ARTS & SCIENCES

NEWSLETTER — CORNELL UNIVERSITY

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Elementary Particle Physics

by Ritchie Patterson

Imagine for a moment that you are looking through a powerful microscope. You look inside a cell to a molecule, inside the molecule to one of its atoms, inside the atom to a proton in its nucleus, and finally, inside the proton itself. You see three quarks, two "up"-type and one "down"-type, jiggling persistently inside; other quarks of all flavors appear in pairs and disappear, momentarily trading energy for mass. The proton teems with gluons, the carriers of the so-called "strong force" that binds the quarks in the proton together in much the same way that electrical forces bind the electrons to the nucleus of our atom. Occasionally a photon, a quantum of light, bursts onto the scene and then disappears.

This is the arena of elementary particle physics, the science of things that are so small that they cannot be seen. Particle accelerators fill in for microscopes, creating these tiny particles and allowing us to study their interactions. Cornell built its first particle accelerator in 1935. This accelerator, known as a cyclotron, was the second one to come into operation after the cyclotron's invention at Berkeley. Accelerators soon followed at many other universities, but by the 1960s most of these early machines had reached their limits and were closed down. Cornell persevered by implementing innovations in subsequent accelerators that increased their energy and collision frequencies. There are now only eight accelerator laboratories for elementary particle physics worldwide, and Cornell is home to one of them.

Research at Cornell and the other accelerators has told us that there are twelve flavors of particles from which all matter is built. Six are the quarks. The other six, known as the leptons, include the electron, along with heavier look-alikes known as the muon and tau and the three neutrinos. Surprisingly, in some ways the quarks and leptons are extraordinarily well-understood. Hundreds of their phenomena have been correctly predicted, a few with an accuracy better than one part in one billion.

The current Cornell accelerator, known as CESR (Cornell Electron Storage Ring), was conceived in the mid-1970s and has been in operation ever since. It lies forty feet under Robison Alumni Fields, south of the Ag Quad, in a tunnel that is almost a half-mile in circumference. In it, bunches of 100 trillion electrons and anti-electrons are accelerated to within one ten millionth of the speed of light. Eighteen million times each second these bunches collide head-on. Most of the time, the bunches pass through one another uneventfully, but once in a million times, an electron and anti-electron annihilate, something interesting happens, and we store the results on a computer for future analysis.

CESR came into operation shortly after the discovery of the fifth of the six quarks, known as the "bottom quark." By coincidence, CESR's energy was ideal for producing bottom quarks in great quantities. The bottom quark is interesting not only in its own right, but also because of the light that it sheds on the bigger questions. Like the quarks in the proton, bottom quarks are bound by the strong force. (The other forces are the weak force, electromagnetism and gravity.) By studying their behavior, we learn about the strong force and

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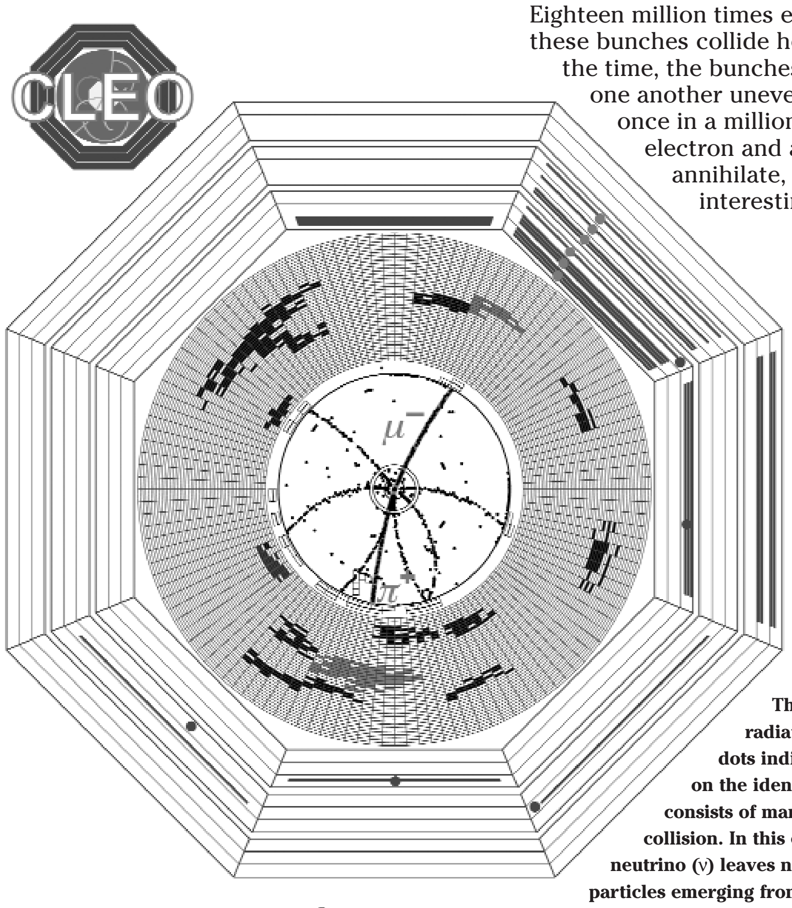
This tunnel under Robison Alumni Fields houses the Cornell Electron Storage Ring (CESR). The arc on the left, called a synchrotron, ramps the electron and anti-electron beams to the needed energy. The beams are then transferred to CESR itself, on the right, where they circulate, colliding once per revolution in the heart of our particle detector, CLEO. After one hour of collisions, the beams are noticeably depleted, and we restock them once again. Nearby, the Cornell High Energy Synchrotron Source (CHESS) takes advantage of x-rays produced by the beams to do a variety of research, including materials science, geophysics, and biology.



$\bar{B}^0 \rightarrow \pi^+ \mu^- \nu$

In this CESR collision, a bottom-type quark bound in a composite particle known as a B-meson decayed via the weak force into an up-type quark contained in a particle called a π-meson. Decays like this one reveal the affinity between the two quark species, which, like the speed of light, is one of the fundamental parameters of nature. The collision occurred in the center of the diagram, and the trails radiating from that point were left by the particles that emerged. The other dots indicate signals left in other detectors that provide additional information on the identities and energies of the particles. Like an onion, a particle detector consists of many layers, each of which provides clues to what transpired in the collision. In this event, we see the emerging π-meson (π^+) and muon (μ^-), while the neutrino (ν) leaves no trace. B-mesons are produced in pairs in CESR, and the other particles emerging from the interaction point are the decay products of the other B-meson.

INSIDE

When installed in CESR, this device, a resonant microwave cavity, will maintain the speed of the electrons and anti-electrons within one ten-millionth of the speed of light. The cavities, which are made of superconducting niobium, operate by sustaining a standing wave of electric and magnetic fields. Just as a surfer times his or her efforts to coincide with the passage of an ocean wave, we arrange for the passage of the electron or anti-electron beam to ride the crest of the electric field, which then accelerates the particles. By using superconducting cavities, we increase efficiency and achieve very high electric fields without disrupting the beam.

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hence the proton. Bottom quarks decay through the weak force, so named because its actions are confined to miniscule regions in space and time. Despite its limited reach, the weak force has a profound role in our lives. It is the vehicle for many of the reactions inside the sun. It is also implicated in the mysterious disappearance of anti-matter from our universe. (The big bang produced matter and antimatter in precisely equal amounts; yet we ended up with a universe made almost purely of normal matter. Only one in 100,000 cosmic rays—atomic nuclei from outside our galaxy—is made of anti-matter.) Finally, the weak force guides physicists as they edge toward deeper theories that might explain the pattern of quarks and leptons. Some of these theories predict the laws governing the weak force; and by measuring these laws experimentally at CESR and elsewhere, we may be able to distinguish the right theory from a plethora of faulty ones.

During the last two decades of operation at Cornell, we have accumulated a data set that comprises almost 35 million instances of bottom quark decay and has allowed us to peel back layer after layer of complexity in the weak force. By this means we have remained a world-class laboratory of high-energy particle physics that today attracts the research of nearly 200 physicists from around the country. In more conventional terms, the scientific harvest of this period consists of more than 350 journal publications and over 100 Ph.D. theses. Research at CESR is the basis for about 25 percent of the articles on accelerator-based particle physics in our nation's premier journals.

