January 25, 2013
College Station, Texas
Hilton Hotel and Conference Center

Presented by
Texas A&M University
College of Science
Dwight Look College of Engineering
Texas A&M Engineering Experiment Station

NUCLEAR POWER INSTITUTE
nuclearpowerinstitute.org

ConocoPhillips

Chevron Phillips Chemical Company

Subsea Tieback Foundation

TEXAS A&M UNIVERSITY

Teacher Summit 2013

Focus on STEM
science and engineering in the classroom

Teacher Summit 2013

Teacher Summit 2013 Evaluation Form

We hope you enjoyed the summit and it provided you with valuable information. Please take a moment to tell us how we did and provide us with any suggestions for improving this event in the future.

Part I: Teacher Summit Program

1) Please rate the <u>overall</u> relevance of this year's ***Teacher Summit – Focus on STEM*** for use in your classroom. (Please circle)

1 Poor 2 Fair 3 Good 4 Very Good 5 Excellent

Comments ____

2) Please rate the ***Research and Education*** presentation. (Please circle)

1 Poor 2 Fair 3 Good 4 Very Good 5 Excellent

Comments ____

3) Please rate the ***How to Best Prepare High School Students for Success in a STEM Major*** presentation. (Please circle)

1 Poor 2 Fair 3 Good 4 Very Good 5 Excellent

Comments ____

4) Please rate the ***resource material*** available at the resource tables. (Please circle)

1 Poor 2 Fair 3 Good 4 Very Good 5 Excellent

Comments ____

5) Please provide feedback below on the ***workshop sessions:***

A. ***Workshop Session Name: Integrated STEM***

- Please rate the "***Integrated STEM***?" session. (Please circle)

  1 Poor 2 Fair 3 Good 4 Very Good 5 Excellent

- If you plan to use this information in your classroom, please let us know the class subject:

Comments ____

- Please provide additional comments for this workshop session below:

____

B. ***Workshop Session Name: Plastics for the Body: From Healing Wounds to Treating Cancer***

- Please rate the "***Plastics for the Body: From Healing Wounds to Treating Cancer***" session. (Please circle)

  1 Poor 2 Fair 3 Good 4 Very Good 5 Excellent

- If you plan to use this information in your classroom, please let us know the class subject:

Comments ____

- Please provide additional comments for this workshop session below:

____

C. ***Workshop Session Name: Shedding Light on Optics***

- Please rate the "***Shedding Light on Optics***" session. (Please circle)

  1 Poor 2 Fair 3 Good 4 Very Good 5 Excellent

- If you plan to use this information in your classroom, please let us know the class subject:

Comments ____

- Please provide additional comments for this workshop session below:

____

D. ***Workshop Session Name: DNA Comparison***

- Please rate the "***DNA Comparison***" session. (Please circle)

  1 Poor   2 Fair   3 Good   4 Very Good   5 Excellent

- If you plan to use this information in your classroom, please let us know the class subject:

Comments ____

- Please provide additional comments for this workshop session below:

____

6) Did you find the **Texas A&M Faculty Panel** session useful?

Yes_____   No______

Comments____

7) Did you find the **Texas A&M Student Presentations** useful?

Yes______   No______

Comments____

8) How did the Teacher Summit affect your impression of STEM majors at Texas A&M University? (Check one)

Improved ______   Did not affect ______   Lowered ______

Please explain. ____

9) How did the Teacher Summit affect your impression of Texas A&M University? (Check one)

Improved ______   Did not affect ______   Lowered ______

Please explain. ____

10) Will you recommend Texas A&M University to your students? (Circle one)

Yes   No   Not sure

Comments ____

Part II: Facilities/Registration

Please rank the facilities and registration below: (1 being the lowest and 5 being the highest)

1) Ease of online registration process

1 2 3 4 5 Suggestions: ____

2) Quality of lodging, conference facility and food

1 2 3 4 5 Suggestions: ____

3) Value of door prizes

1 2 3 4 5 Suggestions: ____

Part III: Please tell us about yourself

4) Identify your expertise area. (Circle all that apply)

a) Astronomy
b) Biology
c) Chemistry
d) Engineering
e) Math
f) Physics
g) Other ____________________
____

5) Identify the grade levels you currently teach. (Circle all that apply)

a) 7^{th} grade
b) 8^{th} grade
c) 9^{th} grade
d) 10^{th} grade
e) 11 grade
f) 12^{th} grade
g) Other _____________________

6) Identify the subject matters you currently teach. (Check all that apply)

1. Algebra I ______ Algebra II______
2. Geometry______ Pre- Calculus______ Calculus______
3. Physics Pre AP_____ Physics AP (non-calculus–based) _____ Physics AP (calculus-based) ______
4. Chemistry Pre AP______ Chemistry AP______
5. Biology Pre AP______ Biology AP______ Anatomy_______
6. Engineering______ Environmental ______ IPC________
7. Other (please specify) ____

7) What is the size of your student population at your school (all grades included)? ______________

Thank you!

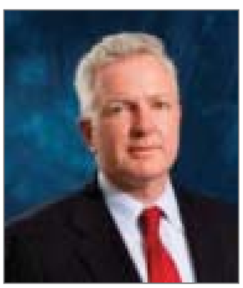
Dr. M. Katherine Banks, P.E.

Vice Chancellor for Engineering, The Texas A&M University System
Dean and Harold J. Haynes Dean's Chair, Dwight Look College of Engineering, Texas A&M University

Banks is vice chancellor for engineering for The Texas A&M University System and dean of the Dwight Look College of Engineering at Texas A&M University. As vice chancellor, she oversees coordination and collaboration among the engineering, academic and research programs at universities throughout the A&M System, as well as three state agencies. As dean of the Look College and holder of the Harold J. Haynes Dean's Chair in Engineering, Banks leads one of the largest engineering schools in the country, with more than 11,000 students and nearly 400 faculty.

Banks was previously the Bowen Engineering Head for the School of Civil Engineering at Purdue University and the Jack and Kay Hockema Professor at Purdue. She received her B.S.E. from the University of Florida, M.S.E. from the University of North Carolina, and Ph.D. in civil and environmental engineering from Duke University.

She is a Fellow of the American Society of Civil Engineers (ASCE) and is a licensed professional civil engineer in Indiana and Kansas. She has received numerous awards, including the ASCE Petersen Outstanding Woman of the Year Award, ASCE Rudolph Hering Medal, Purdue Faculty Scholar Award, Sloan Foundation Mentoring Fellowship and the American Association of University Women Fellowship. She is the author or co-author of more than 150 journal articles, proceedings papers and book chapters, and has made more than 200 scholarly or technical presentations to professional and related groups. Banks has served as editor-in-chief for the *ASCE Journal of Environmental Engineering* and associate editor of the *International Journal of Phytoremediation*.



Dr. Brett P. Giroir, M.D.

Vice Chancellor for Strategic Initiatives, The Texas A&M University System

Giroir is vice chancellor for strategic initiatives for the A&M System and principal investigator of the newly awarded Texas A&M Center for Innovation in Advanced Development and Manufacturing, a public-private partnership with the U.S. Department of Health and Human Services designed to enhance the nation's preparedness against emerging infectious diseases, including pandemic influenza and chemical, biological, radiological and nuclear threats.

Giroir is a former director of DARPA's Defense Sciences Office and chair of the Defense Threat Reduction Advisory Committee Chemical and Biological Defense Panel. He received his undergraduate education at Harvard University and his medical training at the University of Texas Southwestern Medical Center, where he served on the faculty from 1993 to 2008. He has received the A&M System Award for Innovation and the U.S. Secretary of Defense Medal for Outstanding Public Service.

In his role as vice chancellor, Giroir provides leadership for high-impact research and innovation at the system's 11 universities, seven state agencies, and comprehensive health science center, encompassing 28,000 faculty and staff, 120,000 students, a budget in excess of $3 billion, and research expenditures totaling more than $840 million annually. Giroir also leads the system efforts to develop strategic partnerships with external agencies, foundations, academic institutions, and commercial corporations to enhance the system's mission of research, teaching, service, and economic development for the State of Texas.

Dr. Robin Autenrieth

Senior Associate Dean for Academic Affairs, Dwight Look College of Engineering, Texas A&M University

Autenrieth is the A.P. and Florence Wiley Professor in the Zachry Department of Civil Engineering. She was previously associate dean for graduate programs for the Look College. Her research activities include investigating the use of microbial systems for the degradation of target compounds (such as hormones, crude oil, petroleum products, explosives, chemical warfare agents and chlorinated agents) that contaminate soil and water; human health risk assessment; and sustainable engineering practices. She has long promoted engineering awareness in the public education systems and hosts a STEM high school teacher program each summer.

Dr. Elizabeth Cosgriff-Hernandez

Assistant Professor, Department of Biomedical Engineering, Texas A&M University

Cosgriff-Hernandez received her B.S. in biomedical engineering and Ph.D. in macromolecular science and engineering from Case Western Reserve University. Her laboratory specializes in the development of biomaterial scaffolds to regenerate cardiovascular and orthopedic tissues. She has been recognized for her research by the TEES Select Young Faculty Award and was named the William O. and Montine P. Head Fellow in 2012. She was also recognized for her efforts to address issues related to women in science and engineering with the Texas A&M Women's Progress Award and the Women's Initiative Committee Appreciation Award.

Dr. John Criscione, M.D.

Associate Professor, Department of Biomedical Engineering, Texas A&M University

Criscione received his B.S. in applied physics from Purdue University in 1991 and his M.D. and Ph.D. from The Johns Hopkins University in 1999. He received post-doctoral training at The Johns Hopkins University and the University of California, San Diego. Criscione is a Charter Fellow of The Michael E. DeBakey Institute of Comparative Cardiovascular Science and Biomedical Devices. He has received numerous awards in research, teaching, and service. Criscione studies how mechanics — the study of force and motion in matter — applies to the biology of the heart and how to utilize such knowledge to obtain better clinical outcomes. In addition to inventing, prototyping, testing, and designing medical devices, he researches and teaches topics related to regulatory strategy and entrepreneurship.

Dr. Tatiana Erukhimova

Senior Lecturer, Department of Physics and Astronomy, Texas A&M University

Erukhimova received her Ph.D. in physics from the Institute of Applied Physics, Russian Academy of Sciences, in 1999, and is now a senior lecturer in the Department of Physics and Astronomy at Texas A&M. She has been teaching introductory physics classes since 2006 and a summer physics preparatory class for the Dwight Look College of Engineering since 2008. From 2008 to 2011 Erukhimova received four teaching awards. In 2009, with Professor Gerald North, she published a textbook, *Atmospheric Thermodynamics* (Cambridge University Press). Erukhimova is outreach coordinator in the Department of Physics and Astronomy. She coordinated and organized six successful Physics Festivals, which were highly appreciated by the community. She is in charge of the Physics Show.

Dr. Kristen Maitland

Assistant Professor, Department of Biomedical Engineering, Texas A&M University

Maitland received her B.S. and M.S. degrees in electrical engineering from Cal Poly in San Luis Obispo, Calif., with a focus in optics and optical communications. She received her Ph.D. in biomedical engineering from The University of Texas at Austin as a research fellow in the NSF Integrative Graduate Education and Research Traineeship Program in cellular and molecular imaging for diagnostics and therapeutics. She performed clinical studies at M.D. Anderson Cancer Center on precancers of the cervix and oral cavity. Following her Ph.D., Maitland returned to Lawrence Livermore as a staff scientist. Her current research interests include confocal microscopy along with other optical imaging and spectroscopy techniques for disease detection, diagnosis, and treatment; and endoscope and miniature optics development for improved access for in vivo applications.

Dr. Louis S. Nadelson

Associate Professor, College of Education, Boise State University

Nadelson holds a Ph.D. in educational psychology from the University of Nevada at Las Vegas. His scholarly interests include all areas of STEM teaching and learning, in-service and pre-service teacher professional development, program evaluation, multidisciplinary research, and conceptual change. Nadelson uses his more than 20 years of high school and college math, science, and engineering teaching to frame his research on STEM teaching and learning. He brings a unique perspective of research, bridging experience with practice and theory to explore a range of interests in STEM teaching and learning.

Dr. H. Joseph Newton

Dean, College of Science, Texas A&M University

Newton joined the Texas A&M faculty in 1978 and has served as dean of the College of Science and holder of the Richard H. Harrison III/External Advisory and Development Council Endowed Dean's Chair in Science since July 2002. Prior to that appointment, he spent two years as interim dean, two years as executive associate dean, and eight years as head of the Department of Statistics. A native of Syracuse, N.Y., Newton holds a doctorate in statistical sciences and a master of arts in statistics from the State University of New York in Buffalo. He earned his bachelor of science in mathematics from Niagara University. He is the author of numerous research articles and two books in the areas of time series analysis, computational statistics, and technology-mediated instruction. Elected a Fellow of the American Statistical Association in 1995, he currently serves as American co-editor of *Computational Statistics* and as editor of *The Stata Journal*.

Dr. Simon W. North

Professor, Department of Chemistry, Texas A&M University

North is the co-director of the Texas A&M University National Aerothermochemistry Laboratory, the associate director of the Center for Atmospheric Chemistry and the Environment, and the graduate advisor for the Department of Chemistry. He is actively involved in the study of molecular photodissociation dynamics, chemical kinetics, laser-based technique development, and flow visualization. His work has been funded by the National Science Foundation, the U.S. Air Force Office of Scientific Research, the U.S. Environmental Protection Agency and NASA. He has been author or co-author of more than 100 articles on both research and chemical education in peer-reviewed journals. During the past 15 years he has been involved in numerous outreach activities, NSF-sponsored STEM educational projects, and teaching at all levels in the department.

Dr. Timothy P. Scott

Associate Dean for Undergraduate Programs, College of Science, Texas A&M University

Scott is associate dean for undergraduate programs in the College of Science at Texas A&M University, where he also is an associate professor of science education policy. Scott performs research on teaching and learning in science and student success. He also serves as co-director of the Center for Mathematics and Science Education at Texas A&M. Scott's work focuses on national and state science standards and policy as it relates to teacher certification. In 2001, he founded the university's aggieTEACH program, which was developed to address the shortage of teachers in the high need areas of mathematics and science. In addition to aggieTEACH, Scott overseas a number of projects in the center and serves as principal investigator on two NSF-funded projects, the Science Scholars Program and the Texas A&M Robert Noyce Scholarship Program. The projects Scott has acquired and collaborated on during the past 10 years total $25 million.

Anne L. Seifert

STEM Coordinator, Idaho National Laboratory, Executive Director, i-STEM Network

Seifert is the Idaho National Laboratory STEM coordinator and founder and executive director of the i-STEM network. She holds a B.S. in elementary education, an M.A. in education administration, an Ed.S. in educational leadership, and is a 30-year veteran teacher and administrator. Seifert's research interests include STEM education, inquiry and project-based instruction with the incorporation of 21st century learning, change practices, and cultural influences on school effectiveness.

Armando Vital

Math Teacher, Veterans High School, Brownsville, Texas

A mechanical engineering graduate from Texas A&M-Kingsville, Vital previously worked as a manufacturing engineer in assembly plants for Trico Technologies Corp., CMS Hartzell, Firstlogic, and Spellman High Voltage Inc. He has been teaching algebra and geometry for the past five years and says he truly enjoys integrating real-life applications to his classroom lessons. In 2011, he earned a master's degree in educational leadership. He has attended the math pre-AP and AP calculus institutes, as well as numerous professional development trainings. Vital was a participant in the Texas A&M Research Experience for Teachers E3 program during summer 2011 and returned as master teacher for the 2012 E3 program.

Jennifer G. Whitfield

Senior Lecturer, Department of Mathematics, Texas A&M University

Jennifer G. Whitfield is currently a senior lecturer in the Department of Mathematics, the program manager for the Texas A&M University Center for Math and Science Education's aggieTEACH program, the co-director of online homework systems for the Department of Mathematics, and co-director for the Department of Mathematics Personalized Precalculus Program. She has 18 years experience teaching mathematics spanning from 7th grade to university level, has seven years experience delivering professional development to in-service teachers, and has just begun the adventure of working with pre-service teachers. During the past decade, she has worked on numerous projects that use technology to improve mathematics education and help better prepare students for college. Her latest project is the opening of a STEM Teacher Preparation Academy that aims to improve the quality of Texas A&M secondary STEM pre-service teachers.

Meagan Saldua Harris

Doctoral Candidate, Department of Biomedical Engineering, Texas A&M University

She received her B.S. degrees in applied physics and mathematics from Angelo State University in May 2008 and her M.S. in biomedical engineering from Texas A&M in December 2010. Her graduate research efforts include designing and constructing a portable confocal reflectance and fluorescence microscope for large area imaging of epithelial tissues for preclinical studies. She has an interest in academia and enjoys mentoring undergraduate students in research. She currently mentors 13 students on two global health projects through the AggiE-Challenge Program.

Mary Beth Browning

Ph.D. Candidate, Department of Biomedical Engineering, Texas A&M University

Browning is a fourth-year graduate student in the laboratory of Dr. Elizabeth Cosgriff-Hernandez, where she is working on developing a small-diameter vascular graft for bypass surgeries. Browning is the recipient of the National Science Foundation Graduate Research Fellowship and the P.E.O. Scholar Award. She was responsible for jump-starting middle school outreach activities between the Cosgriff-Hernandez lab and College Station Middle School.

Jenny Robinson

Ph.D. Candidate, Department of Biomedical Engineering, Texas A&M University

Robinson is a third year Ph.D. student in the Cosgriff-Hernandez laboratory working on developing an injectable, high-porosity bone graft. She is a National Science Foundation Graduate Research Fellow and was involved in the establishment of the Texas A&M Society for Biomaterials Student Chapter in 2010. She is involved in multiple outreach activities and is the co-facilitator of the monthly science club activities at College Station Middle School.



THE TEXAS A&M CENTER FOR INNOVATION
in Advanced Development & Manufacturing

How STEM Education will Save the World from the Next Pandemic

2013 Teacher Summit
Focus on STEM: Science and Engineering in the Classroom

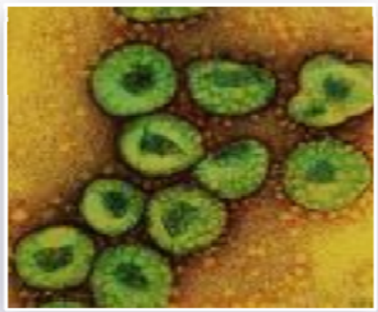
Brett Giroir, M.D.
Vice Chancellor for Strategic Initiatives
Principal Investigator

The New Reality of Emerging Diseases

The Natural Threat

Emergence of new, virulent pathogens
(50 appeared since 1973)

H5N1



SARS

Transportation assures rapid global spread of emerging diseases

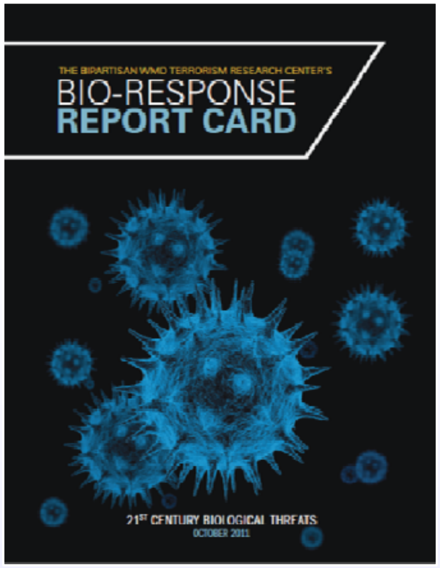
August 16, 2012 7:37 AM

West Nile virus: Dallas declares state of emergency

Novel Influenza A Virus (H3N2)

From July 12 through August 23, 2012, a total of 276 infections with influenza A

CDC



Bioterrorism Report Card: U.S. unprepared

CNN

October 12, 2011

President Obama warns Syria against using chemical or biological weapons

"there would be enormous consequences' if Assad appeared to be preparing to use poison gas or biological weapons"

August 12, 2012

The Bio-Engineered Threat

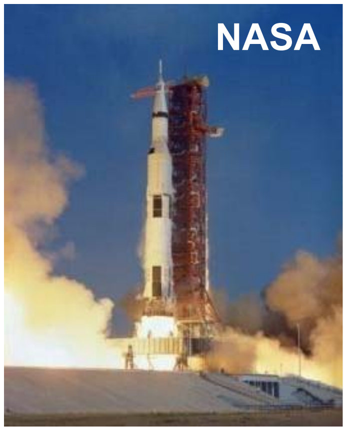
The Economist
10 May 2010

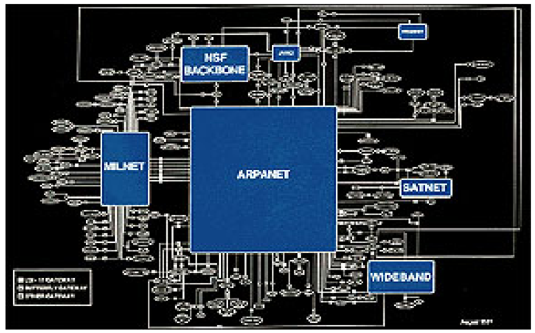
Artificial life, the stuff of dreams and nightmares, has arrived

November 2011

Should a New Recipe for Engineered Bird Flu, Potent Enough to Kill Millions, Be Published?

DARPA: The National Agent for United States Technological Superiority





ARPA-Net

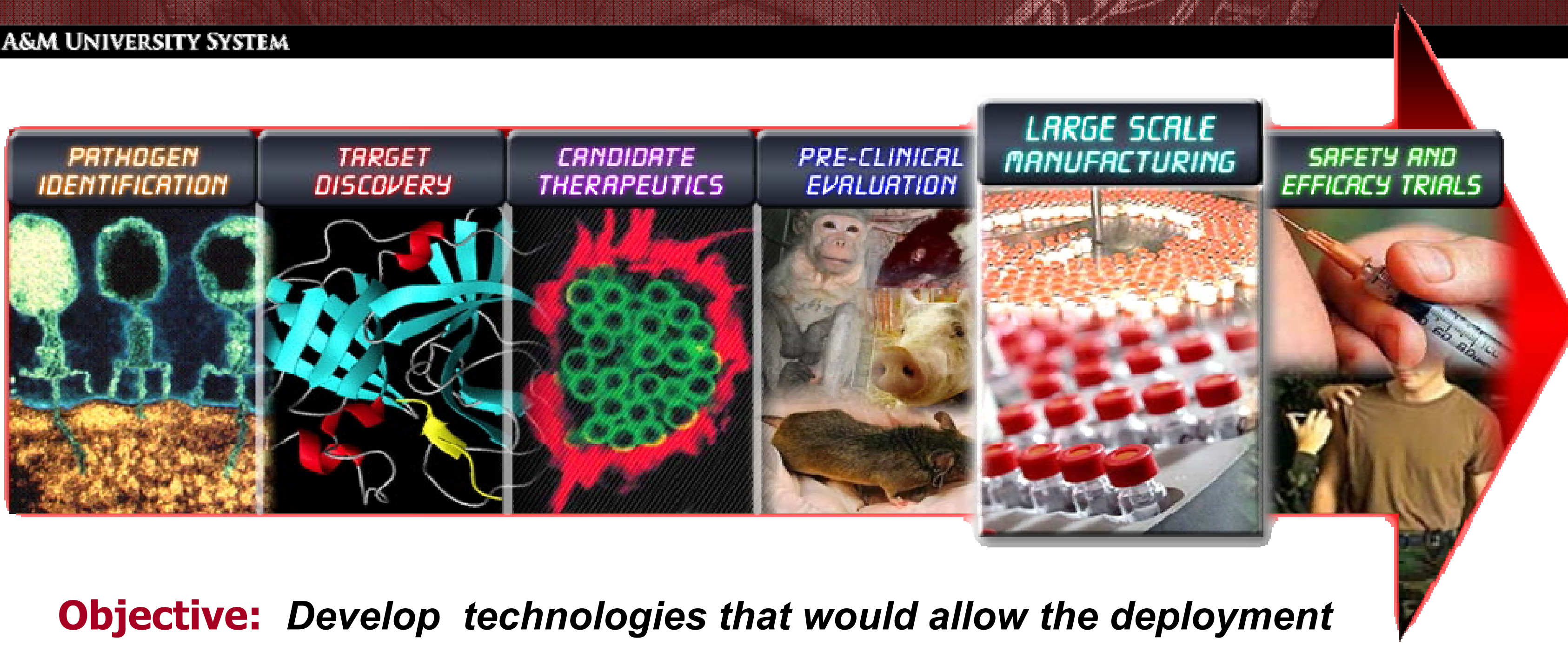
Stealth

Brain Controlled Prosthetics

"Big breakthroughs happen when what is suddenly possible meets what is desperately necessary."

- Thomas L. Friedman
New York Times, May 15, 2012

Accelerating Critical Therapeutics ~2004



Objective: *Develop technologies that would allow the deployment of 100 million doses of a safe and effective vaccine/therapeutic within 16 weeks of a new pathogen emergence*

Supportive Studies

DARPA DSRC

NATIONAL ACADEMY OF ENGINEERING

DARPA

UPMC

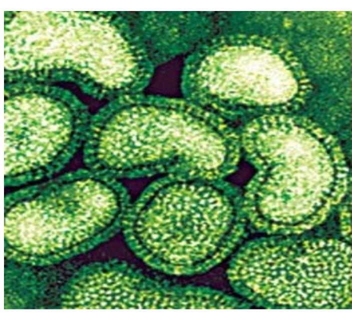
The H1N1 Pandemic Wake-Up Call

Edgar Hernandez
Patient Zero - March 2009

The New York Times

April 27, 2009
U.S. Declares Public Health Emergency Over Swine Flu

Pandemic Declared- June 11, 2009

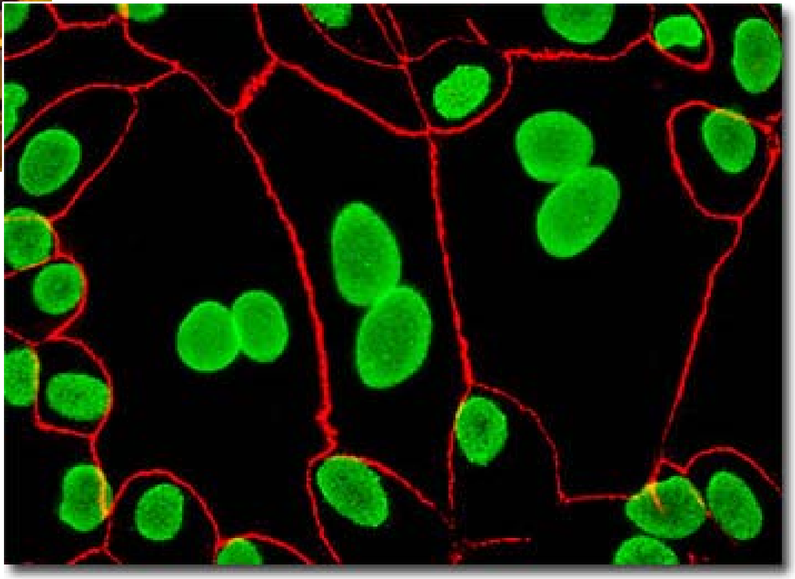


1918, H1N1

2009, H1N1

- 60.8 million cases
- 274,000 hospitalizations
- 12,469 deaths

How Influenza Vaccines are Produced



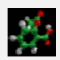
"Modern" Recombinant Vaccines and Antibodies

Must be Manufactured in Genetically Engineered Cells (adapted from Genentech)

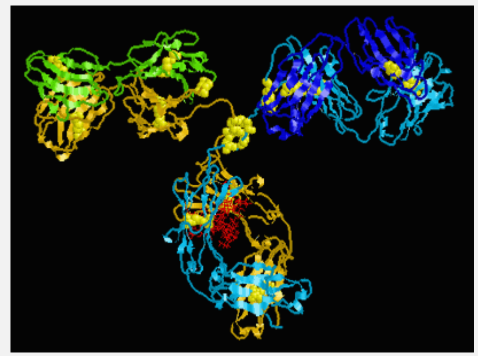
SIZE

COMPLEXITY

"Small Molecule Drug"
Aspirin
21 Atoms



"Biological Drug"
Antibody
~25,000 atoms

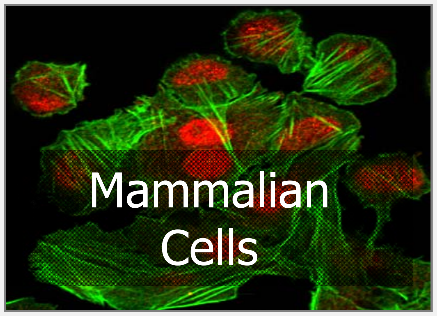


Bike
~20 pounds

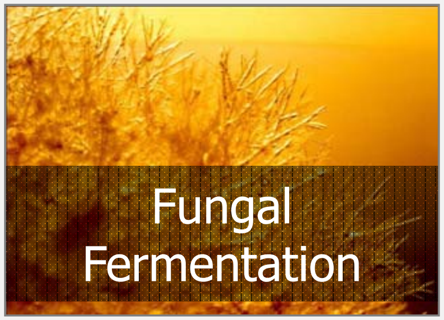
Business Jet
~30,000 pounds

“Modern” Recombinant Vaccines and Antibodies

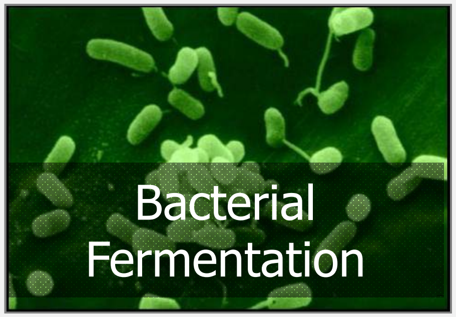
Expression Platforms



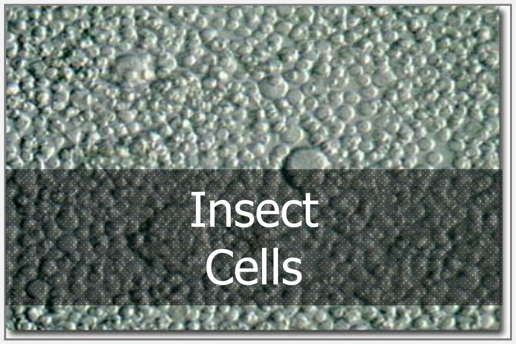
CHO cells



Neurospora crassa



Pseudomonas fluorescens



Spodoptera frugiperda ovarian cells

Nicotiana benthamiana

The U.S. has Launched a New National Biosecurity Initiative

"And we are launching a new initiative that will give us the capacity to respond **faster and more effectively** to bioterrorism or an infectious disease - a plan that will counter threats at home and strengthen public health abroad."

President Barack Obama
State of the Union
January 2010

"Our Nation must have the **nimble, flexible capacity** to produce MCMs rapidly in the face of any attack or threat, known or unknown, including a novel, previously unrecognized, naturally occurring emerging infectious disease."

U.S. Department of Health and Human Services
The Public Health Emergency Medical Countermeasures Enterprise Review
August 2010

Centers For Innovation in Advanced Development And Manufacturing

Objectives

- **Develop a national response capability to manufacture pandemic influenza vaccines for the U.S. population**
  (50 million doses in 4 months: implies new cell-based or recombinant vaccine; Global pharmaceutical partner must be "anchor tenant")
- **Manufacture biothreat vaccines and medical countermeasures for the U.S. Strategic National Stockpile (SNS)**
  (CBRN: Current requirements are for 17 products)
- **Lead the development of new vaccines and countermeasures from ~Pre-IND through licensure**
  (pivotal animal models, clinical trials, regulatory submissions, etc.)
- **Train the U.S. workforce in all aspects of vaccine and MCM development**

TAMUS is the Prime Contractor / System Integrator

Final Proposal Team

THE TEXAS A&M UNIVERSITY SYSTEM

INTEGRATED BIOPHARMACEUTICAL COMPANIES

- GlaxoSmithKline Biologicals (Belgium)

ACADEMIC INSTITUTIONS

- Baylor College of Medicine (Texas)
  - Sabin Vaccine Institute
  - Vaccine Research Unit
  - Texas Children's Hospital
- UTMB-Galveston National Laboratory
- University of Florida
- Blinn College (Texas)

BIOPROCESS TECHNOLOGY PROVIDERS

- Sartorius (Germany)
- GE Healthcare (Sweden)
- deltaDOT (UK)

TAMUS COMPONENTS

- Texas A&M University
- Texas A&M Health Sciences Center
- Texas Engineering Experiment Station (TEES)
- Texas Engineering Extension Service (TEEX)
- Texas Veterinary Medical Diagnostic Laboratory (TVMDL)
- Texas A&M Research Foundation (TAMRF)

NON-PROFIT RESEARCH INSTITUTES

- Lovelace Biomedical and Environmental Research Institute (New Mexico)
- Texas Biomedical Research Institute (Texas)
- Mary Crowley Research Center (Texas)

COMMERCIAL PARTNERS

- Kalon Biotherapeutics (Texas)
- Lonza Houston (Texas)
- PPD, Inc. (North Carolina)
- NDA Partners (California)
- Caliber Biotherapeutics (Texas)

- The Beck Group (Dallas)
- Vaughn Construction (Houston)

Centers for Innovation in Advanced Development and Manufacturing

Announced June 18, 2012

THE TEXAS A&M UNIVERSITY SYSTEM

emergent biosolutions™

THE TEXAS A&M UNIVERSITY SYSTEM

NOVARTIS

Workforce Development

Estimated 1,000 Additional Jobs in the first 5 years

Biotherapeutics Manufacturing and Advanced Development Training Programs

Base Funding: $23.6 Million

Biotherapeutics Manufacturing Curriculum

Certificate Programs to Graduate Degrees

Certificate Programs & Short Courses

Entry-Level Positions in Therapeutics Manufacturing

↓

Associate Degrees/Certificates in Therapeutics Manufacturing

Process Development Assistants

Manufacturing Technicians

Maintenance Technicians

QA/QC Assistants

Process Technicians

Instrumentation & Calibration Technicians

↓

Bachelor Level Certificate in Therapeutics Manufacturing

Process Development

QA/QC Associate/Manager

Process Engineers

↓

Professional Masters Degrees (PPiB, Biomanufacturing)

