forensic scientists do when they are working with prints! How well did you do?

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Applying Numerical Biometrics to your Fingerprint Set

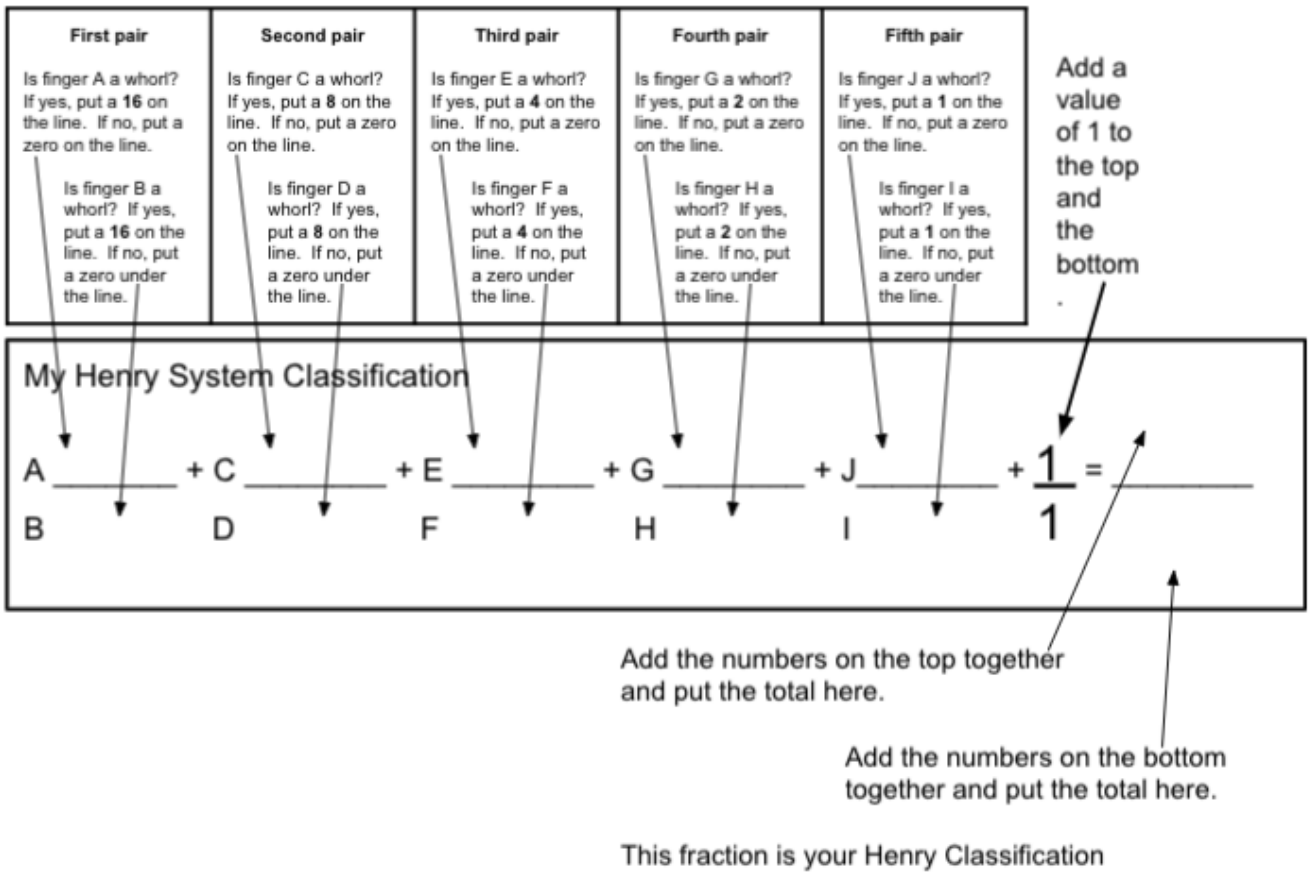
Our systems for fingerprint identification are now computerized in a database that can be searched for rapid identification. But these systems are based on the original Henry System. The Henry system was adopted by Scotland Yard in 1901 and converts the ridge patterns on all ten fingers into a series of letters and numbers arranged in the form of a fraction.

The fraction was used to group fingerprint sets so that they could be easily searched by investigators to identify suspects. At the time, fingerprint records were searched manually which was tedious and time consuming. It allowed police to maintain 100,000 sets of prints so the Henry system is used in a modified form in combination with extensions to increase its capacity. These modifications are collectively known as the FBI system.

We are going to create a Henry System Biometric for your prints!

