Smithsonian Institution

Spotlight on Science at the Smithsonian

SPECIAL EDITION | TOP SCIENCE STORIES OF 2003 | JANUARY, 2004

UNIVERSE

The galaxy M81 as seen by NASA's new Spitzer Space Telescope.

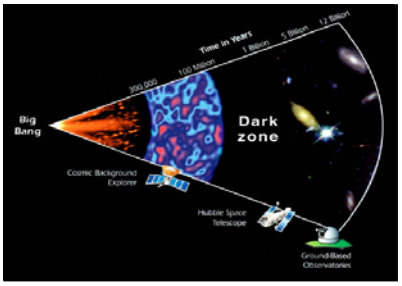
A New View of the Universe

Issue December 19, 2003 -The Spitzer Space Telescope is NASA's fourth and final "Great Observatory"; it follows in the tradition of the Hubble Space Telescope, the Chandra X-Ray Observatory, and the Compton Gamma Ray Observatory. "Spitzer" will offer us a new view of the Universe because it is designed to take images in infrared light -- radiation which can penetrate the cosmic dust that impedes our optical views of the heavens.

SAO astronomer Giovanni Fazio and his team are responsible for one of the three research instruments on Spitzer -- IRAC, the Infrared Array Camera. IRAC can take dramatic, four-color infrared images of obscured regions of space, places that are inaccessible even to Hubble's cameras. Fazio's research on the galaxy M81 was featured in NASA's first press conference announcing the success of Spitzer. His work was chosen in part because it is representative of the dramatic results expected during the five-year lifetime of Spitzer. M81 is in many ways similar to our own Milky Way galaxy. It has about the same amount of mass, and, like our galaxy, is also thought to host a black hole at its nucleus. M81 lies in the general direction of the Big Dipper, and is relatively close to Earth -- only about 12 million light-years away.

In the visible, M81 is dominated by the bright region around its nucleus, but IRAC shows that in the infrared the spiral arms are the dominant features of the galaxy. (The figure above shows the IRAC image of M81, with the optical image of the same view shown as an insert at the top right.) The IRAC image clearly highlights clumpy knots in the spiral arms -- regions of dust that have been heated by embedded luminous stars. Many of these stars are more massive than the Sun, and are very young.

Our Milky Way, and indeed all spiral galaxies, contain large amounts of dust that obscure visible light. Because of this dark veil, it is impossible for astronomers on Earth to use ordinary telescopes to investigate the nature of most parts of our home galaxy. Scientists, however, can study other galaxies like M81 that are similar to the Milky Way. These new IRAC images, besides opening a whole new window through which to view the universe, will help astronomers better understand the nature of our environment in the Milky Way.



History of the Universe.

Mystery Matter in Our Expanding, Accelerating Universe

Issue August 11, 2003 — Astronomers are quite confident that atoms and molecules -- all of the "normal" kinds of matter we are familiar with on Earth -- comprise just a few percent of all of the

matter in the Universe. They began suspecting this strange situation when they noticed that stars in the outer reaches of galaxies orbited in space as if there were much more matter in galaxies than inferred from their visible appearance. Today, several independent lines of research all point to the same conclusion: normal matter constitutes only about 3-4% of all of the matter in the Universe. No one knows -- at least not yet -- what the rest of the material is, but astronomers and other scientists are certainly anxious to find out, not least because all this material determines how our Universe expands and evolves.

SAO astronomers Alexy Vikhlinin, Leon Van Speybroeck (sadly, now deceased), Bill Forman, and Christine Forman-Jones, along with 7 of their colleagues, writing in the Astrophysical Journal, report their study of the hot, luminous, normal matter found in between distant galaxies that are arranged in giant clusters. Using the Chandra X-ray Observatory, they studied the X-ray emission from clusters over a fairly large part of the sky, about 600 times the angular size of the moon. Using some sophisticated but generally uncontroversial assumptions and models, they conclude that normal matter is indeed only a few percent of the total matter in the Universe. Furthermore, they discovered that their results are consistent with a Universe that is accelerating its expansion -- in agreement with the findings of completely different lines of research-- the observations of supernovae and the cosmic microwave background. Their results are important because they use a new and independent line of inquiry to address fundamental quantities in our Universe, and the incredible result that the Universe is now accelerating its outward expansion despite the inward gravitational pull from all its matter.

