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I'll Believe It Even If I Don't See It

For years astrophysicists have observed galaxies and surmised that there must be more to them than meets the eye. That is, the gravity required to make them behave as they do cannot be accounted for by the matter we can see- stars, gases, rocks, atoms, and so on – as there is not enough of this matter to exert so much gravitational force. In fact, 95% of the universe must be comprised of material that is invisible to us – either dark energy or dark matter [1].

Previously, many astrophysicists have argued that gravity simply works differently over the large distance scales among galaxies and clusters of galaxies. Currently, however, Maxim Markevitch of the Harvard-Smithsonian Center for Astrophysics and Doug Clowe of the University of Arizona at Tucson have shown conclusively that dark matter must exist. The hallmark of dark matter is that it does not directly interact with anything; all interactions have to occur indirectly, through gravitational forces. These scientists observed an expanding bullet of matter formed by two colliding galaxy clusters (together called cluster 1E0657-556) and and showed that much of the mass of this bullet consists of particles which, unlike normal gases, do not collide and bounce off each other. Particles that do not collide move faster than those that do, leaving a halo of extra mass around the ball of gas. Consequently, the researchers could infer the presence of dark matter from their observations. As expected, this matter did not appear to interact strongly with itself or normal matter [1,2].

-Anthony Vicari

1. Britt, Robert Roy. "New observations of a great big cosmic collision provide the best evidence yet that invisible and mysterious dark matter really does exist." Accessed: Wednesday, August 23, 2006. <cnn.com>
2. M. Markevitch, A. H. Gonzalez, D. Clowe, A. Vikhlinin, W. Forman, C. Jones, S. Murray, W. Tucker. Direct constraints on the dark matter self-interaction cross-section from the merging galaxy cluster 1E0657-56. 2004, *The Astrophysical Journal*, 606(2): 819-24.

Scientists Attracted to Bacterial Magnetism

Almost everyone is familiar with magnets because they are ubiquitous. They can be found in motors, as electromagnets, in MRI machines, and in the Earth itself. Might they also be present in bacteria? In the 1960s, scientists discovered naturally magnetic bacteria, or magnetotactic bacteria, in aquatic environments with low oxygen levels. Magnetotactic bacteria have the peculiar capability of aligning themselves with the Earth's magnetic field [1]. Known as magnetotaxis, this phenomenon is a result of interesting structures called magnetosomes within the bacteria [2]. These magnetosomes are intracellular, iron-rich, membrane-enclosed magnetic particles that are produced in a similar way to proteins [3].

Magnetotactic bacterium ▶

Magnetotactic bacteria have attracted the attention of many researchers because the utility of magnetotaxis is not well understood. As oxygen is harmful to these anaerobic bacteria, a proposed evolutionary reason for magnetotaxis is that it helps bacteria find regions of low oxygen concentration by directing their movement [4].

Recently, scientists at the Naval Research Labs and Purdue University led by Dr. Lloyd Whitman have tested this hypothesis by quantifying the advantage of magnetotaxis. They worked with both wild-type, magnetic *Magnetospirillum magneticum* as well as a nonmagnetic mutant of this bacteria. By exposing these bacteria to an oxygen gradient and magnetic field, they could see whether magnetotaxis helps them in any way. Whitman's team found that, compared to their nonmagnetic counterparts, the magnetic bacteria were better

credit: http://nai.nasa.gov/news_stories/news_detail.cfm?article=old/magnetite_chains.htm

able to detect oxygen, enabling them to move away from the harmful oxygen gradient. This effect is proportional to the strength of the magnetic field. Magnetotaxis, however, did not increase their speed in moving away from higher oxygen concentrations. Based on these novel results, the scientists concluded that magnetotaxis provides a subtle evolutionary advantage [5].

Magnetotactic bacteria may not be of solely academic interest. Whitman and colleagues eventually want to genetically engineer these fascinating bacteria to become magnetic only when exposed to toxic chemicals, thereby turning them into living biosensors [4].

