School Science | A Quarterly Journal of Science Education

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Form IV (See Rule 8)
SCHOOL SCIENCE

1. Place of Publication	National Council of Educational Research and Training (NCERT)
2. Periodicity of Publication	Quarterly
3. Printer's Name (Whether citizen of India?) (If foreigner, state the country of origin) Address	Manoj Sharma Yes Not applicable Proprietor : Chaar Dishayen Printers Pvt. Ltd. G-40 Sector-3 Noida (U.P.) 201 301
4. Publisher's Name (Whether citizen of India?) (If foreigner, state the country of origin) Address	Ashok Srivastava Yes Not applicable Head, Publication Division, NCERT Sri Aurobindo Marg, New Delhi 110 016
5. Editor's Name (Whether citizen of India?) (If foreigner, state the country of origin) Address	R. Joshi Yes Not applicable Academic Editor (JIE), DESM, NCERT New Delhi 110 016
6. Names and addresses of the individuals who own the newspaper and partner or shareholders holding more than one per cent of the total capital	National Council of Educational Research and Training, New Delhi *(An autonomous body of the Government of India in the Ministery of Human Resource Development)*

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Publisher

Published at the Publication Division by the Secretary, National Council of Educational Research and Training, Sri Aurobindo Marg, New Delhi 110 016 and printed at Vrindaban Graphics (P) Ltd., E-34, Sector-7, Noida (U.P.) 201 301

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EDITORIAL

The year 2011 is being celebrated as an International Year of Chemistry (IYC) to highlight the progress in the field of chemistry and the contributions that chemistry has made for the well-being of human kind. This year also marks the 100th anniversary of the Nobel prize award to Marie Sklodowska Curie. The theme of the celebration is *Chemistry: Our Life, Our Future.* The first article," Where would we be without Chemistry?" is by the chemist and teacher Sir Peter Atkins of the University of Oxford. It is reprinted from the magazine, 'A World of Science', Vol. 9, No.1, 2011. It talks about how chemistry has changed our life and the world around us. It also reminds us about the problems associated with this development. Chemistry has been used to make explosives used in armaments, and to make poison. Above all, the effluents of chemical plants are hazardous to environment. The Bhopal Gas Tragedy in 1984 is still fresh in our mind which was a result of explosion at the Union Carbide Plant. So, while celebrating about the positive contributions of chemistry, one should keep the other negative aspects in mind and efforts should be minimised and contain the ill effects for sustainable development in long range.

The next article in this journal is about the Green Chemistry and how school curriculum in chemistry can be designed with focus on Green Chemistry. It talks about different aspects of Green Chemistry and presents modules/ experiments/lesson plan which could be possibly integrated into a chemistry curriculum. Dr A.K. Mody talks about construction of knowledge and development of multiple intelligence through problem-based learning with examples from physics. A research-based extensive study titled 'A Comparative Study of Scholastic Achievement in Mathematics Examination in Relation to Conceptual Understanding and Mathematics Ability ' is presented by Arundhati Mech and Kuntala Patra. A small article highlighting the contribution of information technology in rural development is also included in this issue, in addition to regular features like web watch and book review.

Your comments and suggestions are welcome.

WHERE WOULD WE BE WITHOUT CHEMISTRY?*

Peter Atkins

University of Oxford
United Kingdom

This year sees the world celebrating the International Year of Chemistry. The celebrations are wholly justified because chemistry is hugely important for all of us, wherever we live. If you were to strip away all the contributions of chemistry to the modern world, you would find yourself back in the stone age, life would be short and painful, you would be underfed, there would be little colour in the world, you would be dressed in skins and surrounded by few of the appliances that entertain us and ease our lives. I will admit from the outset that chemistry, like any great enterprise, does cause problems. It is used to make the explosives used in armaments. It creates poisons and the effluents of chemistry plants can ruin the environment. In some dreadful cases, accidents have killed and maimed thousands. The explosion at the Union Carbide Plant in Bhopal in India in 1984 blighted thousands of innocent lives and the terrible consequences are still with us today. Pollution of water and air has wrought havoc with our surroundings. These disadvantages and horrors have to be acknowledged — but all technological and scientific advances bring difficulties in their train. We should weigh them against the advantages. With some exceptions, the chemical industry is well aware of its obligations to humanity and environment and does what it can to avoid the potentially damaging effects of its activities. In this article, I shall concentrate on the positive contributions that chemistry makes to the modern world and leave you to judge whether the price is too high.