Despite the strides in untangling the mysteries of the quarks and leptons at Cornell and elsewhere, many questions remain. What exactly are the ingredients of the soup inside protons and neutrons? Why is it that the quarks have mass (a single top quark weighs as much as a gold atom), while other particles, such as the photon, the quantum of light, have no mass at all? Why are there six quarks and leptons when only two of each would be enough to form atoms? How did the anti-matter produced in the big bang disappear? What is the mysterious "dark matter" that pervades our universe, but so far has eluded direct detection?

The answers to some of these questions may lie with another type of particle called the Higgs. Physicists postulate that the Higgs confines the weak force to its tiny stage by acting as a cloud in which the weak force must operate. Indeed, if the Higgs exists, it is a field that pervades our universe, and provides the inertia, and hence mass, to all objects. The Higgs may be discovered at Fermilab, near Chicago, or at an accelerator called the Large Hadron Collider (or LHC) that is now under construction at CERN, near Geneva, Switzerland.

At Cornell, we are setting our sights on an accelerator called the linear collider, which, if it turns on in the next decade as hoped, will be the brightest high-resolution microscope ever built, and will go beyond the discovery of the Higgs to illuminate its every nuance. The linear collider may reveal even more. Data from labs around the world tell us that the Higgs must be relatively light—just out of reach of current accelerators. Yet other information tells us that the Higgs should be millions of times heavier. The nearly inescapable conclusion is that as-yet undiscovered particles intervene to lighten it. If so, the linear collider will shine its light on this entourage, as well as the Higgs itself. Whatever the coming decades reveal, we can be sure that nature will once more surprise and thrill.

***Ritchie Patterson** '80 received her Ph.D. from the University of Chicago. The winner of a Sloan Fellowship and a National Young Investigator award, she came to Cornell as a post-doc in 1990 and is now an associate professor in Cornell's physics department and the Newman Laboratory for Elementary Particle Physics. Her research focuses on precision measurements of the weak interaction.*

ARTS & SCIENCES

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Physics and the Humanities

by Ciriaco Morón Arroyo

In my new book, *The Humanities in the Age of Technology* (translated from Spanish; Catholic University of America Press, 2002), I discuss the criteria of rigor in humanistic knowledge and the practical value of the humanities. The first chapters try to find a correct definition of humanities and the humanistic disciplines—language, literature, history, philosophy, and theology—in the strict academic sense, but then there is the world of art, music, and creation in general. At one point I ask: who is the better humanist, the poet or the interpreter of poetry? How do the humanities differ from the social sciences, which are called by some scholars "the human sciences" par excellence? And it would be obtuse to ignore the humanistic dimensions of the natural sciences and technology. It is at this point that I analyze the notion of "the interdisciplinary."

This concept is often used for mere juxtapositions of disparate discourses, but the interdisciplinary in a strict sense is a nucleus, expressed by the "and," in which two disciplines both converge and diverge. In order to deal with that nucleus it is not necessary to be an expert in both disciplines; it suffices to be an expert in one of them, and well informed about the other. For this issue I have been asked to write about the "and" that links physics with the humanities. The conjunction has both a copulative and an adversative function; it displays a difference.

The copulative function highlights the humanistic features of physics, some of which are common to all sciences.

- *Creativity*: Original work in science requires as much imagination as poetry.
- The *aesthetic dimension*: the beauty of micro-or macrocosmic structures.
- The *history* of physics, as a burgeoning scene of enthusiasm and intelligence, conditioned by social forces (Thomas Kuhn).
- The *epistemology* of physics and the relationship between nature and the scientific construct about it. "Nature, in its truth, is in the book of physics" (Hermann Cohen). Heidegger responded that physics inaugurates "the age of the world picture," which is at best a specific historical incarnation of truth.
- The question of *truth*: in physics, in history, in poetry, in our lives generally.

At this point we slide from epistemology to ethics. For, regardless of the level of truth attained in science, the scientist must be a model of veracity. While many practitioners of the humanities relish relativism, scientists are not satisfied with less than truth, however limited and subject to revision. Physics is humanistic in everything pertaining to the environment. A key human question concerns freedom vs. determinism. For centuries this conflict saw the humanists (poets, philosophers, theologians) on the side of freedom, and physics (astronomy) on the side of determinism. Calderón's *Life Is a Dream* dramatizes this conflict. Today this problem seems to have shifted to biology; it is no longer the stars but the DNA that conditions human freedom. At a certain point physics shares the border with metaphysics in questions about the relationship between nature and the spiritual world. Finally, using Popper's concept of "reduction" without further description, physics is humanistic first and foremost because it is a human activity and institution, and is cultivated for the sake of humans.

The "and" also has an adversative function. Physics differs from the humanities both in its subject and its type of discourse. Popper wrote that he was determined to avoid all questions about words, but he had to recognize that science is also a verbal construction. However, unlike physics, the humanities—most clearly literature and the study of literature—center on words in a distinctive way. Language has four functions: intellectual, emotional, sensorial, and structural. Scientific discourse privileges the intellectual function of language—it even creates symbolic terminologies—while the poem conveys ideas and feelings, does it in colorful and musical syntagmas, and in a structure that shapes the content of the text. In literature language reverberates in its full potential, although the "value" of the literary text resides in the value of the world of meaning it sets up [Apollo] "in struggle with the earth" [Dionysos] (Heidegger).

More conspicuous than the theoretical differences between the sciences and the humanities, are the differences concerning their practical value. The uselessness of the humanities is a commonplace in western civilization. Callicles says to Socrates in Plato's *Gorgias*: "When I see an older man still into his philosophy and showing no

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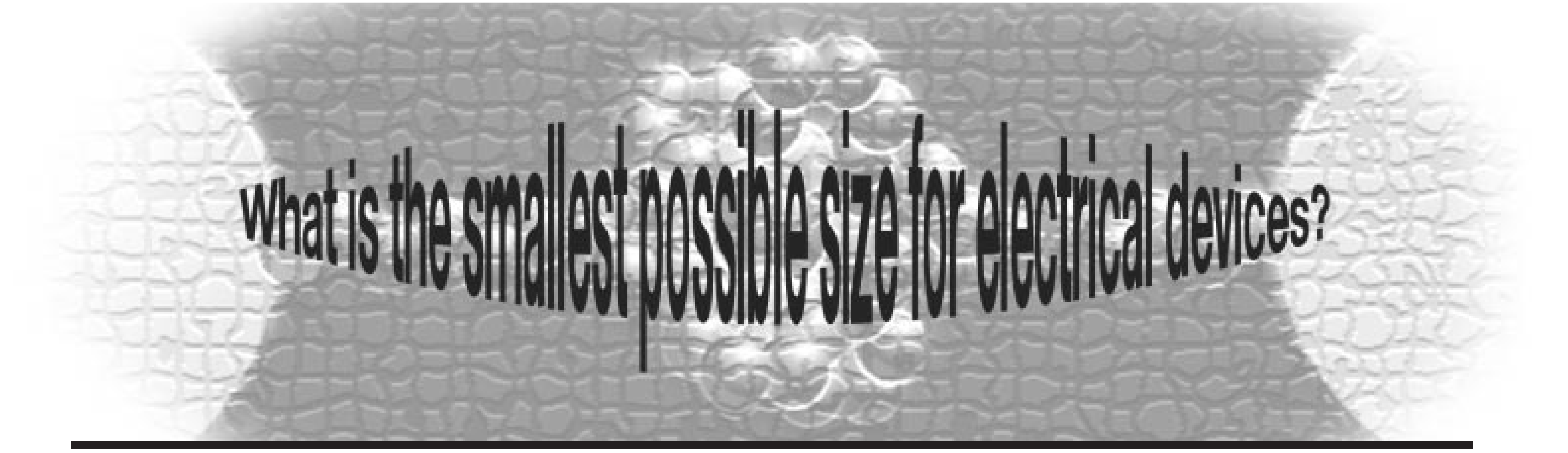


Transistors Made from Single Molecules

by Dan Ralph

Over the last thirty years, the need for increasingly powerful computers has provided the motivation for great advances in the technology of miniaturization. The smallest devices in today's commercial computer chips are only about 130 nanometers (nm) across; this is the length of about 400 atoms placed side by side. The density-per-unit area of circuits on computer chips continues to improve by about a factor of 2 every two years.

