

MIT Science News In Review

[Astronomy]

A Singular Matter

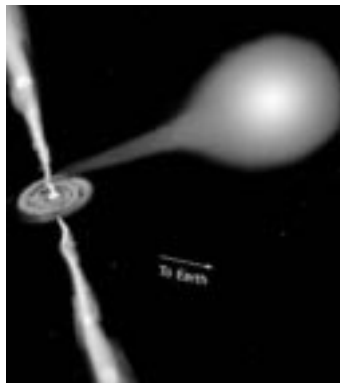
Particle jets, the beams of matter that a black hole discharges even as it sucks other matter in, originate much closer to the singularity than previously thought. Using a high-energy spectrometer, an MIT research team has successfully mapped the region in which the jets are located, yielding the clearest view of their structure yet obtained and possibly opening the door to a new method to learn more about black holes themselves.

By “fingerprinting” elements within the jets, researchers were able to determine numerous characteristics including composition, velocity, temperature range, opening angle, and most crucially the length of the X-ray-emitting section. This data enabled the computation of the distance of the jets from their source, some five times less than earlier measurements. Factoring in the companion star, researchers further estimated the size of the black hole at 16 solar masses.

The investigation centered around SS 433, a 16,000-light-year-distant binary star system that “provides a nice local laboratory to study the formation of and conditions in relativistic jets,” said lead author Laura Lopez. “The high-speed jets in nearby SS 433 may be caused by the same mechanisms as the powerful outflows in the most distant and much more massive black holes, such as quasars.” Since the jets originate so close to the black hole, scientists were able to measure the internal temperature and density with a degree of accuracy not possible for smaller systems.

—D. Barclay

Source: <http://web.mit.edu/newsoffice/nr/2004/blackhole.html>



Graphic: Kimberly Kowal, Harvard-Smithsonian CfA – An artist's rendition of SS 433. Gas from the companion flows to the black hole, forming an accretion disk that heats as it spirals inward. Through a process probably involving magnetic fields, some of the inflowing material is launched into a jet at a speed of 175 million miles per hour (26 percent of the speed of light). The jet gas then cools from 100 million degrees to 10 million degrees as it expands and flows outward. During one of the observations with the Chandra X-ray Observatory, the star blocked the cooler part of the jet, giving investigators an opportunity to measure the size of the binary system and, ultimately, the mass of the black hole.

Sherley and the members of his research team have regulated the biochemistry of rat liver stem cells with a metabolite that allows them to multiply as do embryonic stem cells. Adult stem cells do not divide “symmetrically”; instead, they divide into a replacement cell and a daughter cell that will continue to differentiate to serve its function. Sherley has developed SACK (Suppression of Asymmetrical Cell Kinetics), which will regulate the proliferation of asymmetrically dividing cells. Scientists have found that certain nucleotide metabolites that stimulate the functions of regulatory proteins may be manipulated to control the expression of the p53 gene, which has been repeatedly linked to many human cancers. The expression of the p53 gene forces cells to grow as adult stem cells, while its biochemical manipulation reverts to symmetrical division.

This breakthrough promises to lower the hurdles that have separated biochemists from taking complete advantage of adult stem cells, which are more difficult to isolate and multiply than embryonic stem cells. It is questionable whether adult stem cells are also limited to cells of the tissues in which they reside. SACK has enabled scientists to closely monitor and control the proliferation of adult stem cells, decreasing the tendency toward mutations and cancerous growths. It has allowed the biochemical manipulation of such cells without any alteration in genetics.

Sherley also stated that he believes almost every tissue in our body has the ability to rejuvenate and regenerate. Although adult stem cells have been attributed to only 13 tissues, Sherley emphasizes that “we are not static beings” and that our cells are equipped with a long-term memory of the original form of the organ they belong to.

His work is supported by the Defense Advanced Research Projects Agency (DARPA) and the National Science Foundation Engineering Research Center, among other organizations.

—E. Slutsky

Source: <http://web.mit.edu/newsoffice/nr/2003/sherley.html>

Low Tar Below Par

A recent MIT study has found that lung cancer risk among smokers is unrelated to the level of tar in their cigarettes. Dr. Jeffrey Harris, the study's leader, concluded that “there is no known benefit if you switch from a regular filter brand to a low-tar or ultra-low-tar brand” after examining the habits and health of nearly one million adult smokers. Previous studies indicated that people tend to smoke low-tar cigarettes more intensively, but this was the first to assess the effect on lung cancer vulnerability.

