

NANOTECHNOLOGY

WHAT IS NANOTECHNOLOGY

Nanoscience and nanotechnology are the study and integration of extremely small things. Everything is composed of matter; nanotechnology is the science of manipulating matter to achieve desired properties. Nanotechnology has applications across all fields of the physical sciences such as chemistry, biology, and physics, as well as materials science and engineering.

Nanostructures are measured on the scale of nanometers. To get an idea of how big (or small) a nanometer is, look at a piece of hair from your head. It is likely around 50,000 nanometers wide, which is the average thickness of a single strand of human hair!

Nanoparticles and nanostructure are too small for us to see with our naked eye or even a typical optical microscope. Interestingly, they may exhibit properties that are completely different from the properties exhibited at the macro, or visible, scale. With this understanding, we can achieve desired macro-scale properties of a material by changing the size and shape of its nanostructure.

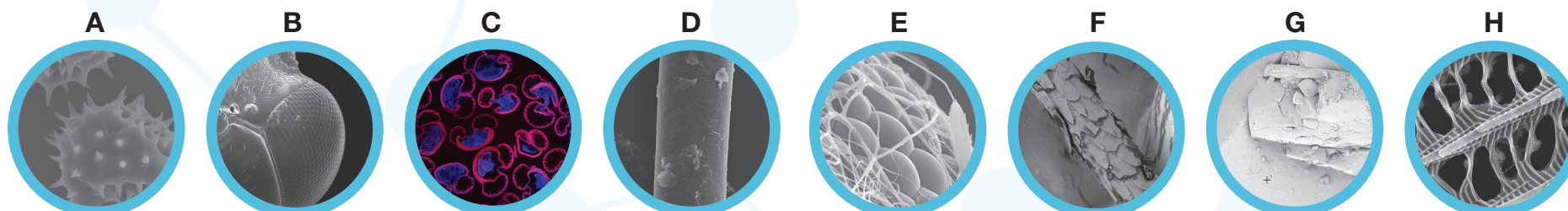


HOW SMALL IS SMALL?

Activity

Below are images taken using nanotechnology equipment, including a scanning electron microscope or confocal microscope. Shown in the first row are common objects zoomed in at the nano and microscale. Try to match the microscope image to the macroscale picture of where the object comes from.

Microscale



Macroscale



For a sense of scale, consider this:
If a marble represents a nanometer, a meter would be the size of the Earth.



This material is based upon work supported by the National Science Foundation under Grant Number 1204279



NORTH SEATTLE COLLEGE
One of the Seattle Colleges



INSPIRING STUDENTS TO LEARN
To register for NIE, visit us at seattletimes.com/nie or call 206.652.6290.

A – E images: SEM and Confocal Images captured by students at the SHINE Nano Lab
F – G images: Image captured by students at a CABOCES CTE Center
H: Lawrence Hall of Science, Rashmi Nanjundaswamy
8: Scientific Image from Bilboq, Wikimedia Commons

NANOTECHNOLOGY

There is a common misperception that nanotechnology is something of the future. While that is certainly true, nanotechnology is also here right now and integrated into our daily lives. There are many companies in the Seattle area, from small startups to massive international corporations, that are built upon nanotechnology and are actively seeking skilled technicians and professionals to operate high-tech equipment and help create new products.

Nanotechnology is not just *one* thing. In a sense, it is *everything* because it has applications in practically *every* field. The field of nanotechnology has the power to change everything from how we produce food to how we fight disease and climate change. Nanotechnology is a multidisciplinary field dedicated to the understanding and control of matter at dimensions between approximately one and 100 nanometers. At this scale, nanotechnologists can enable novel technology applications, such as better imaging and diagnostic tools to pave the way for earlier diagnosis of disease, to flexible, wearable electronics. Below are some real-life examples of how nanotechnology is used.



