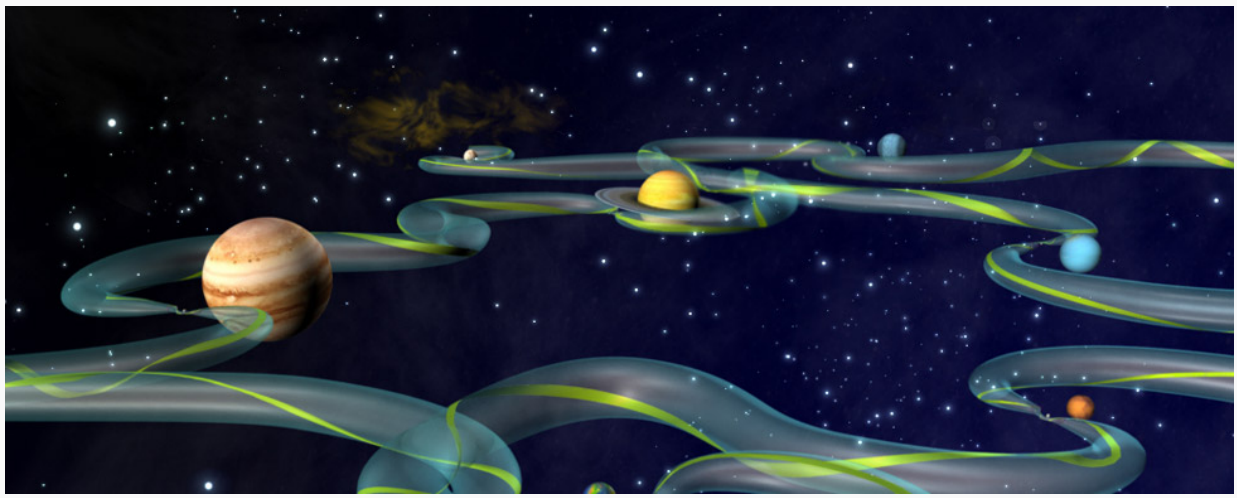
When one question leads to another

By Susan Gaidos / April 7, 2013

Coming up with a cool science fair project takes effort. You have to work hard at finding a topic you like and a question you want to explore.

Science fair projects also take time. Many kids easily can spend weeks following an organized set of steps in answering a question — an approach called the scientific method. Other kids can spend even longer perfecting their projects. They may pursue a project for *years*.



Student Erika DeBenedictis spent years studying the so-called interplanetary superhighway. Her persistence paid off: In 2010, Erika placed first in the Intel Science Talent Search for her research. Credit: Martin Lo, Caltech

Sure, these are often the whiz kids who dazzle judges and win big awards. But it could be you as well. And the benefits from sticking with some research theme for a year or more go well beyond gaining the knowledge to potentially wow teachers and science fair judges. Teens who carry out long-term research projects also gain a life lesson in curiosity, discipline and resilience. These are traits shared by most successful scientists.

Sound scary? It may be easier than you think.

The students (and former students) profiled here have all worked on long-term projects. The tips they offer suggest how you can get started — and why to keep going.

What do you want to know?

Getting started should be the easy part — just follow your curiosity. It can take you all kinds of places. Elizabeth Baker, of Tucson, Ariz., was always curious about insects and other animals. Even in grade school, Liz was on the lookout for different critters. She would tramp through habitats moist and dry, just to explore what was there.

Sometimes, she headed to the local zoo, but not just to observe the animals. She also liked to watch how people responded to the animals. Many would clap, laugh or engage in other antics, just to get some creature's attention.

That gave Liz an idea for her sixth-grade science fair project. She would test which was bigger: the effect

people have on animals' behavior, or how much animals affect the actions of people? For weeks, Liz spent every weekend at the zoo. She watched how apes, lions and giraffes acted when people were around. She also noted how zoo visitors related to the animals. Her early polling data showed the animals were winning: They had a bigger effect on people than the other way around.

In eighth grade, Liz expanded on this theme. But this time, she focused on gibbons, a type of ape. Liz wanted to see how each gibbon interacted both with zoo visitors and other apes of its species. During each visit, Liz wore the same outfit. Soon, the gibbons recognized the teen and relaxed in her presence. She also visited at different times, on the lookout for behaviors that may vary based on the time of day.

Watching patiently, Liz came to appreciate the complex ways apes and humans interact. In fact, throughout high school, Liz developed science projects focusing on animals or people. Each year, her projects won awards at the Intel International Science and Engineering Fair (Intel ISEF). It's the world's largest high school science competition.