Smokers of very-low-tar (≤ 7 milligrams), low-tar (8-14 mg), and medium-tar (15-21 mg) cigarette brands exhibited equal rates of lung cancer risk, regardless of their medical histories, dietary habits, and demographic profile. High-tar cigarettes (≥ 22 mg) were associated with a higher cancer risk, while nonsmokers showed significantly less.

This latest research overturns the conventional wisdom of the prior three decades, which held that reducing the tar levels in cigarettes was a key technique to making them safer. Harris, a professor in MIT's Department of Economics and the Harvard-MIT Division of Health Sciences and Technology, commented, “As a member of the

[Biology]

MIT Scientist Offers Breakthrough in Effort to Harvest Adult Stem Cells

Underscoring the unfortunate overlapping of science and politics, the Bush administration's stringent restriction on biological research using embryonic stem cells has dictated the circumferential path of investigation. Scientists, such as MIT's Associate Professor of Biological Engineering James Sherley, have directed their efforts and attention toward the proliferation of adult stem cells.

public health community, I would suggest that we rethink our current system of rating cigarettes according to machine-measured tar devices." Now the only way to reduce the risks associated with smoking may be to quit.

The study can be found in the January 10 edition of the *British Medical Journal*, or online at <http://bmj.bmjournals.com/cgi/content/full/328/7431/72>.

—D. Barclay

Source: <http://web.mit.edu/newsoffice/nr/2004/cigarettes.html>

Receptor Gene Variants Increase Heart Disease Risk

According to a study by Amanda Shearman, a researcher in David Housman's lab at the MIT Center for Cancer Research, a genetic variation in the estrogen receptor alpha gene (ESR1) leads to an increased risk of cardiovascular diseases (CVD) by three-fold.

In the population, which included 1,739 unrelated men and women from the offspring group of the Framingham Heart Study, 20 percent had a specific estrogen receptor variant on both copies of a chromosome. This genotype was associated with a three-fold increased risk of heart attack compared to individuals with other genotypes.

This study, reported in the Nov. 5 issue of the *Journal of the American Medical Association*, sought to understand how genetics affects estrogen and its role in CVD risk.

The authors report that "[t]hese findings underscore a potentially important role of ESR1 in influencing the development of atherosclerosis and/or in accelerating the transition from subclinical atherosclerosis to plaque rupture and acute thrombotic CVD events."

These results were significant when restricted to male participants because too few women had the genetic variant. This study increases understanding of the role of estrogen receptors in CVD susceptibility for men and provides a basis for future work in studying the effects of hormone therapy on CVD susceptibility in women.

—L. Nambiar

Source: <http://web.mit.edu/newsoffice/nr/2003/heart.html>

[Biophysics]

Understanding *E. coli*'s Defense Mechanism Will Aid in Antibiotic Drug Design

Alexander van Oudenaarden, Assistant professor of Physics at MIT, described the defense mechanism by which *Escherichia coli* form clumps when they are threatened, bringing scientists one step closer to understanding how to best develop drugs for treating bacterial infections.

Van Oudenaarden and colleagues reported how *E. coli* "remember" danger signals in their environment and interact with fellow organisms in the October 28 *Proceedings of the National Academy of Science*. Though *E. coli* bacteria are usually harmless, one strain has led to approximately 73,000 cases of infection and 61 deaths in the United States annually.

Van Oudenaarden's group studied the effects of chemical signals on bacteria cells and found that a communication-signaling pathway tells cells to clump together when stressed. The lab labeled cells with green



Photo: Donna Coveney — Alexander van Oudenaarden, biophysicist and assistant professor of Physics, surveys a slide on which *E. coli* bacteria is present. On the monitor behind him is an image of the clumping of bacteria that occurs when they are threatened.

fluorescent protein and tracked them with fluorescent microscopy, discovering that *E. coli* move in two ways. When the flagellum rotates counterclockwise, the *E. coli* move straight ahead. In the presence of an amino acid that is secreted when *E. coli* are stressed, the labeled cells went to the center of a cluster, forming a clump. In this manner, *E. coli*, as a clump, can resist the effects of antibiotics.

