School Science

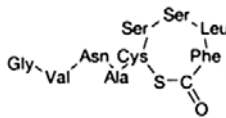## A QUARTERLY JOURNAL OF SCIENCE EDUCATION

Oligopeptide autoinducers

AIP-I (S. aureus)

AIP-II (S. aureus)
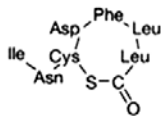
AIP-III (S. aureus)
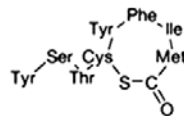
AIP-IV (S. aureus)

Editorial Advisory Committee

Contents

Empowerment of Girl Child, Responsibility of All

EDITORIAL

In the current issue, we have incorporated articles from all streams of Science, including Physics, Chemistry, Biology, Mathematics, etc. The first article 'Cyber Warfare—A Serious Threat to Global Security' is about how cyber warfare has the potential to paralyse crucial government installations and institutions, having serious social and financial ramification. The author also highlights the impact of cyber warfare on individuals' freedom along with UN initiative and the role of CERT (Computer Emergency Response Team) in India.

The second article, 'Quorum Sensing: Cell-to-Cell Signaling Mechanism', describes briefly the role of autoinducer (small chemical signal molecules) in signaling mechanism. Besides, properties and application of quorum sensing have also been elaborated in this article.

The article, 'Problem based Learning in Basic Physics—VIII', talks about solutions for some problems in material properties—elasticity of solid and fluid, as well as, mechanics of fluids. In the article, 'The Method of Finding the Cube Root of Any Perfect Cube Number or Quantity',

three simple processes for finding out the cube root of any perfect cube number have been demonstrated.

The article, 'Activity based Learning of Chemical Reactions at the Secondary Level', has been forwarded by the author after the study had been carried out by researchers at the Government Senior Secondary School at Jaipur. The main focus of the study was on activity based learning and how students build their knowledge about physical and chemical changes and different types of chemical reaction through experiments, project works and quiz competitions.

Further, like the other issues, Science News provides information related to new inventions and investigations in Science. In the Webwatch section, we have included two free websites where you will get to read novels— classic and contemporary — and a website related to Science.

Your suggestions are welcome. We wish you a fruitful and joyful reading.

Science knows no country, because knowledge belongs to humanity, and is the torch which illuminates the world.

Louis Pasteur

CYBER WARFARE : A SERIOUS THREAT TO GLOBAL SECURITY

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The fast-changing pace of information and communication technology has changed the way how we communicate, collaborate, share information and do business. In this age, wherein online communication has become the norm, Internet users and governments face increased risks of becoming the targets of cyber attacks. The new information technologies have posed threats in the form of transnational terrorism, international organised crime, cybercrime or hostile information operations directed against national or global interests. For the individual, the risks include confidentiality of their personal and private communications and use of their personal information for unlawful activities. At national levels, cyber war has the potential to paralyse crucial government installations and institutions having serious social and financial ramifications..

Introduction

The advent and global expansion of the Internet may prove to become the fastest and most powerful technological revolution in the history of mankind. Over the years, the number of individuals actively using the Internet has increased everywhere in the world. Today, states, non-state communities, business, academia and individuals have become interconnected and interdependent to a point never imaginable before. The fast-changing pace of information and communication technology has changed the manner in which information was disseminated prior to this technological revolution. It offered opportunities for corporates, academia, professionals and the governments to expand their networking activities for further economic growth and development. Along with opportunities, it also poses a serious threat to peace and security of the world. As businesses and societies in general ever more rely on computers and Internet-based networking, cyber crime and digital attack incidents have increased around the world. It gave transnational terrorism, international organised crime, cross-border criminal gangs, cyber crime, or hostile information operations the opportunity to create financial scams, computer hacking, downloading pornographic images from the Internet, virus attacks, e-mail stalking and creating websites that promote racial hatred, etc. Many countries are ill-equipped to defend themselves against cyber attacks. This has left countries of the world under-defended against sustained, damaging state-level attacks. Some countries have cyber armies and also use a network of patriotic and mercenary hackers that allow the state to deny responsibility. For the individual, the risks include confidentiality of their personal and private communications, and their personal information being compromised. These also include misuse of their personal information
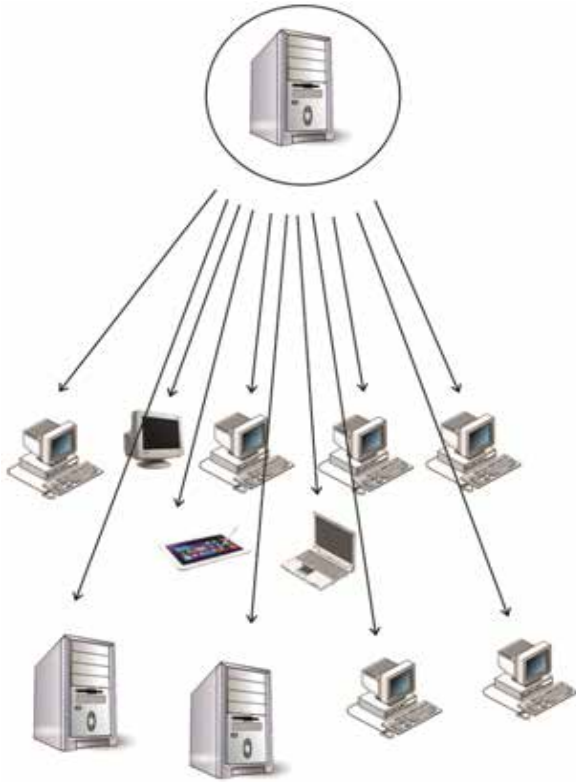
Fig. 1. Scanning Attack Single attack host scans a large number of victims
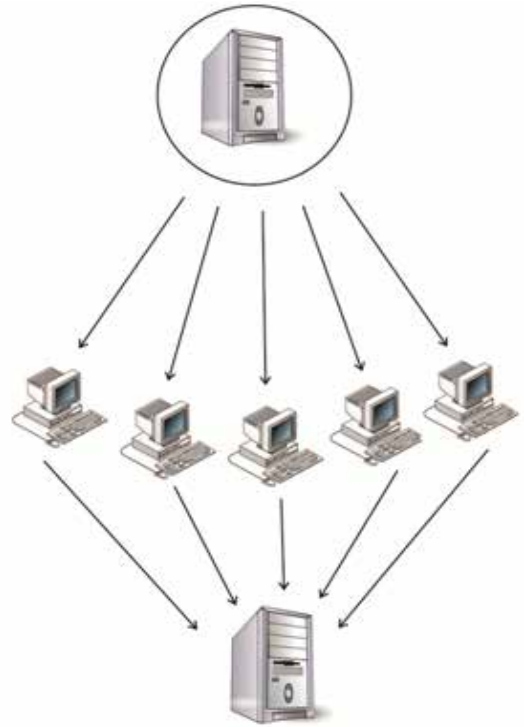
Fig. 2. Denial of Services Attacker uses a number of bots to attack a victim

and additional privacy issues of the smartphone applications and also from mobile operators and service providers.

Cyber Warfare

When interpreting and applying existing international law to cyber warfare, due consideration must be given to the specific characteristics of cyberspace. Most notably, cyberspace is the only domain which is entirely man-made. It is created, maintained, owned and operated collectively by public

and private stakeholders across the globe and changes constantly in response to technological innovation. Cyberspace not being subject to geopolitical or natural boundaries, information and electronic payloads are deployed instantaneously between any point of origin and any destination connected through the electromagnetic spectrum. These travel in the form of multiple digitised fragments through unpredictable routings before being reconstituted at their destination. While cyberspace is readily accessible to governments, non-state organisations, private enterprises

and individuals alike, IP spoofing and the use of botnets, for example, make it easy to disguise the origin of an operation, thus, rendering the reliable identification and attribution of cyber activities particularly difficult.

Cyber war refers to conducting operations which impact national security using information as key means of weapon. It means disrupting or destroying information and communication systems of critical infrastructure installations. It also means trying to know everything about an adversary and subverting information flow to either deny or modify information to gain advantage. Thus, cyber war is a war like conflict in virtual space with means of Information and Communication Technology (ICT) and networks. As other forms of warfare, cyber war aims at psychological manipulation of population and influencing the will and decision making capability of the enemy's political leadership and armed forces in the Operations of Computer Networks. Some examples of cyber attacks are the cyber attack on Estonia in April-May 2007, coordinated South Korean – US attacks in July 2009, Stuxnet Computer Worm Attack on Iran's Nuclear facilities in June 2010, etc.

Key Features of Cyber Warfare

With the exponential growth in the ICTs, some proponents think that cyber war will sooner or later replace kinetic war or at least act as a precursor to a physical attack. More frequently, cyber war is presented as a new kind of war option that is cheaper and attractive with less or no bloodshed, and less risky for an attacker than other forms of armed conflict. There are various factors that make cyber attack an attractive option for potential enemy to unleash the cyber war.

i. Cyber war is cheaper since it does not require large number of troops and weapons.

ii. Cyber war is easy to deliver by stealth via global connectivity from anywhere.

iii. Cyberspace offers the attacker anonymity because it is so difficult to trace the origin of an attack. Operating behind false IP addresses, foreign servers and aliases, attackers can act with almost complete anonymity and relative impunity, at least in the short term.

iv. Cyber war may help to avoid the need to engage in combat operations, and thus, results in minimum causalities for the aggressor.

v. Cyber war leads to the ability to disrupt the adversary rather than the risky means of destroying his forces.

vi. Blurs traditional boundaries: Cyber warfare creates its own 'fog and friction of war'.

vii. Cyber war skips the battlefield. Systems that people rely upon such as banks, the electric power grid, air defence radars are accessible worldwide from cyberspace and can be quickly taken over or knocked out without first defeating a country's traditional defences.

viii. Cyber war happens at almost the speed of light. As photons of attack packets stream down fiber-optic cables, the time between the launch of an attack and its effects is barely measurable, thus, creating more risks for decision makers, particularly in a crisis.

ix. The victim of an attack has to invest considerable resources into neutralizing the threat, which requires teams of dedicated software and hardware experts with specific skill sets. Such persons are difficult to recruit and to retain as private industry offers more attractive terms for their talent.

x. The vulnerabilities of countries increasingly dependent on complex, interconnected, and networked information systems increase over time, thus providing adversaries with a target rich environment and varied attack opportunities.

xi. Cyber war may overwhelm the government, public and private sector resources and services by disrupting functiong of critical information systems. Some of the examples of cyber war threats to individuals, businesses and government are identity theft, phishing, hactivism, compound threats targeting mobile devices and smart phone, compromised digital certificates, denial of services, botnets, and data leakage, etc.

Impacts on Individual Freedom from the Threat of Cyber Warfare

There is often tension between protecting civil liberties and enforcing laws to maintain public safety and order. A new area of such tension has evolved recently from the field of information and communication technology. As cyber space continues to expand in nations as well as globally, so does the increasing cyber attack. Threats in cyber space emanate from a wide variety of sources and manifest themselves in disruptive activities that target individuals, businesses, national infrastructure and governments alike. Their effects carry significant risk for personal freedom, privacy, public safety, the security of nations and the stability of the globally linked international community as a whole. Cyber crime and cyber attacks have resulted in changing the dimension of conflict of individual freedoms and national security to a new height. The fear of real or perceived threat of cyber space and of terrorist attack has made easy for government of many nations to pass harsher policies ranging from

arrest without warrant, preventive detention and snooping on citizens in various ways. This has become one of the serious threats to individual freedoms and rule of law which serves as the pillar of democracy.

UN Initiatives

Considering the increasing possibility of threat to international peace and security arising from misuse of information and communication technologies (ICTs), the UN General Assembly in 2002 had directed UN Secretary General (UNSG) to constitute a Group of Governmental Experts to consider existing and potential threats in the sphere of information security and recommend possible cooperative measures to address them. In pursuance of the Resolution, UNSG constituted the first UN Group of Governmental Experts (UNGGE) on International Information Security in 2004. So far four Groups have been constituted and India has been a Member in first three Groups. The UNGGE report of June, 2013 underscores that international cooperation is essential to reduce risk of misperception and enhance security in the cyber domain. It contains recommendations to promote peace and stability in State use of ICTs. It provides that international law is essential to maintaining peace and stability and promoting an open, secure, peaceful and accessible ICT environment. It also provides for voluntary measures to build trust, transparency and confidence, as well as capacity building for ICT security, especially in developing countries.

Present Scenario

Cyber warfare assumes a significant position in the present scenario owing to some of the parameters that the domain specifically possesses.

a. The omnipresent nature of the warrior is exclusive to this domain wherein the warrior could be present at several locations while carrying out an attack. In fact, the warrior could be digitally present at several locations simultaneously yet be present nowhere.

b. Warrior cloning is yet another exclusive form in this domain of cyber war. Multiplication of systems and innumerable number of instances that can be created at the time of war renders this domain extremely lethal.

c. Geographical spread of a single message may span across several continents.

d. Identity assumptions are so very easy and common in this domain that false flags can be raised easily during conduct of such wars.

e. The entry barriers are so low that the most juvenile nation could enter the domain and start making a difference in the global equations and create assymetries. Cyber attacks have been observed to be originating from cyber space of a number of countries; however, it is difficult to attribute cyber attacks to a particular country. This is because cyber space is virtual, borderless and anonymous due to which it becomes difficult to actually trace the origin of a cyber attack. It has been observed that attackers compromise computer systems located in different parts of the world and user masquerading techniques and hidden servers to hide the identity of the actual system from which the attacks are being launched.

Need for International Cooperation

Cyber warfare is not merely a further technological development in waging war as it represents a completely new category of warfare. The fundamental difference with conventional warfare means that cyber warfare cannot be entirely governed by the current framework of International Humanitarian Law. The regulation of cyber warfare requires an international treaty with global applicability. Focusing on attempts to reconcile cyber warfare within the present Humanitarian Laws needs a relook and requires rectification in the new context of cyber domain. There is an urgent need to regulate the conduct of Nation States in Cyber Space particularly Cyber Weaponization.