Chemistry is the science of matter and the changes that matter can undergo. In the broadest possible terms, chemists take one form of matter and conjure from it a different form. In some cases, they take raw material from the Earth, such as oil or ores, and produce materials directly from them, such as petroleum fuels and iron for steel. They might harvest the skies, taking the nitrogen of the atmosphere and converting it into fertiliser. In many cases, they take more sophisticated forms of matter and convert it into materials suitable for use as fabrics or as the substances needed for high technology.

Communal Living is Possible:Thanks to Chemistry

Take water, for instance, the absolutely essential enabler of life. Chemistry has made communal living possible by purifying water and ridding it of

*Reprinted from "A World of Science", **Vol. 9, No.1,** 2011

pathogens. Chlorine is the principal agent enabling cities to exist: without it, disease would be rampant and urban living a gamble. Chemists have found ways of extracting this element from an abundant source: sodium chloride, common salt. Are there other ways, though? Can future chemists (of which you the reader might be one, or encouraging your students to pursue the study of chemistry) find ways of rendering urban life possible without the environmental disadvantages of using chlorine? Its replacement is highly desirable because chlorine is a dangerous and untrustworthy ally: although, through its potent chemical reactivity, it purifies water, that same reactivity means that it attacks other compounds and, for instance, enters the food chain as dioxins and related compounds. These compounds can attack the nervous system and accumulate in body fat. Chlorine and its compounds also rise high in the atmosphere where they contribute to the destruction of ozone and the formation of acid rain.

The application of a spray-applied membrane designed by BASF on the interior walls of a tunnel being built in the United Kingdom reduces the amount of concrete required, saving millions of euros in construction costs and reducing CO_2 emissions from cement-making

Chemists are at the forefront of the battle to obtain potable water from brackish water, from poisoned water in aquifers, such as the arsenic-laden water from deep aquifers in Bangladesh, and from that most abundant source of all, the oceans, by using water desalination plants. Chemists have contributed in direct ways to this crucial task by developing reverse osmosis, a process in which pressure is applied to brackish water to drive it through a filtering membrane, thereby rendering it potable. Chemists have also contributed in indirect ways by developing the membranes that contribute to the efficiency of the process by reducing its energy demands and increasing the lifetime and effectiveness of the membrane. It goes without saying that chemists' traditional skills of analysis — discovering what is present in it, what can be tolerated and what essential element should be removed to trigger the desired reaction — are crucial to this endeavour.

How the Search for Explosives Spawned a Green Revolution

Then there is food. As the global population grows and the productive land area is eroded, so it becomes more and more important to coax crops into greater abundance. The traditional way to encourage abundance is to apply fertilisers. Here, chemists have contributed nobly by finding sources of nitrogen and phosphorus and ensuring that these can be assimilated by plants. Genetic engineering is another exciting way to proceed but remains controversial because of the fears of some as to the consequences of interfering with inheritable factors and the possibility of uncontrolled transfer into other species. Genetically modified food, though, can reduce the need for chemical pesticides, be resistant to viral infection and drought and can, like natural breeding, result in more abundant yields rich in desirable components. The introduction of golden rice, which includes genes from yellow daffodils to provide a high concentration of precursors of vitamin A, might help millions of people throughout Africa and Southeast Asia who suffer from vitamin A deficiency, responsible for millions of deaths and thousands of cases of irreversible blindness.