An artist's conception of the SWAS satellite in orbit. SAO astronomers and their team proposed, designed, and now operate SWAS for NASA.

Water in Space

Issue August 4, 2003 — The most massive cloud of gas and dust in our galaxy lies about twenty thousand light-years from Earth, in the direction of the center of the galaxy (located in the constellation of Sagittarius). The "Sag B2" cloud, as it is known, contains about four million solar-masses worth of material, and is roughly about 100 light-years in diameter. Three years ago, SAO astronomers and their colleague used the Submillimeter Wave Astronomy Satellite (SWAS) -- a mission which SAO proposed, designed, and now operates for NASA -- to discover abundant water in Sag B2.

In June, SAO astronomers Gary Melnick and Ted-Bergin (the latter now at the U. of Michigan), along with two of their colleagues, reported the new results of their detailed SWAS investigation of the region around Sag B2. They find that water, about a million trillion trillion kilograms of it (or about as much mass as the Sun!), lies not only in the dense cloud itself, but also well outside the cloud in other regions of interstellar space.

EARTH AND PLANETS

Artist's conception of one of the Mars Exploration rovers on Mars.

Roving Eyes on Mars

Issue April 28, 2003 — Two Mars Exploration Rovers, scheduled for launch on June 5 and 25, will arrive on Mars on January 4 and 24, 2004, and begin a 90-day trek across the landscape.

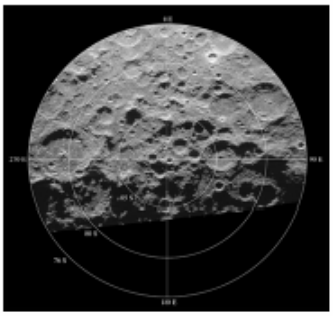
The rovers, which will act as two remotely operated field geologists, will have an instrument package that includes multiple cameras and remote-sensing instruments, some of which are mounted on an arm that can be extended to nearby rocks and soils for detailed close analysis of their properties.

During the mission, John Grant, a geologist at the National Air and Space Museum's Center for Earth and Planetary Studies, will be in residence at NASA's Jet Propulsion Laboratory and will be helping to direct the rovers' activities. Grant has co-chaired the group responsible for recommending landing sites and is a member of the mission's science team.

The two landing sites recently selected by NASA are on opposite sides of the planet in the Meridiani Planum region and Gusev Crater. Though they are very different, both are well suited to achieving mission science objectives, which include determining the history of two sites where evidence has been preserved for past and persistent water activity that may have supported biotic or pre-biotic processes.

At the near-equatorial Meridiani site, the rover will investigate a deposit of gray hematite, an iron oxide whose formation may have been related to past hydrothermal activity or deposition in a standing body of water. In contrast, Gusev Crater (-15^0 latitude) is at the terminus of a large, dry channel that once flowed into the crater and probably created a large lake. The goal at Gusev is to locate and characterize sediments that may have been deposited in the lake in order to evaluate past conditions on Mars.

Images and data from the mission will be readily available on the Internet and on display in the National Air and Space Museum's *Exploring the Planets* gallery.



South polar region of the moon revealed by earthbased radar. Bright reflections expected in polar ice deposits were not detected.

Mapping the Moon's Shadows

Issue December 5, 2003—Most of the Moon's surface is exposed to the Sun's very high temperatures over the course of its monthly cycle. But the Moon also has a small number of areas close to its poles that are never illuminated. Primarily located in crater floors, these regions of permanent shadow could trap and retain deposits of water ice or other frozen volatiles delivered by comet impacts, just as thick layers of ice are found in shadowed polar craters on Mercury.

