NANOTECHNOLOGY

LESSON PLAN FOR BIOLOGY 30 - MEDICAL APPLICATIONS

12

Alberta
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Alberta Innovates Technology Futures

Science Teachers,

This lesson plan was designed for Biology 30 and meets Alberta Education curriculum learning outcomes for science (see the following page for program of studies reference). The plans are easy to understand and implement without any specialized training, additional work or study. Best of all, they make this interesting subject matter engaging to teach.

The lesson plans were focus tested in seven schools throughout Alberta, incorporating teacher's feedback, and received great reviews. These plans provide the tools necessary to guide students through interactive experiences with nanotechnology that will help them understand this aspect of science. Included in the lesson plans are:

- a short explanation on what is nanotechnology,
- an activity description,
- time requirements,
- materials,
- an assessment rubric, and
- an in-depth teacher's background for reference.

Each lesson was designed in a way that allows you to quickly adapt it to your specific class needs and/or level of knowledge. If you wish to go deeper into the material, you can use the links provided under References or Bibliography. These lesson plans are complemented by a Nano Resource DVD for additional resources such as comic strips, videos, photos and more information related to teaching and understanding nanotechnology. These resources are also available for downloading at **nanolessonplans.alberta.ca**.

Did You Know?

The University of Alberta, the University of Calgary, and the Northern Alberta Institute of Technology all offer nanotechnology programs to train the next generation of curious and bright minds.

As you can see, the subject of nanotechnology is rich with opportunities for learning. We hope you will find the lesson plans worth implementing and include this fascinating area of science in your science program for the year.

If you require more information on additional nanotechnology learning experiences, or have any questions about the information provided, please contact nanoAlberta at 780-450-5111 or email nano@albertainnovates.ca. For grades 7 to 12 check out our travelling Scanning Electron Microscope (SEM) program and book it for your school today. This free program supplies the Microscope for a week and an Alberta certified science teacher will come and work with you and your class or school. A great complement to the nano lesson plans.
Visit **nanolessonplans.alberta.ca** for more information on the SEM program.

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1. Lesson planning – Alberta – Outlines, syllabi, etc.
2. Nanotechnology – Alberta –Curricula. I. Alberta. Alberta Advanced Education and Technology. II. Alberta Innovates –Technology Futures.

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These lesson plans are available to view online and can be downloaded free at **nanolessonplans.alberta.ca**

Limited additional copies are available for ordering from the Learning Resource Centre at **lrc.education.gov.ab.ca**

For information, including reproduction for commercial purposes, please contact:
Alberta Innovates - Technology Futures
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Program of Studies Reference:

Biology 30 - Cell Division, Genetics, and Molecular Biology

STS - 30 - C3.2

- Students will explain that scientific research and technological development help achieve a sustainable society, economy, and environment
  - Explore the application of nanotechnology and its implications for clinical diagnostics, pharmacology, biological research or proteomic programs.

Check out these other great Nanotechnology Lesson Plans

Nanotechnology: Lesson Plan for Grade 4 Science
Slippery Leaves

Nanotechnology: Lesson Plan for Grade 5 Science
Small is Different–Classroom Chemistry

Nanotechnology: Lesson Plan for Grade 6 Science
Forestry Nano Superheroes–Trees and Forests

Nanotechnology: Lesson Plan for Grade 7 Science
Nanotechnology and the Environment – Smart Dust

Nanotechnology: Lesson Plan for Grade 8 Science
Nanovision–Light and Optical Systems

Nanotechnology: Lesson Plan for Grade 9 Science
Carbon's Nanocaper–Matter and Chemical Change

Nanotechnology: Lesson Plan for Science 10
"BRANE" Work–Cycling of Matter in Living Systems

Nanotechnology: Lesson Plan for Chemistry 20
Putting it Together-Self Assembly
–The Diversity of Matter and Chemical Bonding

Did You Know?