—Shiv Gaglani

1. Kerr, R.A. "Life slow enough to live on radioactivity." *Science* 312 (2006): 179b
2. "Bacteria found digesting radiated water." *ScienceDaily*, October 19 2006, URL: <http://www.sciencedaily.com/upi/index.php?feed=Science&article=UPI-1-20061019-21292900-bc-us-bacteria-crn.xml>

The Next Universal Anticancer Drug Target

Researchers are beginning to have reason to believe that telomerase inhibitors are the key to treating most types of cancers with minimal side effects. Although these inhibitors are not yet clinically viable, scientists have begun to develop methods of inhibiting a key cellular component involved in cancer proliferation.

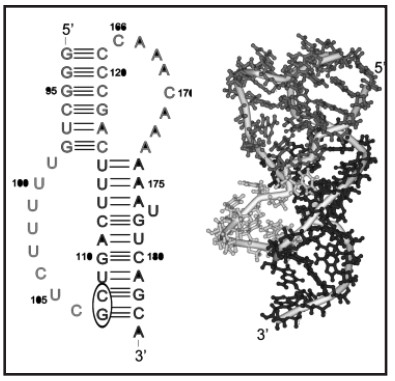
Telomeres are strands of deoxyribonucleic acid (DNA) that occur at the end of chromosomes. Most of the telomere is double-stranded DNA although the very tip of the telomere consists of a single-stranded region.

Telomerase is an enzyme that attaches to these single-stranded regions and catalyzes the extension of the telomeres. During mitosis division of normal cells, the telomeres become shorter with each chromosome replication. This occurs because the DNA polymerase that catalyzes the replication process cannot replicate the very ends of the telomeres, which causes a loss of 50-100 nucleotides per replication. Once the telomeres get too short, mitosis ceases and the cell dies.

Cancer cells are unique in that, although they replicate more rapidly than normal cells, their telomeres do not shorten. This is because cancer cells possess telomerase, which restores the telomere region that would normally be eroded with each round of mitosis. This renders cancer cells effectively immortal and prone to excessive proliferation.

Researchers believe that by targeting telomerase in cancer cells, using small organic molecules or oligonucleotide-based compounds, they can inhibit the activity of telomerase. Dr. Simon H. Friedman of the University of Missouri has attempted to inhibit telomerase by using small molecules to disrupt the RNA-DNA duplex that forms between the RNA template of the telomerase and the DNA of the telomere. This method would hinder the unwinding of the telomere's DNA and prevent the restoration of the telomere end [1].

▼ Telomerase



credit: http://www-lmmb.ncifcrf.gov/~bshapiro/telomerase/telomerase.

Alternatively, Dr. Micheal Jarstfer of the University of North Carolina School of Pharmacy is studying the use of oligonucleotide inhibitors of telomerase. This method blocks key RNA-protein contacts that are necessary for the telomerase to assemble inside the cell. If the telomerase's RNA does not bind with certain proteins, it will be inactive inside the cell, and will not restore the telomere. One oligonucleotide analog, called GRN163L, is currently undergoing human clinical trials. This oligonucleotide has the ability to bind to the active site of the telomerase and thereby inhibit the enzyme's activity [1].

With so much research on the process of telomerase inhibition, researchers soon hope to determine whether they will live up to the hype of being the universal anticancer treatment.

—Chikezie Eseonu

1. Borman, Stu. "Targeting Telomerase." *Chemical & Engineering News* 84 (2006): 32-33.

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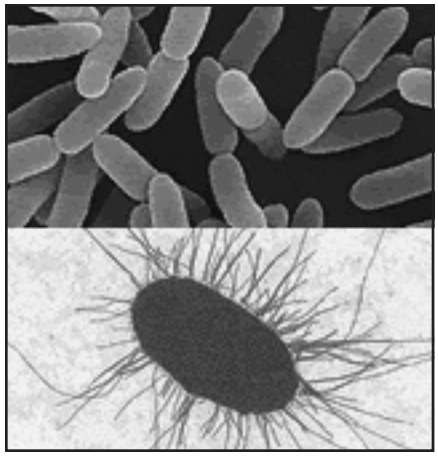
Radioactive Life

Firmicutes, relatives of radioactivity-sustained bacteria



Usually hazardous to most forms of life on Earth, radioactivity was recently found to be an indispensable food source for microorganisms deep under the Earth's surface. There in the abyss, buried for millions of years under cold ocean waters or sweating from heat under South Africa, life was found to be very slow, so slow that the microorganisms are surviving solely by consuming feeble radioactive decay lingering from before the Earth's formation.