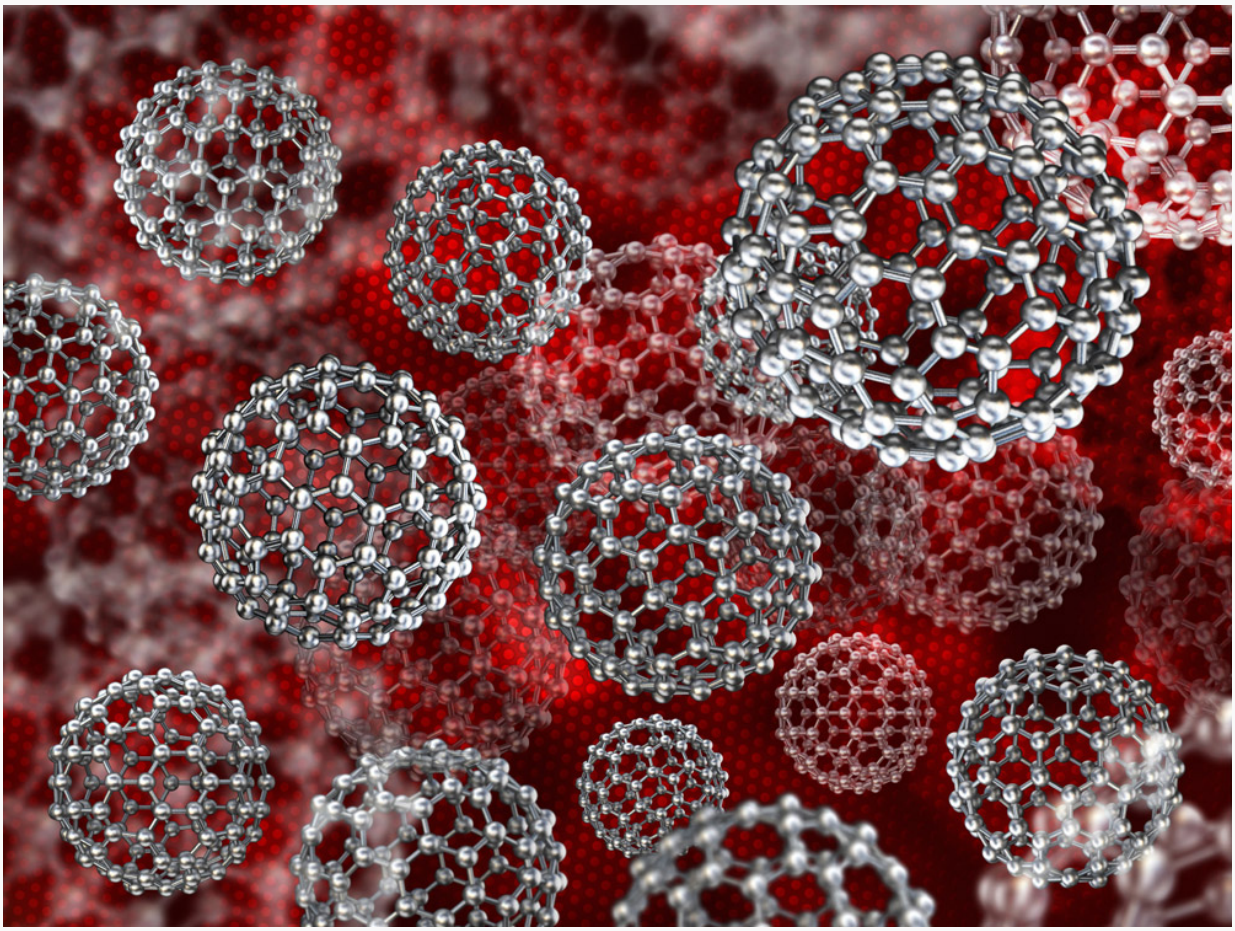
Later, as a college student, Liz continued studying animals and people. And just last year, Liz — now 24 years old — got a chance to join the scientific team working with one of the world's most famous apes, Koko. This gorilla communicates with people using American Sign Language.

Today, Liz works for the Girl Scouts of Southern Arizona. Her job is to encourage young women to consider exciting careers in science, technology, engineering and math (STEM).

Take the next step

Like so many other students, Anirudh Jain, 15, of Portland, Ore., started his science fair project with a simple question. How could he find a way to provide clean drinking water to families without a source of safe water? Three years later, he is still answering that original question — along with a few more that have cropped up along the way.