The Henry System Identification works this way:

1. On your "My Biometrics" card, you can see that each fingerprint has been assigned a letter. This letter has a place on the classification equation.
2. If a fingerprint is a whorl, it will be awarded a numerical value of 16, 8, 4, 2 or 1.
3. If a fingerprint is a loop or an arch, it will be awarded a zero (0).
4. Use the diagram shown below to set up your equation.
5. When you have all of your numbers in place, add the numbers in the top (numerator) to get a total. Then add the numbers in the bottom (denominator) to get a total. The fraction is your Henry Classification. We do not simplify the fraction.



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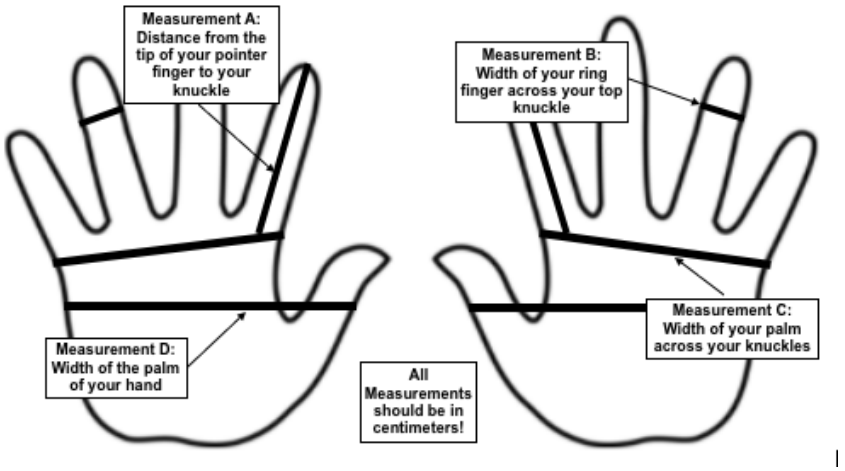
Part B: How can we encode the geometry of our hands into an index number?

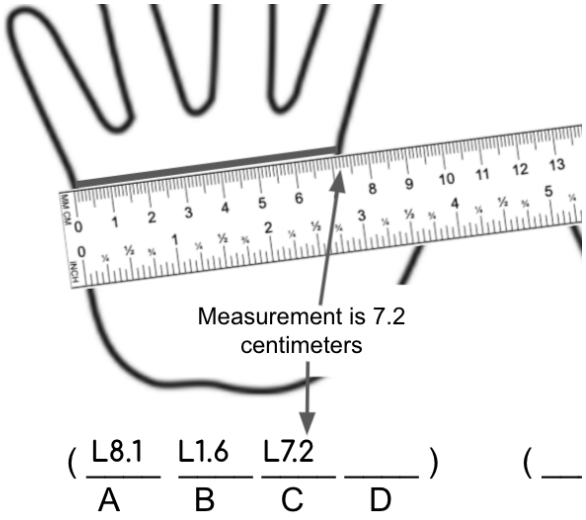
Here's what you will need to find your hand geometry index number:

- Pencil
- Ruler

1. Trace your right hand on the paper provided on the following page. Keep the pencil as close to your skin as possible so that your hand outline is as close to the real size of your hand as possible. If you are having trouble doing this, it may be helpful to have help from someone else.
2. Trace your left hand in the same way. Now you should have outlines of both hands that you can use to make your measurements.
3. Using your ruler, draw lines across the outlines of your hands as you can see them in the diagram below.



4. Now use your ruler to measure each of the lines on your left hand in centimeters and record the measurement on your "My Biometrics" card as shown on the diagram to the right.
5. Do the same measurements for your right hand, but change the L to and R to indicate that the measurements are for your right hand.
6. When you finish, you will have your Hand Geometry Index Number!



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Your Hand Outlines

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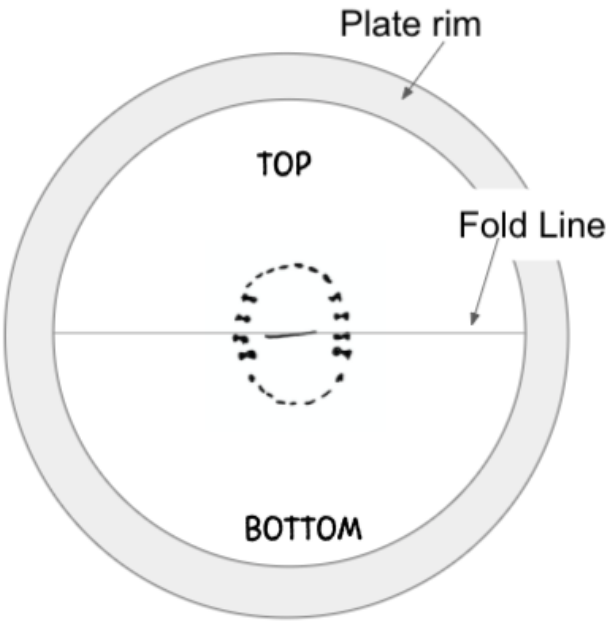
Part C: How can we encode our bite pattern into an identification number?

