World Science News in Review

BIOLOGICAL SCIENCES

Genetic basis to alcoholism revealed

In a recent report in the Journal of Neuroscience, Todd E. Thiele of the University of Washington, and colleagues, state that children of alcoholics are less sensitive to the "biochemical, motor, and perceptual changes induced by intoxicating levels of ethanol relative to children without a family history of alcoholism." It was also noted that these children are at an increased risk for developing alcoholism.

New studies by Thiele and colleagues on mice indicate a strong genetic basis to alcoholism. Mice, bred with behavior remarkably close to that of alcoholism and lacking a gene encoding a specific segment of an enzyme called Protein Kinase A, suffered from deficits in biochemical activity involving Protein Kinase A. Protein Kinase A helps convey chemical signals from the environment to the parts of cells responsible for rendering a gene active or inactive.

The missing gene resulted in a number of metabolic and behavioral effects, including the ability to consume more alcohol than normal mice, to drink significantly stronger alcohol solutions, and to recover far more rapidly from alcohol-induced stupor.

Similar studies on flies reflected a genetic basis for alcohol sensitivity as well. Thiele also showed that mice lacking a substance called Neuropeptide Y drink increased amounts of alcohol and can withstand alcohol-induced sedation. Neuropeptide Y, an important brain chemical, appears to be involved in the same biochemical pathway as Protein Kinase A. Thus, gross alterations in this pathway are responsible for alcoholic behavior.

Future research will uncover whether variations in the biochemical behavior of this pathway are responsible for alcoholism in humans.

Key brain receptor controls response to opiates

Neuroscientists have often coveted the infamous "substance P", a molecule in the brain involved in emotional responses as worrisome as depression and anxiety. The molecule, long believed to hold keys to the understanding of pleasure and pain, now appears to play a central role in the brain's reaction to opiates: drugs like morphine and heroin.

As Stephen Hunt and colleagues report in the May 11 edition of Nature, mice bred to lack a substance P receptor known as neurokinin-1 (NK-1) are less responsive that normal mice to pain. These mice also seem to lack the basic behaviors associated with stress. The mice even fail to act aggressively.

Hunt shows, in his most recent paper, that mice lacking NK-1 fail to respond to substance P and do not experience the pleasurable effects of morphine. The results may have implications for human therapy. Emotional problems like stress or anxiety could be alleviated. But even seemingly unrelated syndromes, like eating disorders, have been correlated to stress and may be resolved through inhibition of NK-1 and its numbing effect on stress and pain.

But wait: the elimination of NK-1 is no hedonist's dream-come-true. The processing of substance P, in an area of the brain known as the nucleus accumbens is associated with the motivation factors for eating and other essential behaviors. And pain is—no matter how unpleasant—an important component of a functioning individual's sensory shield against harm.

Nevertheless, Hunt suggests that NK-1 inhibitors could be used to help drug addicts. Mice lacking the receptor failed to experience the physical effects of morphine withdrawal, suggesting that humans addicted to drugs might be treated in a more efficacious manner. If the link between substance P and stress is indeed a strong one, an NK-1 dampening drug could also eliminate the craving for drugs altogether.

Deadly spider toxins may protect plants

Researchers in Australia and America recently suggested that cereal crops should be made as poisonous as one of the deadliest spiders on Earth. Toxins from the Australian funnel web spider, they report, could make "ideal, and environmentally friendly, plant-produced pesticides".

According to Glenn F. King at the University of Connecticut Medical Center, and colleagues, "crops given the genetic instructions to make the spider toxins would only be poisonous to pests".

Since insects are gradually evolving resistance to conventional pesticides, stronger pesticides are definitely needed.

The venom of the Blue Mountain Spider (Hadronyche versuta) contains over 100 toxins. While all of the toxins combined can kill insects and humans alike, individually the toxins are not all poisonous to us. That is, some are specific for killing insects.

Three years ago, King's group in Australia found one such toxin. In a recent issue of Nature Structural Biology, King reported another more potent insect-specific toxin, which sends the nervous system of cockroaches into overdrive, leading to

paralysis and death.

The toxin consists of 36 or 37 amino-acid building blocks, carefully folded in a specific three-dimensional shape. King named the new toxin Janus-faced atracotoxin, as these new proteins feature "two distinct molecular faces".

Since these venom toxins are too expensive to purify or mass-produce, King suggests "that cereal plants could be given the gene to produce the spider pesticides for themselves, making them toxic to the bite of a hungry caterpillar." This will admittedly be a very controversial practice in Europe, says King, as some researchers fear that the venom gene may leak into the environment.

King also suggested splicing the gene into viruses infecting moths and butterflies, delivering the toxin directly to its target. He is currently negotiating with companies to develop the technology further. The selectivity of the virus would make it incredibly safe, he states, although convincing the public of that is another story.

Natural antibiotics diversify protection

Decades of overuse of antibiotics have rendered many strains of bacteria resistant to the most common antibiotic agents used to combat infection. In 1992 alone, over 13,000 people died in US hospitals resulting from infections caused by resistant bacteria.

A team of US chemists reported in the Journal of the American Chemical Society that natural antibiotics could lead to a varied arsenal of anti-bacterial drugs.

Natural antibiotics have a wide range of structures, including macrolides and polyketides. One of the most common polyketides in use today is erythromycin, which contains carbon and oxygen atoms arranged in a ring-like structure. Erythromycin, like penicillin, is produced by a mold and is used to treat a variety of bacterial infections, including bronchitis.

Polyketide antibiotics are unusual in that a single synthase enzyme facilitates successive steps in the synthetic pathway, whereas in most natural antibiotics a different enzyme mediates each step. The polyketide sythases consist of a number of modules, each responsible for adding a few atoms to the polyketide chain.

Chaitan Khosla of Stanford University in California, and colleagues, are redesigning these synthases in the hopes of constructing a more potent group of polyketide antibiotics. By changing the order of steps in the synthetic pathway or altering the starting material, the researchers plan to generate libraries of polyketide molecules that can then be tested for antibiotic activity.

Khosla's group studied the modular enzyme DEBS, responsible for synthesizing the molecule from which erythromycin is ultimately made. They presented lone modules of DEBS each with different starting material. Surprisingly, the modules preferred non-natural substances.