Stained glass window at Casa Batlló in Barcelona, Spain. Credit: Tony Hisgett

STAINED GLASS

An application of nanotechnology that everyone is familiar with dates back well over one thousand years: stained glass. Some of the beautiful vibrant colors in stained glass are actually a result of gold and silver salts mixed into the

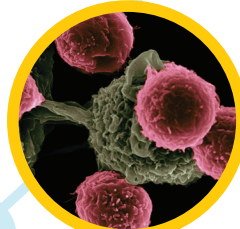
molten glass before it is poured, forming gold and silver nanoparticles. These embedded nanoparticles reflect different wavelengths of light, so the human eye perceives them as different colors depending on their size. This is why stained glass does not fade after years of sun exposure, while art or other materials colored with dye fade in such conditions.

MEDICINE

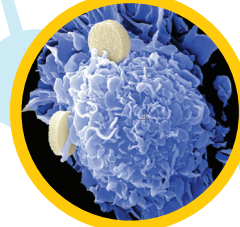
Many of the most recent groundbreaking advancements in cancer research are due to nanotechnology. Chemotherapy has proven effective in significantly reducing or halting the spread of certain types of cancer cells. This benefit comes at the cost of severely weakening the body's immune system, putting the patient at much greater risk of contracting some other illness which can further stress the immune system. Using nanotechnology, scientists have demonstrated that it is possible to create designer molecules containing cancer-killing medicine, direct them to the location of cancer cells, and then cause them to release the medicine. This is essentially like providing chemotherapy at the nano-scale. The ability to direct and target



Nanowires Grown for Potential Biosensing Applications. Credit: National Cancer Institute, Z.L. Wang, Ph.D.



Vaccine-Based Immunotherapy from Novel Nanoparticle Systems. Credit: National Cancer Institute, Victor Segura Ibarra and Rita Serda, Ph.D.



Developing Novel Vaccine Delivery Systems for Cancer Therapy. Credit: National Cancer Institute, Brenda Melendez and Rita Serda, Ph.D.

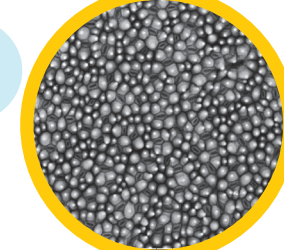
treatment minimizes the adverse effects on the rest of the body.

WATER REPELLENT

Sometimes nanomaterials are patterned from nanoscale phenomena that exist in nature. For example, lotus and many other leaves exhibit hydrophobic properties, meaning that they repel water. Each leaf is covered with nanoscale bumps that decrease the adhesive forces between the leaf's surface and water droplets. The high amount of surface tension present in water droplets causes the water to bead on top of the leaf's surface rather than be absorbed by the leaf. These beads of water serve as a self-cleaner, as they will pick up dirt or other particles on the leaf's surface. This is known as the lotus effect. Many materials that mimic this effect have been produced, including clothing fabric, paint and car wax. These materials are not only hydrophobic, but also repel stains, graffiti, and dirt.



Lotus effect on leaf of taro. Credit: Namazu-tron



Scanning electron microscope image of the surface of a lotus leaf. Credit: Lawrence Hall of Science, Rashmi Nanjundaswamy

The aerospace industry now uses some of these materials on airplanes.

Working at a small company means you have many jobs. My day involves managing the lab which includes equipment maintenance, inventory, safety, and writing Standard Operating Procedures. I also work in Research and Development doing synthesis, formulation, experimental design, and characterization tests. — Carinna Simmons, Research Associate, PolyDrop, Bellevue, Washington

I am currently a research assistant at the Air Force Institute of Technology in Dayton, Ohio. My days typically consist of observing and recording data for the research that I am doing. A lot of my research is done using a SEM, so I get a lot of hands-on time with it. — Greg Cobb, Research Assistant Air Force Institute of Technology, Wright-Patterson AFB, Ohio