Here's what you will need to find your hand geometry identification number:

- Foam Plate
- Acetate square
- Sharpie
- Ruler

1. Bend the foam plate in half so that the bottom of one half of the plate is touching the bottom of the other half of the plate.
2. On the half facing the top, near the rim, write TOP.
3. On the other side, near the rim, write BOTTOM. Don't make any marks in the inner circle part of the plate.
4. Keep the plate folded and make sure that the half that you labeled TOP is facing up. Now, make a bite mark impression on your plate, by biting firmly in the center, along the fold. You will need to bite down just hard enough to make a good impression, but not so hard that you bite through the plate.
5. Open the plate so that you can see the bite mark.



6. Put your piece of acetate over the bite mark. Mark the fold line with your sharpie, Write T on the upper left corner of the acetate to mark the top and write a B on the lower left corner of the acetate to mark the bottom.
7. With your sharpie, trace the dental pattern onto the acetate sheet. Be certain to trace as accurately as possible.
8. See if you can identify each of your types of teeth. Each of your "line" marks is an incisor (cutting) tooth. Incisors make the curve around the front of your jaw. Your canine teeth will each make one puncture mark that will look like a circle. Your premolar and molars are the larger teeth along the sides and back of your jaw. They will make a pattern of 2-4 punctures that may or may not be connected.
9. What do you see? Is there evidence of missing or slanted teeth? Spaces between teeth? Deeper impressions from longer teeth? If you are working with another person, compare your bite patterns. What differences do you see?
10. Use a ruler to measure (in centimeters) the width and the length of the upper jaw. Count the teeth of the upper jaw. Use these numbers to record your identification number on your "My Biometrics Card." Use the diagram on the next page to help you.
11. Do the same measurements for your lower jaw and record your identification number on your "My Biometrics Card."

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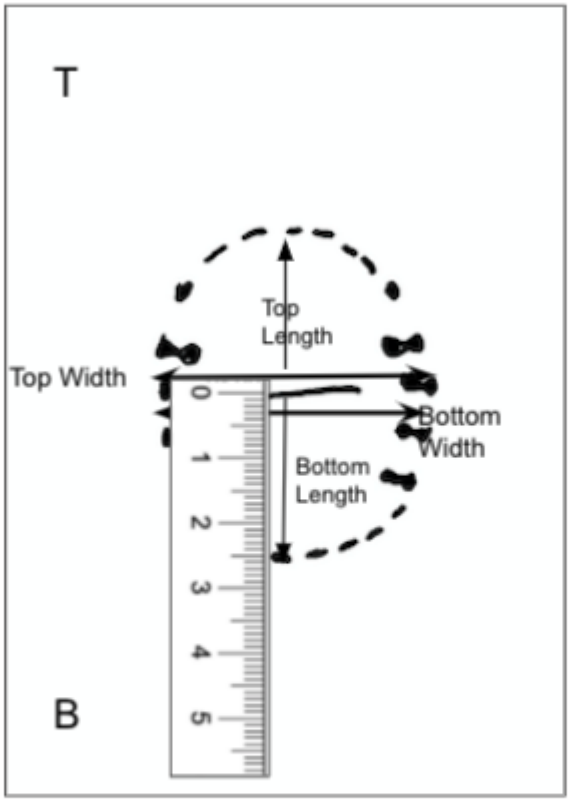
Example:



(T2.6 / T Width T4.6 / T Length T12 / T Tooth #) (B2.6 / B Width B4.5 / B Length B11 / B Tooth #)

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Part D: How can we turn DNA code into a code for secret messages?

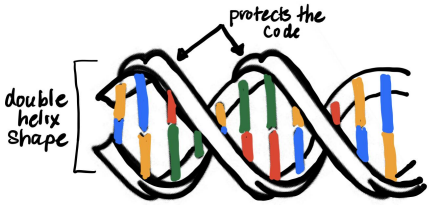
What is a **cryptographer**?
A cryptographer is a person who communicates through secret writing. Cryptographers might use codes, ciphers or a combination of both to keep messages safe from others. What cryptographers create; **cryptanalysts** attempt to uncode. When sending information through the internet, we often use our personal information, like our birthdays and our credit card numbers. Our computers protect this information by encoding the message so that the information cannot be discovered and used by other people. Cryptography is an important part of security. In order to break a code so that you can read it, you need to know what coding system was used. Then you can easily translate and read the message.

