Q&A with Two West Virginia College Students

Brought to you by WV Higher Education Policy Commission, the National Nanotechnology Infrastructure Network and Cornell NanoScale Science & Technology Facility

WV ISSUE • 2013

NANOOZE

THE WEST VIRGINIA ISSUE

LAB ON A CHIP

CAREERS IN NANOTECHNOLOGY

NANO PAST AND PRESENT

NANO AROUND THE STATE

All about the things too small to see

What is a Nanooze? (Sounds like nah-news.*) Nanooze is not a thing, Nanooze is a place to hear about the latest exciting stuff in science and technology. What kind of stuff? Mostly discoveries about the part of our world that is too small to see and making tiny things using nanotechnology. Things like computer chips, the latest trends in fashion, and even important stuff like bicycles and tennis rackets.*

Nanooze was created for kids, so inside you'll find interesting articles about what nanotechnology is and what it might mean for your future. Nanooze is on the Web at ***www.nanooze.org****, or just Google "Nanooze"—you'll find interviews with real scientists, the latest in science news, games and more!*

How can I get Nanooze in my classroom?

Regular editions of Nanooze are free for classroom teachers. Please visit ***www.nanooze.org*** *for more information or email a request for copies to* ***info@nanooze.org****.*

How about this West Virginia issue?

This edition of Nanooze was especially created for West Virginia middle school students.

Additional copies of this edition may be available by calling 304-558-4128, ext 7. An electronic version can be found at ***www.wvresearch.org/nanooze****.*

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Welcome to this very special edition of Nanooze. It is all about nanotechnology in the state of West Virginia, what is cool in the science and who is cool in various places around the Mountain State.

West Virginia has a lot going on in nano, from sensors to labs on chips, at some great colleges and universities, and some great companies as well. Tiny and exciting and it all points to the future!

On the Cover

This eighth-grade student is examining a microfluidic chip made at West Virginia University. Researchers at WVU's NanoSAFE laboratories use chips like this to analyze DNA and study biomarkers, substances injected into a living thing to provide information about cells inside the body. Perhaps this student, and many others in middle school today, will be among the growing number of nanotechnologists working in West Virginia in the future.

Cover credit: Photography by John Sibold, Microfluidic Chip for DNA and Biomarker Analysis, from NanoSAFE Interdisciplinary Research Team 1, West Virginia University.

NANO KNOW-HOW

Learning about nano stuff is fun but it can be complex, so it helps to keep these four important facts in mind:

1. All things are made of atoms.

It's true! Most stuff, like you, your dog, your toothbrush, your computer, is made entirely of atoms. Things like light, sound and electricity aren't made of atoms, but the sun, the earth and the moon are all made of atoms. That's a lot of atoms! And they're incredibly small. In fact, you could lay one million atoms across the head of a pin.

2. At the nanometer scale, atoms are in constant motion.

Even when water is frozen into ice, the water molecules are still moving. So how come we can't see them move? It's hard to imagine that each atom vibrates, but they are so tiny that it's impossible to see them move with our eyes.

3. Molecules have size and shape.

Atoms bond together to form molecules that have different sizes and shapes. For instance, water is a small molecule made up of two hydrogen atoms and one oxygen atom, so it is called H_2O. All water molecules have the same shape because the bonds between the hydrogen atoms and the oxygen atom are more or less the same angle.

Single molecules can be made up of thousands and thousands of atoms. Insulin is a molecule in our bodies that helps to control the amount of sugar in our blood. It is made up of more than one thousand atoms! Scientists can map out the shapes of different molecules and can even build most types of molecules in the lab.

4. Molecules in their nanometer-scale environment have unexpected properties.

The rules at the nanometer scale are different than what we usually encounter in our human-sized environment. For instance, gravity doesn't count because other forces are more powerful at the molecular level. Static and surface tension become really important. What is cool about nanotechnology is that we can make things that don't behave like we expect.

Things are really different down there!!

Q&A

with Two WV Engineering Students

Sara Swanson

Tell us a little bit about your background and what you are currently doing. I am a senior at West Virginia University pursuing an honors degree in chemical engineering with a minor in nanotechnology. I was born and raised in West Virginia; my hometown is Bridgeport. I am the first of my family to go to college.

Since there are so many possibilities for the use of nanotechnology in the medical field, it is incredibly important to understand how nanotechnology can affect our bodies. I have performed research on the toxic effects of nanotechnology with a government organization called the National Institute for Occupational Safety and Health. They make sure that any substance we could come into contact with while working is safe. I studied carbon nanotubes and found that they can cause mutations within cells in our body. I hope that my research will help further our knowledge of how nanotechnology interacts with cells in our bodies.