These results indicated "the most important factor driving the evolution of the modules is not that they work as efficiently as possible but that they make the most biologically effective product—the best antibiotic agent."

Thus, redesigned polyketide synthases may be able to operate on non-natural starting materials, but their ability to do so remains difficult to predict on the basis of their normal function in the cell.

Synthetic molecule mimics hormones

The human body is able to regulate itself by a kind of molecular communication known as signal transduction, in which a molecule in a target cell will respond to a chemical messenger by altering its conformation to trigger new chemical processes.

German chemists Ulrich Koert and colleagues at Humbolt University have designed a synthetic messenger molecule that acts according to the same principles as hormones—it grasps a target, changes shape, and passes a chemical signal.

Hormones such as adrenaline and insulin act as chemical messengers. Synthesized in specialized glands, they are released into the bloodstream where they bind to a receptor on a target cell. These receptor proteins alter their shape, triggering molecules called G proteins to initiate a cascade of chemical processes that transmit the message to the cell.

The molecule synthesized by Koert consists of three units: a receptor, a transducer, and an effector, as reported in the journal Angewandte Chemiel.

The receptor, a "pair of molecular claws", grasps the target, a zinc atom. The transducer unit consists of a backbone of three carbon rings linked side-to-side, attached to the receptor at one of the rings. Once the zinc atom is captured, the rings are turned inside out and the entire backbone changes shape.

The effector unit is comprised of two arms with fluorescent groups at their tips, absorbing light of one wavelength and emitting it at a slightly changed wavelength. Initially close together, the arms swing open upon the change in backbone configuration, thereby causing the groups to emit light of a shorter wavelength. UV light is transmitted as opposed to blue-green light, this change representing the "output signal" for the molecule.

While the principles behind this synthetic transducer are not new, it has paved the way for novel ideas. Perhaps researchers can synthesize a molecule with arms at each end, capable of responding to one chemical signal by releasing another. Or perhaps because of its strong resemblance to the structure of cholesterol, embedded in the cell membrane, this new molecule may be inserted into cell membranes as a means of signal transduction. Regardless of what researchers choose to do with this newfound molecule, the future seems bright.

Stem cells clear away the clouds for cornea patients

The hoopla concerning stem cell research over the past few years has produced the idea that tissues—perhaps even entire organ systems—might be produced for those in need of transplants. Although the prospect seemed far away, two teams

now report that they have artificially constructed one of the most complex portions of the eye: the human cornea.

Ray Jui-Fang Tsai of the Chang Gung Memorial Hospital of Taoyun, Taiwan and Ivan R. Schwab and R. Rivkah Isseroff of the University of California, Davis both describe the bioengineering of the cornea, producing a clear, thin film of epithelial tissue for use in transplants. The fragile cornea, which sometimes becomes clouded or cracks, often results in vision loss in the elderly. And normal transplants mostly fail.

The two teams now report that, using different approaches, they have been able to successfully transplant bioengineering corneas into the victims of vision loss.

Those patients had damaged corneas with depleted stem cells, a situation that would lead to scarring and opacity if a normal transplant were performed.

Tsai solved the problem by growing some corneal stem cells from the patient's healthy eye and feeding them into an amniotic membrane matrix. The cells grew into a layer of tissue that could then be stitched into an impaired eye, replacing damaged corneal tissue. Of the six patients Tsai treated, all regained vision.

But Schwab and Isseroff used a different approach, which reversed vision loss in 10 of 14 patients. They harvested stem cells from the donor, too; but the team first divided them into groups, some of which were placed on amniotic membrane, others frozen for later use. That way, if the transplant failed, the group could provide further treatment without reharvesting the stem cells.

Unfortunately, the results of these two experiments have not been assessed on the long term. But the biomaterials used will already be available in clinics for patients in need of immediate care. "The really exciting thing is where this can take us," Schwab said to reporters at Nature. "Replacing diseased tissues and organs with bioengineered tissue is rapidly moving from the realm of science fiction to reality."

Cell fusions create genetically engineered sheep

The same researchers who created the cloned sheep Dolly and Polly now introduce the genetically modified sheep Cupid and Diana—a major step in the history of genetic engineering. Previously, genetic engineering was carried out by mutating the stem cells of mouse embryos. Modification could result in 'knock-outs' of genes to mimic human disorders. However, mutation of stem cells from other mammals proved unsuccessful.

Alexander Kind and his group at PPL Therapeutics in Edinburg used a simple variation of their cloning procedure to obtain the genetically engineered sheep. Instead of mutating stem cells of an embryo, the group fused a genetically modified sheep cell with sheep eggs whose nuclei had been removed. The egg cell then matured normally. The engineered sheep contained the human gene for alpha-1-antitrypsin along with a gene triggering production of the enzyme only in sheep with mammary glands.

Fourteen clone sheep were created, of whom three (Cupid, Diana, and an unaffected sheep) survive. Diana's milk contains high levels of alpha-1-antitrypsin. Dave Solter, a researcher at the Max Planck Institute of Immunobiology in Freiburg, German, points out that "It was inevitable that this step forward would be taken as soon as the nuclear transfer technique was developed."

While this technique will not, obviously, be used on humans, there is a wide range of alternative uses for this technique." All inbreed dogs seem to have some kind of inherent genetic disorder and these could be corrected," said Solter. Other options include genetically modified farm animals and research animals.

Waste becomes clean energy source

In the age of recycling, 'waste not' is a defining rule. But now, some scientists suggest that waste might be recycled itself, used as a biogas for fuel. Chemists at the Queens University of Belfast, Northern Ireland, revealed in early July that they have devised a way to burn biogas without producing polluting by-products.

Bacteria in swamps and other areas in fact, regularly produce biogas. But most of this fuel is not used because it produces polluting products. The biofuel can also be made by using anaerobic bacteria grown on waste material in airtight tanks.

Robert Burch and Barry Southward now propose that biogas from waste treatment plants in municipal areas or from agricultural sources be used as a renewable energy source. If the fuel is simply burned, it produces ammonia, which generates noxious gases upon further reaction. The two scientists have, however, reported that they have found a catalyst to efficiently convert ammonia into nitrogen gas instead of nitrous oxides. The catalyst is the first to allow for conversion at low temperatures, and consists of a simple mixture of copper oxide and platinum on aluminum oxide.