As we have investigated, the patterns of our bodies can be used to create a special code to identify us. But did you know that we already have our own special code inside every one of our cells? It is a simple code made up of only 4 chemicals and it is able to carry enough information to make a human being...YOU. This code is called DNA and we are going to use the DNA system to make and break our own secret messages!

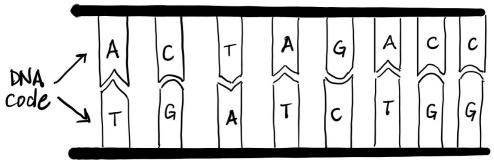
Materials: Internet Access (phone, computer, tablet…)

Procedure:

1. DNA is a molecule that is found in the nucleus of our cells. It is shaped like a twisted ladder called a double helix. The outside of the ladder is designed to hold and protect the code that is hidden on the inside.



2. DNA code uses four chemicals to carry information. They are adenine, thymine, guanine and cytosine. Scientists call them A, T, C and G. They fit together in pairs because of their unique shapes. A fits with T. C fits with G. That allows DNA to carry twice as much code! This is how DNA can carry enough information to build a human being!



3. Your cells are able to break the DNA code to make cell parts. That is something that we cannot do. Instead, we are going to use the DNA code to read and make words and sentences. The DNA coding system is tricky. **It takes TWO steps**. This helps to protect the message. It will also make it tricky for someone to read the code, if they do not know the two step system.

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DECODING THE SECRET CODE:

SECRET CODE 1:

T C G G G T T A G C A T G C C G A G A C A C C G G T G A A A C C C C G G G A G C C A C C G T T G!

The DNA is SECRET CODE 1. It is a coded sequence of A, T, C, and G. It is our coded message!

CODE BREAKING STEP A:

a. Break the SECRET MESSAGE letters into three letter groups. These groups are called CODONS.

T C G | G G T | T A G | C A T | G C C | G A G | A C A | C C G | G T G | A A A | C C C | C G G | G A G | C C A | C C G | T T G!

Now we need to turn the SECRET CODE into our SECRET MESSAGE! To do this, you will need to have access to our digital CRYPTOGRAPHY TOOL on the internet! The link to the CRYPTOGRAPHY TOOL is on the iBIO STEM Kit website. Use the QR code at the top of the page to go to the webpage. This is how you will use this tool.

b. Open the link to the CRYPTOGRAPHY TOOL on the internet. Touch “Present” to activate the tool. Now touch the blue square for the CODE BREAKER TOOL. You will see the four boxes labeled A, C, G and T.

c. Start with the first letter in the first CODON of the SECRET CODE. Touch the first letter of the CODON on the CODEBREAKER TOOL.

d. This will bring you to the second letter in the CODON. Touch the second letter of the CODON on the CODEBREAKER TOOL.

e. This will bring you to the third letter in the CODON. Touch the third letter of the CODON on the CODEBREAKER TOOL.

f. Now you have the first letter of your SECRET MESSAGE!

g. Continue using the CODEBREAKER TOOL until you get to END OF MESSAGE in the code.

h. Did you decode the secret message? Check your secret message on the CRYPTOGRAPHY TOOL to see if you are correct! Just touch “check your decoding of the secret messages” and it will show you the answer!

i. We have two more codes below for you to decode. Then check your decoding on the CRYPTOGRAPHY TOOL.

DNA SECRET CODE 2:

G T A C C C A T G C G T C A A C G C G G T C C A C C G G T G G G T C A C C T A G C A A A G C C G A T T C C A.

DNA SECRET CODE 3:

G C T T A C A T A A T C C C C G C C A A G G T C C A C G T G A A G A T A C C G C T C G G T G C A C T C T A G A T T!

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MAKING THE SECRET DNA CODE FOR YOUR NAME

Now it is your turn! Write a message that you want to send and turn it into a DNA code that you can send. You will need to use the CRYPTOGRAPHY TOOL again, but this time you will be using the CODEMAKER TOOL.

STEP 1:
Let's find the DNA code for your name! Write the letters of your name in the space below.

STEP 2:
Open the link to the CRYPTOGRAPHY TOOL on the internet. Touch "Present" to activate the tool. Now touch the yellow square for the CODE MAKER TOOL. It will bring you to the chart of codes.

STEP 3:
Find the first letter of your name. There will be two or three codons that you can choose to start your message. Choose one and list the first codon. Now continue finding the code for each letter in your name until you have the DNA code for your name!

Your Name: _____

Your DNA Code for your name:

_____

MAKING THE SECRET DNA CODE FOR A QUESTION TO POST ON THE FACEBOOK PAGE

Now that you have the code, you can make coded messages anytime you want! Let's do one that you can share on the Facebook Page. Ask a simple question in DNA CODE that you can post for other campers. Then wait and see the answers from the other campers!

Your Question:_____

Your DNA CODE for your Question: