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REACTIONS

FROM THE AMERICAN NUCLEAR SOCIETY TO TEACHERS INTERESTED IN THE NUCLEAR SCIENCES

Radiation Technologies Have Diverse Applications

High-Intensity X-Rays Applied in Biological and Historical Research

Historians, eager to know what is a real artifact and what is a copy...
Biologists, researching ways to disable the powerful toxins that cause botulism...
Both have recently turned to high-intensity x-rays for help in their research.

Though their goals were different and some of their procedures different, they had one technique in common – x-ray diffraction analysis.

High-intensity X-rays passing through a material are deflected by or bounce off some parts of the material. By analyzing how the x-rays diffract as they pass through or bounce off the materials, researchers are able to learn about the arrangement of atoms in the material.

Two Ancient Astrolabes or One Fake?

Prior to the invention of the telescope, meticulously made devices known as astrolabes were used for astronomical measurements. These were, in essence, analog computers used to tell time through the positions of the stars.

These devices were used by ancient mariners as navigational tools and by followers of Islam in determining the direction to Mecca. Today, astrolabes are used by some hikers and orienteering enthusiasts to determine how much daylight is left.

Ancient hand-made astrolabes are valued for their historical significance and beauty. The detailed hand work involved in creating them meant that an astrolabe maker produced them very slowly, not in large quantities.

The Puzzle

Yet, Chicago's Adler Planetarium Mensing Collection and Harvard University's David P. Wheatland Collection both own astrolabes bearing the name "Ioannes Bos" and the date "24 March 1597." The Adler astrolabe is five inches in diameter while the Harvard instrument is barely four inches in diameter. The idea that the same worker was able to complete two of these intricately made devices on the same day seemed unlikely.

In fact, Bruce Stephenson, director of History of Astronomy Department at the Adler Planetarium and Astronomy Museum, had never seen two genuine astrolabes with the same name and date. His brother, Brian Stephenson, who works at Argonne National Laboratory's Materials Science Division, suggested they use Argonne's Advanced Photon Source (APS) to resolve the question of authenticity. The APS produces brilliant X-rays for research on materials, biological applications, and environmental applications.

Adler Planetarium Astrolabe…

Additional Photo

Photo: Argonne National Laboratory

A Simple Solution

The plan was simple. The APS's brilliant X-rays would help reveal the material composition, crystal structure and thickness of parts in the two astrolabes. And, this information could be gathered without damaging the astrolabes.

Dean Haeffner of Argonne's APS joined the Stephensons to conduct the research. Preliminary tests were conducted on polished brass to be sure that the beam would not tarnish it. Then, in a few days, using separate detectors,

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Deciphering Structure of Botulism-Causing Toxin

A drop of the toxins produced by *Clostridium botulinum* bacteria can paralyze the body, including the muscles responsible for breathing. In severe or untreated cases it can lead to death – by asphyxiation.

People get the botulinum toxins from food tainted with the bacteria (or its spores). The toxins are not detectable by the senses and even so little as a taste of tainted food can cause illness.

Treatment for Botulism

Current treatment involves administration of an antitoxin made from horse serum. For this treatment to be effective, the illness must be correctly diagnosed and the treatment administered soon after exposure to the toxins (before they bind to the nerve cells). In addition, allergies and other complications may prevent treatment with the horse-serum based antitoxin.

New Research

A team lead by Brookhaven National Laboratory biologist Subramanyam Swaminathan has deciphered the structure of botulinum neurotoxin B, one of the seven types of toxins produced by *C. botulinum* bacteria, and determined how it binds to the nerve cells.

The research team, working with Brookhaven's National Sychrotron Light Source (NSLS), bombarded crystalline samples

Additional Photos

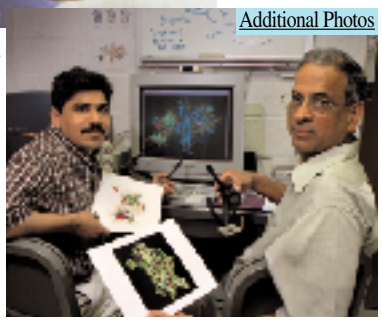

Photo: Brookhaven National Laboratory

Biologists S. Eswaramoorthy and S. Swaminathan with 3-D images for the botulinum toxin.

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Botulism-Causing Toxin...

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of the toxin with high intensity x-rays. By analyzing the diffraction patterns of x-rays passing through and bouncing off part of the crystal, the scientists reconstructed the shape and arrangement of the atoms in the toxin molecule. They also studied the part of the molecule that binds to nerve cells and the part that blocks the release of neurotransmitters.