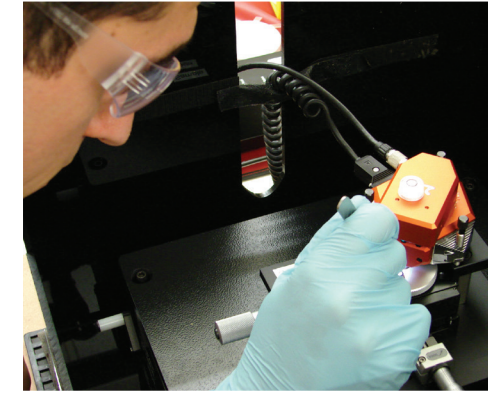
My typical day would involve checking in with the scientists to determine the status of any experiments and what is expected in that day. It could be anything from testing for leaks in the evaporator to force testing to making masks by lithography techniques to actual chemistry! We rapid prototype inventions of all sorts. I also help with lab organization and cleanliness. — Camille Barrat, Laboratory Technician, Keon Research, Seattle, Washington

I work as the NanoLab Manager/Technician at North Seattle College. This job has the fewest 'typical' days of any job I've ever had. That's actually one of the things I enjoy about this particular position: it's rarely the same day to day. — Joseph Amann, Nanotechnology Lab Technician, North Seattle College, Seattle, Washington

WE ASKED SOME OF THE 2016 NANO PROGRAM GRADUATES TO EXPLAIN WHAT A TYPICAL DAY IS LIKE AT THEIR JOB

CAREERS IN NANOTECHNOLOGY

Nanotechnology is a relatively new science and its applications are rapidly growing. As the applications grow, so do the available jobs and career opportunities. Nanotechnology is one of the fastest-growing career tracks. The National Science Foundation has estimated that two million workers will be needed to support nanotechnology industries worldwide within 15 years. Careers in nanotechnology are diverse and include energy, biotechnology, cosmetics, semiconductors, aerospace and materials manufacturing.



Graduates of SHINE's Nano Program at North Seattle College are well prepared to enter the workforce and go on to earn competitive annual salaries. They can be found working out of the Washington Nanofabrication Facility at the University of Washington and for companies throughout the Pacific Northwest, including EnerG2, Keon Research, Lab/Cor Materials, Lawrence Livermore National Laboratory, LiloTree, PolyDrop, RJC Enterprises, and Silicon Designs. They are fabrication engineers, research associates and scientists, and technicians.

Many graduates are employed as nanotechnicians. So what do nanotechnicians actually do? Nanotechnicians manufacture, measure, test and study nanostructures and microstructures. They assist scientists and engineers in their research and keep accurate, detailed records of their daily work. Since nanostructures are invisible to the human eye, nanotechnicians use special high-powered microscopes and tools in their daily work. Two commonly used microscopes are Atomic Force Microscopes (AFM) and Scanning Electron Microscopes (SEM).



Answer Key for Activity from Page 1

- A=5: Dahlia Flower Pollen
- B=1: Ant Eye
- C=4: Pine Tree Pollen
- D=2: Human Hair from a Nano Program Student

- E=6: Bug trapped in a Spider Web
- F=7: Wolf Hair
- G=3: Sugar Crystal
- H=8: Blue Morpho Butterfly Wing

SPOTLIGHT ON JEANIE PEBBLES

Two years ago, Jeanie Pebbles enrolled in the nanotechnology program at North Seattle College to pursue her love for science and to improve her life and her child's. After graduation, Jeanie became a lead technician at Lawrence Livermore National Laboratory. In her new position she is working on the future of biological/medical wearable devices in research and development, helping to create prototypes for further testing.



What do you enjoy the most about your career?

I feel like what I'm doing is impactful.

The culture at the lab is inclusive, and encourages collaboration which makes for a supportive group of peers. We are encouraged to work independently and to diversify skills and they embolden everyone to take advantage of educational opportunities!

What did you find the most challenging, and most rewarding, in the program while you were a student?

Challenges: I'm a single mom. It was tough to split my time with school work and family life.

Rewards: I hold dear my relationships with instructors and directors that helped me throughout the program. We still check in and exchange well-wishes.

So not only did SHINE prepare me for a job, they got me a job. And they are still in my corner!

How did the SHINE program prepare you for your career?

The Nano Program gave me the rich foundation that I use in microfabrication today. It is a direct result of participation in SHINE internships and networking that led to my career. They offered a hands-on-learning style that was not intimidating and they were compassionate to the diverse backgrounds of their students.

Did you always know you wanted to have a career in nanotechnology? If not, what made you decide on this pathway?