Nanotechnology opens students to a wide variety of occupations in an even wider variety of industry sectors. Consider that nanotechnology may be encountered and used in some way by:

- Applications Technician
- Bio Material Engineer
- Cancer Researcher
- Characterization Scientist
- Chemical Technologist/Engineer
- Chemist
- Coating Scientist
- Computational Physicist
- Contact Metallization Process Engineer
- Electron Microscopy Technician
- Materials/Nanotechnology Scientist
- Materials/Metallurgical Engineer
- Mechanical Engineering
- Molecular Biologist
- Molecular Imaging Technologists
- Nanobiologist
- Nanoparticle Development Scientist
- Nanotechnology Business Manager
- Nanotechnology Laboratory Technician
- Nanotoxicologist
- Optical Engineer
- Pharmacologist
- Process Quality Engineer
- Product Marketing Manager
- Tissue Engineer
- Wafer Fabrication Development/Process Engineer

ACTIVITY DESCRIPTION

This lesson has 3 sections:

Part 1: Students take part in a simulation demonstrating how quantum dots are used in cancer diagnosis.

Part 2: Introduction to nanotechnology.

Part 3: In groups of four, students research a number of medical applications of nanotechnology, presenting their findings in the Pecha Kucha format (see Pecha Kucha fact sheet). Students can also include information about scientists in Alberta working on the application they've chosen to investigate.

TIME REQUIRED

Part 1: This demonstration should take about 30 minutes with the quantum dot information.

Part 2: 15 minutes.

Part 3: One class period to introduce the research project and begin research, and one period to present findings.
Each group will need 6 minutes 40 seconds for their presentation.

MATERIALS: for Simulation

- UV beads
- paper clamps
- sunlight or a UV light

Teacher background - Quantum Dots (QD) for medical diagnosis

Adapted from the following sources:

Review of Quantum Dot Technologies for Cancer Detection and Treatment
www.azonano.com/Details.asp?ArticleID=1726

Multicolor quantum dots aid in cancer biopsy diagnosis.
http://www.sciencedaily.com/releases/2010/07/100706150624.htm

GLOSSARY
- microfluidics
- laminar flow
- quantum dots

WHAT ARE QUANTUM DOTS (QD)?

- Inorganic semiconductor nanocrystals 2-8 nanometres (nm) in diameter
- They have unique luminescent properties
- Wavelength of light emitted depends on the particle size
- Usually built of atoms from the II and VI elements (e.g. CdSe and CdTe) or groups III and V elements (e.g. InP and InAs) of the periodic table
- Can be used to track single receptor molecules on the surface of living cells in the body

HOW DO THEY WORK?

- For early diagnosis of cancer, the QD are chemically linked to antibodies which bind to molecules present on the surface or inside of cancer cells.
- Structure consists of:
  - a semiconductor core
  - an additional shell of ZnS to provide chemical and optical stability to the inner core
  - a water-soluble hydrophilic coating
  - functionalized antibodies or other biomarkers complementary to the target cancer cells.
- These QDs are then subjected to UV light to reveal the location of the cancer cells.

CLASS PREPARATION

Introduction to Nanotechnology

15 minutes

1. Show the following video: www.nanowerk.com/nanotechnology/videos/Kavli_Foundation_Introduction_to_Nanoscience.php

2. This PowerPoint presentation from the following NanoSense.org lesson plan can also be used: http://nanosense.org/activities/sizematters/index.html

PART 1: Quantum Dot Simulation

(This simulation is based on an idea proposed by John Griffiths of Harry Collinge High School, Hinton, Alta. Used with permission.)

In this simulation, the teacher is the diagnostician who distributes “antibodies” (the paper clamps) with quantum dots (UV beads) attached. Students are the cells to which the antibodies attach. You present information about what quantum dots are and how they are used to tag malignant cells. When students go outside (or when you shine a UV light on their “antibodies”), the beads will change colour. The UV light from the sun will cause the white beads to change colour, revealing the “code” or sequence of colours. Students will take note of their colour sequence and compare it to a key when they return to the classroom.