An American led team of international geologists found such a self-sustaining community of bacteria living in rocks 1.7 miles beneath the seafloor of the eastern equatorial Pacific [1]. The scientists from collaborating institutes who studied the chemistry of 400 cubic meters of cored sediment say that the bacteria rely on radioactive uranium to convert water molecules into usable energy [2]. In doing so in the ancient and cold mud of the Pacific, these microbes are utilizing extremely low amounts of energy, as low as 2.8 x 10^(-16) kilojoules per cell per year, which is some 10,000 times lower than energy consumption in a slow-living bacterial culture in the laboratory [1]. At that rate, the slow microbes are certainly not "thriving," as most headlines would have it, but rather repairing the inevitable cell degradation processes due to radiation damage and the passage of time.

With such findings it becomes obvious that we know surprisingly little about the limits of life on Earth. The latest discovery of slow-moving bacteria is a confirmed expansion of Earth's biosphere and fuels optimism that life exists in other extreme and perhaps extraterrestrial environments, such as in groundwater beneath the permafrost on Mars [2].

—Tamara Halkina

credit: http://www.nature.com/omics/organisms/proteobacteria/index.html

1. Kerr, R.A. "Life slow enough to live on radioactivity." *Science* 312 (2006): 179b
2. "Bacteria found digesting radiated water." *ScienceDaily*, October 19 2006, URL: <http://www.sciencedaily.com/upi/index.php?feed=Science&article=UPI-1-20061019-21292900-bc-us-bacteria-crn.xml>

Work on RNA and the Early Universe Recognized by Nobel Foundation

This year, five American scientists have been honored with the prestigious Nobel Prize, which includes a cash award of over US$1 million for each category.

Roger D. Kornberg of Stanford University, the son of the 1959 Nobel Laureate Arthur Kornberg, received the Nobel Prize in Chemistry for his study of genetic transcription. Information in DNA is transcribed, or coded, into messenger RNA (mRNA) that is read by protein-synthesizing machinery to effect gene expression. Kornberg published the first molecular picture of the enzyme RNA polymerase as it generated mRNA. This technical feat required painstaking crystallization of the enzyme; interaction of this form with X-rays was then analyzed to create the snapshot. In addition to furthering the study of polymerase helper proteins called transcription factors, Kornberg also discovered the *Mediator* complex, which turns transcription on and off.

The Nobel Laureates in Medicine, Andrew Z. Fire of Stanford University and Craig C. Mello of the University of Massachusetts, were recognized for their discovery of RNA interference (RNAi). In the process of RNAi, a protein complex matches its double-stranded RNA fragments to the code of single-stranded mRNA, which can then be cleaved and silenced. First described in 1998, this method of gene control is a cornerstone upon which treatments for cancer and other diseases are being developed.

The co-recipients of the Nobel Prize in Physics were John C. Mather of the NASA Goddard Space Flight Center and George F. Smoot of the University of California, Berkeley. Mather steered a collaboration of more than 1000 researchers

on the COsmic Background Explorer (COBE), a satellite that permitted both laureates' seminal studies of blackbody microwave radiation. The Big Bang scenario suggests that the universe has been expanding since it began as a body of intense heat. This is the only scenario that accounts for specific wavelengths, blackbody radiation, that correspond to cooling. The experiment headed by Mather bolstered evidence for the Big Bang, since COBE measured the previously unconfirmed blackbody spectrum. Smoot's project used COBE to observe anisotropy, differences as small as a hundred-thousandth degree that indicate how matter clustered into galaxies and celestial bodies.

