SECRETS OF STRAWBERRIES

Follow these steps to discover the DNA hidden in strawberries.

Directions and Observations

1. Put a coffee filter over the top of a plastic cup and secure it with a rubber band.

2. Put a single strawberry in a ziplock bag and seal it. Remove as much air as you can.

3. Smash up the strawberry with your hand and fingers for 1 minute. Then pass it to a partner and let him or her smash it for another minute. Be careful not to break your bag. The best way to mash it is to massage the mixture at the bottom of the bag. Describe the smashed strawberry specimen:

I smell . . .

I feel . . .

I hear . . .

4. Add 12 milliliters of Lysis buffer (in the clear tube **without** a rubber band, made of dish soap, salt, and water) to the bag and zip it closed. Mash again for a minute, then pass it to a partner and let him or her mash it for an additional minute. Describe the sample now:

I see . . .

(continued)

I smell . . .

I feel . . .

I hear . . .

5. Tilt the bag so that the mush collects in one bottom corner of the bag, and open the bag. Carefully pour the mush into the coffee filter. Let the liquid drip through into the cup for about 5 minutes. You can gently stir with the small coffee stirrers. **NOTE:** Be careful not to poke a hole in your coffee filter with the stir stick!

While you wait, figure out whether the following statements are true or false, and discuss with your partner(s).

If the total DNA in one person were laid in a straight line, it would stretch to the sun and back over thirty times (it's ninety-three million miles from here to the sun). True or false? Discuss.

If you had really strong reading glasses, you'd be able to see the double helix or spiral ladder shape of DNA. True or false? Discuss.

6. After most of the reddish liquid has dripped into the cup, carefully remove the filter paper with the strawberry mush and throw it in the trash. Tilt the cup a little and gently pour the 10 milliliters of isopropanol (also known as rubbing alcohol, in the tube **with** a rubber band) into the cup, letting it slowly pour down the side of the cup. **DO NOT MIX!** Describe the sample now:

I see . . .

I smell . . .

(continued)

I feel . . .

I hear . . .

7. Observe and wait another 5 to 7 minutes. You'll see the DNA start to collect as a goopy glob, and you can "spool it out" on the tip of the plastic stick. Then describe the sample:

I see . . .

I smell . . .

I feel . . .

I hear . . .

While you wait, discuss the following statement with your partner(s) and figure out whether it is true or false:

DNA is chemically the same, whether it comes from a fish, a flower, a bacterium, a human, or a hero. If you were to isolate DNA from any of these life forms (like you're doing for your strawberry today), it would all look the same in your test tube. True or false? Discuss.

8. Transfer the spooled DNA into an Eppendorff tube with some isopropanol (eyeball the amount until the tube is about one-third full). You can take the DNA home with you, but keep it tightly closed to avoid evaporation of the alcohol. The DNA is stable in this form for many years.

SUPERCOOKBOOK

	YOUR TRAIT	YOUR HERO'S TRAIT	IS THE TRAIT INHERITED (IN THE DNA)?
Eye color			
Hair color			
Height			
Wears glasses?			
Favorite color			
Talent (for example, singing, playing an instrument, sports, math, magic tricks)			
Favorite "street" clothes			
Hero suit	**Not applicable**		
Ways similar to parents			
Ways different from parents			

What is your hero's superpower?

Do your hero's parents also have this superpower?

Do your hero's grandparents also have this superpower? Do other family members have this superpower? If yes, who?

How did your hero discover his or her superpower?

Was your hero born with this power? Or did something happen later in life that changed the hero and conveyed the power?

What is the planet of origin of your hero? If this planet isn't Earth, what are some of the characteristics of other "people" from this planet?

What is your hero's greatest desire?

What is your hero's greatest fear?

PAPER AIRPLANE TECH SPECS

Record your paper airplane specs here.

Plane 1 Specifications

Complete this section after folding your first plane.

Plane length (tip to tail): _____ centimeters

Plane width (wing to wing): ____ centimeters

Schematic diagram:

I made the following design decisions to help the plane fly:

PAPER AIRPLANE TECH SPECS (continued)

Plane 1 Flight Data (Trial 1)

- Flight distance: ___________ centimeters
- Duration (time) of flight: ___________ seconds
- Speed (Speed = Distance ÷ Time): ___________ centimeters per second

Plane 1 Flight Data (Trial 2)

- Flight distance: ___________ centimeters
- Duration of flight: ___________ seconds
- Speed: ___________ centimeters per second

Plane 1 Flight Data (Trial 3)

- Flight distance: ___________ centimeters
- Duration of flight: ___________ seconds
- Speed: ___________ centimeters per second