The report, in July's "Chemical Communications", suggests that use of this catalyst might be the first step to using waste material as a clean, efficient energy source.

Antibodies fight chemical warfare

Despite seemingly endless debate and political controversy surrounding the use of chemical weapons, some biologists have taken no risks. Plotting ahead with plans to avert major catastrophe, a team of French researchers reported in July that they plan to destroy the toxic substances used in chemical weapons from the inside out: using the body's own antibodies.

Currently, chemical weapons are interdicted using artificial enzymes that hydrolyze, or split, common nerve agents called "organophosphorus" compounds. But for some nerve gases, enzymes don't work and may not even be readily available to treat nerve gas victims.

Pierre-Yves Renard of the CEA Service des Molicules Marquies at Saclay, France, and colleagues have reported that to destroy these nerve gases, one could use a modified antibody. Renard reported in The Proceedings of the National Academy of Sciences USA that antibodies can be tagged to attack specific nerve gas molecules.

Antibodies are normally used by the body's immune system to protect us from infections by attaching themselves to invading particles and marking these invaders for destruction by immune cells. But when nerve gas is attached to these antibodies, the antibodies can be used as enzymes to catalyze the destruction of the nerve gas molecules.

The antibodies constructed by Renard were raised in mice to correspond to the transition states of VX nerve gas. Renard then established that these catalytic antibodies neutralized VX itself.

The possibility of using such antibodies in actual nerve gas cases is strong. Although several nations signed a chemical weapons treaty the Chemical Weapons Convention, many did not, and so are not prohibited from using chemical weapons.

Killer T cells lose their bite when HIV hits

Victor Appay of the Institute of Molecular Medicine at the John Radcliffe Hospital in Oxford, UK, and his colleagues explain in the Journal of Experimental Medicine that certain anti-viral "killer T cells" in people infected with HIV lose their sting over time.

CD8 T lymphocytes, commonly called "killer T cells," are part of the body's front-line of defense. They kill virus-infected cells and produce anti-viral proteins that interfere with virus multiplication. In CD8 T cells that recognize HIV antigens and attack HIV-infected cells, HIV hinders the former function.

In patients who have the virus but have yet to develop AIDS, CD8 T lymphocytes produce small amounts of perforin, a protein that leads to the death of an infected cell. The CD8 T lymphocytes continue to release normal amounts of cytokine proteins, which help kill the virus directly.

To fully mature, CD8 T cells need the help of CD4 T cells. However, HIV directly infects and switches off CD4 cells. Their gradual loss brings on the severely immunodeficient state of AIDS. It is theorized that the disappearance of CD4 T cells also strands the HIV-responsive CD8 T cells at an immature stage of development. The stunted CD8 T cells continue to produce anti-viral proteins, however.

For years, scientists have wondered why the immune systems of HIV-infected patients hold the virus in check for years without eradicating it completely. These findings may help explain what happens during this silent period of chronic HIV infection.

'Super-aspirin' inhibits cancer

One in a hundred colorectal cancer patients lives in constant fear of a relapse. These patients are genetically predisposed to growing clumps of precancerous cells, termed polyps, in their colon. If left untreated, the polyps become cancerous and lethal. The disease, termed familial adenomatous polyposis (FAP), could only be cured until recently by surgery.

Work by Gideon Steinback and his colleagues of the University of Texas in Houston, however, suggests that ingestion of celecoxib may reduce the number and size of polyps—and, correspondingly, the incidence of colon cancer.

Colecoxib, also known as 'super-aspirin', is a non-steroidal anti-inflammatory drug (NSAID), like aspirin. While most NSAIDs inhibit the cancer-produced enzymes *Cox1* and *Cox2*, celecoxib inhibits only *Cox2*. By doing this, celecoxib avoids the side effects that result from NSAID inhibition of *Cox1*: gastric ulcers and hemorrhage. *Cox2* is a formative agent in polyp formation.

This work represents the first time a drug could be used to affect polyps. In this, Mayeto Mark Taketo of the Graduate School of Pharmaceutical Sciences in the University of Tokyo, Celecoxib is extremely useful. "It would be very beneficial to young FAP patients if we could postpone surgery even for 5, 10 or 15 years while they are taking celecoxib, because radical operations of the colon can affect not only the quality of their lives but also their psychological development."

Gene driving metastasis discovered

Cancer-treating physicians have long been frustrated by the process of metastasis, through which cancer cells are able to break off tumors and travel to other parts of the body. The behavior, which can have fatal consequences and is responsible for 90 percent of cancer deaths, is reportedly controlled by a single gene identified by MIT researchers and discussed in a report in the August 3 issue of Nature.

Edwin A. Clark, who, while conducting his work, was a post-doctoral fellow in the Hynes laboratory at MIT's Center for Cancer Research, reported the research. Clark used mouse and human models of melanoma (skin cancer) along with data from the Human Genome Project and gene expression tools called DNA arrays to identify genes that might be responsible for regulating metastasis.

Clark and colleagues examined variants of melanoma cells, classifying them according to their ability to metastasize. They then used DNA arrays to determine how expression patterns of certain genes varied between the metastasizing cells and non-metastasizing cells. They found that 32 genes were expressed more strongly in metastatic cells than in non-metastatic controls.

Clark noticed that the genes were all either cell adhesion, cytoskeletal, or blood cell forming genes. One of these, *rhoC*, is a regulator of both cytoskeletal structure and cell movement, making it a highly likely candidate for metastasis. Clark investigated the gene and found that it played a central role in the metastasis process.

"If we overexpress *rhoC* in poorly metastatic cells, they become highly metastatic. If we express an inhibitor of it in highly metastatic cells, then they show reduced metastasis," said Richard Hynes, Director of the Center for Cancer Research. Hynes also suggested that the discovery of rhoC's involvement in metastasis could provide the basis for new cancer therapies.

"I believe that invasion and metastasis are now ripe for a concerted attack because of two scientific advances: our deeper understanding of the molecular basis of cell adhesion based on

the past couple of decades of cell biology and the availability of mammalian genomic sequences and methods for exploiting that information."