Graduate Fellows in Therapeutics Manufacturing

Engineers

Business Leaders

Researchers

Scientists

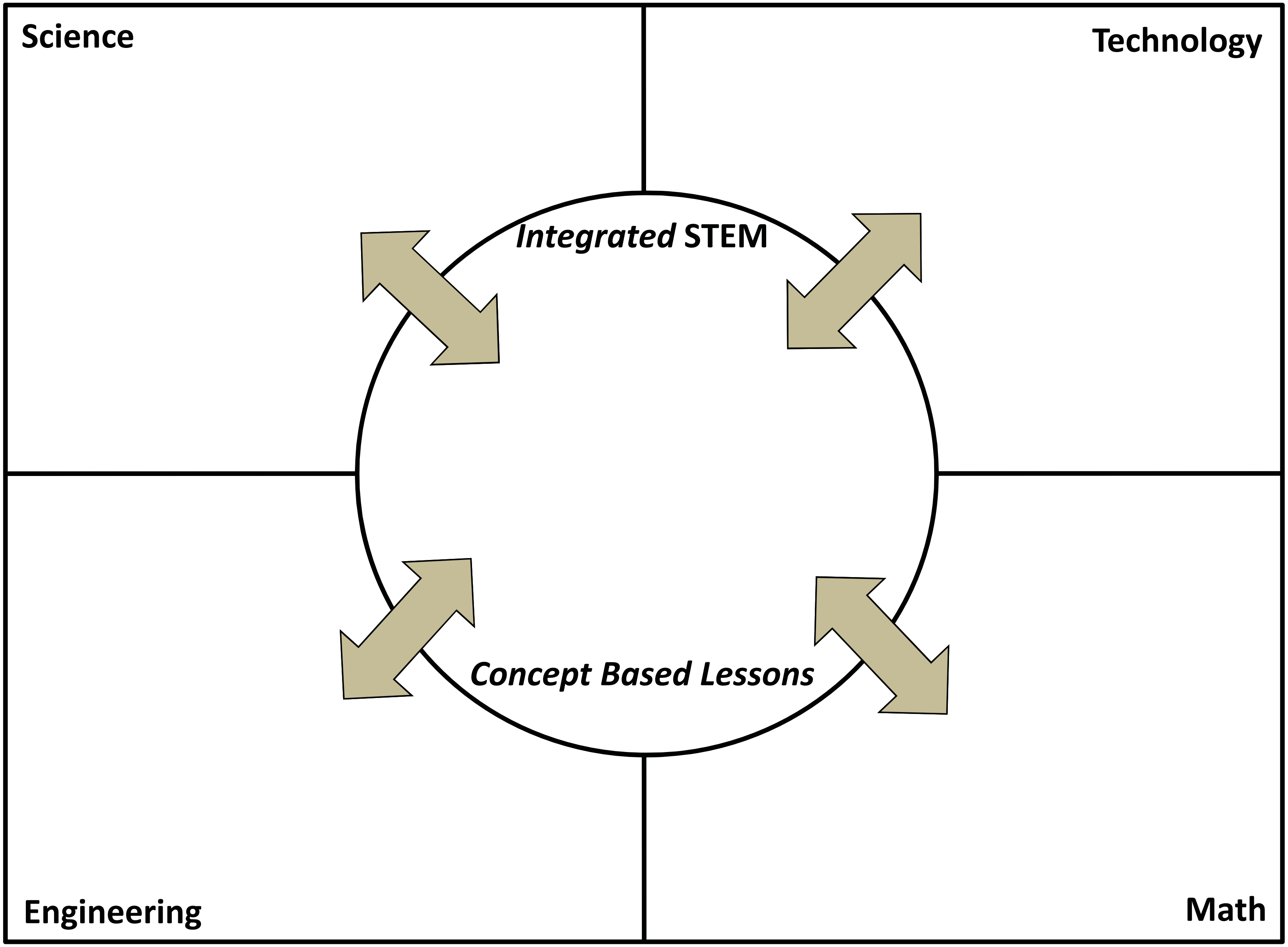
NCTM High School Summer Camp

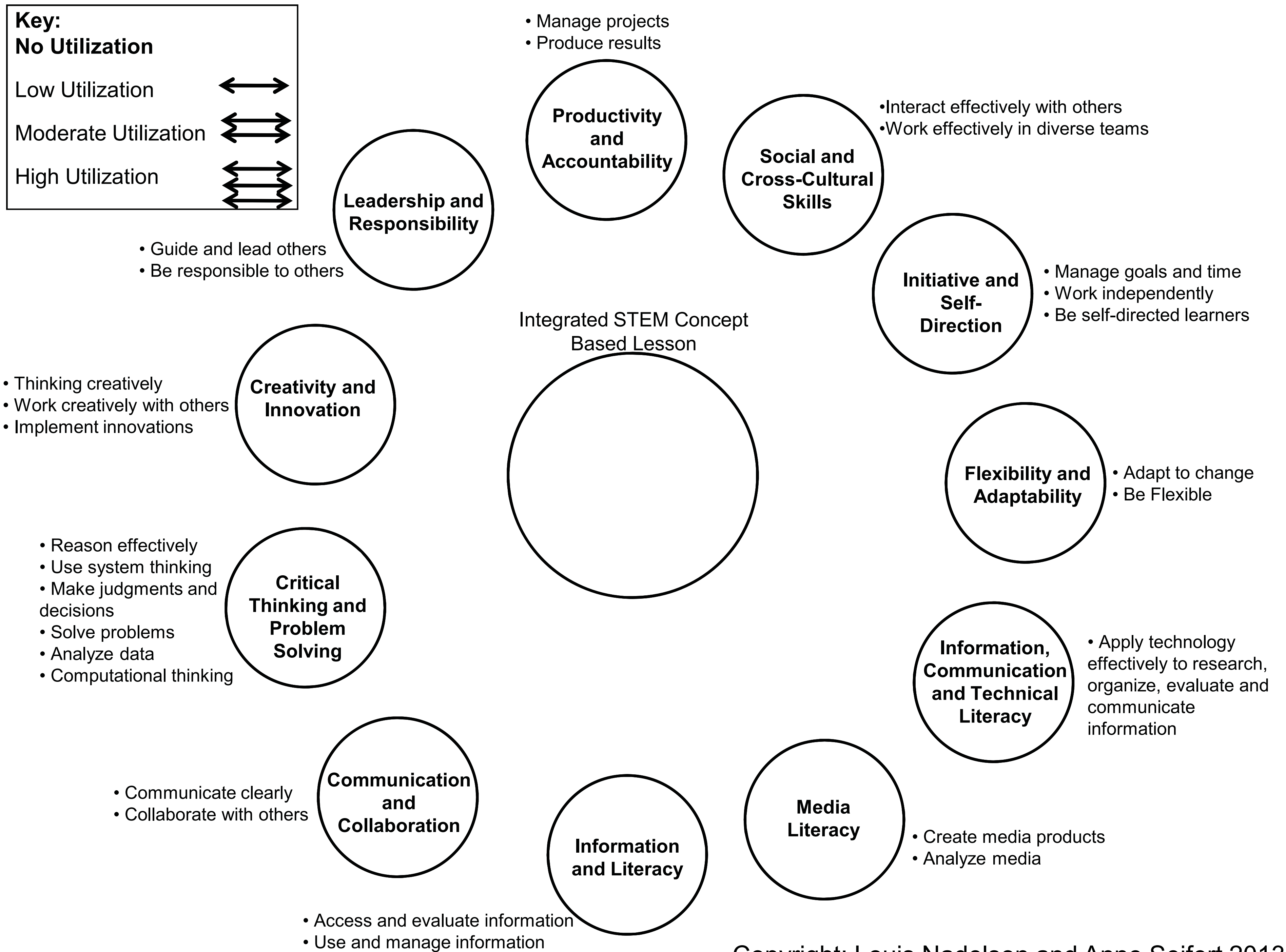
THE TEXAS A&M UNIVERSITY SYSTEM

Teacher Summit 2013

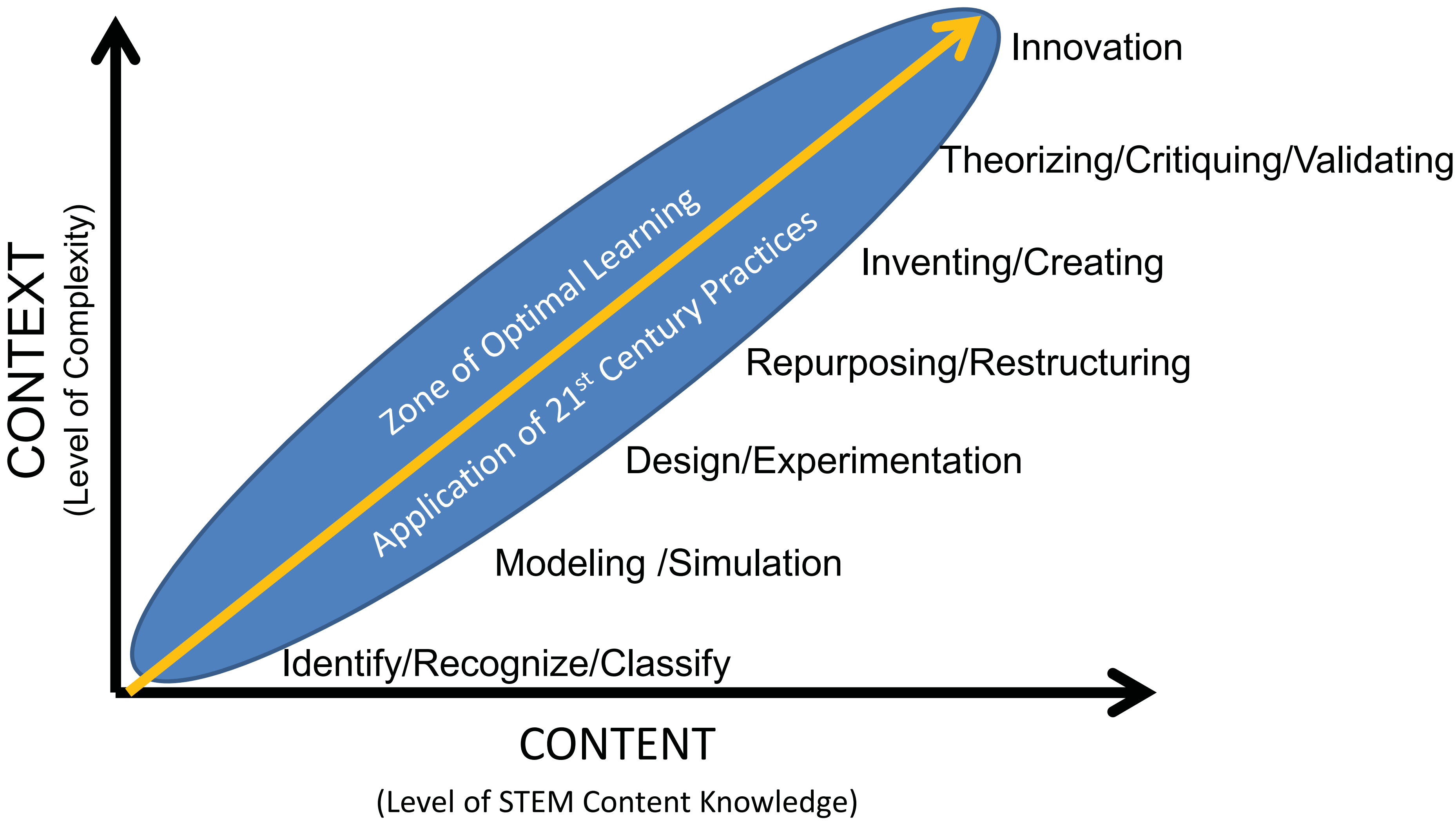
Workshop 1

Integrated STEM


Science
Technology
Integrated STEM
Concept Based Lessons
Engineering
Math


Key:
No Utilization
Low Utilization
Moderate Utilization
High Utilization
• Manage projects
• Produce results
Productivity and Accountability
Social and Cross-Cultural Skills
•Interact effectively with others
•Work effectively in diverse teams
Leadership and Responsibility
• Guide and lead others
• Be responsible to others
Initiative and Self-Direction
• Manage goals and time
• Work independently
• Be self-directed learners
Integrated STEM Concept Based Lesson
Creativity and Innovation
• Thinking creatively
• Work creatively with others
• Implement innovations
Flexibility and Adaptability
• Adapt to change
• Be Flexible
• Reason effectively
• Use system thinking
• Make judgments and decisions
• Solve problems
• Analyze data
• Computational thinking
Critical Thinking and Problem Solving
Information, Communication and Technical Literacy
• Apply technology effectively to research, organize, evaluate and communicate information
• Communicate clearly
• Collaborate with others
Communication and Collaboration
Media Literacy
Information and Literacy
• Create media products
• Analyze media
• Access and evaluate information
• Use and manage information

Content and Context



Workshop 2

Plastics for the Body: From Healing Wounds to Treating Cancer

Plastics for the Body

Raffle KITS

Item	Company	Item Number	Price	#	Subtotal
Jelly Marbles	Steve Spangler	WSAS-550	$9.99	1	$9.99
Water Gel- Magic Slush Powder	Steve Spangler	WSPA-650	$19.99	1	$19.99
5 ml syringes**	VWR				$0.00
12 well plates*	VWR				
Popsicle Sticks, Plastic Cups, Salt, Food Coloring	Local Store		<$20	1	$20.00
Total					$49.98

Materials for Sessions

Item	Company	Item Number	Price	#	Subtotal
Jelly Marbles	Steve Spangler	WSAS-550	$9.99	4	$39.96
Water Gel- Magic Slush Powder	Steve Spangler	WSPA-650	$19.99	4	$79.96
Plastic Cups, Salt, Food Coloring, Popsicle Sticks	Local Store		<$20	1	$20.00
12 well plates (pack of 100)*	VWR	80650-930	83.26	1	$83.26
5 ml syringes (pack of 125)**	VWR	BD309646	$21.01	1	$21.01
Timers + Calculators (5X)	Cosgriff-Hernandez Lab				
Total					$244.19

***1 pack = enough for sessions + 4 kits**
***2 packs = enough for sessions + 8 kits**

**** 1 pack = enough for sessions + 1 kit (25/kit)**
****2 packs = enough for sessions + 6 kits (25/kit)**

Link
http://www.stevespanglerscience.com/product/jelly-marbles-jar
http://www.stevespanglerscience.com/product/water-gel

Link
http://www.stevespanglerscience.com/product/jelly-marbles-jar
http://www.stevespanglerscience.com/product/water-gel
https://us.vwr.com/store/catalog/product.jsp?catalog_number=82050-930
https://us.vwr.com/store/catalog/product.jsp?catalog_number=BD309646

Hydrogels for Medicine Delivery: Instructor Version

Problem Statement:

Researchers have recently developed a new medicine that can be taken orally to treat cancer. They need your help to analyze the effectiveness of a pill that has been made to release the medicine, Cancer-No-More.

Background:

Polymers: *Poly = many; mer = unit → Polymer = many units*

Polymers are made up of many molecules all connected together in long chains. They can have hundreds, thousands, or millions of molecules. Some of the molecules that typically make up polymers are carbon, hydrogen, oxygen, and nitrogen. Find these elements on the periodic table and record their atomic number, molar mass, group, and period in the table below.

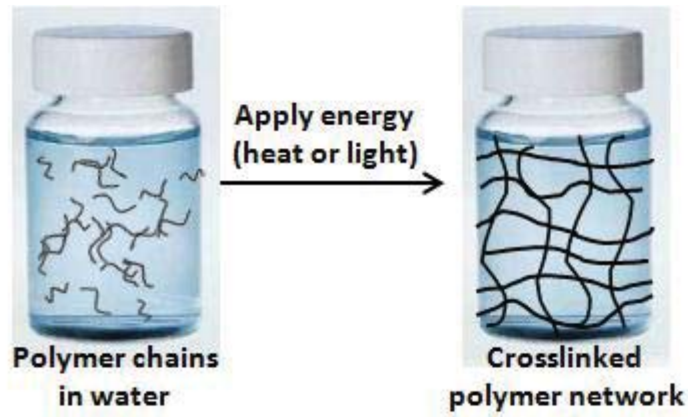
Element	Atomic Number	Molar Mass	Group	Period
Carbon	6	12	14	2
Hydrogen	1	1	1	1
Nitrogen	7	14	15	2
Oxygen	8	16	16	2

Things that you refer to as "plastic" are actually polymers. List some polymers (or plastics) that are in the room right now in the space below:

- Chairs
- Pens
- Clothes (fibers/threads)
- Notebooks/Folders
- Computers/Keyboards/Mice

Hydrogels: *Crosslinked polymer networks capable of swelling up to 100 times their dry weight in water*

To create a polymer network, energy (typically in the form of light or heat) can be introduced to smaller polymer chains in a solution to cause them to "crosslink" or "polymerize" into a solid, three-dimensional network:



Once a polymer is covalently crosslinked into a network, the network cannot be broken down or melted. If the polymer chains are **hydrophilic**, the network is a **hydrogel** that will swell (i.e. grow) when placed in water as it absorbs the water.

> ***Hydrophilic*** = *"water loving" → interacts with water*
> ***Hydrophobic*** = *"water hating" → does not interact with water*

In the table below, list some things that you use or have seen that are hydrophilic (absorbs water) or hydrophobic (repels water):

Hydrophilic	Hydrophobic
• Diapers • Clothing/towels • Soil • Jello • Gauze/wound contacting part of Band-Aids	• Glass (car windows) • Plant leaves • Oil (cooking or motor) • Water balloons (latex) • Outer part of Band-Aids

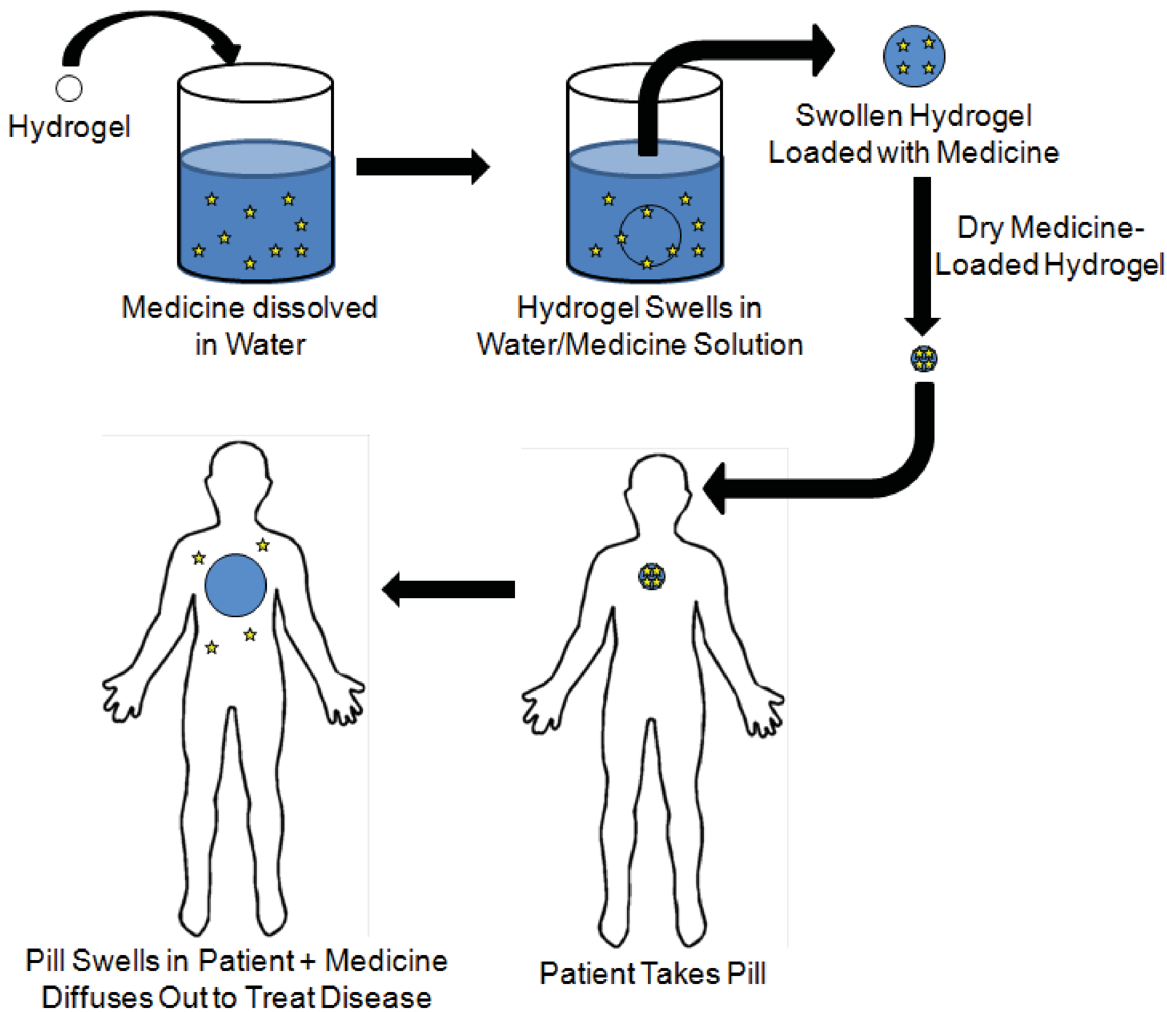
Some hydrogels that you may have seen and used are contact lenses and Jello®. Hydrogels are also used in drug delivery applications, because medicines can be dissolved in the water that a hydrogel is swelled in. As the hydrogel swells, the medicine **diffuses** into the hydrogel network with water:

> ***Diffusion*** = *Movement of material from areas of high to low concentration to obtain a constant concentration throughout space (EX: people huddled on one side of an empty room will spread out so that they are evenly distributed throughout the room)*

List some other examples of diffusion that you can think of below:

- Air fresheners/perfumes → smells diffuse
- Tea bag/making tea → color/flavor diffuses
- Cigarette smoke → smell/smoke diffuses

Once the hydrogel has been loaded with medicine, it can be dried to create a smaller pill with the medicine trapped inside. The patient can swallow the dried hydrogel, or pill, and it re-swells in their body, because the body is mostly made of water. As it re-swells, the medicine that is trapped inside **diffuses** out of the pill and is released inside of the body. Draw a schematic of this process in the space below:



<u>Experimental Setup</u>:

You need to release 10 milligrams (mg) of Cancer-No-More in your patient to effectively treat cancer.
You have a dried hydrogel that absorbs 0.1 milliliters (ml) of solution.
Cancer-No-More dissolves easily in water at 50 mg/ml.

1. What concentration of Cancer-No-More would you need to make your swelling solution (in mg/ml) to ensure that you release the desired amount of medicine from your pill? Is this possible given the solution parameters of Cancer-No-More? If not, what is an alternative solution?

   ***Answers**:* *100 mg/ml*
   No- it is too high
   Dissolve drug at 50 mg/ml and swell two gels in this solution.
   → *the patient must take 2 pills instead of one.*

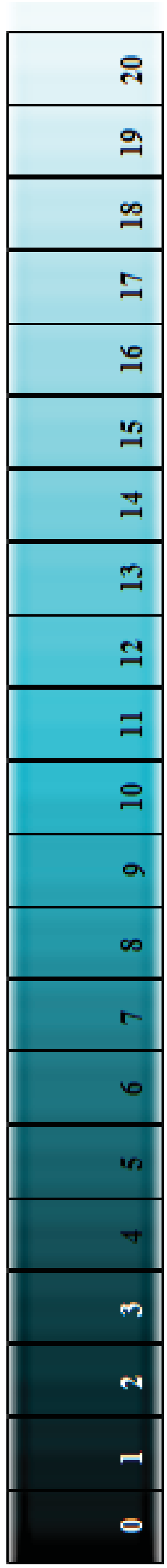
2. How could you test the time that it takes for your pill to release Cancer-No-More?

   ***Answer**:* *Load pill with drug, then place it into fresh water. Change water at regular intervals, and measure amount of drug in solution after each interval until none is left.*

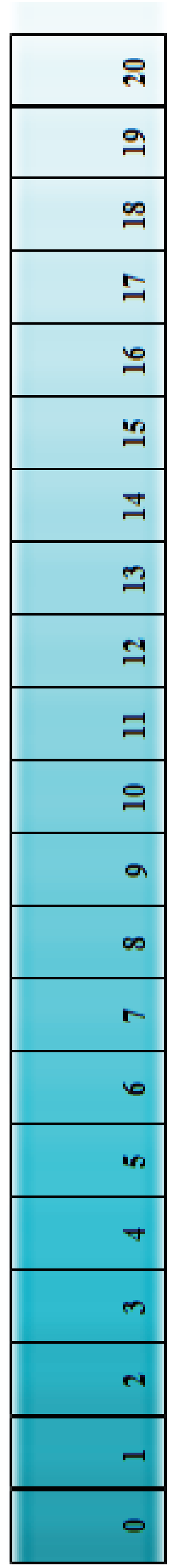
3. What do you think the effect on release time would be if the patient takes the pill in its swollen state instead of dried? When looking at the example pills, what other benefits and drawbacks can you think of to using swollen vs. dried pills?

   ***Answers**:* *Release would be faster from swollen gel.*
   Dried pills are smaller → *easier to swallow*
   Swollen pills would have to be packaged swollen → *less control over how swollen they are + less control over release rate*
   Swollen pills are softer → *may be easier to swallow*

Dried Gel Scale:



Swollen Gel Scale:



Experiment:

Goal: Compare the release times of a medicine from dried pills and swollen pills.

Hypothesis: Release time from dried pills will be **greater than, less than, or equal to (circle one)** release time from swollen pills

Methods:

1. Obtain well plates with medicine-loaded pills that have been swelled in fresh water from the dried (D) or swollen (S) state for up to 8 hours (3 samples/time point).
2. Use the color scales that are provided to measure the level of blue medicine that has been released from each sample at the various release time points. *The dry scale is different from the swollen scale, because dried gels are darker in color. Ensure that you use the appropriate scale for the given samples.*
3. Find the point on the color scale that most closely matches the color of each gel, and record the corresponding scale number for that region to indicate the level of color that remains in the pill at the given release time point. The medicine is blue, so this gives a relative level of medicine that remains in the pill at each time point. At 0 hours, no medicine has been released, so this has been set to "0". Similarly, at 24 hours, all of the medicine has been released, so this has been set to "20". Your teacher has examples of 0 and 24 hour samples that you can look at.
4. Record your results in the tables provided below.

Results:

Time	Dry Pills			Swollen Pills		
Pill Number	**1**	**2**	**3**	**1**	**2**	**3**
0 hours	0	0	0	0	0	0
1 hour						
2 hours						
8 hours						
24 hours	20	20	20	20	20	20

Using the formulas below, calculate and record the mean, variance, and standard deviation of the release level at each time point for the dried and swollen drug carriers:

Time	Dry Pills			Swollen Pills		
Calculation	**Mean**	**Variance**	**Standard Deviation**	**Mean**	**Variance**	**Standard Deviation**
0 hours	0	0	0	0	0	0
1 hour						
2 hours						
8 hours						
24 hours	20	0	0	20	0	0

$$Mean = \frac{Sum\ of\ values}{Number\ of\ samples}$$

$$Variance = \frac{\sum(value - mean)^2}{Number\ of\ samples}$$

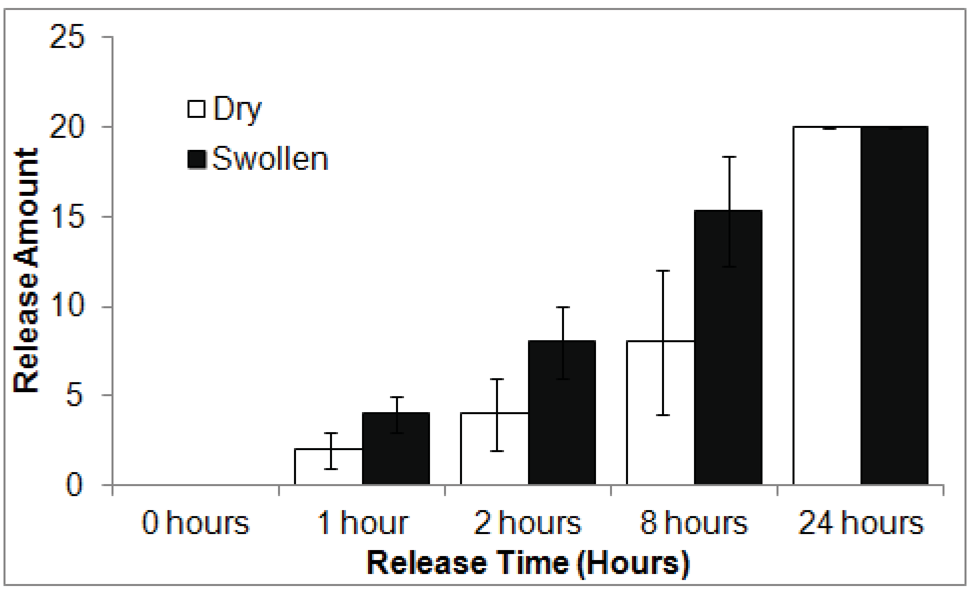
→ *Variance is a measure of how different your values are from your mean, and its used to calculate standard deviation*

$$Standard\ Deviation = \sqrt{Variance}$$

→ *Standard deviation is a measure of how spread out a set of values is*

Make a plot of mean release amount versus release time for both the dried and swelled pills in the space below. Label your axes, and put in bars that display standard deviation above and below the mean values (mean ± standard deviation):

EXAMPLE DATA:



Conclusions:

Make a conclusion based on your results and how they compared to your hypothesis:

BONUS QUESTION: There was a design flaw in the making of these pills. Can you tell what it is by looking at the swollen samples? What do you think that the effect of this design flaw is on release rate (hint: look at the gels that have partially released their medicine under water)? Why is this the case?

Answers: *Design flaw = Gels are different sizes.*
Larger gels release more slowly (when looking at the gels under water, you can see that the remaining drug is isolated in the center of the gel, while the outside of the gel is clear)
It takes longer for the drug to diffuse from the center of the larger gels out into the surrounding solution.

Now that you have seen and worked with hydrogels, what other applications could you think of for hydrogels and/or where else have you seen hydrogels?

- *Wound dressings- keeps wound bed moist to promote healing*
- *Farming- Maintain water in soil over long time periods*
- *Diapers- absorb baby waste*
- *Snot- protects our bodies from inhaling harmful substances through our noses + keeps our noses/mouth from drying out*
- *Jellies/jams- helps preserve fruits/keeps them moist for long time periods*

Hydrogels for Medicine Delivery

Problem Statement:

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Background:

***Polymers**: Poly = many; mer = unit → Polymer = many units*

Polymers are made up of many molecules all connected together in long chains. They can have hundreds, thousands, or millions of molecules. Some of the molecules that typically make up polymers are carbon, hydrogen, oxygen, and nitrogen. Find these elements on the periodic table and record their atomic number, molar mass, group, and period in the table below.

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Hydrogen				
Nitrogen				
Oxygen				

Things that you refer to as "plastic" are actually polymers. List some polymers (or plastics) that are in the room right now in the space below:

-
-
-
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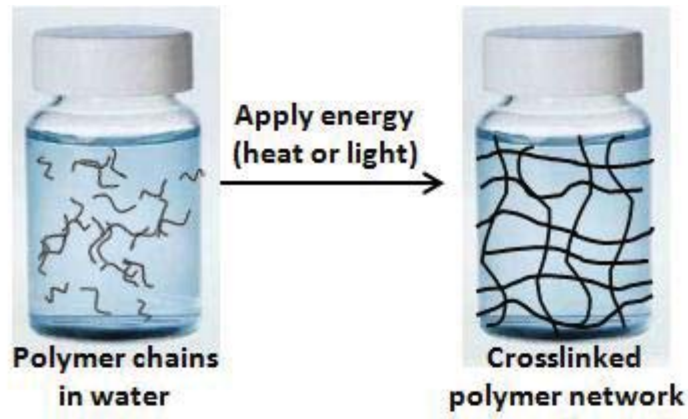

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In the table below, list some things that you use or have seen that are hydrophilic or hydrophobic:

Hydrophilic	Hydrophobic
•	•
•	•
•	•
•	•
•	•

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> ***Diffusion*** *= Movement of material from areas of high to low concentration to obtain a constant concentration throughout space (EX: people huddled on one side of an empty room will spread out so that they are evenly distributed throughout the room)*

List some other examples of diffusion that you can think of below:

-
-
-

Once the hydrogel has been loaded with medicine, it can be dried to create a smaller pill with the medicine trapped inside. The patient can swallow the dried hydrogel, or pill, and it re-swells in their body, because the body is mostly made of water. As it re-swells, the medicine that is trapped inside **diffuses** out of the pill and is released inside of the body. Draw a schematic of this process in the space below:

Experimental Setup:

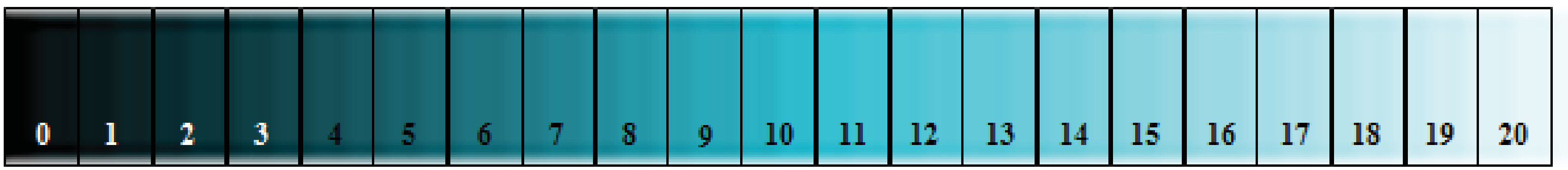
You need to release 10 milligrams (mg) of Cancer-No-More in your patient to effectively treat cancer.
You have a dried hydrogel that absorbs 0.1 milliliters (ml) of solution.
Cancer-No-More dissolves easily in water at 50 mg/ml.

1. What concentration of Cancer-No-More would you need to make your swelling solution (in mg/ml) to ensure that you release the desired amount of medicine from your pill? Is this possible given the solution parameters of Cancer-No-More? If not, what is an alternative solution?

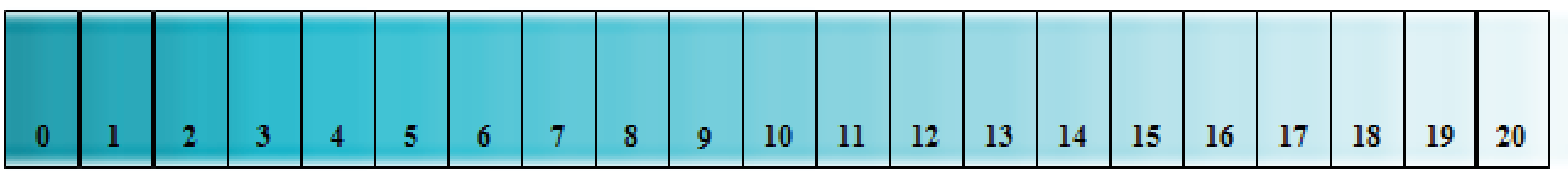
2. How could you test the time that it takes for your pill to release Cancer-No-More?

3. What do you think the effect on release time would be if the patient takes the pill in its swollen state instead of dried? When looking at the example pills, what other benefits and drawbacks can you think of to using swollen vs. dried pills?

Dried Gel Scale:



Swollen Gel Scale:



Experiment:

Goal: Compare the release times of a medicine from dried pills and swollen pills.

Hypothesis: Release time from dried pills will be **greater than, less than, or equal to (circle one)** release time from swollen pills

Methods:

1. Obtain well plates with medicine-loaded pills that have been swelled in fresh water from the dried (D) or swollen (S) state for up to 8 hours (3 samples/time point).
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4. Record your results in the tables provided below.

Results:

Time	Dry Pills			Swollen Pills		
Pill Number	**1**	**2**	**3**	**1**	**2**	**3**
0 hours	0	0	0	0	0	0
1 hour						
2 hours						
8 hours						
24 hours	20	20	20	20	20	20

Using the formulas below, calculate and record the mean, variance, and standard deviation of the release level at each release time point for the dried and swollen drug carriers:

Time	Dry Pills			Swollen Pills		
Calculation	**Mean**	**Variance**	**Standard Deviation**	**Mean**	**Variance**	**Standard Deviation**
0 hours	0	0	0	0	0	0
1 hour						
2 hours						
8 hours						
24 hours	20	0	0	20	0	0

$$Mean = \frac{Sum\ of\ values}{Number\ of\ samples}$$

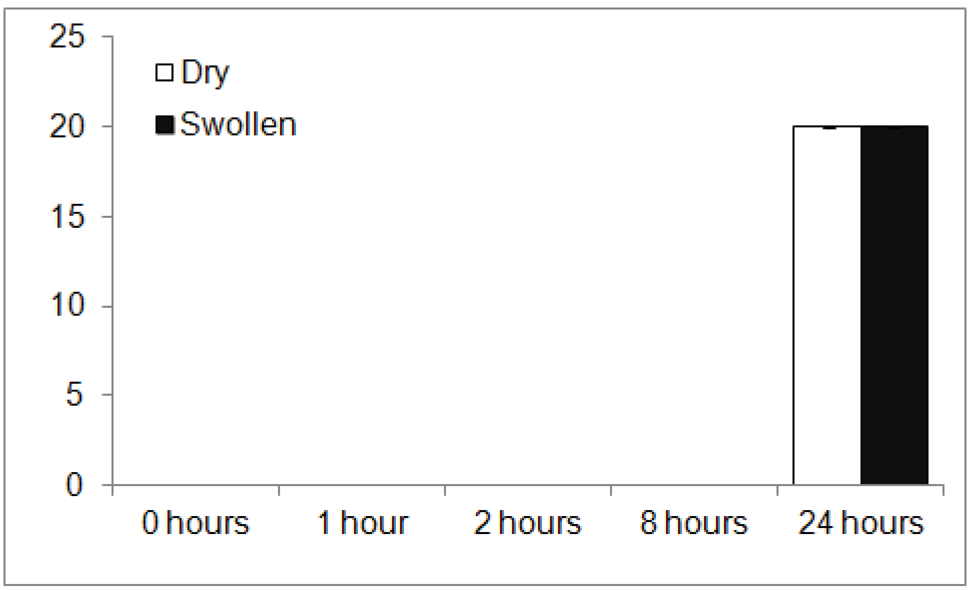
$$Variance = \frac{\sum(value - mean)^2}{Number\ of\ samples}$$

→ *Variance is a measure of how different your values are from your mean, and it is used to calculate standard deviation*

$$Standard\ Deviation = \sqrt{Variance}$$

→ *Standard deviation is a measure of how spread out a set of values is*

Add your data for 1, 2, and 8 hour release levels to the plot below for both the dried (white) and swelled (black) pills. Label your axes (X and Y), and put in bars that display standard deviation above and below the mean values (mean ± standard deviation):



Conclusions:

Make a conclusion based on your results and how they compared to your hypothesis:

BONUS QUESTION: There was a design flaw in the making of these pills. Can you tell what it is by looking at the swollen samples? What do you think that the effect of this design flaw is on release rate (hint: look at the gels that have partially released their medicine under water)? Why is this the case?

Now that you have seen and worked with hydrogels, what other applications could you think of for hydrogels and/or where else have you seen hydrogels?

