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## Research Highlights . . .

### Understanding Ozone pollution

City smog breeds excess ozone, and, thus, most metropolitan areas in the U.S. don't meet national ambient air-quality standards. Too much surface ozone can cause or aggravate respiratory problems in humans and damage crops and other vegetation. Scientists from DOE's Brookhaven National Laboratory are currently studying meteorological conditions in Phoenix, Arizona, where ozone levels are high, to understand the chemical precursors in the region that lead to ozone formation, measure the ozone concentration in the air, and determine what chemicals are created along with ozone. This research may lead to a better understanding of how ozone levels can be reduced.

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### "Cereal Killer" May Protect Crops from Diseases

Malted cereal grains may potentially defend potatoes and other crops from agricultural diseases. Karen B. Barrett of DOE's Idaho National Engineering and Environmental Laboratory won a 1998 R&D 100 Award for discovering that malted grains, such as rye, barley, or wheat, kill an assortment of bacteria and fungi. In petri dishes, potato disks dusted with the biopesticide powder staved off the soft rot pathogen that destroyed unprotected potatoes. Unlike conventional bactericides and fungicides, the malt-based antimicrobial is produced from a renewable resource, safe for agricultural workers, and fully biodegradable. Ultimately, the malt-based antimicrobial could protect crops throughout the agricultural cycle—from seeds to growing plants to stored vegetables.

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### By the numbers

How many randomly generated arithmetic problems can a person answer in 60 seconds? Find out by visiting "The ArithmAttack," a free software program offered to children and other arithmetic students around the world by DOE's Argonne National Laboratory. ArithmAttack can be played on the World Wide Web at "<http://www.dep.anl.gov/aattack.htm>" or downloaded free for use on individual computers. The game randomly creates problems using numbers between 0 and 12. Students or teachers can instruct the game to focus exclusively on addition, subtraction, multiplication, or division, or can let it choose among them at random. The entire program takes up only about 14 kilobytes of memory.

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### Particle Accelerator Project Enters Home Stretch

Construction of the newest accelerator at DOE's Fermilab is coming down the stretch toward the finish line. Workers are pulling the last miles of cable, pouring the final yards of concrete and installing the last components for the six-year, \$229 million project. When it begins operating in 1999, the Main Injector will significantly increase the rate of proton-antiproton collisions at Fermilab's Tevatron, the world's highest-energy particle accelerator. Because the particle interactions that physicists search for are extremely rare, the more particle collisions Fermilab can create, the better the chances for discoveries about the nature of matter at the smallest scale.

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## The Search for Neutrino Mass

**N**eutrinos—those ghostly neutral particles that stream through the universe by the trillions—made headlines recently with the announcement by researchers in Japan of compelling evidence that these enigmatic subatomic particles may have a small mass. Such a finding, if confirmed, would have a profound effect on our understanding of the fundamental workings of the universe.

Now, a collaboration of physicists, including scientists from DOE's Argonne National Laboratory, Fermilab, Lawrence Livermore National Laboratory and Oak Ridge National Laboratory, along with a score of universities, have embarked on an ambitious experiment to provide a definitive answer to the question of neutrino mass.

Experiments over the past 40 years have shown that neutrinos come in three varieties, or flavors: electron, muon and tau. According to basic physics principles, in order for neutrinos to change, or oscillate, from one flavor to another, they must possess mass. Thus, the discovery of neutrino oscillation would prove the existence of neutrino mass.

The researchers at DOE's Fermilab will send a beam of pure muon neutrinos created by Fermilab's new Main Injector accelerator, near Chicago, to a detector 730 kilometers (450 miles) away in a former iron mine in northern Minnesota. Using a ten-thousand ton particle detector deep in the mine, the experimenters will scrutinize the neutrinos in the beam to see if any have oscillated into tau neutrinos on the split-second interstate trip.

Astrophysicists, nuclear physicists and particle physicists have long studied neutrinos produced by the sun and by cosmic ray interactions in the upper atmosphere. In experiments like the one at Super Kamiokande in Japan, they have seen a shortage in the number of neutrinos they expect to observe: some have "disappeared," presumably by oscillation to another flavor.

Fermilab's Main Injector Neutrino Oscillation Search (MINOS for short), an accelerator-based experiment, seeks to observe not only the disappearance of neutrinos of one flavor but their appearance as neutrinos of a second flavor, confirming the results of solar and atmospheric neutrino "disappearance" experiments and providing the first quantitative measurements of the particles' mass.

Construction has begun on the neutrino beamline and the detector for MINOS. Collaborators hope to begin taking data in 2002.

*Submitted by DOE's Fermilab*



*Members of the MINOS collaboration posed at Fermilab last month for a portrait with one of the huge steel "slices" of the 10,000-ton neutrino detector they will build in a Minnesota iron mine.*

## PRINCETON NOBEL LAUREATE TO BRING HANDS-ON SCIENCE TO LIBRARIES

Russell Hulse of DOE's Princeton Plasma Physics Laboratory is not one to rest on his laurels. Through his efforts, hands-on scientific displays soon may join book collections and hushed areas of contemplation at the local library.

Hulse and Plainsboro Public Library Director Jinny Baeckler are spearheading a project called "Contact Science," which will create, disseminate, and support small-scale traveling science exhibits in public libraries. The exhibits would be prototyped at the Plainsboro, New Jersey library and travel to other libraries from there.

"We would like to provide informal science education to children and their parents by placing science centers in libraries through the use of traveling components," said Hulse, a research physicist at PPPL who shared the 1993 Nobel Prize in Physics.

"We want to make learning about science fun and engaging. The purpose of Contact Science is not to teach a science course or serve as a classroom, or be an amusement park. Instead, our goal is to capture the imagination," said Hulse, who is also on an advisory committee for the Hubble Space Telescope traveling exhibit being created by the Smithsonian Institution in collaboration with the Space Telescope Science Institute.

Procter & Gamble, Inc. is funding the Phase I scoping and program development studies for Contact Science, a nonprofit corporation.

Hulse, who is involved in various science education activities - including Contact Science - for PPPL, stressed the importance of instilling in children a sense of adventure about science.

"Science is not just something you learn in the classroom. It is an exciting, fun part of life," said Hulse.

*Submitted by DOE's Princeton Plasma Physics Laboratory*