PART 2: Medical applications research

Students will continue to work in their groups of four to conduct the research and prepare their Pecha Kucha presentations. Show a sample Pecha Kucha so that students can get a feel for the format. Many are available here: www.pecha-kucha.org/presentations/. Students then choose a topic from the list below or do some browsing to find other medical applications. Another refreshing alternative presentation format to PowerPoint is Prezi (found at www.prezi.com).

Students might also include some slides that showcase an Alberta researcher working in the student’s chosen area. The scientists might agree to a short interview to talk about their work. The chart on page 6 includes several of these researchers and their institutions.

Medical Applications List

Here are some samples of nanotechnology applications in medicine. Nanotechnology Now (www.nanotech-now.com) is a very good source of new releases about nanotechnology breakthroughs. It's written at a level that should be appropriate for Grade 12 students.

1. Pharmacology

a. Drug delivery systems: www.nanotech-now.com/news.cgi?story_id=28035
b. Drug smuggling cells: www.nanotech-now.com/news.cgi?story_id=39664

2. Clinical diagnostics

a. Alberta Research Lab on a Chip:
http://nextbigfuture.com/2010/04/radical-research-changes-lab-on-chip.html.
Contact information given in chart below.

b. Lab on a Chip: IBM Scientists Reinvent Medical Diagnostic Testing
www.nanotech-now.com/news.cgi?story_id=35439

c. Lab on a Chip: www.sciencedaily.com/releases/2010/02/100216113905.htm

d. Biosensors: Ultrasensitive Biosensor Can Detect Proteins, Aid in Cancer Diagnosis
www.nanotech-now.com/news.cgi?story_id=40127

3. Cancer treatment

a. Targeted delivery of chemotherapy drugs: www.youtube.com/watch?v=RBjWwlnq3cA

4. Bone grafts and implants

a. www.nanotech-now.com/news.cgi?story_id=37617
b. www.nanowerk.com/spotlight/spotid=8030.php
c. www.understandingnano.com/nanocluster-protein-bone-growth.html

Alberta researchers working in medical applications of nanotechnology
(Source: Alberta's Nanotechnology Asset Map)
Download here: http://www.albertatechfutures.ca/nanoAlberta/AlbertaNanoAssetMap.aspx

Researcher	Research Area
Colin Dalton University of Alberta Electrical & Computer Engineering	glucose sensor, lab on a chip, microneedles
Anastasia Elias University of Alberta Chemical & Materials Engineering	microfluidic devices, biomedical devices
Michael Ellison University of Alberta Biochemistry National Institute for Nanotechnology	automated miniaturized biofab systems capable of assembling modular DNA components into chromosomes at speeds over 100 times faster than conventional methods
Michael James University of Alberta Medicine and Dentistry	Viral enzymes, antiviral compounds, drug development, antibiotic development against tuberculosis.
Todd Lowary University of Alberta Chemistry National Institute for Nanotechnology	Preparation of nanoparticles or devices coated with foreign blood group antigens, which may be implanted into newborns before the immune system is fully developed. If present during the maturation of the immune system, these implants will create tolerance to these antigens in an infant's immune system, which will help prevent organ rejection.
James McMullin University of Alberta Electrical & Computer Engineering National Institute for Nanotechnology	portable diagnostic systems
Sushanta Mitra University of Alberta Mechanical Engineering National Institute for Nanotechnology	**Biological Applications:** - integrated BioMEMS and NanoSensors (real-time heat shock protein 70 monitoring in whole organisms; vitamins in clinical samples; cardiac monitoring) - design, fabrication, and characterization of a micro-filter for point-of-care system
Hasan Uludag University of Alberta Chemical & Materials Engineering	bone regeneration, cancer therapy

ASSESSMENT

Rubrics can be effective if students participate in writing the rubric. At the grade 12 level, this is quite doable. Below are some performance areas that could be included:

1 *Content:*

a. description of the medical application
b. explanation of the science behind the application
c. implications of the technology for sustainability
d. presenter's ideas about future direction or possible application for the technology/application
e. inclusion of Alberta researcher profile

2 *Presentation:*

a. adherence to the "20 slides of 20 seconds" requirement of Pecha Kucha
b. use of images
c. knowledge of subject matter demonstrated by not relying on notes
d. creative use of the Pecha Kucha form

Three to four levels of performance should be developed, with suggestions from students about what the different levels of performance might look like.