-
-
-
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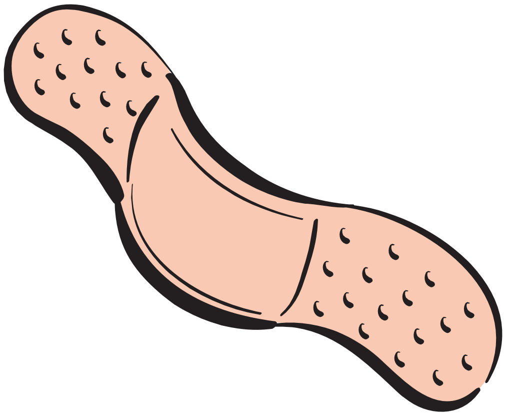
Hydrogels for Wound Dressings

Problem Statement: ***Design a wound dressing (similar to bandage) that is easy to implement, fills the wound void, keeps the wound bed moist, and is easy to remove.***



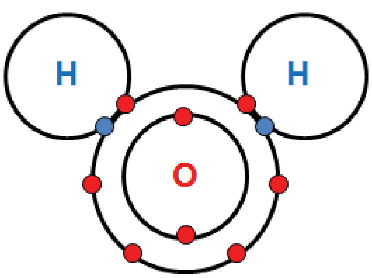
Background Definitions:

Polymers: *Poly* = many; *mer* = unit → *Polymer* = many units
Polymers are molecules composed of many repeat units forming a long chain. They can have hundreds, thousands, or millions of molecules. Some of the atoms that typically make up polymers are carbon, hydrogen, oxygen, and nitrogen. Common materials we call plastics are a class of polymers. How polymers act and feel depend on the molecules of which they are composed. The properties that you can see and feel reflect what is going on at the molecular level.

Hydrophilicity/Hydrophobicity: a measure of how much a material wants to interact with water. *Hydrophilic* materials love water and *hydrophobic* dislike water.

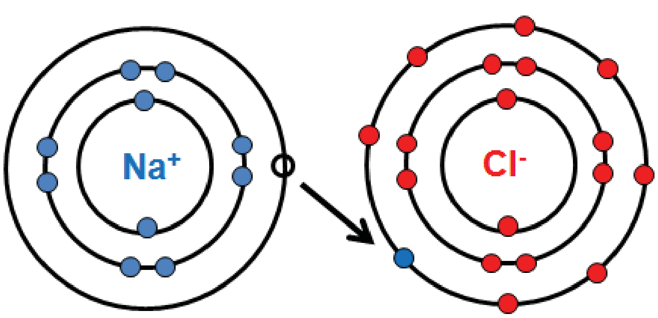
Hydrogels: are composed of *hydrophilic (water loving)* polymer chains that make a network and swell in water. Contact lenses are an example of a common hydrogel system.

Covalent bond: chemical bond where atoms share electrons



A water molecule exhibits covalent bonding between hydrogen and oxygen atoms.

Ionic bonds: chemical bond between two oppositely charged ions which are unstable



Salts experience ionic bonding. **Na^{1+} + Cl^{1-}** are common atoms that exhibit ionic bonds.

INSTRUCTOR VERSION

Experimental Setup:

Materials:
- 3 plastic cups (avoid Styrofoam as it is difficult to make observations about the gel)
- 5 ml syringe
- ¼ tsp measuring spoon
- graduated cylinder or measuring cup
- popsicle stick
- container for water (cup, beaker, et c.)
- 2 tsp polymer powder (gels can be disposed of in normal waste/trash can)
- water
- salt

Conversions	
1 ml water = 0.338 fluid ounces water	1 tsp sodium chloride salt = 4.45 grams sodium chloride salt

Goal: *Dr. Whale is treating a patient who suffers from diabetes and has a diabetic ulcer (wound) that must be filled by a wound dressing. You must determine how much water to add to the dry polymer to make an effective wound dressing and inform the physician. Additionally, Dr. Whale needs information on any side effects to inform the patient.*

Methods:

Put ½ tsp polymer powder in cup. Add 5 ml of water at a time to the dry polymer until the entire polymer is wet (mix with popsicle stick) and the solution gels (cup can be turned upside down without any movement and maintains shape). Note the volume added using tally marks. Continue to add water until it is too slushy to fill wound bed (no longer gels, moves/falls out of cup, or does not maintain shape). How confident are you that these are the correct amounts to tell the doctor? (HINT: Discuss your values with your neighbor.)

~ 10-15 ml to gel

~ 70-100 ml to become slushy

Need more data points to ensure confidence

Repeat 3X, and compare your mean, median, and mode amounts with your first run.

Solid Gel	**Volume of water (ml)**	***Slushy Gel***	**Volume of water (ml)**
Trial 1		**Trial 1**	
Trial 2		**Trial 2**	
Trial 3		**Trial 3**	
Trial 4		**Trial 4**	
Solid Gel	**Volume of water (ml)**	***Slushy Gel***	**Volume of water (ml)**
Mean		**Mean**	
Median		**Median**	
Mode		**Mode**	
Standard Deviation		**Standard Deviation**	

INSTRUCTOR VERSION

What range of water volumes would you recommend to the physician? Are you more confident that these values will be adequate? Why or why not? Determine off standard deviation

---

Because you are knowledgeable about your wound dressing, you know that salt interferes with the ionic bonds in your wound dressing. However, the patient wants to go swimming at a beach. Is this going to ruin their wound dressing? Make 3 new gels to determine the effect of different salt concentrations on gel properties. Mix ½ tsp dry polymer with 25 ml water to make each gel. Use the conversion table on the previous page to determine amount of salt in teaspoons to add to make each solution. Make sure to add only 17 ml of salt solution to each gel at the desired concentration to keep the volume of water constant.

Condition	**Salt Concentration (Add 17 ml salt water to gel)**	**Observations (gel vs. slushy)**
1. Dead Sea	66 mg/ml	very slushy
2. California Coast	16.5 mg/ml	slushy
3. "Beach" at Amusement Park	6 mg/ml	gel

Calculations for salt solutions:

For 66 mg/ml solution:

$\frac{66\text{ mg}}{\text{ml}}$ X 17 ml = 1122 mg = 1.122 g NaCl (salt) needed

Using conversion factor:

1.122 g NaCl X $\frac{1\text{ tsp NaCl}}{4.45\text{ g NaCl}}$ = 0.25 tsp NaCl → ¼ tsp NaCl

¼ tsp NaCl in 17 ml water

For 16.5 mg/ml solution: (limited by mixing spoon size so can't add less then ¼ tsp salt)

Dilute above concentration by 4: ¼ tsp in 68 ml (i.e. 17 ml X 4 = 68 ml water)

Only add 17 ml of salt solution which will contain 1/16 tsp NaCl

For 6 mg/ml solution: (limited by mixing spoon size so can't add less then ¼ tsp salt)

Dilute original concentration by 11: ¼ tsp in 187 ml (i.e. 17ml X 11 = 187 ml water)

Only add 17 ml of salt solution which will contain 1/44 tsp NaCl

From your results, in which condition would it be alright for the patient to swim without affecting the dressing?

The patient could swim at the amusement park without disrupting ionic bonds of wound dressing.

Hydrogels for Wound Dressings

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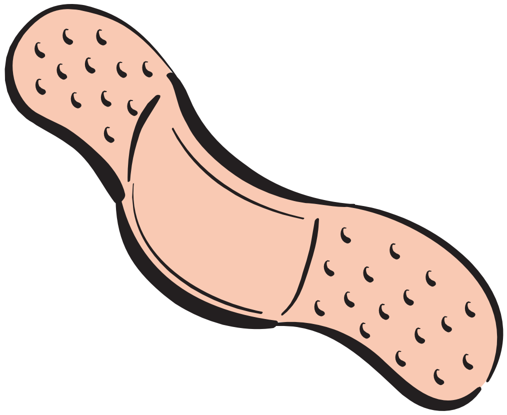

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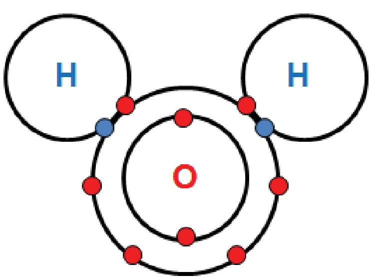

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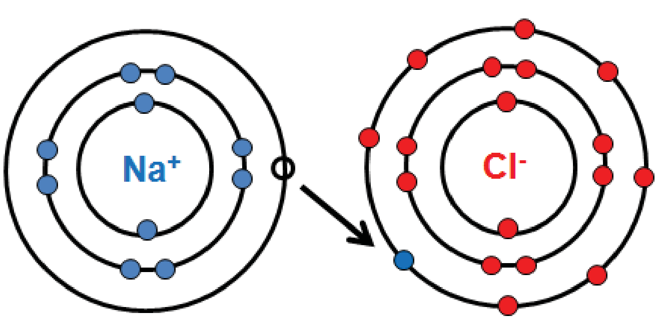

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Experimental Setup:

Materials:
- 3 plastic cups (avoid Styrofoam as it is difficult to make observations about the gel)
- 5 ml syringe
- ¼ tsp measuring spoon
- graduated cylinder or measuring cup
- popsicle stick
- container for water (cup, beaker, et c.)
- 2 tsp polymer powder (gels can be disposed of in normal waste/trash can)
- water
- salt

Conversions	
1 ml water = 0.338 fluid ounces water	1 tsp sodium chloride salt = 4.45 grams sodium chloride salt

Goal: *Dr. Whale is treating a patient who suffers from diabetes and has a diabetic ulcer (wound) that must be filled by a wound dressing. You must determine how much water to add to the dry polymer to make an effective wound dressing and inform the physician. Additionally, Dr. Whale needs information on any side effects to inform the patient.*

Methods:

Put ½ tsp polymer powder in cup. Add 5 ml of water at a time to the dry polymer until the entire polymer is wet (mix with popsicle stick) and the solution gels (cup can be turned upside down without any movement and maintains shape). Note the volume added using tally marks. Continue to add water until it is too slushy to fill wound bed (no longer gels, moves/falls out of cup, or does not maintain shape). How confident are you that these are the correct amounts to tell the doctor? (HINT: Discuss your values with your neighbor.)

Repeat 3X, and compare your mean, median, and mode amounts with your first run.

Solid Gel	**Volume of water (ml)**	***Slushy Gel***	**Volume of water (ml)**
Trial 1		**Trial 1**	
Trial 2		**Trial 2**	
Trial 3		**Trial 3**	
Trial 4		**Trial 4**	
Solid Gel	**Volume of water (ml)**	***Slushy Gel***	**Volume of water (ml)**
Mean		**Mean**	
Median		**Median**	
Mode		**Mode**	
Standard Deviation		**Standard Deviation**	

What range of water volumes would you recommend to the physician? Are you more confident that these values will be adequate? Why or why not?

Because you are knowledgeable about your wound dressing, you know that salt interferes with the ionic bonds in your wound dressing. However, the patient wants to go swimming at a beach. Is this going to ruin their wound dressing? Make 3 new gels to determine the effect of different salt concentrations on gel properties. Mix ½ tsp dry polymer with 25 ml water to make each gel. Use the conversion table on the previous page to determine amount of salt in teaspoons to add to make each solution. Make sure to add only 17 ml of salt solution to each gel at the desired concentration to keep the volume of water constant.

Condition	**Salt Concentration (Add 17 ml salt water to gel)**	**Observations (gel vs. slushy)**
1. Dead Sea	66 mg/ml	
2. California Coast	16.5 mg/ml	
3. “Beach” at Amusement Park	6 mg/ml	

Calculations for salt solutions:

From your results, in which condition would it be alright for the patient to swim without affecting the dressing?

____

Workshop 3

Shedding Light on Optics

Shedding Light on Optics

2013 Teacher Summit

Focus on STEM: Science and Engineering in the Classroom

Dear 2013 Teacher Summit Participant,

Thanks for attending the 2013 Teacher Summit Workshop titled "Shedding Light on Optics." We have enclosed materials for three separate optics demonstrations that we have performed as a chapter over the last several years. Each demonstration and the related questions are designed primarily for high school students but could be tuned accordingly.

Other documents included in this manual:

- List of required materials for the demonstrations
- Step by step optics demonstrations
- Related worksheets that can be used in your classrooms

Please note that these items and lessons are only a starting point when it comes to the demonstrations. They can be tailored with your own creative ideas and improvisations. We welcome your feedback and we would love to hear how you're using the demonstrations found in this packet.

We realize that many of you probably have demonstration ideas of your own. We would love to hear them and any ideas that you may have for possible outreach activities. We are always looking for ways to improve our effectiveness as a chapter in serving the academic community.

Lastly, the Texas A&M Student SPIE Chapter wants to say thank you for exploring strategies to further improve the STEM. Each of us associated with the chapter can name specific teachers that encouraged us toward STEM related fields with a unique vision and outlook; we wouldn't be where we are today without them. Please swing by our booth during the lunch break so we can meet you personally.

Good luck with these demos!

Sincerely,

Meagan Saldua Harris
2012-2013 Texas A&M Student Chapter SPIE President
msaldua@tamu.edu

Brian Cummins
2011-2012 Texas A&M Student Chapter SPIE President
brian.cummins@tamu.edu

SPIE Student Chapter
Texas A&M University

Table of Contents

Required Materials and Vendor List

Diffraction

1. Diffraction glasses
   a. http://cgi.ebay.com/ws/eBayISAPI.dll?ViewItem&item=350691486329
   b. http://www.teachersource.com/product/prism-glasses-double-axis-pkg-of-10/light-colorWhite light source (lamp, room lights)
2. Gas lamps
3. Camera with flash option

Polarization

1. Linear Polarizing Sheets (3x per person/group) each ideally measuring 2" X 2" per sheet
   a. (non-laminated) http://www.polarization.com/polarshop/product_info.php?cPath=21&products_id=28
   b. (laminated) http://www.polarization.com/polarshop/product_info.php?cPath=21&products_id=30
2. White Light Source (i.e. an overhead projector, a light fixture, or a flashlight)
   Tip: an overhead projector is ideal for demonstrating each of the polarization activities listed below to a classroom or large group of people.
3. Optically Active Liquid: Light Corn Syrup
   a. Karo Light Corn Syrup found at local grocery store
4. Birefringent Tape (Tip: The type that says is ok for use with photos, cellulose or cellophane tape)
   a. http://www.teachersource.com/product/polarizing-cellophane-tape/light-color
   b. Find cellulose or cellophane Scotch® brand tape at office supply store
5. Transparency Sheets (1-2" X 2" piece per person or group)
   a. Find at office supply store

Jell-O Optics

1. 1 large plastic cup
2. 1 small plastic cup
3. Plastic sandwich bags with zip-lock seal
4. Red gelatin (1 small box per group)
   a. Can be found at local grocery store
5. Scissors
6. Ruler
7. Wax Paper
8. Red laser pointers
9. Calculator

History of SPIE Demos/Optics Outreaches

SPIE is a non-for-profit international professional society for optics and photonics technology. It was founded in 1955 and currently organizes technical conferences, trade exhibitions, and scientific publications for scientists and engineers in industry, academia, and government. It has a strong desire to be involved in optics education and outreach programs around the world. In 2012, it provided $3.3 million to these programs, part of which goes to student chapters at universities from across the world to organize student events like the demonstrations seen here.

Texas A&M University re-established its student chapter in 2009 with a new constitution and a desire to complement the current experience of undergraduate and graduate students who were studying biomedical optics. Soon after, our chapter wanted to get involved with outreach events. The chapter applied for an Outreach Activity Grant from SPIE in May 2010 with a list of optics demonstrations to be performed to high school students. Soon thereafter, we were awarded a large grant to perform many of the demonstrations you will see today, as well as others using laser graffiti, fish-tank optics, and the magnetic optics board.

These demonstrations display the properties of light in a dynamic way that can easily be seen and have been presented to hundreds of students since being awarded this grant. This has included collaborations with the Society of Women Engineers', Aggieland Saturday, E12 Program, and the Girl Scouts. We even setup in downtown Bryan at the monthly community gathering called First Friday and presented these optics demonstrations to all ages. The largest outreach event we have done to date was the 2011 Optics Tour where we went to three East Texas high schools and presented to science classes for three full days.

We continue to modify these demonstrations in an attempt to improve their effectiveness in teaching students the material and getting them excited about science. As part of these outreach events, biomedical-related applications are typically explained in terms of what was illustrated in an attempt to make STEM-related fields more tangible and to help answer the question we all asked at some point: "why do I need to learn this?"

We have recently been thinking about ways to share these demonstrations with high school teachers because of the many requests that we have been unable to fill. We are excited about the opportunity to share them with you here at the Teacher Summit, realizing that you can reach many more students than we could. We hope that you find the demonstrations useful. We would love to hear any feedback and ideas that you may have regarding ways to improve them. Thanks again!

spie.org
spie.tamu.edu
bmot.tamu.edu

Diffraction

Background

Diffraction is a phenomenon that can occur with all types of propagating waves. When a wave encounters an obstacle, some of the wave bends or *diffracts*, around the obstacle. This phenomenon can also be seen in the way waves spread out after passing through a small opening. The degree of bending or diffraction depends on several parameters such as the size of the obstacle and the wavelength of the wave. The individual photons that make up the light that we see propagate as waves, and thus undergo diffraction. Similar effects occur when light waves travel through media with different refractive indexes. While diffraction can occur whenever a propagating wave encounters a change, its effects are generally more pronounced for waves whose wavelength is roughly similar to the dimensions of the diffracting object. Diffraction patterns can become more complex depending on the geometry of the obstructing object. This is caused by a secondary effected called interference, which results in constructive and destructive addition of multiple diffracted waves.

The effects of diffraction of light were first observed by Francesco Maria Grimaldi in the 1600's, but Thomas Young's famous "double slit" experiment in 1803 demonstrated diffraction from multiple slits and the resulting interference pattern.

Several equation exist that can be used to calculate a diffraction pattern. These equations vary based on the object causing the diffraction, whether it is a round object, a slit, or circular aperture. A basic diffraction equation for a single object is shown below:

$$\mathbf{w = L \times \lambda \div d}$$

Here, w indicates the spacing between diffraction spots, L is the length between the diffracting object and the screen where the pattern is being observed, d is the diameter of the object, and λ (lambda) is the wavelength of the light. From this equation, it can be seen that a narrower slit, or smaller object, will result in wider spacing between diffraction bands.

Diffraction patterns will vary based upon the diffracting object. For rectangular or square apertures, a pattern such as the one in figure 1 appears. Circular patterns are seen following diffraction of a wave after propagating through a circular aperture.

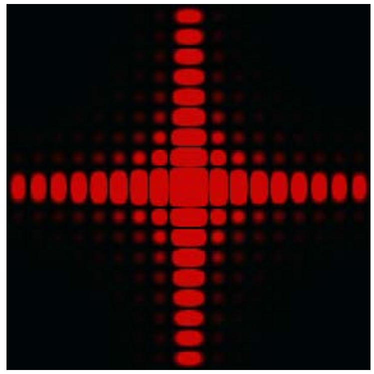


Figure 1. Diffraction from a rectangular aperture

In the case of multiple, closely spaced slits, multiple diffraction events will occur. As waves spread out from the multiple openings, they will overlap and begin to constructively or destructively add together. This phenomenon is called interference, and can be used to explain the diffraction patterns we see. Figure 2 shows a graphical depiction of the famous “Young’s double slit” experiment. Here, two slits were cut in the screen placed as S2, causing the incident wave to diffract at both ‘b’ and ‘c’. The pattern to the right of F is what is observed on a screen. We see the fluctuation in intensity due to the waves adding together. Where magnitudes of overlapping waves are equal and opposite, destructive interference occurs and no light is detected. Where the overlapping waves are equal in magnitude, constructive interference occurs and brighter bands appear.

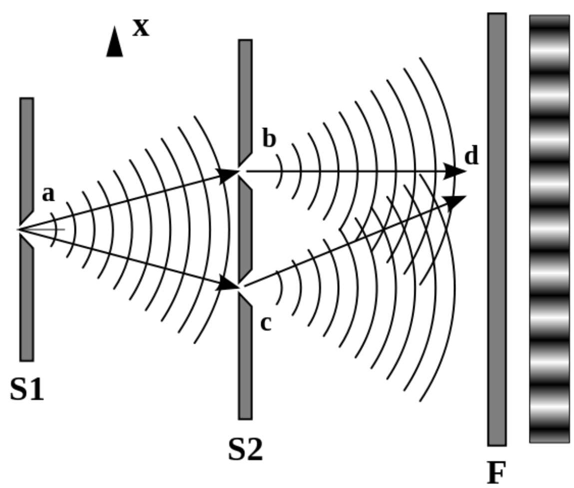


Figure 2. Depiction of Young's double slit experiment

Diffraction is employed in devices used in everyday life. The most common example of diffraction involving light is the closely spaced tracks on a CD or DVD. We can physically observe the differences in the spacing of the slits in a CD and DVD by simply shining a flashlight on them and observing the reflected rainbow pattern. Holograms on credit cards or other devices can be created using a diffraction grating designed to generate the desired image.

Diffraction in the atmosphere can cause bright rings to appear when taking photographs in sunny settings. As mentioned above, diffraction can occur with any type of wave. Ocean waves diffract around jetties and other obstacles. Sound waves can diffract around trees or other solid objects. Finally, diffraction proves to be a technical limitation for optical design. It sets the fundamental limit to the resolution of an optical system such as a camera, telescope, or microscope.

Introduction
In these demonstrations, students will explore diffraction through the use of diffraction glasses. They will begin by exploring the effects of diffraction glasses on a white light source. Following this, we will examine how diffraction gratings can be used to help identify chemical and molecular species.

Objectives
Students will be able to understand and explain the phenomenon of diffraction
Students will gain an understanding for how diffraction can be used in practice

Materials List
Diffraction glasses (1 pair per person)
White light source (any room light will suffice)
Gas Lamps (Helium, Hydrogen, or any other common gas)
Camera with flash

Advanced Preparation
Estimated time: 10 minutes. Gas lamps need to be setup for the demonstration. Care should be taken when handling the bulbs, as improper handling can destroy the bulb. Distribute 1 pair of diffraction glasses to each student or participant.

Activity 1 - White light with polarization glasses
Goal: *Explore the effect of a diffraction grating on a white light source.*

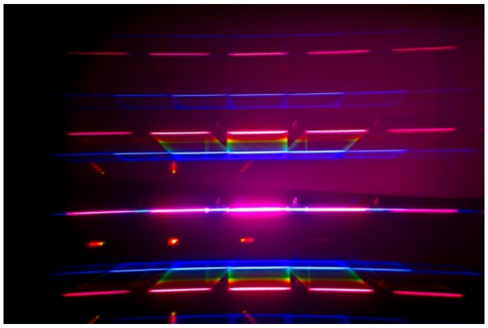
Demo
Put on the diffraction glasses and look at the light from a floor lamp or ceiling light. Students should observe a rainbow pattern from the light source.

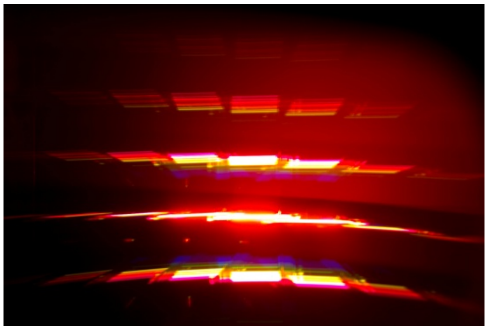
Suggested Questions
Ask the students to predict what might happen when they put on their diffraction glasses and look at the white light.

Activity 2 - Gas Lamps
Goal: *Demonstrate how diffraction gratings can be used to identify the unique spectral signature of different gases.*

Demo

Have the students put on the diffraction glasses and observe the light from different gas lamps. For each gas type, different distinct color bands should be visible, allowing for unique identification of the gas in the bulb.





Notes

Diffraction gratings make up the basis for most spectrometers. These devices are commonly used in chemistry, medicine, and biological sciences to help identify unknown chemical or molecular species. Spectrometers typically employ a light source which shines light on a sample chamber. The transmitted light is then directed onto a diffraction grating. A diffraction grating spreads the light out into its individual colors, which are then detected by a camera. Several spectrometers were included on the Curiosity rover, currently on Mars.

Activity 3 - Camera flash

Goal: *Take a fun group picture with your diffraction glasses on*

Demo

Making sure that the camera flash is on; take a group photograph of the class with their diffraction glasses on. The flash should be fun for the students, especially multiple flashes!

Final Discussion

Q: Why do we need diffraction glasses to see white light?

A: White light is the sum of all colors; we need diffraction glasses to bend the colors away from each other so we can distinguish one from another.

Q: What would happen if the diffraction grating spacing was increasing in size?

A: The colors would not diffract as strongly.

Q: A wave of constant wavelength diffracts after passing through an opening. As the size of the barrier decreases, the diffraction effects become __________?

A: Stronger

Q: Parallel wavefronts of increasing wavelength are incident on a fixed size opening. Which wavefront will diffract more?

A: Larger wavelengths and smaller openings diffract the most. So, the longest wavelength will diffract more than a shorter wavelength with a fixed sized opening.

Additional resources

1. http://www.nationalstemcentre.org.uk/elibrary/resource/2081/diffraction-of-laser-light
2. http://www.exploratorium.edu/snacks/diffraction/index.html
3. http://www.dallastopsecretscience.com/DiffractionGlasses.html
4. High School Physics: Diffraction http://www.youtube.com/watch?v=htxbDyWcMk0
5. http://ocw.mit.edu/high-school/labs/physics-electricity-and-magnetism-labs-from-8.02/8_02_spring_2007_experiment9.pdf
6. http://ocw.mit.edu/high-school/physics/physical-optics/interference-diffraction/8_02_spring_2007_ch14_inter_diffr.pdf

Polarization

Background

Polarization is a property of light and it can exist in three polarization states which are circular, elliptical, and linear. You may not be aware of it, but polarized light and technologies that utilize the concepts of polarization are all around you. For example, do you own a laptop, LCD flat screen TV, calculator, cellular phone, or any other liquid crystal display device? If so, then you have already been exposed to polarized light. Another product, you are likely familiar with, that is designed to interact with and eliminate polarized light, created after being reflected from a non-metallic surfaces (such as snow, roads, a tabletop, or water) is polarized sunglasses. Polarized light can be produced through several different methods such as reflection, double refraction, selective absorption, and scattering.

Polarizers: Most types of light sources, including sunlight and most indoor lighting, generate light that exists in an unpolarized state. Unpolarized light is composed of several transverse waves each oscillating in a sinusoidal fashion. However, these oscillations occur in an infinite number of planes as illustrated in Figure 3. Linear polarizers sheets are designed in a way such that they only transmit light that exists in a single plane. Thus, when putting a linear polarizer in-line with an unpolarized light source, (see Figure 3 below), all the light that is not oscillating in the same plane as the initial linear polarizers orientation will be blocked, or eliminated, resulting in light oriented in a single plane (oriented in parallel with the initial polarizers orientation) transmitted through the polarizer. The light exiting the polarizer is termed linearly polarized light. As shown in Figure 3, the beam of light transmitted through the initial linear polarizer is transformed from an unpolarized light beam consisting of sinusoidal electromagnetic oscillations in many planes into a beam consisting of an electromagnetic oscillation in a single plane (the Vertical plane) oriented parallel to the initial polarizers preferred axis.

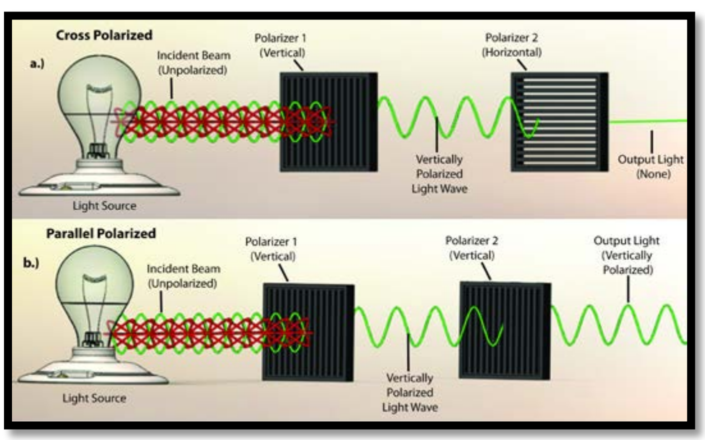


Figure 3. An illustration of how unpolarized light becomes linearly polarized through the application of polarizers. **(a)** The cross polarized configurations with two polarizer, the second being oriented perpendicular to the first. and **(b)** Parallel polarized configuration showing how light is transmitted through the two polarizers when they are oriented in parallel.

Picket Fence Analogy: Linear polarizers are devices that block unpolarized light (light waves), from passing through the polarizer, traversing all planes except the plane matching the orientation of the polarizer. It is easiest to think of each polarizer as a “molecular picket fence" resembling an ordinary picket fence in composition, as shown in Figure 4. It is then possible to explain the process of polarization similar to the process of oscillating a rope (sinusoidal) through the pickets of a picket fence. Polarizers only transmit the optical wave oriented in the same path as the initial polarizer is oriented. When the pickets of two fences are oriented in the same direction (or in parallel) the linearly polarized light (or rope) can pass through both of the picket fences. When a second fence (oriented perpendicular to the first fence) is added into the path the light wave, the vertical vibrations of the rope pass through the first fence just as it would in previous example. However, unlike when there are two parallel fences the second fence oriented perpendicular to the first fence completely blocks the passage of the vibrating rope. Similarly, linearly polarized light passed through a cross polarized configuration with a second polarizer, oriented perpendicular to the first polarizer, added after the first polarizer would result in the light wave being blocked by the second polarizer. This concept of cross polarization is illustrated using the picketed fence/rope analogy in Figure 4b.

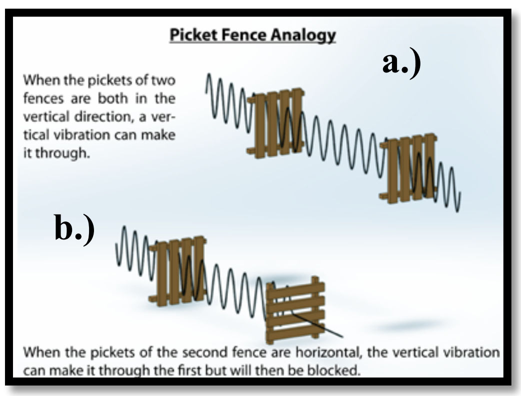


Figure 4. Picket Fence Analogy for explaining polarizer function **(a)** when aligned in parallel and **(b)** when aligned perpendicular with respect to the pickets on the first fence.

Optical Activity: Certain materials have the ability to “rotate” the plane of polarization of linearly polarized light. This is known as optical rotation and the amount of rotation within a sample is wavelength dependent. Karo and corn syrup are both optically active liquids. Meaning they are capable of rotating the plane of polarization of light transmitted through them by an amount proportional to their path length. Common optically active substances include sugar solutions, turpentine, amino acids, Karo syrup, corn syrup and some crystals. Many naturally occurring organic compounds such as sugar, tartaric acid and turpentine, are optically active and thus rotate the light passing through a sample when in the liquid state. The equation used to describe the optical rotation of polarized light is shown below. This illustrates that optical activity is associated with the individual molecules themselves. Thus, when linearly polarized light from a white light source is transmitted through an optically active fluid each wavelength, or color, in the underlying spectrum changes in polarization independently from the other light. As a result at each angle the second polarizer is rotated will result in a change in the observed color with respect to angle of polarization when examined between two polarizers sheets.

$$\boldsymbol{\alpha} = [\boldsymbol{\alpha}]_{\boldsymbol{\lambda}} \cdot \boldsymbol{C} \cdot \boldsymbol{L}$$

where, α is the observed rotation, $[\alpha]$ is the specific rotation at a given wavelength, C is the concentration of optically active sample, L is the sample path length. The specific rotation is wavelength dependent hence each wavelength or color of light will appear at an observed angle of rotation occurs as the specific rotation of each color of light is slightly different.

Introduction

In this lesson, students will investigate and explore several optical phenomena involving polarized light through a sequence of activities examining how polarizers can affect light. Students will begin by exploring light polarizing sheets and how changing the arrangement and position of these elements can produce different results. In the second part, properties that can affect polarized light such as optical activity and birefringence will be explored. Specifically, these hands on demonstrations will help the students visualize and understand that light travels as a wave in addition to how the light beam changes as it travels through polarizers and or traverses materials that are optical active or birefringent.

Objectives

The main objective of the polarization activities is for students to have the opportunity to investigate and explore polarized light and how it can affect the perceived light. After completion of these activities students will be able to explain:

- What polarizers are used for.
- The relationship of a mechanical model of waves to polarizers and light.
- How optical activity can affect polarized light.
- Birefringence and how it can effect polarized light.
- The conclusion that light acts similar to a wave.

Materials

Each of the activities listed below as part of the Polarization Exploration Demo require at minimum, two linear polarizer sheets in addition to a white light source, ideally chosen to be an overhead projector, as it is very beneficial for demonstrating the observed polarization effects to a large group of people prior to having everyone individually explore the respective activity using the polarized sheets provided. A list of the materials needed for each activity in addition to some web links to purchase the material are listed below.

- An overhead projector is ideal for demonstrating the polarization activities
- Linear Polarizing Sheets
- White Light Source (i.e. overhead projector, light fixture, or flashlight)
- Karo Light Corn Syrup
- Cellophane/Cellulose Tape
- Transparency Sheet
- Samples of flat molded clear plastic objects such (fork, spoon, or any other plastic object) (**Optional**)

Advance Preparation
Estimated time: as long as it takes to make you comfortable with each of the demonstrations and the concepts involved with optical polarization

- **Wave practice**
  It is recommended that before attempting to teach any information on controlling the mechanical wave should practice using either a slinky, spring, or a rope before teaching the information. To do this, grasp the slinky, rope, or spring with both hands (or have a volunteer assist in these demonstrations). One hand/side will be used to control the waves (input) and the other hand/side is used to hold the (output) end still. Alternatively, you could connect one end up to a wall, or as discussed have a volunteer hold it. This would mean that only the use of one hand to control the input wave is needed. The demonstration represents an easy and visual method for explaining how light waves propagate in addition a providing a basic model explaining the concept of polarization to the students.

  - **Vertical transverse standing waves**: Begin by shaking the input end of a slinky or short rope up and down repeatedly to produce a train of crests and troughs, this should look similar to a sinusoidal oscillating wave. When oscillating at the right frequency, the device will resonate and, a standing wave will emerge. The resulting wave within the sample provides a good illustration of what the transverse waves of visible light looks like.

Activity 1 – Crossed Polarizers
Goal: This activity allows students the opportunity to discover what polarizers are and how they function. They will be able to describe and predict how the amount of light transmitted through the polarizers changes with orientation.

Hand out a total of three polarizers to each student (**if there are enough available**), in instances where this may not be feasible adjust the number to hand out accordingly. Ask students to find a partner or form small groups. Encourage the students to use their polarizers (two polarizers stacked, one placed directly on top of the other) and observe how they affect the viewable light from a few different available light sources (*i.e. fluorescent lights, sunlight, reflections, cell phone screens, etc...).* Many students will discover how the amount of light changes with the respect to the orientation of the polarizers, but you may need to nudge some students. This is a good time to ask the students about their observations and illustrate the effects of rotating the second polarizer using the overhead projector. While discussing the student's observations it is beneficial to demonstrate the polarization concepts on the overhead projector.

Begin by exploring the relationship between the rotation angle of the two polarizers sheets and its effects on the observed light transmission. Take two polarizers, and place one at a time on the overhead projector. Initially, attempt to locate the angle that orients the two polarizers in parallel, see Figure 5a for orientation information. Two polarizers are parallel when the sheets are aligned in the same direction. This can be easily verified through examination of the amount of light transmitted. To confirm the polarizer sheets are positioned in parallel fix one polarizer at a constant angle and slowly rotate the second polarizer on the overhead projector. Have the students help in determining the stacked orientation that provides the highest transmitted light through the polarizers, indicating the two sheets are oriented in parallel. Rotate the top polarizer to find the point when the light transmitted through the filters is completely blocked. When this occurs the two filters are said to be **cross polarized**, configuration shown in Figure 5b. **What happens with the intensity of the light in the cross polarization configuration?** Now rotate the filter an additional 90° from the cross polarized position. **What do you observe?** Rotate the filter through an additional 90° and explain what is happening to the transmitted light. **Explain what is happening as you rotate the filters?**

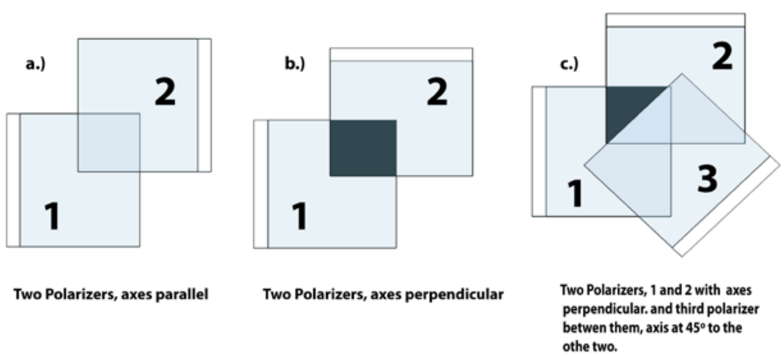


Figure 5. Two linear polarizer sheets oriented in **(a)** parallel resulting in maximum light transmission through the stacked polarizers and **(b)** Perpendicular (cross polarized) resulting in no light passage. Additionally, **(c)** illustrates the effect of three linear polarizers, two oriented 90 degrees apart (cross polarized) resulting in no light passage and a third inserted 45 degrees between the first two again allowing light to transmit through.

