



# REACTIONS

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

## Nuclear Technologies Listed Among Top Engineering Achievements of 20th Century

**Nuclear Technologies have been named to a list of Top Engineering Achievements of the 20th Century. The list consists of 20 engineering achievements judged to have had the greatest impact on quality of life in the 20th Century.**

**T**he National Academy of Engineering (NAE) press release announcing the list stated, "One hundred years ago, life was a constant struggle against disease, pollution, deforestation, treacherous working conditions, and enormous cultural divides unbreachable with current communications technologies. By the end of the 20th century, the world had become a healthier, safer, and more productive place, primarily because of engineering achievements."

The NAE provided leadership in developing the list. It worked in conjunction with the American Association of Engineering Societies and National Engineers Week.

The achievements were nominated by 29 professional engineering societies and selected and

ranked by a panel of the nation's top engineers. To ensure its deliberations were unbiased, the committee, convened by NAE, worked in anonymity.

### Armstrong Announces List

The Achievements list was announced during National Engineers Week by astronaut/engineer Neil Armstrong, who spoke on behalf of the National Academy of Engineering at a National Press Club luncheon in late February.

"As we look at engineering breakthroughs selected by the National Academy of Engineering, we can see that if any one of them were removed, our world would be a very different – and much less hospitable place," said Armstrong.

"Almost every part of our lives underwent profound changes during the past 100 years thanks to the efforts of engineers, changes impossible to imagine a century ago. People living in the early 1900s would be amazed at the advancements wrought by engineers," Armstrong continued. "As someone who has experienced firsthand one of engineering's most incredible advance-

ments – space exploration – I have no doubt that the next 100 years will be even more amazing."

### Contributions of Nuclear Technologies

In the materials released by the National Academy of Engineering, Nuclear Technologies were cited for changing the nature of war, offering a new source for electrical power generation, and improving medical diagnostic techniques.

While these are among the best known impacts, there are many others. Nuclear technologies have contributed medical treatment techniques as well as an ever expanding range of diagnostic approaches. Industrial applications include vulcanization of rubber for tires; measuring thicknesses of coatings, papers, plastic films; gauging the fill level in cans; testing for integrity of materials and structures; and many more. Nuclear technologies are used in oil well logging measurements, studies of ground water and its movement, research on environmental issues, determining the age of historical artifacts, and many other basic science investigations in chemistry, physics, and biology.

### Nuclear Technologies and Other Achievements

Nuclear technologies also contribute significantly to ongoing progress in other achievements on the list. For example, nuclear technologies are used to generate about 20% of electrical power in the U.S. and a significantly larger portion in many other countries. Nuclear technologies contribute to research and development work involved in design and manufacture of new automobiles. Nuclear materials are used in airplane construction. Nuclear technologies are used for gauging during the construction of roads and highways. Nuclear technologies currently help power spacecraft instrumentation and are being considered for propulsion systems. Nuclear technologies contribute significantly to the development of new medical imaging techniques, are used to sterilize medical supplies and contribute to the research which develops new pharmaceu-

## 20 Greatest Engineering Achievements of the 20th Century

**T**he achievements which have had the greatest impact on quality of life in the 20th century, as selected and ranked by a panel of the nation's top engineers.

- |  |  |
|--|--|
| 1. Electrification                     | 11. Highways                                 |
| 2. Automobile                          | 12. Spacecraft                               |
| 3. Airplane                            | 13. Internet                                 |
| 4. Water Supply and Distribution       | 14. Imaging                                  |
| 5. Electronics                         | 15. Household Appliances                     |
| 6. Radio and Television                | 16. Health Technologies                      |
| 7. Agricultural Mechanization          | 17. Petroleum and Petrochemical Technologies |
| 8. Computers                           | 18. Laser and Fiber Optics                   |
| 9. Telephone                           | 19. Nuclear Technologies                     |
| 10. Air Conditioning and Refrigeration | 20. High-performance materials               |

**For more information about the Greatest Engineering Achievements, visit the web site [www.greatachievements.org](http://www.greatachievements.org)**

## PET Helps Determine How Aging Affects Brain Chemistry

**S**ome answers to the question of how aging affects the brain have been obtained through the use of positron emission tomography (PET), an imaging method in which radioactive tracers are injected into the patient, flow through the blood, and concentrate in areas that

have active metabolism (increased blood flow).