-Michelle Siao

"Information for the Public." The Official Website of the Nobel Foundation. 2 November 2006. URL: <www.nobelprize.org>.

Invisibility Cloak Not Just For Harry Potter

The idea of an invisibility cloak is no longer exclusive to Harry Potter and his posse. A team of scientists from Duke University and Imperial College in London have developed a rudimentary invisibility cloak that can bend microwaves. The device forces microwaves to slide around an object in a way that looks like water running over a rock [1].

Microwaves bounce off objects just like visible light waves, but their high frequencies are not visible to the human eye. The researchers used instruments to see how microwaves interacted with objects in the invisibility cloak [2]. The structure of the cloak, which consists of concentric copper circles on fiberglass board, is designed to deflect electromagnetic waves. By changing the distribution of waves, the invisibility cloak alters shadows and reflections [1].

British scientist Sir John Pendry of Imperial College in London theorized the structure and then worked with Duke researchers to build the actual model [1]. The scientists tested the model at Duke, where they used the cloak to partially hide a small copper cylinder. First, they measured electromagnetic waves in an area without any obstacles. They then placed the copper cylinder in the same area and measured the disturbance in the microwaves. Finally, they cloaked the cylinder and found that the device reduced the disturbance so that there was less indication of the object's presence [2].

David R. Smith, a professor of electrical and computer engineering at Duke, believes that a cloak that can make objects in the visible spectrum completely invisible is challenging because it would have to deflect all wavelengths of light [1]. According to Smith, "as an application, it's not clear that you're going to get the invisibility that everyone thinks about - as in Harry Potter's cloak, or the Star Trek cloaking device" [2].

Further development of this technology could be useful to the military as a way to avoid radar detection or to prevent cell phone signals from tampering with equipment [1]. The researchers believe that hiding an object from microwaves will make it invisible to radar [2].

—Katelyn Foley

1. Schwartz, John. "Scientists take a step toward invisibility." *The New York Times*, 20 October 2006
2. Rincon, Paul. "Experts test cloaking technology." *BBC News*, 19 October 2006. <http://news.bbc.co.uk/2/hi/science/nature/6064620.stm>

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Noble Prizes

On October 5, 2006, the scientific community was focused on Harvard's Sander's Theater. It was the night of, not the Nobel Prize Ceremony, but the Ig Nobel Prizes. Founded in 1991 by Marc Abrahams, the Ig Nobel Prizes are handed out by actual Nobel Laureates to honor the achievements of those who have done things that "first make people laugh, and then make them think."

With winners in 10 categories, prizes were awarded for everything from studies by Ivan R. Schwab of the University of California Davis and the late Philip R.A. May of the University of California Los Angeles on why woodpeckers do not get headaches (Ornithology Prize) to the invention of telephone ring tones audible to teenagers but not to adults (Peace Prize) by Howard Stapleton of Merthyr Tydfil, Wales.

The subject of food seemed to be particularly popular as the Chemistry and Biology Prizes both went to experiments on cheddar and limburger cheeses, respectively, and the Physics Prize to a study on spaghetti and why it often tends to break into more than two pieces.

The Medicine Prize went to Francis M. Fesmire of the University of Tennessee College of Medicine, along with Majed Odeh, Harry Bassan, and Arie Oliven of Bnai Zion Medical Center in Israel, for their work on "the termination of intractable hiccups with digital rectal massage," while the Mathematics Award went to Nic Svenson and Piers Barnes of the Australian Commonwealth Scientific and Research Organization for calculating the number of photographs that must be taken to (almost) guarantee that nobody in a group photo will have their eyes closed.

Perhaps the most entertaining part of the ceremony itself was the creative attire of not only the enthusiastic spectators, but the winners themselves, many of whom dressed up in costumes in keeping with the spirit of the night's festivities [1].

—Susan Ehrenkranz De Wolf

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[1] "Improbable Research." 30 October 2006. URL: <www.improbable.com>.