Nitrogen is astonishingly abundant, making up nearly three-quarters of the atmosphere, but it is there in a form that cannot be assimilated by most plants. One of chemistry's greatest achievements, made in the opening years of the twentieth century under the impetus not of a humane desire to feed but of an inhumane desire to kill, was to discover how to harvest nitrogen from the air and turn it into a form that could be absorbed by crops. The original impetus was the need to replace the natural source of nitrogen, nitrates mined in arid regions of Chile, by far more abundant and reliable supplies that at the time of the First World War (1914–1918) were needed for the manufacture of explosives. The development in Germany of an effective, economical process for converting non-reactive gaseous nitrogen into a reactive form by the German chemist Fritz Haber and his compatriot the chemical engineer

Rice farmer in China. The introduction of golden rice might help millions of people throughout Africa and Southeast Asia who suffer from vitamin A deficiency.

Carl Bosch initially in 1909 and on an industrial scale in 1913 was a landmark achievement for the chemical industry, for as well as depending on the discovery of appropriate catalysts, the production of fertiliser required the development of an industrial plant that operated at temperatures and pressures never previously attained.

The discovery of reactive nitrogen revolutionised agriculture in the twentieth century by permitting more abundant yields. But the process remains energy-intensive. It would be wonderful if the processes known to occur in certain bacteria associated with the root systems of leguminous plants, such as clover, alfalfa and peanuts, could be emulated on an industrial scale to harvest nitrogen. In the natural process, nitrogen is released, in a usable form, when the plant dies and so becomes available to other plants. This is the basis for crop rotation in traditional farming practice and the emulation of traditional methods in organic farming. Chemists have invested decades of research into this possibility, dissecting in detail the enzymes that bacteria use in their quiet and energy-efficient, low-pressure, low-temperature way. There are glimmerings of success but if you want to go down in history as the chemist who cracked the problem of feeding the world, here is your opportunity.

Recycling the Dead to Feed the Living

Phosphorus is abundant too, being the remains of prehistoric animals. Their bones of calcium phosphate and their special internal power source– the molecules of adenosine triphosphate (ATP) that powered everyone of their cells – lie in great compressed heaps below the oceans and the continents of the world. The most important use of phosphorus is for the production of fertilisers – derived from phosphate rock. Most of the world's phosphate rock reserves are concentrated in Morocco. Taken together, China

In a scene imagined by palaeo-artist Peter Trusler, a dinosaur lies dying about 110 million years ago when the South Pole enjoyed a more clement climate. If the body of this Leaellynasaura amicagraphica is rapidly covered by sediments, it may fossilise, thereby trapping phosphorus in its bones in the form of phosphate rock

and Morocco alone count 91 per cent of the world's reserves. Thus, by turning fossilised animals into fertiliser, chemists help to recycle the dead to feed the living.

Without Energy, Civilisations would Collapse

After water and food, we need energy. Nothing happens in the world without energy. Civilisations would collapse if it ceased to be available. Civilisations advance by deploying energy in ever greater abundance. Chemists contribute at all levels and to all aspects of developing both new sources and more efficient applications of current sources.

Petroleum is one of the legacies of the past, being the partially decomposed residue of organic matter, such as plankton and algae, that sank to the bottom of lakes and seas and was later subjected to heat and pressure. It is, of course, an extraordinarily convenient source of energy, as it can be transported easily, even in weight-sensitive aircraft. Chemists have long contributed to the refinement of the raw material squeezed and pumped from the ground. They have developed processes and catalysts that have taken the molecules provided by nature, cut them into more volatile fragments and reshaped them so that they burn more efficiently.

But burning nature's underground bounty might be seen by future generations as the wanton destruction of an invaluable resource. It is also finite and, although new sources of petroleum are forever being discovered, for the time being at least, they are proving hazardous and increasingly expensive. We have to accept that, although the empty Earth is decayed off, one day it will arrive. Chemists will need to contribute to the development of new sources of energy. Young people entering the profession today will find that they have great opportunities to make an impact on the future well-being of the world and its populations.

