NANO R&D HAS A GIANT IN ITS CORNER.

NANO DESIGN WORKS

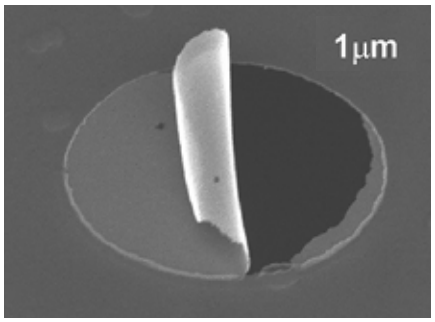
FEW TECHNOLOGIES HOLD MORE POTENTIAL TO POSITIVELY TRANSFORM OUR SOCIETY THAN NANOTECHNOLOGY.

THE REVOLUTIONARY POTENTIAL OF NANOTECHNOLOGY IS READY TO BE RECOGNIZED.

It has already revolutionized the electronics industry and is bringing a new set of powerful tools and advanced materials to developers seeking to speed up synthetic chemical reactions; transform raw materials into finished products such as plastics and gasoline; seek out and attack cancer cells; reduce the size of integrated circuits; and enhance a vast range of common products, from sunscreen to food packaging.

Recognizing the power of this technology and seeking to accelerate its impact, the U.S. Department of Energy's Argonne National Laboratory has created a new collaborative center known as Nano Design Works (NDW) that provides an innovative pathway for business and industry to access Argonne's unparalleled scientific resources. NDW will help speed discoveries to market to ensure U.S. industry maintains a lead in this global technology race.

An Argonne researcher works with a new magnetic nanofiber that is used to create more efficient magnets. The new technology could lead to improvements in diverse applications, including those in medicine, water treatment, and harvesting of radio frequency energy, which could allow a battery to recharge itself by using energy from signals traveling through the air.



Argonne researchers are able to curve or fold gold nanoparticle membranes into a complex three-dimensional structure using an electron beam. The findings open the way for scientists to design membranes with tunable electrical, magnetic, and mechanical properties that could be used in electronics and may even have implications for understanding biological systems.

NANOSCIENCE REQUIRES BIG THINKING.

Entrepreneurs find it increasingly difficult to get their ideas to market. Firms of more than 10,000 employees now account for just half of company-funded domestic R&D, so investment in fundamental research often falls on the shoulders of small- and medium-sized-businesses.

This responsibility for early-stage research means small firms need access to the type of resources that can only be found at leading scientific institutions in order to fulfill the promise of American innovation.

By fusing the nation's entrepreneurial spirit with Argonne's expertise and world-class facilities, NDW will empower American industry to continue leading the world in nano discovery while providing the high-tech jobs critical to the nation's economic prosperity.

Realizing the full potential of these resources requires a liaison that can access the complete spectrum of capabilities from diverse scientific fields. This concierge approach will help industry benefit from cutting-edge facilities beyond the research budgets of all but the largest corporations.

In addition to answering industry's most difficult questions, NDW will provide access to fundamental research conducted at Argonne that is poised for development into practical products. The chance to build on existing scientific discovery is a unique opportunity for businesses in the nano field.

INNOVATION VIA COLLABORATION

NDW reaches across Argonne to assemble the right combination of talent and instrumentation for each partner to match industry's nano needs. The laboratory's breadth of cutting-edge resources ensure the most rapid route to discovery on time and on budget.

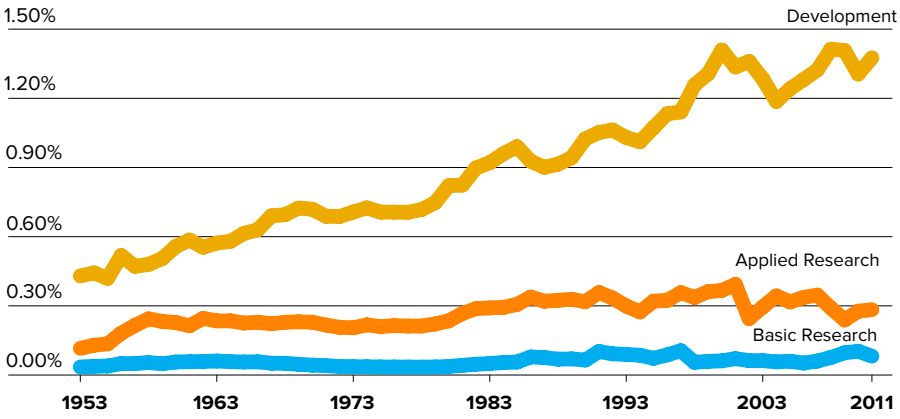
NDW's unique collaborative framework will be instrumental in nano's journey from the laboratory to the marketplace.