Chocolate keeps arteries clean

As if one needed yet another reason for eating chocolate, yet another has been created: Chocolate is good for your heart. Chocolate, according to a recent report in the American Journal of Clinical Nutrition, contains flavanoids.

Flavanoids, which may also be found in red wine, tea, onions, and parsley, protect the heart in two ways.

They reduce the amount of low-density lipoproteins (the 'bad' cholesterol) in the blood. Flavanoids also reduce the clumping of blood platelets, a symptom that sometimes leads to atherosclerosis.

Carl Keen from the Department of Nutrition of the University of California at Davis found that subjects who drank cocoa, as opposed to caffeinated drinks and water, had lower platelet activation. Blood took longer to clot. Despite this, the benefits of chocolate in combating atherosclerosis is debatable.

Tissa Kappagoda of the Preventive Cardiology Unit of the University of California at Davis warns that chocolate "contains a significant proportion of fat calories and it may not be the best option for patients with coronary atherosclerosis".

Depression influences developing fetuses

Prenatal depression affects the developing fetus in many negative ways, including premature birth, lowered IQ in later life, and slower response time.

Fetuses and newborns have levels of cortisol that reflect maternal levels. High levels of this hormone are often found in depressed people.

Tiffany Field of Nova Southeastern University in Fort Lauderdale, Florida, notes that "If you measure the cortisol level in the mother at 28 weeks gestation, you can predict with 98% certainty if the baby will be born premature." Massage and exercise that lowers cortisol levels seem to counteract this effect.

The brain activity of two-day-old babies of depressed mothers is concentrated in the right side, often associated with negative emotions. These babies respond poorly to the "Brazelton assessment," a test for newborns that analyzes facial expression, movement and response to sound.

Depressed babies also have erratic sleep patterns in which they frequently alternate between deep and active sleep, which is called "indeterminate sleep." It turns out that the only neonatal variable that has any bearing on the predicted IQ of 12-year-olds was whether or not they had had indeterminate sleep.

Another group looked into whether or not full-term newborns of depressed mothers differ in their behavior and responses to sensory stimulation. All the babies could distinguish differences in the weight and roughness of objects, but they took twice as long as normal to do so. These babies also showed no preference for their mother's faces and spent less time exploring new objects.

PHYSICAL SCIENCES

Laser shines from chemicals in a beaker

Lasers are now so commonplace that the average student can hardly escape being annoyed by the sight of a red laser dot flash across a lecture hall. Now scientists are planning to dispense them all over: so ubiquitously, in fact, that bacteria might have them.

In the May 22 issue of Applied Physics Letters, Hui Cao and colleagues from Northwestern University describe a new laser no bigger than a microbe. And this is no standard lecture pointer. Mixing chemicals in a beaker produces the laser, reports Cao.

Cao devised a chemical synthesis to generate particles of the semiconductor zinc oxide. The particles, which are a few nanometers in size, can be made to clump together in aggregates, creating a random jumble of nanoparticles inside a beaker. The tiny zinc oxide particles scatter short-wavelength ultraviolet light, much like water droplets in clouds scatter sunlight. The scattering can become so extreme, in fact, that light cannot travel far without being sent in a new direction—causing the light to localize to what Cao calls 'optical cavities'.

When Cao then stimulated his zinc oxide mix with a laser, he found that his concoction emitted ultraviolet light with a very narrow range of wavelengths—the characteristic signature of a laser beam. Normally, laser light's wave-like oscillations are all in sequence with one another, unlike ordinary light. First, light is emitted from a substance that has been 'excited'; then the light stimulates the emission of more light, and a chain reaction results. The light produced is confined to a chamber by mirrors, which cause the light to bounce back and forth, stimulating more emission with each bounce.

The tiny beaker-laser made by Cao might be easier to make than the common mirror-guided laser. So does Cao call for mass production? Not so fast, say his colleagues. One disadvantage of the system is that its properties are hard to control. The emission wavelengths are also randomly generated, and so the laser beam produced might be quite unfocused. Nevertheless, Cao's discovery opens the door to the prospect of true nano-laser light.

Lightning misses the point

New research indicates that the common belief that sharp rods make the best lightning conductors is false, as blunt tips attract lightning more than sharp ones.

According to legend, Benjamin Franklin established the electrical nature of electricity by flying a kite in a thunderstorm. In another experiment, Franklin discharged electrified objects with a metal needle, concluding that a sharp iron rod on rooftops may similarly discharge thunderclouds when lightning strikes. Franklin had successfully invented the lightning conductor.

Recently, however, Charles Moore from the New Mexico Institute of Mining and Technology, and colleagues, discovered that a blunt-tipped rod is in fact a better conductor. Moore set up an array of aluminum rods ranging from half an inch to two inch-

es in diameter at the summit of South Baldy Peak, a 3,288-meter mountain in New Mexico. Blunt and sharp tips were placed approximately six meters apart, thereby giving the lightning a clear choice.

This study was continued for seven years, during which no sharp rods were hit, but twelve blunt rods were struck, as reported in the journal Geophysical Research Letters.

Moore's group also tested new lightning-protection devices called early streamer emitters (ESEs), which apparently reduce the severity of a lightning strike by emitting a "rapid return stroke" (streamer) back up to the thundercloud. These devices are said to provide a greater area of protection and typically use sharp-tipped rods. The researchers concluded that ESEs do not emit "early streamers" during thunderstorms and that they, in fact, do not offer any more protection that any ordinary rod.

Thus, the researchers concluded, "Franklin's method for providing [lightning] protection has been made less effective than it could be, by his urging that the tip of lightning rods be sharpened."

Potent sensor amplifies signal

The best sensors generate large signals when it detects a small amount of the substance of interest, but amplification of the signal is usually done electronically. However, a molecule that acts as both a sensor and an amplifier has been developed by the groups of Vincenzo Balzani at the University of Bologna in Italy, and Fritz Vvgtle, a chemist at the University of Bonn in Germany. Their findings were recently published in Chemical Communications.

Balzani's team has created molecules that signal when they attach themselves to target molecules. Most sensors work in 1:1 relationships; that is, for every target, you need one sensor. However, researchers have made a molecule with 32 light-emitting units that all turn off when the molecule binds a single target, an ion of cobalt.