Where do chemists currently look for new sources? The Sun is an obvious source and the capture of its energy that nature has adopted, namely photosynthesis, an obvious model to try to emulate. Chemists have already developed moderately efficient photovoltaic materials and continue to improve their efficiency. Nature, with her four-billion year start on laboratory chemists, has already developed a highly efficient system based on chlorophyll. Although the principal features of the process are understood, a challenge for current chemists and perhaps future chemists like yourself will be to take nature's model and adapt it to an industrial scale. One route is to use sunlight to split water (H_2O) into its component elements and to pipe or pump the hydrogen to where it can be burned.

I say 'burned'. Chemists know that there are more subtle and efficient ways of using the energy that hydrogen and hydrocarbons represent than igniting them, capturing the energy released as heat and using that heat in a mechanical, inefficient engine or electrical generator. Electrochemistry, the use of chemical reactions to generate electricity and the use of electricity to bring about chemical change, is potentially of huge importance to the world. Chemists have already helped to produce the mobile sources, the batteries, that drive our small portable devices,

Solar panels on the roof of a sports stadium in the Spanish town of Baeza

such as lamps, music players, laptops, telephones, monitoring devices of all kinds and, increasingly, our cars.

Chemists are deeply involved in collaboration with engineers in the development of fuel cells on all scales, from driving laptops to powering entire homes and conceivably villages. In a fuel cell, electricity is generated by allowing chemical reactions to dump and extract electrons into and from conducting surfaces while fuel, either hydrogen or hydrocarbons, is supplied from outside. The viability of a fuel cell depends crucially on the nature of the surfaces where the reactions take place and the medium in which they are immersed. Here is another branch of chemistry where you, the reader, perhaps the aspiring chemist, could make a profound difference to the future of your country and the world.

Even nuclear power, both fission and one day fusion, the emulation on Earth of the Sun, depends on the skills of chemists. The construction of nuclear reactors for nuclear fission depends on the availability of new materials. The extraction of nuclear fuel in the form of uranium and its oxides from its ores involves chemistry.

Everyone knows that one fear holding back the development and public acceptance of nuclear energy, apart from political and economic concerns, is the problem of how to dispose off the radioactive spent fuel. Chemists contribute by finding ways to extract useful isotopes[1] from nuclear waste and by finding ways to ensure that it does not enter the environment and become a hazard for centuries to come. If you could collaborate with nuclear engineers to solve this problem, the world might take a more relaxed view about the perils of nuclear power and give a breathing space for the less hazardous nuclear fusion to be developed.

Nuclear fusion depends on smashing isotopes of hydrogen together and capturing the energy released as they merge to form helium, as happens on the Sun. The challenge is to achieve high temperatures because only then do the nuclei smash together with sufficient force to overcome their electrical repulsion – and to avoid the entire apparatus melting. The major nuclear fusion research effort taking place in France, known as the International Thermonuclear Experimental Reactor (ITER) project (*iter* is Latin for 'the way'), involves international collaboration on an unprecedented scale, involving countries representing half the world's population.

Plastics from Oil

I have alluded to the seemingly wanton destruction of an invaluable resource when the complex organic mixture we know as oil is sucked from the ground where it has lain for millennia then casually burned. Of course, not all the oil goes through the exhausts of our cars, trucks, trains and aircraft. Much is extracted and used as the head of an awesome chain of reactions that chemists have developed which constitute the petrochemicals industry.

Look around you and identify what chemists have achieved by taking the black, viscous crude oil that emerges from the Earth, subjecting it the reactions that they have developed and passing on the products to the manufacturers of the artefacts of the modern world.

An assortment of everday household items. One urgent challenge chemists face is to reduce the time it takes for plastics, aluminium cans and the like to biodegrade

1. Each element has a given number of protons. Isotopes of an element share the same number of protons but the number of neutrons may change. Carbon 12, Carbon 13 and Carbon 14, for example, are three isotopes of carbon. The atomic number of the element always remains the same; in the case of carbon, it is six, as each carbon atom has six protons.