The Lunar Prospector spacecraft has mapped areas of greater hydrogen abundance near the Moon's poles, but these measurements have not established whether ice may be in the form of thick layers or scattered grains. Working with collaborators at the Smithsonian Astrophysical Observatory, Cornell, and the Arecibo Observatory, National Air and Space Museum scientist Bruce Campbell collected new radar maps of the lunar poles using a 70-centimeter radar wavelength to probe 5 meters or

more into the lunar dust. Because the Moon "wobbles" as it orbits the Earth, the scientists have opportunities every few months to observe some of the polar shadowed terrain. Even if buried beneath a few meters of lunar dust, thick ice layers would appear as very bright radar reflections. However, the team did not find such reflections in the floors of shadowed craters. Thus, any ice in the Moon's permanent shadows must be distributed as small grains or thin layers within the dust, making it less useful as a future lunar resource. This research was featured in a recent article in *Nature.*

BIODIVERSITY

Adult Male Red Siskin (*Cardeulis cucullata)* from a newly discovered population in Guyana.

Rare Birds Discovered in Guyana

Issue July 7, 2003—A research team led by National Museum of Natural History scientist Michael Braun and Mark Robbins of the University of Kansas has discovered a previously unknown population of red siskins, a bird feared to be nearing extinction in the wild. Once widespread in the coastal mountains of Venezuela and Colombia, the red siskin was nearly wiped out by trapping after it became popular both in that region and in Europe in the 1800s. The bird was particularly valued for its bright red feathers and in Latin America it is know as *el cardinalito*, or the little cardinal.

The research team was conducting a survey of birds in Guyana, when Robbins came across the new population. Census estimates put the population size at several thousand birds, larger than any known elsewhere in the wild. The discovery was made in April of 2000 with sponsorship from NMNH's Biodiversity of the Guianas Program, but was kept under wraps until a conservation plan could be developed providing legal protection for the birds in Guyana.

Conservation efforts are being undertaken by an international coalition of concerned groups, including American Bird Conservancy, American Federation of Aviculture, Bushnell Sports Optics, Guyana Environmental Protection Agency, Conservation International, the National Aviary, Rupununi Conservation Group, Rupununi Development Corporation, Smithsonian Institution, the University of Guyana and the University of Kansas. The goal of the conservation plan is to avoid damage to the wild population, and not to prevent people from raising the birds in cages. Red siskins have been protected in neighboring Venezuela since the1940s, and have a history of being bred with canaries to yield brightly colored pet birds. The researchers' discovery was published in the latest issue of *The Auk,* the journal of the American Ornithologists Union. Announcement of the findings has been widespread, as the story was picked up by the Associated Press.

A female American redstart guards her offspring.

Lean Winters Hinder Summertime Breeding

Issue August 25, 2003—Migratory songbirds have become scarcer in recent decades, partly because their tropical wintering grounds are being degraded and many birds don't survive the winter. A new study uses a chemical marker in birds' blood to suggest that this habitat loss has a ripple effect in surviving birds that extends well into the breeding season, when the birds may be a continent away from their wintering grounds.

In 1998, Peter Marra of the Smithsonian Environmental Research Center in Edgewater, Maryland, and coworkers developed a chemical technique that can identify the kind of habitat in which a bird overwinters. Because plants that grow in richer, wetter tropical habitats—such as mangroves and wet lowland forests—use different pathways for photosynthesis, they contain less of the carbon-13 isotope than do plants in dryer areas, such as scrub. Insects eat the plants, birds eat the insects, and the habitat leaves a carbon-13 signature in the birds' blood.

The American redstart, a warbler, spends winters in the Caribbean, Central America, and northern South America and summers in the temperate forests of the United States and Canada. There the birds mate and produce up to five chicks. Marra's team used the carbon-13 isotope to show that redstarts arrive up north sooner and in better physical condition when they have spent the winter in a rich habitat.

A new study by a team led by graduate student Ryan Norris of Queens University in Kingston, Ontario, with Marra as his advisor, shows a striking correlation between carbon-13 levels in redstarts' blood and breeding success. Norris spent two summers monitoring about 90 male and female redstarts nesting north of Lake Ontario. He found that males that had better winter diets not only arrived earlier at the breeding grounds but also sired more young. And females that arrived from richer habitats produced up to two more chicks and fledged them a month earlier than did females that wintered in sparser grounds.

Norris observes, "Negative effects in one season can be negative again in another season." This "carryover" effect underscores the fact that conserving migratory birds will require saving wet tropical forests and mangroves, which are rapidly being lost to logging and development.