The sensor is a dendrimer, or cascade of branching molecular chains that form a multi-armed core. The chains clump together to form a roughly spherical shape. In the dendrimer created by Balzani's and Vvgtle's groups, all 32 branch tips glow green under ultraviolet light. The inside chains contain nitrogen atoms that interact with the cobalt ions. When the dendrimer traps one cobalt ion, the 32 branch tips stop fluorescing.

Twenty-five micrograms of cobalt in a liter of water, three to five times the safe daily intake for humans, can produce a significant change in intensity of the sensor.

The value of this research is in its principles, not in immediate practical applications. Designer dendrimer branches may be able to recognize and trap other targets selectively or may become better at amplification. Scientists are currently exploring the possibility of using dendrimers as drug molecule transports or as catalysts.

Diamond yields to beta-carbon nitride in hardness

In 1989, beta-carbon nitride was predicted to be possibly harder than diamond, the hardest known substance. Physicist Marvin Cohen of the University of California first proposed beta-carbon nitride in 1985.

Knowing that hard materials contain atoms linked by short, strong bonds, Cohen realized that similar bonds form between carbon and nitrogen atoms. He believed that these atoms could form a stable crystalline solid where the expected ratio of nitrogen to carbon would be 1:3:1.

Yip-Wah Chung at Northwestern University in Illinois and colleagues report in Applied Physics Letters that they have something matching the description of beta-carbon nitride.

A superlattice of alternating layers of zirconium nitride (ZrN) and a mixture of carbon and nitrogen, each a few atoms thick, has features expected of Cohen's hypothetical material. It is tentatively called CNx, and the precise composition and structure is not fully known.

The strongest evidence comes from measuring X-rays kicked out of the CNx layers by the energetic electron beam, and from the way that the material absorbs infrared radiation. These measurements suggest that the bonds between the carbon and nitrogen atoms have the proper predicted characteristics. And finally, the ratio of nitrogen to carbon in the films matches the prediction of 1:3:1.

Bouncing electrons off the layers shows that CNx films contain orderly, crystalline regions. The density is also roughly the same as that predicted for beta-carbon nitride.

Though promising, this evidence stops short of providing definitive evidence that beta-carbon nitride has been found.

Synthetic surface binds proteins at will

University of Chicago researchers have developed a surface capable of binding and releasing proteins at will. The 'self-assembled monolayer' is created from a molecule-thick coating of 'alkylthiol' organic molecules on a surface of gold. Alkylthiol molecules are composed of an oil-like carbon tail with a sulfur head that binds to the gold. Different ligands may modify the properties of the surface.

Drs. Hodneland and Mrksich reasoned that a surface capable of releasing bound ligands at a trigger would be useful in studying cell adhesion. The ligand chosen was biotin, to which the protein streptavidin binds.

To create the surface, the researchers tipped the carbon tails of alkylthiols with a quinonepropionic ester (QPE), to which the biotin ligand was attached. The QPE responds to voltage, freeing the biotin ligand from the alkylthiol surface. The surface functioned effectively in practice, binding streptavidin to the surface, then releasing it with biotin when voltage was run through the gold surface.

Theoretically, any ligands may be connected to a similar surface, making a number of applications feasible. In addition to studying cellular adhesion, such a surface may be eventually used to control the release of drugs.

Additives make carbon dioxide better solvent

Non-toxic carbon dioxide in its compressed or "supercritical" state is a promising, cheap alternative to organic solvents now used in chemical industry. The gas is colorless, odorless, non-flammable and can be easily depressurized and released after use. It is also a picky solvent. For example, it can strip away caffeine without disturbing the chemicals that give coffee its flavor.

However, as Walter Leitner of Max Planck Institute in Mulheim, Germany, notes, the "poor solubility of many interesting target substances places severe restrictions on the widespread use of carbon dioxide [as a solvent]." Dangerously high pressure or expensive additives must be used to dissolve insoluble catalysts into carbon dioxide.

Fortunately, researchers have developed a suitable, chemical go-between that could lead to widespread carbon dioxide use. Eric J. Beckman and colleagues at the University of Pittsburgh, Pennsylvania, report in Nature that they have a cheap additive that easily dissolves in low-pressure carbon dioxide.

Beckman's group has linked together two distinct chemical groups (polyether and carbonyl). Formerly insoluble catalysts and reagents can be attached to this low-cost chain that falls apart in carbon dioxide. This high solubility helps to dissolve the attached groups. Other functional groups may stabilize useful emulsions between water and carbon dioxide.

This development could dramatically lower the cost of using carbon dioxide in commercial applications such as dry-cleaning and pharmaceutical production.

Scientist plumbs gravity at atomic level

Decades ago, Bose and Einsten proposed the existence of a new state of matter: the Bose-Einstein condensate (BEC), in which atoms are sustained at such low temperatures that they exist in the same quantum ground state. BEC could provide an ideal system from which to study basic quantum phenomena.

In the late June edition of Physics Review Letters, Gershon Kurizki and Duncan O'Dell of the Weizmann Institute report that BEC could also be used to examine atomic responses to forces like gravity.

Kurizki and O'Dell propose that if they were to induce long-range attraction between atoms, the force would produce a gravity-like state; unlike gravity, the force could be made strong enough to allow for an examination of the behavior of atoms at a microscopic level.

The proposal is the first to concern the examination of gravitational forces using BEC. Previously, atoms in BEC could interact only at very short range. But by streaming intense laser light into the BEC, O'Dell and Kruizki say they can induce a long-range force, producing an artificial gravity-like attraction. Their proposed apparatus uses 18 different lasers focused at unique angles to induce the appropriate force.

But MIT Prof. Wolfgang Ketterle told Nature reporters, "The laser power is at the limit of what is available," he said. "To use 18 such beams is extremely difficult."

Alternatively, one could conduct the experiment using lasers of shorter wavelength, creating small condensates with just a few atoms. "The experimental challenges are considerable," admits Duncan O'Dell of Kurizki's group.

But "the ability to emulate gravitational interactions in the lab is fascinating," says Kurizki.

Telescope data confirms Euclidean nature of universe at the Big Bang

The history of cosmology is filled with a spirit of revision. Models are postulated, new observations recorded, old models discarded, and new theories constructed. But in violation of this seemingly impenetrable historical rule, cosmologists recently received data that confirmed an old theory.