Perhaps, the greatest impact of these processes has been the development of plastics. A century ago, the everyday world was metallic, ceramic or natural, with objects built from wood, wool, cotton and silk. Today, an abundance of objects are built from synthetics derived from oil. Our fabrics have been spun from materials developed by chemists, we travel carting bags and cases formed from synthetics. Our electronic equipment like televisions, telephones and laptops are all moulded from synthetics. Our vehicles are increasingly fabricated from synthetics. Even the look and feel of the world is now different from what it was a hundred years ago: touch an object today and its texture will be typically that of a synthetic material. For this transformation, we are indebted to chemists. Even if you mourn the passing of many natural materials, you can still thank chemists for their preservation where they are still employed. Natural matter rots but chemists have developed materials that postpone decay. For instance, new wood preservatives, typically based on copper, have been developed to avoid problems with the old preservatives leaching into the soil and poisoning it with arsenic, copper and chromium.

Lighter Cars, Molecular Computers and Intelligent Clothing

Plastics are but one face of the materials revolution that has characterised the last one hundred years and is continuing vigorously today. Chemists develop the ceramics that are beginning to replace the metals that we use in vehicles, lightening them and thereby increasing the efficiency of our transport systems. Ceramics are already used in the exhaust manifolds of some high performance cars and experiments have been conducted on replacing the entire engine block with ceramics. The car engine's cooling system has been simplified and its weight lessened because today's engines can withstand high temperatures. There remain problems with fabrication and crack-resistance, which you might be able to help to solve. Chemists are also responsible for developing the semiconductors that underlie the modern world of communications and computation. Indeed, one of the principal contributions of chemistry is currently the

Thai monk with a laptop. Chemists collaborate with engineers to develop the fuel cells that drive laptops

development of what could be regarded as the material infrastructure of the digital world. Chemists develop the semiconductors that lie at the heart of computation and the optical fibres that are increasingly replacing copper for the transmission of signals. The displays that act as interfaces with the human visual system are a result of the development of materials by chemists.

Currently, chemists are developing molecular computers, where switches and memories are based on changes in the shape of molecules. The successful development of such materials – with the optimism so typical of science, we can be confident that this endeavour will be successful – will result in an unprecedented increase in computational power and an astonishing compactness. If you are interested in the development of such smart materials, you can expect to contribute to a revolution in computation. There is also the prospect of the development of quantum computing. This will depend on chemists being able to develop appropriate new materials and result in a revolution in communication and computation that defies the imagination.

A model on the catwalk at a fashion show promoting Central Asian designs. Modern fabrics are heavily dependent on chemistry

Modern fabrics depend crucially on the contributions of chemistry. Take away those contributions and we are left almost naked, cold and drab. Even traditional dyes, such as those used in Javanese batik and Indian block-printing, are chemicals that have been extracted from plants and applied to fabrics. Modern fabrics include polyesters, nylon and polyamides. However, chemistry makes more subtle contributions than providing the material itself. It contributes to flame retardants by incorporating typically bromine compounds into the fabric. Modern developments include incorporating nanomaterials into fabrics to prolong their resistance to chafing, introducing resistance to bacteria and suppressing wrinkling. We are on the edge of even more exciting developments to which you might contribute: e-textiles (so called 'intelligent clothing') are being developed with embedded electronic capabilities, the ability to change colour, with swirling, changing, patterns (and advertisements!) that reflect our mood. Such textiles will be able to adjust their thermal properties to the ambient conditions and, let's hope, be self-cleaning.

This nineteenth century patient has been given nitrous oxide (N_2O) to dumb the pain of having a tooth extracted. Also known as laughing gas, nitrous oxide was identified as an anaesthetic in 1772 by the English Chemist Joseph Priestly

Agents Against Disease: Pharmaceutical Companies

I have barely mentioned health. One of the great contributions of chemistry to human civilisation –and, it must be added, to the welfare of our herds – has been the development of pharmaceuticals. Chemists can be justly proud of their contribution to the development of agents against disease. Perhaps, their most welcome contribution has been the development of anaesthetics in the late nineteenth and early twentieth centuries and the consequent amelioration of the prospect of pain. Think of undergoing an amputation two hundred years ago, with only brandy and gritted teeth to sustain you! Some of the anaesthetics currently used, such as procaine, have been developed by chemists to avoid adverse side-effects, including addiction, that accompanied the use of materials derived from traditional medicine, such as cocaine obtained from Peruvian coca. Next in importance has been the development by chemists of antibiotics, often by observing nature closely. A century ago, bacterial infection was a deadly prospect; now it is curable. We have to hope that it remains that way but, we still need to prepare for the opposite.