Suggested Questions

What do you think the polarizers are doing? What happens when the polarizers are rotated? Can you hypothesize a rule for when light gets through and when it doesn't? What would be the expected result when the two polarizer sheets are crossed on the overhead projector? How about when they are aligned in parallel?

Activity 2 – Three Polarizers Phenomenon
Goal: This activity allows students to discover the addition of a third polarizer (at approximately 45 degrees) between two perpendicularly oriented polarizers will let light through.

Ask the students to cross two of their polarizer sheets; the orientation shown is in Figure 5b. If needed, remind the students this orientation occurs at the angle between the polarizers that when no light is transmitted through. **Encourage the students to investigate the effects of adding a third polarizer,** at an angle of 45°, oriented midway **between each filter in the cross polarized setup.** Have them look at the light source through all three filters configurations. ***What do you observe? How does this occur?*** Now using the overhead projector, insert a third polarizer at 45°; oriented midway between the two polarizers oriented in the crossed configuration. Observe how light is transmitted through the three filter system. The resulting three polarizer transmission should look similar to the image in Figures 5c and 6b.

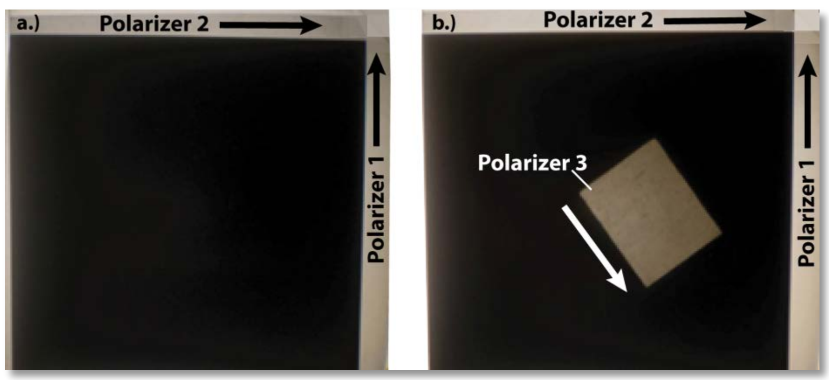


Figure 6. Overhead projections generated **(a)** with two polarizer sheets, in the cross polarized configuration, and **(b)** using three polarizer sheets, as described above, with a third polarizer (**Polarizer 3**) placed between the crossed polarizers sheets at approximately 45 degrees.

Suggested Questions
What they think will happen if a third polarizer is added between the two current polarizers? What do you observe? How does this occur? What happens when the third polarizer is oriented at 45° which is midway between the polarizer and analyzer?

Activity 3 – Optically Active Substances:
Goal: Students will be able to identify and explain how polarized light is affected as it is passed through an optically active sample.

Certain materials have the ability to **"rotate" the plane of polarization,** of polarized light. The amount of rotation that occurs is wavelength dependent. Sugar is an optically active compound, and thus, solutions containing it such as Karo syrup and corn syrup are optically active liquids.

Meaning these solutions are capable of rotating the plane of polarization of polarized light as it passes through by an amount proportional to path length of the solution. Observe how optically active substances can rotate the plane of polarization to allow transmission of certain wavelengths of light when the sample is placed between two linear stacked polarizers. Changes in thickness, depth, of the optically active sample and/or the angle of the polarizers result in change in the color of the transmitted light, as shown in Figures 7 and 8. For the effects of optical activity to occur, the light must be polarized prior to passing through the sample. Place a polarizer sheet on the overhead projector (labeled "Polarizer 1" in Figure 8).

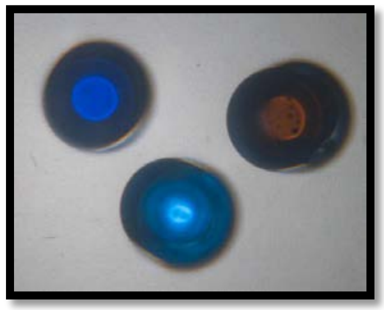


Figure 7. Karo syrup optical rotation example

Examine how changes in volume, of the optically active sample, effect the transmitted light. Position multiple containers on top of the first polarizer and fill each container with a different volume, height, of Karo syrup. Then hold a second polarizer over the top of the containers. The required positions for the polarizers and containers are shown in Figure 8. Adjust the focus on the overhead and begin pouring in additional syrup or rotating the top polarizer. Keeping the position of both polarizer fixed look at the transmitted light for each container. ***What do you observe? How does this occur? Where do you different colors come from?*** Now rotate the angle of the second polarizer slowly. ***What changes do you observe? What do you think is happening?***

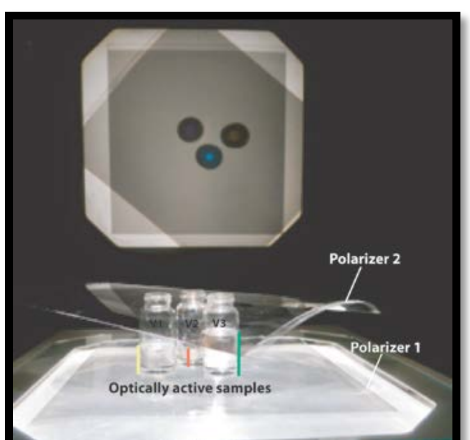


Figure 8. Optical activity demonstration using three different volumes (V1, V2, V3) of Karo syrup placed on an overhead projector between two polarizers (labeled 1 and 2).

Activity 4 – Birefringent Tape Art

Goal: Students will be able to identify different types of birefringence and the presence of birefringence in materials. Students will understand the effects of birefringence on polarization.

Due to their **birefringent** (materials with two indices of refraction) nature, some transparent tapes produce brilliant colors when viewed between polarizing filters. When a ray of un-polarized light enters a birefringent material, it divides into two rays. The two rays have different speeds and are polarized at right angles to each other, meaning that two different colors can be seen depending on the orientation of the polarizers. Just how the volume of the corn syrup determined the colors seen, the thickness of tape also determines color, so by layering tape, a multitude of colors can be seen at once. Cellophane tape can be layered on a transparency to produce colorful art due to its birefringent property from two indices of refraction. When the optical path length (thickness of layered tape) changes, different colors are observed when the art is placed between two polarizers. The top polarizer may be rotated to view how the colors change with varying polarization angles.

Hand out a total of two polarizers to each student (**if available**) in addition to a small transparency slide and a roll birefringent tape. Have the students cover their transparency piece with overlapping layers of transparent tape, crisscrossing to form a 'stained glass' type pattern. Colors will appear brighter and more prominently with longer path length using additional layers of tape. To save time, it is suggested to cut slices into the roll about 5 layers deep before distributing out individual pieces of tape. Place the transparency with the tape between the two linear polarizers. Hold them up to a light source so as much light is getting through as possible. Rotate the top filter and see the colors change!

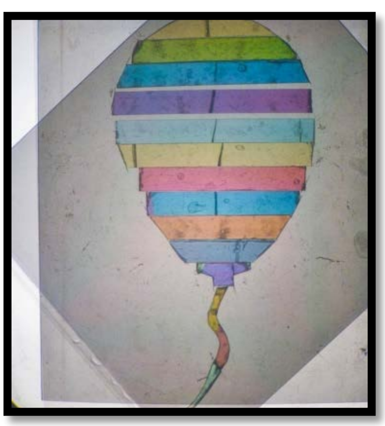


Figure 9. Tape art, using cellophane tape, to demonstrate birefringence **(a)** using a balloon design and **(b)** adding features to a drawing.

Activity 5 – Stress Birefringence (Optional)
Goal: Students will be able to identify stress induced birefringence in stressed plastic. Students will be able to identify how polarized light is affected as it passes through a transparent plastic material with stressed birefringence.

Many clear molded plastic, and some glass objects, are known to exhibit a form of **birefringence** when stress is applied to the object. On molded clear plastics this can often times be generated from stresses induced on the object during its manufacturing process. This stess can be frozen into the plastic. This is called stress birefringence and it can at times be used to identify weaknesses in the manufacturing processes of plastics. The stresses and manufacturing flaws can be examined through the use of two cross polarizers. When this effect is viewed between two cross polarizing sheets the birefringence of the material appear as colored contour lines visible within the matieral.

Hand out a total of two polarizers to each student (**if available**) in addition some type of plastic object such as a fork, knife, or spoon or glass object that stress birefringence can be observed within. Clear plastic forks are great objects to observe this. Place the plastic fork between two polarization filters. Be sure to note the presence of colored stress lines. If visible contours do not exist in the object, use the filters to apply a stress to the material and notes the effect of using the filters to stress the material. Take the plastic fork between the two polarizer sheets and carefully squeeze the tines together and observe the effect this has on the stress birefringence. ***What happens to the colored stress lines when applying the added stress to the fork?***

Activity 6 – Final Discussion
Estimated time: about 20 minutes
Goal: Students will be able to describe what polarization is and how polarizers work. They will be able to describe what a polarizer is used for and associate certain optical phenomena with changes in polarimetric properties of light. Students will be able to conclude from the demonstrations, model, and polarizers that light acts like a wave.

After exploring the affect of two polarizers in parallel, cross, and 3 polarizer demonstrations it is a good time test the students understanding in the key concepts of polarized light again and how the linear polarizers are function. Ask students to share any observations they have made with the class. Ask if they have any idea ***why a second polarizer sometimes can block the light and other times doesn't? Can they hypothesize a rule for when light gets through and when it doesn't? Do they have any idea why a third polarizer lets light through?***

Begin a group discussion, letting student's responses lead you to the next question:
- Where can you find a polarizer at home?
- What does a polarizer do?

- Was there a pattern to how the polarizers blocked the light as you rotated the filter?
- Any idea why a second polarizer sometimes can block the light and other times doesn't?
- What is happening when the third polarizer is added between the cross polarized filters?
- Can you describe how polarized light is affected by passing through an optically active sample?
- Was there a pattern to how the wavelengths of light were rotated, when passing through an optically active sample?
- Are there any similarities between the light/polarizers and the rope/picket fences example?
- Can you make a hypothesis about the light/polarizers?
- What does the rope represent? The picket fences?
- Can you describe how birefringence can affect polarized light?
- In the tape art demonstration, what variable altered the amount of birefringence observed?
- When some concepts are hard to grasp, model can be used to better understand.
- What does the picket fence in our model represent? What does the rope represent?
- What conclusions can you draw about light and polarizers from this model?

This lesson can easily be related to the student's daily lives by discussing how polarized sunglasses, LCD flat screen TV, calculator, cellular phone, or any other liquid crystal display device all utilize polarization. They may not be aware of it, but polarized light and technologies that utilize the concepts of polarization are all around you. For example, do they own a laptop, LCD flat screen TV, calculator, cellular phone, or any other liquid crystal display device? If so, then they have already been exposed to polarized light. Another product, they are likely familiar with, that is designed to interact with and eliminate polarized light, created after being reflected from a non-metallic surfaces (such as snow, roads, a tabletop, or water) is polarized sunglasses.

Notes

- During the fabrication of a polarizer, molecules are forced to arrange themselves into long lines along the direction of pull, caused by the plastic stretching that occurs. This results in the creation of a grid of molecules. It's important to note that *the pickets in the picket fence model do not represent the lines of molecules, but the polarizer as a whole*. In polarizers, light doesn't slip through gaps between the lines like the rope passes through the spaces in the picket fences. In a polarizer with molecules stretched in vertical lines it absorbs and reflects the vertical part of the light and will only pass horizontally polarized light.

- ***So what is happening when the third polarizer is added*?** Think about what is happening to the light; refer back to Figure 3a for a good illustration of what is occurring to the light as it travels through the two polarizers. Now imagine the unpolarized light going through three filters instead of two. The first filter has a polarization axis at 90°, the second at 45°, and the third at 0°. Light enters the first polarizer and is vertically polarized. The second polarizer then linearly polarizes the light at 45°, since the vertical light has a parallel component with respect to the second polarization axes. Finally, the third polarizer linearly polarizes the light at 0°, since the 45° light has a component parallel this polarization axis. Thus, instead of allowing no light to be transmitted through the polarizers, by inserting the 45° polarizer between the two perpendicular sheets allows some of the light to be transmitted.

- The result from inserting the 45° polarizer between the crossed polarizer setup is quite remarkable. Although the third filter only absorbs some of the light, more light is now transmitted, after the insertion of this absorber. When a third polarizer is placed between the crossed polarizers, a significantly higher light intensity is transmitted through the polarizers than compared to the crossed polarizer configuration. Photographs of two polarizers sheets oriented perpendicular on an overhead projector and crossed with the third 45° polarizer are shown in Figures 6a and 6b, respectively.

- ***So what is happening when an optically active medium added*?** As the volume of the syrup increases or the polarizer angle changes, the wavelength of light transmitted through the polarizers will change. If you recall, white light is made up from an entire spectrum of colors (**Hint:** think of a rainbow). Thus, the variation in the color transmitted through the polarizers occurs when polarized white light passes through an optically active liquid such as Karo syrup. Each of the colors, or wavelengths, of light are rotated at different angles specific to the individual wavelength of the light. When this occurs, the plane of polarization for each of its constituent colors, in the white light spectrum, is rotated by different amounts.

Jell-O Optics

Background

One important parameter that governs how a lens will transmit light is its shape, especially its radius of curvature. For a circle, the radius of curvature is its radius. For a point on a curve other than a circle, the radius of curvature is the radius of a circle that best approximates the curve at the vertex of interest. A bi-convex lens is a lens with two convex surfaces, each usually having different radius of curvature.

Refraction is the bending of light in a plane when it passes from one material into another, governed by Snell's Law. How much the light bends depends on the index of refraction of the material it enters. This is the mechanism a lens uses to focus light (even lenses made from Jell-O!). When light switches from traveling in one material to another with a different index of refraction, it has to change speed. If the light goes into the new material at an angle, some of the light (wave) starts to slow down or speed up before the rest of the wave, which makes it bend toward a new direction! Think about someone in a canoe paddling faster on one side than the other… making the canoe turn. Lenses make light turn this way.

Overview

In this demo, students will explore the parameters that govern how lenses focus light by creating their own lenses made of Jell-O. They will measure the radius of curvature of their lenses and the focal length, and use these to calculate the index of refraction of Jell-O with the Lens Maker's equation.

Objectives

Students will be able to explain radius of curvature, a parameter that governs how a lens will transmit light

Students will be able to define index of refraction and relate it to the bending of light

Lens systems

Materials

1 large plastic cup
1 small plastic cup
Plastic sandwich bags with zip-lock seal
Red gelatin (1 small box per group)
Scissors
Ruler
Wax paper
Red laser pointers
Calculator

Advanced Preparation

Estimated time: 30 min prep, minimum 4 hours for gelatin to set

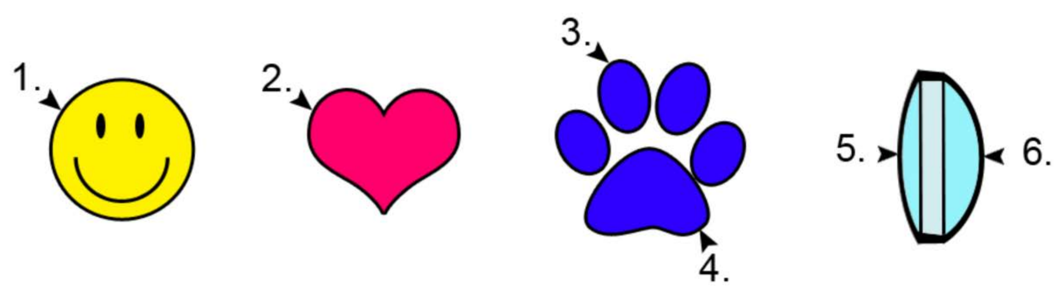
1. Making the Jell-O more concentrated will keep it from breaking during the demo. To do this, add 1 cup of boiling water to the mix from one small box of Jell-O and stir for two minutes. Then add 1/3 cup of cold water (instead of 1 cup cold water) and allow Jell-O to cool for 5 minutes.
2. Pour Jell-O into a sandwich bag. As you seal the top, try to remove all the air from inside the bag by gently squeezing the sides.

3. Put the sandwich bag flat on its side so the Jell-O will set in a square shape. Let Jell-O refrigerate at least four hours.

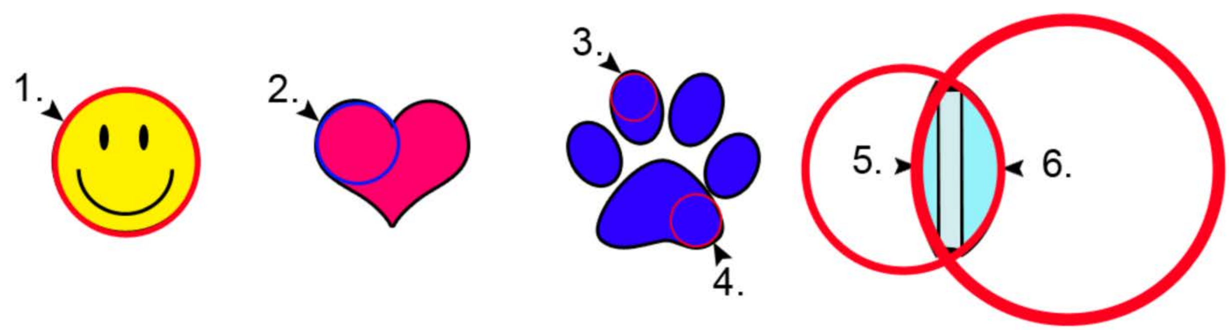
Activity 1 - Radius of Curvature
Goal: Students will understand the definition of radius of curvature for complex objects.

One important parameter that governs how a lens will transmit light is its shape, especially its radius of curvature. For a circle, the radius of curvature is its radius. For a point on a curve other than a circle, the radius of curvature is the radius of a circle that best approximates the curve at the vertex of interest.

Q. In the picture below, for each vertex draw a circle with a radius that fits the radius of curvature at that point.

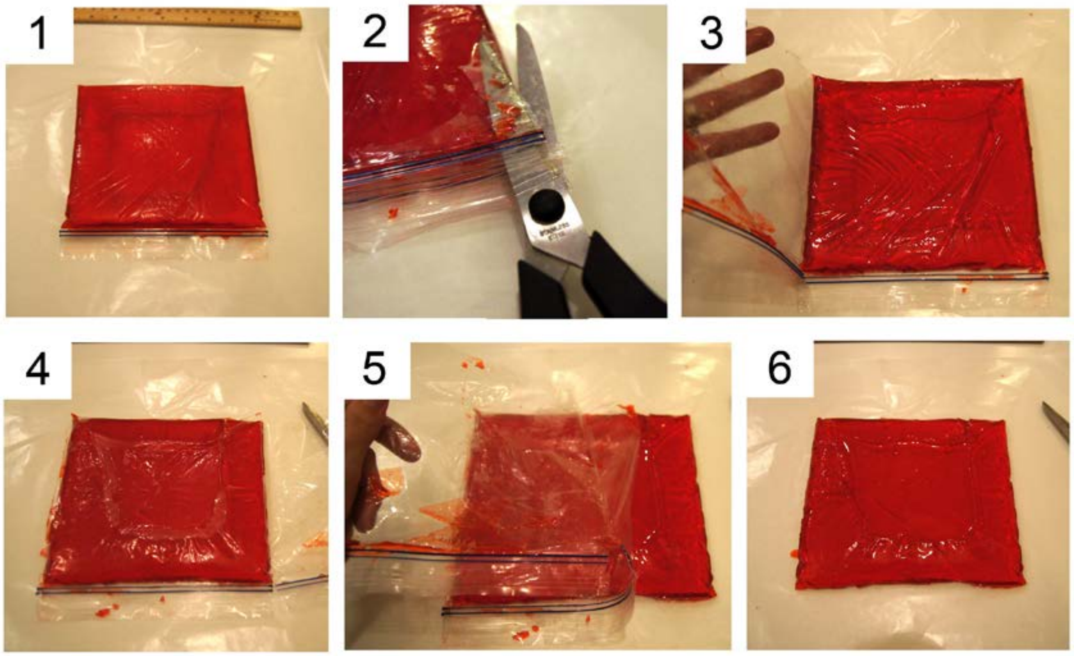


A:

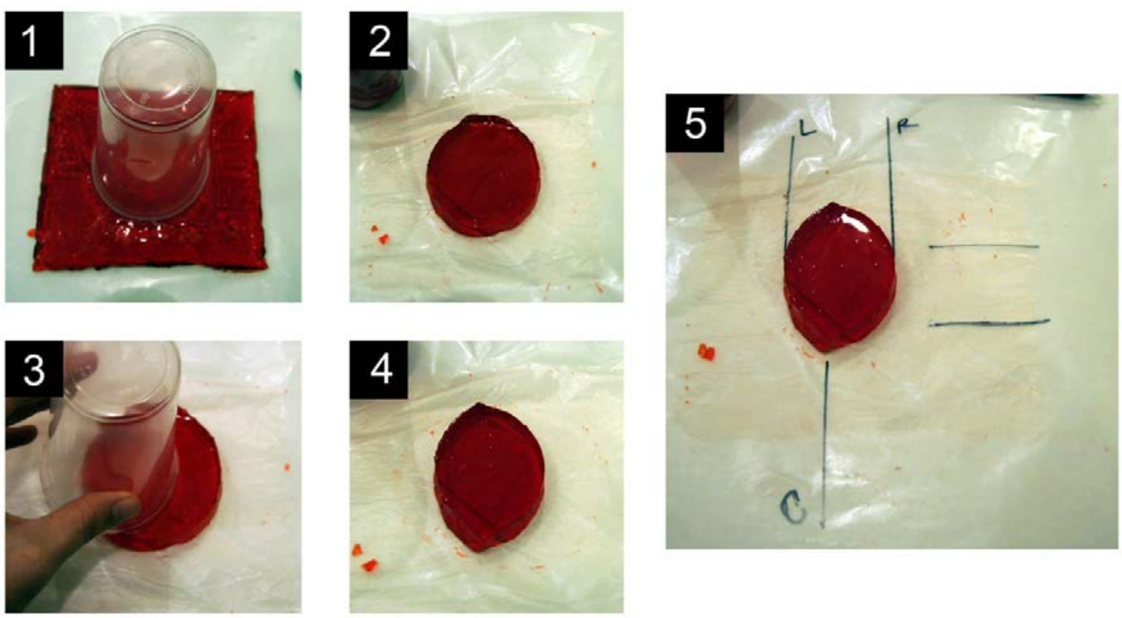


Now we can use this concept when making our Jell-O lenses. Let's make a lens like the one in the picture above (5, 6). This is a bi-convex lens, since both surfaces of the lens are convex.

First we need to remove the Jell-O from the sandwich bag following the steps in the picture below. Use the scissors to cut along one side and the bottom of the sandwich bag, leaving one side still attached. ***Slowly*** peel the sandwich bag away from the Jell-O. Then ***carefully*** flip the Jell-O in the sandwich bag over so the Jell-O is directly in contact with the wax paper and ***gently*** remove the sandwich bag.



To make the lens, use the large cup to cut a circle out of the center of the Jell-O, and then use the smaller cup to cut the lens from the circle, as shown in the pictures below.



Then label the left side, right side, and center of the lens as shown above (5). Also make two parallel lines that are perpendicular to the lens that will be where we put the laser pointers later.

We want to know the radius of curvature of each side of our Jell-O lens. Measure the diameter, d, of each cup so you can find its radius (r=d/2). When using the ruler, make sure you measure the largest distance across the top of the cup (like shown below) so you don't underestimate the radius. In the picture below, the cup's diameter is about 3.5".

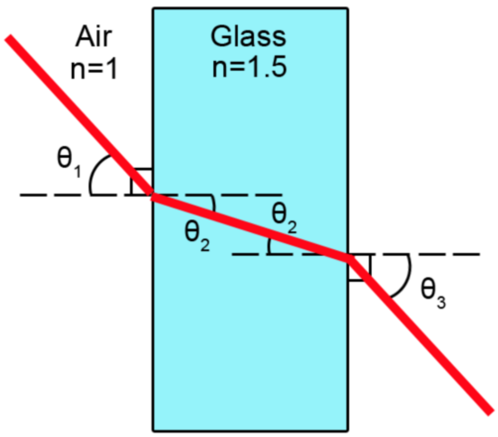
Radius of curvature is one important factor that governs how lenses bend light. Another is index of refraction, which we will discuss next.

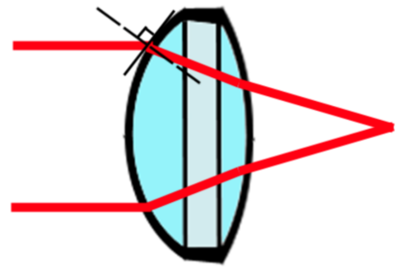
Suggested Questions
Q. What is the radius of curvature of the left side of the lens (bigger cup)? Of the right side (smaller cup)?
A. Answers will vary depending on the cup.
Q. Will the surface of a lens with a larger radius of curvature appear flatter or more rounded than a surface with a smaller radius of curvature?
A. Flatter.
Q. What is the radius of curvature of a flat surface?
A. Infinity. Think of the flat surface as the edge of a circle that gets infinitely large, with a correspondingly infinitely large radius.
Q. What would a lens with a negative radius of curvature look like?
A. A concave lens.

Activity 2 - Index Of Refraction
Goal: Students will understand the phenomenon of refraction, the bending of light, and be able to use Snell's law to calculate how much light is refracted by glass in this example.

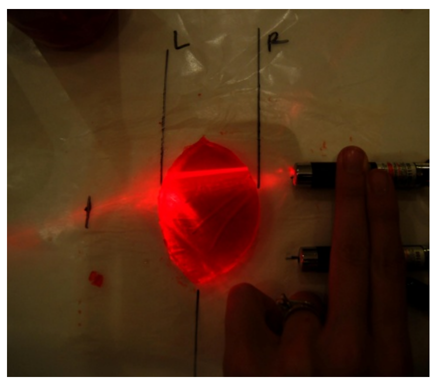
Refraction is the bending of light in a plane when it passes from one material into another, a phenomenon governed by Snell's Law (the actual person who came up with the law was called Lord Snellius). How much the light bends depends on the index of refraction. This is the mechanism a lens uses to focus light (even lenses made from Jell-O!).

Snell's Law: $n_1\sin\theta_1=n_2\sin\theta_2$



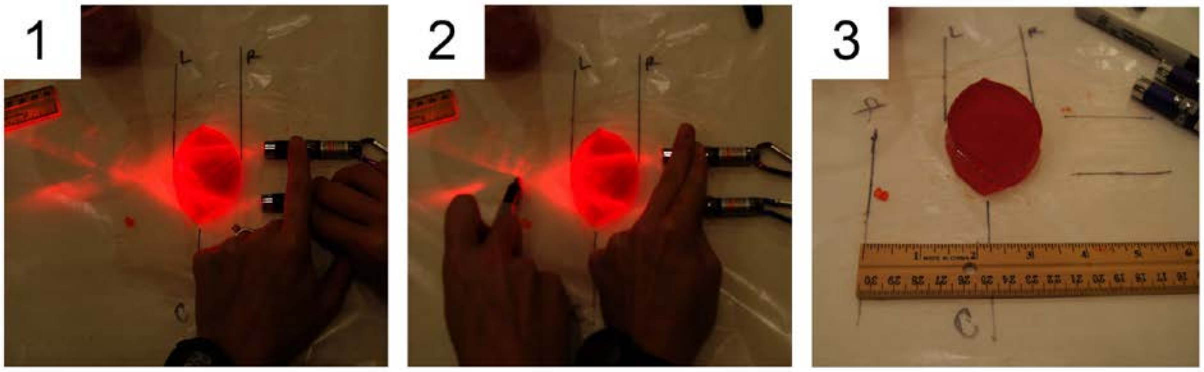


We will use our Jell-O lenses and measure how much they refract light to calculate their index of refraction. See in the picture below how Jell-O can refract (bend) a red laser beam.



Let's find out how much our Jell-O lens bends red laser light. Line up two laser pointers so they travel parallel to each other into the more curved side of the lens (like the pictures below). Mark the following places on the wax paper: where the rays cross on the paper, the center of the lens, and the left and right sides like in the picture below.

Teacher's note: This is easier to do with the lights dimmed, but you can still do it with the lights on if you need to.



Measure the distance from the focal plane to the center of the lens, the focal distance which is a measure of how much the lens refracts light.

Suggested Questions

Q. From the picture above, use Snell's law calculate what θ_2 and θ_3 will be if θ_1 is 45°.

A. $\theta_2 = 28.12$, $\theta_3 = \theta_1 = 45°$.

Q. If light travels from a material with a *lower* index of refraction (air) to a material with a *higher* index of refraction (glass), will the light bend *toward* or *away* from the normal (dotted line)?

A. Toward.

Q. If light travels from a material with a *higher* index of refraction (glass) to a material with a *lower* index of refraction (air), will the light bend *toward* or *away* from the normal (dotted line)?

A. Away.

Q. What is the focal distance of your lens?

A. Answers will vary from group to group.

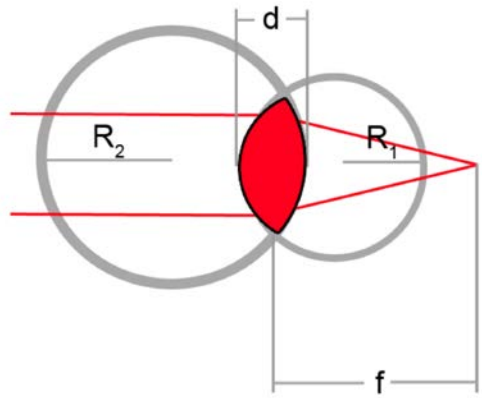
Next we will use these quantities we've measured, radius of curvature and focal distance, to calculate the index of refraction is of Jell-O.

Activity 3 - Lens Maker's Equation and Thin Lens Approximation
Goal: Students will learn to deal with sign conventions to do calculations and also appreciate how formulas can be simplified using approximations, in this case the thin lens approximation.

The location of the spot we just marked where the laser lines cross, called the focus of the lens, is dictated by the index of refraction of the material and the radius of curvature of the lens surfaces. One equation we can use to describe this relationship is the Lens Maker's equation.

Lens Maker's equation (in air):

$$\frac{1}{f} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2} + \frac{(n-1)d}{nR_1R_2}\right]$$



R_1 is the radius of curvature of the surface that is hit by the light first (left for us, notice that the lens is flipped in this diagram compared to the measurements we previously took) and R_2 is the second surface (right for us). There is a special sign convention for R_1 and R_2. For convex surfaces (both sides of our Jell-O lens are convex) R_1 is positive and R_2 is negative.

For most lenses, the distance d between the surfaces is small compared to the radius of curvature of the surfaces and the above equation can be simplified by assuming d is zero.

Lens Maker's equation (in air, thin lens approximation):

$$\frac{1}{f} \approx (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

Suggested Questions
Q. Which cup gives us R_1? R_2?
A. R_1=is the small cup and R_2=is the large cup.
Q. What are the signs (positive or negative) of each radius?
A. R_1 is positive and R_2 is negative.
Q. Using the focal distance you measured, the distance d from the left and right sides and R_1 and R_2, calculate the index of refraction, *n,* of the Jell-O using the full Lens Maker's equation.
A. Answers will vary group to group. Something close to 1.3, the index of refraction of water, is reasonable or maybe a little higher since the Jell-O is concentrated. With some imprecision factored in, anything between 1 and 2 is good! I calculated n=1.4 when I practiced this demo

and found the easiest way to solve the equation was to enter the values I had, expand it into the standard quadratic equation form, then use the quadratic formula.
Q. Calculate the index of refraction of the Jell-O using this approximation. Does it match what you calculated before? If it does, do you think this is a good approximation? If not, why do you think there is a difference?
A. Answers will vary group to group. In my practice demo I calculated n=1.34 with the thin lens approximation.

Teacher's notes: Follow up thoughts on why refraction happens
Ask the students some questions to get them thinking about index of refraction.
Q. *What is the fastest you've ever traveled in miles per hour?*
A. Probably somewhere between 100mph (car) and a few hundred mph (airplane).
Q. *Does anyone know how fast light travels in mph?*
A. 671 million mph. That's 186,000 miles per second, which means light could go all the way around the world more than 5 times in less than one second!
Q. *Did you know that light can be slowed down? Light actually travels at different speeds in different materials.*
Q. *Can anyone guess the slowest anyone has ever measured light traveling?*
A. 38 mph. Pretty slow!
http://abcnews.go.com/Technology/story?id=99111&page=1#.UFD4IRzFLMs

When light switches from traveling in one material to another, it has to change speed. If the light goes into the new material at an angle, some of the light (wave) starts to slow down or speed up before the rest of the wave, which makes it bend toward a new direction! Think about someone in a canoe paddling faster on one side than the other… making the canoe turn. This is how refraction works.

Final Discussion
Q. What is refraction?
A. The bending of light when it moves from one material into another at an angle.
Q. What are two of the important factors that govern how a lens refracts light?
A. Radius of curvature and index of refraction.
Q. How do engineers use index of refraction and other properties of lenses for special designs?
A. To manipulate the path of light by directing, focusing, and transferring light.
Q. Was your calculation of the index of refraction of Jell-O reasonable? If not, what are some potential sources of error in your measurements and calculations?
A. Varies among students. You want to convey that engineers estimate things frequently and if their initial estimate is unreasonable they re-evaluate their method and look for ways to improve it. Iteration is a key component of good engineering.
Q. Can you think of ways to improve the accuracy of your estimate of the refractive index of Jell-O or other ways to measure it?
A. Varies among students. You could test the Jell-O using Snell's law, for example, or try to take multiple measurements and average them to improve accuracy, perhaps with more sophisticated measurement apparatus.

Supplementary Jell-O Activities

Activity S1- Scattering and Absorption
Goal: Students will understand the difference between scattering and absorption and how it is related to wavelength of light. What you see is reflected, and everything else is absorbed.

Scattering and absorbance are light phenomena exhibited when we see an object that is a particular color, that is because it bounces that color from the light toward us (scatters) while it keeps the other colors (absorbs).

Ask the students some questions to get them thinking about scattering and absorbance.

Q. Where does the color of something come from?
A. We know that white light is made of all the colors like sunlight. We see all the colors in sunlight when we see a rainbow. When we see an object that is a particular color, that is because it bounces that color from the light toward us (scatters) while it keeps the other colors (absorbs).
Q. So if something looks white, which colors does it reflect/scatter?
A. All of them! It bounces them all to your eye and doesn't keep any of them. Remember white light is a combination of all the colors.
Q. And if something looks black, which colors does it reflect/scatter?
A. None of them! It keeps them all and bounces almost none to you.

Red laser scattering.
Q. If you point the red laser into the red Jell-O, will you be able to see it?
*A. **DEMO:** Have students point the red lasers into the red Jell-O to find out. The beam of the laser should be easily visible because it is scattered by the red Jell-O.*

Green laser absorbance.
Q. Do you think we can see the green laser if we shine it in the Jell-O?
*A. **DEMO:** Have students point the green lasers into the red Jell-O to find out. The beam of the laser should disappear quickly because it is absorbed by the red Jell-O.*

Activity S2 - Relay Lenses
Goal: Students will hypothesize and then test what happens when 2 gelatin lenses are used to form a relay lens combination.

Demo
1. Place a second gelatin lens on the wax paper with the flatter sides facing each other.

2. Place the 2 red lasers parallel to each other on the left side of the left lens. Observe what happens to the beams after passing through the second gelatin lens.

Suggested Questions
Q. Can anyone think of some things that could happen if we tried to use a combination of lenses?
A. Kids answer.

Q. What if we use two plano-convex lenses? If we use one to focus the laser beams, is there a way we could use another of the same lenses to straighten the beams so they are parallel again? Try it and let me know if you figure it out.
A. Kids answer. Let kids problem solve this one and go around showing them if they don't get it.
Q. Can anyone guess how big the biggest lens ever built was?
A. 50 inches! Almost as tall as some of you I bet. It was in an old telescope, which use mirrors now instead of lenses.
http://en.wikipedia.org/wiki/Great_Paris_Exhibition_Telescope_of_1900
Q. Can anyone guess how small the smallest lens is?
A. 1 millimeter! It's for your smartphone.
http://www.geek.com/articles/mobile/tiny-new-glass-lens-paves-way-for-projectors-in-smartphones-2011081/

Additional Resources

- Sock 2008 Kit: http://www.spsnational.org/programs/socks/2008_sock_guide.pdf
- Gummy bears and light: http://www.laserclassroom.com/sites/default/files/pdfs/Gummy%20Bears%20and%20LASERS%20compressed.pdf
- http://www.math.com/students/calculators/source/quadratic.htm
- http://www.calctool.org/CALC/phys/optics/reflec_refrac

Suggested Student Worksheets

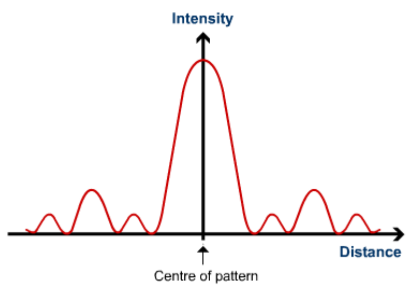
Diffraction

Activity 1 – White Light: Put on diffraction glasses and look directly at the white light source. These glasses separate the light source into wavelengths of individual color bands.