Further, threats emanating from the borderless cyber domain necessitate international cooperation amongst States to reduce risk and enhance security. Cooperation in areas such as information sharing and mutual assistance may become essential in responding to a cyber crisis and cyber crimes. These developments show that, in recent years, wider debate has intensified on the development of possible norms of State behaviour and a set of confidence-building measures in the cyber security domain. The challenge is to develop multilaterally agreed principles in areas related to cyber security.

In order to address the problem of Cyber War, there should be a Cyber War Limitation Accord (CWLA) involving all member countries of the United Nations. To start with, CWLA should focus on:

• Establishment of a Cyber Risk Mitigation Centre (CRMC) for sharing information and providing assistance to nations at risk.

• Create international law concepts like obligation to assist and national cyber accountability.

• Limiting cyber attacks to military infrastructure only in case of conflicts and imposing a ban on cyber attacks against civilian infrastructure.

- Impose a ban on usage of Cyber Espionage against rival countries to gather intelligence.

- Prohibit the preparation of the battlefield in peacetime by the deployment of trapdoors, logic bombs on civilian and financial infrastructure.

India and Cyberspace

India ranks third in terms of number of Internet users after USA and China. This number is projected to grow six-fold during the period 2012-2017 with a CAGR (Compound Annual Growth Rate) of 44 per cent. It is worth noting that there are over 381 million mobile phone subscriptions with Internet connectivity in India. As more and more citizens become net savvy, incidences of cyber crime are also expected to increase. These figures confirm that the use of the Internet and ICT – enabled services are becoming more and more an indispensible part of our everyday life. With increasing dependency on technology – be it mobile phones, laptops or tablets, a new breed of tech-savvy fraudsters is coming out with new and more innovative ways of carrying out cyber attacks. According to the Indian Computer Emergency Response Team (CERT-In) there were 8,266 instances of cyber security breaches in 2009. This shot up to 13,201 in 2011. It should be noted that these are reported cases only. As per available reports around 63 per cent of smart-phone users in India have experienced some form of cyber crime. In 2012, the number of cyber crime cases that were registered under the IT Act 2002 in India was 2,876. This number rose by 61 per cent compared to 1,791 cases registered in 2011.

India's Response to Threats in Cyber Space

In India, CERT–In (the Indian Computer Emergency Response Team) has been created as a government-mandated Information Technology (IT) security organization and operates under the Department of Information Technology. Keeping in view the need for a stringent legal regime to deal with cyber crimes and cyber attack, the Parliament of India has enacted the Indian Information Technology Amendment Act, 2008. The Act mandates CERT–In to oversee and ensure that the provision of the legislation are implemented and fully adhered to. Further, CERT–In is also the national nodal agency to respond to computer security incidents. It reports on vulnerabilities and promotes effective IT security practices throughout the country. In 2008, the Indian Information Technology Act was amended to define Cyber Terrorism as an Act punishable with life imprisonment. Taking cognizance of the significant growth in cyber breach instances in India, the Government came out with the National Cyber Security Policy (NCSP) in July 2013. It covers a wide range of topics, from institutional frameworks for emergency response to indigenous capacity building. Also, the Government of India has proposed a cyber-security architecture which envisages a multi-layered approach for ensuring defense in-depth.

Cyber-crime and cyber attacks have resulted in changing the dimension of conflict of individual freedoms and national security to a new height. The fear of real or perceived threat of cyber space and of terrorist attack has made easy for government of many nations to pursue policies ranging from arrest without warrant, preventive detention, snooping on citizens,

etc. This has raised concerns about individual freedoms and rule of law which serves as the pillar of democracy. However, the government of India is profoundly concerned about human rights violations.

India is aware that terrorism in all its forms poses a major threat to national security, human security and individual freedoms all over the world. India's anti-terrorism legislations are in line with the relevant international instruments and commitments including the United Nations Global Counter-Terrorism Strategy. Such legislations are assessed at regular intervals so as to ensure that it is fully compatible with national security and individual freedom.

Conclusions

The phenomenon of cyber warfare does not exist in a legal vacuum, but is subject to well-established rules and principles. That being said, transposing these pre-existing rules and principles to the new domain of cyberspace encounters certain difficulties and raises a number of important questions. Some of these questions can be resolved through classic treaty interpretation in conjunction with a good measure of common sense, whereas others require a unanimous policy decision by the international legislator, the international community of states. For the time being, cyber warfare has not had dramatic humanitarian consequences, and it is to be hoped that this state of affairs will not change in the future. The potential for human tragedy, however, is already enormous, it is likely to increase with our growing dependence on computer-controlled systems to sustain our daily lives. It is all the more important, therefore, that states be aware not only of their legal duty to examine whether new weapons and methods employed in cyber warfare would be compatible with their obligations under existing law, but also of their moral responsibility towards generations to come.

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QUORUM SENSING: CELL TO CELL SIGNALING MECHANISM

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Introduction

Communication is considered as the strongest and most important property ever evolved by nature for every living creation. It takes place by cell-to-cell signaling process which is prerequisite for development of multicellular organisms such as animals and plants but has also evolved in groups which are not usually described as multicellular, i.e., bacteria and unicellular fungi. It is perhaps an important tool in battle for survival. One of the mechanisms for bacterial cell-to-cell signaling and behaviour coordination under changing environments is referred to as quorum sensing. Quorum sensing was first observed in Vibrio fischeri, a bioluminescent bacterium that lives as a mutualistic symbiont in protophore (or light producing organ) of the Hawaiian bobtail squid. In case of free living Vibrio fischeri, autoinducer (small signaling molecule) is at low concentration and thus cells do not luminance. But when they are highly concentrated in the protophore (about 10^{11} cells/ml) transcription of luciferase is induced, leading to prominent bioluminescence.

Quorum sensing can be defined as the ability to coordinate gene expression in accordance with population density. Quorum systems are found in both gram-negative and gram-positive bacteria. It is assumed that quorum sensing represents both intra (occurs within single bacterial species) and interspecies (between two or more distinct species) signaling. Hence this corporation is for benefit of local or population as a whole. It is a way of individual cell to exchange information using small molecules that bind to sensory proteins and thus directly or indirectly affect transcription and translation process. These small chemical signal molecules are termed as autoinducers whose external concentration increases as a function of increasing cell population density. The corresponding bacterial cells detect the accumulation of minimal threshold stimulatory concentration of these autoinducers and alter gene expression. There are chemically distinct classes of autoinducers have been identified; the structures of few are the following:

Acetyl Homoserine Lactones (AHLs)

AHLs are called as autoinducer 1 type molecules which are composed of homoserine lactone ring with an attached fatty acid chain. This chain will contain carbon atoms numbering between 4 to 8 along with or without keto group on third position, e.g., in Vibrio fischeri, AHL synthase LuxI produces $3OC_6$ homoserine lactone with

keto group on third of 6 carbons, whereas, in case of Agrobacterium tumefaciens, there is production of $3OC_8$ molecule which has keto group on 8 carbon. Most of AHLs cross membranes by diffusion then they bind to LuxR like response regulators, which simultaneously act as sensors and transcription factors. This type of signal transduction where signal binding domain and transcription regulating DNA binding domain are fused called as one component signal transduction system.

Autoinducer 2

These type of autoinducers are compounds containing furanosyl borate diester whose precursor is 4, 5-dihydroxy-2,3-pentanediene (DPD). It is synthesized by LuxS from S-adenosyl methionine (SAM).

Oligopeptide Autoinducers

These are processed peptides containing amino acid residues with length ranging from 40 to 65. For peptide communication except peptide signal itself, the cell must contain membrane bound histidine kinase and response regulator with an aspartate phosphorylation residue. Hence, it constitutes a component signal transduction system. Peptide signals can be more flexible than small communication molecules as they do not require any special synthase and can change to adapt to ecological niches by simple codon mutation. Oligopeptide autoinducers are mostly used by gram positive bacteria, e.g., Staphylococcus aureus, which has autoinducing peptides derived from precursor accessory gene regulator (AgrD).
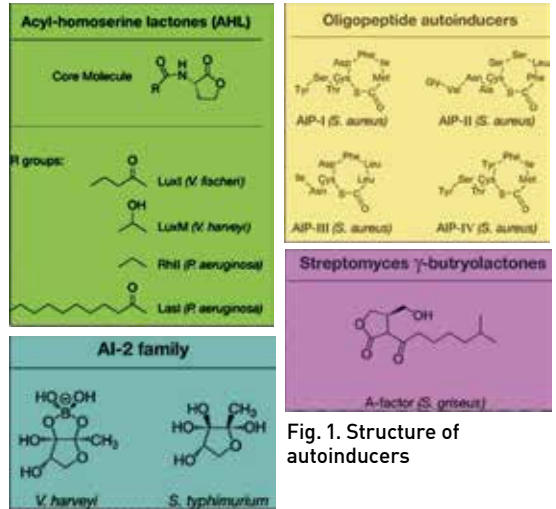
Fig. 1. Structure of autoinducers

Quorum Sensing in Gram Positive Bacteria

Quorum sensing system among the gram positive bacterium is studied best in Staphylococcus sp. They communicate by using processed oligopeptides as autoinducers and two component-type membranes bound sensor histidine kinases as receptors. In this class of bacteria, as peptides signals are not diffusible across the membrane, hence, signal release is mediated by using oligopeptide exporters. Further the sensing is mediated by phosphorylation cascade that influences the activity of DNA binding transcriptional regulatory protein termed as response.

The accessory gene regulator (Agr) system regulates toxin and protease secretion in Staphylococcus. In Staphylococcus aureus autoinducing peptides (AIP) is encoded by AgrD gene. Agr B then adds a lactone ring to this peptide and transports AIP out of the cell. Further AIP continues with its receptors,

i.e., sensor kinase Arg C and Agr C's cognate response regulator, Agr A. After binding with Agr C it transfers a phosphate group to Arg , which further activates transcription of arg operon for autoregulation. This leads to activation of RNA III, regulatory RNA which in turn leads to repressed expression of cell adhesion factors and induced expression of secreted factors.

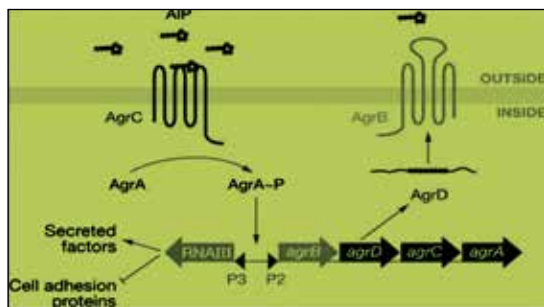**Fig. 2: Using a two-component response regulatory system, Staphylococcus aureus detects and responds to an extracellular peptide. Small red circles indicate the AIP. P2 and P3 designate the promoters for agrBDCA and RNAIII, respectively.**

Quorum Sensing in Gram Negative Bacteria

It is carried out by production and reception of diffusible molecules of signal in the form of acylhomoserine lactones (AHLs). These signals are released by AHL synthase encoded by homologues of AHL synthase gene. LuxR is a family of response regulator proteins which perceives AHLs. After attaining a threshold concentration of AHL signal molecules form complex with receptor protein which become activated. These activated complex in turn dimers or multimers with other activated LuxR—AHL complexes. These products function as transcriptional regulators controlling expression of quorum sensing regulated target genes. A large number of gram negative proteobacteria have LuxR/I type of proteins and communicate with AHL signals. These systems are used for intraspecies communications as extreme specificity exists between Lux R proteins & their cognate AHL signals. Lux I type proteins link and lactonize methionone moiety from SAM to specific fatty acyl chains carried on acyl carrier proteins. Best described Lux I/R type quorum sensing is in Pseudomonas aeruginosa. It uses quorum sensing to activate several genes for colonization and persistence within host. Pseudomonas aeruginosa produces to AHLs N-(-3-oxodecanoyl)-L-homoserine lactone ($3OC_{12}HSL$) and N butanoyl-L-homoserine lactone (C_4HSL) which binds to LasR & RIhR transcription factors respectively.

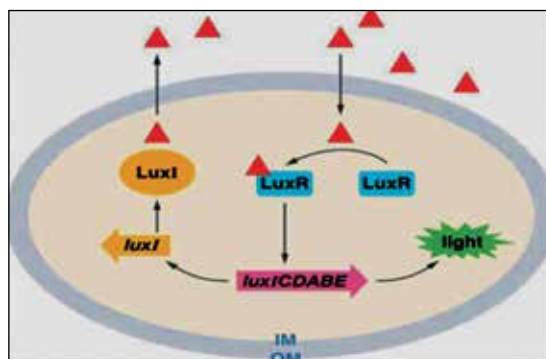**Fig.3: Quorum sensing in Vibrio fischeri; a LuxIR signaling circuit. Red triangles indicate the autoinducer that is produced by LuxI. OM outer membrane; IM inner membrane.**

Properties Exhibited by Quorum Sensing

Bacterial groups exhibit remarkable social behavior by using quorum sensing system, e.g., Myxococcus Xanthus cells show socially dependent swarming across surfaces which allows population to seek out bacterial prey.

There are many other phenotypes regulated by quorum sensing which include bioluminescence, exopolysaccharide production, virulence, conjugal plasmid transfer, antibiotic and exoenzyme production, biofilm formation and growth inhibition. Antibiotic resistance is cooperative behavior by species of E.coli, Klebsiella through quorum sensing which is exhibited by production of extracellular enzymes, e.g., β lactamase to breakdown antimicrobials. Quorum sensing has the property of modulating immune response to facilitate survival of microbes within host, e.g., P.aeruginosa, Porphyromonas gingivalis, and Helicobacter pylori. Some data show that some bacteria may also regulate transition into stationary (a phase of quiescent) which alters patterns of gene expression to allow extended cell survival in the absence of nutrientss.

Applications

- This study of communication and its effects on transcription in unicellular organisms promises a variety of practical applications. It could be a novel target for antimicrobial drug therapy.

- Inhibition of quorum sensing offers an alternative to traditional antibiotics because these strategies are not bactericidal and occurrence of bacterial resistance therefore could be reduced.

- Quorum sensing associations may improve industrial scale production of natural and engineered bacterial products.