In order to help lead the way toward future developments, research physicists and engineers have been exploring the properties of even smaller devices. This has proved to be a very interesting area of investigation, because we have learned that electrical devices smaller than about 100 nm can be designed to operate by very different rules than for larger samples. For example, the flow of individual electrons can sometimes be controlled one by one, and the electrons can also exhibit wavelike properties (in accord with the wave-particle duality in quantum mechanics) that affect how current flows. These features may eventually enable the production of new types of electronic devices for computation, data storage, or sensors.

I am part of an interdisciplinary group of researchers at Cornell working to investigate the ultimate limits for miniaturizing electronics. We are combining techniques from chemistry and physics to make electrical devices out of single molecules. We have reached the point where we can control the flow of electrons through a single atom. The main idea of our work is to make molecular-scale transistors—switches for controlling the flow of electrons. The transistor is the fundamental building block out of which computer circuits are made. To accomplish this, we design and synthesize molecules with chemical bonds arranged so that the electrical resistance for the flow of electrons through the molecule can be controlled by an externally-applied voltage. This tunable resistance allows the molecule to act as a switch for electron flow.

The picture shows a depiction of a molecule that was synthesized for this purpose by Professor Héctor Abruña and his graduate student, Jonas Goldsmith, in the Department of Chemistry and Chemical Biology. The key feature of the molecule is a central cobalt atom, which provides low-energy states in and out of which electrons can hop. Bonded on each side of the cobalt atom are two linker arms composed of carbon, nitrogen, and hydrogen. These do not contain low-energy electronic states, so that they serve as partial barriers to the flow of electrons. On the ends of the linker arms are individual sulfur atoms, which can be used to provide a strong bond between the molecule and gold electrodes on each side.

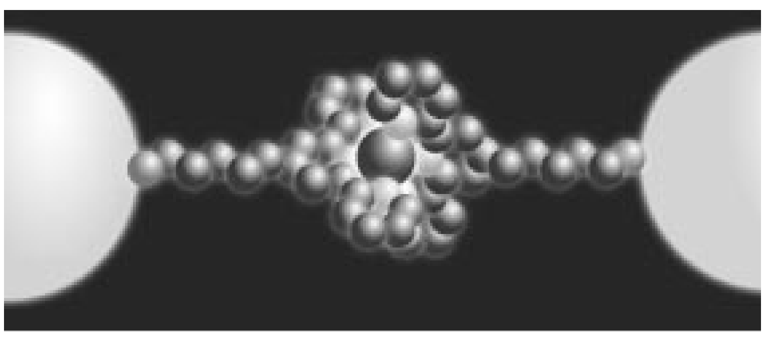
Synthesizing this molecule is a significant accomplishment by itself. However, in order to test whether it actually functions as a transistor, it was also necessary to figure out some way of properly assembling one molecule between two different gold electrodes, with one linker arm of the molecule bonded to each side, in order to measure the molecule's electrical properties. This was a major challenge, because the entire length of the molecule is only 2.4 nm. A solution was worked out by the graduate students Abhay Pasupathy and Jiwoong Park, working with Professor Paul McEuen and me in the Department of Physics. We began by making a continuous gold wire and dipping it in a solution of the molecules so that they attached to the gold by at least one linker arm. We then used a trick called electromigration to break the wire and form a narrow gap between the broken ends. We simply passed a large current through the wire, which caused some of the gold atoms to move until the wire developed a narrowed weak spot, and eventually this broke to leave a 1- to 2-nm gap. In about one third of the devices, one molecule fell across the gap during this process and became bonded to both sides. We could then make detailed studies of its electrical properties as a function of external voltages, temperature, and magnetic field to verify that it was a single molecule and to study how it worked. The operational principle of the device is that voltage (applied from beneath the molecule) can tune the energy of the electronic states on the cobalt atom and thereby turn electron flow on or off. We did indeed verify that this was the case, demonstrating for the first time true transistor action on the molecular scale for electrons flowing through the cobalt atom.

Molecular devices will not replace silicon transistors anytime soon. But work at Cornell provides an important step toward opening a new field of research.

It is important to emphasize that these molecular devices will not be replacing the silicon transistors in your computer anytime soon. While they are extremely small, these molecular transistors are currently much slower than silicon transistors, they cannot be used to amplify signals in the way that silicon transistors can, and so far they work only at temperatures much lower than room temperature. And at this point we have no way of connecting them together reliably to make complicated circuits. But our work does provide a significant step toward opening a new field of research. We can now use all the tricks of chemical synthesis to make systematic changes to our molecules, and see how they affect the electron flow. This will give us an unprecedented understanding of how electrons move, with details at the level of individual chemical bonds. We have in fact already begun this process. We have varied the length of the linker arms in the molecules and have found, as expected, that shorter arms give much lower electrical resistances. We will soon be examining a wide variety of molecules, formed from different types of atoms and containing different types of branching structures and even movable parts.

For those interested in learning more, Cornell has many electronic resources which describe ongoing work on the nanometer scale. Cornell is in fact a world leader in many fields of nanoscience, due in part to the presence on campus of the Cornell Nanofabrication Facility. This is a national user facility, funded primarily by the National Science Foundation, which brings together a large selection of high-tech tools needed for making structures on the smallest possible scales, as well as highly skilled staff members who teach researchers how to use the tools best. Details can be found at *www.cnf.cornell.edu/*, *www.ccmr.cornell.edu/*, and *www.nbtc.cornell.edu/*.

***Dan Ralph** is an associate professor of physics. He works on the development of new nanoscale fabrication techniques and their application to understand the properties of magnets, superconductors, and molecules. He is on the executive committee of the Cornell Nanofabrication Facility and has served as the director of undergraduate studies in physics.*



This picture illustrates the structure of a molecular-scale transistor. The resistance for the flow of electrons, which hop from the gold electrode on the left to a cobalt atom in the center to the other gold electrode on the right, can be controlled by applying an external voltage to the molecule.

A footprint of the present accelerator under Robison Alumni Fields. The facility is used to generate SR x-rays for CHESS.

A Bright and Penetrating Light

by Sol M. Gruner

On November 8, 1895, Wilhelm Roentgen noticed a green glow emanating from a phosphor screen near an experimental electrical apparatus enclosed in black paper in his Würzburg, Germany, laboratory. Evidently some invisible ray produced by the Crookes tube apparatus could penetrate the paper and excite the phosphor. Roentgen had discovered x-rays. He then did what every good scientist would do: He locked himself in his laboratory and spent the next seven weeks intensively investigating this new phenomenon. Roentgen's report on his discovery, published on December 28, 1895, had an immediate and enormous impact on both physics and medicine, as evidenced by the astonishingly rapid flow of events (delightfully chronicled in Bettyann Kevles's book, *Naked to the Bone: Medical Imaging in the Twentieth Century*).

- January 5: X-rays were front-page news in the Viennese newspaper *Neue Freie Presse*.
- January 6: X-rays were reported in the *New York Sun*.
- January 31: A report was published in *Science*, then, as now, the foremost American general scientific journal.
- February: X-rays were used at Columbia University to help remove buckshot from the hand of gun accident victim Prescott Butler.
- February 22: *Electrical World* reports that no Crookes tubes could be found in Philadelphia, the entire supply having been bought out by eager investigators.
- April: Thomas Edison introduced his new invention, the fluoroscope, at New York City's Electrical Exhibition. This was barely three months after the announcement of the discovery.

By December 31, 1896, one year after the discovery, 1,044 papers and 49 serious monographs had been published about x-rays. So much for the misconception that science proceeded at a more sedate pace back then! Over the next century, x-rays figured centrally in no fewer than thirteen Nobel prizes, including the very first physics Nobel, awarded to Roentgen himself. The discovery of x-rays took the world by storm because it provided a powerful new tool both for fundamental scientific discovery and for immediate practical application in medicine and technology.