In nanotechnology, there is no problem so small it can't yield a huge breakthrough. Project scale and duration is flexible, ranging from single-day solutions to multi-year investigations.

NDW paves the way for access to Argonne's broad range of scientific expertise—modeling and simulation, X-ray imaging, chemical science, materials, and energy systems are all well within the laboratory's research portfolio.

The Trend In Today's R&D

INDUSTRY INVESTMENT IN R&D, AS A SHARE OF GDP

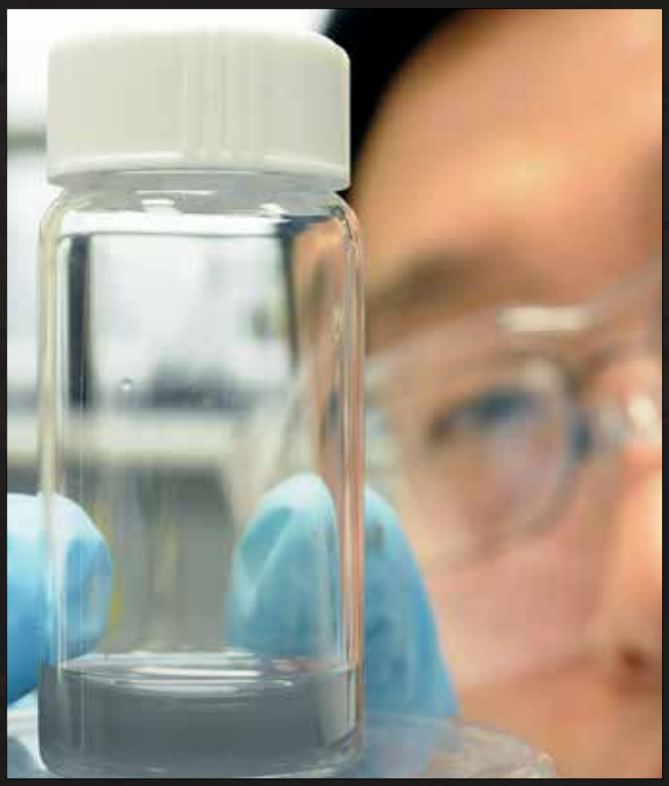


Source: National Science Foundation, Science and Engineering Indicators, 2015.

NDW PROVIDES **A PATHWAY TO THREE** CRITICAL CAPABILITIES.

Innovation and commercialization require an enhanced understanding of materials at the nanoscale. NDW has the capacity to assist with fabrication, characterization and predictive models enabling businesses to effectively translate the power of fundamental R&D into impactful products.

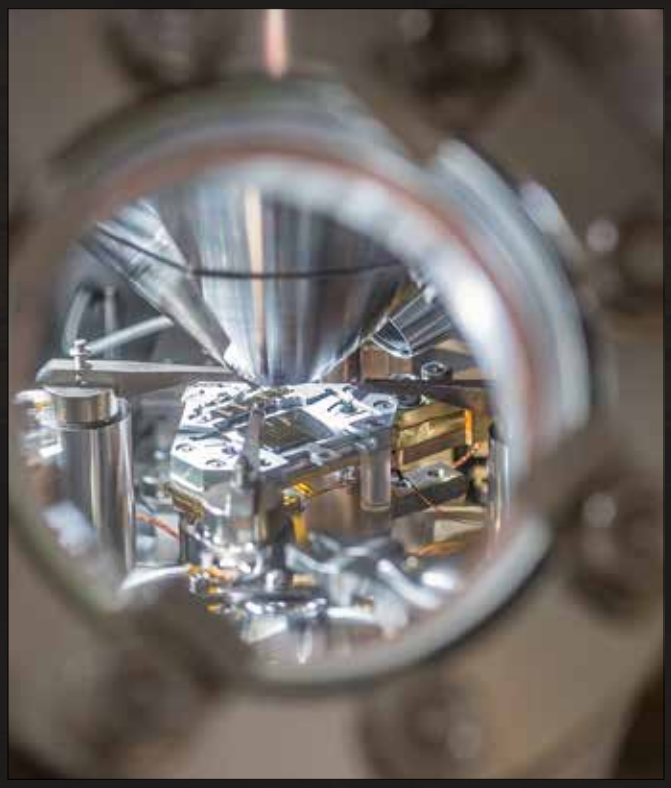
A battery shuttle scaled from gram to kilogram at Argonne's Materials Engineering Research Facility, where materials developed at the bench are scaled up for commercial evaluation.