Plane 1 Flight Data (Trial 4)

- Flight distance: ___________ centimeters
- Duration of flight: ___________ seconds
- Speed: ___________ centimeters per second

Plane 1 Average Flight Data of Trials

- Average flight distance: ___________ centimeters
- Average duration of flight: ___________ seconds
- Average speed: ___________ centimeters per second

PAPER AIRPLANE TECH SPECS (continued)

Engineering Reflections

1. I liked that . . .____

____

2. I was surprised that . . .____

____

3. One change I would like to make to my plane is . . .________________________________

____

4. I think this change will . . .____

____

____

Plane 2 Specifications

Complete this section after folding your second plane.

Plane length (tip to tail): _____ centimeters

Plane width (wing to wing): _____ centimeters

Schematic diagram:

I made the following design revisions to help the plane fly:

PAPER AIRPLANE TECH SPECS (continued)

Plane 2 Flight Data (Trial 1)

- Flight distance: ___________ centimeters
- Duration (time) of flight: ___________ seconds
- Speed (Speed = Distance ÷ Time): ___________ centimeters per second

Plane 2 Flight Data (Trial 2)

- Flight distance: ___________ centimeters
- Duration of flight: ___________ seconds
- Speed: ___________ centimeters per second

Plane 2 Flight Data (Trial 3)

- Flight distance: ___________ centimeters
- Duration of flight: ___________ seconds
- Speed: ___________ centimeters per second

Plane 2 Flight Data (Trial 4)

- Flight distance: ___________ centimeters
- Duration of flight: ___________ seconds
- Speed: ___________ centimeters per second

Plane 2 Average Flight Data of Trials

- Average flight distance: ___________ centimeters
- Average duration of flight: ___________ seconds
- Average speed: ___________ centimeters per second

PAPER AIRPLANE TECH SPECS (continued)

Engineering Reflections

1. I noticed that my second plane flew . . .____

____

____

2. I was surprised that the change I made . . .______________________________________

____

____

3. If I could change one more thing, I would . . .____________________________________

____

____

4. I think this change will . . .____

____

____

Any other notes or comments you might have:

HOW TO BE A SUPERENGINEER!!!!

Engineering is like a superpower. It's what lets you design the tallest buildings—and the vehicles that can leap over them in a single bound. Fortunately, it's a superpower you don't have to be born with. You can learn how to do it! Here are the steps every good engineer follows:*

* These steps are drawn from the following sources: "Engineering Design Process," *http://www.teachengineering.org/engrdesignprocess.php*; "Engineering," *http://www.engr.ncsu.edu/theengineeringplace/educators/*.

(continued)

Step 1: Understand

Engineers can't solve a problem for a client if they do not understand the problem that the client needs solved. Engineers take considerable time at the start of a job to understand the project. Imagine that you have been asked to build a bridge. It might be great fun to go off and start designing the bridge, but without some really critical pieces of information, you are unlikely to solve the right problem (though you may design a lovely bridge), and you will be unaware of any design constraints. In this case, important questions to ask the client might include: What is the bridge over? How long does the bridge need to be (span length)? Does anything need to be able to pass under the bridge (for example, tall ships)? Who will use the bridge? For what? What are the weather conditions the bridge will experience? Your plans for a pedestrian bridge over a creek on a hiking trail would be very different from those for a bridge over a river that carries lots of traffic on a busy interstate highway.

Step 2: Brainstorm

With this information, engineers (individuals or teams) will brainstorm ideas for how to solve the problem. The goal of a brainstorm is to come up with lots of ideas—a wide variety of possible solutions. Expert brainstormers will tell you that you shouldn't judge ideas at this point. You want to have a lot of possibilities.

Step 3: Select an Idea

After brainstorming, go back over your problem and constraints again, and with these criteria in mind, review your ideas; compare them to one another (perhaps mixing and matching different components of different ideas) to see which ideas are likely to provide the best solution; and add information (about materials, costs, and so on). Finally, select the design you want to take to the next phase.

Step 4: Plan

Draw a diagram of your design. What materials will you use? What do you know about how those materials work (or when they fail)? In drawing your plan, look to see if you notice anything that could cause problems when you build and test your design. If so, how will you correct it?

Step 5: Create and Test

Now it is time to build a prototype—a first-draft model—of your plan, and test it against your design constraints. Does it meet your (and your client's) goals? Is there anything that can be improved?

Step 6: Improve

Think about what went well, and what could be improved in your design based on what you learned in your tests. Using these new ideas, refine your ideas. This process could include drawing new designs, rebuilding, and retesting. Your goal should be to make the best product you can—something that you can be proud of that solves the stated problem and meets the client's needs.