It was quickly established that x-rays are another form of light, but with wavelengths thousands of times shorter than visible light, well beyond the ultraviolet part of the spectrum. Until the mid-twentieth century, Roentgen's method of x-ray generation—bombarding a target material with energetic electrons—was the only practical method for producing x-rays. Then in 1947, workers at the General Electric laboratory in Schenectady, NY, chanced upon visible light emanating from a room-sized electron accelerator. In 1949, Julian Schwinger (who was later to win a Nobel prize for work on quantum electrodynamics) published a theoretical explanation for the light seen by the GE workers, now known as synchrotron radiation (SR). Cornell's physics department also had an electron accelerator, located in the basement of Newman Lab. Physics department faculty decided to build the world's first synchrotron radiation beam line on this machine to study the new phenomenon. In 1952 physics faculty Paul Hartmann, Diran Tomboulian, and Dale Corson (later to become president of Cornell) published their first investigations of SR. The work done on this machine soon established the essential characteristics of SR and ushered in a new era of radiation science.

Some terminology would be useful here. The energy of a particle or electromagnetic photon is typically measured in units of electron volts (eV). A visible light photon has an energy of a few eV while an x-ray typically has an energy of thousands of eV. In order to produce x-ray SR it is necessary to have a machine capable of accelerating electrons to billions of eV. Large electron accelerators capable of doing this began to appear in the 1960s. Over the next three decades, improved SR sources increased in brightness by more than a million-million times. To grasp the magnitude of this increase, the brightness of a scene visible to the eye by room light is only about a million times higher than the same scene illuminated by starlight. Imagine how much more difficult it would be to do the things you do daily if they always had to be done by starlight. The applications of x-rays prior to SR were comparably limited.

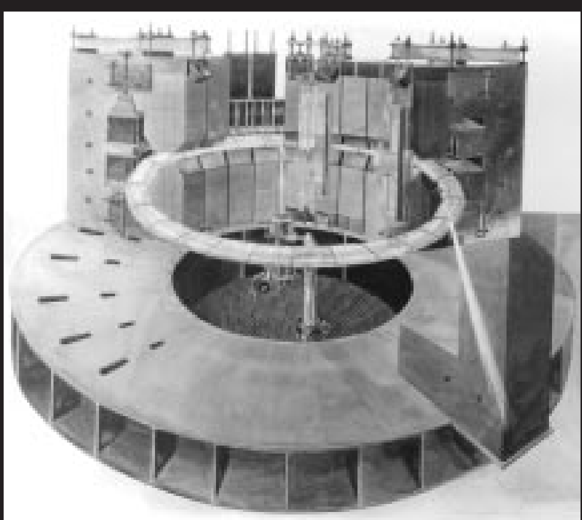
An example of a powerful SR source is the Cornell High Energy Synchrotron Source (CHESS) in Wilson Laboratory. The large accelerator described by Ritchie Patterson in this issue is simultaneously used for elementary particle physics experiments and for generation of SR x-rays for CHESS. Physicists, chemists, biologists, and engineers from around the world make almost a thousand visits a year to CHESS to use the powerful x-ray beams for an incredibly wide range of experiments. The productivity and diversity of the CHESS scientific community is amazing. On the average, CHESS users generate a new scientific paper for each day of beam. Users mixing with one another on the few thousand square feet of CHESS experimental floor space range from Nobel prize winners to undergraduates, with a heavy dose of graduate students (to date 449 graduate theses have relied on CHESS data). Although CHESS is operated by Cornell for the National Science Foundation as a national facility, Cornell makes very good use of the x-rays—roughly a third of the usage is by Cornell faculty, students, and staff. CHESS users have won numerous national and international awards and accomplished many scientific "firsts" with CHESS data. Examples include awards for work on the structures of viruses (Harrison, Wiley/Harvard; Rossmann/Purdue); ultrahigh pressure research (Bassett, Ruoff/Cornell); polymers (Kramer/Cornell; Bunning, Wright/Patterson Air Force Base); protein ion channels (MacKinnon/Rockefeller University); laser annealing of silicon (Larson/Oak Ridge National Laboratory); and ribosomes (Yonath/Weitzmann Institute, Israel). But perhaps the most significant output of CHESS is people: CHESS is certainly one of, if not the, foremost training grounds for SR beamline scientists.

Users at Cornell's High-Energy Synchrotron (CHESS) range from Nobel prize winners to undergraduates, with a heavy dose of graduate students, and include physicists, chemists, biologists, and engineers.

The largest user community at CHESS are the scientists who determine the atomic structure of proteins and viruses by x-ray crystallography. The biological revolution that is sweeping the world is based upon two technological developments: genetic engineering and protein crystallography. CHESS was centrally involved in the development of the cryo-freezing and x-ray detector methods that most protein crystallographers now use to determine molecular structure. In consequence, CHESS data have been used for determining roughly a fifth of the most important protein and virus structures published in the last decade worldwide, even though CHESS represents only a few percent of the world's SR x-ray resources.

The rapidly growing importance of SR to so many different areas of science has resulted in a proliferation of SR machines throughout the Americas, Europe, and Asia. All of the x-ray SR machines are based on technology quite similar to the very first synchrotron radiation machines in the basement of Newman Lab. This "storage ring" technology involves injecting electrons into a doughnut-shaped vacuum chamber, which is surrounded by magnets that serve to confine the electron trajectory to a closed orbit. One or more short accelerating cavities in the ring accelerate the electrons so they get a little boost in energy every time they come around. In this way one can store electrons orbiting at very nearly the speed of light for hours; hence the name storage ring. At various places along the ring, magnets bend the paths of the electrons and cause the emission of SR as beams of x-rays tangential to the ring. These beams exit the vacuum chamber by passing through thin metal windows and are then used by experiments positioned around the ring. Between the 1960s and 2000, successive storage rings got bigger and produced brighter x-ray beams. However, the fundamental limits of storage ring technology are well understood and have nearly been reached by a huge machine in Japan. This machine, called SPring-8, is built around the top of a small mountain. It is so large in circumference (about 1.5 kilometers) that the mountain peak sticks out through the middle of the doughnut-shaped building! Further advances in the quality of SR x-ray beams will require some totally different approach to generating SR.

A different approach involves superconducting technology. Back in 1965, Maury Tigner, the present director of Cornell’s Laboratory for Elementary Particle Physics (LEPP), proposed that superconducting linear accelerators could be used first to accelerate particles and then, by appropriate adjustments, to decelerate the particles. A linear accelerator is a specially constructed long, straight tube into which one injects both microwaves and electrons. In the accelerating mode, the electrons gain energy from the microwaves. In the decelerating mode, precisely the reverse happens: The very energetic electrons give their energy back to the microwave field. Maury pointed out that if the linear accelerator is made of superconducting metal, almost all the energy can be recovered. In 1965, the technology to produce superconducting linear accelerators was in its infancy.



The 300 MeV electron accelerator (circa 1952) that was built in Newman Lab. It had the world's first synchrotron radiation beamline.

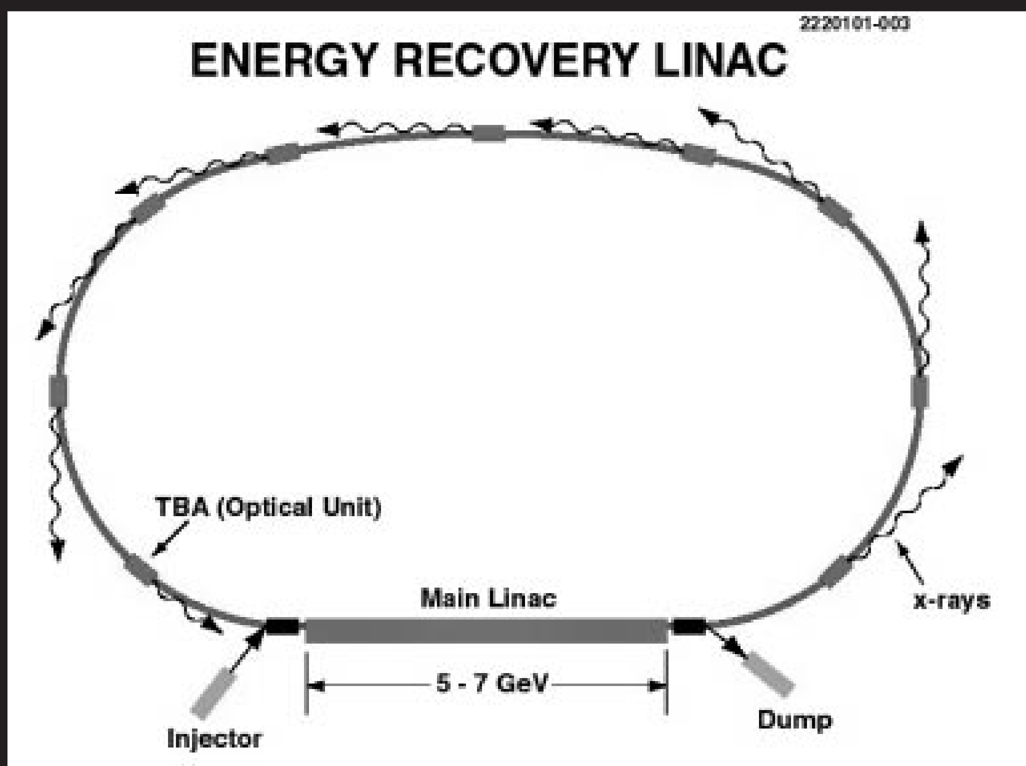
However, there has been steady progress in this area, especially at Cornell, which is a world leader in developing these kinds of accelerators. In the last few years the technology has sufficiently advanced so that one could envision an entirely new kind of SR producing machine that circumvented the limitations of storage rings. Two accelerators built at the Thomas Jefferson National Accelerator Facility (Jlab) in Newport News, Virginia, using superconducting cavity designs from Cornell, helped convince the community that the technology for superconducting acceleration and energy recovery was finally ripe.