- By using RNA III inhibiting peptide (RIP) as quorum sensing inhibitor on Staphylococcus strains (i.e. S.aureus & S.epidermidis), which cause biofilm production various surfaces.

- Bacillus thuringenesis show the biocontrol activity through AHL lactonase, AHL degrading enzyme.

- There are few bacteria which can disrupt quorum sensing by degrading AHL autoinducers e.g. soil bacterium Bacillus produces lactonase enzyme which hydrolyzes lactone ring of AHLs. The activity interferes with AHL signaling of other bacterial species. in addition transgenic plants expressing Bacillus lactonase show resistance to quorum sensing dependent bacterial infection.

- It is reported that AHLs have the ability to modulate gene expression of mammalian organisms. Administration of $3OC_{12}$—HSL in an in vitro model of B cell activation leads to production of IgG1 antibodies and elevated IgE. Hence AHL acts as modulator of T cell mediated immune response

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PROBLEM BASED LEARNING IN BASIC PHYSICS - VIII

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Introduction

In this article, seventh in the series of articles, we present problems for a problem based learning course from the area of material properties. We present the learning objectives in this area of basic physics and what each problem tries to achieve with its solution.

Methodology and philosophy of selecting these problems have already been discussed. (Pradhan 2009, Mody 2011)

To review methodology in brief, we note here that this PBL (problem based learning) starts after students have been introduced to formal structure of physics. Ideally, students would attempt only the main problem. If they find it difficult, then depending upon their area of difficulty, right auxiliary problem have to be introduced by a teacher who is expected to be a constructivist facilitator. The teacher may choose as per his/her requirement or may construct questions on the spot to guide student to right idea and method.

Material Properties: Elasticity of Solids and Fluids, as well as, Mechanics of Fluids

1. To understand the role that property of elasticity of solid, liquid and gases plays within material according to Hooke's law along with laws of physics and how it works in known situations.

2. To understand the behaviour of fluids according to Archimedes principle, equation of continuity and Bernoulli's principle.

Problems

1. A sphere of mass 1 kg is suspended at the end of 2 m long steel wire whose other end is fixed to the ceiling. The wire has a cross-sectional area of 1 mm^2. The sphere is raised by some height and then dropped to give sudden jerk to the wire. Find the maximum height to which the ball can be raised so that wire doesn't break. [Given: Y-steel= 2×10^{11} N/m^2 and breaking stress for steel = 1.1×10^9 N/m^2]

Tasks involved in this problem are:

a. to relate spring constant with elastic modulus.

b. to apply conservation of energy to the wire to find its extension assuming the model of elastic spring.

c. to calculate stress based on extension of the wire.

d. to estimate maximum height that will not allow stress to exceed is breaking limit.

2. A rod of length 1.05 m having negligible mass is supported at its ends by two wires, A of

steel and B of aluminium of equal lengths as shown in figure. The cross-section areas of wires A and B are 1.0 mm^2 and 2.0 mm^2 respectively. At what point along the rod should a mass m be suspended in order to produce (a) equal stress and (b) equal strains in both the wires?

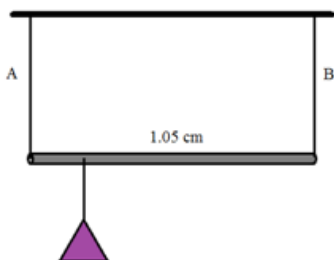[Given: Y steel = 20×10^{10} N/m^{2}Yaluminium = 7×10^{10} N/m^2]   [NCERT XI]

Fig. 1

Tasks involved in this problem are:

a. to apply condition of equilibrium under given situation.

b. to calculate position where mass to be hanged to meet the required condition.

3. A wire of density 9 gm/cm^3 is stretched between two clamps 100 cm apart, while subjected to an extension of 0.05 cm. What is the lowest frequency of transverse vibrations in the wire, assuming Young's modulus of the material to be 9×10^{11} dyne/cm^2?   [JEE 1975]

Tasks involved in this problem are:

a. to calculate tension due to stretching of wire.

b. to calculate fundamental frequency of vibration based on this tension.

4. A rail track made of steel having length 10 m is clamped on a railway line at its two ends. On a summer day due to rise in temperature

by 20°C, it is deformed as shown in the figure. Find x, (displacement of the centre) if α steel = 1.2×10^{-5} /°C andYsteel = 20×10^{10} N/m^2] [NCERT EP XI]
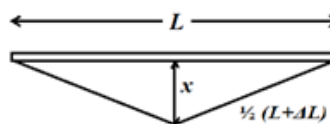
Fig. 2

Tasks involved in this problem are:

a. To calculate increase in length in accordance with property of thermal expansion.

b. To find geometric deformation.

Fluids

5. A piece of brass (alloy of copper and zinc) weighs 12.9 g in air. When completely immersed in water it weighs 11.3 g. What is the mass of copper contained in the alloy? Specific gravity of copper and zinc, are 8.9 and 7.1 respectively.   [JEE 1966]
[Note: This is the problem similar to what Archimedes must have faced when he was assigned the task to estimate gold in the crown.]

Tasks involved in this problem are:

a. to frame the equations for total mass and loss of weight.

b. to realize that it is volume of the body that decides the weight of the liquid displaced and hence loss of weight.

c. solve the two equations for volume of the constituent and hence estimate the masses.

[Here auxiliary problems are given to assist in realizing formation of simple

equation for loss of mass and how it relates to volume of the object.]

Auxilliary Problems

a. What percentage of volume of ice remains submerged while it is floating on the water surface? Ice has specific gravity is 0.91.

b. A piece of copper having an internal cavity weighs 264 g in air and 221 g in water. Find the volume of the cavity. Density of copper = 8.8 g cm^{-3}.   [JEE 1963]

6. A boat carrying number of large stones is floating in a water tank that is about to overflow. If the stones are unloaded into the water tank, what will happen to water level in water tank? Will water in the tank over flow? Give scientific explanation based on Archimedes principle.

Tasks involved in this problem are:

This is not necessarily a mathematical problem. However one can write conditions to arrive at the conclusion. One can also argue qualitatively.

7. A cylindrical vessel of height 500 mm has an orifice (small hole) at its bottom. The orifice is initially closed and water is filled in it up to height H. Now the top is completely sealed with a cap and the orifice at the bottom is opened. Some water comes out from the orifice and the water level in the vessel becomes steady with height of water column being 200 mm. Find the fall in the height (in mm) of water level due to opening of the orifice. [Take atmospheric pressure = $1.0×10^5$ N/m^2, density of water = 1000 kg/m^3 and g = 10 m/s^2. Neglect any effect of surface tension.]   [JEE 2009]

Tasks involved in this problem are:

a. to realise and write equation for the condition

that has to be satisfied once the orifice is opened for liquid to stop flowing out.

b. to understand the thermodynamic condition of air trapped above the water.

c. to solve the two conditions to estimate the loss of height of water.
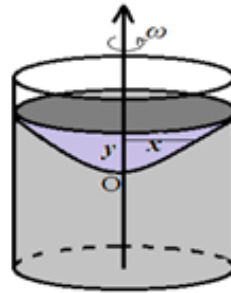
Fig. 3

8. Water in a cylinder is being rotated at constant angular speed ω about the axis of the cylinder (see the figure). Ignore effect of surface tension and find the equation of the surface of water. Can you identify the surface?

Tasks involved in this problem are:

a. to find the net force direction on a mass element on the liquid surface so that surface assumes position perpendicular to the force.

b. geometrically finding the angle to arrive at equation of the surface.

9. A non-viscous liquid of constant density 1000 kg/m3 flows in a streamline motion along a tube of variable cross-section. The tube is kept inclined in the vertical plane as shown in the figure 3. The area of cross-section of the tube at two points P and Q at heights of 2 metre and 5 metre are respectively 4×10 – m^2 and 8×10 – 3m^2. The velocity of the liquid at

point P is 1 m/s. Find the work done per unit volume by the pressure and the gravity forces as the fluid flows from point P to Q. [JEE 1997]
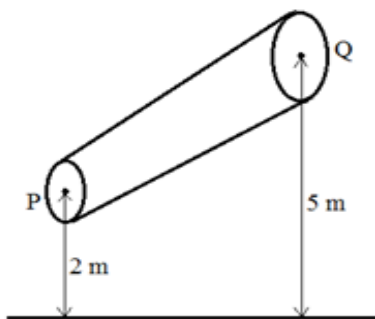
Fig. 4

Tasks involved in this problem are:

a. to apply equation of continuity to estimate speed of the fluid at the other end.

b. to calculate pressure difference at the two ends using Bernoulli's principle.

c. to estimate the work/energy accordingly.

10. A uniform wire having mass per unit length λ is placed over a liquid surface. The wire causes the liquid to depress by y (y < a) as shown in the figure. Find the surface tension of the liquid. Neglect end effect. [JEE 2004]
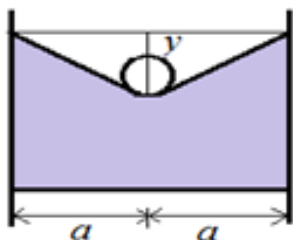
Fig. 5

Tasks involved in this problem are:

a. to understand using free body diagram as how does the force of surface tension support this object to float on the liquid surface.

b. to understand how and why small angle approximation have to be applied to solve the equations obtained in part 'a' to get the expression for surface tension.

11. A soap bubble having surface tension T and radius R is formed on a ring of radius b (b < R). Air is blown inside tube with velocity v as shown. The air molecules collide perpendicularly with the wall of the bubble and stops. Calculate the radius at which the bubble separates from the ring.

[JEE 2003]
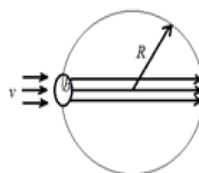
Fig. 6

Tasks involved in this problem are:

a. to apply Bernoulli's principle inside and outside the bubble.

b. to use excess pressure inside the bubble concept to understand why bubble would separate away from the ring. [Remember this is a popular toy-based problem which children play with.]

12. Eight droplets of mercury, each of radius 1 mm, coalesce into a single drop. Find (i) the radius of the single drop formed (assuming all the droplets and the drop to be spherical in shape), (ii) the change in the surface energy of the mercury drop, (iii) the change in the

temperature of the mercury. [Surface tension of mercury = 0.465 J/m², Density of mercury = 13.6×10³ kg/m³, Specific heat of mercury = 140 J Kg⁻¹ K⁻¹]

[Ans: (i) 2 mm (ii) 2.337×10⁻⁵ J (iii) 3.663×10⁻⁴ K]

Tasks involved in this problem are:

a. to understand that volume /mass of the liquid drop/s remain same when they combine or breakup.

b. to understand need for energy in breaking or release of energy when drops combine.

c. to realise what happens to excess (surface) energy in accordance with energy conservation principle.

Solutions

1. Let the sphere be raised to height h. When it reaches the bottom, the gravitational P.E. at the bottom point gets converted in to elastic P.E. due to extension of the wire.

   i.e., $mgh = \frac{1}{2} kx^2$ where x is the extension of the wire. [Here $k = \dfrac{YA}{L}$ from Solution of P(2) above.]

   This strain causes $\text{Stress} = \dfrac{Y}{L}x = \dfrac{Y}{L}\left(\dfrac{2mghL}{YA}\right)^{1/2}$

   To prevent breaking this has to be less than breaking stress SB. Which gives the condition

   $h < \dfrac{ALS_B^2}{2mgY}$.

2. Let T_A and T_B represent tensions in string A (steel) and B (aluminum) respectively, then

Fig. 7

(a) For equal stress : $\dfrac{T_A}{A_A} = \dfrac{T_B}{A_B}$ and for torque around point of suspension of weight to be in equilibrium, $T_A x = T_B (L - x)$

(b) For equal strain : $\Delta l_A = \Delta l_B$ which gives

   $\dfrac{T_A Y_A}{A_A} = \dfrac{T_B Y_B}{A_B}$ and for torque around point of suspension of weight to be in equilibrium, $T_A x = T_B (L - x)$-

Solving the two equations gives :

$x = \left(\dfrac{A_B Y_A}{A_B Y_A + A_A Y_B}\right)L = \dfrac{7}{47} \times 1.05 = 0.1564\,\text{m}$

3. For a wire extended under tension,

   $T = Y\dfrac{\Delta l}{L}A$ and frequency of vibrating string

   $n = \dfrac{1}{2l}\sqrt{\dfrac{T}{m}}$ where m is mass per unit length

   of the wire.

   In terms of given quantities, m = pA which gives

   $n = \dfrac{1}{2l}\sqrt{\dfrac{Y\Delta l}{\rho l}}$

4. Referring to the figure given and applying Pythagoras,
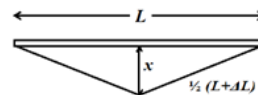
Fig. 8

$x^2 = \dfrac{1}{4}(L^2 + 2L\Delta L) - \dfrac{1}{4}L^2$ (neglecting higher order term of ΔL we get $x^2 = \frac{1}{2} L\Delta L$,

Which gives $x = \sqrt{\dfrac{L\Delta L}{2}} = L\sqrt{\dfrac{\alpha T}{2}} \approx 11\,cm$

5. Let 1 denote Copper and 2 denote zinc.

The given information than gives $m^1 + m^2 = p$ $_1V_1 + p_2V_2 = 12.9$ gm and $pw(V_1 + V_2) = 1.6$ gm Substituting appropriate specific gravities (note $pw= 1$) , we get $m_1 = 7.61$ gm

Auxiliary Solutions

A. For the floating ice, let V be the volume of ice and V' be the volume of the submerged portion.

Weight of the ice = weight of the water displaced

$\therefore P_{ice}Vg = P_{water}V'g$

$\therefore \dfrac{V'}{V} = \dfrac{V_{water}}{V_{ice}} = \dfrac{\rho_{ice}}{\rho_{water}} = 0.91$

B. Let V be the volume of the metal piece and V0 be that of cavity.

Then we have $p(V - V_0) = 264$ and $pwV = 264 - 221 = 43$

Solving which we get $V_0 = 13$ cm$_3$.

6. Volume of water displaced = (weight of the stone)/($pwaterg$)

and volume of stone = $pstone\,Vstoneg$

this gives $V_{water} = \left(\dfrac{\rho_{stone}}{\rho_{water}}\right) V_{stone}$ and since

$Pwater<Pstone$ we get $Vstone<Vwater$

The tank will not over flow.