SECRET LAIR BLUEPRINT

Engineers use science and math to design and build solutions to solve important problems. And a hero without a lair is definitely a very big problem. Fortunately, you have the engineering skills to save the day.

The first step to building a good lair is to understand what your hero client needs.

Client name: ____

Lair location (circle one in each row): Urban (in a city) Rural (in the country)

Aboveground Underground

If the lair is in a city, what type of building is it likely to be in or under?

____

____

If the lair is in the country, will the lair be a stand-alone structure or part of another building or landform?

____

____

Types of activities the lair will be used for (circle any that apply):

Hiding

Storing vehicles

Inventing tools and gadgets

Changing from everyday identity into hero

Tracking nemeses

Other: ____

How many rooms will the lair need?___________

What will keep the secret lair secret (how will it be camouflaged)?

____

____

Engineers draw plans for a given solution (in this case a secret lair), then they build a prototype or model to get a better idea of whether their plan meets the needs of their client. They then revise their model based on both their own ideas and feedback from others to make it better.

Draw a schematic (diagram) of the lair you plan to build. If you need more drawing space, use the back of this sheet.

SAVING THE EGG

Egg Protection Device Design Plan

Materials used:

Design plan:

SAVING THE EGG (continued)

I chose the materials for my protection device because . . .

____

____

My device is designed to protect the egg by . . .

____

____

Drop Data

Height of egg drop: _________ feet

Name of drop engineer (person who drops egg): ______________________________

Status of egg after drop (circle one):
Intact   Small cracks   Large cracks   Oozing egg   Completely smashed

Describe the appearance of your device and egg after the drop (in words or in pictures):

Engineering Reflections

1. I was surprised that . . . ____

____

____

2. One change I would like to make to my device is . . . ________________________

____

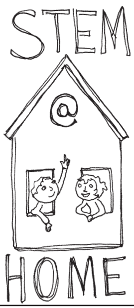
____

3. I think that this change will . . . ______________________________________

____

____

STEM@HOME: SESSION 1 (TRACING TRAITS)



All humans (including heroes) are unique, but they share many **traits** with their parents and siblings. Traits are observable characteristics that are passed down from parents to a child. What traits do you share with your relatives?

Trait Inventory

Interview your relatives to track who inherited which traits. If you want to interview even more relatives—great!—track their traits on a separate piece of paper.*

	Me		**Relative Name** ______________		**Relative Name** ______________	
Can roll tongue?	Yes	No	Yes	No	Yes	No
Has dimples?	Yes	No	Yes	No	Yes	No
Is right-handed?	Yes	No	Yes	No	Yes	No
Has freckles?	Yes	No	Yes	No	Yes	No
Has naturally curly hair?	Yes	No	Yes	No	Yes	No
Has allergies?	Yes	No	Yes	No	Yes	No
Can see the colors red and green (is not color blind)?	Yes	No	Yes	No	Yes	No

Traits are passed down from parent to child in **DNA** (deoxyribonucleic acid). DNA is like a cookbook—every cell of a human includes all the recipes needed to make a human. Small differences in the DNA of individuals (for example, between you and a classmate) make us unique and account for our individual traits (hair color, eye color, whether or not we can roll our tongue, and so on).

Fun DNA Facts**

- DNA is chemically the same, whether it comes from a fish, a flower, a bacterium, a human, or a hero. If you were to isolate DNA from any of these life forms (like you did for your strawberry today), it would all look the same in your test tube—just like if you look at two books from very far away, you cannot tell that there are any differences in the books. You would have to get close enough to read the books to see the differences between them. Similarly, you would have to get a close-up of the DNA to be able to "read" the differences between fish and flower DNA.

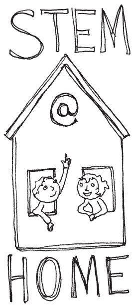
*Adapted from *http://teach.genetics.utah.edu/content/begin/traits/traitsinventory.pdf*

**Facts are adapted from "Genes in Common," *http://genetics.thetech.org/online-exhibits/genes-common*; "Amazing DNA Facts," *http://sciencecentres.org.uk/projects/handsondna/4.8%20-%20Amazing%20facts%20and%20quiz%20 questions.pdf*; EmilyC, "Genetic Similarities of Mice and Men," *http://blog.23andme.com/23andme-and-you /genetics-101/genetic-similarities-of-mice-and-men/*.