"The Boomerang results fit the new cosmology like a glove," Michael S. Turner of the University of Chicago. Turner had been referring to data from the Boomerang telescope, which, along with the telescope Maxima, has been used to confirm postulates about the very beginning of the universe.

To discover fundamental events making up the big bang, both telescopes were used to track levels of cosmic microwave background radiation—radiation sources believed to have been left as remnants of the big bang.

Boomerang flew over Antarctica and tracked just 3 percent of the sky; Maxima covered even less area, flying over Texas, but had greater resolution than its counterpart. By constructing data from the two telescopes, cosmologists determined approximately when the radiation might have been released. It is believed that the photons of background radiation were bound in a plasma state; some parts of the plasma were denser than others, attracting particles toward them. Pressure, on the other hand, pushed the particles apart, creating a battle between pressure and inertia. The plasma oscillated, creating vibrations like sound waves.

Picking up those vibrations in the cosmic atmosphere, Boomerang and Maxima were able to confirm what physicists expected: that oscillations would be found at a particular frequency, then half of that frequency, and so on. Both telescopes confirm that the vibrations existed, and lead to a framework to discuss the very early geometry of the universe. Because of the specific patterns detected by the two telescopes, cosmologists were able to demonstrate that the early universe was in fact Euclidean in form: the rules of Euclidean trigonometry applied. But odd data from the two telescopes also show that the universe is slightly spherical, meaning that it was likely to be very close to completely flat originally and has now been distended by forces of gravity.

Scientists indirectly measure 'dark' matter

Cosmologists have calculated how much matter should be in the Universe, but they can't find it. The mass of all the stars, galaxies, black holes, and light particles, gives only a few per cent of the total. However, David Wittman of Bell Labs, Murray Hill, New Jersey, and his colleagues have a solution. Dark matter can now be measured indirectly, based on the shape of distant galaxies.

Large objects, such as galaxies, bend passing light slightly towards themselves. The heavier they are, the more the light deviates. This "weak gravitational lensing" may be used to estimate how much mass lies between us and distant galaxies. As light from far-off nebulae comes towards us, intervening mass and dark matter causes its path to deviate and distorts the image. The team found that adjacent galaxies appear to be squashed by approximately 1%. These distortions are used to make the calculations.

Their result may knock out the popular "cold dark matter" model, which claims that sub-atomic particles make up most of the missing mass. However, these new findings support the "vacuum-energy" theory—the idea that space itself has a dark energy that may oppose gravity.

The team plans to look at approximately 100 million sources across the sky to develop a picture of the distribution of matter. "We now have a completely independent, direct way of measuring mass distribution—it has a fantastic future," says Anthony Tyson, a member of Wittman's team.

Brown dwarves flare like other stars

Celestial brown dwarfs, though bigger than the biggest planets, are much smaller than the smallest stars, which themselves maintain just enough mass to be able to sustain thermonuclear reactions in their cores. Also known as failed stars, brown dwarfs can only shine about one tenth of a percent as brightly as the sun.

Recently, however, as reported in the July 20 issue of Astrophysical Journal Letters, scientists working with NASA's Chandra X-ray Observatory saw the brown dwarf LP 944-20 unleash a bright x-ray flare. "We were shocked," said Robert Rutledge, professor at the California Institute of Technology. "This is really the mouse that roared. We didn't expect to see flaring from such a lightweight object."

Researchers expected detecting a few photons per hour in observing LP 944-20. However, LP 944-20, like all brown dwarfs, lacks the ability to support strong fusion reactions, obtaining most of its energy from release of gravitational energy as it contract a few inches per year.

"It was as if we were searching for a dim bulb and instead found a bright flash of light," added Lars Bildsten, a researcher from the University of California at Santa Barbara. Moreover, the energy contained in the flare was comparable to a small solar flare and approximately one billion times greater than x-rays emitted from Jupiter.

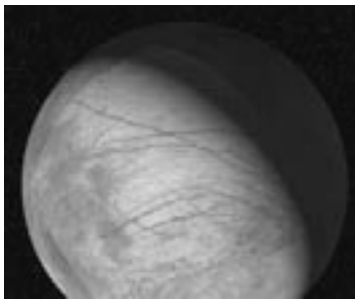
This dynamic flare also offers some evidence that brown dwarfs and perhaps even giant planets have magnetic fields. Principal investigator Gibor Basri suggests that the flare may have resulted from turbulent magnetized material below the surface of LP 944-20, producing a twisted magnetic field. "A subsurface flare could heat the atmosphere, allowing currents to flow and give rise to the x-ray flare-like a stroke of lightning," he remarked.

This x-ray flare, although the first ever observed from a brown dwarf, will most likely not be the last. Basri confirms, "New sky surveys show that the objects may be as common as stars."

The search for aliens turns to Jupiter

Although extraterrestrial life seekers have often looked to Mars for signs of water, spectacular images from NASA's Galileo spacecraft have redirected focus elsewhere: Jupiter's moon Europa. Galileo has taken pictures of what scientists conclude is a liquid water ocean on the Jovian moon hidden beneath surface ice several hundreds of meters thick. But believers in extraterrestrial creatures haven't won this battle: the buried ocean is, unfortunately for them, probably too dark to support complex photosynthetic organisms.

But the latest theory in a hotly contested debate on Europa's frozen ocean suggests that the water body may have indeed supported photosynthetic life at some time in the past. The theory comes from Eric Gaidos of the Jet Propulsion Laboratory in Pasadena and Francis Nimmo of the University of Cambridge, UK. The duo suggest that Jupiter's gravity could cause ice flow on Europa, creating frictional heat and producing warm, soft ice. The warmer ice, they say, explains "ridges" in the moon observed by the Galileo spacecraft after its Jupiter fly-by.



If Gaidos and Nimmo are correct, Europa's ocean could have small pockets of salty water, melted by friction and sufficiently warm to allow "liquid water and sunlight coexist—a requisite combination for photosynthetic life," according to Gaidos. "Terrestrial organisms may be able to survive many thousands of years without a source of energy, frozen in ice or permafrost," he said. But these lifeforms are probably far from the quintessential alien characters invading 1950's movie screen. If they do exist, the organisms are probably frozen bacteria, given a chance to grow because of the combination of sun and water on Europa's warm ice pockets.