Discuss with the students what the levels of performance will look like within each category, developing the criteria and levels together.

A sample rubric for PowerPoint presentations can be found at the following link: www.surfturk.com/composition/powerpointrubric.html.

EXTENSIONS

The following activity is a simulation/model of how the microfluidic flow works in a Lab on a Chip (LOC).

Lab on a Chip (LOC)

LOCs are credit card-sized devices based on capillary action or microfluidics (the ability to manipulate tiny volumes of liquid). They are used for faster point-of-care diagnostic medical tests and require much smaller samples than traditional lab analyzers. The chips are silicon-based and work at the nanoscale. The chips use the principle of laminar flow to control the mixing of samples and reagents. Laminar flow allows individual streams of fluid to flow separately without a physical barrier between them. Mixing between the streams occurs only through diffusion, and reactions can occur at the interfaces.
(http://www.youtube.com/watch?v=1_H2ZEsV8Rs)

This article explains a lot of the mechanics of lab on a chip: http://pubs.acs.org/doi/pdf/10.1021/ac002800y. This is large file, so it may download slowly—be patient. The second 'Y' channel Jell-O chip demonstrates laminar flow for students.

One possible application of LOC technology is for diagnosing heart attacks. The protein myoglobin floods the circulatory system during the minutes before a heart attack. Patients at risk might be issued a handheld device to test their own blood for elevated myoglobin levels. A patient who feels ill could test their own blood with a simple pinprick and then call for help if elevated levels were detected. This would help them get treatment much faster if a heart attack does occur.
(http://nextbigfuture.com/2010/04/radical-research-changes-lab-on-chip.html)

Lab on a Chip is just one of the medical applications of nanotechnology that students might research. There are a great number of others. The web links noted below will provide some basic information on the technologies for teachers as well as students. The NSTA (National Science Teacher Association) Learning Center has published a very good book called The Big ideas in Nanoscale Science and Engineering (Shawn Y. Stevens, LeeAnn M. Sutherland, Joseph S. Krajcik. Arlington, VA: NSTA Press. 2009. ISBN: 9781935155072), which is an excellent resource for teachers wanting to learn more about nanoscale science and its applications.

JELL-O CHIP FABRICATION

One class period (55 minutes), plus time for cells to cure.
Best done on a Friday so they can cure over the weekend.

The protocol is detailed in Appendix A and is used with permission of the principal investigator:

Dr. Eric Lagally
Michael Smith Laboratories & Department of Chemical and Biological Engineering
#301 - 2185 East Mall
University of British Columbia
Vancouver, BC
V6T 1Z4

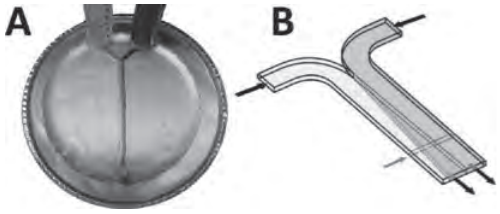
Source: Using Inexpensive Jell-O Chips for Hands-On Microfluidics Education
http://pubs.acs.org/doi/abs/10.1021/ac902926x

Detailed Protocol: See Appendix A

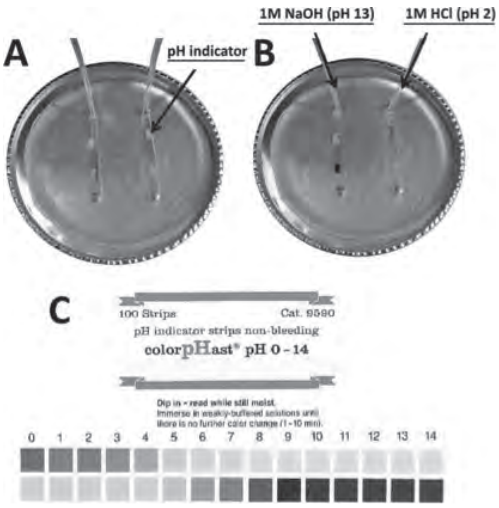
There are three possible chips that students can make. Teachers should choose the one best-suited to their curricular objectives. The options are:

One with a channel that spells out Jello-O:

One that demonstrates laminar flow:



One that demonstrates a pH application:



RESOURCES

Sargent, Ted. The Dance of the Molecules: How Nanotechnology is Changing Our Lives. This is a good source of information on the possibilities of nanotechnology. (ISBN-10: 1560258098, ISBN-13: 978-1560258094)

BIBLIOGRAPHY

1. Vashist, Sandeep, et al. "Review of Quantum Dot Technologies for Cancer Detection and Treatment." *Journal of Nanotechnology Online.* 13 September 2006. Web. 16 April 2011. http://www.azonano.com/Details.asp?ArticleID=1726

2. "Multicolor Quantum Dots Aid in Cancer Biopsy Diagnosis." *ScienceDaily.* 7 July 2010. Web. 16 April 2011. http://www.sciencedaily.com/releases/2010/07/100706150624.htm

3. Kavli Foundation: Introduction to Nanoscience." *KavliFoundation.* YouTube. 6 March 2008. Online Video. 16 April 2011. http://www.nanowerk.com/nanotechnology/videos/Kavli_Foundation_Introduction_to_Nanoscience.php

4. "Size Matters: Introduction to Nanoscience." *NanoSense.* 15 November 2007. Web. 16 April 2011. http://nanosense.org/activities/sizematters/index.html

5. "IBM Scientists Reinvent Medical Diagnostic Testing." YouTube. *IBMResearchZurich.* 17 November 2009. Online Video. 16 April 2011. http://www.youtube.com/watch?v=1_H2ZEsV8Rs

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7. Cairney, Richard. "Radical research changes lab-on-a-chip design." *PhysOrg*. 31 March 2011. Web. 16 April 2011. http://www.physorg.com/news189273259.html

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9. Yang, Cheng, Eric Ouellet, and Eric T. Lagally. "Using Inexpensive Jell-O Chips for Hands-On Microfluidics Education." *Analytical Chemistry* (May 2010): 5408-5414. Web. 16 Apri 2011. http://pubs.acs.org/doi/abs/10.1021/ac902926x

10. Sargent, Ted. *The Dance of the Molecules: How Nanotechnology is Changing Our Lives.* New York: Basic Books, 2006.

STUDENT SHEET

Medical Applications of Nanotechnology:

Your task is to research a medical application of nanotechnology with particular emphasis on work being done by Alberta researchers. Some suggestions for topics and preliminary information sources are listed below:

1. Pharmacology

a. Drug delivery systems: www.nanotech-now.com/news.cgi?story_id=28035
b. Drug smuggling cells: www.nanotech-now.com/news.cgi?story_id=39664

2. Clinical diagnostics

a. Alberta Research Lab on a Chip:
http://nextbigfuture.com/2010/04/radical-research-changes-lab-on-chip.html.
Contact information given later in a chart.

b. Lab on a Chip: IBM Scientists Reinvent Medical Diagnostic Testing
www.nanotech-now.com/news.cgi?story_id=35439

c. Lab on a Chip: www.sciencedaily.com/releases/2010/02/100216113905.htm

d. Biosensors: Ultrasensitive Biosensor Can Detect Proteins, Aid in Cancer Diagnosis
www.nanotech-now.com/news.cgi?story_id=40127

3. Cancer treatment

a. Targeted delivery of chemotherapy drugs: www.youtube.com/watch?v=RBjWwlnq3cA

4. Bone grafts and implants

a. www.nanotech-now.com/news.cgi?story_id=37617
b. www.nanowerk.com/spotlight/spotid=8030.php
c. www.understandingnano.com/nanocluster-protein-bone-growth.html

Please include:

- Description of the technology and what it does. What area—clinical diagnostics, pharmacology, biological research, or proteomic programs?
- Explanation of the nanoscience behind the application.
- Discussion of implications for sustainability.
- What stage is the technology—research and development, patent protection, pre-clinical trials, clinical trials, Health Canada's review process? See the following brochure below for details: www.pharmacists.ca/content/hcp/resource_centre/drug_therapeutic_info/pdf/DrugApprovalProcess.pdf
- One or two slides highlighting an Alberta researcher connected to your chosen application.