Knowledge of the toxin's molecular structure and its methods of "attack"on nerve cells may aid in the development of a practical vaccine or other therapeutic drugs.

Therapeutic Use of Toxin

While botulinum toxins have the potential to be a serious health risk, they are also used to treat involuntary movement disorders. Minute quantities of the toxin are sometimes injected into spasmodic muscles, such as those which cause facial twitches, writer's cramp or stuttering, to calm them. The treatments are temporary and must be repeated. Researchers hope that the knowledge gained in this research could improve efficacy of such treatments.

Other potential applications of the new knowledge would be to improve tests for the presence of botulinum toxins in foods, weapons, or weapons factories.

Point your web-browser to "botulism" for additional general information.

For more information, about therapeutic uses of botulinum toxin, go to http://www.fda.gov/fdac/features/095_bot.html

Teacher Workshops Scheduled

Many teacher workshops are scheduled in the months ahead. These workshops provide information about radiation and nuclear technology, ideas for classroom instruction, curriculum materials, a Geiger counter, and more.

As of September 1, the following workshops were scheduled:

AL: Alabama Science Teachers' Association, Birmingham; 50-minute breakout session at annual meeting, 10/20-21. See their meeting program for details.

AZ: NSTA Regional, Phoenix; 75-minute Exhibitor workshop, date to be announced. (Convention is Dec. 7-9). See NSTA program for details.

CA: ANS Northern California Section, Palo Alto; full-day "Teaching Nuclear Science" workshop, Friday, December 8, at Stanford University. Limited to 25. Contact: cehn@aol.com

DC: ANS Teacher workshop, Washington, DC area; full-day session, Saturday, 11/11. Contact: ANS website <www.ans.org>, ANS Outreach Dept. at 708-352-6611, or outreach@ans.org

ID: NSTA Regional, Boise; 75-minute Exhibitor workshop, 10/6. See NSTA program for details.

IL: Iroquois Kankakee Regional Office of Education, Kankakee, IL. Full-day workshop (T918), Friday, 12/1. Contact: Candy Olesen at 815-937-3944 or colesen@roe32.k12.il.us

MD: NSTA Regional, Baltimore; 75-minute Exhibitor workshop on, 11/18. See NSTA program for details.

PA: ANS Pittsburgh Section, Pittsburgh; March 2001 in conjunction with Pittsburgh Regional Science Fair. For info, watch ANS web site for workshop listing.

VA: Virginia Association Science Teachers (VAST) annual conference, Roanoke, November 9-11. Contact: <www.vast.org> (See "Field Trips & Workshops")

WI: NSTA Regional, Milwaukee, Wisconsin; 75-minute Exhibitor workshop, 10/20. See NSTA program for details.

WI: University of Wisconsin, Madison; three, separate, full-day sessions on 10/14, 11/11, and 11/18. For info or brochure, contact: Linda Shriberg, Office of Education Outreach, 608-262-4477 or shriberg@education.wisc.edu

We expect additional workshops to be added to the schedule. Check the ANS web site <www.ans.org> for additional listings and more information. See the "Public Information" page.

Schedule for Women in Discovery: "Marie Curie Exhibit"

Medical Applications

Radioisotope Treatment Has Promise: Preventing Reblocking of Coronary Arteries

Deposits of fatty material (plaque) in the coronary arteries narrow them, reducing blood flow. As the deposits accumulate and grow thicker, flow of blood to the heart muscle is further reduced, perhaps even completely blocked, and serious problems result.

Every year, nearly 500,000 Americans undergo a coronary angioplasty to solve this problem. During an angioplasty, a catheter is threaded into the clogged coronary artery. A tiny balloon at the tip of the catheter is inflated to clear the blockage. This procedure is less invasive and far less expensive than coronary bypass surgery.

Unfortunately, between 30 and 50 percent of those treated with angioplasty experience restenosis, or reclogging, within six months. Contributing to the reclogging (restenosis) is the proliferation or buildup of smooth muscle cells. These cells proliferate as the body attempts to heal damage to the blood vessel, damage which takes place as the angioplasty balloon is inflated.

Those patients who experience restenosis must have either another angioplasty or heart bypass surgery to unclog their reclogged arteries. The required second treatments add significantly to the nation's health care costs.