An Argonne researcher creates photocatalytic colloidal nanoparticles in a solution. When added to liquids contaminated with organic pollutants and exposed to light, the nanoparticles cause the contaminants to break down into harmless components.

FABRICATION AND SYNTHESIS

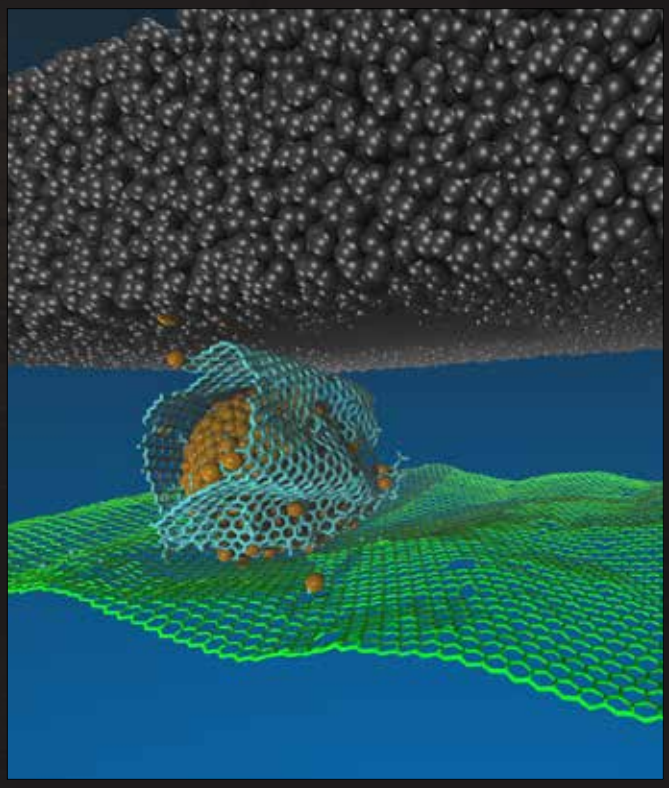
For optimal performance, materials may need to be modified, or novel nanomaterials created. The laboratory's thin-film deposition, material synthesis, and semiconductor processing tools, along with Argonne's fully equipped clean room, can help industrial partners customize or create materials unique to their needs.



Argonne's instrumentation, such as this Omicron ultra-high vacuum nanoprobe system with integrated scanning electron microscope, allows for precise characterization of nanoscale materials and devices.

CHARACTERIZATION

Determining defects, discerning composition and structure, and observing interfaces at the nanoscale are challenges that require sophisticated tools. Argonne's Advanced Photon Source and electron and scanning probe microscopy capabilities make achieving these vital insights more possible than ever.



This visualization shows how Argonne researchers were able to achieve "superlubricity" through the innovative use of nanoparticles. As they rub against the black diamond-like carbon surface, the gold nanodiamond particles are wrapped up by the blue patch of graphene, creating a "nanoscroll" that reduces friction to near zero.

PREDICTIVE UNDERSTANDING

Developing predictive models saves valuable time in translating fundamental research into marketplace adoption and is critical to both understanding and fabricating novel materials. The laboratory's unparalleled expertise in modeling and simulation coupled with the Argonne Leadership Computing Facility create the perfect environment for predictive model development.