What is your recollection about the first time you did an experiment? In elementary school we did a lot of experiments with plants. I remember an experiment using food coloring and celery. We were able to see how the celery absorbed the colored water because we could see the color throughout the stalk. One of the first "real" experiments I did was in my high school chemistry course; we could relight a blown out match by touching it to pure oxygen!

Who helped shape your decision to go to college and study science? My parents really shaped my decision to go to college. I am a first-generation college student, and my parents really pushed for me to attend school in order to have a successful life.

In high school I recognized my passion for chemistry and my chemistry teacher inspired me to pursue chemical engineering. I participated in "ChemOlympics," a chemistry team competition between high schools, took the national chemistry exam and won for my region, and taught third-graders about chemistry with experiments.

What are your career goals? Currently, I have accepted a job for a natural gas company in Oklahoma City, OK. I would like to use my nanotechnology knowledge in order to improve the energy sector. I would also like to go back to school one day after I have industry experience so that I can teach.

Who is the coolest scientist? The coolest scientist to me is probably Bill Nye the Science Guy. I grew up with him on television, and he really made science interesting for me. Now that I have grown up, I would also probably add Carl Sagan, Neil deGrasse Tyson, and Albert Einstein to that list. I even got to see equations written by Einstein on the original blackboard from 1931 at the Museum of the History of Science in Oxford, England.

What is the smallest thing that you can see with just your eyes? Not much without my contacts! If I have the aid of lenses, the smallest thing I can see is a grain of sand or salt.

What is the smallest thing that you can think of? The smallest thing I can think of is a quark, which is a subatomic particle that makes up the proton that makes up an atom.

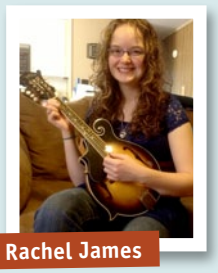
What do you like to do for fun? I love scuba diving, ice skating, tae kwon do, listening to music, and reading. I also like to travel, especially abroad. I have been pretty lucky because I was able to study abroad in England and Italy, and visit several other countries while in Europe.

One of my favorite things to do, though, is to volunteer with the Society of Women Engineers and teach young people about science-related fields, including nanotechnology.

Sara visits London!

Volunteering at the Children's Discovery Museum of West Virginia

Photos courtesy of Sara Swanson



Rachel James

What is your background and what are you up to these days? I grew up on a farm in Lewis County, WV, with my mother and five younger brothers. I'm currently a junior civil engineering major at West Virginia University.

Other than science what do you like to do? I love to spend time with my friends, my family, and my two cats—Minnie Mouse and Lilly. I also enjoy watching Disney movies; *Beauty and the Beast* is my favorite movie ever! Lastly, I'm attempting to learn to play the mandolin, so some of my free time is dedicated to this endeavor.

Who was your inspiration to pursue a career in engineering? My grandparents inspired me to attend college. When I was four, my grandparents told me that the only way I could improve my life was through higher education. Since then, I've always tried my best in school.

However, YOU, Nanooze readers, are my inspiration too! I decided to pursue a career in engineering because I wanted to prove to students that anyone can be an engineer if they try hard enough, including girls and first-generation college students! I hope I can inspire you too. There are so many awesome careers out there in science, technology, engineering and math. I do a lot of outreach through High School Visitation Day, 8th Grade Day, Girl Scout Day and Boy Scout Day.

What are your career goals? After I graduate with my bachelor's degree, I want to go to graduate school. Eventually, I want to get my doctorate and become a professor of civil engineering at a university. I want to spend the rest of my life teaching students and conducting research.

Why do you think engineering is cool? I like engineering because it gives me a chance to be creative through solving problems. Society depends on engineering; I can use math and science to make people's lives better.

Charles Darwin vs. Albert Einstein, who wins? As a civil engineer, most of my classes are based off of Newton's three laws of motion; therefore, my favorite is Sir Isaac Newton. However, because he is not one of my options, I'll side with Albert Einstein, as some of his work is based off Newton's!

What is the smallest thing that you can see with just your eyes? A grain of sugar.

What is the smallest thing that you can think of? An electron!

Rachel and her five younger brothers

Photos courtesy of Rachel James

LAB ON A CHIP

Lab on a chip? A potato chip? No, not that kind of chip—on a chip kind of like a computer chip. One tiny device that can function on its own outside of a laboratory.