Animal studies showed that treating the blood vessels with radiation from radioisotopes inhibited uncontrolled growth of smooth muscle cells. The approach was to use saline for a high-pressure balloon inflation and follow that with a low-pressure inflation using a radioisotope.

Preliminary human studies have been conducted. Those studies have shown a very encouraging reduction in the percentage of patients who experience restenosis. Clinical trials of the procedure are underway in several countries, using a number of radioisotopes, including rhenium-188.

When safety trials are completed, a double-blind, randomized trial is anticipated. In that trial, neither the patients nor the staff will know who is receiving the experimental treatment. This will help doctors and scientists evaluate the effectiveness of the treatment objectively.

For more information about this research, use your web browser to search for key terms, such as "restenosis+rhenium-188"

Oak Ridge National Laboratory developed a rhenium-188 generator and methods for concentrating the rhenium-188 solution being used in the current clinical trials.

Project 63 – Careers

***Goal:* Help students discover that there are many career areas where knowledge of radiation and nuclear technology is necessary.**

Students may think that knowledge of radiation and nuclear technology is used by a very limited number of people. A little thinking and some research may help them think differently.

Using the stories in this issue as a starting point, assign students these questions for research or discussion.

Q. In researching the two astrolabes, what two areas of knowledge came together?

A. *history and science (physics in particular)*

Q. In looking for information about botulism toxins, people from more than one scientific discipline worked together. What were those disciplines?

A. *biology and physics (physicists with knowledge of x-ray diffraction)*

Q. Based on the information available, what job titles or work experience was probably required in developing the facilities where the X-ray research was done?

A. *probably physicists; architects; a variety of engineering disciplines such as electrical, structural, civil, etc.; health physicists with knowledge of protecting workers from radiation exposure*

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Biology, Genetics, Radiation

Quantifying Radiation Damage to DNA

Scientists at Brookhaven National Laboratory have developed a way to detect and quantify certain types of radiation damage to DNA. The technique could help assess the radiation risks faced by astronauts, improve the cancer-killing potential of radiation therapy, and distinguish between DNA damage caused by normal living and that caused by low-level radiation.

Scientists have long known that deoxyribonucleic acid (DNA), the genetic-code carrying molecule that tells cells which proteins to make, can be damaged. That damage might come from ionizing radiation, such as gamma rays and x-rays. Or, it might come from something as mundane and inescapable as the oxygen we must breathe to sustain life processes.

Fortunately, our bodies are *usually* able to repair the damage caused by oxygen and everyday radiation sources such as sunlight. But, if the damage isn't repaired or if the "repairs" are faulty, the damage can be lethal to the cells or cause cancer.

It is known that when the damage to DNA involves closely-spaced breaks in both strands of the double helix, the cells have difficulty making repairs. Scientists have hypothesized that radiation might lead to other forms of clustered damage on both strands of DNA. And, they've wondered if such clusters of damage could be equally, or more, harmful.

Until now, no one had a way to determine if radiation caused these kinds of damage, to measure how often it happened, and to assess repairability.

A team of Brookhaven scientists, led by biologist Betsy Sutherland, irradiates DNA or cells in culture. They treat the DNA with special enzymes (supplied by collaborating French researchers). The enzymes are known to cut the DNA strands at sites where specific kinds of damage occur. Then, the team separates the fragments using electrophoretic gels. Finally, they count the fragments using a special electronic imaging system to determine the levels of fragments containing various kinds of damage.

Surprisingly, data from the research on DNA in solution and human cell cultures have shown that double strand breaks comprise only about 20 percent of the damage from radiation. The other 80 percent of complex damage sites consist of places where the base is simply knocked off the DNA sugar backbone (abasic sites) or oxidized DNA bases.

Biologist Sutherland has noted that the effects of most types of complex DNA damage in cells and how they are repaired are unknowns. She explained that the only way to find out about them is to make careful measurements. Now, the team has a way to do just that.

Scientists could use this technique to investigate whether all the cells in the body respond in the same way or to determine if different species or different people show varying degrees of susceptibility to certain kinds of damage. This information could be useful in selecting people for long-term missions in space. (It is estimated by the National Aeronautics and Space Administration that one-third of an astronaut's cells will be hit by a heavy charged particle during each year in space.)

Studies could help researchers determine the potential of antioxidants to counteract or prevent DNA damage. And, the knowledge developed as a result of this new technique could also help develop ways to use radiation more effectively in fighting cancer.

electrophoresis - the movement of suspended particles through a fluid or gel under the influence of an electromotive force applied to electrodes in contact with the suspension

ionizing radiation -Radiation that has enough energy to remove an electron from a struck atom, thus leaving positively charged particles (ions) behind. (Not all types of radiation are ionizing.)