—L. Nambiar

Source: <http://web.mit.edu/newsoffice/nr/2003/ecoli.html>

[Civil/Environmental Engineering]

Soil-moisture Measurements Will Provide a Clearer View of the Water Cycle and Weather Forecasts

Hydros (the Hydrosphere State mission), a project governed by MIT and approved by NASA, will measure the soil moisture of the Earth from space. Scientists need to measure soil moisture in order to gauge the effects of evaporation, which connects the water cycle, the energy cycle, and the carbon cycle. Overall, these measurements will reveal valuable



Graphic: Dara Entekhabi — The Hydros satellite will rotate to focus its beam for scanning a wide area of Earth's surface as it circles the planet every 90 minutes at an altitude of 670 kilometers.

data that contribute to weather forecasting, climate, and the rate of the water cycle. Dara Entekhabi, an MIT professor of Civil and Environmental Engineering, said that soil moisture has been difficult and therefore expensive to measure. Hydros will incorporate concrete observations into the numerical models commonly used in predicting the weather. It will also be able to differentiate between moisture levels in frozen soil, which will allow scientists to gauge the growing season in certain areas and to determine whether the forest emits or collects carbon.

Hydros will be launched into orbit near the Earth in December of 2009. Its satellite will contain a rotating reflector antenna similar to that used in cell phones, along with radar and a radiometer that operate in the range of low-frequency microwaves. The \$250 million project will be run by MIT's Department of Civil and Environmental Engineering and Center for Space Research, NASA's Jet Propulsion Laboratory and Goddard Space Flight Center, and the Canadian Space Agency, with the Department of Defense. Two other projects approved by the Earth System Science Pathfinder (ESSP) program are the Aquarius, which will measure oceanic salinity, and the Orbiting Carbon Observatory, which will monitor carbon dioxide.

—I. Lim

Source: <http://web.mit.edu/newsoffice/nr/2004/hydros.html>

[EAPS]

Flaring Solar Havoc and Earthly Clarity

Our view of the universe, since the days of Aristotle, has hinged upon the controversial Sun-Earth connection. Atmospheric scientists internationally, including those at MIT's Haystack Observatory, have accepted the task of charting, monitoring, and analyzing the Sun and Earth interactions that seem to dictate the state of our ionosphere.

October 28, 2003, was greeted with far more than a sunrise: a solar flare showered space with energy and particles. On a scale of X-ray intensity ranging from a low of 1 to a high of 20, this solar flare registered a 17.2, securing its position as the third most powerful to date. The next two days brought a repetition of the event, only to a lesser degree. The earthly result: a breathtaking auroral display that stretched to hover over regions as far south as Texas.

The Earth's upper atmosphere, or ionosphere, is a plasma found from about 100 to 1,000 kilometers above the earth's surface. It has served as a monitor fine-tuned to the solar storm that was raging, tracking its fierce solar winds and exhibiting the magnetic disturbances caused by the flow of plasma interacting with the Earth's magnetic field.

Months later, the recorded data has only begun to be analyzed by the crew at the Haystack Observatory and its affiliated bases. John Foster, the observatory's associate director and leader of the Atmospheric Sciences Group at Haystack, will lead a team to use the dramatic disturbances of the ionosphere to enrich our knowledge of space weather and its effects on the Earth. Space weather might be the integral link that elucidates Sun-Earth interactions. It is known that space weather is caused by the collision between solar outbursts laced in magnetic fields and Earth's magnetosphere. This ionospheric alteration bends radio and radar signals, providing tangible evidence of its effects.

Foster's present efforts focus on the redistribution phenomena that, within a 30-minute time period, relocate space weather's materials from Earth's lower latitudes to the atmosphere over the polar regions. On a similar note, he is fascinated by the particularly attention-grabbing atmospheric disturbances over North America during these celestial storms.

—E. Slutsky

Source: <http://web.mit.edu/newsoffice/nr/2003/solar.html>

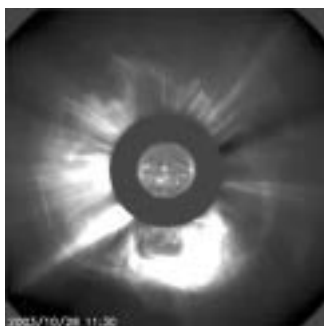


Image: Soho (Esa & Nasa) – One of the largest solar flares ever observed by the Solar & Heliospheric Observatory set off a strong high-energy proton event and a fast-moving coronal mass ejection that hit Earth early on October 29 2003. MIT's Haystack Observatory atmospheric scientists utilized an array of detectors to track changes to Earth's ionosphere as a result of this ejection.