A collaborative effort of researchers from Brookhaven National Laboratory, the State University of New York at Stony Brook and the University of Pennsylvania School of Medicine found evidence of chemical changes in the brain

that may underlie cognitive deterioration associated with aging. The research was carried out using PET.

"In this study, we have shown that the age-related loss of dopamine, the brain chemical associated with pleasure and reward, slows metabolism in regions of the brain that are related to cognition. This finding may be helpful in developing interventions for age-related cognitive

decline," said Nora Volkow, Brookhaven's Associate Laboratory Director for Life Science and the lead author of the study.

The researchers found that age is associated with a significant decline in dopamine D<sub>2</sub> receptors, the molecules that transmit signals that are associated with pleasure and reward in the brain. In this study, researchers discovered for the first time that, when dopamine D<sub>2</sub> receptors decreased, so did regional glucose metabolism in areas of the brain that are related to cognition. Decreased glucose metabolism translates to deterioration of brain function.

In a group of healthy participants, glucose metabolism decreased with age in the frontal brain regions and a part of the brain called the anterior cingulate gyrus. The frontal brain region controls functions such as problem-solving, abstract thinking, and the ability to carry out multiple tasks simultaneously. The anterior cingulate gyrus is the center for attention span, impulse control and mood.

Other evidence in the study suggests that dopamine may also influence brain metabolism regardless of age.

*In this study, researchers measured dopamine D<sub>2</sub> receptors and glucose metabolism in the brains of 37 healthy subjects, ages 24 to 86 years. No participant took medication during the study, and all participants were screened for psychoactive drug use.*



**Note: This story based on an article in *Brookhaven Bulletin*, March 17, 2000. Photo courtesy of Brookhaven National Laboratory.**

**Teacher Tip: Using the phrase "positron emission tomography" in your browser's search engine should locate a number of web sites with more information about PET.**

## Neutron Scattering Data May Help Stop Paper Jams

**T**he mundane but annoying problem of paper jams in printers and photocopiers may become a thing of the past, thanks to a study being conducted at an Australian research reactor.

The research is a collaboration between scientists at Monash University and the Australian Nuclear Science and Technology Organization (ANSTO). It focuses on how water from the atmosphere combines with the cellulose in paper.

Paper expands and contracts with changes in humidity and gains weight when the humidity is high. That is because water molecules in the air bond with the giant cellulose molecules in paper. It is this hydration of cellulose which is responsible for many paper jams in offices around the world.

Researchers at the Monash University Pulp and Paper Institute, working with ANSTO, have used the Small Angle Neutron Scattering (SANS) facility

attached to ANSTO's HIFAR reactor to pinpoint the water in paper molecules.

The SANS device directs a narrow beam of neutrons down a beamline to the target material, in this case the paper. The neutrons scatter slightly on impact with the microstructure in the paper samples.

The scattered neutrons enter a large vacuum tank which prevents further scattering. At the rear of the tank is a neutron detector containing the exotic gas, helium-3. The gas captures each neutron and generates a small electrical charge. This charge is detected by a grid of gold-coated tungsten wires, each only as thick as a human hair. The data on each neutron strike is transmitted to computers, which build up the scattering pattern for analysis.

By analyzing the pattern, scientists can determine the material's structure. It is hoped that the research may lead to ways to modify paper at the molecular level to make it more resistant to humidity.