7. Initially the pressure of air above the liquid is P_A : the atmospheric pressure after the orifice is opened, the pressure of air above the liquid is $P = P_A - hpg$ and also $P_A (L - H) A = P (L - h)$

A where A is the area of cross-section of the cylinder and $L = 500$ mm and $h = 200$ mm. finding P and solving the equations we get $H = 206$ mm so that $H - h = 6$ mm.
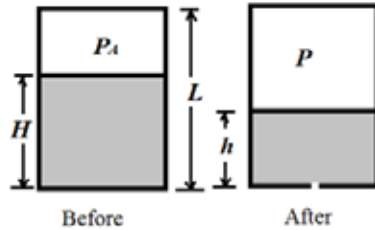
Fig. 9

8. Referring to figure above, $\tan\theta = \dfrac{dy}{dx} = \dfrac{m\omega^2 x}{mg}$ for a small element of mass mat (x, y)

Integration yields, $y = \left(\dfrac{\omega^2}{2g}\right)x^2$, which is equation of parabola.
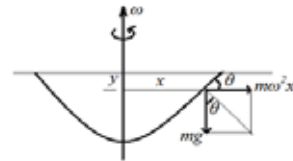
Fig. 10

9. From equation of continuity $v_p A_p = v_q A_q$ that gives vq = ½ m/s.

Work done by gravity = $pgh = 29.4\times10^3$ J/m^3

From Bernoulli's equation we have $P_p + \frac{1}{2} pvp^2 = Pq + \frac{1}{2} pvq^2 + pgh$

This gives work by pressure force = $P_p - P_q = pgh - (\frac{1}{2} pvp^2 - \frac{1}{2} pvq^2) = 29.03\times10^3$ J/m^3
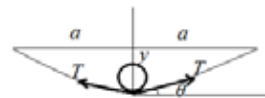
Fig. 11

10. Referring to the figure, when the needle is in equilibrium, $tan\,\theta = \dfrac{y}{a}$ and $2T\sin\theta = \lambda g$ in small angle approximation: $tan\,\theta \approx sin\,\theta$ wihich gives
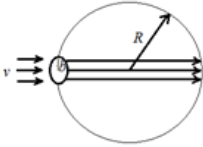
Fig. 12

11. Referring to figure : and using Bernoulli's equation for outside the bubble and inside the bubble, we get $P_{out} + \frac{1}{2}\rho v_{out}^2 = P_{in} + \frac{1}{2}\rho v_{in}^2$

$P_{in} = \dfrac{4T}{R} + P_{out}$ where T is the surface tension and $v_{in} = 0$ yields $R \geq \dfrac{8T}{\rho v^2}$

12. When drops coalesce into one, the total volume remains constant : i.e.,

$8 \times \dfrac{4\pi}{3} r^3 = \dfrac{4\pi}{3} R^3$ which gives $R = 2r = 2\,mm$

Also loss of surface energy results in rise in temperature of the drop.

i.e., $\Delta U_{surface} = ms\Delta\theta$

$\Delta U = T\left(8(4\pi r^2) - 4\pi R^2\right) = 2.337 \times 10^{-5}\,J$

which gives $\Delta\theta = 3.663 \times 10^{-4}$ K

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METHOD OF FINDING THE CUBE ROOT OF ANY PERFECT CUBE NUMBER OR QUANTITY

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Introduction

We can find cube root of any perfect cube number with the method given below.

We know that:

$$(a+b)^3 = a^3 + 3ab\,(a+b)+b^3$$

The value of b^3 is equal to the cube of ones digit of the given quantity or number. Now table of ones digit number and value of b is given below:

Ones digit of given number	Value of b
0	0
1	1
8	2
7	3
4	4
5	5
6	6
3	7
2	8
9	9

Now suppose given number is N,

Then:

If

	N	Value of a
1.	$(a+b)^3 < 1000$	0
2.	$(a+b)^3\ 1000$	10
	and $(a+b)^3 < 8000$	
3.	$(a+b)^3\ 8000$	
	and $(a+b)^3 < 7000$	20
4.	$(a+b/\ 27000$	
	and $(a+b)^3 < 64000$	30
5.	$(a+b)^3\ 64000$	
	and $(a+b]^3 < 125000$	40
6.	$(a+b)^3\ 125000$	
	and $(a+b)^3 < 216000$	50
7.	$(a+b)^3\ 216000$	
	and $(a+b)^3 < 343000$	60
8.	$(a+b)^3\ 2343000$	
	and $(a+b)^3 < 512000$	70

9.	$(a+b)^3$ 2512000	
	and $(a+b)^3$ ←729000	90
1o.	$(a+b)^3$ 2729000	
	and $(a+b)^3$← 10,00000	90

4.	$(8000)^{113}$ = a+b = $(20+0)$ = 20	1.	Ones digit = b = 0 and 8000 < 8000 ∴a= 20

First Process

This method is very simple. We can easily get the cube root of any perfect cube number without any Calculation. Only by seeing the values of a and b with the help of tables given above.

Examples:

Examples		Process	
1.	$(2744)^{1/3}$ =a+b=10+4=14	1.	Ones digit = b =4
		2.	2744 > 1000 and 2744 < 8000 ∴. a= 10
2.	$(15625)^{1/3}$ = a+b = 20+5 = 25	1.	Ones digit = b = 5
		2.	15625 > 8000 and 15625 < 27000 ∴. a = 20
3.	$(46656)113$ = a+b = 30+6 = 36	1.	Ones digit = b =6
		2.	46656 > 27000 and 46656 < 64000 ∴ a= 30

Second Process

Other Method of finding the value of space:

1. b and b^3
2. $(N-b^3)$
3. Find the factor of $(N-b^3)$ in terms of 10, 20, 30 etc. The factors are equal to values of a, respectively. In other words $(N-b^3)=N_1 X (a-10n) = 0$

Where n = 0, 1, 2, 3, ...
Now put $N_1 (a-10n) = 0$

Examples		Process	
1.	$(2744)113$ =a+b = 10+4 = 14	2.	$b^3 = 64$
		3.	2744-64 = 2680 = 268 X 10 ∴. a = 10
2.	$(15625)113$ = a+b = 20+5 = 25		1. Ones digit = b = 5 2. 2. b3 ∷ 125 3. 15625-125=15500=776X20 ∴. a= 20
3.	$(46656))^{1/3}$ = a+b = 30+6 = 36	1.	Ones digit = b =6
		2.	b3 ∷ 216
		3.	46656-216 =46440 =1548X30 ∴. a= 30

4.	$(8000)^{1/3} = a+b$ $= 20+0$ $= 20$	1. Ones digit $= b = 0$ 2. $b^3 = 0$ 3. $8000-0=8000$ $= 400 \times 20$ $\therefore a = 20$
5.	$(15.625)^{\frac{1}{3}} = \left(\frac{15625}{1000}\right)^{\frac{1}{3}}$ $\left(\frac{a+b}{10}\right) = \left(\frac{20+5}{10}\right) = 2..$	1. Ones digit$= 5 = b$ 2. $15625 > 8000$ and $15625 < 27000$ $\therefore a = 20$

Third Process

We know that:

$(a+b)^3 = a^3 + b^3 + 3ab (a+b)$

Now finding the cube root, The process is given below:

$$
\begin{array}{r|l}
 & a+b \\
\hline
a^3 & a^3+b^3+3ab\,(a+b) \\
 & a^3 \\
\hline
 & b^3 \\
a^3 & -b^3 \\
\hline
 & 3ab\,(a+b) \\
 & 3ab\,(a+b) \\
\hline
 & \times \\
\end{array}
$$

$\therefore$ Cube root $= (a+b)$

Example:

1. $(15625)^{1/3} = (a+b) = 20+5$

$= 25$

$$
\begin{array}{r|l}
 & 20 + 5 \\
\hline
20^2 & 15625 \\
 & -8000 \\
\hline
5^2 & 7625 \\
 & -125 \\
\hline
 & 7500 \\
3 \times 20 \times 5\,(20+5) & 7500 \\
\hline
 & \times \\
\end{array}
$$

$3ab\,(a+b)$
$= 3 \times 20 \times 5\,(20+5)$
$= 7500$

2. $(0.389017)^{1/3} = a + b$

$= 0.7 + .03$

$= 0.73$

$$
\begin{array}{r|l}
 & .7 + .03 \\
\hline
7^2 & 0.389017 \\
 & -.343 \\
\hline
(.03)^2 & .046017 \\
 & .000027 \\
\hline
 & .045990 \\
3 \times .7 \times .03\,(.73) & .04599 \\
= .04599 & \\
\hline
 & \times \\
\end{array}
$$

3. $(15.625)^{1/3} = a+b$

$= 2+0.5$

$= 2.5$

$$
\begin{array}{r|l}
 & 2 + .5 \\
\hline
2^2 & 15.625 \\
 & -8 \\
\hline
5^2 & 7.625 \\
 & -.125 \\
\hline
 & 7.500 \\
3 \times 2 \times .5\,(2+5) & 7.500 \\
= 3 \times 2.5 & \\
\hline
 & \times \\
\end{array}
$$

ACTIVITY BASED LEARNING OF CHEMICAL REACTIONS AT THE SECONDARY LEVEL

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In the present study activity based learning method was employed in learning chemical reactions at the secondary level in an SC/ST dominated rural school. For effective participation of students in learning chemical reactions, activities like group exercise, group work, quiz, seminar and projects were carried out. The students were also encouraged to participate in presentation of concepts of chemical reactions. Friendly environment was created for expression of thoughts and interaction of students during the teaching–learning process of chemical reactions.

Key words: *Chemical reactions, activity based and meaningful learning.*

Introduction

NCF 2005 says that the education system does not function in isolation from the society of which it is a part. Hierarchies of caste, economic status and gender relations, cultural diversity as well as the uneven economic development that characterise Indian society also deeply influences access to education and participation of children in school (NAS, 2012). Thus the students belonging to ST and SC communities, the rural and urban poor, and disadvantaged sections of religious and other ethnic minorities are educationally most vulnerable (NCF, 2005 and Tulasi, 2005). Reports indicate that relative learning achievements of the students belonging to ST/SC communities especially of rural back ground are very low as compared to that of the other categories and it appears that these students have no sufficient ideas to construct the knowledge because of their social and economic background (NAS, 2012).The constructivist approach of learning is based on the idea that learning occurs when a learner actively constructs a knowledge representation in working memory (Evangelisto, 2002). According to this theory the learner is a sense maker whereas the teacher is a cognitive guide who provides guidance and modelling on authentic academic tasks (Senapaty, 2012). Role of the teachers is to create environment in which learner interacts meaningfully with academic material resources fostering the learning processes of selecting, organizing and integrating information (Fosnot, 1996). All children are, whatever their backgrounds have tremendous potential and if opportunity is given to them they produce wonderful results (Sharma, 2013). Therefore, keeping the aforesaid in view, present study has been carried out using 5 Es (explore, engage, explain, elaborate and evaluate) model of constructivist approach (Barufaldi, 2002). The findings of the study related with learning of chemical reactions in a

SC/ST dominated rural secondary school are presented and its implications are discussed.

Sample

The present study was carried out during field work of the researcher (from 17 July 2012 to 18 October 2012) at Government Senior Secondary School, Shivdaspura located in a SC/ST dominated area of Jaipur district of Rajasthan state. This school is a Hindi medium school and has professionally qualified teachers. General observation of teaching learning process in this school revealed that teachers were running the process in traditional way. Even in certain classes it was observed that students are simply reading the chapters in front of their classmates. Rajasthan State Government has adopted NCERT curriculum in which main focus is on Activity-based Learning method, i.e., learning- by-doing method. A general interaction with the teachers revealed that learning by doing method is not feasible in SC/ST dominated rural schools as students do not have attitude to learn. This was taken as a challenge and accordingly teaching learning process was initiated in Class X on the topic Chemical Reactions using aforesaid approach.

Process

The first important task in initiating the process was to develop student friendly class room. Since the study was carried out in a rural school which was located in a SC/ ST dominated area, therefore, to develop student friendly class room, it was necessary to know about learners especially on the issues of their background, socio-economic problems and attitude.

Development of Student-friendly Class Room

The information/knowledge about learners were collected through personal interaction in the form of general conversation and interview. The information was also collected using a questionnaire which comprised of the following questions:

- Write about your family background.
- How many brothers and sisters do you have and what is your sequence in them?
- Which behaviour of your parents do you like the most and why?
- Which behaviour of your parents you don't like?
- In your family whom you like most and why?
- Why do you afraid of your teacher?
- Any incident from your life after which you feel afraid of your teachers.
- Why do you hesitate in expressing yourself?
- What do you want to be in your life and why?

Students were given friendly treatment and therefore, they openly shared their views on the above aspects related with them. This information helped the researcher in developing learning environment in the classroom. The common problems of the students were linked with their family environment as it does not encourage them properly for learning. Secondly, in most of the cases there was no one to motivate the students for learning. Though the teachers of Shivdaspura School were good enough to encourage the students for learning but in traditional ways only.

It was also observed that students were suffering from teachers' phobia. However, the phobia about teachers in the students about asking

questions and expressing themselves was based on the following prejudices:

- Teacher will become angry.
- Teacher will say something and he/she may insult them.
- Whatever they are going to express may not be proper.
- Friends will make fun of him/her on committing mistakes.
- Sometimes when their teacher asks questions, they hesitate to answer because they think that their teacher may get a bad impression of them if they could not answer properly.

Considering all the aforesaid issues, student friendly environment was a pre-requisite condition and therefore, all the facts related to their problems were discussed and they were motivated to interact with field investigator. They were also encouraged to discuss their problems. They were assured that the discussion will remain confidential. By these experiments, faith of these students of rural background could be gained.

Medium of instruction was another issue in the teaching learning process as all the students were from rural background and they were not able to communicate in even Hindi properly. Therefore, interaction was made in Hindi and sometimes in regional language also, which was comfortable for the students. Getting the students to learn effectively, following important aspects of effective teaching learning process were also included:

- asking open-ended questions and allowing wait time for responses.
- encouraging the higher-level thinking.
- engaging students in dialogue with the field investigator and with each other.