Your research will be presented in the Pecha Kucha style, which shows 20 slides for 20 seconds each (set on automatic advance). You might also use Prezi to present your research to the class.

STUDENT SHEET

Pecha Kucha Basics

Pecha Kucha, pronounced "peh cha' chkuh", is the Japanese word for "chatter".

- specific PowerPoint format using 20 slides each lasting exactly 20 seconds
- slides are set to change automatically
- total presentation time is 6 minutes 40 seconds
- description of Pecha Kucha: www.youtube.com/watch?v=wGaCLWaZLI4
- Daniel Pink on Pecha Kucha: www.youtube.com/watch?v=9NZOt6BkhUg

Examples

Clowns Without Borders: www.pecha-kucha.org/presentations/195
PangeaSeed - Save the Ocean: www.pecha-kucha.org/presentations/204
Picture books: www.pecha-kucha.org/presentations/170

Alternative presentation method: Prezi

Prezi is free interactive online presentation software that can provide a refreshing alternative to PowerPoint. You can find it at http://prezi.com.

STUDENT SHEET

Alberta researchers working in medical applications of nanotechnology

Below is a chart showing a number of Alberta researchers who are working on different medical applications of nanotechnology.

Researcher	Research Area
Colin Dalton University of Alberta Electrical & Computer Engineering	glucose sensor, lab on a chip, microneedles
Anastasia Elias University of Alberta Chemical & Materials Engineering	microfluidic devices, biomedical devices
Michael Ellison University of Alberta Biochemistry National Institute for Nanotechnology	automated miniaturized biofab systems capable of assembling modular DNA components into chromosomes at speeds over 100 times faster than conventional methods
Michael James University of Alberta Medicine and Dentistry	Viral enzymes, antiviral compounds, drug development, antibiotic development against tuberculosis.
Todd Lowary University of Alberta Chemistry National Institute for Nanotechnology	Preparation of nanoparticles or devices coated with foreign blood group antigens, which may be implanted into newborns before the immune system is fully developed. If present during the maturation of the immune system, these implants will create tolerance to these antigens in an infant's immune system, which will help prevent organ rejection.
James McMullin University of Alberta Electrical & Computer Engineering National Institute for Nanotechnology	portable diagnostic systems
Sushanta Mitra University of Alberta Mechanical Engineering National Institute for Nanotechnology	**Biological Applications:** - integrated BioMEMS and NanoSensors (real-time heat shock protein 70 monitoring in whole organisms; vitamins in clinical samples; cardiac monitoring) - design, fabrication, and characterization of a micro-filter for point-of-care system
Hasan Uludag University of Alberta Chemical & Materials Engineering	bone regeneration, cancer therapy

Source: Alberta's Nanotechnology Asset Map (download here) :
http://www.albertatechfutures.ca/nanoAlberta/AlbertaNanoAssetMap.aspx

APPENDIX A:

SUPPORTING INFORMATION

(Used with permission of Dr. Eric Lagally)

Detailed Chip Fabrication Protocol

List of Materials Required for Jell-O® Chip Fabrication

- Two 85g boxes of lemon-flavored Jell-O® jelly powder (Kraft Canada)
- One pouch (7g) of unflavoured (the Original) Knox Gelatine (Associated Brands LP)
- 2 beakers of 120mL of purified water for dissolving Jell-O® and Knox Gelatine
- Six 6” foam plates, round (Safeway Limited Canada)
- One drinking straw, round (Safeway Limited Canada)
- PAM® Original no-stick cooking spray (ConAgra Foods Canada Inc.)
- Several 7” wooden coffee stirrers (Starbucks Coffee Company Canada)
- Food-grade colour dye, green (McCormick Canada)
- Single- and double-sided tape (3M Canada)
- Six 5” aluminum weighing pan (Cat No. 12175-001, VWR International)

