Groundwater dropping globally

GROUNDWATER levels have dropped in many places across the globe over the past nine years, a pair of gravity-monitoring satellites finds. This trend raises concerns that farmers are pumping too much water out of the ground in dry regions.

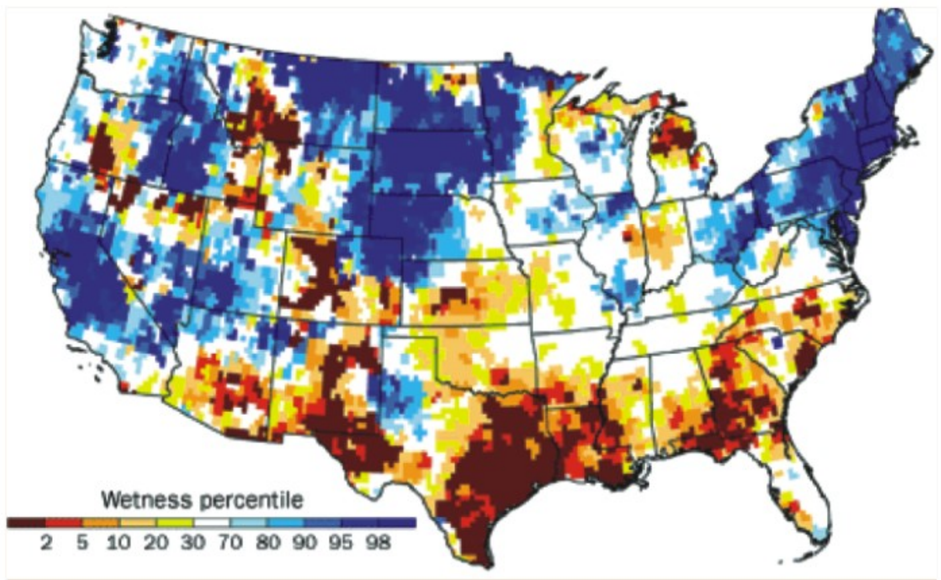
Water has been disappearing beneath southern Argentina, western Australia and stretches of the United States. The decline is especially pronounced in parts of California, India, the Middle East and China, where expanding agriculture has increased water demand.

"Groundwater is being depleted at a rapid clip in virtually of all of the major aquifers in the world's arid and semiarid regions," says Jay Famiglietti, a hydrologist at the University of California Center for Hydrologic Modeling in Irvine, whose team presented the new trends December 6 at a meeting of the American Geophysical Union.

Famiglietti and his colleagues detect water hidden below the surface using the modern equivalent of a dowsing rod: a pair of car-sized satellites, nicknamed Tom and Jerry, that are especially sensitive to the tug of gravity from below.

This joint mission between NASA and the German Aerospace Center called the Gravity Recovery and Climate Experiment, or GRACE has been creating monthly snapshots of global groundwater since 2002. The trends now identified in this data help fill in monitoring gaps and confirm problems in places where official groundwater information is unreliable or nonexistent.

"GRACE is very good for areas of the world where we don't have good ground observations," says Marc Bierkens, a hydrologist who studies groundwater at Utrecht University in the Netherlands.



Simulation based on data from the GRACE satellites and historical weather records reveals the effects of this year's drought in Texas (driest conditions shown in dark red)

China, for example, has been shown to underestimate groundwater use. The country lacks the nationwide network of monitoring wells found in the United States. GRACE's measurements suggest that water levels have been dropping six or seven centimeters per year beneath plains in the northeast.

In some areas, short-term climate variability may be to blame. For example, the plains of Patagonia in Argentina and areas across the southeastern United States areas that have been hit hard by droughts store less groundwater today than they did in 2002.

But there's little doubt as to what's behind the biggest drops: farming. An agricultural boom in northern India has helped to squeeze nearly 18 cubic kilometers of water from the ground every year (SN: 9/12/09, p. 5). That's enough water to fill more than seven million Olympic swimming pools. And in California's Central Valley, which supports about one-sixth of the nation's irrigated land, the ground has been sinking for decades as landowners drill more wells and pull out almost 4 cubic kilometers of water per year (SN: 1/16/10, p. 14).