[EECS]

Detecting Terrorism with Radar

In collaboration with the U.S. government, scientists at Lincoln Laboratory are adapting Doppler radar for a new use: detecting biological and chemical weapons. Doppler radar determines the characteristics of weather systems by emitting pulses of energy and analyzing the part of this energy that is returned by particles in the air such as raindrops.

The new research aims to recognize particles in the sky not natural to the environment so authorities can examine them more closely. This would allow early warnings if terrorist agents are suspected. The U.S. Army recently began testing this technology, using substances such as water mixed with antifreeze and clay as their test particles. If the tests succeed, a network of radar towers at major airports will be used to detect possible terrorist emissions from airplanes.

The current research is nothing more than preventative. Members of the research group emphasize that though many terrorist groups possess biological and chemical weapons, they lack the resources to use them effectively and therefore favor other methods of terrorism.

—K. Rivoire

Source: <http://web.mit.edu/newsoffice/tt/2003/dec17/warning.html>

[EECS/Biology]

Double Data Sets Reveal Gene Regulatory Pathways

MIT computer scientist David Gifford, Whitehead Institute for Biomedical Research scientist Richard Young, and colleagues have developed a computer program named GRAM (Genetic Regulatory Modules) that uses two different sets of information to examine gene regulatory pathways. Traditionally, researchers use only one data set to try to figure out the pathways, but this is usually inefficient in solving the mystery of gene regulation. By using two data sets, researchers have more information to piece together the puzzle and are able to cross-check the results deduced from both information sets separately. One data set recognizes regulators while the other reads the level of gene products. The team has already applied GRAM to the examination of the effect of rapamycin, a medication for transplant patients, on yeast's gene regulatory pathways. The ability to accurately map the gene regulatory pathways can lead to more efficient drug discovery. The team is looking forward to incorporating other data sets into the software.

—W. V. Lee

Source: http://www.whitehead.mit.edu/nap/features/nap_feature_algorithm_exp.html

[EECS/Materials Science]

Data Mining for New Material

MIT engineers are now using data mining, a technique that looks for patterns within a large amount of information based on statistics and correlations, to search for new materials. For instance, data mining has been applied to predict customer preferences on an online bookstore. The technique has also been used to discover properties and structures of proteins.



Photo: Donna Coveney – MIT Professor Gerbrand Ceder (left) and research associate Dane Morgan, both of the Department of Materials Science and Engineering, mine for materials with computers.

MIT professor Gerbrand Ceder and research associate Dane Morgan of the Department of Material Science and Engineering and their colleagues proposed and demonstrated a new application for data mining. Applying quantum mechanics, they developed a computer technique that can predict the structures and properties of material mixtures. The technique will also be able to incorporate previous information and calculations, saving scientists a tremendous amount of time. The team hopes the project will lead to a public online database to help search for new materials to be used with any application or design. This part of the project is funded by the National Science Foundation.

—W. V. Lee

Source: <http://web.mit.edu/newsoffice/nr/2003/datamining.html>

[Mechanical Engineering]



Photo: Shannon Culpepper – Assistant Professor Martin Culpepper with the HexFlex Nanomanipulator (foreground), which won a 2003 R&D 100 Award.

HexFlex-es Its Way to the Top

The impact of the nano revolution is anything but small. However, the feasibility of mass-produced nano-materials has yet to be proven. The recent creativity of MIT innovators may be a key to opening the doors to a nano world.

HexFlex, a nanomanipulator that resulted from research led by Martin Culpepper, an assistant professor of Mechanical Engineering, can make a significant impact in the world of nano research. Nanomanipulators are key components in the fabrication of nano particles. They must accurately and precisely move

objects smaller than the width of human hairs a distance no longer than a few atoms apart. A cheap and efficient manipulator is paramount for the realization of commercial nanotechnology.