Sources of Chemicals and Materials

Lemon-flavored Jell-O® Jelly Powder, unflavoured gelatin, round foam plates (6”), drinking straws, no-stick cooking spray, wooden coffee stirrers (7”), food-grade colour dyes, and single- and double-sided tape were obtained from local convenience stores. Aluminum weighing pans (5”), 10 mL syringes and Disposable Transfer Pipets were purchased from VWR International. ColorpHast Indicator Strips (pH 0-14) were acquired from EM-Reagents. Sodium Hydroxide (NaOH) and Hydrochloric Acid (HCl, 37% A.C.S. reagent) were obtained from Sigma. All solutions were prepared using ~18.2 M-cm water treated with a water purification system (Barnstead EASYpure® II Ultrapure).

Jell-O® Chip Fabrication

Initially, the molds with desired features were made using foam plates, coffee stirrers and double-sided tape. To make the chips, two pouches of Jell-O® jelly powder were dissolved in 120 mL of purified water in a beaker. One pouch of Knox Gelatine powder was dissolved in the same amount of water in a second beaker. The beaker containing the Jell-O® solution was placed on a hot plate and heated to a boil. This beaker was removed from the heat and the gelatin solution was added to it. The mixture of Jell-O® and gelatin solution was again heated to a boil and removed from the heat. Prior to pouring the mixture of Jell-O® and gelatin solution into the mold, cooking spray was dabbed onto the inside rim of the foam plate to facilitate the peeling process after curing.

The mixture solution was poured into six molds and they were transferred to a 4°C refrigerator for curing. Curing the chips overnight was usually sufficient; however, curing for at least two days in the refrigerator resulted in more robust Jell-O® chips. After curing, Jell-O® chips were carefully peeled off and placed on aluminum pans for experimental demonstrations. Lemon-flavored Jell-O® jelly powder was used because it produced chips with the best optical transparency. Inlet and outlet holes were punctured using a drinking straw. In all of the chips produced, the natural and reversible seal between the Jell-O® chip and the aluminum pan was adequate for the flow rates that were encountered. Lawson and Abbot, both high school students in Vancouver, BC, fabricated the chips and conducted the initial experiments presented here, demonstrating the accessibility of this technology to students at this educational level.

Module I: Pressure-driven flow

Materials Required:

- One Jell-O® microfluidic chip with a continuous channel depicting the letters “JELLO” (see Supporting Information regarding detailed chip fabrication protocol)
- One 5” aluminum pan (Cat No. 12175-001, VWR International)
- One disposable transfer pipet (Cat No. 16001-178, VWR International)
- A small vial of water with a few drops of green food coloring dye (~30mL)

Mold Fabrication Guide:

The coffee stirrers were cut into rectangular shapes of various lengths. They were then

taped onto the foam plate, forming the letters “JELLO”, using double-sided tape. Single-sided tape was taped at junctions of coffee stirrers to ensure a smooth overall mold surface.

Additional Tips:

The Jell-O® chips should be stored in the 4°C refrigerator until immediately prior to peeling the chips and running the experiments. Thicker chips can be made by reducing the number of molds made (to three or four). However, increasing the thickness of the chips will most likely affect and lengthen the curing time. From experience, a ratio of 4 people per chip is adequate for these demonstrations.

Module II: Dimensionless parameters

Materials Required:

- One Jell-O® microfluidic chip with a Y-shaped channel
- One 5” aluminum pan (Cat No. 12175-001, VWR International)
- Two disposable BD 10mL syringes (Product No. 309604, BD Canada)
- A small vial of water (~30mL)
- A small vial of water with a few drops of blue food coloring dye (~30mL)

Mold Fabrication Guide:

Two pieces of coffee stirrers were required for forming the Y-channel mold. A long rectangular-shaped coffee stirrer was first obtained (~3 inches long) by trimming the first coffee stirrer at both ends. One end of this coffee stick should be flat (outlet) and the other end should be dagger-shaped. The second coffee stirrer can be cut into two smaller rectangular-shaped sticks of the same length (~1 inch long). The longer coffee stirrer was taped near the middle of the foam plate using double-sided tape. The two smaller sticks were similarly taped at the dagger-shaped end of the longer stick, forming a mold with the letter “Y”. Single-sided tape was taped at the junction of three coffee stirrers to ensure a smooth mold surface.