Why is that important? Most instruments for detecting chemicals and other things can be quite large and are usually found in a laboratory. That works well sometimes, but other times it is important to move the laboratory to the thing you are trying to sample or test. To do that you need to have something that is small, lightweight (don't want to be hauling around some big piece of equipment) and also gives you an answer…fast.

COMPUTER CHIPS AND ELECTRONS

Computer chips do one specific thing: they move around electrons and have tiny switches called *transistors*. We can now make transistors *insanely* small and we can make parts of a computer chip that are less than 50 nanometers across. How small is that? You could take about 2,000 of these parts and lay them side by side and it wouldn't even be the width of a strand of hair. To think about it another way, those 50 nanometers are hardly even 100 atoms. Some layers in a computer chip are not much thicker than a few atoms.

BUILDING A LAB ON A CHIP

Making a lab on a chip is a lot more complicated than making a computer chip. What might we need to make a lab on chip? Well, we would need some electronic parts, but we also need ways of grabbing the tiny thing we want to detect, moving liquids around, and also shining light on a sample material or substance to help figure out what is in it. All of that is far more complicated than your standard computer chip design.

Different kinds of scientists and engineers are working together to figure out how to make these different parts. And then once they have all the individual parts figured out they can get together and figure out how to make it all fit into a small device, about the size of a cell phone, that can be carried around. That's what we call a *lab on a chip*.

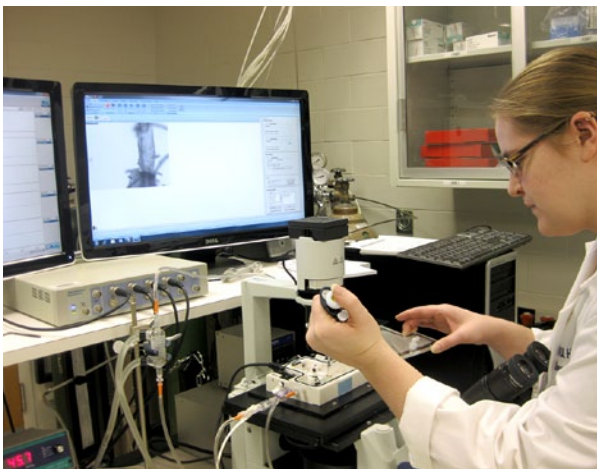
A microfluidic device
This *lab on a chip* was designed to provide the right kind of environment for cells to grow. Scientists can use this device to study living cells that make up our blood vessels and are able to test new treatments for disease.

Teeny tiny tubes
The plumbing channels in a microfluidic device are designed to mix and separate tiny amounts of fluids. The circles are places where the sample and other agents are added. The tiny channels are hardly wider than a human hair (that's about 100 micrometers across).

Microfluidic device design

John Sibold

So what kind of labs on chips are researchers creating in West Virginia?



A graduate student prepares a sample for conducting microfluidics experiments.

Lab: West Virginia University, Tweezers: Public domain / Wikipedia

Electrophoresis:

Pushing things with electrons

Moving things at the nanometer scale is not always easy. Moving electrons is easy because many materials can conduct them easily, but moving other things like tiny molecules in water is not so easy. Usually we think about using pumps and pipes to move water, but those are hard to make small and use a lot of energy. Nature has an efficient way of moving water. Plants, even gigantic redwoods, move water and nutrients up to great heights. Sometimes you can even move stuff through water without moving the water itself.

Scientists at Marshall University and West Virginia University are using *electrophoresis* to not only move but also to separate different things in a sample. Electrophoresis is not new and originates with another process called *electrolysis,* which is one way that metals are coated on things like car bumpers (back before they were made of plastic!).

In electrophoresis you have an electrical current that is applied to material that is something like jello. The electrical current makes molecules that have a charge move one way and the speed at which they move depends on their size. Using electrophoresis you can separate different-sized proteins or DNA.

Scientists are figuring out ways of making really small electrophoresis components to help separate different molecules and make them easier to detect. Sensors are being developed that will help identify people, giving law enforcement officers a new tool that is kind of like a molecular fingerprint analyzer. Maybe you will see their next sensor on CSI.

Leaves and canary: iStockphoto

Big trees can move tiny molecules!
Nature has very efficient ways of moving tiny things. Trees and plants move molecules of water and nutrients from their roots all the way to the tips of their leaves.

Some chips function like tiny tweezers and can grab individual molecules!