Cornell, in collaboration with Jlab, has proposed to the National Science Foundation to develop this technology at Cornell for the production of x-ray SR. Our intention is to do this in two stages. First, we’ve proposed a five-year program to build and operate a small, low-energy demonstration machine to develop critical aspects of the technology that still need improvement. Then we would propose the construction of a large, high-energy SR source to be built at Cornell for completion early in the next decade. This machine would allow Cornell to continue its historical leadership and training roles in both accelerator physics and x-ray science. Cutting-edge SR x-ray sources have invariably attracted communities of the best scientists working in areas ranging from biology to medicine, from materials science to applied x-ray technology. The novel aspects and challenges of the ERL are already proving attractive to students interested in accelerator physics.

The proposed machine, dubbed an Energy Recovery Linac (ERL) x-ray SR source, would provide beams with capabilities available nowhere else in the world. It would make Cornell a continuing magnet for many kinds of scientists and have enormous impact on multiple science and engineering departments for many years to come. The plans for an ERL have not gone unnoticed, however, and, in the last two years groups at two U.S. national laboratories, Germany (two places), England, and Japan have all announced intentions to build ERL x-ray sources. At this point the Cornell/Jlab team is the acknowledged leader in the technology, but the competition is stiffening fast!

At this point the Cornell/Jlab team is the acknowledged leader in the technology, but the competition is stiffening fast!

Why are people so excited about the x-ray SR beams possible from an ERL? The answer is that ERLs circumvent the fundamental limitations imposed by storage rings. So, for example, ERLs could produce beams many times brighter than any existing storage ring. With storage rings, the beams are very different in the vertical and horizontal directions, which limits the ultimate size of x-ray probes. The combination of round beams and brilliance possible with an ERL makes x-ray probes small enough to perform many unprecedented studies on nanomaterials and the microstructure of many kinds of specimens. Another aspect of ERL beams is that they have the laser-like quality of transverse coherence. This enables entirely new kinds of x-ray microscopies and imaging methods. Yet another distinction is that ERLs allow the production of x-ray pulses that are incredibly short in duration, less than a 100 femtoseconds. (To appreciate just how short a time this is, a femtosecond, i.e., 10^{-15} seconds, is to a second as one second is to 32 million years.) Scientists have long dreamed of studying structural changes in physical systems in the 1 to 1,000-femtosecond time scale. This is the time scale of electronic transition states in enzymes and catalysis, of thermal relaxation of excited electrons in metals and semiconductors, and of many other physical processes of fundamental importance. The ERL offers a way to study these systems.



A schematic of the proposed future ERL synchrotron radiation source.

Cornell physicists have been doing x-ray research for a long time. Professor George Moler was taking x-ray photographs within weeks of Roentgen’s discovery. He was followed by succession of eminent faculty throughout the first half of the twentieth century who made Cornell a center for x-ray physics. This led naturally to the interest at Cornell in synchrotron radiation, in CHESS, and now to the ERL. I’ve always thought it fitting that the facility used to design and test the superconducting cavities to be used for the ERL is, in fact, the refurbished area in the basement of Newman Lab where the world’s first SR beamline was made, back in 1952. With luck, support, and perseverance, Cornell will continue to lead the way in x-ray science for many years to come.

***Sol Gruner** is professor of physics and director of the Cornell High Energy Synchrotron Source (CHESS). He studies biological and soft-condensed matter materials, and the development of techniques to study these substances.*

Physics and the Humanities,
continued from page 2

sign of giving it up, he seems to me to be asking for some hard knocks." And C. P. Snow: "The young scientists know that with an indifferent degree they'll get a comfortable job, while their contemporaries and counterparts in English or history will be lucky to earn 60 percent as much" (*The Two Cultures*, Cambridge UP, 1983, p. 18). However, the usefulness of physics does not depend on its money-making potential, which is matched or even surpassed by some branches of the humanities—the novel made into film, the lyrics of musical groups, and even the successful textbook in academia. And, of course, the usefulness and value of the academic study of the humanities derives from the topics they deal with.

- Individual identity: All of Shakespeare's comedies are obsessed with our reality and possible falsifications.
- Collective identity: culture, migration, nationalism, racism, terrorism in the name of some of these notions.
- Communication: All lyric poetry has been and is a yearning for love and satire against injustice.
- The ultimate sense of life: affirmative, nihilistic attitudes, and the in-between—"the tragic sense of human existence" (Unamuno).
- Creativity: As much as a narrative, *Don Quixote* is a workshop on how to build a long fictional narrative that is a "son of the intellect" (search for truth), not of wild imagination.

While science contributes to lengthen human life and make it more comfortable, those who benefit most from scientific progress—affluent societies—have to cope every day with their personal identity, their role in the different groups to which they belong, communication with their intimate family and the world around them, the meaning of their existence, and with the reflection on everything they do: creativity. Cultivating the interdisciplinary does not mean that a professor of literature dares to write about physics. It means that we are anxious (ethical attitude) and able (intellectual preparation) to listen and to learn about nature, society, and culture.

***Ciriaco Morón Arroyo**, a native of Spain, obtained the M.A. in philosophy at the Pontifical University of Salamanca, and the Ph.D. at the University of Munich in 1963. He has been the Emerson Hinchliff Professor of Spanish Literature at Cornell since 1971. He has taught Spanish thought and poetry in the Department of Romance Studies, and European thought in Comparative Literature. His book,* El sistema de Ortega y Gasset *(Alcala, 1968), won him acclaim as the foremost authority on the Spanish thinker. In addition to other books, this year he has published his 100th article, all exploring the ideal reading at the university, the nature of humanistic knowledge, and the practical value of the humanities.*

This is a Hubble space telescope image of a 300-light-year-wide spiral shaped disc of dust and gas fuelling a massive black hole at the center of galaxy NGC 4261. Black holes like this will be a prime source of gravitational waves.

Listening to the Cosmos

by Eanna Flanagan

Normally the air that surrounds us is a passive backdrop for events, a backdrop we do not notice. However, we know that it can make its presence felt in the form of winds and hurricanes, and also that it is the medium through which sound waves travel and bring us information. Similarly, we used to think of space and time as forming a passive backdrop for the events that take place within it. However, Einstein taught us that this is not so: there can be "hurricanes" in the fabric of spacetime itself in the form of rotating black holes. Moreover, violent events in distant galaxies will produce tiny vibrations in the fabric of spacetime, just like sound waves, called gravitational waves. If these vibrations are ever detected, they will allow us to hear the rumbles and crashes of distant events and open up a new branch of astronomy.

In 1974, astronomers using the Cornell-administered Arecibo radio telescope in Puerto Rico discovered a binary star system of two neutron stars in the direction of the constellation Sagitta, at a distance of about 3,000 light years. The two stars—each about the size of Ithaca, yet as massive as our sun—orbit each other roughly once every eight hours. General relativity predicted that the two stars should give off gravitational waves, and consequently should very gradually spiral in towards one another. In 1993, the Nobel prize in physics was awarded to Joseph Taylor and Russell Hulse of Princeton University for their precise measurement of the gradual in-spiral that agreed with general relativity's prediction. Thus, today we are confident that gravitational waves exist.