WHEN WORKING AT THE SMALLEST SCALES,

YOU
NEED THE
BIGGEST
RESOURCES
POSSIBLE.

Overcoming the barrier to nanoscience R&D has always been prohibitively expensive; the cost of instrumentation alone prevents widespread entry into the field.

NDW WILL ASSIST FIRMS WITH PROMISING TECHNOLOGIES AND UNIQUE CHALLENGES, FACILITATING ACCESS TO SOME OF THE **WORLD'S MOST SOPHISTICATED SCIENTIFIC USER FACILITIES.**

The microwave plasma chemical vapor deposition (MPCVD) system for the synthesis of diamond thin films in the clean room at the Center for Nanoscale Materials.

CENTER FOR **NANOSCALE** MATERIALS **(CNM)**

The CNM facility provides expertise, instruments, and infrastructure for interdisciplinary nanoscience and nanotechnology research to generate scientific insights, create innovative materials with unique functionality, and contribute significantly to energy-related research and development programs. Three critical pillars underpin this effort in the areas of materials discovery, manipulation, and visualization.

An Argonne researcher mounts a sample in the Center for Nanoscale Materials/Advanced Photon Source's Hard X-ray Nanoprobe, one of the world's most powerful X-ray microscopes.

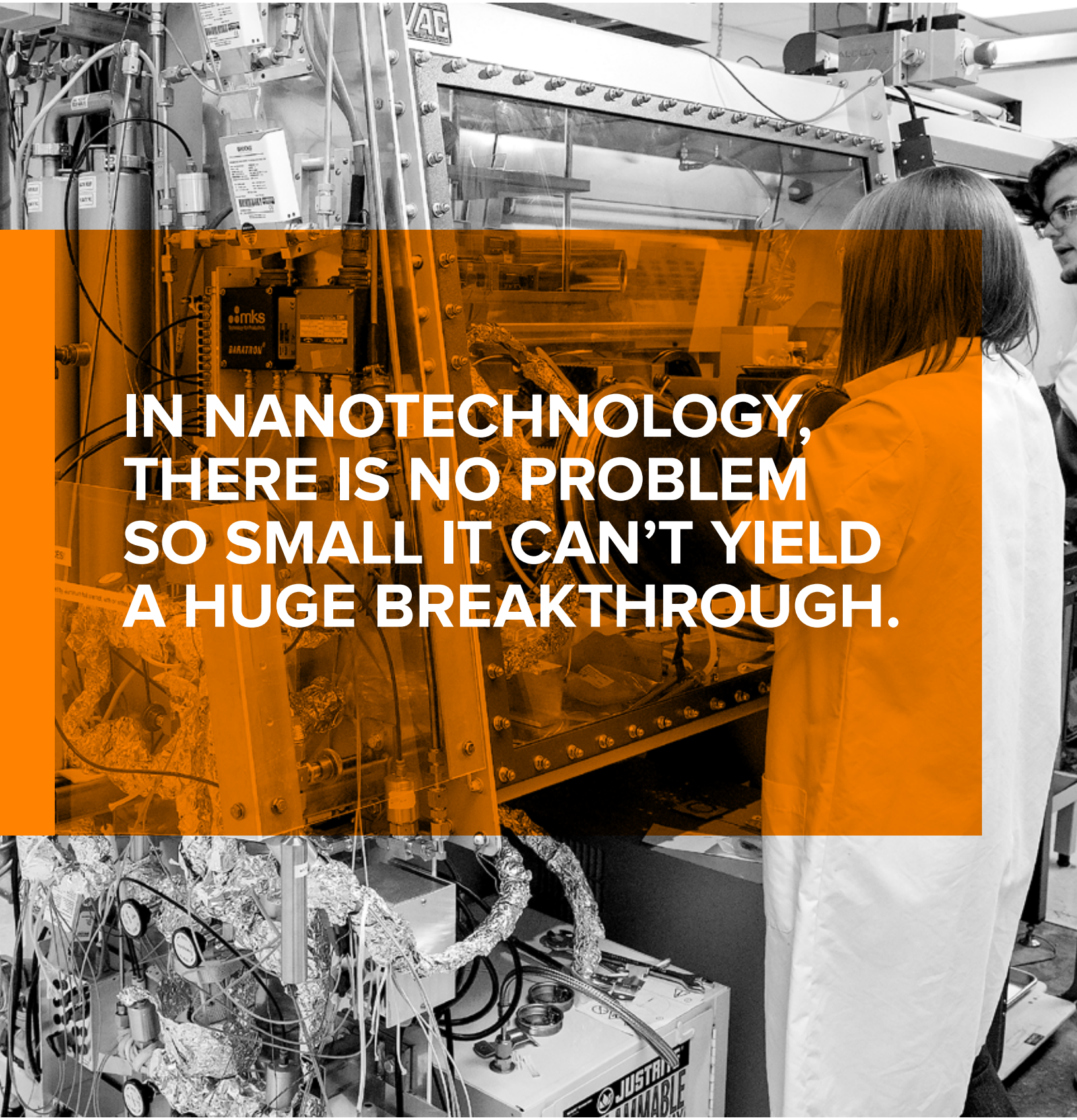
ADVANCED **PHOTON** SOURCE **(APS)**

The APS provides the brightest storage ring-generated X-ray beams in the Western Hemisphere for research in materials science, chemistry, biology, physics, earth and planetary science, and environmental science.

Argonne Leadership Computing Facility staff verify interconnect cabling on Mira, the 10-petaflop supercomputer that enabled an Argonne nanoscientist to identify a new mechanism for "superlubricity".

ARGONNE LEADERSHIP **COMPUTING** FACILITY **(ALCF)**

The ALCF is half of the leadership computing facility supported by the U.S. Department of Energy, and is home to Mira, the fifth-fastest supercomputer in the world. ALCF staff provides expertise and assistance to support user projects to achieve top performance of applications and to maximize benefits from the use of computing resources.

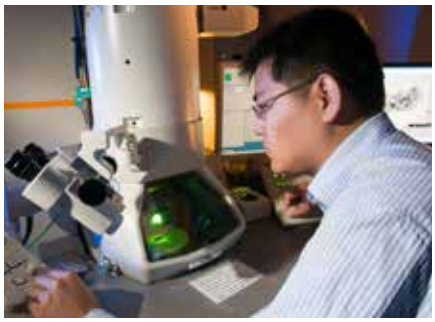