One of over 100 black-footed ferret kits produced by artificial insemination at the National Zoo's Conservation and Research Center, Front Royal, VA.

Black-Footed Ferrets—Once Lost, Now Found

Issue November 7, 2003—North America's only native ferret once inhabited the Great Plains from Canada into northern Mexico, preying almost exclusively on prairie dogs. When prairie dogs were declared a pest species because they competed with livestock for forage, an effective extermination campaign decimated them and their principal predator—the black-footed ferret.

During the 1980s, the Wyoming Fish and Game Department (WFGD) sent some newly discovered black-footed ferrets to selected breeding facilities, including the National Zoo's Conservation and Research Center (CRC), whose staff had developed and mastered artificial insemination techniques that could increase ferret populations and maintain vital genetic diversity. Their breeding successes led to the release of 49 ferrets into Wyoming's Shirley Basin in October 1991, that were believed to have been wiped out by sylvatic plague three years later. Despite this setback, over the next twelve years, more than 1,600 black-footed ferrets were released onto seven sites in the Great Plains, with 90 of the animals released provided by CRC.

In August 2003, a WFGD biologist found a surviving group of about 40 ferrets some distance from the original 1991 release site. DNA analysis found that the population was inbred, confirming assumptions that the original population in Wyoming was drastically reduced by plague and remained at low numbers for many generations. CRC scientists were extremely gratified that not only has their hard work

paid off with the success of more recent reintroductions, but that all along, the initial release in 1991 had actually been a twelve-year success. This discovery bodes well for the future of the tough little black-footed ferret on the Great Plains.

American crow—one of the chief sufferer of the disease.

Scientists Investigate Spread of West Nile Virus

Issue August 18, 2003—In August 1999, a resident of New York City became ill with what would be diagnosed as the first documented case of West Nile virus (WNV) in the New World. The disease, more typically found in Africa, can cause encephalitis—an inflammation of the brain due to a viral or bacterial infection. The principal vectors, or transmitters, of WNV are mosquitoes, especially *Culex pipiens.*

The virus was first described in a human patient in Uganda in 1937. By the 1950s, WNV outbreaks occurred in Egypt and Israel. By the next decade, the disease had spread to horses in France and Egypt. Then, in 1999, horses and humans in North America came down with the virus. Clearly WNV had "jumped" from the Old World and was spreading throughout the New World. But how?

John Rappole, NZP researcher at the Conservation and Research Center in Front Royal, Virginia, and Colleague Zdenek Hubalek, from the Institute of Vertebrate Biology in Czech Republic, investigated the introduction and movement of WNV from its New York City origins as it spread north, south, and west. The most likely candidates for transmitting the disease to North America were birds (imports, usual migrants, or storm-driven birds blown off course). Once established in New York, WNV spread fairly rapidly-roughly 70 kilometers (27 miles) a month. By the end of 2002, the virus was reported in every state of union, except Oregon, Nevada, Utah, and Arizona.

Rappole and Hubalek investigated migratory and non migratory birds as possible hosts that could spread the virus. They first believd that susceptible New World migratory birds might be the principal transmitters that brought the virus to sites hundreds of miles from New York. However, if this were the case, the virus would have moved hundreds of miles in a matter of days. Rappole and Hubalek did not find this pattern of movement. They wrote: "Instead, the virus moved a maximum of 300 km (about 186 miles) during three months of known activity in 1999, and another 400 km (249 miles) during seven months of known activity in 2000. This rate of travel is very slow if migratory birds are involved." Also migrants move on a north-south axis, and the virus moved nearly as far west as it did north and south.

These facts led Rappole and Hubalek to consider especially susceptible nonmigratory birds, such as house sparrows and American crows as even more likely candidates for spreading WNV. House sparrows, for example, travel significant distances during dispersal periods—a young adult can travel 15 or more kilometers (9 miles) from its point of origin. House sparrows were introduced into North America in New York City in 1851. By 1886, 35 years later, they were established in south Texas. Today, house sparrows populate a vast area throughout North America, from central Canada south to Nicaragua.