The theory, however, has not received a warm welcome from planetary scientists. Gaidos and Nimmo, themselves, admit that a melted water pocket will probably quickly lose heat and may only last for a few years. The problem was discussed by Astrobiologist

Bruce Jakosky of the University of Colorado, who said that "People are trying to understand the liquid water budget, what energy sources there are, and whether there is there adequate energy to support life…we don't know what life would look like in such a different environment."

Mother Earth may wreck anti-pollution drive

Global warming is steadily increasing and shows no sign of stopping. An increase of 0.1 to 0.3 degrees C in the next ten to fifteen years may conclusively prove that the global warming is manmade, but an untimely volcanic eruption may cool the world and stunt current efforts to contain pollution. The most significant attempt to control the greenhouse-gas emissions was the Kyoto Protocol, developed in 1997. In order to be effective, however, the treaty must be ratified with 55 signatures. As of yet, only 22 countries have signed the protocol.

Island and low-lying countries whole-heartedly approve of the protocol, but countries with less to lose are less enthusiastic. Developing countries blame developed nations for the bulk of greenhouse gases, and developed countries are stalling until underdeveloped nations take the first step. This political bickering is only helped by the argument that the greenhouse effect may not be manmade.

William Hyde and Thomas Crowley of Texas A&M University state that a volcano's cooling effect on the earth within the next decade "would likely confuse the debate about temperature trends and impede detection of the climate change signal."

Volcanoes cool the earth by shooting sulfate aerosols into the atmosphere that reflect the Sun's heat and cool the earth. Hyde and Crowley investigated ice cones recording climate-changing eruptions over the past six centuries.

Using this history, they concluded that the possibility of another major eruption within the next decade is 37%. The possibility of two eruptions within a decade is 15%, and the possibility of a single eruption with three times as much cooling effect as a major volcano is 20%.

While these percentiles are crude approximations, they do provide a starting point from which to start working with future climatic changes.

Volcanoes boil sulfur away

New research shows that sulfur, also known as brimstone, may burn up in volcanoes. Sulfur has been long associated with volcanoes, both in ancient mining sites and in the delectable sulfuric stench of rotten eggs around some volcanic regions. Geologists have also sighted lakes of liquid sulfur around a volcano in Costa Rica. Despite this, frozen greenish-yellow flows of sulfur are rarely found around volcanoes. Geologists assumed that this was due to the lack of sulfur around active volcanoes. The only previous sighting of a sulfur flow, documented by Japanese researchers in 1936, supported the assumption that any sulfur present would have solidified.

Andrew Harris and Robert Wright from the Open University, UK, along with Sarah Sherman from the University of Hawaii witnessed a significantly different scene. The molten, dark red sulfur lakes they found burned with a bluish flame, releasing sulfur dioxide. The lake burned away within four hours, leaving a characteristic trench that the researchers found elsewhere around the volcano. The lack of sulfur flows around volcanoes thus seems to be due to the heat of the volcanoes and not to the lack of sulfur itself. This new evidence may force a reconstruction of volcanic deposits on Earth as well as Io, Jupiter's closest moon.

ENGINEERING AND TECHNOLOGY

Molecular transistors show some 'gain'

Miniaturized computers are certainly in demand. The only problem is that silicon chips can only get so small before they start malfunctioning. In response, some scientists have turned to the construction of chips through small molecules with the ultimate goal of producing a molecular transistor.

Transistors are essentially on-off switches, determining whether or not current will flow through a wire by applying a voltage to a 'gate' electrode that sits between the input and output electrodes. Transistors commonly have three terminals: an input ('source') electrode, an output ('drain'), and a control electrode ('gate'). But a transistor is not only a gate: it can also act as an amplifier, boosting weak currents passing through it. This amplifying property, or "gain", is an essential component of any modern information processing circuit.

Although attempts to achieve gain through molecular devices had often resulted in failure, Massimiliano di Ventra of Vanderbilt University and his colleagues report in June 2 edition of Applied Physics Letters that gain may very well be achieved in a molecular device. Di Ventra used computer calculations to predict the behavior of a three-terminal molecular device: a benzene molecule connected with sulfur atoms that acted as drains and sources. Two tiny metal disks placed above and below the ring served as a gate. Using his computer simulation, di Ventra was able to show that the conductance of his model molecule increased sharply if the voltage on the gate was adjusted to a particular value.

A channel through the molecule acted like a bridge for current, an effect known as 'resonant tunneling'. The result demonstrates that a molecule-sized transistor may indeed be a feasible creation—perhaps one arriving to us in the near future.

Metal-binding peptides attract nanocrystals

There are two ways to build an object: carve it from a singular block of material or build it from its many parts. Traditionally, electronic circuits are created using the former method. Flat sheets of silicon with dopant atoms are cut into sandwich-like pieces and carved into useful structures. Researchers now are working to further miniaturize the assem-

bly process by using 'nanocrystals' of semiconducting materials to build circuits.

Nanocrystals are small items, only a few nanometers across. This makes them several times smaller than the transistors in regular integrated circuits. Nanocrystals can then plausibly be used as switching mechanisms or memory element.

The small crystals are organized by metal-binding peptides. Our cells move materials on the same small scale as the nanocrystals. Nature is used to work with organic-based compounds, and is not adapted to semiconductor materials.

Previous research done at the University of Copenhagen revealed that proteins have chemical groups that bond to certain metals. Scientists found peptides that have the right molecular structure to fit on the surface atoms of the metals.

At the University of Texas at Austin, Angela Belcher and other researchers have found the analog of the peptides and metals for semiconducting materials. After 5 rounds of trials of running different peptides chemically linked to protein coats of colphage they discovered which phage particles were capable of sticking to the metals, and from that were able to isolate the useful peptides.

Lasers stretch cells

Researchers at the University of Texas used Newton's third law to create an optical stretcher. Optical stretchers are used to manipulate cells and will allow cancer researchers increased flexibility to handle cells.

The predecessor to the optical stretcher is the optical tweezers. The tweezers consist of two equal and opposite laser beams that hold a cell in between them as the forces from the moving photons cancel each other out. This device is regularly used to manipulate cells, particles, and DNA.

Josef Kas (UT) discovered that by utilizing stronger but less focused laser beams, that cells could be stretched without being damaged.