IN NANOTECHNOLOGY, THERE IS NO PROBLEM SO SMALL IT CAN'T YIELD A HUGE BREAKTHROUGH.

HOW TO GET A GIANT IN **YOUR** CORNER.

Argonne works with industry partners to solve their enduring R&D challenges, identify commercialization opportunities, license new technologies, and introduce transformational discoveries to the marketplace.

Argonne offers multiple avenues for collaborating with outside groups to accommodate both small and large firms. Licensing and contractual agreements vary based on particular situations, we will work with you to meet specific needs including addressing intellectual property concerns. For additional information on how to work with Argonne, visit **www.anl.gov/technology/partnerships**.



An Argonne nanoscientist employs a high-resolution transmission electron microscope to visualize the atomic arrangements of nanoparticle surfaces. The information derived can help explain, and ultimately tune, surface activity of nanoparticles for various applications.

Users from Argonne's High-Energy Physics Division, working with researchers from the Center for Nanoscale Materials, created 10-atomic-layer-thick, high-mobility, transparent thin-film transistors with ambipolar device characteristics.

Nanotechnology is unique in that it spans the scientific spectrum. With expertise in nanomaterials, computing, chemistry, materials, and energy systems, along with its world-class facilities.

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ARGONNE IS THE PERFECT MATCH FOR COMPANIES LOOKING TO MAKE A BIG IMPACT WITH TINY MATERIALS.

NANO DESIGN WORKS

Argonne NATIONAL LABORATORY

ABOUT ARGONNE NATIONAL LABORATORY

- U.S. Department of Energy research facility
- Midwest's largest federally funded R&D facility
- Located in Lemont, IL, about 25 miles (40 km) southwest of Chicago, IL (USA)
- Conducts basic and applied research in dozens of fields
- 1,400 world-class staff scientists and engineers
- Unique suite of leading-edge and rare scientific user facilities

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U.S. DEPARTMENT OF ENERGY

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