STEM@HOME: SESSION 1 (continued)

- Humans and chimpanzees share 98 percent of their DNA (and humans share 7 percent of their DNA with bacteria!).
- Each human cell contains about 3.5 billion base pairs of DNA.
- If you were to unwind the DNA in just one of your cells, it would be approximately six feet long.
- If you unraveled all of your DNA from all of your cells and laid out the DNA end to end, the strand would stretch from Earth to the sun hundreds of times (the sun is approximately ninety-eight million miles away from Earth).
- You could fit twenty-five thousand strands of DNA side by side in the width of a single adult hair.

STEM@HOME: SESSION 2



Paper airplanes may seem simple, but there can be some pretty advanced engineering involved.

Challenge Yourself

There are lots of different ways that you can launch a paper airplane. How does changing the way you launch a plane change its behavior?

Some variables to try:

- Light throw versus hard throw.
- Nose pointed up on release versus nose parallel to the ground.
- Holding the plane closer to the nose versus holding it closer to the tail.
- Pointing the plane toward the wind (fan or air conditioner) versus pointing it away from the wind (fan or air conditioner). Note that this mimics planes having a head- or tailwind.

Think of some more variables to test!

Fun Flight Facts*

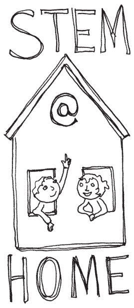
- Aerospace engineers, aircraft manufacturers, and scientists all use paper aircraft to test aircraft behavior—just like you did.
- Ken Blackburn holds the Guinness world record for longest (duration) paper aircraft flight—27.6 seconds!
- Tony Fletch holds the world record for longest distance flown by a paper aircraft—193 feet (longer than the distance of the Wright brothers' first flight)!
- The largest paper airplane ever built had a wingspan of 40 feet. It flew 114 feet before crashing and smashing its nose.

Learn More

- Ken Blackburn explains how paper airplanes fly (*www.paperplane.org/paero.htm*) and has patterns for making additional planes (*www.paperplane.org/patterns.htm*).
- There are lots of other great plane patterns available at *www.augq07.dsl.pipex.com/paamain/links.html*.

* Facts are adapted from "Paper Aircraft Association 'Amazing Facts,'" *http://www.augq07.dsl.pipex.com/paamain/facts.html*.

STEM@HOME: SESSION 3



Today you solved an important problem for your hero by designing and building his or her secret lair. Can you keep thinking like an engineer?

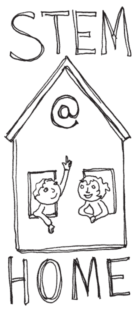
Talk to your family members. What are some important problems that you can help them solve? Are there things that frustrate them? Is there something they wish were different?

For example:

- Do you ever not know if the dishes in the dishwasher are dirty or clean?
- Do you or your parents have a hard time keeping track of important notices from school?
- Do you wish you had a way to know if your younger sibling went into your room while you were at school?
- At dinner, have you and your family members ever all wanted different things to eat?
- Have you ever been really, really hot on a summer's day and wanted to invent a way to cool off?
- Have you ever misplaced an important item, like the keys to your house, and needed a way to keep track of it?

Brainstorm a list of possible problems you could engineer a solution to, then get down to work and design a solution. Test your design, and after getting feedback from your family, refine or revise it.

STEM@HOME: SESSION 4



Humans have invented lots of devices that save the day—and save lives. A few examples:

- Seat belts save nearly eighteen thousand lives each year.*
- Vaccines save more than three million lives worldwide each year.**
- Installation of modern sewer systems eliminated deadly cholera epidemics from the world's major cities beginning in the late 1800s.†
- The discovery of penicillin, the first antibiotic, has saved more than eighty-two million lives.‡
- Invention of the incubator for premature babies has increased survival rates from only 15 percent to 85 percent.§

You don't have to save a life to save the day, however. Ask your parents, grandparents, an aunt, an uncle, or an adult friend about something they did that made them feel super. This could be an accomplishment they were proud of or something they did to help someone else.

Are there ways that you can imagine saving the day? What are some choices you can make in your life that will help you save the day sometime in the future?

* "Seat Belts: Your Single Most Effective Safety Step," *http://www.nsc.org/safety_road/DriverSafety/Pages/SeatBelts.aspx*.

** "F.A.Q," *http://www.sanofipasteur.com/en/faq.aspx*.

† "Cholera Prevention," *http://wonder.cdc.gov/wonder/prevguid/p0000002/p0000002.asp.*

‡ "Lives Saved," *http://www.scienceheroes.com/*.

§ Stina Caxe, "The Baby Sideshow: A History of the Incubator," *http://stinacaxe.hubpages.com/hub/caxe21incubator*.