Q1. Describe what you see. How does white light differ from natural sun light?

A1. The diffraction grating glasses have very small slits or apertures that cause light to bend as it passes through. This bending or refraction allows us to see the color components of white light.

Below is a diagram of the shape and direction of a wave after passing through a slit:



Q2. A beam of monochromatic light approaches a barrier with various slit lengths. Which size opening would cause the greatest diffraction?

A2. The greatest diffraction would be observed with the smallest slit size.

Q3. How do short wavelengths passing through a large opening effect diffraction?

A3. The short wavelengths would not be as affected by a large opening compared to a smaller one. The wavelengths would not diffract very strongly.

Activity 2 – Gas Lamps: Put on diffraction glasses and look directly at the light coming from the spectral gas lamps.

Q4. What are the types of gas lamps used and how do their spectra differ?

A4. (Depending on availability, students can identify gas lamps by their "spectral fingerprints" or spectral lines by comparing what they see to an online web search conducted prior to class)

Q5. What is a possible use of the differential spectra you observe?

A5. Scientists and researchers can identify gases on stars and planets; diffraction is a popular technique in imaging to gather more information about a tissue or material.

Polarization

Activity 1 – Crossed Polarizers: Use two polarizer sheets to observe maximum light transmission when aligned. Look at a source of light through the filters while rotating one of the filters.

Q1. Describe what you see. Rotate the filters 90 degrees. What do you observe now? Rotate the filters through an additional 90 degrees. Explain what is happening.

A1. After finding the orientation with maximum transmission and then fixing one polarizer at a constant angle and slowly rotating the second polarizer you should notice the intensity of the light will vary from completely blocked to maximum transmission as you rotate the second polarizer in a full circle. **(2.)** Rotating the top polarizer 90 degrees from maximum transmission results in a minimum transmission of light. The point when the light transmitted through the filters is completely blocked. When this occurs the two filters are said to be <u>cross polarized</u>. **(3.)** As the polarizer is rotated an additional 90 degrees, the transmission through the polarizer sheets is again at a maximum. This is due to the fact that every 90 degrees angle between the two polarizers will either results in the polarizers preferential axis being aligned for the polarizers, (leading to maximum transmission), or the axis being perpendicular leading to cross polarized orientation, (the transmitted light is completely blocked).

Activity 2 – Three Polarizers Phenomenon: Introduce a third polarizer in between the two crossed polarizers and observe how light is now transmitted.

Q2. What do you observe? Rotate the center polarizer. At which angle is the maximum amount of light observed?

A2. Although the third polarizer only absorbs some of the light, more light is now transmitted, after the insertion of this absorber. When a third polarizer is placed between the crossed polarizers, a significantly higher light intensity is transmitted through the polarizers than compared to the crossed polarizer configuration. **(2.)** Maximum amount of light is transmitted in a three polarizer setup when the third polarizer in the center is oriented at an angle of 45°, oriented midway **between each filter in the cross polarized setup.**

Activity 3 – Optically Active Substances: Observe how an optically active substance, such as Karo syrup, transmits light when placed between two polarizers.

Q3. What causes the appearance of color? Why does each beaker display a different color?

A3. Certain materials have the ability to **"rotate" the plane of polarization,** of polarized light. The amount of rotation that occurs is wavelength dependent. Thus, since a white light is made up from an entire spectrum of colors (**Hint:** think of a rainbow) each respective color will be rotated at different amounts as the polarized white light is passed through an optically active sample. **(2.)** Each beakers displays a different color because of the different volumes of solution in the containers. The effect of rotating the plane of polarization in an optical sample is proportional to the volume, or path length, the light travels through the sample.

Q4. Now rotate the angle of the second polarizer slowly. What changes do you observe? What do you think is happening?

A4. As the polarizer angle changes, the wavelength of light transmitted through the polarizers will change. Since white light is made up from an entire spectrum of colors (**Hint:** think of a rainbow). Thus, the variation in the color transmitted through the polarizers occurs when polarized white light passes through an optically active liquid such as Karo syrup. Each of the colors, or wavelengths, of light are rotated at different angles specific to the individual wavelength of the light. **(2.)** The plane of polarization for each of its constituent colors, in the white light spectrum, to be rotated by different amounts. Resulting in the appearance of a specific color of light at each angle of the polarizer.

Activity 4 – Birefringent Tape Art: Cover a transparency piece with overlapping layers of transparent tape and place between two polarizers. Rotate the top polarizer so that the most vivid colors are observed.

Q5. Now rotate the top polarizer by 45̊. What do you see? Explain what happens when light enters a birefringent material.

A5. As the polarizer is rotated different colors can be seen depending on the orientation of the polarizers. When a ray of light enters a birefringent material, it divides into two rays. The two rays have different speeds and are polarized at right angles to each other, meaning that two different colors can be seen depending on the orientation of the polarizers.

Acknowledgements

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  - Meagan S. Harris, *Ph.D. Student, SPIE President 2012-13*
  - Brian Cummins, *Ph.D. Student, SPIE President 2011-12*
  - Holly Gibbs, *Ph.D. Student, SPIE Outreach Coordinator*
  - Casey Pirnstill, *Ph.D. Student, SPIE Vice President*
  - Joel Bixler, *Ph.D. Student, SPIE Journal Club Coordinator*

- Behind the Scenes:
  - Haley Marks, *Ph.D. Student, SPIE Secretary*
  - Candice Haase, *Ph.D. Student, SPIE Member*
  - Cory Olsovsky, *Ph.D. Student, SPIE IT Officer*
  - Scott Mattison, *Ph.D. Student, SPIE Member*

SPIE
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Shedding Light on Optics

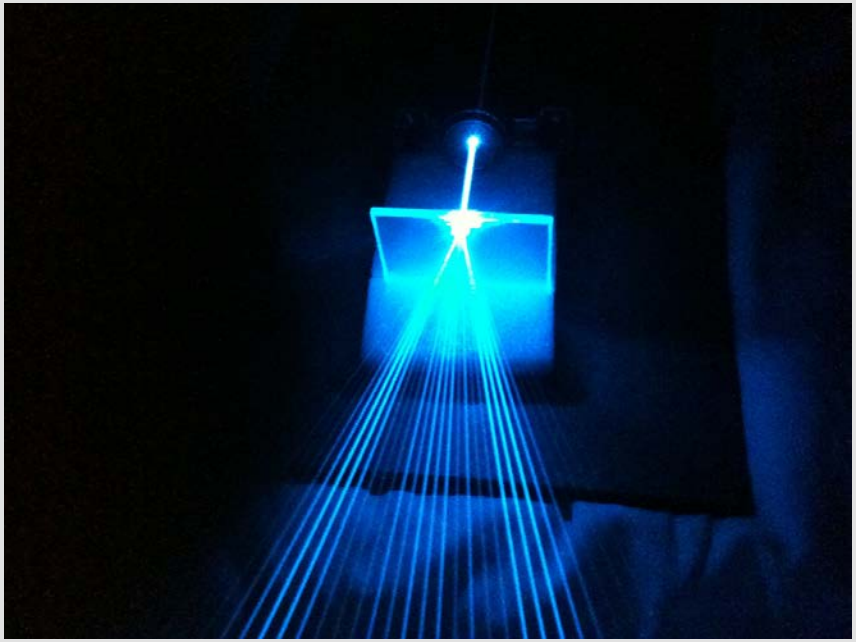
Texas A&M University Chapter of SPIE

2013 Teacher Summit
Focus on STEM: Science and Engineering in the Classroom

Fish Tank Optics

Diffraction

- What is diffraction?
  - The effect is a wave phenomenon occurring whenever a portion of a wavefront is obstructed in some way.
  - Word 'diffraction' originated from Latin " *diffringere*" which means "to break into pieces."
  - Any wave (sound, matter, light) will diffract.
  - There is no significant physical difference between interference and diffraction



http://www.flickr.com/photos/7461930@N06/5220409274/

Principles of Diffraction

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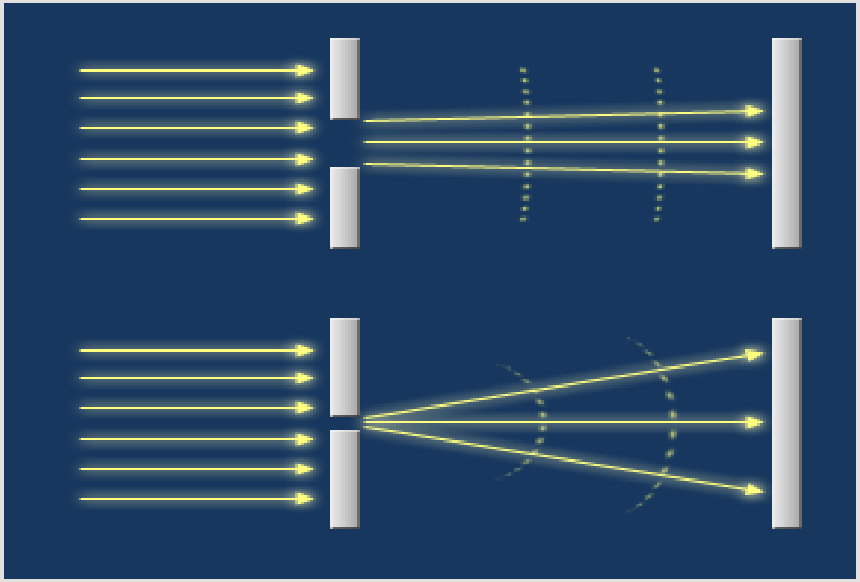
- While all waves can diffract, the effects are most noticeable when the wavelength of the wave is similar to the size of the obstruction.
- Small features cause light to spread out quicker.
- Many types of objects cause diffraction
  - Circular or rectangular apertures
  - Small particles in the atmosphere
- Diffraction is wavelength dependant
  - Different colors of light will spread out at different angles

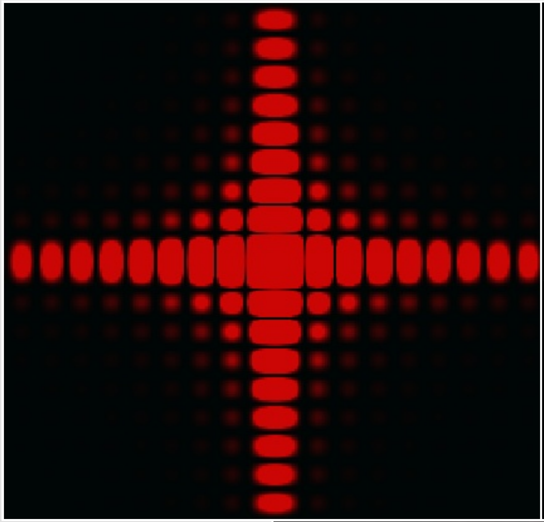


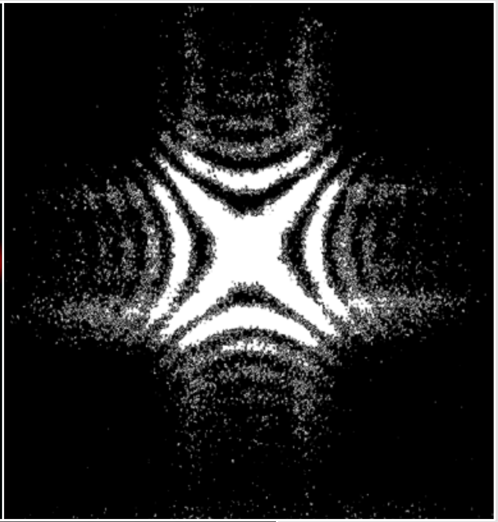
$$\lambda = d \sin \theta_{min}$$

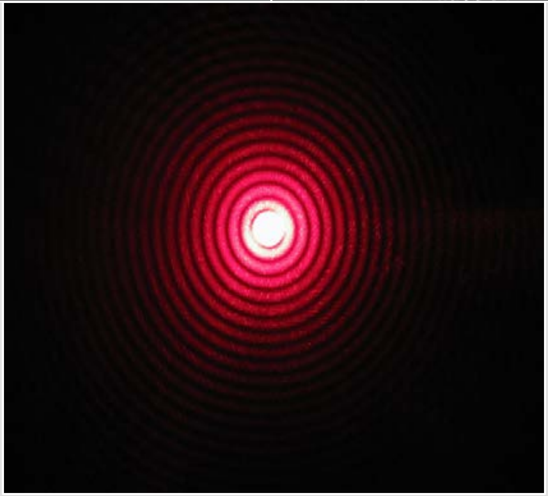
d is the width of the slit
λ is the wavelength of light

Diffraction Patterns

- Different geometry objects will result in different diffraction patterns
- We can design diffraction gratings to generate any diffraction pattern
  - Holograms are made this way
- Diffraction provides one of the fundamental limits in the resolution we can achieve with cameras, microscopes, and telescopes.







Activity 1 - White light with diffraction glasses

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- *Goal: Explore the effect of a diffraction grating on a white light source.*
- Demo: Pass out diffraction glasses to students. Have them put them on and look at a white light source located somewhere in the room. (Ceiling lights work fine for this)
- Notes: As diffraction is wavelength dependant, a rainbow pattern should be observed

Continued

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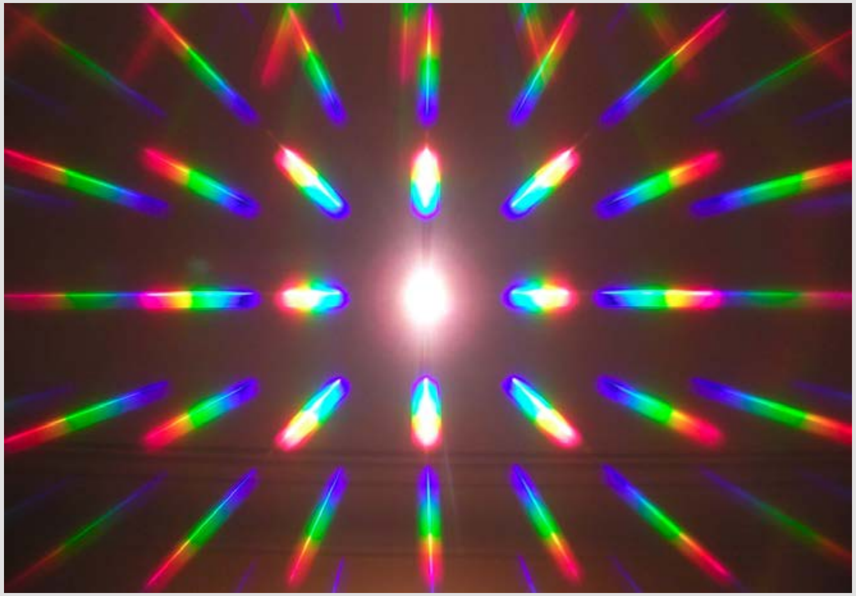

- Questions:
  - Ask the students to predict what they might see before they put on diffraction glasses and look at white light.
  - This principle allows for unique identification of molecular and chemical species using different types of spectroscopy.

Activity 2 – Gas Lamps

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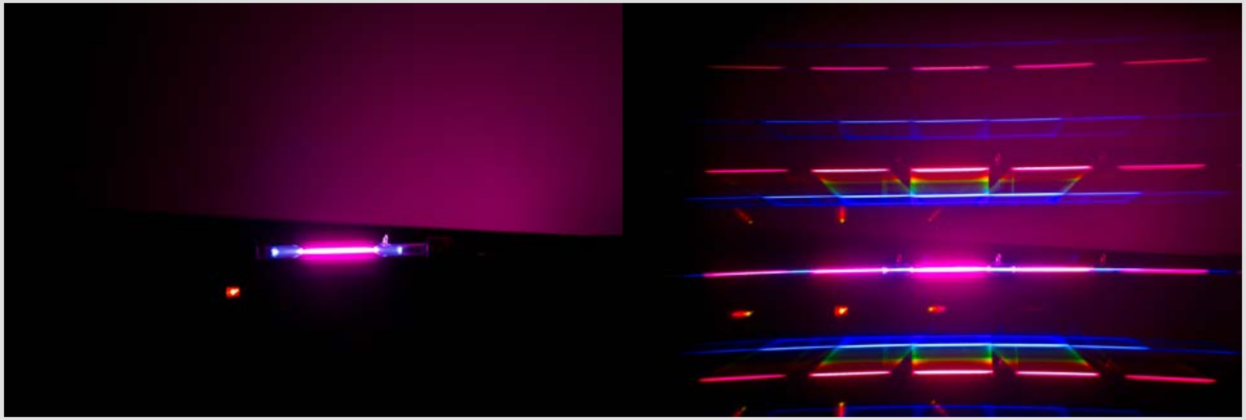
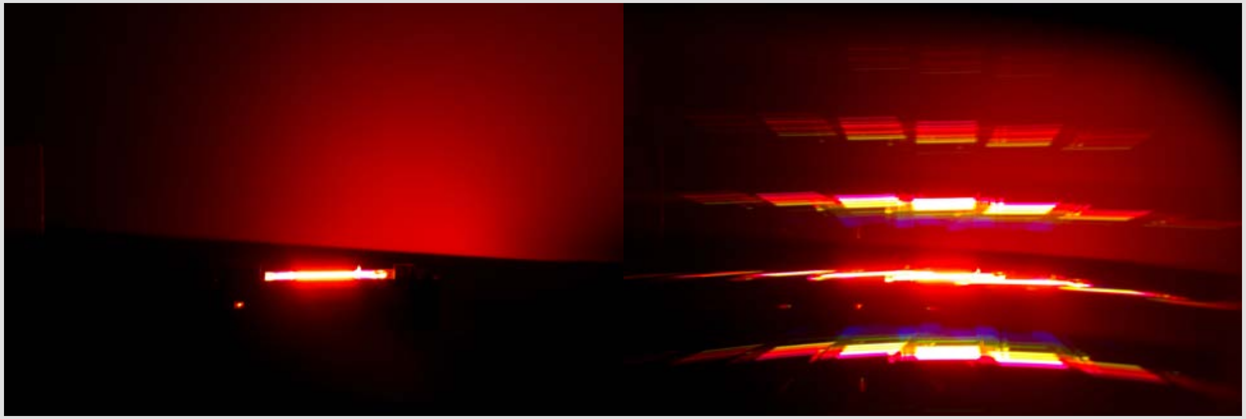
- *Goal: Demonstrate how diffraction gratings can be used to identify the unique spectral signature of different gases.*
- Demo: Have the students put on diffraction glasses and view the light emitted from a gas lamp.
  - Each bulb type should have its own unique color bands when viewed with diffraction glasses.

Continued



Hydrogen Gas Lamp



Neon Gas Lamp

Activity 3 – Camera Flash!

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- *Goal: Take a fun group picture with your diffraction glasses on.*

- Demo: Making sure that the camera flash is on, take a group photograph of the class with their diffraction glasses on. The flash should be fun for the students.

Polarization

- Polarization is a property of light
- Three primary states of polarization are:
  - Circular
  - Elliptical
  - **Linear**
- Produced through several methods :
  - Reflection, Double refraction, Selective absorption, Scattering

Polarization Examples

You may not be aware of it, but polarized light and technologies utilizing concepts of polarization are all around you

- Do you own a laptop, LCD flat screen TV, calculator, cellular phone, or other liquid crystal display device?
  - If so, you have already been exposed to polarized light

Polarized sunglasses

- Interact with & eliminate polarized light
- Reflections from non-metallic surfaces (i.e. snow, roads, a tabletop, or water)

Polarizers

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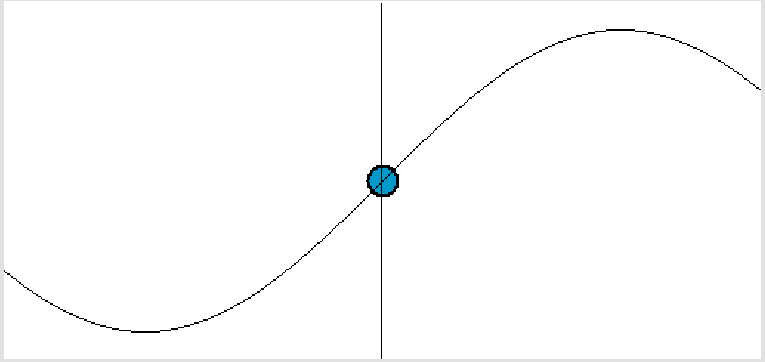
- Unpolarized light
  - Composed of several transverse waves
  - Most types of light sources (i.e. sunlight and most indoor lights)
- Linear polarizer sheets
  - Only transmit light existing in a single plane
  - Placed in-line with an unpolarized light source
    - Block light in all planes except plane matching polarizer



http://en.wikipedia.org/wiki/File:Simple_harmonic_motion_animation.gif

Picture Fence Analogy

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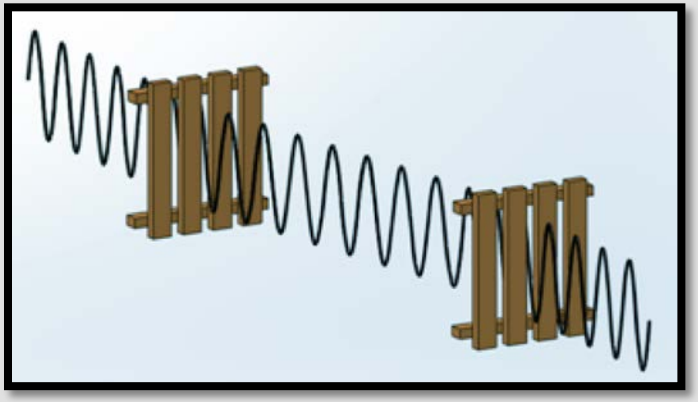
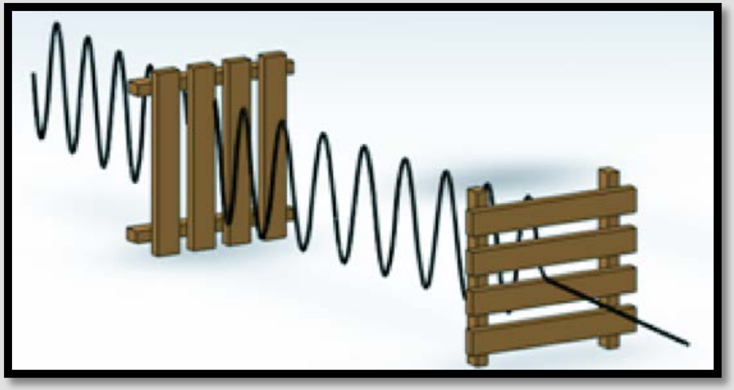
Picture each polarizer as "*molecular picket fence*"

- Process of polarization similar to oscillating a rope (sinusoidal) through pickets of a fence
- Pickets of two fences (oriented parallel)
  - Vibrations of rope, pass through both fences
- Pickets of two fences (oriented perpendicular)
  - Vibrations of rope, blocked by second fence





Activity 1 – Crossed Polarizers

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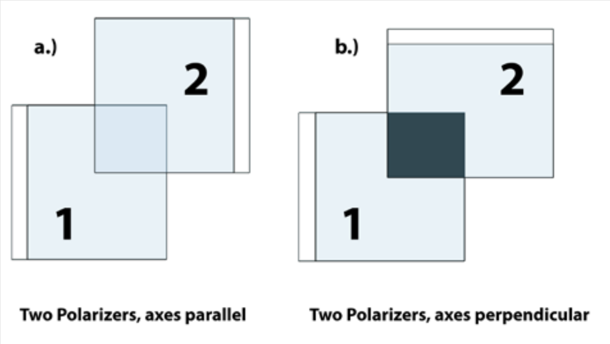
- *Goal: This activity allows students the opportunity to discover what polarizers are and how they function. They will be able to describe and predict how the amount of light transmitted through the polarizers changes with orientation.*

Explore relation between rotation angle of two polarizer sheets:

- Locate the angle that orients the two polarizers in parallel
- Rotate the top polarizer to find the point when the light through the filters is completely blocked (**cross polarized**)

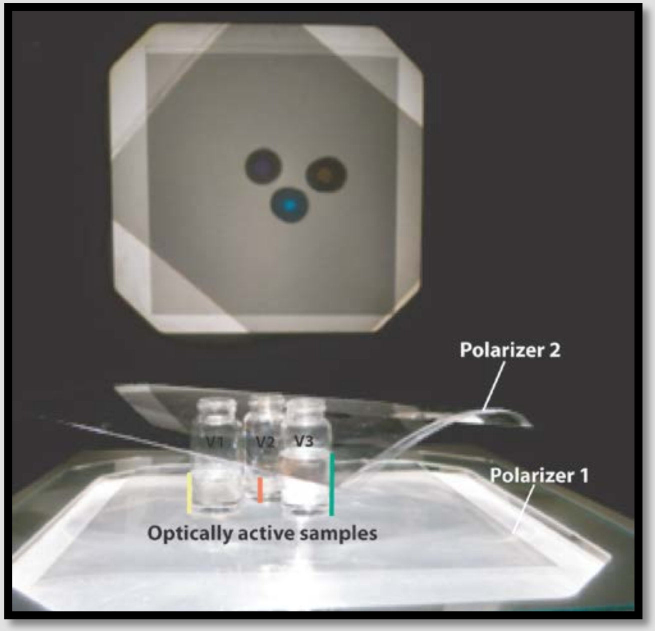
Materials:

- Linear Polarizing Sheets
- White Light Source (i.e. overhead projector or light fixture)



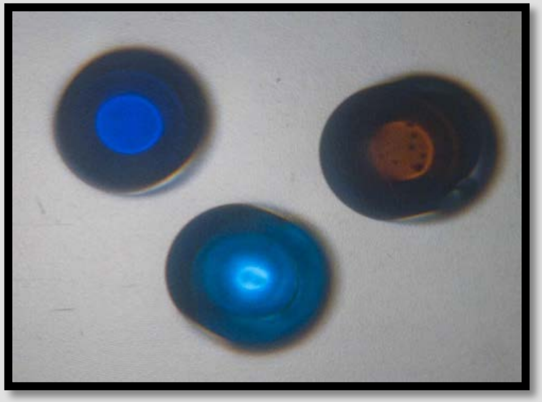
Activity 2 – Optical Activity

- *Goal: Students will be able to identify and explain how polarized light is affected as it is passed through an optically active sample.*



Materials:

- Linear Polarizing Sheets
- White Light Source
- Karo Light Corn Syrup



Optical activity

- Rotation of linearly polarized light as it travels through a solution of chiral molecules
- Rotation is wavelength dependent
- Karo and corn syrup are optically active liquids
- When polarized white light is transmitted through an optically active fluid each wavelength, color of light, is rotated by different amounts

$$\alpha = [\alpha]_{\lambda} \cdot C \cdot l$$

where,

α is the observed rotation

[*α*] is the specific rotation at a given wavelength

C is the concentration of optically active sample

l is the sample path length

Birefringence

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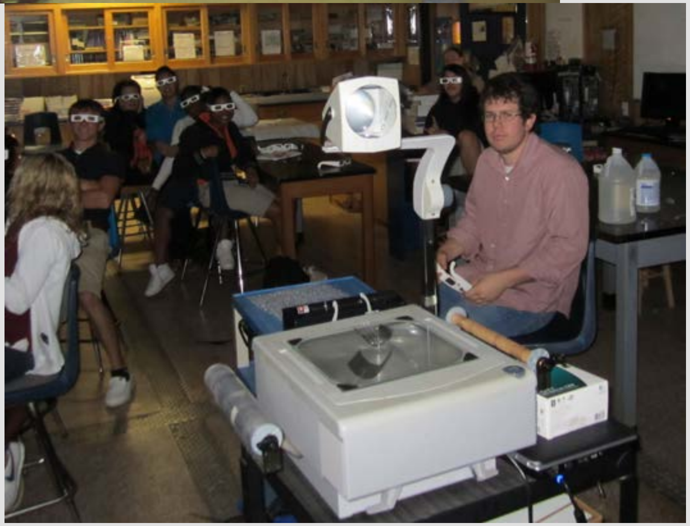
- Birefringence refers to material with two indices of refraction
- Splits non-polarized light into two rays
- Different colors can be seen depending on the orientation of the polarizers



Activity 3 – Birefringent Tape Art

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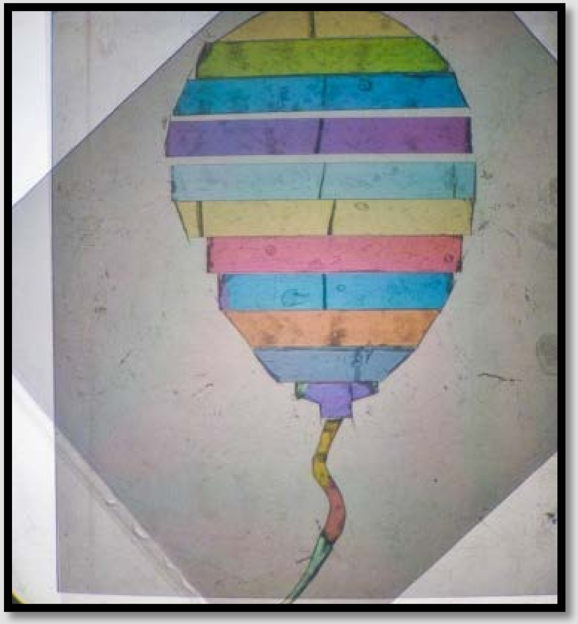
- *Goal: Students will be able to identify the presence of birefringence and its effects on polarized light.*

Materials:

- Linear Polarizing Sheets
- White Light Source (such as overhead projector, light fixture, or flashlight)
- Cellophane/Cellulose Tape
- Transparency Sheet



Jell-O Optics

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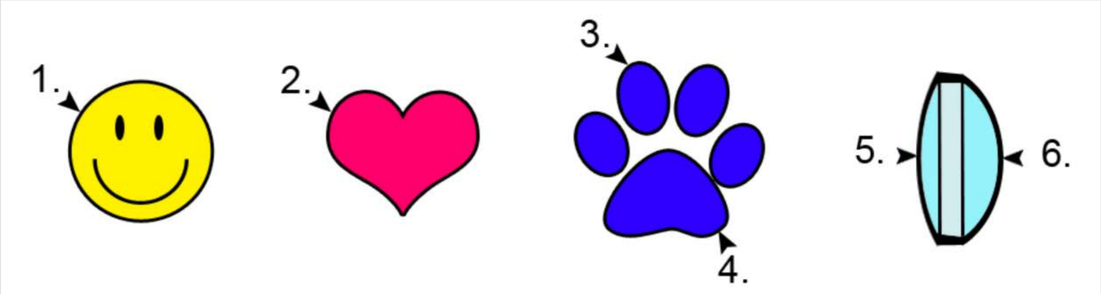
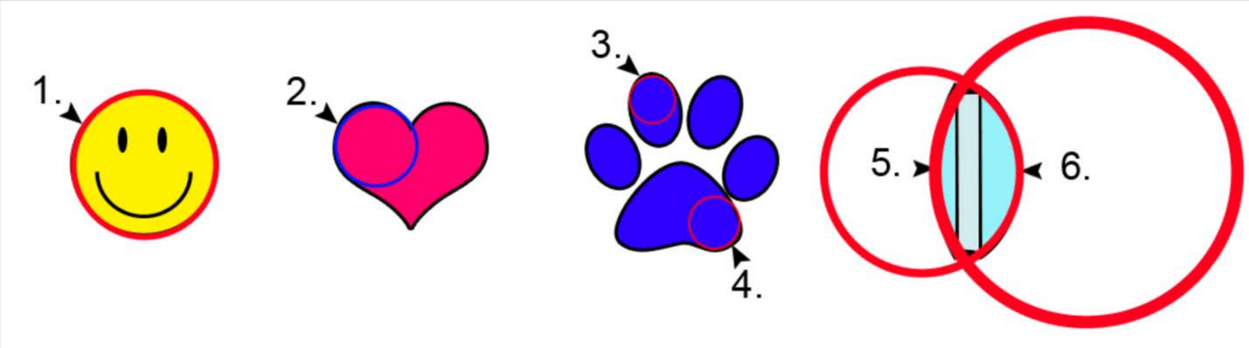
- In this demo, students will explore the parameters that govern how lenses focus light by creating their own lenses made of Jell-O.
- They will measure the radius of curvature of their lenses and the focal length, and use these to calculate the index of refraction of Jell-O with the Lens Maker's equation.

Radius of Curvature

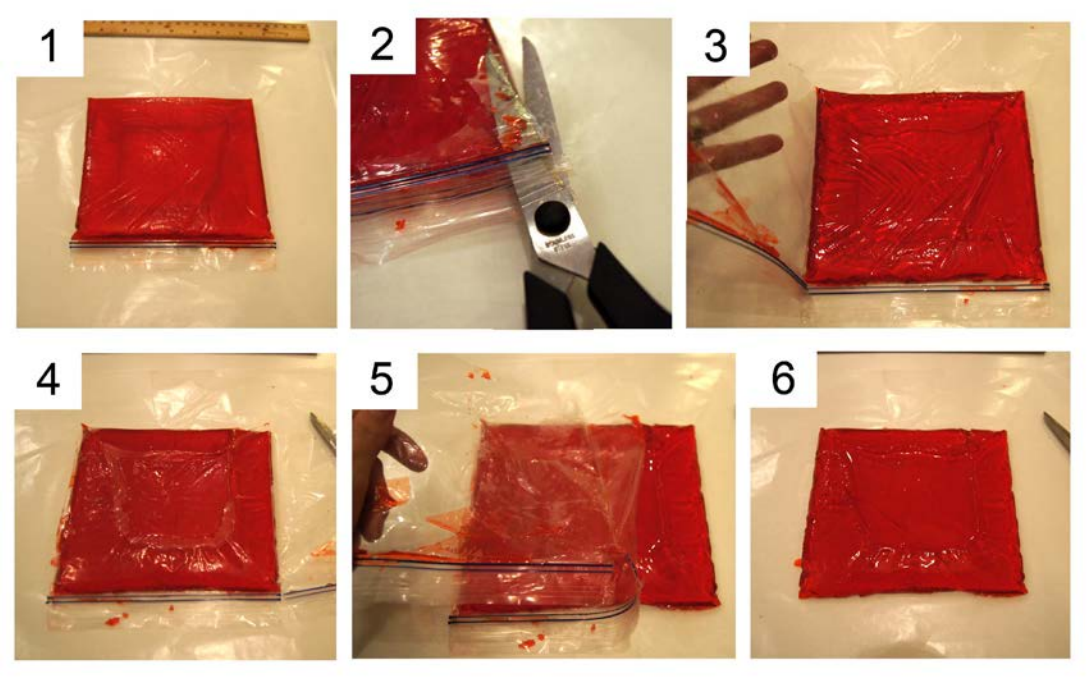
- For a circle, the radius of curvature is its radius. The radius of a circle that best approximates the curve at the vertex of interest.





Activity 1 - RoC

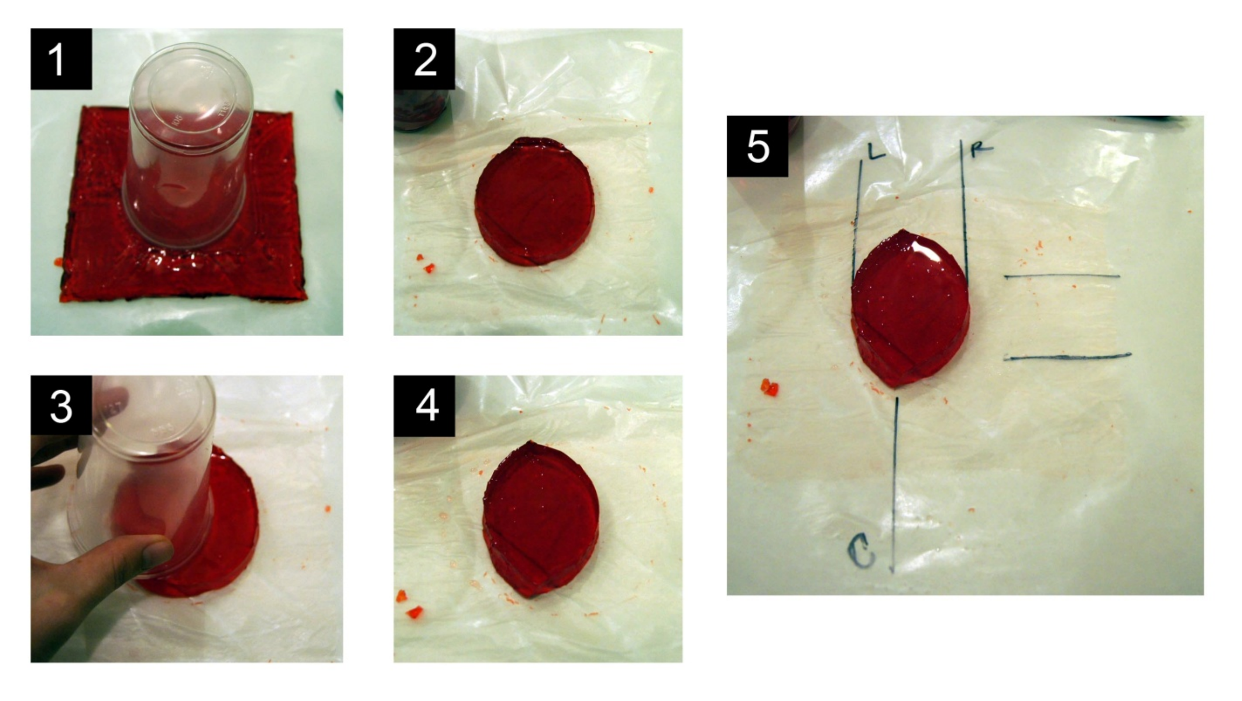
- *Goal: Students will understand the definition of radius of curvature for complex objects.*



MATERIALS
1 large plastic cup
1 small plastic cup
Plastic sandwich bags with zip-lock seal
Red gelatin (1 small box per group)
Scissors
Ruler
Wax Paper
Red laser pointers
Calculator

Continued

- To make the lens, use the large cup to cut a circle out of the center of the Jell-O; then use the smaller cup to cut the lens from the circle, as shown in the pictures.