## Nuclear Power Status in 1999

**A** total of 436 nuclear power plants were operating around the world in 1999, according to information supplied by the International Atomic Energy Agency in March 2000. In 1999, four nuclear power plants were connected to the grid (one each in France, India, Republic of Korea and the Slovak Republic).

Construction was started on seven new reactors in 1999 – one in China and two in Taiwan, China, two in Japan, and two in the Republic of Korea. This brought the total of reactors reported under construction to 38.

The ten countries with the highest reliance on nuclear power in 1999 were: France, 75%; Lithuania, 73.1%; Belgium, 57.7%; Bulgaria, 47.1%; Slovak Republic, 47%; Sweden, 46.8%; Ukraine, 43.8%; Republic of Korea, 42.8%; Hungary, 38.3%; and Armenia, 36.4%. In total, 17 countries and Taiwan, China, relied upon nuclear power plants to supply at least a quarter of their total electricity needs. The United States relied on nuclear power plants for 19.8% of its electricity needs.

Cumulative worldwide operating experience from civil nuclear power reactors at the end of 1999 exceeded 9400 reactor-years.

## Positrons Contribute to Paint-Durability Test

**P**ainting a large bridge is a costly and time-consuming task. Maintenance costs are even greater if the paint job does not last and must be repeated or if paint failure leads to material damage from rust and corrosion. As a result, scientists have been working on ways to test paint durability before the brushes even get wet.

Bent Nielsen, a visiting scientist at Brookhaven National Laboratory's Physics Department, working in collaboration with Jerry Jean and others at the University of Missouri at Kansas City, has developed a way to use positrons to probe the molecular structure of paints. Findings from this research may lead to a quick, sensitive test for paint durability.

In a technique called positron annihilation, scientists bombard small painted samples of metal with a beam of positrons (positively charged electrons). When these "anti-electrons" interact with the electrons in the molecules of paint, they annihilate, sending out gamma rays. Scientists are able to gather, from the gamma rays, information about the molecules in the paint.

Using this technique scientists are able to detect nanometer-scale\* holes and defects in the paint molecules; free radicals, indicating the presence of broken chemical bonds; and cross linking, which may contribute to brittle paint.

Early results indicate that the technique is useful in detecting damage early, well before visible cracks form in the paint. In addition,



the experiments have shown that some paints are less durable when exposed to ultraviolet (UV) light. The studies may help scientists learn more about the fundamental mechanisms involved in paint degradation. This may result in development of more durable paints.

\*nanometer – billionth of a meter;  $1 \times 10^{-9}$  meter

## Project 62 – Research Activity

### Nuclear Reactors, Electrical Power, Sustainable Development

**H**ave students work independently or in teams to complete the following activities:

- 1) Create a map showing the locations of nuclear power plants in the U.S.
- 2) Create diagrams of nuclear power plants, showing the differences between a Boiling Water Reactor (BWR) and a Pressurized Water Reactor (PWR).
- 3) Research information on the nearest nuclear power plant. Determine what type of reactor is used (BWR or PWR), the area it serves, the amount of electrical energy produced, environmental impact/contributions, etc.
- 4) Learn what impact a nuclear power plant has on carbon dioxide emissions. Determine which countries have been successful in reducing carbon dioxide emissions. Learn which countries produce the largest portion of their electricity using nuclear power.
- 5) Develop a list of ways that nuclear technology contributes to sustainable development (development that meets the needs of the present without compromising the ability of future generations to meet their own needs).

Possible internet resources are found on the following sites:

[www.ans.org/pi/brochures/pdfs/sustainabledev.pdf](http://www.ans.org/pi/brochures/pdfs/sustainabledev.pdf)

[www.nrc.gov](http://www.nrc.gov)

[www.ans.org/pi/brochures/pdfs/co2emissions.pdf](http://www.ans.org/pi/brochures/pdfs/co2emissions.pdf)

[www.nei.org](http://www.nei.org)

[www.ans.org/pi/glossary](http://www.ans.org/pi/glossary)

<http://library.thinkquest.org/3471>

[www.nrc.gov/NRC/teachers.html](http://www.nrc.gov/NRC/teachers.html)

Also, using your internet browser, search for information about NUCLEAR POWER, NUCLEAR REACTORS, and other related topics. (Careful assessment is needed to separate those with accurate and complete information from those with a goal of influencing via partial information.)