The pharmaceutical companies often come under attack for what many regard as their profligate profits and exploitation but they deserve cautious sympathy. Their underlying motive is the admirable aim of reducing human suffering by developing drugs that combat disease. Chemists are at the heart of this endeavour. It is highly regrettable that drug development can be so expensive. Modern computational techniques are helping in the search for new lines of approach and to reduce reliance on animal testing. However, extraordinary care needs to be exercised when introducing foreign materials into living bodies and years of costly research can suddenly be trashed if, at the last stage of testing, unacceptable consequences are discovered. Your involvement in the industry one day might transform it in a manner we cannot yet foresee and you might become one of the proud chemists who have contributed to save millions of lives.

How Biology Became Chemistry 50 Years Ago

Closely allied with the contribution of chemists to the alleviation of disease is their involvement at a molecular level, biology became chemistry just over 50 years ago when the double helix structure of DNA was discovered. Molecular biology, which in large measure has sprung from that discovery, is chemistry applied to organisms. Chemists, often disguised as molecular biologists, have opened the door to understand life and its principal characteristic, inheritance, at a most fundamental level and have thereby opened up great regions of the molecular world to rational investigation. They have also transformed forensic medicine, brought criminals to justice and transformed anthropology by tracing ethnic origins and ancestry.

The shift of chemistry's attention to the processes of life has come at a time when the traditional branches of chemistry – organic, inorganic and physical – have reached a stage of considerable maturity and are ready to tackle the awesomely complex network of processes going on inside organisms, human bodies in particular. The approach to treat disease – and more importantly to prevent it – has been put on a rational basis by the discoveries that chemists continue to make. If you plan to enter this field, genomics (the study of the genome of organisms) and proteomics (the study of the panoply of proteins that spring from the genome) will turn out to be of crucial importance to your work because they help to put the treatment of disease on a rational basis and relate it directly to the individual. This is truly a region of chemistry where you can feel confident about standing on the shoulders of the giants who have preceded you and know that you are attacking disease at its roots.

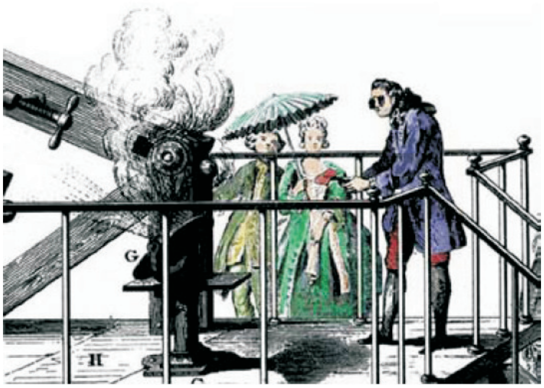
Magicians of Matter

I have focussed on a few of the achievements of applied chemistry, for they are the tangible outcome of the labours of myriad working chemists over the ages and, it must be said with some caution, the Alchemists. Even though Alchemists were misguided in their efforts to turn base metals into gold, through their experiments they nevertheless acquired familiarity with matter and the transformations it can undergo.