Measuring RoC

- We want to know the radius of curvature of each side of our Jell-O lens. Measure the diameter, d, of each cup so you can find its radius (r=d/2). When using the ruler, make sure you measure the largest distance across the top of the cup (like shown below) so you don't underestimate the radius. In the picture below, the cup's diameter is about 3.5".

Refraction

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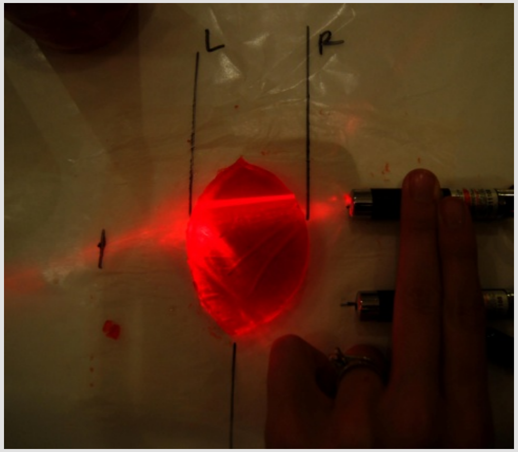
- The bending of light in a plane when it passes from one material into another is a phenomenon governed by Snell's Law (the actual person who came up with the law was called Lord Snellius).
- We will use our Jell-O lenses and measure how much they bend light in order to calculate their index of refraction.

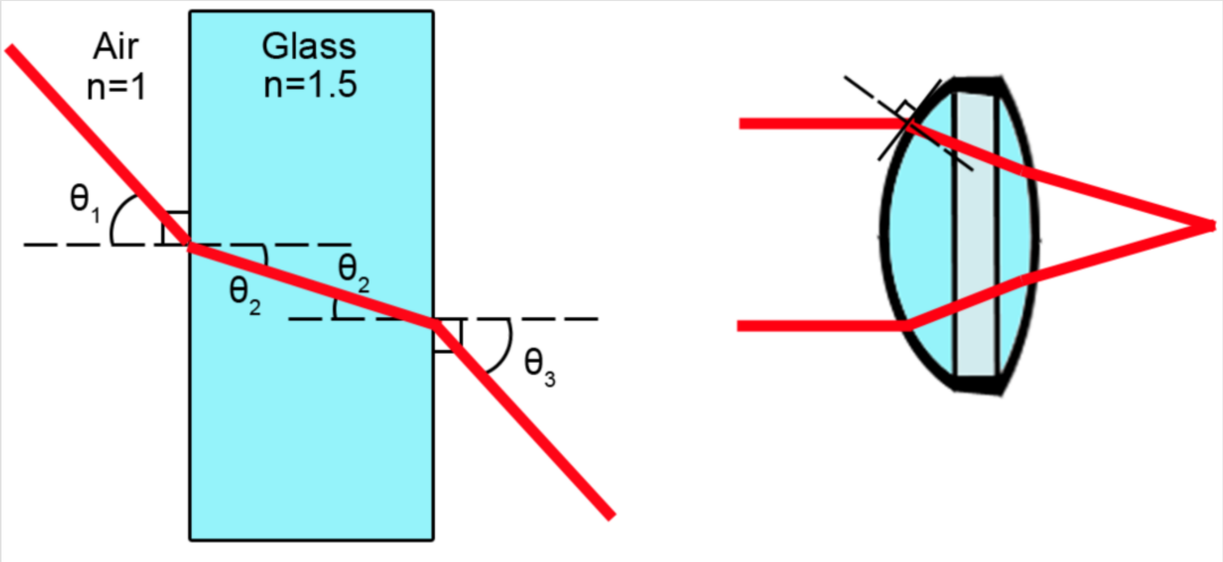


Snell's Law

- How much the light bends depends on the index of refraction. This is the mechanism a lens uses to focus light (even lenses made from Jell-O!).

Snell's Law:

$n_1 \sin\theta_1 = n_2 \sin\theta_2$



Activity 2 - Refraction

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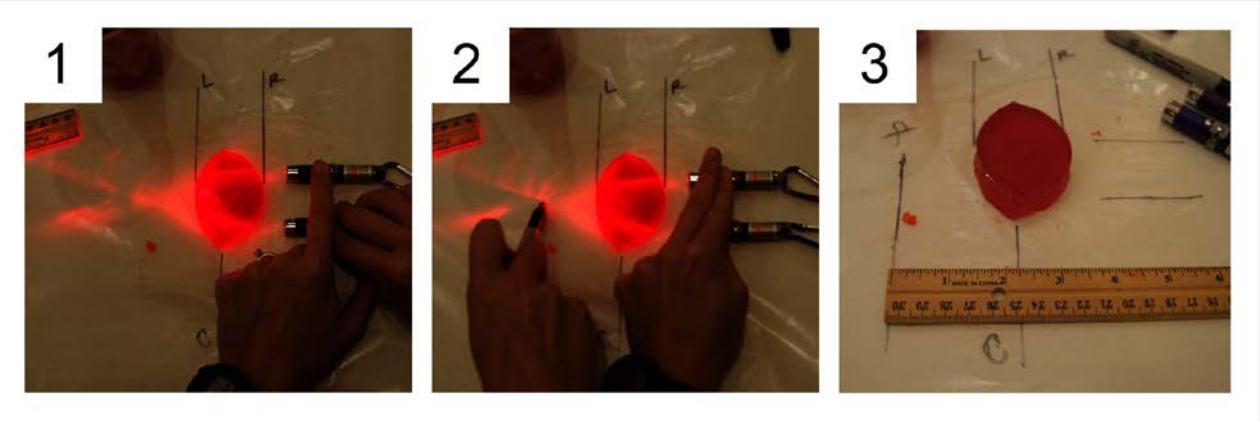
- *Goal: Students will understand the phenomenon of refraction, the bending of light, and be able to use Snell's law to calculate how much light is refracted by glass in this example.*



- Measure the distance from the focal plane to the center of the lens, the focal distance which is a measure of how much the lens refracts light.

Activity 3 – Lens Maker's Eq.

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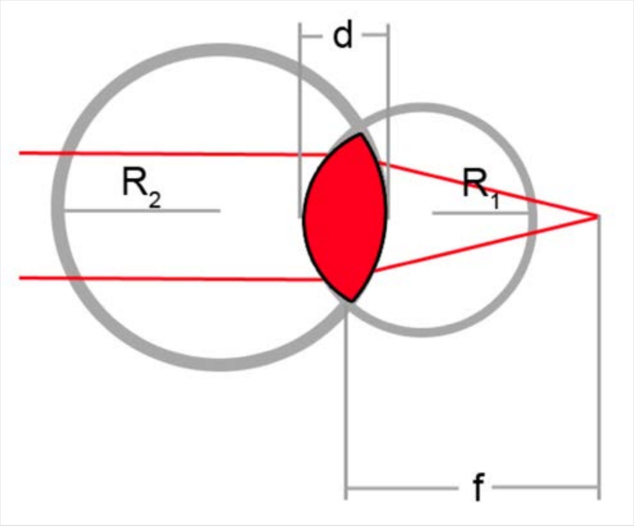
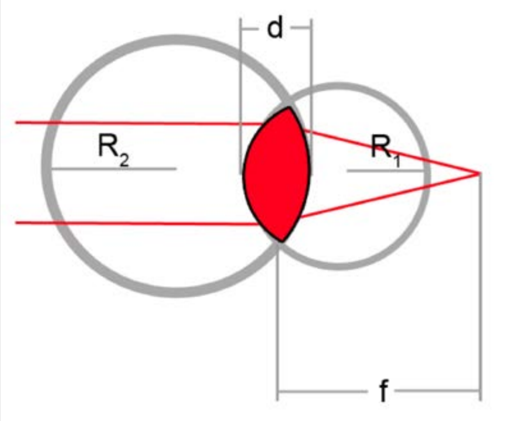
- *Goal: Students will learn to deal with sign conventions to do calculations and also appreciate how formulas can be simplified using approximations, in this case the thin lens approximation.*



$$\frac{1}{f} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2} + \frac{(n-1)d}{nR_1R_2}\right]$$

Thin Lens Approx.

- R_1 is the radius of curvature of the surface that is hit by the light first (left for us, notice that the lens is flipped in this diagram compared to the measurements we previously took) and R_2 is the second surface (right for us). There is a special sign convention for R_1 and R_2. For convex surfaces (both sides of our Jell-O lens are convex) R_1 is positive and R_2 is negative.



$$\frac{1}{f} \approx (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

Acknowledgements

SPIE Student Chapter
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- 2013 Teacher Summit for allowing us to host this workshop
- Dr. Kristen Maitland, *SPIE Faculty Sponsor*
- SPIE Workshop Instructors:
  - Meagan S. Harris, *Ph.D. Student, SPIE President 2012-13*
  - Brian Cummins, *Ph.D. Student, SPIE President 2011-12*
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- Behind the Scenes:
  - Haley Marks, Candice Haase, Cory Olsovsky, Scott Mattison

Contact/Reference

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- You can find our handouts and suggested worksheets at the following locations:
  - Spie.tamu.edu
  - Resource page on Teacher Summit Website

Q&A and Kit Drawing

SPIE Student Chapter
Texas A&M University

Workshop 4

DNA Comparison

2013 TAMU Teacher Summit

Connecting Algebra and Biology

Armando Vital
Mathematics Teacher
Veterans High School
Brownsville ISD
Brownsville, TX

http://www.google.com/imgres?imgurl=http://journals.iucr.org/d/issues/2002/06/02/za0051/za0051fig1thm.gif&imgrefurl

Background:
My E3 Experience in Summer 2011

Summer Teacher Program at Texas A&M

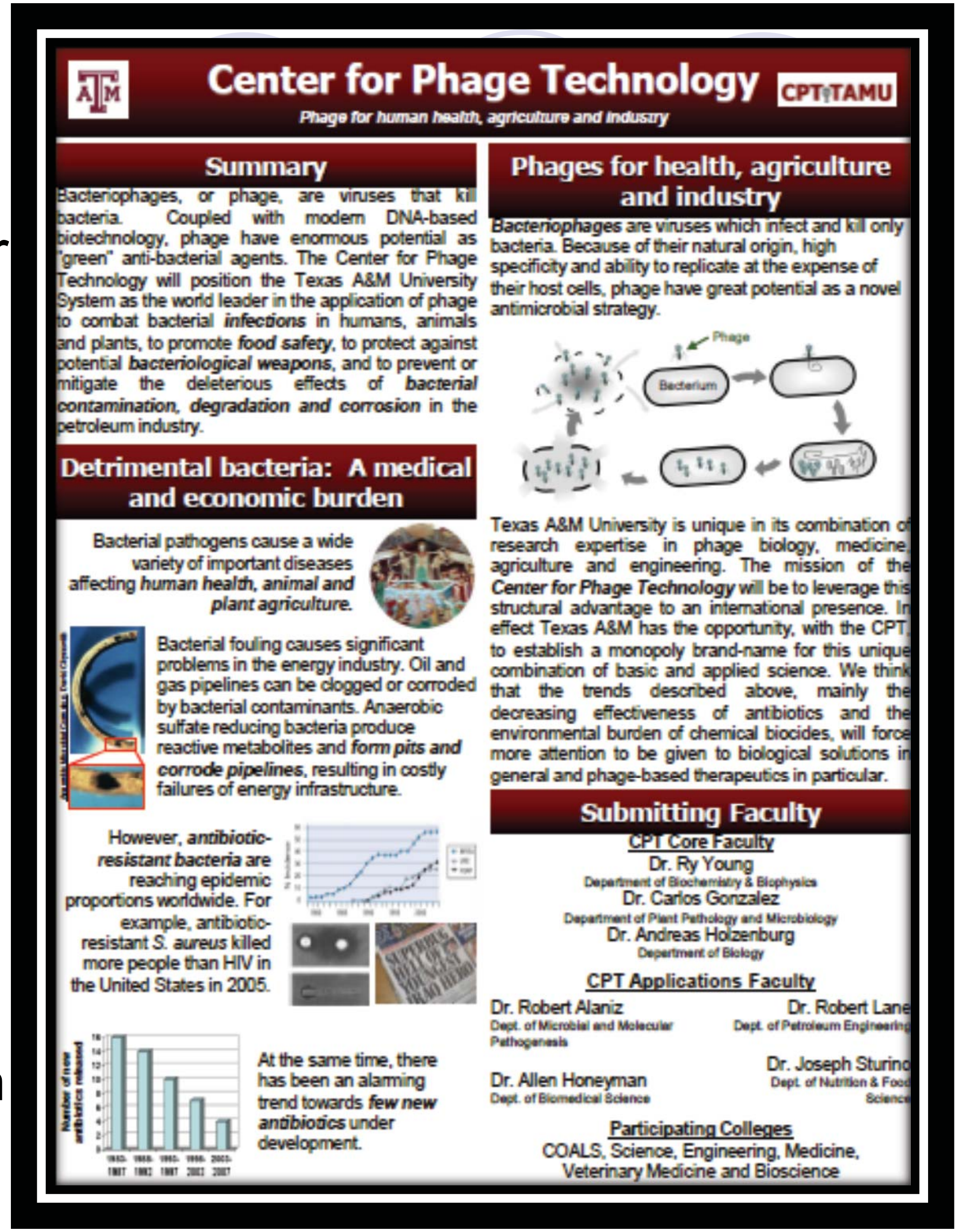
- Assigned to faculty in Environmental Engineering and the Center for Phage Technology

Dr. Kun-Hui (Bella) Chu
Assistant Professor
Civil Engineering
(Environmental Engineering)
Texas A&M University

Dr. Jason Gill
Program Director
Center for Phage Technology
Texas A&M University

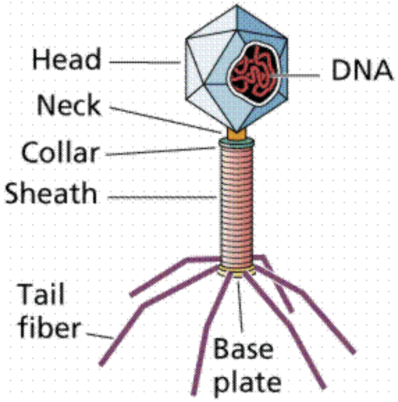
Center for Phage Technology

- Will position Texas A&M University as a world leader in the application of phages to combat:
  - Bacterial infections in humans, animals, and plants.
  - Promote food safety
  - Protect against potential bacteriological weapons
  - Prevent or mitigate the deleterious effects of bacterial contamination, degradation, and corrosion in the petroleum industry



My E3 Experience in Summer 2011

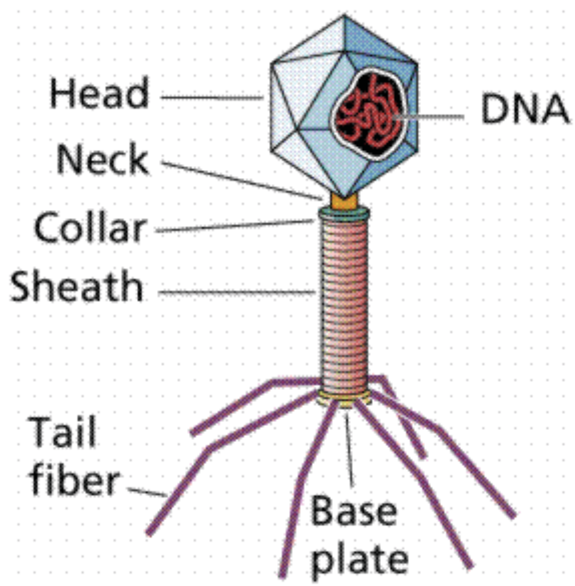
Fellow E3 teacher (Andy Hernandez) and I worked together to collect soil samples from a wastewater treatment facility, and conducted various lab procedures to isolate the phages in the soil. Andy is a science teacher in Gregory-Portland ISD.



Relevance of the Research

- Research Question
  - A tale of two phages: Is phage DNA sequence highly conserved over time and space?

- Significance: Phage Genome Evolution



Relevance of the Research

Research Activities
Phage Titration

Prepare 4 litters of R2A broth (media/nutrients)

Prepare broth with 1.5% Agar (solid)

Prepare petri dishes

Prepare broth with 0.8% Agar (gel)

Add *R. opacus* to molten agar

Collect soil samples

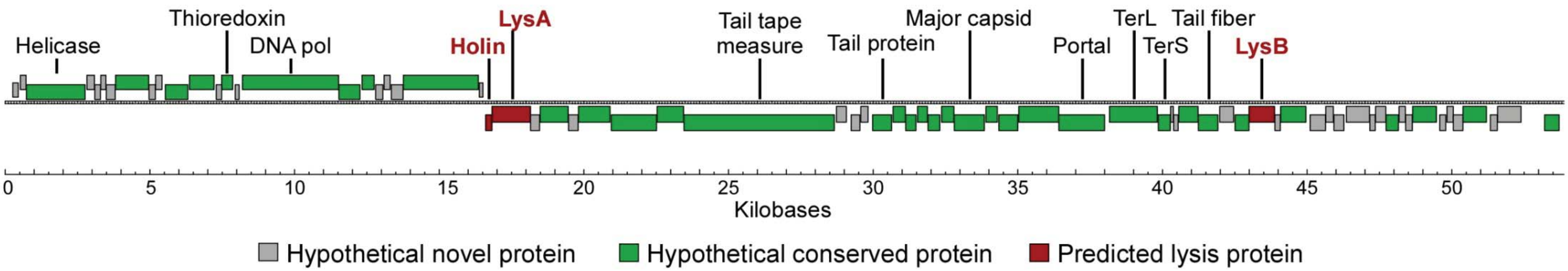
Collect phage from soil

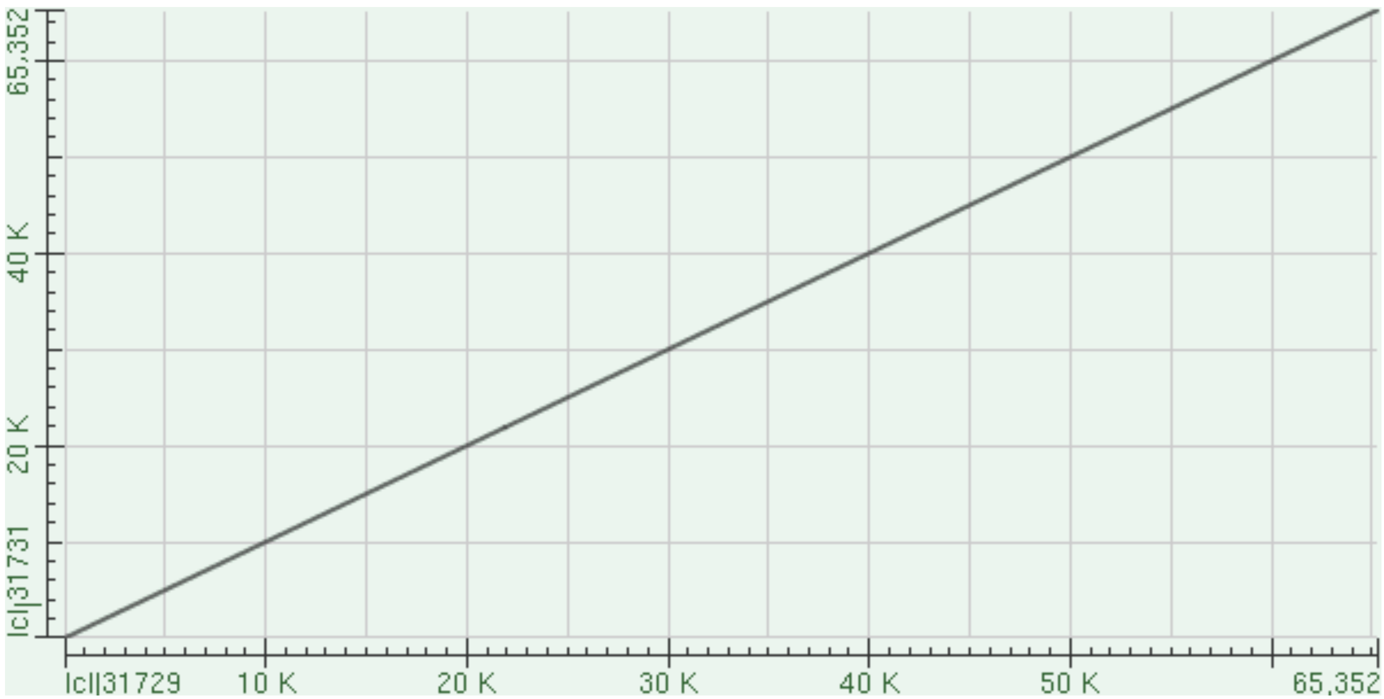
Pour bacterial lawn to petri dishes to achieve an even growth of bacteria

Apply phage spots to bacterial lawn

Proceed to full-plate titration of phage.

DNA sequence of RopaN4 vs Ropa1 (2010)



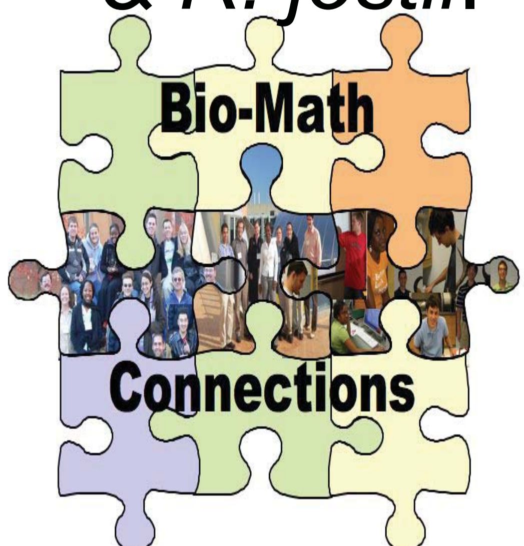


The RopaN4 sequence is represented on the X-axis, RopaN1 on the Y-axis. A straight line with a slope of 1 indicates the DNA sequences match all along their length (the 2 sequences are identical in 65,350 of 65,353 bases)*-Dr. J. Gill*

Core Element Bridged

Algebra ⟷ ***Biology***

Learning about DNA sequence base pairs of phages that infect bacteria *R. opacus* & *R. jostii*.



Compare DNA sequence base pairs using the **concept of slope** and **scatter plots** to identify if two phage are identical or different.

Educational Standards for Algebra

TEKS

A.6 (A) – Develop the concept of slope and determine slopes from graphs and tables.

A.6 (B) – Interpret the meaning of slope in situations using data or graphs.

A.1(E) – Interpret and make decisions, predictions, and critical judgment from functional relationships.

A.2 (D) – Collect and organize data, make and interpret scatterplots.

EOC CRS (College Readiness Standards)

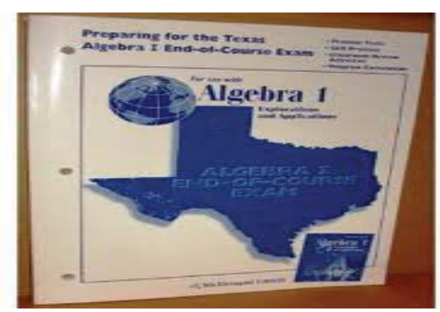
II.D.1 – Interpret and translate among multiple representations of equations and relationships.

VI.C.3 – Analyze relationships between paired data using graphing calculators.

ELPS (English Language Proficiency Standards)

1.C – Use mapping, drawing, comparing, contrasting, and reviev to acquire basic and grade level vocabulary.

2.E – Use visual, contextual, and linguistic support to enhance a confirm understanding of increasingly complex and elaborate spoken language.



Educational Standards for Biology

TEKS

B.2 (E) – Plan and implement descriptive, comparative, and experimental investigations, including asking questions, formulating testable hypotheses, and selecting equipment, and technology.

B.2 (F) Organize quantitative data.

B.2(G) – Analyze, evaluate, make inferences, and predict trends from data, and communicate valid conclusions supported by the data.

B.6 (B) Recognize that components that make up the genetic code are common to all organisms.

B.6(E) Identify and illustrate changes in DNA and evaluate the significance of these changes.

ELPS (English Language Proficiency Standards)

1.C – Use mapping, drawing, comparing, contrasting, and reviewing to acquire basic and grade level vocabulary.

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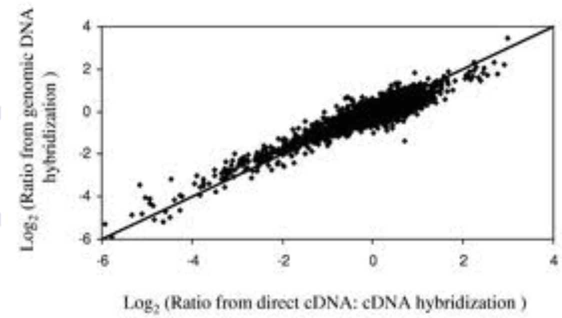
Lesson Design



Objective

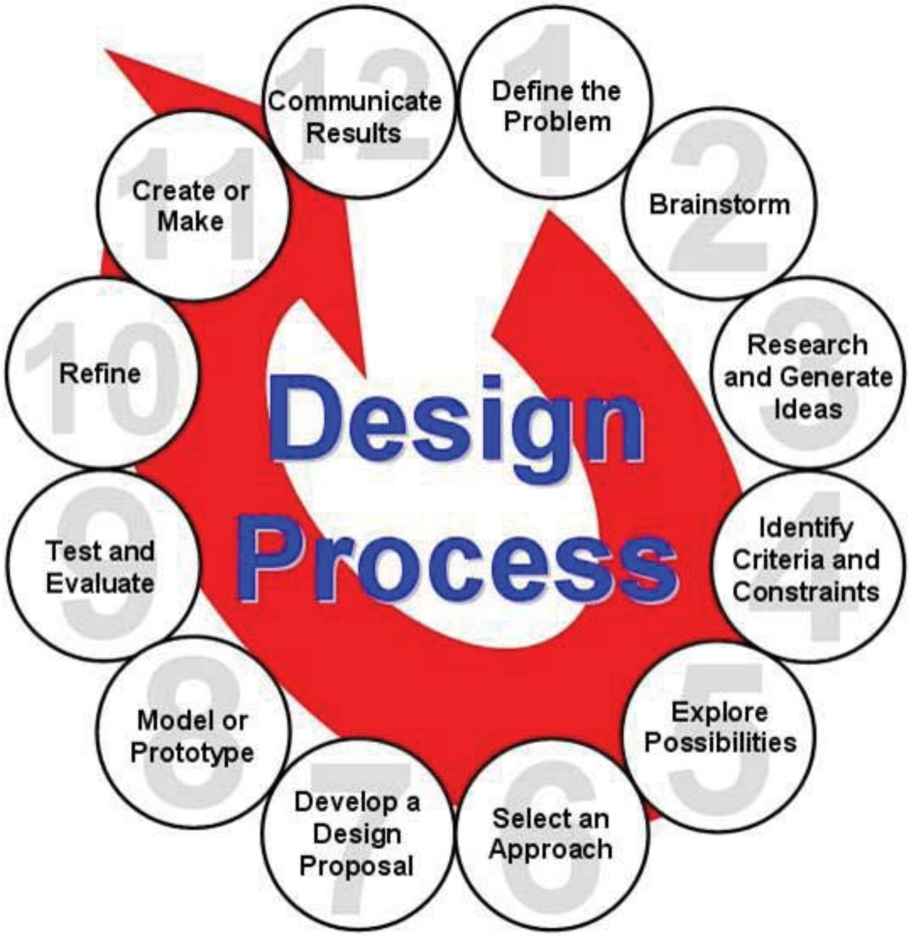
- Combine Algebra with Biology concepts to engage students in an interdisciplinary project that follows the Engineering Design Process, and allows them see how these concepts work together in the real world.
- In the real world, complex math models using differential equations have been generated.

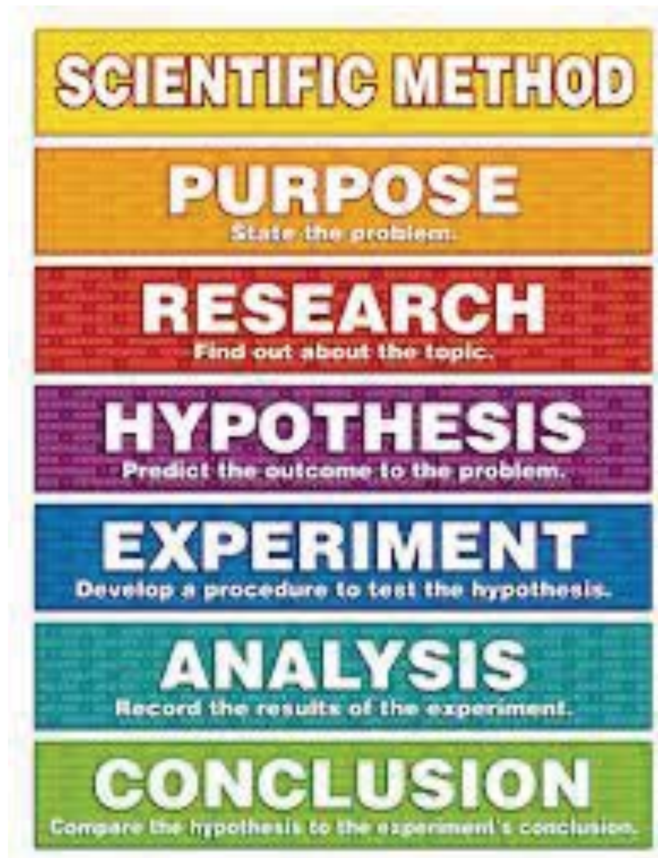
Key vocabulary terms

- Scatter plot, positive correlation, negative correlation, line of best fit, slope, equation in slope-intercept form, bacteria, phage, DNA sequence, lyse process.

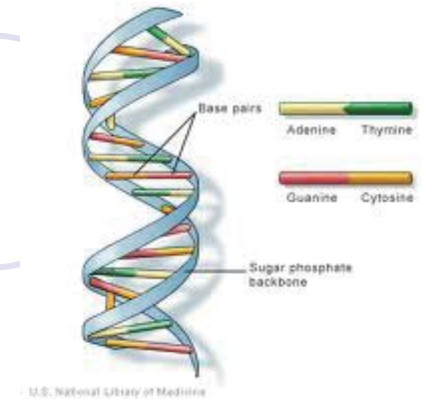
Investigative Approach

Engineering Design vs Scientific Method





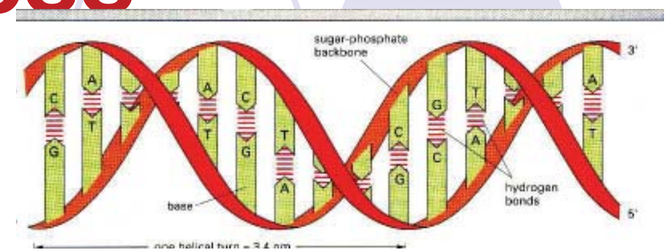
Classroom Lesson Design



Materials

- Write up of Hypothetical Situation
  - *"Finding your best sidekick to defeat the invader"*
- Video: ***The Virus Entry System***
- 4 datasets of DNA sequence base pairs: UFO-N1-ALPHA001, UFO-N1-BETA002, UFO-N1-DELTA003, UFO-N1-GAMMA004
- Eiki Projector
- Poster board
- Crayons and/or markers
- Ruler and yardstick
- Graphing Calculators
- Other materials to enhance colorfulness and creativity

Engineering Design Process



Define the Problem

- A bacterial species from outer space threatens the human race. Fortunately, an alien virus (ALPHA001) capable of killing the bacteria, but benign to humans, may also exist on Earth. The challenge is finding it based on analysis of various datasets of DNA genome sequence data.

Brainstorm

- The DNA genome sequence data provided is given in various forms. Have the students generate ideas as to how to arrange the data for possible comparisons.

Engineering Design Process

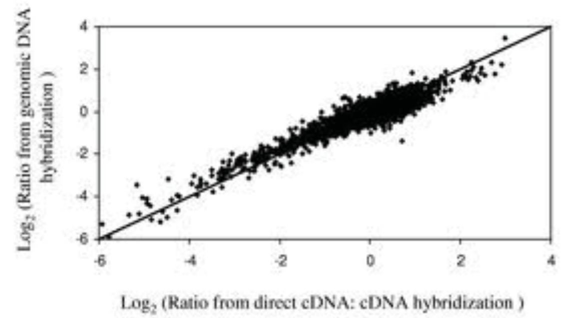
Generate Ideas

- Facilitate various comparison methods. Allow students to discuss which one will be the best to use.

Identify Criteria and Explore Possibilities

- Define the minimum number of identical DNA base pairs required to establish that the virus is identical.
- Determine what data can be considered outliers.

Engineering Design Process



Select an approach

- Students are to select the best comparison method.
- Encourage using the graphing calculator to use technology to their advantage.
- If computers are available, creating graphs using Excel will add color and variety to the method selection.

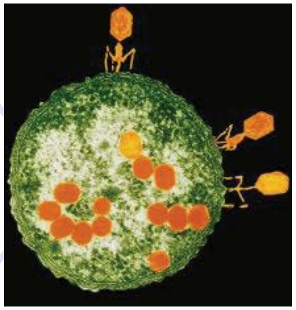
Decide on which is the identical virus

- Students are to select the virus that is identical to the one found in space by comparing the DNA base pairs from the DNA sequence data.
- For enrichment purposes, students are to determine the equation of the line generated. They may enter the data in their calculator and generate a line of best fit.

Engineering Design Process
Hands-on Activity

- Review the DNA base sequence pair for UFO-N1-ALPHA001 Virus
- Review the other sets of data provided to determine that type of data given.
- Determine the steps required to make an accurate comparison.
- Select a set of data that you believe is the most similar to ALPHA001 data.
- Analyze using your preferred method. Use ALPHAN001 on X-axis and the other on Y-axis
  - Create a graph using Excel
  - Use STAT feature on calculator to create a graph
- **Determine the slope of the line**

Engineering Design Process



Model – Student teams will design a 4-quadrant poster.

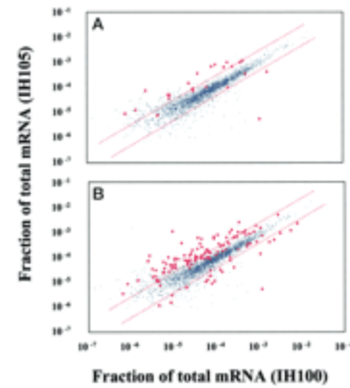
- 1st quadrant – Their conclusion of what it means to generate a slope=1 when comparing the DNA genome sequence.
- 2nd quadrant – The equation of the line from their comparison data.
- 3rd quadrant – A table containing the DNA genome sequences shown as X- and Y-axis values.
- 4th quadrant – A graph generated from the table using the base pairs of one virus on the X-axis and the base pairs of the 2nd virus on the Y-axis

Engineering Design Process

Presentation: Communicate the results

- The students' ideas are to be clearly explained on the poster.
- Poster needs to be well organized, neat, and colorful.
- Students may also present their poster, and explain the process used to decide on the specific DNA genome sequences selected.

Grading Rubric



- Active Participation during Brainstorm and Generate Ideas session
  - 20 Points
- Level of engagement during Poster Design and Creation activity
  - 20 Points
- Accuracy of information on Poster
  - 20 Points
- Neatness, colorfulness, and creativity of Poster
  - 20 Points
- Quality of Presentation
  - 20 Points

Concluding Activity

TEXAS A&M ENGINEERING

- Teacher will explain the similarities and differences of the phages using posters.
- Explain impact of phages conservation of their DNA through time and space, and importance of genome sequencing for humans.
- Encourage students to view science, math, and engineering as integrated teams working together to solve problems affecting humanity and the environment.