Aptamers:

Grabbing molecules

Imagine that you had a tiny pair of tweezers that could grab just one molecule. No, wait… not just any molecule but only the one that you wanted out of a gazillion molecules. Sound a bit far-fetched? Now imagine that you could make this tiny pair of tweezers pick out any molecule that you wanted and imagine you could construct those tweezers out of DNA.

Aptamers are just those kinds of tweezers. About 25 years ago, scientists figured out how to make aptamers and now they are used for all sorts of things, including treating cancer. Scientists at WVU are creating sensors that use aptamers to grab specific molecules in a sample, making contaminants easier to detect.

Grabbing and concentrating the molecule you want to detect is one way to make your sensor more sensitive. Some of the sensors that scientists are working on will detect heavy metals like lead and mercury, which will help locate sources of these pollutants and clean up the environment.

Some chips function like a tiny canary in a coal mine.

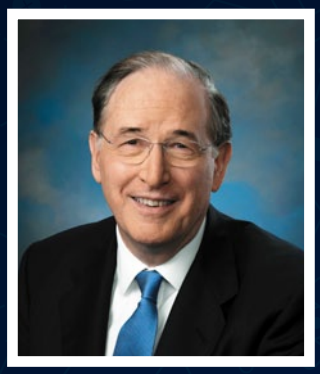
Detecting toxins:

Canary on a chip

Back a long time ago, miners brought canaries into coal mines to warn them of dangerous gases like carbon monoxide and methane. When those gas levels were too high, the poor canary died, so the miners knew they had to get out fast. Sometimes Mother Nature has a better way of detecting toxins than any sensor we might build.

We don't want to kill any more canaries, so scientists in West Virginia are using different kinds of cells as early warning systems for toxins. The cells are placed in a chip and the challenge is to keep them alive and healthy until they get exposed to a toxin. Then using electronics they can tell when these cells are sick, indicating the presence of a toxin. Using these living sensors, scientists will have a much better way of detecting things that might cause us harm such as bad bacteria, dangerous chemicals or even explosives.

PEOPLE IN NANO



Courtesy photo

Jay Rockefeller

U.S. Senator for West Virginia

As chairman of the committee on Commerce, Science and Transportation, Jay Rockefeller is a champion for investments in nanotechnology research.

"Nanotechnology research may one day lead to a cure for cancer, or discover ways to solve some of our energy problems and create thousands of jobs. We owe it to ourselves and our children to make sure we do what we can to unlock the vast potential of nanotechnology."

- Senator Jay Rockefeller

"Nanotechnology involves extremely small things that have a huge world impact."

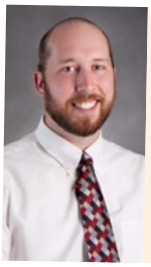
Name: Jeremy Dawson
Job: Research Assistant Professor at West Virginia University
Degree: Ph.D., Electrical Engineering
Hometown: Keyser, West Virginia

John Sibold

"Nanotechnology provides new ways to approach big problems."

Name: Tanner Bakhshi
Job: Student at Marshall University
Degree: B.S., Molecular Biology, minors in Mathematics and Chemistry.
Hometown: Lakeland, Florida

John Sibold



"Nanotechnology is like playing with tiny Legos. You build complex structures from molecular blocks."

Name: Justin Swick
Job: Director of Engineering at Vandalia Research
Degree: B.S., Integrated Science & Technology
Hometown: Chesapeake, Ohio

Courtesy photo

"Nanotechnology can keep you safe and healthy because of the power of small!"

Name: Letha Sooter
Job: Assistant Professor at West Virginia University
Degree: Ph.D., Biochemistry
Hometown: Ponca City, Oklahoma

West Virginia University

"Nanotechnology is knowing what atoms can do and putting each of them to work for humanity."

Name: Michael Norton
Job: Chemistry Professor at Marshall University and Co-director of the Molecular and Biological Imaging Center
Degree: Ph.D., Solid State Chemistry
Hometown: Shreveport, Louisiana

Rick Haye / Marshall University

"Materials can drastically change their properties when they are nano-sized."

Name: Tim Corrigan
Job: Professor at Concord University
Degree: Ph.D., Materials Science and Engineering
Hometown: Scottsdale, Arizona

Courtesy photo

"Every material improvement in life starts with an idea. Science makes that idea a reality!"

Name: Alicia Morgan
Job: Laboratory Manager at Protea
Degree: B.S., Chemistry and M.S., Inorganic Chemistry from WVU
Hometown: McMechen, West Virginia

Courtesy photo

Stained glass: iStockphoto

Gold Nanoparticles
The color in some stained glass comes from gold nanoparticles, not from red pigment.