Over the last several decades, physicists and astronomers around the world have worked to open the new window on the universe that gravitational waves constitute. The most promising technology is to monitor the relative displacement of suspended test masses in a vacuum using laser interferometry. Passing gravitational wave bursts will cause the test masses to oscillate back and forth, and this motion is detected using the laser. Unfortunately the amplitude of oscillation is expected to be smaller than the size of an atomic nucleus, so the instrument needs to be extraordinarily sensitive. In November 1999, the Laser Interferometer Gravitational Wave Observatory (LIGO) was inaugurated; this instrument consists of two separate laser interferometers in two sites in Washington and Louisiana, each 4 kilometers long. LIGO was funded by the National Science Foundation and constructed by a team of physicists and astronomers from around the country, led by Caltech and MIT. The first gravitational wave searches with LIGO are taking place this year. Similar instruments are being constructed in Europe and Japan. There are also plans to operate a space-based detector by bouncing lasers between spacecraft in orbit around the sun. Such a system is being planned for around 2015 as a joint venture by NASA and the European Space Agency.

The cosmic signals we expect to hear are primarily caused by cataclysmic events involving black holes and neutron stars.

In parallel with this experimental effort, theoretical physicists and astrophysicists are preparing for gravitational wave astronomy. A gravitational wave detector is something like the sonar on a submarine that is used to track other submarines. Sonar operators need to be skilled at distinguishing between screw noises and sounds from fish, whales, and other natural sources of noise. Similarly, gravitational wave astronomers will have to be skilled at separating out the signals we seek from the background cacophony due to various sources of noise in the detector.

The LIGO facility in Hanford, Washington, showing the two beam tubes, each four kilometers long.

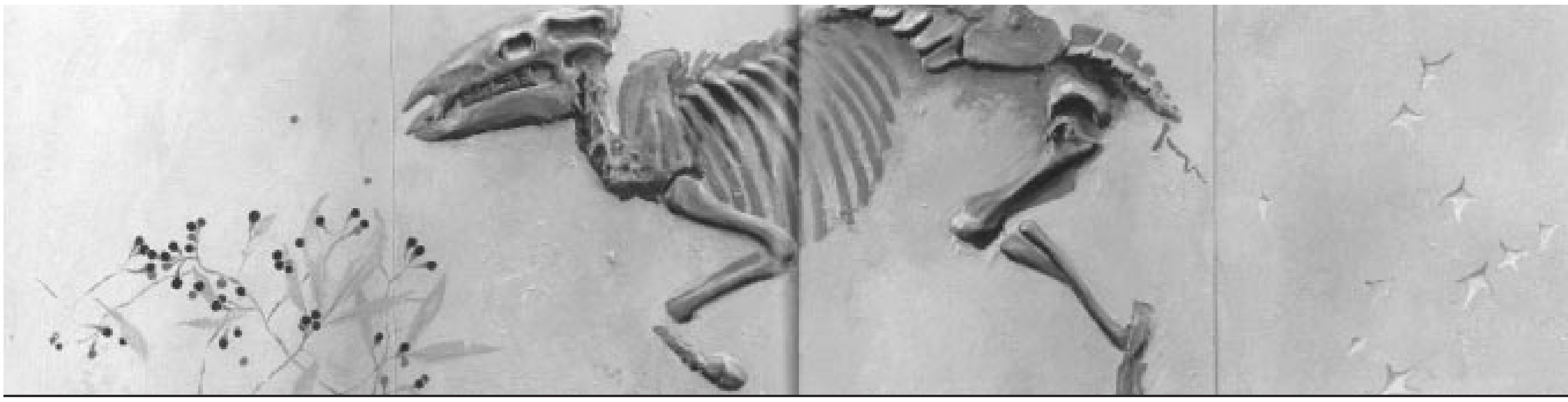
Because the signals are so weak, such separation cannot be done by the human ear; it requires sophisticated data analysis algorithms and significant computational power. Theoretical predictions of signal characteristics from various types of sources will be vital for interpreting the signals we detect, as well as for aiding in the detection process. Making these predictions keeps gravitational theorists like me busy.

What cosmic signals do we expect to hear? Primarily cataclysmic events involving black holes and neutron stars. These objects have very strong gravitational fields and can be efficient emitters of gravitational waves. Neutron stars can spin at speeds of up to 60,000 rpm, as fast as a laboratory ultracentrifuge. We hope to hear the high pitched whine coming from several spinning neutron stars in our galaxy. The physicist Freeman Dyson pointed out back in the 1960s that a binary system of two in-spiralling neutron stars (or black holes) will give off a very strong and distinctive gravitational wave signal in the last few minutes of its in-spiral, before the two stars merge. This may well be the first type of signal we detect.

Over the last few years, astronomers have discovered that a majority of galaxies contain enormous black holes at their centers. Every so often, neutron stars (or small black holes) in the central regions of galaxies will get knocked towards the large black hole, will gradually spiral around it, and eventually fall inside. During the last year of in-spiral, the neutron star might orbit the black hole a few hundred thousand times, moving at close to the speed of light. The gravitational waves produced will carry encoded within them a detailed map of the warpage of space and time near the large black hole, something that has never been observed before. Reconstructing this map is one of the holy grails of gravitational wave astronomy.

To reconstruct this map, we need to be able to predict the complicated motions of the neutron star near the black hole. Although in principle this motion is dictated by the theory of general relativity, in practice various complexities prevent theorists from predicting the motion except in special cases due to various complexities. The issue is the computation of the force that acts on the neutron star due to its own gravitational field, which is analogous to the reaction force associated with synchrotron radiation that acts on electrons in Cornell's electron storage ring. Over the last few years, I have

Fossilized remains of a primitive horse and berry bush share space in one of the more than 500 painted panels by Barbara Page, MFA '75, in Warren Allmon's *Rock of Ages, Sands of Time* (see Faculty Books, page 8).



Books by Alumni/ae

Carol Aneshensel, Ph.D. '76, wrote *Theory-Based Data Analysis for the Social Sciences* (Pine Forge Press, 2002). Aneshensel presents a method for aligning data analysis and statistical technique with social theory. It includes a description of the elaboration model and introduces into it a new cause-and-effect relationship, the "focal relationship." Aneshensel is a researcher in social stress and mental health and a professor at the School of Public Health, University of California, Los Angeles.

Don Asher '47 has published considerable fiction beginning in the 1960s and a memoir, *Notes from a Battered Grand* (Harcourt Brace, 1992). *Raise Up Off Me: A Portrait of Hampton Hawes*, by Hampton Hawes with Asher, the jazz pianist's autobiography, was recently re-published (Thunder's Mouth Press, 2001).

Aimée Boutin, Ph.D. '98, wrote *Maternal Echoes: The Poetry of Marceline Desbordes-Valmore and Alphonse de Lamartine* (University of Delaware Press, 2001). It examines maternal imagery in the poetry of two French Romantic poets: the increasingly popular Desbordes-Valmore and the critically marginalized Lamartine. Boutin is assistant professor of French at Florida State University.

Listening to the Cosmos, *continued*

been working with a number of other gravitational theorists from around the world to develop the required mathematical and computational tools. Each year we have organized a workshop to review progress and make plans for the coming year. The first of these workshops took place in 1998 at the ranch of movie director Frank Capra (now owned by Caltech) in southern California, so the workshops have been dubbed the "Capra Ranch radiation reaction workshops." Our goal is now almost at hand; we hope within a year or two to have detailed predictions for the gravitational wave signals.

It is now almost four hundred years since Galileo first raised a telescope to the sky and discovered the moons of Jupiter. Today, using gravitational waves, several hundred physicists and astronomers around the world are attempting to open a completely new window onto the universe. My students and I find it tremendously exciting to be part of this effort. No doubt, the gravitational wave signals, when they are finally detected, will bring lots of surprises.