The jury is still out on which candidate is the principal vector of WNV. Rappole and Hubalek believe there may be more than one type of carrier. They are seeking more evidence regarding migratory birds because the virus has reached the Caribbean island of Cayman Brac, 560 km (348 miles) south of Key West. While susceptible nonmigratory birds very likely play a major role in spreading the disease, migratory birds and wind-blown mosquitoes (and possibly even ticks that hitch-hike on avian migrants) may transmit WNV to distant locations. disease.

At the moment, concern is growing over what will happen when West Nile virus reaches the New

World tropics—as it eventually will. Rappole and Hubalek predict that WNV will spread rapidly through the region, given the year-round abundance of both mosquitoes and susceptible birds. The two scientists point out that the "likely results of such an epidemic are unknown." Yet, they remain hopeful that, for animals and humans in the New World tropics, previous exposure to similar viruses, such as yellow fever, may confer some level of immunity and moderate the damage that WNV may cause. Rappole is not the only SI research studying the spread of the West Nile Virus. Pete Marra from SERC has been tracking WNV since it appeared. He has worked with the State of New York's monitoring and tracking efforts and in 2003 held the first multidisciplinary conference on WNV. The conference held at SERC included scientists, managers, policy makers, epidemiologists, health officials, virologists, and ecologists to discuss the issues surrounding WNV.

Intense herbivory by insects on tropical plants have resulted in the evolution of chemical compounds that the plants use for their defense. The same chemical compounds may have medicinal proper-

Bioprospecting Today for Tomorrow's Cures

Issue October 31, 2003—Smithsonian Tropical Research Institute (STRI) research associates Phyllis Coley, Todd Capson, and Thomas Kursar and their colleagues have published a report presenting the first evidence that ecological rules of thumb derived from plant defense researchcan aid the search for pharmaceuticals in nature.

The researchers found that chemicals extracted from young leaves—a part of the plant that is usually overlooked—are much more potent than mature leaves in tests against human diseases, such as cancer, HIV, malaria, leishmaniasis, and trypanosomiasis. Young leaves rely more heavily on chemical defenses than mature leaves because they are growing and cannot be protected physically by toughness. The research also supports another long-standing ecological theory suggesting that extracts from slow-growing species are significantly more active against disease targets than extracts from fast-growing species.

The report also presents a novel approach for linking drug discovery to conservation. Most drug discovery programs collect samples in nations of biodiverse, but conduct all the research in the developed world. Thus, royalties from successful drugs—which are rare—are the sole source of benefits to developing nations. In contrast, all of the collaborators in this research were based at institutions in Panama, STRI, the University of Panama, and the Institute of Advanced Scientific Investigations and High Technology. By conducting all of the research in Panama with local scientists, the researchers have shown that a significant portion of the $40–$50 billion spent annually on drug discovery research funding could successfully be reallocated to conduct research in developing nations.

Research based in the source country provides education, research opportunities and pride in discoveries about the value of their biodiversity. In fact, this sustainable use of biodiversity may simulate biodiversity-rich countries to initiate their own conservation measures.

Coral Reef Ecosystems Began Centuries Ago

A group of scientists led by John M. Pandolfi, former STRI fellow from SI's National Museum of Natural History that includes STRI staff scientists Richard C. Cooke and Jeremy B.C. Jackson published "Global trajectories of the long-term decline of coral reef ecosystems" in the issue of *Science*. Degraduation of coral reef ecosystems began centuries ago, but there is no global summary of the magnitude of change. The authors compiled records, ex-

tending back thousands of years, of the status and-trends of seven major guilds of carnivores, herbivores, and architectural species from 14 regions. Large animals declined before small animals and architectural species, and Atlantic reefs declined before reefs in the Red Sea and Australia, but the trajectories of decline were markedly similar worldwide. All reefs were substantially degraded long before outbreaks of coral disease and bleaching. Regardless of these new threats, reefs will not survive without immediate protection from human exploitation over large spatial scales.

HUMAN CULTURES

Dr. Doug Owsley working on the Tennessee cast iron coffin case as Secretary Small, Dave Evans, Sheila Burke, and Cristian Samper observe.