Ancient Nanowires
Scientists have discovered tiny nanowire structures in the steel blades of ancient Damascus swords.

Public domain / Wikipedia

NANO PAST AND PRESENT

Nano is all about atoms and molecules having interesting properties at the nanometer scale. Scientists have only recently discovered the science behind these nanoscale properties. But even before people knew about atoms and molecules, they were creating nanomaterials!

While you need very powerful microscopes to actually see atoms and molecules, you can still experience nanometer-scale phenomena in everyday life. And it isn't something that was discovered today. It dates back to medieval times or even before.

NANOWIRES AND SWORDS

Back around A.D. 900, swords being made in Damascus were really strong and really sharp. Rumor has it that these swords could slice through a piece of silk while it fell to the ground.

Researchers in Germany recently used a powerful microscope to look at one of these ancient swords and found that it contained nanowires. What? There are a lot of different ways nanowires (and other nanometer-scale structures) are formed. Most involve the combination of certain compounds (like steel) and heating. So a thousand years ago swordmakers were creating nanomaterials without even knowing it.

NANOPARTICLES AND STAINED GLASS

Around the same time as the first Damascus swords, other craftsmen were creating stained glass using materials like silicon oxide (glass) and metals such as gold and silver. Hundreds of different colors of glass could be made by just tweaking the recipe. So by adding a bit of charcoal or heating it a little longer, you get different colors without adding any pigment. How is that possible?

In recent years when scientists used powerful microscopes to look at different samples of stained glass, they found nanometer-sized particles made up of different metals. Turns out that nanometer-sized particles of a material can have different properties. Gold can have a different color than the shiny gold that we expect; its color ranges from red to yellow depending upon the size and the shape of the nanoparticles.

NANOTECHNOLOGY TODAY

Nowadays there is nano all around us. We can find tennis rackets that are reinforced with carbon nanofibers, there are pants and other clothing specially treated with superhydrophobic (hates water!) coatings. And of course we have computers with parts that are less than 50 nanometers in size. That means 2,000 of them can fit across the width of a hair. And some of the stuff that we find in everyday life has nanometer-sized material in it. Things like mayonnaise, paint and even suntan lotion. *Nano is everywhere!*

Where can you find nano in *your* life?

Food
Some foods, such as mayo, contain nanometer-sized material.

Sunblock
If sunblock rubs in clear, it probably contains titanium dioxide nanoparticles.

Sports Equipment
Some tennis rackets are reinforced with carbon nanotubes.

Nano products: Emily Maletz

Clothing
Nano pants are treated with nano coatings that repel water; some socks contain nanosilver to inhibit the growth of bacteria.

Paint
Nano-enhanced paint is easier to keep clean.

WHERE IS NANO HAPPENING IN WEST VIRGINIA?

NETL, DOE Lab
National Energy Technology Lab
NETL scientists and engineers are researching efficient ways to provide environmentally friendly energy.

Mylan Pharmaceuticals
Scientists, doctors, and business people work collaboratively to manufacture low-cost medicines and create new and better drugs.

NIOSH, CDC lab
National Institute for Occupational Safety and Health
Scientists here are working hard to prevent workplace injuries and illnesses in different work environments such as agriculture, construction, health care, public safety, and transportation.

Alicia's Hometown
I grew up in McMechen, now I work at Protea.

Protea Biosciences
This company invents new ways to identify molecules that are important for life science research. They build equipment that biologists and chemists use to study bio-molecules like proteins and metabolites; this field is called bioanalytics.

Robert C. Byrd Institute
The Advanced Flexible Manufacturing facilities of RCBI help manufacturers and people with good ideas to design new things, some of which might unleash the $1 trillion potential of nanotechnology with new product breakthroughs.

Jeremy's Hometown
Growing up in Keyser, I always liked taking things apart and putting them back together.

Children's Discovery Museum of West Virginia
Here you can explore hands-on activities and learn about science, nutrition, careers, and cultures. There are special events throughout the year, such as NanoDays, Space Day and much more!

Sara's Hometown
I was born in West Milford, WV. I moved to Bridgeport when I was 9.

Vandalia Research
A spin-out of Marshall University, Vandalia is a biotechnology custom manufacturing organization that can produce DNA sequences on a large scale.

Rachel's Hometown
I grew up on a farm in Crawford.

Parabon NanoLabs
A new and growing technology company, Parabon *"designs drugs one molecule at a time."* Huffington Post named one of their products *"among the best inventions of 2012."*