Eanna Flanagan *is an associate professor of physics and astronomy and specializes in theoretical astrophysics and general relativity. He has been the recipient of Fermi, Sloan, and Radcliffe fellowships.*

Joseph Conte '82 wrote *Design and Debris: A Chaotics of Postmodern American Fiction* (University of Alabama Press, 2002), which discusses the relationship between order and disorder in the works of John Hawkes, Harry Mathews, John Barth, Gilbert Sorrentino, Robert Coover, Thomas Pynchon, Kathy Acker, and Don DeLillo. Conte is professor and chair of English at the University of Buffalo.

Adam Engst '89 wrote *iPhoto 1.1 for Mac OS X: Visual QuickStart Guide* (Peachpit Press, 2002), which helps Macintosh users make the most of Apple's free iPhoto program for managing and sharing digital photos. Engst publishes the online newsletter *TidBITS* and chairs several Internet non-profit organizations.

Joel Fetzer '88 wrote *Public Attitudes toward Immigration in the United States, France, and Germany* (Cambridge University Press, 2000). Fetzer is assistant professor of political science at Pepperdine University.

Nick Fowler '89 wrote *A Thing (or Two) about Curtis and Camilla* (Pantheon Books, 2002), a comic and poignant "slacker" romance set in Manhattan. Fowler lives in Los Angeles and is working on his next novel.

Eric Freedman '71 wrote *How to Transfer to the College of Your Choice* (Ten Speed Press, 2002), a guide for the one out of four students who are so dissatisfied with the college of their freshman year that they do not return. Freedman is a Pulitzer Prize-winning journalist, senior writer for *Community College Week*, and an assistant professor at Michigan State University's School of Journalism.

Seth Kibel '96 is instrumentalist, composer, arranger, and producer for the klezmer band The Alexandria Kleztet, which has released its second CD, *Delusions of Klezmer*. Kibel developed his love of klezmer music while part of the Cayuga Klezmer Revival, a favorite of Ithaca audiences in the mid-1990s.

Hugh E. Kingery '54 edited the *Colorado Breeding Bird Atlas* (Colorado Bird Atlas Partnership and Colorado Division of Wildlife, 1998). The atlas reports the results of eight years of fieldwork by 1,200 volunteers. This fieldwork followed a protocol developed, in part, at a conference sponsored by the Cornell Laboratory of Ornithology. Kingery worked for 20 years as an attorney for Husky Oil Co. before retiring to his twelve-year stint directing the Colorado Breeding Atlas project.

Bette H. Kirschstein '79 edited *Life Writing/Writing Lives* (Krieger Publishing Company, 2001). Kirschstein is an associate professor of English at Pace University.

Douglas Kleiber '69 wrote *Leisure Experience and Human Development: A Dialectical Interpretation* (Lives in Context Series, Basic Books, 1999). Kleiber reviews the predictable changes in leisure activities over the life span, which stimulate developmental change less often and less effectively than they might. He then considers the role that leisure experience can play in addressing the problems of socialization, identity formation, and adjustment to life circumstances, including aging. Kleiber is professor and director of the School of Health and Human Performance at the University of Georgia and past president of the Academy of Leisure Sciences.

Joan B. Landes '67 wrote *Visualizing the Nation: Gender, Representation, and Revolution in Eighteenth-Century France* (Cornell University Press, 2001) and *Women and the Public Sphere in the Age of the French Revolution* (Cornell University Press, 1988). Landes is professor of women's studies and history at Pennsylvania State University.

John J. Macionis '70 wrote the textbook *Social Problems* (Prentice Hall, 2001). The book applies various theoretical paradigms, including social-conflict, structural-functional and symbolic-interaction, and conservative, liberal, and radical political perspectives. Macionis is professor and Prentice Hall Distinguished Scholar of Sociology at Kenyon College. He recently received the American Sociological Association's Award for Distinguished Contribution to Teaching.

Scott McDermott '94 wrote *Charles Carroll of Carrollton: Faithful Revolutionary* (Scepter, 2002). Carroll was the only Catholic signer of the Declaration of Independence, the wealthiest man in America at the time, and the last signer to die. McDermott focuses on Carroll's political thought as part of the natural law tradition.

Nicholas Paige '88 wrote *Being Interior: Autobiography and the Contradictions of Modernity in Seventeenth-Century France* (University of Pennsylvania, 2001). The book speaks to scholars and to readers interested in constructions of gender and authorship, the history of private life and reading practices, and the past and future of interiorized subjectivity. Paige is associate professor of French at the University of California, Berkeley.

Stuart Peterfreund '66 wrote *Shelley among Others: The Play of the Intertext and the Idea of Language* (Johns Hopkins University Press, 2002). The book lays out Shelley's ideas of language and its relation to the theory of poetry, and demonstrates how those ideas contribute to reading the poems. Peterfreund is professor of English and director of graduate studies at Northeastern University.

Joshua H. Roth, Ph.D. '99, wrote *Brokered Homeland: Japanese Brazilian Migrants in Japan* (Cornell University Press, 2002). Since the late 1980s, Japanese firms have hired foreign workers in increasing numbers. Among these foreigners are roughly 250,000 Nikkeijin—overseas Japanese, mostly from Brazil—who were presumed to assimilate more easily into Japanese society. In fact, however, Japanese and Japanese Brazilians distinguish themselves from each other. The interactions between Nikkeijin and natives, says Roth, play a significant role in the emergence of an increasingly multicultural Japan. Roth is assistant professor of anthropology at Mount Holyoke College.

Martin Rudolph '61 wrote *EZ-101 Calculus* (Barron's Educational Series, 2002), a study guide/class notes for a first term calculus course. Rudolph teaches mathematics at Oceanside High School in New York. In 1997, he won the Presidential Award for Excellence in Mathematics Teaching and in 1995 the Tandy Technology Scholar Award.

Jeffrey Ruoff '85 wrote *An American Family: A Televised Life* (University of Minnesota Press, 2002). The 1973 PBS documentary/cinema verite of the Loud family reached an unprecedentedly large audience. Ruoff's book is a study of this series—influential on both the documentary film and fictional TV American families—and a bridge to ongoing discussions of reality television. Ruoff is a film historian, documentary filmmaker, and assistant professor of film and television studies at Dartmouth College.

Douglas Rutzen '87 co-authored (in Macedonian) *Associations and Foundations* (Faculty of Law, Iustinian First, 2001). This law school textbook discusses the legal framework underlying the renaissance of civil society in Macedonia and Central/Eastern Europe. It is the first of its kind in the region and the first textbook co-authored by a foreign expert in the 50-year history of the law school in Skopje. Rutzen is senior vice president of the International Center for Not-for-Profit Law in Washington, DC.

Rawley Silver '39 created *Three Art Assessments: The Silver Drawing Test, Draw a Story: Screening for Depression and Age or Gender Differences, and Stimulus Drawing* (Brunner-Routledge, 2002). The Silver Drawing Test assesses cognitive skills without using language and is uniquely suited to clients who have difficulty understanding others and making themselves understood. Draw-a-Story focuses on using art to uncover and treat depression in children. Stimulus Drawings assess personal associations and fantasies.

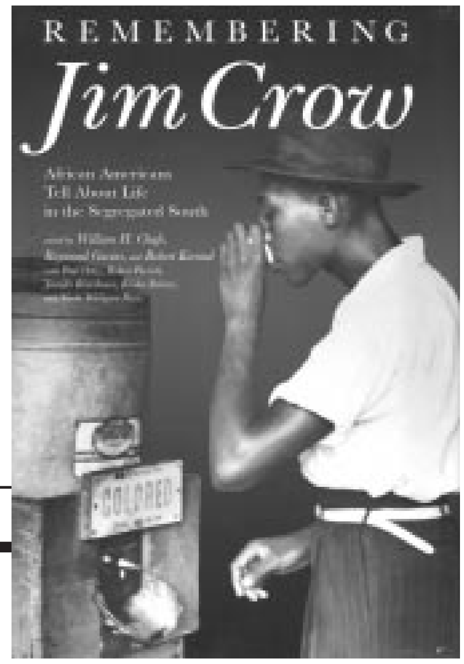
James Sturz '87 wrote *SASSO* (Walker & Co., 2002), a literary thriller set in a 1970s cave town in southern Italy, which the *Sunday Telegraph* called "one of the most intriguing and original books I read so far this year." Sturz is a freelance journalist and author based in New York.