- engaging students for experimentation and discussion.
- inquiring about understanding of concepts.

Assessment of Previous Knowledge

To assess the previous knowledge and achievement level of the students, pre and post tests were also conducted. Since the topic under consideration was already discussed through traditional method of teaching by regular teacher of the school and there is a topic on physical and chemical change in Class VII, therefore, it was assumed that students have some previous knowledge about the topic (NCERT textbooks 2006). Considering the above facts, pre test on the chemical reactions was administered on the students of sample size 60. After discussing the topic through Activity-based Learning method again a test (post-test) was administered. An analysis of the responses given by the students in pre and post tests indicates that there is improvement in learning of the students about the concept of chemical reactions (Fig. 1 and 2). The relevant data are tabulated below.

Table 1: Percentage correct responses of the learners

Item No.	Pre – Test (Percentage of Correct Responses)	Post – Test Percentage of Correct Responses)
1.	64.86	73.07
2.	21.62	38.46
3.	48.64	53.84
4.	45.94	50.00
5.	13.51	26.92
6.	40.54	65.38
7.	48.64	50.00

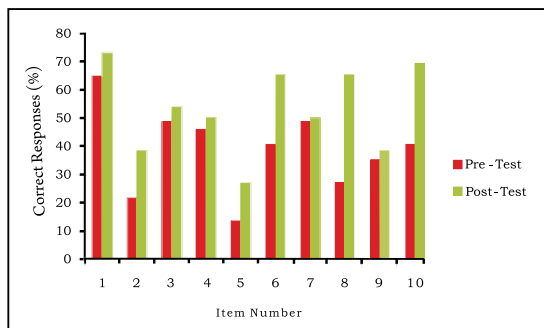| 8. | 27.02 | 65.38 |
| 9. | 35.13 | 38.46 |
| 10. | 40.54 | 69.23 |

Fig 1: Pre-and post-test data indicating improvement in learning
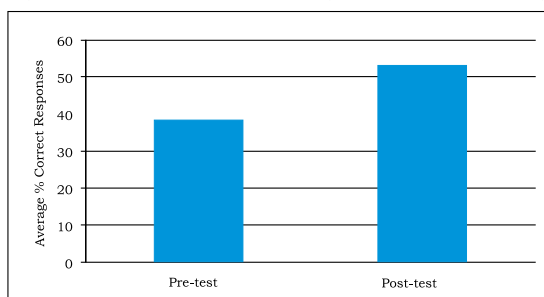
Fig 2: Average of percentage of correct responses of pre-and post-tests

Initiation of Teaching–Learning Process

After developing student-friendly classroom situation, teaching-learning process was initiated on the topic Chemical Reactions in Class X of Government Senior Secondary School, Shivdaspura, Jaipur. The process of teaching learning was initiated in the following way:

First of all, students were asked about some changes occurring in our daily life like vaporization, formation of curd from milk, rusting, pouring water from one pot to another

and folding of paper, etc. The students had knowledge about them but they were not able to distinguish them as physical and chemical change. So students were facilitated to perform some activities in classroom.

Learning of Physical and Chemical Change

There were 60 students in this class. So, just to encourage the participation of each and every student, 10 random groups were made and each group was facilitated to perform the following activities and record their observations:

1. boiling of water in a test tube followed by condensation of vapours.

2. burning of Magnesium ribbon followed by collection of end product.

3. addition of Phenolphthalein in aqueous solution of sodium hydroxide.

4. interaction of HCl and Zn metal followed by contact of evolved gas with flame

5. heating of $CaCO_3$ followed by passing the evolved gas in $Ca(OH)_2$ solution.

6. decomposition of H_2O in Volta meter and collection of gases evolved on electrode.

Now observations of the students were interpreted in terms of physical and chemical changes. For it, theoretical background of the changes was made clear by stating that a physical change in a substance doesn't change what the substance is. In a chemical change, where there is a chemical reaction, a new substance is formed and energy is either given off or absorbed. In general, chemical changes are irreversible. It was also discussed that following observations can help us to determine whether a chemical reaction had occurred or not (NCERT Text Books, 2006):

- change in state.
- change in colour.
- evolution of gas.
- change in temperature.

Now students' observations were interpreted one by one as given below:

1. during boiling of water only physical state is changing. No change in chemical composition has occurred so it is a physical change.

2. burning requires oxygen, so in this case magnesium oxide (collected in watch glass) is forming. This is a chemical change because chemical composition has changed.

3. addition of phenolphthalein in aqueous NaOH solution causes colour change, so it is chemical change.

4. in the interaction of HCl and Zn metal a gas is evolved. Since the evolved gas burnt with a noise so it is hydrogen gas. Evolution of gas is also indication of chemical change.

5. heating of $CaCO_3$ evolves CO_2 gas which makes the lime water milky so evolution of gas and change in colour of lime water are indicating chemical change.

6. phase change is taking place in decomposition of water in Volta meter, so it is also a chemical change.

Students were also given chance to reflect, predict and infer during knowledge construction stage. They were also encouraged to explain their views and to promote logical thinking.

Learning of Different Type of Chemical Reactions

Using the same type of approach, teaching-learning process was carried out in the teaching of the types of reactions.

Decomposition Reactions

Students were facilitated to perform the Following activities and to record their observations:

a) $(NH_4)_2 Cr_2O_7$ was taken on a white tile and was burned by the help of match sticks.

b) $CuCO_3$ was taken in a nickel crucible and it was gently heated.

c) $Pb(NO_3)_2$ was taken in a boiling tube and it was gently heated.

d) heating of $CaCO_3$ was done in a boiling tube and the gas evolved was passed in the $Ca(OH)_2$ solution.

e) decomposition of H_2O was again carried out in Volta meter and the gases evolved on electrodes were collected in test tubes.

Now theoretical aspects of decomposition reactions were discussed by defining these reactions as "the reaction in which a single compound splits/breaks into two or more simple substance(s) under suitable conditions is decomposition reaction".

Now the observations of the students were interpreted as follows:

(a) in burning of $(NH_4)_2 Cr_2O_7$ following reaction takes place

$(NH_4)_2Cr_2O_7(s) \longrightarrow Cr_2O_3(s) + N_2(g) + 4H_2O(g)$,
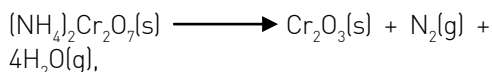
since $(NH_4)_2Cr_2O_7(s)$ is breaking in to $Cr_2O_3(s)$, $N_2(g)$ and $H_2O(g)$ so this reaction is an example of decomposition reaction. Students themselves stated it as a chemical reaction, as evolution of some gases occurred.

(b) heating of $CuCO_3$ results breaking it into its constituents. Colour of compound also changes from green to black upon heating.

It is an example of decomposition reaction.

$$CuCO_3(s) \longrightarrow CuO(s) + CO_2(g),$$
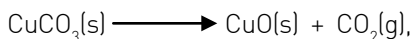
(c) on heating $Pb(NO_3)_2$, its decomposition takes place as follows

$$2Pb(NO_3)_2(s) \longrightarrow 2PbO + 4NO_2(g) + O2(g),$$

the brown gas evolved is NO_2.

(d) heating of $CaCO_3$ gives CaO and CO_2 as shown below:

$$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g),$$

when the CO_2 gas was passed through the $Ca(OH)_2$ solution initially calcium bicarbonate is formed which changes to $CaCO_3$ on further passing of CO_2 and turns the solution milky.

(e) following decomposition reaction takes place in Volta meter

$$2H_2O \longrightarrow 2H_2 + O_2,$$
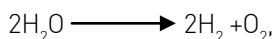
which gases are evolving, was confirmed by noting the volume of water in test tubes. Test tube having less volume of water means more volume of gas. This indicates that it is hydrogen. The other test tube has oxygen. This was further confirmed by burning the gases. The gas in first test tube burns with sound so it is definitely hydrogen gas. In other test tube intensity of flame increases so it is oxygen gas.

Fig. 3: Students performing activities and being observed by teachers

Project Activities for Effective Learning

For proper learning of decomposition reactions students were facilitated to prepare some projects as given below.

(i) Construction of a Volta meter by low cost materials: Each group constructed a Volta meter by arranging a plastic bottle and graphite electrodes from discharged Leclanché cell. Test tubes were made available from the laboratory. Now students were asked to demonstrate the decomposition reaction of water using it.

Fig. 4: Students performing project work

(ii) Preparation of charts on the different type of reactions: Each group prepared charts on chemical reactions through group work. They prepared very nice charts on these reactions.

Organisation of Quiz Competition

Just to revise the concept, quiz competition was also conducted. Students actively participated in the competition and their responses were clearly indicating how much they have learned. Other students of the school were also invited to attend the science quiz.

Fig. 5: students participating in quiz competition related with chemical reactions

Displacement reactions

Students were facilitated to perform the following activities and to record their observations.

(a) Add Zinc strips in aqueous blue solution of $CuSO_4$.

(b) Add aqueous solution of $BaCl_2$ into aqueous solution of Na_2SO.

(c) Add KI in the aqueous solution of $Pb(CH_3COO)_2$.

(d) Mix aqueous solution of $(NH_4)_2CO_3$ into aqueous solution of $CaCl_2$.

Now displacement reactions were discussed in term of the reactions in which there is displacement of an element/ion of one compound by element/ion of another compound. There are two types of displacement reactions:

(i) single displacement reactions: These are the reactions in which an element/ion of one compound is displaced by the element/ion of another compound.

(ii) double displacement reactions: In these reactions, there is exchange of ions between the reactants.

Now students' observations were interpreted to construct the knowledge about displacement reactions as given below:

• in first activity students observed that on adding zinc strips in the solution of $CuSO_4$ its blue colour starts to disappear. This was explained by indicating the following reaction:

$$Zn + CuSO_4 \longrightarrow Cu + ZnSO_4.$$

• zinc being more reactive than copper, displaces copper from the solution of copper sulphate and thus zinc sulphate is formed which is colourless. Since zinc is displacing copper, so it is an example of single displacement reaction.

• mixing of aqueous solution of $BaCl_2$ with aqueous solution of Na_2SO_4 gives white precipitate so the observation can be interpreted in terms of the following reaction:

$$BaCl_2 + Na_2SO_4 \longrightarrow NaCl + BaSO_4,$$

$BaSO_4$ is formed by exchange of ions between $BaCl_2$ and Na_2SO_4 so this reaction is an example of double displacement reaction. $BaSO_4$ being insoluble in water appears as white precipitate.

• appearance of yellow colour on mixing of aqueous solutions of $Pb(CH_3COO)_2$ and KI is due to ion exchange between $Pb(CH_3COO)_2$ and KI. Formation of PbI is as per the reaction given below:

$$Pb(CH_3COO)_2 + 2KI \longrightarrow PbI_2 + 2K(CH_3COO),$$

so the above reaction is also an example of double displacement reaction.

• when aqueous solution of $(NH_4)_2CO_3$ is mixed with aqueous solution of $CaCl_2$ white precipitate of $CaCO_3$ is obtained due exchange of ions between $(NH_4)_2CO_3$ and $CaCl_2$ as given below:

$$(NH_4)_2CO_3 + CaCl_2 \longrightarrow CaCO_3 + 2NH_4Cl.$$
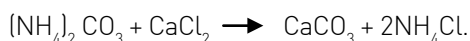
Organisation of Seminars

To ensure proper learning of the concept, each student was facilitated to prepare a topic for seminar on chemical reactions and they were made free to present their topic thoroughly. Students were also encouraged to actively

participate in the open session. Initially some hesitation was observed in the students as they felt difficulty in expressing themselves but through motivational sessions they did very well later on. Feedback/views of the students were taken, which are as follows:

- they were highly afraid and hesitant before seminar but during seminar they felt confident because of friendly environment of the classroom. Their hesitation gets removed due to this activity.

- due to this activity they were well-versed in the topic taught.

- during open sessions some students asked questions and presenter replied, it was very much enjoyable and helped them in building up the confidence.

- this was the first step towards eradication of phobia in expressing themselves.

- they felt appreciated when students of their own class clapped on their performance.

- they felt as if they are on moon. They really enjoyed it.

Feedback of the Students about Learning Outcomes

Feedback of the individual student was also taken about their learning out comes. Feedbacks of some students are given below:

- when our teacher taught us, we were used to think, how reaction takes place, what are chemical reactions but now I came to know what a chemical reaction is and how it occurs.

- by doing activities, we have learned the topic by heart. We have learned a lot about

chemical reactions.

- we used to simply read the topic but we could not understand about chemical reactions but when we did the activities we got the command on the topic.

- whatever is taught in this way is very well remembered and we will never forget this topic. We also enjoyed a lot in the classroom.

- we want that we should be taught in this way.

- when we used to see the figures in books nothing came to our mind but you showed us everything in reality. Sir, smile has come on our face.

- we are enjoying the teaching learning process. We think that other topics of science should also be taught in this way.

- by seeing these activities it appears that science is not a difficult subject if we are taught in this way.

- we should be taught in this way (activity based) so that we can learn the topic properly.

- learning in this way has motivated us to go ahead in life.

- when our teachers used to teach us in traditional way we were not able to concentrate on studies as we used to be bored, but when you taught us using activity based way, we never felt bored. We should be given such type of environment in the classroom.

- teaching in this way encourages us to learn effectively.

Conclusion

From the findings of the study, it may be concluded that if students are properly motivated and activity-based learning method is used in teaching-learning process, even the students considered as not to have attitude for active learning can also do wonder. In the present case simultaneous assessment has indicated that students were learning well and enjoying the teaching learning process. Performance in state board examination was also improved. This may be attributed due to the motivation and activity-based learning of students towards their studies.

Acknowledgements

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Higher Dementia Risk Linked to More use of Common Drugs

A large study links a significantly increased risk for developing dementia, including Alzheimer's disease, to taking commonly used medications with anticholinergic effects at higher doses or for a longer time. Many older people take these medications, which include nonprescription diphenhydramine (Benadryl). JAMA Internal Medicine published the report, called "Cumulative Use of Strong Anticholinergic Medications and Incident Dementia."