Enrichment Activity - Research Paper Topic

Impact of inexpensive full genome sequencing for humans

- It will be a major accomplishment for the entire human civilization.
- May be used to predict what diseases a person may contract in the future
  - Predictive Medicine
  - Personalized Medicine

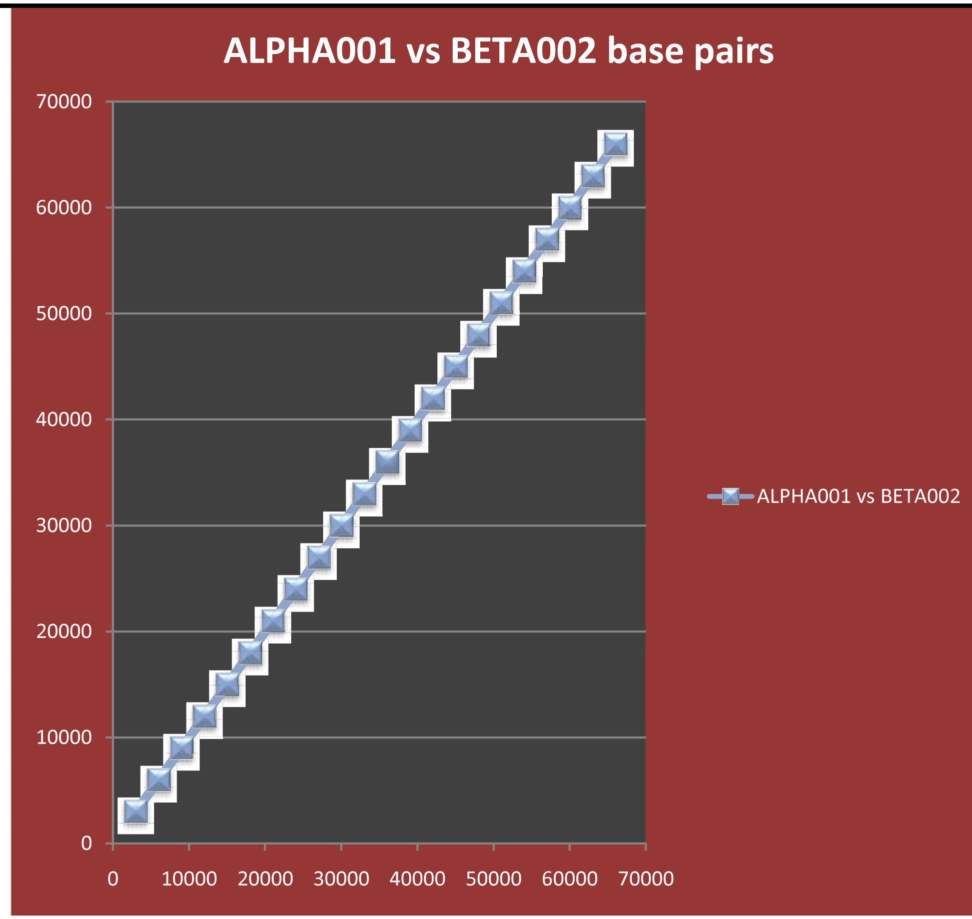
Expected Student Outcomes

4-Quadrant Poster – Identical Phage

When comparing the ALPHA001 vs BETA002 DNA base pairs, the graphs approximates a **slope of 1**. This means that the DNA base pairs are almost identical. Thus, the phages (virus) are almost identical.

Y = 1.00001 X

VIRUS: UFO-N1-ALPHA001	*VIRUS: UFO-N1-BETA002*
3000	3000.03
6000	5999.994
9000	9000.024
12000	11999.988
15000	14999.952
18000	17999.982
21000	20999.946
24000	23999.99976
27000	26999.9994
30000	29999.97
33000	33000
36000	35999.964
39000	38999.994
42000	41999.958
45000	44999.988
48000	48000.018
51000	50999.982
54000	53999.946
57000	56999.976
60000	59999.94
63000	62999.97
66000	66000



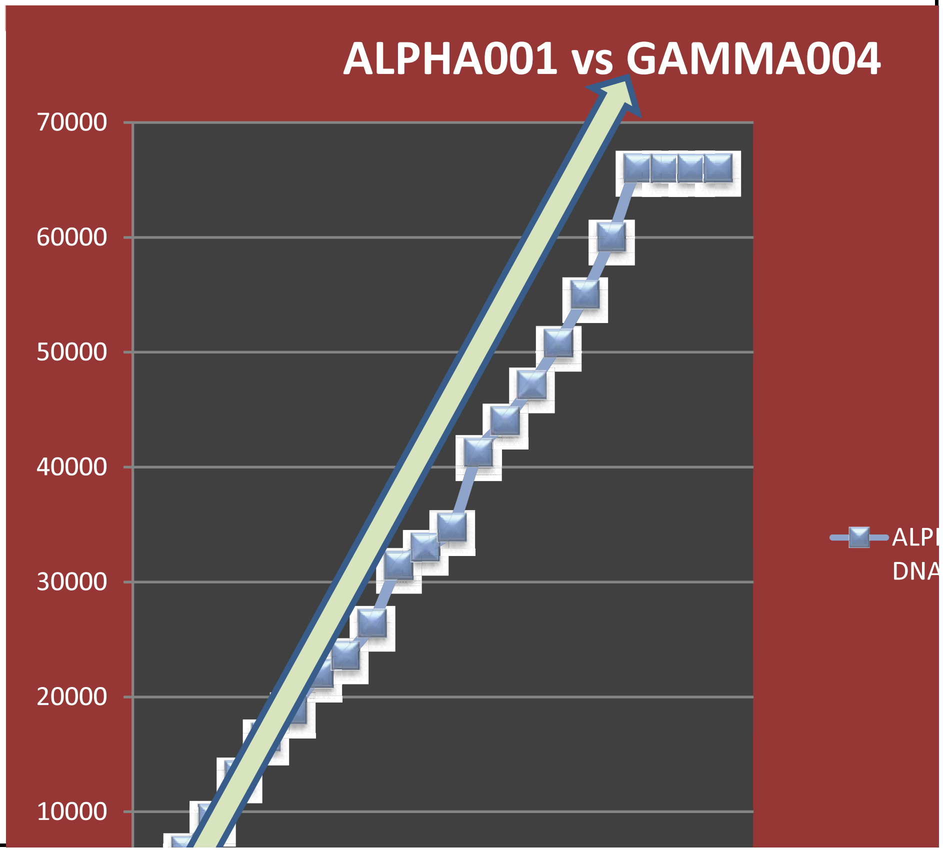
Expected Student Outcomes

4-Quadrant Poster – Different Phage

When comparing ALPHA001 and GAMMA004 DNA base pairs, the line of best fit approximates a **slope of 1.164.** This means that the DNA base pairs are similar but not identical, representing two completely different phage types.

Y = 1.164 X + 1000

VIRUS: UFO-N1-ALPHA001	*VIRUS: UFO-N1-GAMMA004*
3000	3143
6000	6600
9000	9429
12000	13200
15000	16500
18000	18857
21000	22000
24000	23571
27000	26400
30000	31429
33000	33000
36000	34737
39000	41250
42000	44000
45000	47143
48000	50769
51000	55000
54000	60000
57000	66000
60000	66000
63000	66000
66000	66000



ACKNOWLEDGMENTS

TEXAS A&M ENGINEERING

- TAMU Teacher Summit
- TAMU E^3 Program (http://e3.tamu.edu)
  - National Science Foundation
  - Dr. Kung-Hui (Bella) Chu
  - The Center for Phage Technology
  - Dr. Jason Gill and Dr. Ry Young
  - Andy Hernandez (fellow E3 teacher)


Gracias
Köszönettel
Merci
Vielen Dank
THANK YOU!
Grazie
Díky
Hvala
Ευχαριστώ
ขอบคุณ

Name ______________________________________ Date _______________Period ___________

MATH AND BIOLOGY TEAM UP!

Student Lesson

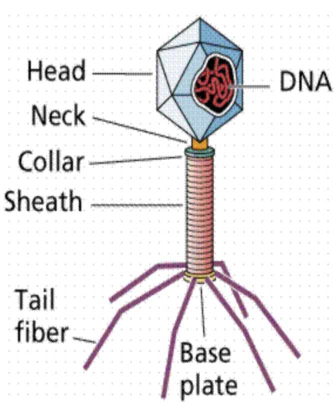
Problem

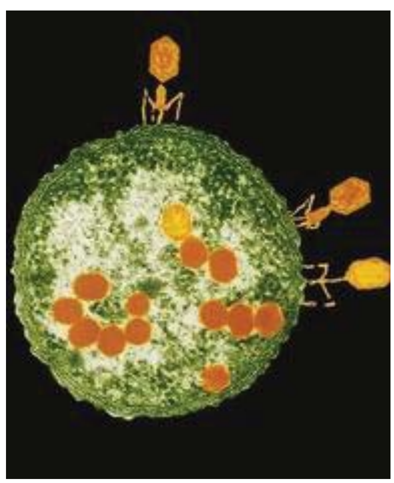
A bacterial species from outer space threatens the human race. Fortunately, an alien virus (ALPHA001), capable of killing the bacteria but benign to humans, may also exist on Earth. The challenge will be identifying it while examining scrambled DNA genome sequence data.

Background

Bacteriophages, or phages, are viruses that kill bacteria. Coupled with modern DNA-based biotechnology, phages have enormous potential to (1) combat bacterial infections in humans, animals, and plants, (2) promote food safety, and (3) protect against potential biological weapons. Texas A&M University has state-of-the-art laboratories that focus on the study of bacteriophages - *Source: Center for Phage Technology TAMU*

In this exercise, students will learn about bacteriophages and combine the Algebra concepts of slope and scatter plots to analyze various phages.





Objective

Each student team will follow the engineering design process and methodology to solve the problem stated in the "Math and Biology Team UP!" scenario (see pages 3-4). Basic biology knowledge (bacteria, viruses, DNA) is combined with algebra skills to perform an analysis of hypothetical DNA base pair sequences.

Key vocabulary terms

Scatter plot, positive correlation, negative correlation, line of best fit, slope, equation in slope-intercept form, bacteria, virus, bacteriophage, phage, DNA sequence, lyse process, trend analysis.

Materials

- Poster board
- Crayons and/or markers
- Ruler and yardstick
- Graphing Calculators
- Four data sets of DNA base pairs belonging to bacteriophages
- Other materials to enhance colorfulness and creativity

Name ____ Date ________________Period ____________

MATH AND BIOLOGY TEAM UP!

DNA Genome Sequencing Analysis

Finding your best sidekick to defeat the invader!

BACKGROUND: In his book, *The Andromeda Strain,* author Michael Crichton describes the possibility of a species of bacteria arriving from space that could cause devastating damage to the human race.

YOUR SITUATION: You are a scientist working for NASA in charge of decontaminating the astronauts as they return from space missions. Without your knowledge, one of the astronauts has hidden a small shiny pebble that he collected from a tiny meteorite stuck to the enclosure of the Space Station. Over the weekend, the astronaut became extremely sick, and was taken to the hospital intensive care unit. The doctors discovered a bacterial species in his bloodstream that they had never seen before.

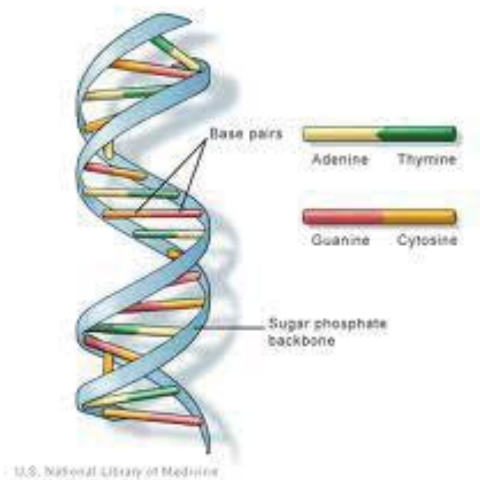
The astronaut is now on a life support system as his vital bodily functions begin to fail. NASA suspects that the alien bacterial species is the culprit and sends a team of specialists to search the astronaut's home. They find a small tightly sealed container that holds the small shiny blue pebble. After analysis, they conclude that the bacterial species found on the pebble is identical to the bacterial species identified in the astronaut's bloodstream. They fear the worst: bacteria that can be fatal to humans with no antibiotic available for treatment.

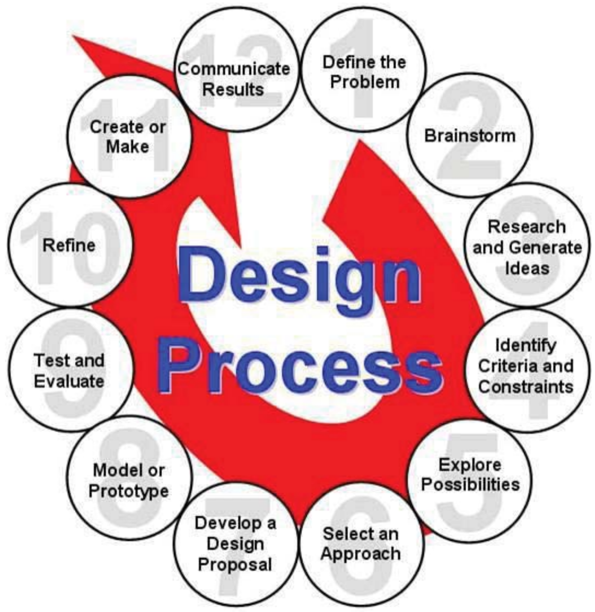
Fortunately, the next day, the astronaut quickly begins to recover. By the end of the day, he feels fine and wants to go home. Doctors are amazed! They run additional blood tests and discover that the alien bacteria is rapidly dying. Also, they discover that an unknown virus is invading the bacterial cells and splicing them. Yet, this virus appears to be benign to humans. NASA scientists find the same viral species on the small shiny pebble, but the virus appears to be dormant. They conclude that the dormant virus becomes viable once in the human bloodstream, and can help destroy the alien bacteria. The next day, 20 people in the city are admitted to the hospital because of infection by the alien bacteria. To make matters worse, all traces of the friendly alien virus are gone. The doctors fear that a pandemic will occur since there is no known treatment for an infection by the alien bacteria, except the friendly alien virus which appears to have vanished.

Scientists have done a full genome DNA sequencing on the friendly alien virus, and it is now up to YOU and your team to determine if the same viral species already exists on Earth. You are given a set of viral DNA data of the friendly alien virus, and three other sets of viral DNA data of three similar viruses that are abundant on Earth. You need to analyze the DNA base pairs and find out which of the three viruses from Earth is identical to the friendly alien virus.

Name ____ Date _______________Period ____________

Procedures: Student teams will use the Engineering Design Process described below for this classroom activity. The Engineering Design Process may follow 12 steps, and it is used by engineers to solve difficult and intricate problems that affect humanity and/or the environment.





Courtesy of Project Lead the Way

Twelve Steps of the Engineering Design Process

1. Define the Problem

After reading ***"Math and Biology Team UP!"*** what is the problem that humanity is facing?

2. Brainstorm

Based on the information provided by the NASA scientists, what can you do to solve the problem? How is it possible to find a virus on Earth that is identical to the virus from space? What data is available that can help you solve the problem? Which sets of data will you need to compare?

3. Research and Generate Ideas

Your teacher will provide DNA genome sequence data in various forms. What can you and your team do with the data? Discuss options with your fellow team members. Suggestions:

- Arrange numbers ascending order
- Arrange numbers in descending order
- Use the same type of numbers (convert fractions to decimals, scientific notation to whole numbers, etc.)
- Create bar chart
- Create a pie chart
- Use scatter plots and do a line of best fit.
- Find the slope

4 & 5. Identify the Criteria and Constraints. Explore Possibilities.

- Your teacher will define the minimum number of identical DNA base pairs required to establish that two phages (viruses) are identical.
- Discuss what data can be considered outliers.

6. Select an approach

As a team, select the best comparison method. Find a way to compare the data using the graphing calculator. If computers are available, explore the use of Excel to create various types of graphs.

7. Select a DNA Design of the virus that will help defeat the invader!

- Select the virus that is identical to the one found in space by comparing the DNA base pairs from the DNA sequence data.
- Determine the equation of the line that helps you verify that the two phages are identical.

8-11. Model and Create

Design a 4-quadrant poster.

- 1st quadrant – Your team's conclusion of what it means to generate a slope=1 when comparing the DNA genome sequence.
- 2nd quadrant – The equation of the line from your comparison data.
- 3rd quadrant – A table of DNA genome sequences on X- and Y-axis.
- 4th quadrant – A graph created from the table using the base pairs of ALPHA001 on the X-axis and the base pairs of the 2nd virus on Y-axis.

12. Communicate the Results

- Your team's ideas are to be clearly explained on the poster.
- Your poster needs to be well organized, neat, and colorful.

- You may also present your poster, and explain the process used to decide on the specific DNA genome sequences selected.

Grading Criteria

- Active Participation during Brainstorm and Generate Ideas session - 20 Points
- Level of engagement during Poster Design and Creation activity – 20 Points
- Accuracy of information on your poster – 20 Points
- Neatness, colorfulness, and creativity of your poster - 20 Points
- Quality of your presentation – 20 Points

Concluding Activity

- Your teacher will explain the similarities and differences of the phages using posters.
- Consider science, math, and engineering as possible careers. A college major in one of these fields may lead to a career that allows you to discover and study new concepts such as phage genome evolution!

Enrichment Activity (Optional)

Research Paper on impact of inexpensive full genome sequencing for humans

- It will be a major accomplishment for the entire human civilization.
- May be used to predict what diseases a person may contract in the future
    - Predictive Medicine
    - Personalized Medicine

CONNECTING ALGEBRA AND BIOLOGY

Teacher Edition of Lesson

Overarching Objective of Classroom Activity

Combines Algebra with Biology concepts to engage students in a cooperative learning interdisciplinary project that follows the Engineering Design Process, and allows them see how these concepts work together in the real world.

The lesson combines the concepts of slope and scatter plots to be used as tools to analyze and compare the DNA base pair sequences of virus ALPHA001 with those of three other viruses (ie., BETA002, DELTA003, and GAMMA004) and identify which virus is identical to ALPHA001. An added level of difficulty includes providing the student with data in different formats to encourage group discussion and decision making.

Hypothetical Problem

A bacterial species from outer space threatens the human race. Fortunately, an alien virus (ie., ALPHA001), capable of killing the bacteria but benign to humans, may also exist on Earth. The challenge is identifying it by comparing DNA genome sequence data.

Background

Biology – Bacteria, virus, bacterio(phage), DNA sequencing, DNA comparison, base pairs, trend analysis

Mathematics (Algebra 1 and 2, Geometry) - slope of a line, scatter plots, equations in slope-intercept form, data analysis in graphical and table form.

TEKS

A.6 (A) – Develop the concept of slope and determine slopes from graphs and tables.

A.6 (B) – Interpret the meaning of slope in situations using data or graphs.

A.1(E) – Interpret and make decisions, predictions, and critical judgment from functional relationships.

A.2 (D) – Collect and organize data, make and interpret scatterplots.

B.2 (E) – Plan and implement descriptive, comparative, and experimental investigations, including asking questions, formulating testable hypotheses, and selecting equipment, and technology.

B.2 (F) Organize quantitative data.

B.2(G) – Analyze, evaluate, make inferences, and predict trends from data, and communicate valid conclusions supported by the data.

B.6 (B) Recognize that components that make up the genetic code are common to all organisms.

B.6(E) Identify and illustrate changes in DNA and evaluate the significance of these changes.

EOC CRS (College Readiness Standards)

II.D.1 – Interpret and translate among multiple representations of equations and relationships.

VI.C.3 – Analyze relationships between paired data using graphing calculators.

ELPS (English Language Proficiency Standards)

1.C – Use mapping, drawing, comparing, contrasting, and reviewing to acquire basic and grade level vocabulary.

2.E – Use visual, contextual, and linguistic support to enhance and confirm understanding of increasingly complex and elaborated spoken language.

Key vocabulary terms

Scatter plot, positive correlation, negative correlation, line of best fit, slope, equation in slope-intercept form, bacteria, virus, bacteriophage, phage, DNA sequence, lyse process, trend analysis.

Materials Needed for Classroom Project

- Video: *The Virus Entry System* http://www.youtube.com/watch?v=nh18FvzjFnQ
- Four DNA sequence base pairs datasets: ALPHA-001, BETA-002, DELTA-003, GAMMA-004
- Eiki Projector
- Poster board
- Crayons and/or markers
- Ruler and yardstick
- Graphing Calculators
- Computer with Excel (enrichment activity)
- Other materials to enhance colorfulness and creativity

Hypothetical Situation Used to Engage the Students

MATH AND BIOLOGY TEAM UP!

DNA Genome Sequencing Analysis

Finding your best sidekick to defeat the invader!

BACKGROUND: In his book, *The Andromeda Strain,* author Michael Crichton describes the possibility of a species of bacteria arriving from space that could cause devastating damage to the human race.

YOUR SITUATION: You are a scientist working for NASA in charge of decontaminating the astronauts as the return from space missions. Without your knowledge, one of the astronauts has hidden a small shiny pebble that he collected from a tiny meteorite stuck to the enclosure of the Space Station. Over the weekend, the astronaut became extremely sick, and was taken to the hospital intensive care unit. The doctors discovered a bacterial species in his bloodstream that they had never seen before.

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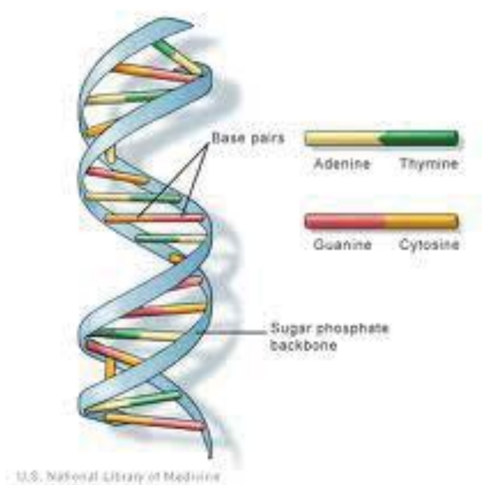
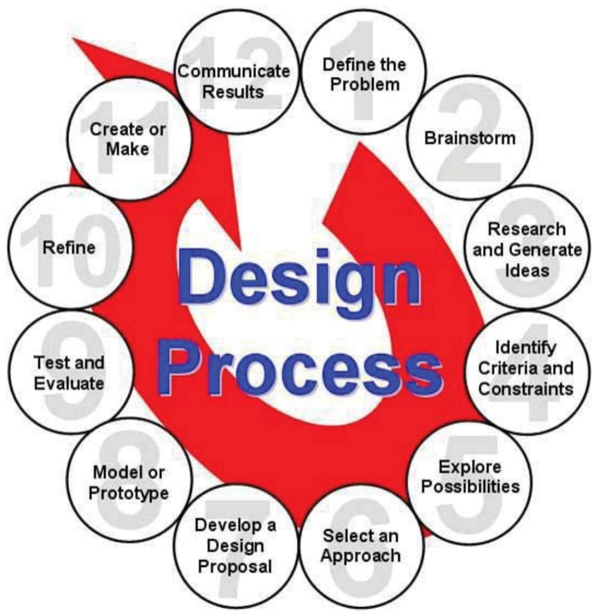
Fortunately, the next day, the astronaut quickly begins to recover. By the end of the day, he feels fine and wants to go home. Doctors are amazed! They run additional blood tests and discover that the alien bacteria is rapidly dying. Also, they discover that an unknown virus is invading the bacterial cells and splicing them. Yet, this virus appears to be benign to humans. NASA scientists find the same viral species on the small shiny pebble, but the virus appears to be dormant. They conclude that the dormant virus becomes viable once in the human bloodstream, and can help destroy the alien bacteria. The next day, 20 people in the city are admitted to the hospital because of infection by the alien bacteria. To make matters worse, all traces of the friendly alien virus are gone. The doctors fear that a pandemic will occur since there is no known treatment for an infection by the alien bacteria, except the friendly alien virus which appears to have vanished.

Scientists have done a full genome DNA sequencing on the friendly alien virus, and it is now up to YOU and your team to determine if the same viral species already exists on Earth. You are given a set of viral DNA data of the friendly alien virus, and three other sets of viral DNA data of three similar viruses that are abundant on Earth. You need to analyze the DNA base pairs and find out which of the three viruses from Earth is identical to the friendly alien virus.

Structure of Classroom Activity: Student teams (3-4 students) are asked to follow the engineering design process (see schematic below) as they solve the problem stated above.





Courtesy of Project Lead the Way

<u>Twelve Steps of the Engineering Design Process</u>

1. Define the Problem

Students will define the problem based on the information provided. In summary, bacteria from space threatens the human race. A virus that kills the bacteria, is also from space and can survive in the human bloodstream. Using the Engineering Design Process, analyze the DNA genome sequence of various viruses and compare their base pairs to determine if the same virus can be found on Earth.

2. Brainstorm

Students will discuss various methods to arrange the data to make comparisons. Encourage active participation from every team member.

3. Research and Generate Ideas:

Provide DNA genome sequence data in various forms. Allow students to discuss which data format will be the best to use. Entertain the idea that a combination of methods may work best. Finding the slope will be the ideal method. Facilitate discussion within each student team to help them reach this conclusion.

- Arrange numbers ascending order
- Arrange numbers in descending order
- Use the same type of numbers (convert fractions to decimals, scientific notation to whole numbers, etc.)
- Create bar chart
- Create a pie chart
- Use scatter plots and do a line of best fit.
- Find the slope.

4 & 5. Identify Criteria, Constraints, and Explore Possibilities

Define the minimum number of identical DNA base pairs required to establish that the virus is identical.

- Determine what data can be considered outliers. Up the 65,000 base pairs is normally what is used to conclude that two phages are identical.

6. Select an approach

Student teams are to select the best comparison method. Encourage the use of a graphing calculator, ie., using technology to their advantage. In the Nspire, students may use the LIST function and the DATA and STATISTICS function to establish and analyze the “x” and “y” variables. If computers are available, creating graphs using Excel will add color and variety to the method selection.

7. Develop a Design

Students are to select the virus that is identical to the one found in space by comparing the DNA base pairs from the DNA sequence data.

- Students are to determine the equation of the line that shows that the viruses are identical. The equation of the line will have a slope = 1.

8-11. Model and Create

Students will design a 4-quadrant poster.

- 1st quadrant – Their conclusion of what it means to generate a slope=1 when comparing the DNA genome sequence.
- 2nd quadrant – The equation of the line from their comparison data.
- 3rd quadrant – A table containing the DNA genome sequences shown as X and Y axis values.
- 4th quadrant – A graph generated from the table using the base pairs of one virus on the X-axis and the base pairs of the 2nd virus on Y-axis.

12. Communicate the Results

- The students' ideas are to be clearly explained on the poster.
- Poster needs to be well organized, neat, and colorful.
- Students may also present their poster, and explain the process used to decide on the specific DNA genome sequences selected.

Grading Rubric

- Active Participation during Brainstorm and Generate Ideas session - 20 Points
- Level of engagement during Poster Design and Creation activity– 20 Points
- Accuracy of information on Poster – 20 Points
- Neatness, colorfulness, and creativity of Poster - 20 Points
- Quality of Presentation – 20 Points

Concluding Activity

- Teacher will explain the similarities and differences of the phages using the student posters.

- Explain impact of phage conservation of their DNA through time and space,
- Encourage students to view science, math, and engineering as possible areas of interest as they plan for college. Encourage them to consider these fields when thinking about a possible career. Who knows, they may land in a career that allows them to investigate concepts such as phase genome evolution!

Enrichment Activity

Research Paper on Impact of inexpensive full genome sequencing for humans

- It will be a major accomplishment for the entire human civilization.
- May be used to predict what diseases a person may get in the future
    - Predictive Medicine
    - Personalized Medicine

Datasets for Virus DNA Base Pairs

VIRUS DNA BASE PAIRS	*VIRUS: UFO-N1-ALPHA001*	*VIRUS: UFO-N1-BETA002*
	Qty	Qty
Adenine - Guanine	3000	4.5455%
Adenine - Thymine	6000	9.0909%
Adenine - Cytosine	9000	13.6364%
Guanine - Thymine	12000	18.1818%
Guanine - Cytosine	15000	22.7272%
Thymine-Cytosine	18000	27.2727%
Adenine - Guanine	21000	31.8181%
Adenine - Thymine	24000	36.3636%
Adenine - Cytosine	27000	40.9091%
Guanine - Thymine	30000	45.4545%
Guanine - Cytosine	33000	50.0000%
Thymine-Cytosine	36000	54.5454%
Adenine - Guanine	39000	59.0909%
Adenine - Thymine	42000	63.6363%
Adenine - Cytosine	45000	68.1818%
Guanine - Thymine	48000	72.7273%
Guanine - Cytosine	51000	77.2727%
Thymine-Cytosine	54000	81.8181%
Adenine - Guanine	57000	86.3636%
Adenine - Thymine	60000	90.9090%
Adenine - Cytosine	63000	95.4545%
Guanine - Thymine	66000	100.0000%
TOTAL	**66000**	**66,000**

VIRUS DNA BASE PAIRS	*VIRUS: UFO-N1-ALPHA001*	*VIRUS: UFO-N1-DELTA003*
	Qty	Qty
Adenine - Guanine	3000	2.5×10^3
Adenine - Thymine	6000	6.7×10^3
Adenine - Cytosine	9000	8.25×10^3
Guanine - Thymine	12000	1.159×10^4
Guanine - Cytosine	15000	1.5×10^4
Thymine-Cytosine	18000	1.77×10^4
Adenine - Guanine	21000	2.155×10^4
Adenine - Thymine	24000	2.45×10^4
Adenine - Cytosine	27000	2.7×10^4
Guanine - Thymine	30000	2.999×10^4
Guanine - Cytosine	33000	3.385×10^4
Thymine-Cytosine	36000	3.61×10^4
Adenine - Guanine	39000	3.899×10^4
Adenine - Thymine	42000	4.225×10^4
Adenine - Cytosine	45000	4.5×10^4
Guanine - Thymine	48000	4.888×10^4
Guanine - Cytosine	51000	5.111×10^4
Thymine-Cytosine	54000	5.42×10^4
Adenine - Guanine	57000	5.73×10^4
Adenine - Thymine	60000	6.001×10^4
Adenine - Cytosine	63000	6.355×10^4
Guanine - Thymine	66000	6.699×10^4
TOTAL	**66000**	**6.7×10^4**

VIRUS DNA BASE PAIRS	*VIRUS: UFO-N1-ALPHA001*	*VIRUS: UFO-N1-GAMMA004*
	Qty	Qty
Adenine - Guanine	3000	66000/21
Adenine - Thymine	6000	66000/10
Adenine - Cytosine	9000	66000/7
Guanine - Thymine	12000	66000/5
Guanine - Cytosine	15000	66000/4
Thymine-Cytosine	18000	66000/3.5
Adenine - Guanine	21000	66000/3
Adenine - Thymine	24000	66000/2.8
Adenine - Cytosine	27000	66000/2.5
Guanine - Thymine	30000	66000/2.1
Guanine - Cytosine	33000	66000/2
Thymine-Cytosine	36000	66000/1.9
Adenine - Guanine	39000	66000/1.6
Adenine - Thymine	42000	66000/1.5
Adenine - Cytosine	45000	66000/1.4
Guanine - Thymine	48000	66000/1.3
Guanine - Cytosine	51000	66000/1.2
Thymine-Cytosine	54000	66000/1.1
Adenine - Guanine	57000	66000/1
Adenine - Thymine	60000	66000/1
Adenine - Cytosine	63000	66000/1
Guanine - Thymine	66000	66000/1
TOTAL	**66000**	**66,000**

TEXAS A&M Student Presentations

Teacher Summit 2013

TEXAS A&M STUDENT PRESENTATIONS

Teacher Summit 2013

COLLEGE PREPARATION

MATH 151 - Common Exams Archive

Please Note: Solutions may not be available for all past exams.

Fall 2012

Examinations: 1A 1B 2A 2B 3A 3B
Solutions: 1A 1B 2A 2B 3A 3B

Spring 2012

Examinations: 1A 1B 2A 2B 3A 3B
Solutions: 1A 1B 2A 2B 3A 3B

Fall 2011

Examinations: 1A 1B 2A 2B 3A 3B
Solutions: 1A 1B 2A 2B 3A 3B

Spring 2011

Examinations: 1A 1B 2A 2B 3A 3B
Solutions: 1A 1B 2A 2B 3A 3B

Fall 2010

Examinations: 1A 1B 2A 2B 3A 3B
Solutions: 1A 1B 2A 2B 3A 3B

Spring 2010

Examinations: 1A 1B 2A 2B 3A 3B
Solutions: 1A 1B 2A 2B 3A 3B

Fall 2009

Examinations: 1A 1B 2A 2B 3A 3B
Solutions: 1A 1B 2A 2B 3A 3B

Spring 2009

Examinations: 1A 1B 2A 2B 3A 3B
Solutions: 1A 1B 2A 2B 3A 3B

Fall 2008

Examinations: 1A 1B 2A 2B 3A 3B
Solutions: 1A 1B 2A 2B 3A 3B

Spring 2008

Examinations: 1A 2A 3A
Solutions (not all available yet): 1A 2A 3A

Fall 2007

Examinations: 1A 1B 2A 2B 3A 3B
Solutions: 1A 1B 2A 2B 3A 3B X1 Supplement

Spring 2007

Examinations: 1A 2A 3A
Solutions: 1A 2A 3A

Fall 2006

Examinations: 1A 1B 2A 2B 3A 3B
Solutions: 1A 1B 2A 2B 3A 3B

Spring 2006

Examinations: 1A 1B 2A 2B 3A 3B
Solutions: 1A 1B 2A 2B 3A 3B

Fall 2005

Examinations: 1A 1B 2A 2B 3A 3B
Solutions: 1A 1B 2A 2B 3A 3B

Spring 2005

Examinations: 1A 1B 2A 2B 3A 3B
Solutions: 1A 2A 3A

Fall 2004

Examinations: 1A 1B 2A 2B 3A 3B
Solutions: 1A 1B 2A 2B 3A 3B

Spring 2004

Examinations: 1A 2A 3A
Solutions: 1A 2A 3A

Fall 2003

Examinations: 1A 2A 3A

Spring 2003

Examinations: 1A 2A 3A

Fall 2002

Examinations: 1A 2A 3A
Solutions: 1A 2A 3A

Fall 2001

Examinations: 1 2 3
Solutions: 1 2 3

Fall 2000

Solutions: 1A 1B 2A 3A

Spring 2000

Solutions: 1A 2A 3A

Fall 1999

Solutions: 1 2 3A 3B

Spring 1999

Examinations: 1 2 3

Fall 1998

Examinations: 1 2 3
Solutions: 1 2 3

Spring 1998

Examinations: 1A 1B 2A 2B 3A
Solutions: 1 2 3

Fall 1996

Examinations: 1 2 3
Solutions: 1 2 3

Spring 1996

Examinations: 1 2 3
Solutions 1 2

Fall 1995

Examinations: 1 2 3

Please send comments, questions, or suggestions regarding this page to webmaster

MATH 151, FALL SEMESTER 2012
COMMON EXAMINATION I - VERSION A

Name (print):____

Signature: ____

Instructor's name: ____

Section No: ____

GUIDELINES

1. In Part 1 (Problems 1–14), mark your responses on your ScanTron form using a No: 2 pencil. *For your own record, mark your choices on the examination paper as well*. ScanTrons will be collected at the conclusion of the examination; they will *not* be returned.

2. Calculators **should not be used** throughout the examination.

3. In Part 2 (Problems 15–19), present your solutions **in the space provided**. **Show all your work** neatly and concisely, and **indicate your final answer clearly**. You will be graded, not merely on the final answer, but also on the quality and correctness of the work leading up to it.

4. Be sure to **write your name, section number, and version letter of the examination on the ScanTron form**.

Part 1 – Multiple Choice (56 points)

Each question is worth **4 points**. *Mark your responses on the ScanTron form and on the examination paper itself.*

1. Let P, Q, and R denote the vertices of a triangle. If $\overrightarrow{PQ} = \mathbf{c}$ and $\overrightarrow{PR} = \mathbf{d}$, what is $\overrightarrow{QR}$?

(a) $-\mathbf{c} - \mathbf{d}$

(b) $\mathbf{c} - \mathbf{d}$

(c) $\mathbf{c} + \mathbf{d}$

(d) $\mathbf{d} - \mathbf{c}$

(e) $\mathbf{d}$

2. Suppose that $\mathbf{a}$, $\mathbf{b}$, and $\mathbf{c}$ are vectors. Which of the following expressions are meaningful? (i) $(\mathbf{a} + \mathbf{b}) \cdot \mathbf{c}$, (ii) $\mathbf{a} + (\mathbf{b} \cdot \mathbf{c})$, (iii) $(\mathbf{a} \cdot \mathbf{b}) \cdot \mathbf{c}$, (iv) $(\mathbf{a} \cdot \mathbf{b})\mathbf{c}$

(a) only (ii) and (iii)

(b) only (i) and (iv)

(c) only (ii)

(d) only (iii)

(e) all four

3. Determine the value of the real number x for which $\langle 3, 4 + 5x \rangle \cdot \langle x, -4 \rangle = 1$.

(a) 0

(b) 1

(c) $-15/23$

(d) -1

(e) no such x exists

4. Let $\mathbf{a} = \mathbf{i} - 2\mathbf{j}$, $\mathbf{b} = -2\mathbf{i} + 4\mathbf{j}$, and $\mathbf{c} = 6\mathbf{i} + 3\mathbf{j}$. Decide on the truth/falsity of each of the following statements: (i) $\mathbf{a}$ is parallel to $\mathbf{b}$; (ii) $\mathbf{a}$ is parallel to $\mathbf{c}$; (iii) $\mathbf{a}$ is orthogonal to $\mathbf{b}$; (iv) $\mathbf{b}$ is orthogonal to $\mathbf{c}$.