Catherine Taylor '85 wrote *Giving Birth: A Journey into the World of Mothers and Midwives*. Taylor is a doula (birth attendant) and wrote this guidebook from personal observations of midwives at work; her own two children were born with the assistance of midwives. After many years of teaching creative writing to at-risk populations, Taylor is now assistant professor of English at Drake University.

Lillian Trager '69 wrote *Yoruba Hometowns: Community, Identity, and Development in Nigeria* (Lynne Rienner Publishers, 2001). A Nigerian edition has been published (Spectrum Books, Ibadan Nigeria) as well as a companion video, *Yoruba Hometowns and Local Development in Nigeria*. Trager is professor of anthropology at the University of Wisconsin-Parkside.

Bob Zeidman '81 wrote *Designing with FPGAs and CPLDs* (CMP Books, 2002), a guide for engineers designing programmable devices and managers planning and scheduling such a design. In addition to describing the technologies and architectures of these devices, the book details a new, concise, reliable system for hardware design called the Universal Design Methodology (UDM). Zeidman is the president of Zeidman Consulting, a contract research and development firm.

For 40 years, **Robert H. Lieberman**, a senior lecturer in physics, has written novels (most recent is *The Last Boy*, noted in the last issue of this newsletter) and directed documentaries in his free time. His first feature film, *Green Lights*, recently opened in Los Angeles and received a rave review from *Variety*, which said it achieved “spectacularly funny results . . . delivers the small town-meets-Hollywood vibe David Mamet was shooting for with the failed *State and Main*.” *Green Lights* also played in New York City as part of the New Filmmakers Series and at the Rhode Island International Film festival, where the film critic for the *Providence Journal* cited it as the best film in the festival. A tale about a hapless movie location scout who goes to Ithaca, N.Y., and is mistaken for a big-time Hollywood producer, the film uses Cornell faculty members, employees, and students and Ithaca citizens in cameo roles working around a core of professional film actors. Lieberman has had several offers for national distribution; nonetheless he says he plans to continue teaching Maxwell’s equations and Newton’s laws to Cornell undergraduates.



Books by Faculty

Rock of Ages, Sands of Time (University of Chicago Press, 2001), written by **Warren Allmon** (earth and atmospheric sciences) with paintings by Barbara Page, MFA ’75, of Trumansburg, is a history of life on Earth in 500 painted panels. Allmon is director of the Paleontological Research Institution in Ithaca.

Asteroid Rendezvous: NEAR Shoemaker’s Adventures at Eros (Cambridge University Press, 2002), edited by **James Bell** (astronomy) and Jacqueline Mitton (Royal Astronomical Society), is a collection of essays and images by Cornell astronomers and engineers who made NEAR (Near Earth Asteroid Rendezvous) an astonishing success. This was the first mission to orbit and eventually land on an asteroid; it was one of the first tests of NASA’s new “better, faster, cheaper” planetary exploration and returned hundreds of thousands of images, spectra, and other measurements.

Power in the Portrayal: Representations of Jews and Muslims in Eleventh- and Twelfth-Century Islamic Spain (Princeton University Press, 2002), by **Ross Brann** (Near Eastern studies and Milton R. Konvitz Professor of Judeo-Islamic Studies), is the first book to study the construction of social meaning in Andalusi Arabic, Judeo-Arabic, and Hebrew literary texts and historical chronicles. The approach illuminates nuances of respect, disinterest, contempt, and hatred reflected in the relationship between Muslims and Jews in eleventh- and twelfth-century Iberia.

New Testament Judaism: Collected Works of David Daube, Volume 2 in *Studies in Comparative Legal History* (Regents of the University of California at Berkeley, 2001), edited by **Calum Carmichael** (comparative literature), is a study of New Testament literature in light of Jewish and Hellenistic sources (all indexed, translated, and defined).

Inventing Nanjing Road: Commercial Culture in Shanghai, 1900-1945 (Number 103 in the Cornell East Asia Series), edited by **Sherman Cochran** (history), is a collection of seven essays that frame debates about the construction of commercial culture in China.

Diffusions, Superdiffusions, and Partial Differential Equations (American Mathematical Society, 2002), by **E.B. Dynkin** (mathematics and Bullis Professor of Mathematics), presents the connections between linear and semilinear differential equations and the corresponding Markov processes called diffusions and superdiffusions.

Plato 1: Metaphysics and Epistemology and Plato 2: Ethics, Politics, Religion, and the Soul (Oxford University Press, 1999), edited by **Gail Fine** (philosophy), are two volumes in the Oxford Readings in Philosophy Series. Both volumes contain substantial introductions by the editor. This series aims to bring together important recent writing in major areas of philosophical inquiry from a variety of sources not otherwise conveniently available.

Music and Film (Adam Mickiewicz University Press, 2002), edited by **Don Fredericksen** (theatre, film, and dance), and Marek and Malgorzata Hendrykowski, is a collection of essays first presented at an international film and music conference in Poznan, Poland.

Vishnu in Hollywood: The Changing Image of the American Male (Scarecrow, 2000), by **David Grossvogel** (Romance studies), is a historical overview as well as a psychological and sociological analysis of the American male as reflected on the silver screen.

Didn’t You Used to Be Depardieu? Film as Cultural Marker in France and Hollywood (Peter Lang, 2002), by **David Grossvogel** (Romance studies), analyzes the cultural differences between the two countries by contrasting American remakes with their French originals.

Rebecca Harris-Warrick (music) has recently overseen the publication of the first volume in the new critical edition of the complete works of Jean-Baptiste Lully, the official composer for King Louis XIV of France. This volume (Georg Olms Verlag, 2001), the first of a projected set of forty, includes the music for three of Lully’s spectacular court ballets, all of which were danced by the king and his courtiers during the 1660s. None of the three has been published before; Harris-Warrick and her co-editors had to sort through the multiple versions found in various manuscript sources in order to establish the musical text as Lully had conceived it. Along with James R. Anthony she edited one of the three, *Les Amours Déguisés*, and she also co-ordinated the editions of the other two works.

Science on Stage: Expert Advice as Public Drama (Stanford University Press, 2000), by **Stephen Hilgartner** (science and technology studies) examines the production of science advice by bodies like the American National Academy of Science. Goffman’s dramaturgical theory provides the starting point for Hilgartner’s analysis of three National Academy committee reports on diet and health, two successfully completed and one not.

Advances in Chemical Signals in Vertebrates (Kluwer Academic/Plenum Press, 1999), edited by **R.E. Johnston** (psychology), D. Mueller-Schwarze, and P.W. Sorensen, stemmed from a 1997 Cornell conference on the topic and covers a wide array of approaches in vertebrates, from amphibians to humans.

The First Quarto of Othello (Cambridge University Press, 2001), edited by **Scott McMillin** (English), is the first modernized and edited version of the 1622 *Othello*. Arguing that the Quarto was printed from a theatre script reflecting cuts and actors’ interpolations, McMillin accounts for the mystery of thousands of differences from the Folio version that came out the following year.

Israelian Hebrew in the Book of Kings (CDL Press, 2002), by **Gary A. Rendsburg** (Near Eastern studies), is a linguistic study on ancient Hebrew regional dialects. The main focus of the book is a reconstruction of the Israelian, or northern dialect, of ancient Hebrew, as evidenced by those portions of the book of Kings which detail the history of the northern kingdom of Israel.

Eblaitica: Essays on the Ebla Archives and Eblaite Language, volume 4 (Eisenbrauns, 2002), co-edited by **Gary A. Rendsburg** (Near Eastern studies) and Cyrus H. Gordon (d. 2001), is the final volume in this series of essays devoted to the history, religion, culture, and language of ancient Ebla, a major city in northern Syria, which flourished during the third millennium B.C.E.

Remembering Jim Crow: African Americans Tell About Life in the Segregated South (The New Press, 2001), co-edited by William H. Chafe, Raymond Gavins, and Robert Korstad with Paul Ortiz, Robert Parrish, Jennifer Ritterhouse, Keisha Roberts, and **Nicole Waligora-Davis** (English), represents the fruits of over a thousand interviews (housed in Duke University’s Special Collections archive) conducted by graduate students over several years and throughout much of the South. The book is at once a history of the social and legal customs of Jim Crow and a mapping of African Americans’ thick and diverse encounters with and responses to segregation.

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