This project started when Anirudh was in seventh grade. That's when he made a water filter filled with silver



Anirudh Jain patiently spent three years studying silver nanoparticles. In answering questions, the teen often turned up more questions than answers. But he never quit. Credit: iStockphoto

nanoparticles. (Nano is a prefix meaning billionth. So nanoparticles tend to be just a few nanometers — *billionths* of a meter — across.) They are way too small to be seen with even a traditional microscope. But they can have a huge impact because nanoparticles of silver are powerful germ fighters. Nanosilver, as it's called, can kill almost any bacteria or virus.

Although Anirudh's filter could slay germs in water, it worked only a few times. Then he had to throw it away. That created a new problem, because a trashed filter could leak silver nanoparticles. And once in the environment, those nanoparticles might harm fish and other wildlife. This nanosilver waste might also taint the soil used to grow food.

Rather than ignore this, Anirudh designed a follow-up project to tackle this problem. First, the eighth-grader found a way to detect nanoparticles of silver. This allowed him to see if any had spread into water or soil. His persistence paid off. Anirudh won second-place in the technology division at the 2012 Broadcom MASTERS. This is a national STEM competition for sixth-, seventh- and eighth-graders.

Now in high school, Anirudh is at work on yet another related project. The teen is probing ways to limit any harm silver nanoparticles might pose if they get loose in the environment. This is the "logical next step," he says. It also offers an example of how real progress can take time.

Digging deeper

Some problems are a real tough nut to crack. They can take a whole mix of approaches to solve.

When Meredith MacGregor, of Boulder, Colo., was in 11th grade, she ran into such a problem. Whenever she opened a can of mixed nuts, Meredith noticed that the largest nuts always ended up on top. There's even a

name for this — the Brazil-nut effect. The idea is this: If you shake a container filled with different-sized nuts (or any granular particles), the nuts will sort themselves according to size. Larger nuts (including, yes, Brazil nuts) wind up on top. Smaller ones settle to the bottom.

Meredith MacGregor, at right, celebrates alongside two other award-winning young scientists at the 2006 Intel International Science and Engineering Fair. Meredith won a $50,000 scholarship for her research. Credit: Intel Corp

Meredith designed a project to see how the nuts separated. The results were always the same: large on top, small on bottom. But she wanted to know why. Over the next year, she read scientific papers and studied the problem some more. Finally, in her senior year, her discipline paid off. Meredith found a way to study the process.

First, she needed a way to control the shaking. She went to an electronics store and bought a type of speaker known as a subwoofer. It produces low-frequency sound — the type you can feel as the speaker vibrates. She then placed a brace over the top of the speaker that would hold a container of nuts.

The speaker's deep bass sounds shook the nuts. To make sure they did so in a precise way, Meredith wrote a computer program to control the pitch and intensity of the sound coming from the speaker. The computer also controlled the sound's duration. Her innovative approach allowed her to see how fast large particles rose to the top under various conditions. It also vaulted her to the top. She became a winner in the 2007 Intel Science Talent Search (Intel STS). Along the way, she decided to make a career of science. Now 24, she studies astrophysics at Harvard.

Honing your skills

Erika DeBenedictis, of Albuquerque, N.M., is not a rocket scientist. At least not yet. But she has used her well-developed computer skills to solve a problem that she then shared with real rocket scientists. It came from applying herself, year after year, to solving a series of related problems.

As a child, Erika learned how to write computer programs. By middle school she had learned ways to model — or represent using a computer program — how objects move and change over time. In seventh grade, she even wrote a program to show how frozen water molecules join together to form six-sided snowflakes.

From then on, Erika tackled a different project each year. Her goal was always the same: Find a way to use computers to solve some new challenge. She often looked through her father's science journals for ideas. The colorful images inspired her.

One particular picture caught her eye. It showed the orbits, or paths, followed by the planets circling the sun. It also showed smaller bodies, such as moons, asteroids and comets, moving through space. All these objects tugged on one another with their gravity.

However, at certain points, one object's gravity would balance another's. These are called Lagrange points. Intrigued, Erika set out in 10th grade to create a program to chart how spacecraft would pass through those points. Doing so traces a path through the gravity fields that spacecraft could use to travel quickly and efficiently.

Erika DeBenedictis visits the particle accelerator at the European Laboratory for Particle Physics, outside Geneva, Switzerland. Credit: Erika DeBenedictis

Erika spent two years working on the project. It proved time well spent: In 2010, she won first place in the Intel STS for her findings. A side benefit: She was invited to the White House to explain her research to President Obama and others.