"People are using groundwater faster than it can be naturally recharged," says Matthew Rodell, a hydrologist and GRACE team member at NASA's Goddard Space Flight Center in Greenbelt, Md.

Agricultural pressures are particularly worrisome in places like the Middle East, another hotspot on the new GRACE map. Water pumped out of the Arabian aquifer beneath Saudi Arabia and surrounding countries today fell as rain thousands of years ago. Once this fossil water disappears, there's little new rainfall to replenish it.

Climate change will only worsen the problem, says Famiglietti. Precipitation patterns are becoming more extreme, increasing the severity of droughts. Wet areas are also becoming wetter and dry areas drier, which may accelerate declines in groundwater in some places over the coming years.

But even as the researchers sound the alarm, they don't know how loud to crank up the volume. GRACE reveals only changes in groundwater. It doesn't divulge how much water is left.

"We don't really know how stressed the world's largest aquifers are," says Sasha Richey of the University of California Center for Hydrologic Modeling.

Some reservoirs, like the giant Nubian Aquifer that underlies North Africa, may be large enough to meet demand for centuries. But few reliable estimates exist of the amount of groundwater stored in the world's aquifers.

Despite the uncertainties, Leonard Konikow, a hydrogeologist at the U.S. Geological Survey in Reston, Va., says that water use has become unsustainable in many places. Better irrigation systems that use less water could help to curb the problem, he says. So could channeling water during especially wet periods into aquifers instead of letting it run off into the ocean.

"There are too many areas in the world where groundwater development far exceeds a sustainable level," says Konikow. "Something will have to change."

Source: Science News

FIRMAMENT FATS

Stars in the sky

DEBASHISH CHAKRABARTY

IN the 2nd century BC, Hipparchus classified the visible stars in the night sky according to their brightness, and by the time of Ptolemy (around 140 AD) it was customary to categorize the stars into six "magnitudes", with the "first magnitude" being the brightest stars, and the sixth being the faintest stars visible to the naked eye.

In the mid 1800's this traditional classification scheme was quantified based on precise luminosity measurements (with the aid of telescopes), and it was found that 5 "magnitudes" represents a factor of 100 in actual brightness. A log scale was established, with the "first magnitude" ranging from 0 to +1, the second magnitude ranging from

+1 to +2, and so on. An increase of 1 in magnitude corresponds to a decrease in brightness by a factor of $100^{(1/5)} = 2.51188...$

Using this scale, it was found that the stars traditionally placed in the same category sometimes had brightness's that fall outside the numerical bounds for that category. In fact, a few stars are brighter than the first magnitude, so to accommodate these extreme cases it's necessary to assign them negative magnitudes. The brightest star in the sky is Sirius, whose magnitude is -1.45.

(Incidentally, Sirius is called the Dog Star, since it's the most prominent star in the constellation Canis Major, and it becomes visible in the Northern hemisphere only during a certain span of time in the summer, which is why we call that period the "dog days of summer".) The next brightest star visible from Earth is Canopus, which has a magnitude of -0.7. However, this star is in the Southern sky and is not visible from most places in the Northern hemisphere.

Sirius and Canopus are the only two stars with significantly negative "magnitudes". Alpha Centauri and Arcturus (the 3rd and 4th brightest stars in the sky) have magnitudes very close to 0.0 (actually just slightly negative), and all the remaining stars have positive magnitude. Only about a dozen stars have magnitude less than (i.e., brighter than) 1.0.

Here's a little chart showing the maximum apparent magnitudes of various astronomical objects

QUANTUM DOTS

This paste of cadmium sulfide-coated titanium dioxide nanoparticles could turn large surfaces into solar cells

Paint-on solar cell

IMAGINE if the next coat of paint you put on the outside of your home generates electricity from light -- electricity that can be used to power the appliances and equipment on the inside.

A team of researchers at the University of Notre Dame has made a major advance toward this vision by creating an inexpensive "solar paint" that uses semiconducting nanoparticles to produce energy.