The HexFlex is a new generation of nanomanipulators that is in all ways better than its predecessors. The key is its namesake, a six-pronged monolithic structure. With the help of magnetic actuators, three of the prongs are used to manipulate objects, allowing for six degrees of freedom, while the other three are stabilized to the base. The monolithic structure allows for better and cheaper control, due to the elimination of assembly and connection of parts with less accurate bearings. The fundamentally new design gives HexFlex twice the range of operation and three hundred times better stability, with finer movements (in 10 nanometer increments), at only one-sixteenth the cost of current equipment.



Photo: Prototype of HexFlex Nanomanipulator with magnet-coil actuators.

The HexFlex recently won an R&D 100 Award, which honors the year's 100 most technologically important innovations. –T. He
Source: <http://web.mit.edu/newsoffice/nr/2003/hexflex.html>

[Neuroscience]

Inducing Synapse Growth May Help Cure Alzheimer's

By understanding the mechanism of brain synapse loss, Morgan Sheng, an MIT Neuroscience professor, hopes to aid in the development of drugs that may treat neurological diseases associated with synapse loss.

Elimination of synapses is a normal process, allowing for the growth of new synapses; however, it is also characteristic of neurodegenerative diseases, such as Alzheimer's. "We focus on synapses

because that is where information is processed and stored in the brain," Sheng said.

Serum-inducible kinase (SNK), which is involved in the cell cycle, degrades proteins that make up synapses. It breaks the connection between neurons that are communicating to each other through chemical signaling. Sheng and colleagues used molecular biology techniques to inhibit SNK, causing neurons to grow more synapses. Although this was found to be true in tissue culture, Sheng is still unsure if this is probable in the human brain. –L. Nambiar

Source: <http://web.mit.edu/newsoffice/nr/2003/sheng.html>

Understanding Parkinson's with the Help of Yeast

Researchers at the Whitehead Institute for Biomedical Research are using yeast in their search to understand Parkinson's disease. Led by Susan Lindquist, the scientists are trying to determine why specific proteins form clusters in the brain that lead to cell death, causing the symptoms of the disease. The group has used yeast before for its studies of human proteins, due to similarities in biological processes between yeast and humans.

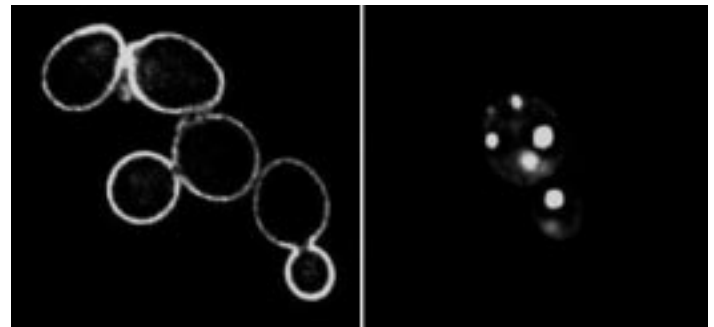


Image: Tlago Outeiro – Living test tubes. In the image on the left, the α Syn proteins, expressed at moderate levels, fluoresce on the yeast cell membranes and illuminate an almost perfect circle. In the next image, α Syn expression is slightly increased, and the proteins abandon the membrane and begin to aggregate into clumps. At that point, the cell begins to die.

For the study, researchers compared cells with different levels of the protein alpha-synoclein, known to be related to Parkinson's disease, which causes other proteins in the cell to change shape to form the debilitating clusters. Results showed that normal cell function occurred at low levels of alpha-synoclein, but with higher levels, proteins located near alpha-synoclein began to change shape and induce cell death. Lindquist's data shows that diseases can be caused by an imbalance of the correct quantities of different proteins.

Her group of researchers also joined with a group at the University of Washington to study the protein huntingtin, which causes Huntington's disease, another disorder of the nervous system. Working with a vast library of strains of yeast, the groups were able to determine which genes help prevent each of the two diseases; their results showed that the proteins involved in Parkinson's disease were entirely different from those associated with Huntington's disease.

Lindquist hopes that their results will prove to others that yeast is a suitable organism for the study of neurological diseases; previously, some had thought it too simple. She also believes that yeast may prove useful in the testing of pharmaceutical products. –K. Rivoire

Source: http://www.wi.mit.edu/nap/features/nap_feature_alpha_syn.html .