Before this was revealed, scientists had problems trying to use the tweezers to stretch cells because they were not able to grab the cell strongly enough to pull it. Handles had to be attached to the cells by means of particle attachments to the cells. This technique was limited by how strongly the handles could be attached.

The advent of the optical stretcher will lead to more explorations in cell mechanics and complex deformation of complex cells.

Optical torch to distinguish single molecules soon

Leeuwenhoek's optical microscope is far from out of date in current research. With the development of optical torches (essentially tiny light sources) researchers can now view objects 500 nanometers across lit up by a single-molecule probe.

Vahid Sandoghar and colleagues at the University of Kanstanz (Germany) built their probe based upon an old technique called scanning near-field optical microscopy (SNOM). The restriction of the old technique was that the resolution of the old microscopes could not be focused on a point finer than its own wavelength (diffraction limit).

The optical torch developed by Sandoghar consists of a tapering optical fiber that has a single molecule on its tip. On the molecule, there is a single organic crystal, which has a few molecules of fluorescent terrylene in it. The laser light absorbed by the terrylene molecule can be tuned to excite just one of the terrylene molecules. Thereby, creating a singular molecule of light: the optical torch.

Researchers expect soon to be able to achieve resolutions capable of picking out individual molecules.

Atomic manipulation reveals possibility for quantum chips

The prospect of producing an electronic circuit out of just a few atoms has received hot debate—but with few results. The idea proposed is to use atoms instead of electrons; and while few have produced a chip itself, researchers in Austria recently demonstrated that atoms could in fact be guided along tiny wires, perhaps forming the basis for entirely new types of computers.

Jvrg Schmiedmayer of the University of Innsbruck, Austria and colleagues report in the journal Physical Review Letters that atoms can be moved down chip-sized wires just a few thousandths of a millimeter wide. Schmiedmayer believes that he can use this movement of atoms just like a conventional electron current, performing the computational operations that occur in our everyday computers at an even smaller level. The atomic wires, says Schmiedmayer, could act as magnetic guides to direct atoms in a chip.

Schmiedmayer used gold-plated semiconductor chips etched with 'ditches' to allow electrical current to pass and induce a magnetic field. Combining this magnetic field with fields produced by nearby, thicker wires, the researchers create a magnetic "canyon" to move magnetic atoms along a defined path.

Why use atoms instead of electrons? Unlike electrons, atoms can be moved into quantum states known as Bose-Einstein condensates, allowing for scientists to use the laws of quantum theory to achieve a computing power greater than that in conventional computers.

Quantum logic gate structure proposed

As silicon-base hardware rapidly nears its limits, quantum computers—capable of processing information billions of times greater than conventional machines—seem to be the holy grail of the computer industry. The idea of storing information in the quantum properties of particles was thought up by Nobel Laureate Richard Feynman. A quantum computer would represent data, termed qubits, though the quantum state of particle, such as the spin of the nucleus.

Carlo Jacoboni's group in the University of Modeno, Italy, has proposed a structure for a quantum logic gate—the basic component of a quantum computer. The logic gate, consisting of a pair of superconducting wires separated by a control wire, regulates the passage of electrons through the gate by using

interference properties of quantum particles in the control wire. The setup may be viewed as a preferential capacitor, which allows passage only if the control and data electrons meet and interact. Then, the data electron is pulled to the end of the control wire, where it travels on.

Unfortunately, this system is not robust. Any uncontrolled interaction of the data electron with the environment (termed quantum decoherence) would trigger an unpredictable effect on the system, corrupting the information. In addition, the system must operate at extremely low temperatures to ensure that the electrons pass along the wires without interacting with the outside.

Nonetheless, Jacoboni insists that the logic gate has potential. "Our proposed system allows an arbitrary number of qubits in a very limited space," says Jacoboni. It is also "integrable with the conventional electronics needed to interact with the end user."

The quantum computer is definitely in the future, but Carboni's quantum logic gate may be a large step towards creating it.

Device detects the sound of breaking bonds

Chemists at Cambridge University, UK, have developed a super-sensitive listening device capable of picking up the faintest of noises. The device, invented by David Klenerman and colleagues, is able to detect even the attractive forces between atoms.

Chemical bonds make molecules behave differently from the individual atoms contained within them. Bonds range from weak forces to strong covalent bonding that holds together brittle minerals. Klenerman's group investigated bond strengths using microscopic latex balls stuck to a shaking gold surface of a quartz crystal microbalance (QCM). The surface and the spheres were coated with different chemicals, thus creating stronger bonds. As the surface was shaken, the bonds holding together the balls and the surface ruptured, allowing the balls to roll away.

The rupturing of these chemical bonds generates noise. The gold platform, also vibrating, can be used as a microphone that can detect the range of weak sounds created upon breaking chemical bonds. Using this device, Klenerman's group was able to conclude that a covalent bond is about 600 times stronger than weak, non-specific attraction and ten times stronger than a hydrogen bond.

The group, reporting their results in the journal Langmuiri, states that despite being unable to pinpoint exact bond strengths, this new method could offer revolutionary ways of separating chemicals and produce biosensors capable of detecting biological molecules from the way they link together.

Miniature balance counts bacteria

While it is relatively easy for tests to reveal the presence of specific bacteria in large quantities, it is far more difficult to detect and, furthermore, count individual bacteria of a given species.

Harold G. Craighead and his colleagues from Cornell University at NY and the Institute of Microelectronics at Singapore have created an instrument capable of doing this.

The instrument resembles a miniature set of scales. It consists of a springboard-like cantilever made from silicon nitride. When the lever moves, it deflects a laser aimed at the unattached end. The oscillation frequency of the cantilever, derived from the light deflections, is dependent on the cantilever's mass. Since the cantilever is so small, a relatively small number of bacteria is needed to start oscillation. For example, the researchers demonstrated that a mere 16 E. coli bacteria were necessary to induce a detectable oscillation.

Specificity of the machine for a distinct species is achieved by attaching antibodies to the cantilever. The antibody guarantees specificity not only of species but also of particular strains of bacteria.

The organism used to test the cantilever was *O157:H7*, a toxic strain of E. coli. The scale was able to differentiate between the toxic E. coli and Salmonella bacteria.