"We want to do something transformative, to move beyond current silicon-based solar technology," says Prashant Kamat, John A. Zahm Professor of Science in Chemistry and Biochemistry and an investigator in Notre Dame's Center for Nano Science and Technology (NDnano), who leads the research.

"By incorporating power-producing nanoparticles, called quantum dots, into a spreadable compound, we've made a one-coat solar paint that can be applied to any conductive surface without special equipment."

The team's search for the new material, described in the journalACS Nano, centered on nano-sized particles of titanium dioxide, which were coated with either cadmium sulfide or cadmium selenide. The particles were then suspended in a water-alcohol mixture to create a paste.

When the paste was brushed onto a transparent conducting material and exposed to light, it created electricity.

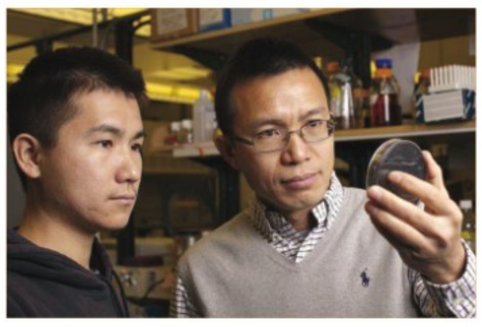
Source: Science Daily

FILCHING BRICKS

How bacteria make home

BACTERIA are able to build camouflaged homes for themselves inside healthy cells -- and cause disease -- by manipulating a natural cellular process.

Purdue University biologists led a team that revealed how a pair of proteins from the bacteria Legionella pneumophila, which causes Legionnaires disease, alters a host protein in order to divert raw materials within the cell for use in building and disguising a large structure that houses the bacteria as it replicates.



Professor Zhao-Qing Luo, at right, and student Yunhao Tan look at the growth of Legionella pneumophila bacteria in a petri dish

Zhao-Qing Luo, the associate professor of biological sciences who headed the study, said the modification of the host protein creates a dam, blocking proteins that would be used as bricks in cellular construction from reaching their destination. The protein "bricks" are then diverted and incorporated into a bacterial structure called a vacuole that houses bacteria as it replicates within the cell. Because the vacuole contains materials natural to the cell, it goes unrecognized as a foreign structure.

"The bacterial proteins use the cellular membrane proteins to build their house, which is sort of like a balloon," Luo said. "It needs to stretch and grow bigger as more bacterial replication occurs. The membrane material helps the vacuole be more rubbery and stretchy, and it also camouflages the structure. The bacteria is stealing material from the cell to build their own house and then disguising it so it blends in with the neighborhood."

The method by which the bacteria achieve this theft is what was most surprising to Luo.

The bacterial proteins, named AnkX and Lem3, modify the host protein through a biochemical process called phosphorylcholination that is used by healthy cells to regulate immune response. Phosphorylcholination is known to happen in many organisms and involves adding a small chemical group, called the phosphorylcholine moiety, to a target molecule, he said.

The team discovered that AnkX adds the phosphorylcholine moiety to a host protein involved in moving proteins from the cell's endoplasmic reticulum to their cellular destinations. The modification effectively shuts down this process and creates a dam that blocks the proteins from reaching their destination.

The bacterial protein Lem3 is positioned outside the vacuole and reverses the modification of the host protein to ensure that the protein "bricks" are free to be used in creation of the bacterial structure.

This study was the first to identify proteins that directly add and remove the phosphorylcholine moiety, Luo said.

"We were surprised to find that the bacterial proteins use the phosphorylcholination process and to discover that this process is reversible," he said. "This is evidence of a new way signals are relayed within cells, and we are eager to investigate it."

The team also found that the phosphorylcholination reaction is carried out at a specific site on the protein called the Fic domain. Previous studies had shown this site induced a different reaction called AMPylation.

It is rare for a domain to catalyze more than one reaction, and it was thought this site's only responsibility was to transfer the chemical group necessary for AMPylation, Luo said.

"Revealing that this domain has dual roles is very important to identify or screen for compounds to inhibit its activity and fight disease," he said. "This domain has a much broader involvement in biochemical reactions than we thought and may be a promising target for effective treatments."