I didn't know much about nanotechnology before enrolling. A quick google search caught my attention and I was hooked after taking Nano 101. If you're at all interested, I encourage you to take Nano 101 and find out for yourself!



NANOTECHNOLOGY

Located at North Seattle College is SHINE: Seattle's Hub for Industry-driven Nanotechnology Education, a National Science Foundation Advanced Technological Education Regional Center. SHINE enables people from across the region to pursue a career in nanotechnology by providing an educational pathway that exists nowhere else in the Pacific Northwest. Students enter the NSC nanotechnology program with diverse education and past experiences including high school diplomas, undergraduate degrees in science, work experience in manufacturing or construction, military service and more. The program provides students with hands-on experience and skills while they work side-by-side with leaders in the growing nanotech industry on some of the most cutting-edge technology in our region.

To learn more visit www.seattlenano.org, and see how the region's first and only two-year nanotechnology degree is training the workforce of tomorrow.



RESOURCES FOR TEACHERS

SHINE partners with educators to develop and support nanoscience education in secondary and community college classrooms. One unique resource offered by SHINE and other institutions allows students to access cutting-edge microscopes and tools in your classroom, for free! The Remotely Accessible Instruments for Nanotechnology (RAIN) network is a group of centers located at community colleges and universities that work to deliver relevant nano-related activities into your classroom. Through Remote Access, students and teachers can control expensive microscopes and tools over the Internet to image and study materials. These tools include the scanning electron microscope, atomic force microscope and profilometer, which are generally not available to most classrooms.

See SHINE's Educator page for more details on their teacher resources.
<http://www.seattlenano.org/educators.html>



PREPARING FOR A CAREER IN NANOTECHNOLOGY

Jobs in nanotechnology are very diverse and include people from different disciplines and educational backgrounds. You don't have to get a PhD to work in this field. There are jobs available for students with many different education levels, from technical school to a doctorate degree. If you are considering pursuing a career in nanotechnology, there are several things you can do now to prepare yourself for success.

While in high school:

- Take science, math, and engineering classes
- Research the nanotechnology field and pay attention to developments in the field
- Conduct an informational interview with a person in the field to learn about what they do
- Explore options for education in the nanotechnology field, from technical training programs to earning a bachelor's degree (and beyond) at a larger college or university

Resources: www.seattlenano.org, whatisnano.org, www.nano.gov, www.nisenet.org

Hear from recent NSC Nano Program graduates about their experience with the program and their advice for students considering a career path in nanotechnology.

"The Nano Program gave me a foundation of knowledge and skills that enabled me to successfully enter the science community. Participating in the internships in the Nano program helped me get my foot in the door in an industry I had no experience in."
— Carinna Simmons

"SHINE's Nano Program provided a solid education and hands-on experience in the subjects I needed to learn in order to begin to pursue that career change. The curriculum, innovation, and relative flexibility of the Nano Program allowed me to pursue my own independent research project that brought together my interests in biology, materials science, chemistry, and nanotechnology."
— Joseph Amann

"The part I enjoy most about my career is, whether I'm working for the staff faculty or private industry, I am contributing to the advancement of a diverse range of technological innovations spanning from medical, electronic, materials, or environmental applications. These highly technical applications result in cross-functional collaboration as well as an inspiring and supportive environment to grow. I would encourage high school students interested in nanotechnology to develop a positive and motivated frame of mind and consistently apply it to internship opportunities, networking events, advanced courses or lab work."
— Nathan Fairbanks

"Always be willing to learn new things. I have had to pick up skills that I never thought I would learn in order to proceed with my research, and this is true for most people."
— Greg Cobb

"The Nano Program revealed a new avenue of study I had never before considered. I believe I gained an incomparable level of experience and exposure to people through this program."
— Leon Park

"The Nano Program and SHINE staff were really, really great. They want nothing more than to see their students succeed and go to great lengths to help this happen. In particular, their support of reaching out to industry makes it possible to find internships and creates a pathway for companies to find employees through the program. The internships I did were very rewarding because I was able to see very different types of research possibilities. It gave me some ideas of types of places I would and wouldn't want to work."
— Scott Merry