The study used more rigorous methods, longer follow-up (more than seven years), and better assessment of medication use via pharmacy records (including substantial nonprescription use) to confirm this previously reported link. It is the first study to show a dose response: linking more risk for developing dementia to higher use of anticholinergic medications. And it is also the first to suggest that dementia risk linked to anticholinergic medications may persist and may not be reversible even years after people stop taking these drugs.

"Older adults should be aware that many medications including some available without a prescription, such as over-the-counter sleep aids have strong anticholinergic effects," said Shelly Gray, PharmD, MS, the first author of the report, which tracks nearly 3,500 Group Health seniors participating in the long-running Adult Changes in Thought (ACT), a joint Group Health-University of Washington (UW) study funded by the National Institute on Aging. "And they should tell their health care providers about all their over-the-counter use," she added.

For instance, the most commonly used medications in the study were tricyclic antidepressants like doxepin (Sinequan), first-generation antihistamines like chlorpheniramine (Chlor-Trimeton), and antimuscarinics for bladder control like oxybutynin (Ditropan). The study estimated that people taking at least 10 mg/day of doxepin, 4 mg/day of chlorpheniramine, or 5 mg/day of oxybutynin for more than three years would be at greater risk for developing dementia. Dr. Gray said

substitutes are available for the first two: a selective serotonin re-uptake inhibitor (SSRI) like citalopram (Celexa) or fluoxitene (Prozac) for depression and a second-generation antihistamine like loratadine (Claritin) for allergies. It's harder to find alternative medications for urinary incontinence, but some behavioral changes can reduce this problem.

"If providers need to prescribe a medication with anticholinergic effects because it is the best therapy for their patient," Dr. Gray said, "they should use the lowest effective dose, monitor the therapy regularly to ensure it's working, and stop the therapy if it's ineffective." Anticholinergic effects happen because some medications block the neurotransmitter called acetylcholine in the brain and body, she explained. That can cause many side effects, including drowsiness, constipation, retaining urine, and dry mouth and eyes.

"With detailed information on thousands of patients for many years, the ACT study is a living laboratory for exploring risk factors for conditions like dementia," said Dr. Gray's coauthor Eric B. Larson, MD, MPH. "This latest study is a prime example of that work and has important implications for people taking medications and for those prescribing medications for older patients." Dr. Larson is the ACT principal investigator, vice president for research at Group Health, and executive director of Group Health Research Institute (GHRI). He is also a clinical professor of medicine at the UW School of Medicine and of health services at the UW School of Public Health.

Some ACT participants agree to have their brains autopsied after they die. That will make it possible to follow up this research by examining whether participants who took anticholinergic

medications have more Alzheimer's-related pathology in their brains compared to nonusers.

One Nanoparticle, Six Types of Medical Imaging

Using two biocompatible parts, University at Buffalo researchers and their colleagues have designed a nanoparticle that can be detected by six medical imaging techniques:

- computed tomography (CT) scanning;
- positron emission tomography (PET) scanning;
- photoacoustic imaging;
- fluorescence imaging;
- upconversion imaging; and
- Cerenkov luminescence imaging.

In the future, patients could receive a single injection of the nanoparticles to have all six types of imaging done.

This kind of "hypermodal" imaging, if it came to fruition, would give doctors a much clearer picture of patients' organs and tissues than a single method alone could provide. It could help medical professionals diagnose disease and identify the boundaries of tumors.

"This nanoparticle may open the door for new 'hypermodal' imaging systems that allow a lot of new information to be obtained using just one contrast agent," says researcher Jonathan Lovell, PhD, UB assistant professor of biomedical engineering. "Once such systems are developed, a patient could theoretically go in for one scan with one machine instead of multiple scans with multiple machines."

When Lovell and colleagues used the nanoparticles to examine the lymph nodes of mice, they found that CT and PET scans

provided the deepest tissue penetration, while the photoacoustic imaging showed blood vessel details that the first two techniques missed. Differences like these mean doctors can get a much clearer picture of what's happening inside the body by merging the results of multiple modalities.

A machine capable of performing all six imaging techniques at once has not yet been invented, to Lovell's knowledge, but he and his coauthors hope that discoveries like theirs will spur development of such technology.

The research, Hexamodal Imaging with Porphyrin-Phospholipid-Coated Upconversion Nanoparticles, was published online Jan. 14 in the journal *Advanced Materials*.

The researchers designed the nanoparticles from two components: An "upconversion" core that glows blue when struck by near-infrared light, and an outer fabric of porphyrin-phospholipids (PoP) that wraps around the core.

Each part has unique characteristics that make it ideal for certain types of imaging. The core, initially designed for upconversion imaging, is made from sodium, ytterbium, fluorine, yttrium and thulium. The ytterbium is dense in electrons, a property that facilitates detection by CT scans.

The PoP wrapper has biophotonic qualities that make it a great match for fluorescence and photoacoustic imagining. The PoP layer also is adept at attracting copper, which is used in PET and Cerenkov luminescence imaging.

"Combining these two biocompatible components into a single nanoparticle could give tomorrow's doctors a powerful, new tool for medical imaging," says Prasad, also a SUNY Distinguished Professor of chemistry, physics, medicine and electrical engineering

at UB. "More studies would have to be done to determine whether the nanoparticle is safe to use for such purposes, but it does not contain toxic metals such as cadmium that are known to pose potential risks and found in some other nanoparticles."

"Another advantage of this core/shell imaging contrast agent is that it could enable biomedical imaging at multiple scales, from single-molecule to cell imaging, as well as from vascular and organ imaging to whole-body bioimaging," Chen adds. "These broad, potential capabilities are due to a plurality of optical, photoacoustic and radionuclide imaging abilities that the agent possesses."

Lovell says the next step in the research is to explore additional uses for the technology.

For example, it might be possible to attach a targeting molecule to the PoP surface that would enable cancer cells to take up the particles, something that photoacoustic and fluorescence imaging can detect due to the properties of the smart PoP coating. This would enable doctors to better see where tumors begin and end, Lovell says.

Functional Tissue-engineered Intestine Grown from Human Cells

A new study by researchers at Children's Hospital Los Angeles has shown that tissue-engineered small intestine grown from human cells replicates key aspects of a functioning human intestine. The tissue-engineered small intestine they developed contains important elements of the mucosal lining and support structures, including the ability to absorb sugars, and even tiny or ultra-structural components like cellular connections.

Tissue-Engineered Small Intestine (TESI) grows from stem cells contained in the intestine and offers a promising treatment for short bowel syndrome (SBS), a major cause of intestinal failure, particularly in premature babies and newborns with congenital intestinal anomalies. TESI may one day offer a therapeutic alternative to the current standard treatment, which is intestinal transplantation, and could potentially solve its largest challenges donor shortage and the need for lifelong immunosuppression.

NASA finds good news on forests and carbon dioxide

A new NASA-led study shows that tropical forests may be absorbing far more carbon dioxide than many scientists thought, in response to rising atmospheric levels of the greenhouse gas. The study estimates that tropical forests absorb 1.4 billion metric tons of carbon dioxide out of a total global absorption of 2.5 billion.

"This is good news, because uptake in boreal forests is already slowing, while tropical forests may continue to take up carbon for many years," said David Schimel of NASA's Jet Propulsion Laboratory, Pasadena, California. Schimel is lead author of a paper on the new research, appearing online in the Proceedings of National Academy of Sciences.

Forests and other land vegetation currently remove up to 30 percent of human carbon dioxide emissions from the atmosphere during photosynthesis. If the rate of absorption were to slow down, the rate of global warming would speed up in return.

The new study is the first to devise a way to make apples-to-apples comparisons of carbon dioxide estimates from many sources at different scales: computer models of ecosystem processes, atmospheric models run backward in time to deduce the sources of today's concentrations (called inverse models), satellite images, data from experimental forest plots and more. The researchers reconciled all types of analyses and assessed the accuracy of the results based on how well they reproduced independent, ground-based measurements. They obtained their new estimate of the tropical carbon absorption from the models they determined to be the most trusted and verified.

"Until our analysis, no one had successfully completed a global reconciliation of information about carbon dioxide effects from the atmospheric, forestry and modeling communities," said co-author Joshua Fisher of JPL. "It is incredible that all these different types of independent data sources start to converge on an answer."

The question of which type of forest is the bigger carbon absorber "is not just an accounting curiosity," said co-author Britton Stephens of the National Center for Atmospheric Research, Boulder, Colorado. "It has big implications for our understanding of whether global terrestrial ecosystems might continue to offset our carbon dioxide emissions or might begin to exacerbate climate change."

As human-caused emissions add more carbon dioxide to the atmosphere, forests worldwide are using it to grow faster, reducing the amount that stays airborne. This effect is called carbon fertilization. "All else being equal, the effect is stronger at higher temperatures, meaning it will be higher in the tropics than in the boreal forests," Schimel said.

But climate change also decreases water availability in some regions and makes Earth warmer, leading to more frequent and larger wildfires. In the tropics, humans compound the problem by burning wood during deforestation. Fires don't just stop carbon absorption by killing trees, they also spew huge amounts of carbon into the atmosphere as the wood burns.

For about 25 years, most computer climate models have been showing that mid-latitude forests in the Northern Hemisphere absorb more carbon than tropical forests. That result was initially based on the then-current understanding of global air flows and limited data suggesting that deforestation was causing tropical forests to release more carbon dioxide than they were absorbing.

In the mid-2000s, Stephens used measurements of carbon dioxide made from aircraft to show that many climate models were not correctly representing flows of carbon above ground level. Models that matched the aircraft measurements better showed more carbon absorption in the tropical forests. However, there were still not enough global data sets to validate the idea of a large tropical-forest absorption. Schimel said that their new study took advantage of a great deal of work other scientists have done since Stephens' paper to pull together national and regional data of various kinds into robust, global data sets.

Schimel noted that their paper reconciles results at every scale from the pores of a single leaf, where photosynthesis takes place, to the whole Earth, as air moves carbon dioxide around the globe. "What we've had up till this paper was a theory of carbon dioxide fertilization based on phenomena at the microscopic scale and observations at the global scale that appeared to contradict those phenomena. Here, at least, is a hypothesis that provides a consistent explanation that includes both how we know photosynthesis works and what's happening at the planetary scale."

NASA monitors Earth's vital signs from land, air and space with a fleet of satellites and ambitious airborne and ground-based observation campaigns. NASA develops new ways to observe and study Earth's interconnected natural systems with long-term data records and computer analysis tools to better see how our planet is changing. The agency shares this unique knowledge with the global community and works with institutions in the United States and around the world that contribute to understanding and protecting our home planet.

Record-breaking Black Hole Outburst Detected

Last September, after years of watching, a team of scientists led by Amherst College astronomy professor Daryl Haggard observed and recorded the largest-ever flare in X-rays from a supermassive black hole at the center of the Milky Way. The astronomical event, which was detected by NASA's Chandra X-ray Observatory, puts the scientific community one step closer to understanding the nature and behavior of super massive black holes.

Haggard and her colleagues discussed the flare today during this year's meeting of the American Astronomical Society in Seattle.

Super massive black holes are the largest of black holes, and all large galaxies have one. The one at the center of our galaxy, the Milky Way, is called Sagittarius A* (or, Sgr A*, as it is called), and scientists estimate that it contains about four and a half million times the mass of our Sun.

Scientists working with Chandra have observed Sgr A* repeatedly since the telescope was launched into space in 1999. Haggard and fellow astronomers were originally using Chandra to see if Sgr A* would consume parts of a cloud of gas, known as G2.

"Unfortunately, the G2 gas cloud didn't produce the fireworks we were hoping for when it got close to Sgr A*," she said. "However, nature often surprises us and we saw something else that was really exciting."

Haggard and her team detected an X-ray outburst last September that was 400 times brighter than the usual X-ray output from Sgr A*. This "megaflare" was nearly three times brighter than the previous record holder that was seen in early 2012. A second enormous X-ray flare, 200 times brighter than Sgr A* in its quiet state, was observed with Chandra on October 20, 2014.

Haggard and her team have two main ideas about what could be causing Sgr A* to erupt in this extreme way. One hypothesis is that the gravity of the super massive black hole has torn apart a couple of asteroids that wandered too close. The debris from such a "tidal disruption" would become very hot and produce X-rays before disappearing forever across the black hole's point of no return (called the "event horizon").

"If an asteroid was torn apart, it would go around the black hole for a couple of hours, like water circling an open drain before falling in," said colleague and co-principal investigator Fred Baganoff of the Massachusetts Institute of Technology in Cambridge, MA. "That's just how long we saw the brightest X-ray flare last, so that is an intriguing clue for us to consider."

If that theory holds up, it means astronomers have found evidence for the largest asteroid ever to be torn apart by the Milky Way's black hole.

Another, different idea is that the magnetic field lines within the material flowing towards Sgr A* are packed incredibly tightly. If this were the case, these field lines would occasionally interconnect and reconfigure themselves. When this happens, their magnetic energy is converted into the energy of motion, heat and the acceleration of particles which could produce a bright X-ray flare. Such magnetic flares are seen on the Sun, and the Sgr A* flares have a similar pattern of brightness levels to the solar events.

"At the moment, we can't distinguish between these two very different ideas," said Haggard. "It's exciting to identify tensions between models and to have a chance to resolve them with present and future observations."

In addition to the giant flares, Haggard and her team also collected more data on a magnetar, a neutron star with a strong magnetic field located close to Sgr A*. This magnetar is undergoing a long X-ray outburst, and the Chandra data are allowing astronomers to better understand this unusual object.

As for the G2: Astronomers estimate that the gas cloud made its closest approach, still about 15 billion miles away from the edge of the black hole in the spring of 2014. The researchers estimate the record breaking X-ray flares were produced about a hundred times closer to the black hole, making it very unlikely that the Chandra flares were associated with G2.

Toxic Ebola Protein Fragment Identified

William Gallaher, PhD, Emeritus Professor of Microbiology, Immunology & Parasitology at

LSU Health New Orleans School of Medicine, has discovered a fragment of an Ebola virus protein that is toxic to cells and may contribute to infection and illness. The findings were published online January 20, 2015, in the open access journal, Viruses.