## Nuclear Power and High-Speed Ships

**N**uclear power is among the alternatives to be considered for use on the next class of large, high-speed ocean-going ships, according to a news release from the Society of Naval Architects and Marine Engineers (SNAME).

The SNAME release described the new class of ships as having a higher speed (over 40 knots) and more installed power (325,000 hp) than the largest aircraft carriers or the most powerful merchant ship ever built previously, the SS United States. The ships of this type currently being built will use up to five, diesel-fueled, gas-turbine engines similar to the jet engines of the largest airliners.

Experts consider these new ships only the beginning. They speculate that as the new ships prove themselves in transatlantic service ship owners will be drawn to Pacific Ocean trade routes, needing larger ships with even higher speeds and power levels.

SNAME has concerns about the environmental impact of these ships. As a result, SNAME has established a panel of experts to examine power plant options for these large ships. Alternatives to be studied include fuel-cells and nuclear plants. Criteria to be considered include low environmental impact, technical and economic feasibility, safety, and social and political acceptability.

**Note: This story based on an article in Brookhaven Bulletin, April 21, 2000. Photo courtesy of Brookhaven National Laboratory.**



**Web Sites of Interest**

**H**ere are some web sites that teachers may find of interest. Their listing here does not imply an endorsement of the organization or its web site. They are listed only as a service to teachers, who will make their own decisions about use of the material.

**<http://www.food-irradiation.com>**

The Foundation for Food Irradiation Education describes itself as “a member-supported organization managed in Canada and hosted in the United States. Its purpose is to provide factual and informative information and to improve communications about food irradiation to the public, the industry, media and academia.”

**<http://www.cbvcp.com/nmrc/>**

This is the web site for the Nuclear Medicine Research Council, a nonprofit organization promoting the beneficial uses of radioisotopes to prevent, diagnose, and treat disease.

**<http://c14.sci.waikato.ac.nz/webinfo/index.html>**

A web information source about radiocarbon dating from the Radiocarbon Laboratory of University of Waikato, New Zealand.

**<http://www.asrt.org/asrt.htm>**

The web site of American Society of Radiologic Technologists. Contains information about Radiologic Technologists and imaging procedures. Includes career information. (Site may require that you type “https” at the beginning of the address as part of a security system.)

**Nuclear Steam Generators to be Recycled**

**A** team of Bechtel, GTS Duratek and Siemens Power Corporation has received a contract from Wisconsin Public Service to replace steam generators removed from its Kewaunee nuclear plant. This marks the first time that steam generators from a nuclear plant in the U.S. have been reused rather than buried for final disposal.

Bechtel will perform the steam generator replacement. The removed steam generators will be transported to a GTS Duratek facility in Tennessee. Siemens will decontaminate the steam generators using its CORD (Chemical Oxidation Reduction Contamination) process, which uses only agents that can be destroyed by UV light to give CO<sub>2</sub> and water. The process is notable for reducing the quantity of waste from the decontamination process.

GTS Duratek will then dismantle the steam generators, melt them down, and reuse the metal as radiation shield blocks for DOE advanced energy research.

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tics. In addition, nuclear technologies contribute to the development of new high-performance materials.

Clearly, nuclear technologies made a signifi-

cant contribution to quality of life in the 20th century. They will continue to make a contribution in the century ahead. It is critical that today's students learn about those contributions

so that some of them will consider a career in the nuclear field. It is even more important that all students understand how nuclear technologies make a positive contribution to everyday life.

**Refer to the February 2000 issue of *ReActions* for a classroom activity related to careers in nuclear technology.**

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