The Case of the Iron Coffin

Issue June 16, 2003—An iron coffin dating to the middle of the 19th century was discovered during the 2002 relocation of the Mason family cemetery in Giles County, Tennessee. No headstone or marker was present, and the identity of the assumed family member in the coffin was unknown.

The Mason family and the Tennessee state archaeologist contacted physical anthropology curator Doug Owsley to determine the person's identity and to glean scientific information about this individual and the era in which he lived. Iron coffins were extremely expensive for their time period and typically were used by wealthy individuals. Examining this coffin offered a rare opportunity to obtain information on burial customs, period clothing, body preservation, and forensic data collection.

The coffin was delivered to the National Museum of Natural History on May 27. Assisting Doug Owsley, Kari Bruwelheide, and pathologist Larry Cartmell in the analysis were Laurie Burgess, Dave Hunt, Ashley McKeown, Rebecca Snyder, and a host of volunteers and interns. After a thorough examination of the clothing, by textile expert Shelly Foote of the Museum of American History, and a complete forensic examination of the remains, the person was tentatively identified as Isaac Newton Mason, who served in the Confederate cavalry during the early part of the Civil War and died in 1862. The Discovery Channel and 20/20 will air their filming of this project later this summer.

Tularosa cob.

Unlocking Ancient Secrets from Ancient Maize

Issue December 19, 2003—Maize today is one of the world's most important crop plants. Yet relatively little is known about its early history, and how it was gradually developed by farmers over thousands of years of cultivation and selection for desired characteristics. New genetic technology, however, is now allowing scientists to unlock secrets from ancient maize that has long been stored in the collections of the National Museum of Natural History and other museums. Last summer, Bruce D. Smith, a National Museum of Natural History archaeologist, obtained permission to extract several kernels from a corncob excavated from Tularosa Cave in New Mexico in 1903. Radiocarbon dating of one of the kernels showed the Tularosa cob to be 1,000 years old. An-

other kernel from the Tularosa cob was then sent to the Max Planck Institute in Germany for genetic analysis, along with samples Smith obtained from ten other cobs stored at the Field Museum in Chicago and the Harvard Herbarium.

Geneticists at the Max Planck Institute then successfully extracted and amplified DNA from the eleven maize samples, and were able to document selection by human farmers for improved characteristics of corn over a span of 3,000 years, from 4,400 to 1,000 years ago. Allele frequency changes at three key genes indicated that humans were actively selecting for improved plant shape and better starch characteristics. Ongoing genetic studies of ancient maize should provide further information regarding the early history of this important crop plant.

Florescent murals glow under ultraviolet light at the Alameda Theater.

Glowing Murals Get a Facelift

Issue August 4, 2003—Smithsonian Center for Materials Research and Education (SCMRE) conservation scientists are assisting in the preservation of 1949 "blacklight" murals in the Alameda Theatre in San Antonio, Texas. These paintings, which depict scenes of San Antonio's Mexican heritage, are examples of a dramatic trend in interior theater decoration in the 1940s and early 1950s. They were created with fluorescent paints, resulting in a spectacular glowing three-dimensional appearance under ultraviolet illumination. (The term fluorescent should be differentiated from phosphorescent, luminescent, or glow-in-the-dark, because the murals do not continue to fluoresce in the absence of an ultraviolet light source.)

After a financially unsuccessful conversion to a triple-plex movie theatre in the 1960s, the Alameda Theatre spent decades in disrepair. Museo Americano, a Smithsonian affiliate museum and performing arts center allied with Washington's Kennedy Center, is committed to a careful and educated approach to the complete restoration of the Alameda's historic structure. The conservation program's development involves a collaboration of an historic theater preservation architect, painting conservators, and scientists from SCMRE.

Publications

Smithsonian scientists published peer review articles, books and chapters this year. Of these, 76 articles appeared in *Science* magazine, 40 articles in *Nature* magazine and 28 articles in *PNAS*.

Spotlight on Science at the Smithsonian

Spotlight on Science at the Smithsonian is a weekly electronic newsletter about Science at the Smithsonian. It is produced for the Smithsonian community by the Office of the Under Secretary for Science. To contact the editor, e-mail mellendickt@si.edu.

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