The fragment was found within a grouping of amino acids that is made in parallel with the protein involved in attachment of the virus to cells. Called the "Delta peptide," it has been shown recently to block the Ebola virus from attaching to already-infected cells. The new findings suggest that Delta peptide possibly functions by changing membrane permeability.

Following his discovery, Dr. Gallaher contacted Robert Garry, PhD, Professor of Microbiology and Immunology at Tulane University School of Medicine, a longtime collaborator, to produce a structural model and potential mechanism of action. The results of that modeling work were fashioned into a manuscript that was subjected to rigorous peer view by experts in the field and are being made public only after acceptance into a special issue on "Advances in Ebolavirus, Marburgvirus, and Cuevavirus Research 2014-2015" in Viruses.

Although preliminary studies using synthetic peptides have confirmed the potential of the fragment, its specific role and potency in its natural environment within Ebola virus-infected cells are yet to be determined. However, Dr. Gallaher and his colleagues have determined how to deactivate the toxic properties of the Ebola protein fragment in the laboratory environment. He and his colleagues are also developing inhibitors of the toxic mechanism, which may ultimately be useful as drugs, should a role for Delta peptide in Ebola virus disease become established by future studies.

According to the Centers for Disease Control and Prevention (CDC), the 2014 Ebola epidemic is the largest in history, affecting multiple countries in West Africa. Two imported cases, including one death, and two locally acquired cases in healthcare workers have been reported in the United States. As of January 16, 2015, the CDC and World Health Organization report 13,510 laboratory-confirmed cases and 8,483 deaths worldwide.

Scientists announce Anti-HIV Agent so Powerful it can Work in a Vaccine

In a remarkable new advance against the virus that causes AIDS, scientists from the Jupiter, Florida campus of The Scripps Research Institute (TSRI) have announced the creation of a novel drug candidate that is so potent and universally effective, it might work as part of an unconventional vaccine.

The study shows that the new drug candidate blocks every strain of HIV-1, HIV-2 and SIV (simian immunodeficiency virus) that has been isolated from humans or rhesus macaques, including the hardest-to-stop variants. It also protects against much-higher doses of virus than occur in most human transmission and does so for at least eight months after injection.

"Our compound is the broadest and most potent entry inhibitor described so far," said Michael Farzan, a TSRI professor who led the effort. "Unlike antibodies, which fail to neutralize a large fraction of HIV-1 strains, our protein has been effective against all strains tested, raising the possibility it could offer an effective HIV vaccine alternative."

When HIV infects a cell, it targets the CD4 lymphocyte, an integral part of the body's

immune system. HIV fuses with the cell and inserts its own genetic material, in this case, single-stranded RNA and transforms the host cell into a HIV manufacturing site.

The new study builds on previous discoveries by the Farzan laboratory, which show that a co-receptor called CCR5 contains unusual modifications in its critical HIV-binding region, and that proteins based on this region can be used to prevent infection.

With this knowledge, Farzan and his team developed the new drug candidate so that it binds to two sites on the surface of the virus simultaneously, preventing entry of HIV into the host cell.

"When antibodies try to mimic the receptor, they touch a lot of other parts of the viral envelope that HIV can change with ease," said TSRI Research Associate Matthew Gardner, the first author of the study with Lisa M. Kattenhorn of Harvard Medical School. "We've developed a direct mimic of the receptors without providing many avenues that the virus can use to escape, so we catch every virus thus far."

The team also leveraged preexisting technology in designing a delivery vehicle an engineered adeno-associated virus, a small, relatively innocuous virus that causes no disease. Once injected into muscle tissue, like HIV itself, the vehicle turns those cells into "factories" that could produce enough of the new protective protein to last for years, perhaps decades, Farzan said.

Data from the new study showed the drug candidate binds to the envelope of HIV-1 more potently than the best broadly neutralizing antibodies against the virus. Also, when macaque models were inoculated with the drug

candidate, they were protected from multiple challenges by SIV.

Novel Crumpling Method Takes Flat Graphene from 2-D to 3-D

Researchers at the University of Illinois at Urbana-Champaign have developed a unique single-step process to achieve three-dimensional (3D) texturing of graphene and graphite. Using a commercially available thermally activated shape-memory polymer substrate, this 3D texturing, or "crumpling," allows for increased surface area and opens the doors to expanded capabilities for electronics and biomaterials.

"Fundamentally, intrinsic strains on crumpled graphene could allow modulation of electrical and optical properties of graphene," explained SungWoo Nam, an Assistant Professor of mechanical science and engineering at Illinois. "We believe that the crumpled graphene surfaces can be used as higher surface area electrodes for battery and supercapacitor applications. As a coating layer, 3D textured/crumpled nano-topographies could allow omniphobic/anti-bacterial surfaces for advanced coating applications."

Graphene, single atomic layer of SP2-bonded carbon atoms has been a material of intensive research and interest over recent years. A combination of exceptional mechanical properties, high carrier mobility, thermal conductivity, and chemical inertness, make graphene a prime candidate material for next generation optoelectronic, electromechanical, and biomedical applications.

"In this study, we developed a novel method for

controlled crumpling of graphene and graphite via heat-induced contractile deformation of the underlying substrate," explained Michael Cai Wang, a graduate student and first author of the paper, "Heterogeneous, Three-Dimensional Texturing of Graphene," which appeared in the journal Nano Letters. "While graphene intrinsically exhibits tiny ripples in ambient conditions, we created large and tunable crumpled textures in a tailored and scalable fashion."

"As a simpler, more scalable, and spatially selective method, this texturing of graphene and graphite exploits the thermally induced transformation of shape-memory thermoplastics, which has been previously applied to microfluidic device fabrication, metallic film patterning, nanowire assembly, and robotic self-assembly applications," added Nam, whose group has filed a patent for their novel strategy. "The thermoplastic nature of the polymeric substrate also allows for the crumpled graphene morphology to be arbitrarily re-flattened at the same elevated temperature for the crumpling process."

"Due to the extremely low cost and ease of processing of our approach, we believe that this will be a new way to manufacture nanoscale topographies for graphene and many other 2D and thin-film materials."

The researchers are also investigating the textured graphene surfaces for 3D sensor applications.

"Enhanced surface area will allow even more sensitive and intimate interactions with biological systems, leading to high sensitivity devices," said Nam.

Mixing Plant Waste and Plastic to Obtain Building Materials

A new company PLASTINOVA has intertwined the science of chemical engineering and technology to recycle all kinds of useless plastics and tequila agave bagasse similar to wood, but with greater resistance used as formwork in the construction industry or in the manufacture of benches, tables and chairs.

Generally the falsework used to build roofs, arches or any structure is made of wood or aluminum. However, the offer of the young entrepreneurs in Jalisco, westcoast state of Mexico, aims to achieve a medium point between both materials in terms of physical properties while reducing the cost, as well as recycling organic and inorganic waste.

The composition of the tabloid goes from 10 to 35 percent of agave fiber, completed with recycled plastic, as the latter is the matrix of this building material, said Alberto Medina-Mora Urquiza one of four partners of PLASTINOVA, together with Eloy Aquino Herrán, Milton Vázquez Lepe and Ignacio Reyes González.

PLASTINOVA lasted a year as a project, and in recent months managed to establish itself as a functioning company producing composite materials from recycled plastic and agave bagasse, which after a series of treatments obtains the necessary fiber to make the formwork tabloids.

Although PLASTINOVA was established in an area where tequila is produced, is very difficult to obtain agave bagasse because companies use it as fuel for boilers. The entrepreneurs, however, reached an agreement with two tequila companies to harness the waste plant.

To process one hundred kilograms of agave the machinery requires about 36 hours. And one more day to transform the fiber in a ton of pellets or beads of recycled plastic, with which the tabloids are manufactured, which measure 1.20 meters by one meter and are 10 centimeters thick.

The manufacture of the tabloids requires a three-part process. First, with the help of a physical process the alcohol, sugar, bone and shell is removed from the agave bagasse, leaving only the fiber for cleaning. After that it is dried, ground and pulverized, to obtain a flour-like powder.

During this process a compatibilizing agent is added to the fiber, which is a special substance that serves to alter the chemical composition of the waste, which makes it more resistant and compatible with various types of plastics, such propylene used in spoons or the high density polyethylene used in milk gallons, Medina-Mora explained.

Among the future plans of the company is to replace agave fibers with ones from coconut, since according to their laboratory tests are sturdier and have more suitable physical properties for use in building. Although for this they require further participation in entrepreneurial competitions as they did last year in the Cleantech Challenge or become widely known to attract investors to support them in order to increase the capacity of the machinery.

Sunlight Continues to Damage Skin in the Dark

Much of the damage that ultraviolet radiation (UV) does to skin occurs hours after sun exposure, a team of Yale-led researchers concluded in a study that was published online by the journal Science.

Exposure to UV light from the sun or from tanning beds can damage the DNA in melanocytes, the cells that make the melanin that gives skin its color. This damage is a major cause of skin cancer, the most common form of cancer in the United States. In the past, experts believed that melanin protected the skin by blocking harmful UV light. But there was also evidence from studies suggesting that melanin was associated with skin cell damage.

In the current study, Douglas E. Brash, clinical professor of therapeutic radiology and dermatology at Yale School of Medical, and his co-authors first exposed mouse and human melanocyte cells to radiation from a UV lamp. The radiation caused a type of DNA damage known as a cyclobutane dimer (CPD), in which two DNA "letters" attach and bend the DNA, preventing the information it contains from being read correctly. To the researchers' surprise, the melanocytes not only generated CPDs immediately but continued to do so hours after UV exposure ended. Cells without melanin generated CPDs only during the UV exposure.

This finding showed that melanin had both carcinogenic and protective effects. "If you look inside adult skin, melanin does protect against CPDs. It does act as a shield," said Brash, also a member of Yale Cancer Center. "But it is doing both good and bad things."

The researchers next tested the extent of damage that occurred after sun exposure by preventing normal DNA repair in mouse samples. They found that half of the CPDs in melanocytes were "dark CPDs", CPDs created in the dark.

In searching for an explanation of these results, Sanjay Premi, associate research scientist in the Brash laboratory, discovered that the UV light activated two enzymes that combined to "excite" an electron in melanin. The energy generated from this process, known as chemiexcitation, was transferred to DNA in the dark, creating the same DNA damage that sunlight caused in daytime. Chemiexcitation has previously been seen only in lower plants and animals.

While noting that news of the carcinogenic effect of melanin is disconcerting, the researchers also pointed to a ray of hope: The slowness of chemiexcitation may allow time for new preventive tools, such as an "evening-after" sunscreen designed to block the energy transfer.

Nanotubes Self-organize and Wiggle: Evolution of a Nonequilibrium System Demonstrates MEPP

The second law of thermodynamics tells us that all systems evolve toward a state of maximum entropy, wherein all energy is dissipated as heat, and no available energy remains to do work. Since the mid-20th century, research has pointed to an extension of the second law for nonequilibrium systems: the Maximum Entropy Production Principle (MEPP) states that a system away from equilibrium evolves in such a way as to maximize entropy production, given present constraints.

Now, physicists Alexey Bezryadin, Alfred Hubler, and Andrey Belkin from the University of Illinois at Urbana-Champaign, have demonstrated the emergence of self-organized structures that drive the evolution of a non-equilibrium system to a state of maximum entropy production. The

authors suggest MEPP underlies the evolution of the artificial system's self-organization, in the same way that it underlies the evolution of ordered systems (biological life) on Earth. The team's results are published in Nature Publishing Group's online journal Scientific Reports.

MEPP may have profound implications for our understanding of the evolution of biological life on Earth and of the underlying rules that govern the behavior and evolution of all nonequilibrium systems. Life emerged on Earth from the strongly nonequilibrium energy distribution created by the Sun's hot photons striking a cooler planet. Plants evolved to capture high energy photons and produce heat, generating entropy. Then animals evolved to eat plants increasing the dissipation of heat energy and maximizing entropy production.

In their experiment, the researchers suspended a large number of carbon nanotubes in a non-conducting non-polar fluid and drove the system out of equilibrium by applying a strong electric field. Once electrically charged, the system evolved toward maximum entropy through two distinct intermediate states, with the spontaneous emergence of self-assembled conducting nanotube chains.

In the first state, the "avalanche" regime, the conductive chains aligned themselves according to the polarity of the applied voltage, allowing the system to carry current and thus to dissipate heat and produce entropy. The chains appeared to sprout appendages as nanotubes aligned themselves so as to adjoin adjacent parallel chains, effectively increasing entropy production. But frequently, this self-organization was destroyed through avalanches triggered by the heating and charging that emanates from the emerging electric current streams.

"The avalanches were apparent in the changes of the electric current over time," said Bezryadin.

Following avalanches, the chains with their appendages "wiggled," resembling a living thing, similar to an insect.

"Toward the final stages of this regime, the appendages were not destroyed during the avalanches, but rather retracted until the avalanche ended, then reformed their connection. So it was obvious that the avalanches correspond to the 'feeding cycle' of the 'nanotube inset'," comments Bezryadin.

In the second relatively stable stage of evolution, the entropy production rate reached maximum or near maximum. This state is quasi-stable in that there were no destructive avalanches.

The study points to a possible classification scheme for evolutionary stages and a criterium for the point at which evolution of the system is irreversible--wherein entropy production in the self-organizing subsystem reaches its maximum possible value. Further experimentation on a larger scale is necessary to affirm these underlying principals, but if they hold true, they will prove a great advantage in predicting behavioral and evolutionary trends in nonequilibrium systems.

The authors draw an analogy between the evolution of intelligent life forms on Earth and the emergence of the wiggling bugs in their experiment. The researchers note that further quantitative studies are needed to round out this comparison. In particular, they would need to demonstrate that their "wiggling bugs" can multiply, which would require the experiment be reproduced on a significantly larger scale.

Such a study, if successful, would have implications for the eventual development of technologies that feature self-organized artificial intelligence, an idea explored elsewhere by co-author Alfred Hubler, funded by the Defense Advanced Research Projects Agency.