Additional Tips:

To prevent leaking from the inlets, the syringes should be perfectly perpendicular with the surface, and the head of the syringes should completely seal the inlets. Both clear and green water should be injected slowly but evenly into the channels, in order to create the laminar flow profile. The most common problem we encountered with the Y-Channel chip was with peeling the chip off of the mold, especially at the junction of the three coffee stirrers. Patience, care, and experience will help with the peeling process. If Y-Channel chips are too difficult to make, simple T-Channel chips can also

produce the same results. Two rectangular-shaped coffee stirrers can be combined to make the letter “T” on a foam plate. Two inlet holes and one outlet hole should still be punctured as before. Laminar flow profile can still be seen with the T-Channel chips.

Module III: Fundamentals of pH Sensing & Parallelization

Materials Required:

- One Jell-O® microfluidic chip with two straight channels
- One 5” aluminum pan (Cat No. 12175-001, VWR International)
- Two disposable transfer pipets (Cat No. 16001-178, VWR International)
- Two small pieces of acid-sensing pH paper (Cat No. 9590, EM Science)
- Two small pieces of base-sensing pH paper (Cat No. 9590, EM Science)
- A small vial of 1M hydrochloric acid (258148, Sigma-Aldrich) (or cooking vinegar)
- A small vial of 1M sodium hydroxide (S8045, Sigma-Aldrich) (or dissolved antacid solution)

Mold Fabrication Guide:

Two pieces of coffee stirrers were required for forming the pH Sensor mold. Two long rectangular-shaped coffee stirrers of the same length were obtained (~2.5 inches long). These sticks were then taped onto the foam plate using double-sided tape, at ~1 inch apart.

Additional Tips:

Extreme caution should be taken when working with one-molar NaOH and HCl. Constant supervision is required, and this step is not suitable for younger students. Household solutions that are milder may be used instead of HCl and NaOH. Common acidic solutions include vinegar and lemon juice; common basic solutions include dissolved antacid solutions and soapy water.

Further Information and Videos

Further information about the most effective teaching methods for this material and to see videos of the chips in operation, please see: http://www.msl.ubc.ca/training/outreach

NOTES:

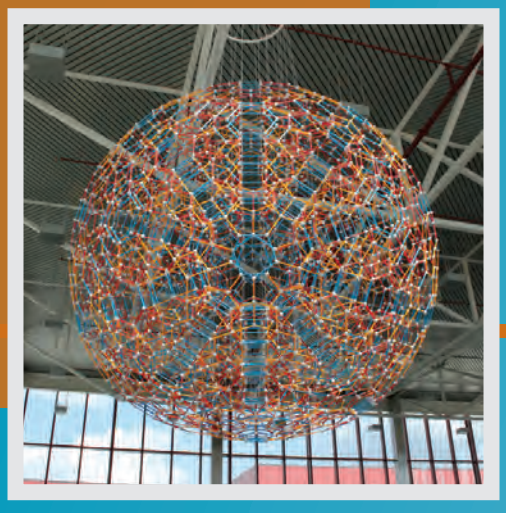
WHAT YOU'LL FIND HERE

- a "pick-up-and-go" lesson plan that will add science currency to your science program
- activities that meet science curriculum learning outcomes
- interesting subject matter that is engaging to teach
- easy to implement experiments (no specialized training needed)
- a quickly adaptable lesson with worksheets and rubrics for your class needs

Nano is... the scientific term meaning one-billionth (1/1,000,000,000). It comes from the Greek word meaning "dwarf".

Nano Science is... the discovery, research and understanding of all things nano.

Nanotechnology is...
the application of science at the molecular level.



Nanotechnology
is revolutionizing medicine, energy production, environmental protection, bioindustries and more!

Government of Alberta