(a) (i) and (iv) are true, the rest are false

(b) (i) and (ii) are true, the rest are false

(c) (ii) and (iii) are true, the rest are false

(d) (iv) is true, the rest are false

(e) (i) is true, the rest are false

5. A constant force with the vector representation $\mathbf{F} = 10\mathbf{i} + 18\mathbf{j}$ moves an object along a straight line from the point $(2, 3)$ to the point $(4, 9)$. Find the work done, if the distance is measured in meters and the magnitude of the force is measured in newtons.

(a) 74 J

(b) 96 J

(c) 128 J

(d) 202 J

(e) 162 J

6. Which of the following is a Cartesian equation of the parametric curve determined by the equations $x(t) = \cos^2 t$, $y(t) = \sin t$, for $0 \le t \le 2\pi$?

(a) $xy = 1$

(b) $x^2 + y = 1$

(c) $x^2 + y^2 = 1$

(d) $x + y = 1$

(e) $x + y^2 = 1$

7. Compute $\lim_{x\to 2^-} \dfrac{x-2}{|2x-4|}$.

(a) $-1/2$

(b) $1/2$

(c) -1

(d) 1

(e) does not exist

8. Compute $\lim_{x\to 1} \left[\dfrac{1}{x-1} - \dfrac{2}{x^2-1}\right]$.

(a) 1

(b) $+\infty$

(c) $-\infty$

(d) 0

(e) $1/2$

9. Calculate $\lim_{t\to -\infty} \dfrac{\sqrt{2t^2-t-2}}{2t+1}$.

(a) does not exist

(b) $\sqrt{2}/2$

(c) -1

(d) 1

(e) $-\sqrt{2}/2$

10. Let a be a real number. Suppose that $\lim_{x \to a} f(x) = 5$ and that $\lim_{x \to a} [(x+a)f(x)] = 3$. Determine the value of a.

(a) 3/5

(b) 3/10

(c) 10/3

(d) 5/3

(e) 5

11. Consider the following curves:

$$\text{(I)} \quad y = \frac{x^2 - x - 2}{x^2 - 1} \qquad \text{(II)} \quad y = \frac{x^2 + x - 2}{x^2 - 1} \qquad \text{(III)} \quad y = \frac{x}{\sin(\pi x)}$$

The line $x = 1$ is a vertical asymptote for

(a) all three

(b) (II) and (III) only

(c) (I) only

(d) (III) only

(e) (I) and (III) only

12. Which of the following curves has a horizontal asymptote?

$$\text{(I)} \quad y = \cos x \qquad \text{(II)} \quad y = \frac{2\sqrt{x}}{1 + \sqrt{x}} \qquad \text{(III)} \quad y = \frac{2x}{1 + \sqrt{x}}$$

(a) none of the three

(b) (II) and (III) only

(c) (I) and (III) only

(d) (II) only

(e) all three

13. The function $f(x) = 1 - |x+1|$ is

(a) differentiable at every real number

(b) not differentiable at 1

(c) not differentiable at -1

(d) discontinuous at -1

(e) not differentiable at 0 and -1

14. The line $y = 3x - 6$ is the tangent to the graph of f at the point $(2, 0)$. Compute $\lim_{x \to 2} \dfrac{x^2(2x+1)f(x)}{x-2}$. Hint: Note that $f(x) = f(x) - f(2)$.

(a) 0

(b) 24

(c) 60

(d) 20

(e) does not exist

Part 2 (49 points)

Present your solutions to the following problems (15–19) **in the space provided**. **Show all your work** *neatly and concisely, and* **indicate your final answer clearly**. *You will be graded, not merely on the final answer, but also on the quality and correctness of the work leading up to it.*

15. Consider the function

$$f(x) = \sqrt{1 + 2x}, \qquad \text{for } x \geq -\frac{1}{2}.$$

(i) (`9 points`) Use the **definition of the derivative** to compute $f'(1)$. (Note: No credit will be given for using any other method, correct answer notwithstanding.)

(ii) (`5 points`) Obtain a Cartesian equation of the tangent to the curve $y = f(x)$, when $x = 1$.

16. (`7 points`) Obtain a <u>vector equation</u> (that is, an equation in the standard form $\mathbf{r}(t) = \mathbf{r}_0 + t\mathbf{v}$, for $-\infty < t < \infty$) of the straight line which passes through the point $(3, -1)$, and is *perpendicular* to the vector $\langle 1, 7 \rangle$.

17. (`7 points`) Let L_1 denote the line given by the parametric equations $x(t) = -3 + 2t$, $y(t) = -1 + 4t$, for $-\infty < t < \infty$. Let L_2 denote the line given by the parametric equations $x(s) = -1 + s$, $y(s) = s$, for $-\infty < s < \infty$. Determine the point of intersection of L_1 and L_2.

18. (`7 points`) Let $A(1,0)$, $B(5,1)$, and $C(2,3)$ be the vertices of a triangle. Compute the cosine of the angle subtended at the vertex B (*i.e.*, the angle $\angle ABC$). The final answer need not be simplified.

19. Let a be a real number, and let g be the function defined as follows:

$$g(x) = \begin{cases} x^2 + ax - 2, & \text{if } x < 2; \\ 0, & \text{if } x = 2; \\ \frac{x^3+x+2a}{(2x-1)^2}, & \text{if } x > 2. \end{cases}$$

(i) (`4 points`) Calculate $\lim_{x \to 2^-} g(x)$ and $\lim_{x \to 2^+} g(x)$.

(ii) (`6 points`) Determine the value a for which $\lim_{x \to 2} g(x)$ exists. Compute the limit.

(iii) (`4 points`) Is g continuous at 2 for the value of a determined in part (ii) above? Explain your reasoning clearly and concisely.

Rough(Scratch) Work

This blank page is meant for rough work only; work presented here will <u>*not*</u> *be graded.*

QN	PTS
1–14	
15	
16	
17	
18	
19	
TOTAL	

MATH 151, FALL SEMESTER 2012
COMMON EXAMINATION I - VERSION A

Name (print):____________________________________

Signature: ____________________________________

Instructor's name: ____________________________________

Section No: ____________________________________

GUIDELINES

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Part 1 – Multiple Choice (56 points)

Each question is worth **4 points**. *Mark your responses on the ScanTron form and on the examination paper itself.*

1. Let P, Q, and R denote the vertices of a triangle. If $\overrightarrow{PQ} = \mathbf{c}$ and $\overrightarrow{PR} = \mathbf{d}$, what is $\overrightarrow{QR}$?

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(b) $\mathbf{c} - \mathbf{d}$

(c) $\mathbf{c} + \mathbf{d}$

(d) $\mathbf{d} - \mathbf{c}$

(e) $\mathbf{d}$

2. Suppose that $\mathbf{a}$, $\mathbf{b}$, and $\mathbf{c}$ are vectors. Which of the following expressions are meaningful? (i) $(\mathbf{a}+\mathbf{b})\cdot\mathbf{c}$, (ii) $\mathbf{a}+(\mathbf{b}\cdot\mathbf{c})$, (iii) $(\mathbf{a}\cdot\mathbf{b})\cdot\mathbf{c}$, (iv) $(\mathbf{a}\cdot\mathbf{b})\mathbf{c}$

(a) only (ii) and (iii)

(b) only (i) and (iv)

(c) only (ii)

(d) only (iii)

(e) all four

3. Determine the value of the real number x for which $\langle 3, 4+5x\rangle \cdot \langle x, -4\rangle = 1$.

(a) 0

(b) 1

(c) $-15/23$

(d) -1

(e) no such x exists

4. Let $\mathbf{a} = \mathbf{i} - 2\mathbf{j}$, $\mathbf{b} = -2\mathbf{i} + 4\mathbf{j}$, and $\mathbf{c} = 6\mathbf{i} + 3\mathbf{j}$. Decide on the truth/falsity of each of the following statements: (i) $\mathbf{a}$ is parallel to $\mathbf{b}$; (ii) $\mathbf{a}$ is parallel to $\mathbf{c}$; (iii) $\mathbf{a}$ is orthogonal to $\mathbf{b}$; (iv) $\mathbf{b}$ is orthogonal to $\mathbf{c}$.

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(c) 128 J

(d) 202 J

(e) 162 J

6. Which of the following is a Cartesian equation of the parametric curve determined by the equations $x(t) = \cos^2 t$, $y(t) = \sin t$, for $0 \leq t \leq 2\pi$?

(a) $xy = 1$

(b) $x^2 + y = 1$

(c) $x^2 + y^2 = 1$

(d) $x + y = 1$

(e) $x + y^2 = 1$

7. Compute $\lim_{x \to 2^-} \dfrac{x-2}{|2x-4|}$.

(a) $-1/2$

(b) $1/2$

(c) -1

(d) 1

(e) does not exist

8. Compute $\lim_{x \to 1} \left[\dfrac{1}{x-1} - \dfrac{2}{x^2-1}\right]$.

(a) 1

(b) $+\infty$

(c) $-\infty$

(d) 0

(e) $1/2$

9. Calculate $\lim_{t \to -\infty} \dfrac{\sqrt{2t^2-t-2}}{2t+1}$.

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(c) -1

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10. Let a be a real number. Suppose that $\lim_{x \to a} f(x) = 5$ and that $\lim_{x \to a} [(x+a)f(x)] = 3$. Determine the value of a.

(a) 3/5

(b) 3/10

(c) 10/3

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The line $x = 1$ is a vertical asymptote for

(a) all three

(b) (II) and (III) only

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(d) (III) only

(e) (I) and (III) only

12. Which of the following curves has a horizontal asymptote?

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(a) none of the three

(b) (II) and (III) only

(c) (I) and (III) only

(d) (II) only

(e) all three

13. The function $f(x) = 1 - |x+1|$ is

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(b) not differentiable at 1

→ (c) not differentiable at -1

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14. The line $y = 3x - 6$ is the tangent to the graph of f at the point $(2, 0)$. Compute $\lim_{x \to 2} \dfrac{x^2(2x+1)f(x)}{x-2}$. Hint: Note that $f(x) = f(x) - f(2)$.

(a) 0

(b) 24

→ (c) 60

(d) 20

(e) does not exist

Part 2 (49 points)

Present your solutions to the following problems (15–19) **in the space provided. Show all your work** *neatly and concisely, and* **indicate your final answer clearly**. *You will be graded, not merely on the final answer, but also on the quality and correctness of the work leading up to it.*

15. Consider the function

$$f(x) = \sqrt{1+2x}, \qquad \text{for } x \geq -\frac{1}{2}.$$

(i) (9 points) Use the **definition of the derivative** to compute $f'(1)$. (Note: No credit will be given for using any other method, correct answer notwithstanding.)

$$\lim_{h\to 0} \frac{\sqrt{1+2(1+h)} - \sqrt{3}}{h} = \lim_{h\to 0} \frac{\sqrt{3+2h} - \sqrt{3}}{h}$$

$$= \lim_{h\to 0} \frac{(\sqrt{3+2h} - \sqrt{3})\cdot(\sqrt{3+2h} + \sqrt{3})}{h\left[\sqrt{3+2h} + \sqrt{3}\right]} = \lim_{h\to 0} \frac{2h}{h\left[\sqrt{3+2h} + \sqrt{3}\right]}$$

$$= \lim_{h\to 0} \frac{2}{\sqrt{3+2h} + \sqrt{3}} = \frac{2}{2\sqrt{3}} = \frac{1}{\sqrt{3}}.$$

Thus $f'(1) = \frac{1}{\sqrt{3}} = \frac{\sqrt{3}}{3}$.

(ii) (5 points) Obtain a Cartesian equation of the tangent to the curve $y = f(x)$, when $x = 1$.

$$y - f(1) = f'(1)(x-1)$$

$$\Rightarrow y - \sqrt{3} = \frac{1}{\sqrt{3}}(x-1).$$

16. (7 points) Obtain a <u>vector equation</u> (that is, an equation in the standard form $\mathbf{r}(t) = \mathbf{r}_0 + t\mathbf{v}$, for $-\infty < t < \infty$) of the straight line which passes through the point $(3, -1)$, and is *perpendicular* to the vector $\langle 1, 7 \rangle$.

One may choose $\underline{v} = \langle -7, 1 \rangle$ as a direction vector for the line. The resulting equation of the line is:

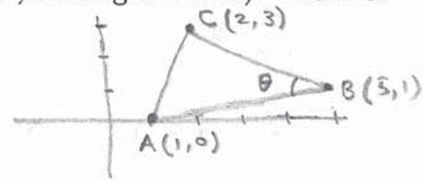
$\underline{r}(t) = \langle 3, -1 \rangle + t \langle -7, 1 \rangle$, for $-\infty < t < \infty$.

17. (7 points) Let L_1 denote the line given by the parametric equations $x(t) = -3 + 2t$, $y(t) = -1 + 4t$, for $-\infty < t < \infty$. Let L_2 denote the line given by the parametric equations $x(s) = -1 + s$, $y(s) = s$, for $-\infty < s < \infty$. Determine the point of intersection of L_1 and L_2.

Setting $-3+2t = -1+s$ and $-1+4t = s$, we find that $-3+2t = -1 + [-1+4t] = -2+4t$

$\Rightarrow \boxed{t = -\frac{1}{2}}$. So the point of intersection is given by $\left(-3 + 2\cdot\left(-\frac{1}{2}\right), -1 + 4\left(-\frac{1}{2}\right)\right) = (-4, -3)$.

18. (**7 points**) Let $A(1,0)$, $B(5,1)$, and $C(2,3)$ be the vertices of a triangle. Compute the <u>cosine of the angle</u> subtended at the vertex B (*i.e.*, the angle $\angle ABC$). The final answer need not be simplified.



$$\cos\theta = \frac{\vec{BC} \cdot \vec{BA}}{\|\vec{BC}\| \, \|\vec{BA}\|}$$

$$= \frac{\langle -3, 2\rangle \cdot \langle -4, -1\rangle}{\|\langle -3,2\rangle\| \, \|\langle -4,-1\rangle\|} = \frac{10}{\sqrt{13}\sqrt{17}}.$$

19. Let a be a real number, and let g be the function defined as follows:

$$g(x) = \begin{cases} x^2 + ax - 2, & \text{if } x < 2; \\ 0, & \text{if } x = 2; \\ \frac{x^3+x+2a}{(2x-1)^2}, & \text{if } x > 2. \end{cases}$$

(i) (**4 points**) Calculate $\lim_{x\to 2^-} g(x)$ and $\lim_{x\to 2^+} g(x)$.

$$\lim_{x\to 2^-} g(x) = \lim_{x\to 2^-} (x^2+ax-2) = 2+2a.$$

$$\lim_{x\to 2^+} g(x) = \lim_{x\to 2^+} \frac{x^3+x+2a}{(2x-1)^2} = \frac{10+2a}{9}.$$

(ii) (6 points) Determine the value of a for which $\lim_{x \to 2} g(x)$ exists. Compute the limit.

$\lim_{x \to 2^-} g(x) = \lim_{x \to 2^+} g(x) \Rightarrow 2 + 2a = \frac{10+2a}{9}$

$\Rightarrow 18 + 18a = 10 + 2a$

$\Rightarrow 16a = -8 \Rightarrow \boxed{a = -\frac{1}{2}}$

In particular, $\lim_{x \to 2} g(x) = 2 + 2\left(-\frac{1}{2}\right) = 1.$

(iii) (4 points) Is g continuous at 2 for the value of a determined in part (ii) above? Explain your reasoning clearly and concisely.

$\lim_{x \to 2} g(x) = 1$ from (ii). As $1 \neq 0 = g(2)$,

g is discontinuous at 2.

Rough(Scratch) Work

This blank page is meant for rough work only; work presented here will <u>not</u> be graded.

QN	PTS
1–14	
15	
16	
17	
18	
19	
TOTAL	

2011

EXAM I Physics 218

Name..Section Number.........

USEFUL INFORMATION

$$If \quad f(x) = kx^n \qquad \frac{df}{dx} = nkx^{n-1}$$

$$If \quad f(x) = kx^n \qquad \int f(x)dx = \frac{1}{n+1}kx^{n+1} + C$$

For the **SPECIAL CASE:**
CONSTANT ACCELERATION IN ONE DIMENSION

$$x(t) = \frac{1}{2}a_c t^2 + v(0)t + x(0).$$

Do Not Spend Too Much Time on Algebra!

1.

2.

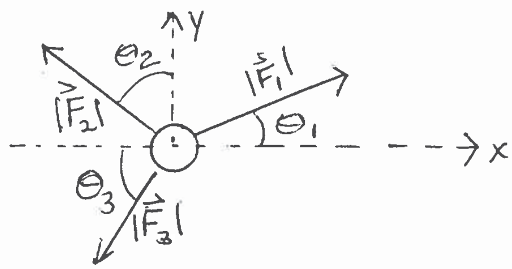
3.

1a. (32 points)You are driving at a constant, known velocity, v_1, along a straight road. Your computer controlled car begins to accelerate with $a = c_1 - c_2 t$ where you can enter the constants c_1 and c_2 as input and where t is the time, starting when the acceleration begins. You see a cliff a distance D from your car at $t = 0$. For a given c_2 what value of c_1 must you enter in order to just stop at the edge of the cliff? (No algebra please. Stop when you have a sufficient number of equations to determine the unknowns.)

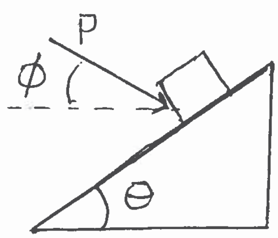
1b. (2 points) For the case when $c_2 = 0$ solve the equations from part a. for c_1.

2. (33 points)

a. In a physics lab experiment a ring is subjected to three forces as shown. Find the components of each force in the given coordinate system and determine how the magnitudes and directions of the three forces must be related in order for the ring to be in equilibrium.



b. A block of mass m is placed at rest on an inclined plane as shown below. The plane is frictionless and makes the angle θ with the horizontal as shown. If another force of magnitude P is applied to the block at the known angle ϕ as shown, draw the free body diagram for the block and determine what the value of P must be if the block is to remain at rest.



3. (33 points)A terrorist fires a cannon at you from a distance D away. The bullet has an initial velocity of magnitude v_b and the cannon is pointed at the angle θ as shown. You hope to intercept the bullet by firing a rocket at it the instant the cannon goes off. Your rocket starts at rest and is to be aimed at the angle ϕ. It is so powerful that it goes in a straight line, its acceleration having a magnitude that increases with time according to $c_1 t$, always directed at the original angle ϕ. (In other words neglect gravity for the rocket.) Obtain the equations that could be solved on a computer that determine the relationship between all the variables in order to hit the bullet.

1A. Which of the following compounds are *not* soluble?

$Sr(OH)_2$
KNO_3
Na_2SO_4
$PbCl_2$
$BaSO_4$

a) $PbCl_2$
b) $PbCl_2$, $BaSO_4$
c) $Sr(OH)_2$, $BaSO_4$
d) $PbCl_2$, $Sr(OH)_2$, $BaSO_4$
e) $PbCl_2$, $Sr(OH)_2$, $BaSO_4$, KNO_3

2A. In the combustion of heavy oil ($C_{20}H_{42}$), how many moles of CO_2 are produced per mole of heavy oil?

a) 20
b) 30.5
c) 40
d) 61
e) unable to determine

3A. How many of the following statements are true?

'The nucleus contains protons and electrons'
'^{35}Cl and ^{37}Cl are isotopes'
'Electrons has a -1 charge'
'An atom with a +1 charge has more electrons than protons'
'Atoms contain proton, neutrons, and electrons'

a) 1
b) 2
c) 3
d) 4
e) 5

4A. What is the oxidation number of the chromium (Cr) in $Cr_2O_7^{2-}$?

a) 0
b) +12
c) -2
d) +6
e) +3

5A. What is the molar mass of iron (II) nitrate?

a) 57 g/mol
b) 88 g/mol
c) 118 g/mol
d) 180 g/mol
e) unable to determine

6A. How many neutrons are associated with a ^{79}Br atom?

a) 79
b) 31
c) 35
d) 80
e) 44

7A. If 17.0 g of hydrogen and 101 g of oxygen is burned what is the mass of water produced?

a) 208.6
b) 56.9 g
c) 303.5 g
d) 113.6 g
e) 151.7 g

8A. 49.9 grams of $CuSO_4$ hydrate of is heated until all the H_2O is driven off. The resulting mass of pure $CuSO_4$ is 31.9 grams. What is the formula of the hydrate?

a) $CuSO_4 \cdot 2H_2O$
b) $CuSO_4 \cdot 3H_2O$
c) $CuSO_4 \cdot 4H_2O$
d) $CuSO_4 \cdot 5H_2O$
e) $CuSO_4 \cdot 6H_2O$

9A. Which of the following matched pairs of name and formula has an error?

	Formula	Name
a)	N_2O_4	dinitrogen tetraoxide
b)	$CaCO_3$	calcium carbonate
c)	$NaNO_3$	sodium nitride
d)	NH_4Cl	ammonium chloride
e)	KSO_4	potassium sulfate

10A. A 2.4 L aqueous solution is 0.25 M in glucose. What is the molarity of the solution if diluted with water to a total volume of 6.2 L?

a) 0.16 M
b) 0.04 M
c) 0.096 M
d) 0.64 M
e) 10.3 M

11A. Balance the following reaction:

$$P_4O_{10} + \ Ca(OH)_2 \rightarrow \ Ca_3(PO_4)_2 + \ H_2O$$

What is the stoichiometric coefficient in front of the water?

a) 2
b) 3
c) 4
d) 5
e) 6

12A. A 12-ounce (355 mL) can of coca-cola classic contains 34.5 mg of caffeine ($C_8H_{10}N_4O_2$, M.W. 194.2) Express this amount of caffeine as a molarity.

a) 9.7×10^{-2} M
b) 5.0×10^{-4} M
c) 9.7×10^{-5} M
d) 5.0×10^{-1} M
e) 9.7×10^{-3} M

13A. How many of the following are *false*?

'The Haber process involves the production of CH_4 from coal and hydrogen'
'Oxygen gas is required for a reaction to be considered combustion'
'Cars emit CO_2 from the combustion of gasoline'
'Having a balanced chemical reaction ensures that a chemical reaction will take place'

a) 1
b) 2
c) 3
d) 4
e) 0

14A. How many molecules in a drop of water assuming the mass of a drop is 0.05 g?

a) 2.8×10^{-2} molecules
b) 5.5×10^{23} molecules
c) 1.7×10^{21} molecules
d) 6.0×10^{23} molecules
e) unable to determine

15A. What is the mass percent of nitrogen in a 6.2 g sample of nitrogen dioxide?

a) 13%
b) 35%
c) 30%
d) 46%
e) 44%

16A. Rank the following compounds from lowest to highest in regards to the oxidation number of the chlorine atom.

$HClO_2$ Cl_2 ClF HCl $HClO_4$

a) HCl and ClF, Cl_2, $HClO_2$, $HClO_4$
b) HCl and ClF, Cl_2, $HClO_4$, $HClO_2$
c) HCl, Cl_2, ClF, $HClO_4$, $HClO_3$
d) Cl_2, HCl, ClF, $HClO_3$, $HClO_4$
e) HCl, Cl_2, ClF, $HClO_3$, $HClO_4$

17A. An isolated organic acid is found to be 40.0% carbon, 6.7% hydrogen, and 53.3% oxygen by mass. What is the empirical formula for the acid?

a) CH_2O
b) CHO
c) $C_{12}H_2O_{16}$
d) $C_2H_4O_2$
e) C_6HO_8

18A. Given the following balanced chemical equation,

$2\ Al + 6\ HCl \rightarrow 2\ AlCl_3 + 3\ H_2$

How many of the following statements are true?

‘Aluminum is the oxidizing agent’
‘HCl is the oxidizing agent’
‘Aluminum is the reducing agent’
‘Hydrogen is oxidized’
‘Aluminum is oxidized’

a) 0
b) 1
c) 2
d) 3
e) 4

19A. Chemical analysis has determined that a compound has an empirical formula of CH_2. If the molar mass is 56 g/mol what is the molecular formula?

a) C_3H_{20}
b) C_4H_8
c) C_4H_2
d) C_2H_4
e) C_5H_{10}

20A. When 3.5 g of magnesium metal is burned, 3.9 g of MgO is produced. What is the percent yield of MgO?

$2\ Mg + O_2 \rightarrow 2\ MgO$

a) 67%
b) 90%
c) 112%
d) 0.9%
e) 1.12%

Work Sheet:

The Periodic Table of the Elements

1 **H** Hydrogen 1.00794																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012182											5 **B** Boron 10.811	6 **C** Carbon 12.0107	7 **N** Nitrogen 14.00674	8 **O** Oxygen 15.9994	9 **F** Fluorine 18.9984032	10 **Ne** Neon 20.1797
11 **Na** Sodium 22.989770	12 **Mg** Magnesium 24.3050											13 **Al** Aluminum 26.981538	14 **Si** Silicon 28.0855	15 **P** Phosphorus 30.973761	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.4527	18 **Ar** Argon 39.948
19 **K** Potassium 39.0983	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.955910	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.9415	24 **Cr** Chromium 51.9961	25 **Mn** Manganese 54.938049	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933200	28 **Ni** Nickel 58.6934	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92160	34 **Se** Selenium 78.96	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.80
37 **Rb** Rubidium 85.4678	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.90585	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.90638	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.90550	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.8682	48 **Cd** Cadmium 112.411	49 **In** Indium 114.818	50 **Sn** Tin 118.710	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90447	54 **Xe** Xenon 131.29
55 **Cs** Cesium 132.90545	56 **Ba** Barium 137.327	57 **La** Lanthanum 138.9055	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.9479	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.078	79 **Au** Gold 196.96655	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.3833	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98038	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (262)	108 **Hs** Hassium (265)	109 **Mt** Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

				58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.90765	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.92534	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93032	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93421	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.967
				90 **Th** Thorium 232.0381	91 **Pa** Protactinium 231.03588	92 **U** Uranium 238.0289	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)

Teacher Summit 2013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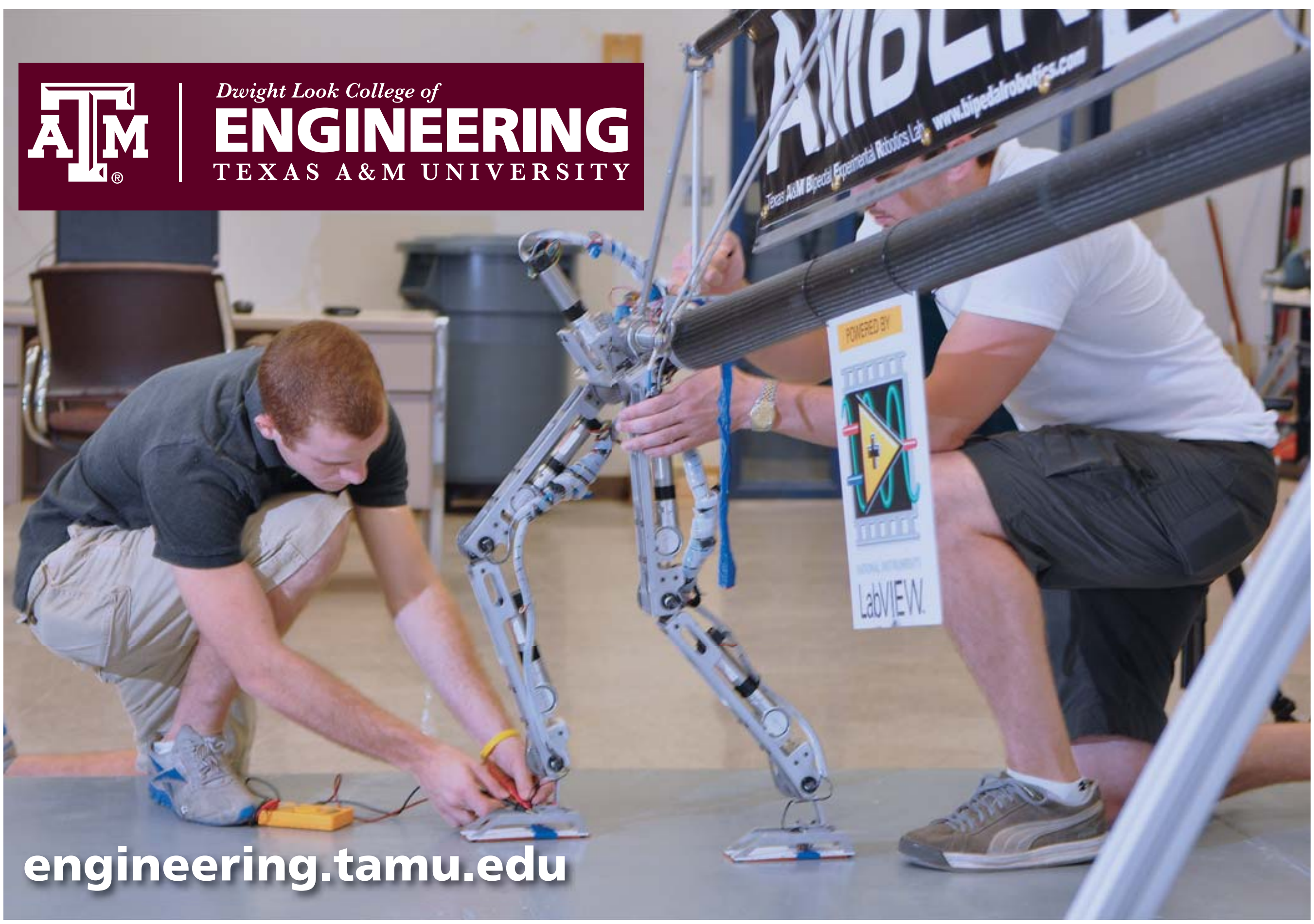
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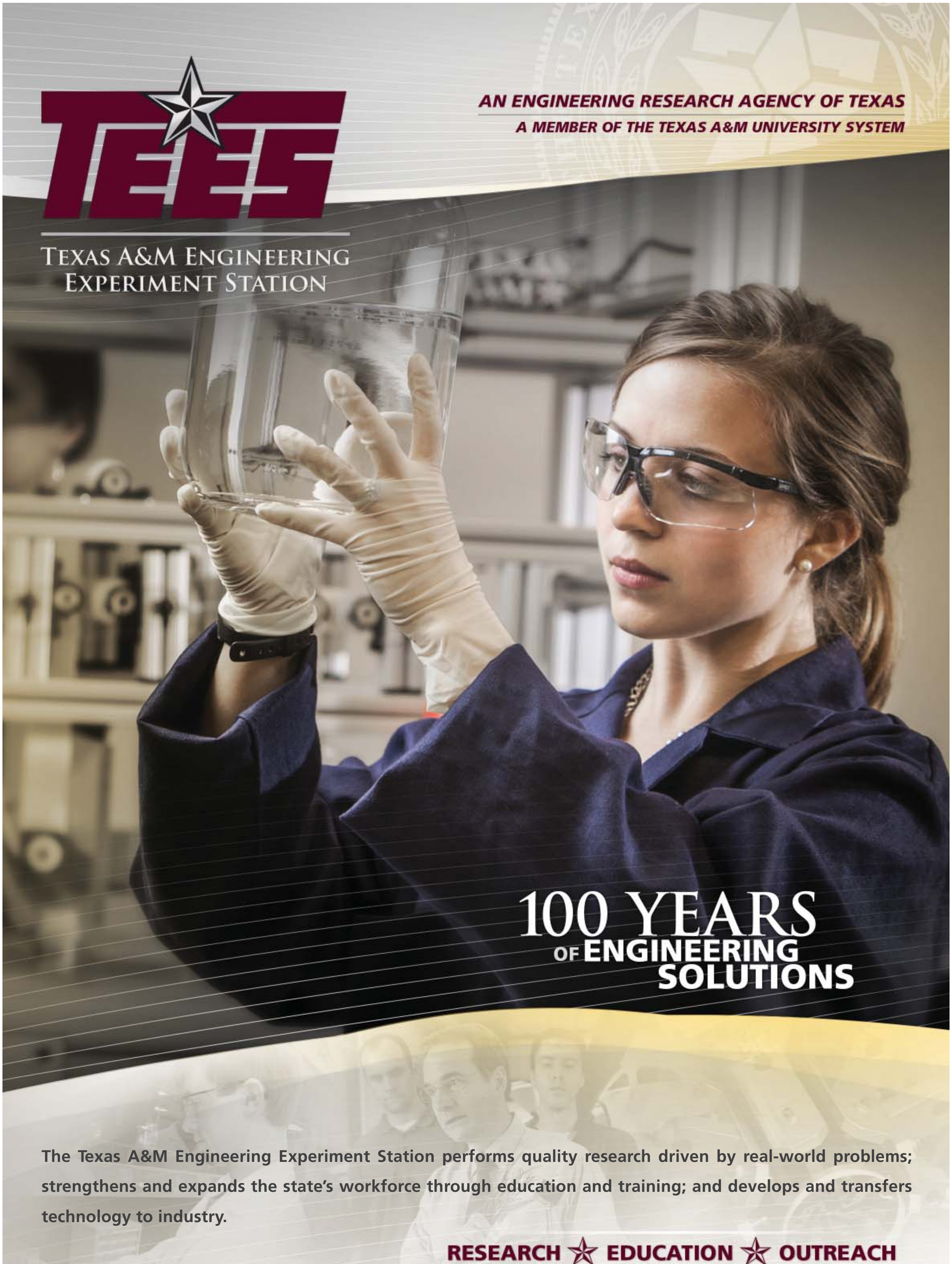
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Teacher Summit 2013 SCHEDULE

Thursday, January 24, 2013 | College Station Hilton Hotel and Conference Center

5:30–7:30 p.m.	**Registration** *Front Lobby*
6–8 p.m.	Welcome Reception (Hors d'oeuvres and opportunity to visit resource tables) *Ballrooms 4-7*

Friday, January 25, 2013 | College Station Hilton Hotel and Conference Center

7:30–9 a.m. **Registration** *Front Lobby*

7:30–8:15 a.m. **Hot Breakfast Buffet** *Hallway near Ballrooms & Ballroom 3*

8:15–8:30 a.m. **Welcome and Opening Remarks** *Ballroom 3*
Dr. M. Katherine Banks, Vice Chancellor and Dean of Engineering, Texas A&M University

8:30–9 a.m. **General Session: How to Best Prepare High School Students for Success in a STEM Major** *Ballroom 3*
Dr. Robin Autenrieth, Senior Associate Dean for Academic Affairs, Dwight Look College of Engineering, Texas A&M University
Dr. Timothy P. Scott, Associate Dean for Undergraduate Programs, College of Science, Texas A&M University

9–9:30 a.m. **General Session: Research and Education** *Ballroom 3*
Dr. Brett P. Giroir, Vice Chancellor for Strategic Initiatives, The Texas A&M University System

9:30–9:40 a.m. **Break**

9:40–10:35 a.m. **Workshop Session 1**
- Team Howdy: Integrated STEM *Ballroom 1*
- Team Gig 'em: Shedding Light on Optics *Ballroom 2*
- Team 12th Man: DNA Comparison *Mockingbird Rooms A&B*
- Team Reveille: Plastics for the Body: From Healing Wounds to Treating Cancer *Mockingbird Rooms C&D*

10:40–11:35 a.m. **Workshop Session 2**
- Team Howdy: Shedding Light on Optics *Ballroom 2*
- Team Gig 'em: Integrated STEM *Ballroom 1*
- Team 12th Man: Plastics for the Body: From Healing Wounds to Treating Cancer *Mockingbird Rooms C&D*
- Team Reveille: DNA Comparison *Mockingbird Rooms A&B*

11:35 a.m.–1 p.m. **Lunch, Resource Tables & Prize Drawings** *Ballrooms 4-7*

1–1:10 p.m. **Diamond Sponsor Remarks: Nuclear Power Institute** *Ballrooms 4-7*

1:15–2:10 p.m. **Workshop Session 3**
- Team Howdy: DNA Comparison *Mockingbird Rooms A&B*
- Team Gig 'em: Plastics for the Body: From Healing Wounds to Treating Cancer *Mockingbird Rooms C&D*
- Team 12th Man: Integrated STEM *Ballroom 1*
- Team Reveille: Shedding Light on Optics *Ballroom 2*

2:15–3:10 p.m. **Workshop Session 4**
- Team Howdy: Plastics for the Body: From Healing Wounds to Treating Cancer *Mockingbird Rooms C&D*
- Team Gig 'em: DNA Comparison *Mockingbird Rooms A&B*
- Team 12th Man: Shedding Light on Optics *Ballroom 2*
- Team Reveille: Integrated STEM *Ballroom 1*

3:10–3:20 p.m. **Break**
3:20–3:50 p.m. **General Session: Faculty Panel Presentation** *Ballroom 3*
3:50–4:10 p.m. **General Session: Texas A&M Student Presentations** *Ballroom 3*
4:10–4:30 p.m. **Closing, Door Prize Drawings & Survey** *Ballroom 3*