During infection bacteria deliver hundreds of proteins into healthy cells that alter cellular processes to turn the hostile environment into one hospitable to bacterial replication, but the specific roles of only about 20 proteins are known, Luo said.

Source: Science Daily

BIRD POWER

Pigeon's maths talent

PIGEONS, who aren't even distant uncles to a monkey, have matched primates in a test of learning an abstract numerical concept.

Trained on one-two-three, the pigeons then had to put pairs of numbers up to nine in order, says comparative psychologist Damian Scarf of the University of Otago in New Zealand. Pigeons rivaled rhesus monkeys tested earlier at the same task, Scarf and his colleagues report in the Dec. 23 Science.

The results "suggest that despite completely different brain organization and hundreds of millions of years of evolutionary divergence, pigeons and monkeys solve this problem in a similar way," says Elizabeth Brannon of Duke University, a coauthor of the original study of numerical order in monkeys.

Humankind may be pretty proud of its numerical prowess, but numbers four succulent fruits versus eight, one lurking lion versus three matter very much in animal life, too. Research is uncovering various kinds of number-related abilities in animals as diverse as the honeybee, mosquitofish, grey parrot, Plethodon salamanders and a waterbird called a coot.

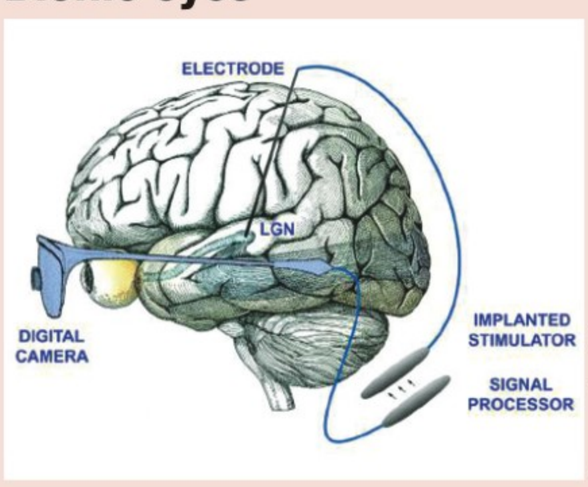
So pigeons could be compared with other species, Scarf used Brannon's numerical-order test, which baboons and lemurs as well as some monkeys have passed. For training, pigeons saw computer screens displaying sets of three images, each with one, two or three shapes. The shapes varied so that a bird couldn't get the number order right just by pecking at increasing surface area. Scarf then rewarded birds for pecking in one-shape, two-shapes, three-shapes order.

Source: Science News

Pigeons rival rhesus monkeys at putting groups of shapes in numerical order

SIGHT AGAIN

Bionic eyes

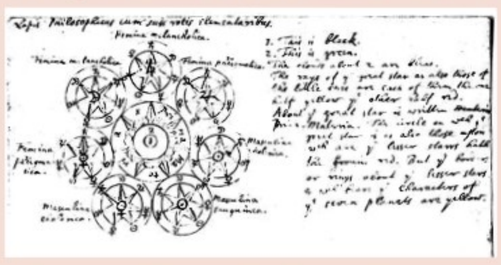


Source: Live Science

When you're blind, being able to see even the basics of light, movement and shape can make a big difference. Both the Argus II Retinal Prosthesis, currently in FDA trials, and a system being developed by Harvard Research Fellow Dr. John Pezaris record basic visual information via camera, process it into electronic signals and send it wirelessly to implanted electrodes. The Argus II uses electrodes implanted in the eye, which could help people who've lost some of their retinal function. Dr. Pezaris' system, still in the early stages of research, would bypass the eyes entirely, sending visual data straight to the brain.

DID YOU KNOW?

Do you know Newton the Alchemist?



A recently rediscovered papers of Newton revealed his secret interest in alchemy (of turning base metal into gold) and that he wrote extensively about his experiments:

Newton's alchemical studies were kept secret during his lifetime. The making of gold and silver was a felony under an act of 1404.

Newton was a creature of his time when many scholars believed in a philosopher's stone that could transmute base metal into gold. They tended to record their studies in wilfully obscure language.

(Source: Guardian)