"The general trend of the evolution of biological systems seems to be this: more advanced life forms tend to dissipate more energy by broadening their access to various forms of stored energy," Bezryadin proposes. Thus a common underlying principle can be suggested between our self-organized clouds of nanotubes, which generate more and more heat by reducing their electrical resistance and thus allow more current to flow, and the biological systems which look for new means to find food, either through biological adaptation or by inventing more technologies.

Vitamin D Deficiency Linked more Closely to Diabetes than Obesity

People who have low levels of vitamin D are more likely to have diabetes, regardless of how much they weigh, according to a study published in the Endocrine Society's Journal of Clinical Endocrinology & Metabolism.

The results help clarify the connection between vitamin D, obesity and diabetes. According to the Society's Scientific Statement on the Non-skeletal Effects of Vitamin D, studies have found that people who have low levels of vitamin D are more likely to be obese. They also are more likely to have Type 2 diabetes, prediabetes and metabolic syndrome than people with normal vitamin D levels.

Vitamin D helps the body absorb calcium and maintain bone and muscle health. The skin

naturally produces this vitamin after exposure to sunlight. People also absorb smaller amounts of the vitamin through foods, such as milk fortified with vitamin D. More than 1 billion people worldwide are estimated to have deficient levels of vitamin D due to limited sunshine exposure.

The cross-sectional study compared vitamin D biomarkers in 118 participants at the university hospital Virgen de la Victoria in Malaga as well as 30 participants from the Hospital Universitari Dr. Josep Trueta in Girona, Spain. All participants were classified by their body-mass index (BMI) as well as whether they had diabetes, prediabetes or no glycemic disorders. Researchers measured levels of vitamin D in the participants' blood streams and vitamin D receptor gene expression in adipose tissue.

The analysis found that obese subjects who did not have glucose metabolism disorders had higher levels of vitamin D than diabetic subjects. Likewise, lean subjects with diabetes or another glucose metabolism disorder were more likely to have low levels of vitamin D. Vitamin D levels were directly correlated with glucose levels, but not with BMI.

"Our findings indicate that vitamin D is associated more closely with glucose metabolism than obesity," said one of the study's authors, Manuel Macías-González, PhD, of Complejo Hospitalario de Málaga (Virgen de la Victoria) and the University of Málaga. "The study suggests that vitamin D deficiency and obesity interact synergistically to heighten the risk of diabetes and other metabolic disorders. The average person may be able to reduce their risk by maintaining a healthy diet and getting enough outdoor activity."

Artificially Intelligent robot scientist 'Eve' could Boost Search for New Drugs

Eve, an artificially-intelligent 'robot scientist' could make drug discovery faster and much cheaper, say researchers writing in the Royal Society journal Interface. The team has demonstrated the success of the approach as Eve discovered that a compound shown to have anti-cancer properties might also be used in the fight against malaria.

Robot scientists are a natural extension of the trend of increased involvement of automation in science. They can automatically develop and test hypotheses to explain observations, run experiments using laboratory robotics, interpret the results to amend their hypotheses, and then repeat the cycle, automating high, throughout hypothesis, led research. Robot scientists are also well suited to recording scientific knowledge: as the experiments are conceived and executed automatically by computer, it is possible to completely capture and digitally curate all aspects of the scientific process.

In 2009, Adam, a robot scientist developed by researchers at the Universities of Aberystwyth and Cambridge, became the first machine to independently discover new scientific knowledge. The same team has now developed Eve, based at the University of Manchester, whose purpose is to speed up the drug discovery process and make it more economical. In the study published today, they describe how the robot can help identify promising new drug candidates for malaria and neglected tropical diseases such as African sleeping sickness and Chagas' disease.

"Neglected tropical diseases are a scourge of humanity, infecting hundreds of millions of

people, and killing millions of people every year," says Professor Steve Oliver from the Cambridge Systems Biology Centre and the Department of Biochemistry at the University of Cambridge. "We know what causes these diseases and that we can, in theory, attack the parasites that cause them using small molecule drugs. But the cost and speed of drug discovery and the economic return make them unattractive to the pharmaceutical industry.

"Eve exploits its artificial intelligence to learn from early successes in her screens and select compounds that have a high probability of being active against the chosen drug target. A smart screening system, based on genetically engineered yeast, is used. This allows Eve to exclude compounds that are toxic to cells and select those that block the action of the parasite protein while leaving any equivalent human protein unscathed. This reduces the costs, uncertainty, and time involved in drug screening, and has the potential to improve the lives of millions of people worldwide."

Eve is designed to automate early-stage drug design. First, she systematically tests each member from a large set of compounds in the standard brute-force way of conventional mass screening. The compounds are screened against assays (tests) designed to be automatically engineered, and can be generated much faster and more cheaply than the bespoke assays that are currently standard. This enables more types of assay to be applied, more efficient use of screening facilities to be made, and thereby increases the probability of a discovery within a given budget.

Eve's robotic system is capable of screening over 10,000 compounds per day. However, while simple to automate, mass screening is still relatively slow and wasteful of resources as every compound in the library is tested. It is also unintelligent, as it makes no use of what is learnt during screening.

To improve this process, Eve selects at random a subset of the library to find compounds that pass the first assay; any 'hits' are re-tested multiple times to reduce the probability of false positives. Taking this set of confirmed hits, Eve uses statistics and machine learning to predict new structures that might score better against the assays. Although she currently does not have the ability to synthesise such compounds, future versions of the robot could potentially incorporate this feature.

Professor Ross King, from the Manchester Institute of Biotechnology at the University of Manchester, says: "Every industry now benefits from automation and science is no exception. Bringing in machine learning to make this process intelligent.

To test the viability of the approach, the researchers developed assays targeting key molecules from parasites responsible for diseases such as malaria, Chagas' disease and schistosomiasis and tested against these a library of approximately 1,500 clinically approved compounds. Through this, Eve showed that a compound that has previously been investigated as an anti-cancer drug inhibits a key molecule known as DHFR in the malaria parasite. Drugs that inhibit this molecule are currently routinely used to protect against malaria, and are given to over a million children; however, the emergence of strains of parasites resistant to existing drugs means that the search for new drugs is becoming increasingly more urgent.

"Despite extensive efforts, no one has been able to find a new antimalarial that targets

DHFR and is able to pass clinical trials," adds Professor King. "Eve's discovery could be even more significant than just demonstrating a new approach to drug discovery."

The research was supported by the Biotechnology & Biological Sciences Research Council and the European Commission.

SOHO sees Something New Near the Sun: Comet Survives Close Encounter

An unusual comet skimmed past the sun on Feb 18-21, 2015, as captured by the European Space Agency (ESA) and NASA's Solar and Heliospheric Observatory, or SOHO.

This comet was interesting for two reasons. First it's what's called a non-group comet, meaning it's not part of any known family of comets. Most comets seen by SOHO belong to the Kreutz family, all of which broke off from a single giant comet many centuries ago.

The second reason it's interesting is because the vast majority of comets that come close enough to the sun to be seen by SOHO do not survive the trip. Known as sungrazers, these comets usually evaporate in the intense sunlight. This comet made it to within 2.2 million miles of the sun's surface.

"There's a half-decent chance that ground observers might be able to detect it in the coming weeks," said Karl Battams, a solar scientist at the Naval Research Lab in Washington, D.C. "But it's also possible that events during its trip around the sun will cause it to die fairly fast."

Since launching in 1995, SOHO has become the number one comet finder of all time this was comet discovery number 2,875. However, SOHO sees non-group comets like this only a few times a year.

Anti-inflammatory Mechanism of Dieting and Fasting Revealed

Researchers at Yale School of Medicine have found that a compound produced by the body when dieting or fasting can block a part of the immune system involved in several inflammatory disorders such as type 2 diabetes, atherosclerosis, and Alzheimer's disease.

"These findings are important because endogenous metabolites like BHB that block the NLRP3 inflammasome could be relevant against many inflammatory diseases, including those where there are mutations in the NLRP3 genes," said Vishwa Deep Dixit, professor in the Section of Comparative Medicine at Yale School of Medicine.

BHB is a metabolite produced by the body in response to fasting, high-intensity exercise, caloric restriction, or consumption of the low-carbohydrate ketogenic diet. Dixit said it is well known that fasting and calorie restriction reduces inflammation in the body, but it was unclear how immune cells adapt to reduced availability of glucose and if they can respond to metabolites produced from fat oxidation.

Working with mice and human immune cells, Dixit and colleagues focused on how macrophages specialized immune cells that produce inflammation respond when exposed to ketone bodies and whether that impacts the inflammasone complex.

The team introduced BHB to mouse models of inflammatory diseases caused by NLP3. They found that this reduced inflammation, and that

inflammation was also reduced when the mice were given a ketogenic diet, which elevates the levels of BHB in the bloodstream.

In the Quantum World, the Future Affects the Past: Hindsight and Foresight Together more Accurately 'Predict' a Quantum System's State

We're so used to murder mysteries that we don't even notice how mystery authors play with time. Typically the murder occurs well before the midpoint of the book, but there is an information blackout at that point and the reader learns what happened then only on the last page.

If the last page were ripped out of the book, physicist Kater Murch, PhD, said, would the reader be better off guessing what happened by reading only up to the fatal incident or by reading the entire book?

The answer, so obvious in the case of the murder mystery, is less so in world of quantum mechanics, where indeterminacy is fundamental rather than contrived for our reading pleasure.

Even if you know everything quantum mechanics can tell you about a quantum particle, said Murch, an assistant professor of physics in Arts & Sciences at Washington University in St. Louis, you cannot predict with certainty the outcome of a simple experiment to measure its state. All quantum mechanics can offer are statistical probabilities for the possible results.

The orthodox view is that this indeterminacy is not a defect of the theory, but rather a fact of nature. The particle's state is not merely unknown, but truly undefined before it is measured. The act of measurement itself that forces the particle to collapse to a definite state.

It's as if what we did today, changed what we did yesterday. And as this analogy suggests, the experimental results have spooky implications for time and causality.

Measuring a phantom

Until recently physicists could explore the quantum mechanical properties of single particles only through thought experiments, because any attempt to observe them directly caused them to shed their mysterious quantum properties.

But in the 1980s and 1990s physicists invented devices that allowed them to measure these fragile quantum systems so gently that they don't immediately collapse to a definite state.

The device Murch uses to explore quantum space is a simple superconducting circuit that enters quantum space when it is cooled to near absolute zero. Murch's team uses the bottom two energy levels of this qubit, the ground state and an excited state, as their model quantum system. Between these two states, there are an infinite number of quantum states that are superpositions, or combinations, of the ground and excited states.

The quantum state of the circuit is detected by putting it inside a microwave box. A few microwave photons are sent into the box, where their quantum fields interact with the superconducting circuit. So when the photons exit the box they bear information about the quantum system.

Crucially, these "weak," off-resonance measurements do not disturb the qubit, unlike "strong" measurements with photons that are

resonant with the energy difference between the two states, which knock the circuit into one or the other state. A quantum guessing game In Physical Review Letters, Murch describes a quantum guessing game played with the qubit.

"We start each run by putting the qubit in a superposition of the two states," he said. "Then we do a strong measurement but hide the result, continuing to follow the system with weak measurements."

They then try to guess the hidden result, which is their version of the missing page of the murder mystery.

"Calculating forward, using the Born equation that expresses the probability of finding the system in a particular state, your odds of guessing right are only 50-50," Murch said. "But you can also calculate backward using something called an effect matrix. Just take all the equations and flip them around. They still work and you can just run the trajectory backward.

"So there's a backward-going trajectory and a forward-going trajectory and if we look at them both together and weight the information in both equally, we get something we call a hindsight prediction, or "retrodiction."

The shattering thing about the retrodiction is that it is 90 percent accurate. When the physicists check it against the stored measurement of the system's earlier state it is right nine times out of 10.

Down the rabbit hole

The quantum guessing game suggests ways to make both quantum computing and the quantum control of open systems, such as chemical reactions, more robust. But it also has implications for much deeper problems in physics.

For one thing, it suggests that in the quantum world time runs both backward and forward whereas in the classical world it only runs forward.

"I always thought the measurement would resolve the time symmetry in quantum mechanics," Murch said. "If we measure a particle in a superposition of states and it collapses into one of two states, well, that sounds like a process that goes forward in time."

But in the quantum guessing experiment, time symmetry has returned. The improved odds imply the measured quantum state somehow incorporates information from the future as well as the past. And that implies that time, notoriously an arrow in the classical world, is a double-headed arrow in the quantum world.

"It's not clear why in the real world, the world made up of many particles, time only goes forward and entropy always increases," Murch said. "But many people are working on that problem and I expect it will be solved in a few years," he said.

In a world where time is symmetric, however, is there such a thing as cause and effect? To find out, Murch proposes to run a qubit experiment that would set up feedback loops (which are chains of cause and effect) and try to run them both forward and backward.

"It takes 20 or 30 minutes to run one of these experiments," Murch said, "several weeks to process it, and a year to scratch our heads to see if we're crazy or not."

"At the end of the day," he said, "I take solace in the fact that we have a real experiment and real data that we plot on real curves."

WEB WATCH

In this Section, we present websites and a brief introduction about them. Inclusion of a site does not imply that School Science endorses the content of the site. Sites have been suggested on the basis of their possible utility to school systems.

- **www.treehugger.com**

  This website is dedicated to a greener environment. It gives green news, solutions, and product information. The website also publishes up to minute blogs, weekly and daily newsletter and radio interviews too. One will get information and news related greener sustainable resources.

- **www.bestfree-book.com**

  This website is for those avid fiction readers. The website contains novels belonging to different genres—vampires, horror, thriller, fantastic fiction, science fiction, mystery or suspense, romance and classics. One will get to read fiction for free in this website.

- **www.pagebypagebooks.com**

  This website is dedicated to classic literature. It contains hundreds of classic literature which one can read online and for free. The website is an ideal way to expand your horizons when it comes to classic literature.

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To Our Contributors

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भारतीय आधुनिक शिक्षा (त्रैमासिक) (Bhartiya Aadhunik Shiksha) A Quarterly Journal in Hindi	₹50.00	₹200.00
The Primary Teacher A Quarterly Journal for Primary Teachers	₹65.00	₹260.00
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