Erika's work also gained the attention of the National Aeronautics and Space Administration. While still in high school, Erika received an invitation from NASA to share her program with a group of engineers at its Jet Propulsion Laboratory. Now 20, Erika is a student at the nearby California Institute of Technology. She hopes to someday help plan space missions.

Getting help from experts

Never be afraid to ask for help. Even scientists rely on other experts. That's a lesson Kartik Sameer Madiraju, of Montreal, Canada, learned firsthand when he set out to study renewable energy.

Kartik already knew a lot about the topic. In seventh grade, he studied wind turbines that harness the movement of the wind to generate electricity. In eighth grade, he did a project on nuclear fusion. (In fusion, atoms are combined, or fused, to form a larger atom. One day, the process could produce large amounts of energy.)

Watch Erika DeBenedictis explain in this 2010 video her research on how to travel throughout our solar system

following the interplanetary superhighway.

By ninth grade, Kartik was fascinated with how bacteria can produce electricity while feasting on wastes. Devices that do this are called microbial fuel cells. As bacteria feast, they convert the chemical energy in wastes into carbon dioxide, protons and electrons. Those electrons, in turn, produce an electrical current.

The concept suggested an idea to the teen for a science project about magnetic bacteria. As these germs eat iron, they create tiny magnets inside themselves. Kartik was curious whether they could be used in fuel cells. But he needed a bit of guidance before he could test that out.

So the teen wrote a letter outlining his idea and explained why he thought it would work. He then sent the letter to several scientists at McGill University, near his home.

John Sheppard, one of those scientists, was impressed with Kartik's knowledge of science. "He had done a lot of background reading and was well informed on the topic," says Sheppard, who is now a professor at the University of North Carolina. The teen also impressed this scientist that he could make his idea work.

Sheppard invited Kartik to his lab and showed him how to grow bacteria. Kartik started out slow. He spent the first year learning the basics, such as lab safety and how to write lab reports. Over time, Kartik developed a keen sense of detail. He also learned to do everything the same way each time so that his bacteria would grow reliably. By the time Kartik was in 10th grade, he was designing his own experiments.

By that point, Kartik says, "I could be more daring, since the groundwork was familiar to me."

For three years, Kartik worked on his project. When his original idea didn't work as planned, Kartik changed his approach. He kept at it. And that dedication paid off: In 2005, 2006 *and* 2007, he placed first in the environmental sciences division at the Intel ISEF competition.

Today, Kartik is 23 years old and done with college — but not with fuel cells. He still studies the technology. In the future, however, he plans to focus on environmental law. He credits what he learned in the laboratory — perseverance, patience and diligence — in helping him reach his goals.

"These qualities are helpful not only in science," Kartik says, "but in all types of work and life situations."

Power Words

air pressure The force exerted by the weight of air molecules.

American Sign Language A way of communicating using hand shapes and body movements.

amplitude The height of a sound wave.

asteroid A rocky object in orbit around the sun.

bacterium (plural **bacteria**) Tiny organism made up of only one cell.

comet A frozen mass of dust and gas that orbits the sun.

frequency The number of times something is repeated in a certain period of time.

fuel cell A device that converts chemical energy into electrical energy.

gibbon A small, slender ape with long arms.

granular Composed of granules or grains.

gravity A force that physically attracts any objects with mass.

hypothesis A testable idea.

nanoparticle A small particle measured in the billionths of a meter.

nuclear fusion The process of forcing together the nuclei of atoms.

resilience The ability to recover quickly from a setback.

subwoofer A type of a loudspeaker used to produce low-pitched sounds.

wind turbine A wind-powered device — similar to the type used to mill grain (windmills) long ago — used to generate electricity.

Word Find (click here to print puzzle)

WHEN ONE QUESTION LEADS TO ANOTHER

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APPROACH
ASTROPHYSICS
BEHAVIOR
BRAZIL NUT
COMMUNICATE
CRITTER
CURIOSITY
DAZZLE
DETAIL
DILIGENCE
DISCIPLINE
ENVIRONMENT
FUEL CELL
FUSION
GIBBON
GIRAFFE
HABITAT
INTENSITY
MAGNETIC
MISSION
MOLECULE
NANOSILVER
OBAMA
PERSEVERANCE
QUESTION
RESILIENCE
SIGN LANGUAGE
SNOWFLAKE
SPACECRAFT
SUBWOOFER
TECHNOLOGY
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