To See Photo

Two Ancient Astrolabes or One Fake?... Continued from page 1

the team determined elemental composition of the alloys using fluorescence analysis, crystal structure using diffraction analysis, and information on thickness variations using scanning radiography.

The Results

Data was gathered using three techniques:

Technique (what it reveals)	Adler Planetarium's Astrolabe	Harvard collection Astrolabe
x-ray fluorescence (material composition)	copper-zinc alloy with silver, tin, lead, nickel, and antimony impurities (old brass)	no zinc; gold-plated copper; contains mercury and silver from gilding process, with lead and tin impurities
x-ray diffraction analysis (crystal pattern)	random orientation of crystals in the metal, indicating it was probably hand-hammered	strong directional pattern of crystal orientations; probably made of rolled metal (a technique not available for plates this large in 1597)
scanning radiography (thickness)	irregular thickness; consistent with hand-hammering	uniform thickness; consistent with a rolled plate

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Nuclear Sciences

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Q. Why would each type of worker involved in developing the facility need to know something about nuclear technology and radiation?

A. *physicists to provide information on types of facilities needed, types of equipment to be used in research; architects to assure aesthetic qualities of building; electrical engineers to determine unique electrical needs of the facility; structural engineers to work with architects in assuring that the structure will be able to sustain the loads and demands caused by the required equipment (considering size, weight, unique stresses, etc.); civil engineers to consult with architects and help assure that all necessary utility services are available, that proper disposal is available for all waste from the building, etc.; health physicists to assure proper shielding of radiation sources, etc.*

Q. Why would a historian need to know anything about radiation and nuclear technology?

A. *in order to be aware of the types of information that could be gathered from artifacts using these technologies; in order to consider using these research techniques to provide information used in solving historical mysteries or disputes*

Q. Many professions and scientific specialties might be involved in the research and treatment which focused on preventing coronary arteries from reblocking following angioplasty. Which ones would need to have knowledge of nuclear technology and radiation safety?

A. *cardiologists, anesthesiologists, physicists (who designed the device for generating rhenium-188), nuclear pharmacists (at the local hospital where procedure is done and the rhenium-188 is "generated" and used), nurses assisting with procedures, health physicist (to monitor radiation exposures and help assure safety of patient and staff using the radioactive materials)*

Two Ancient Astrolabes or One Fake?...

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Conclusions

The researchers concluded that the composition and microstructure of the Adler Planetarium's astrolabe are consistent with the metallurgical technology of 1597. However, data from the Harvard instrument revealed a more recent manufacturing technology; it is a copy, not an original. Scientists speculate that the Harvard piece was part of a group of reproductions used as collectibles or souvenirs.

Point your web-browser to "astrolabes" for more information about such devices.

Point your web-browser to "x-ray diffraction" for more information about the techniques.

Web-only Edition of *ReActions* in November

The next issue of *ReActions*, a special full-color edition, will be available to teachers on the ANS web site <www.ans.org> in November. It will contain graphics for which our two-color printing process would be inadequate. As a result, ***the November edition will not be printed or mailed***. It will be a web-only edition. However, web site visitors with color printers will be able to produce their own color copy.

Recent editions on web site

Previously, only the text of *ReActions* articles was available on the web site. Now, this issue and three other recent issues of *ReActions* have been posted in graphic format. We believe the graphic version will be more meaningful and useful to site visitors. Check out the web version of this issue for a hint of the future.

Register for e-mail notification

You won't want to miss the November special edition! We would be glad notify you by e-mail when the November issue is posted. All you need to do is register for the service. Registering is simple:

1) Visit our web site **<www.ans.org>**.
2) Click on "Public Information"
3) Under "Teachers", click on "*ReActions*."
4) Click on "Register for *ReActions* Email Notification."
5) Fill in the information boxes as directed.

We'll send e-mail notification of the November issue and other information of interest.

Printed Edition in February

After November, we plan two more issues of *ReActions* during this school year. The next printed edition is being planned for February mailing.

September 2000

The Future is in the Atom

Special, Web-only Edition of ReActions in November

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555 N. Kensington Avenue
La Grange Park, IL 60526-5592
REACTIONS

Non-Profit
BULK RATE
U.S. Postage
PAID
PERMIT No. 139
Hinsdale, IL 60521