Muhammad ibn Zakariya ar-Razi (865–925) was a Persian Alchemist, chemist, physician and philosopher. Many firsts are attributed to him, including that of writing the first book on paediatrics. He was also the first to discover sulphuric acid, after perfecting the methods of distillation and extraction, as well as numerous other chemicals and compounds, including kerosene, alcohol and ethanol

Professor Tebello Nyokong in her laboratory in the Department of Chemistry at Rhodes University of South Africa. One of the five L'OREAL–UNESCO laureates in 2009, she earned the award for her research on chemical compounds known as phthalocyanine dyes. These could be used to attack cancerous tissues in a procedure that would be less intrusive than chemotherapy. Activated by exposure to a red laser beam, the dyes are used to target cancerous tissues selectively. With her in the laboratory are Wu Xi, an exchange student from China, and Taofeek Ogunbayo, a South African Ph.D. student

There is, however, another aspect of chemistry that should not go unnoticed and which, for many, is its justification. Chemistry provides insight into matter and the workings of the material world. It is thus a deeply cultural pursuit: it is fitting that, in the light of UNESCO's support



Antoine Lavoisier (1743–1794) experimenting a combustion engine that focussed sunlight over flammable materials. The French chemist determined that water was composed of oxygen and hydrogen and that the air was a mixture of primarily nitrogen and oxygen. He was guillotined at the height of the French Revolution

of the International Year of Chemistry, chemistry should at the same time be educational, scientific and cultural. Chemistry opens our inner eye to the properties and behaviour of matter. Moreover, it is a truly transnational and transcultural activity, with advances built on contributions from almost every country in the world.

Chemists like Englishman John Dalton (1766–1844) brought the existence of atoms and molecules to our attention and their descendents have shown us how to relate those entities to what we observe. Although we can take pleasure from merely looking at the vibrant colour of a flower, through chemistry we can perceive the molecular origin of the colour and thus deepen our delight.

The early chemists began to understand why one substance reacted with another but not with something else. Their descendents have discovered the motive power of chemical change and have thereby opened our understanding of why anything happens in the world. We understand what drives the world forward, why crops grow, why we live and die and why anything happens at all.

Much remains to be done, of course. Although the fundamental principles of chemistry are now well-established, their application remains as challenging and vigorously pursued as ever. Chemistry lets us plumb the depths of matter, enabling chemists on Earth to fabricate subtle arrangements of atoms that might not exist anywhere else in the Universe and which possess properties that are exquisitely tuned for a hitherto unforeseen application. If you are or intend to become a chemist, then you will become a magician with matter, able to conjure unexpected or intended new forms from what surrounds us. But you will not be an actual magician: you will be a rational, understanding manipulator, an architect on the scale of molecules.

The International Year of Chemistry is rightly a celebration of the transformation of the world and the lives of its inhabitants. It rightly celebrates current achievements, the impact of chemistry on people everywhere and its advancement by collaboration throughout the world. It also rightly anticipates its putative contributions to the unforeseen new world yet to come.

EDUCATION IN GREEN CHEMISTRY : INCORPORATING GREEN CHEMISTRY IN SCHOOL CURRICULUM

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There is a sufficiency in the world for man's need but not for man's greed.
Mahatma K. Gandhi

In the midst of a more vigorous concern for the environment, several terms have been put forward to capture an important idea. They represent the supposition that chemical processes that carry environmental negatives can be replaced with less polluting or non-polluting alternatives. Chemistry has historically been part of the problem, but now we hope it can be part of the solution. Here, the term "Green Chemistry" will be the focus since it is now the most widely used term. The Green Chemistry is a perfect fit for a school curriculum committed to the well-being of its responsible citizens with core human values. The principles of Green Chemistry that can energise our classrooms and bring long-term meaning and direction to a component of academic research await clear definition. This paper has been prepared to help to introduce the concepts of Green Chemistry in school curriculum and to give students and teachers a chance to think about the field of chemistry from a different perspective.

What is Green Chemistry?

Green Chemistry is a pro-active approach to pollution prevention. It targets pollution at the design stage, before it even begins. If chemists are taught to develop products and materials in a manner that does not use hazardous substances, then much waste, hazards and cost can be avoided. Green Chemistry is designing chemical products and processes that reduce or eliminate the use and/or the generation of hazardous substances. The term "Green Chemistry", as adopted by the IUPAC Working Party on Synthetic Pathways and Processes in Green Chemistry, is defined as: "The invention, design and application of chemical products and processes to reduce or to eliminate the use and generation of hazardous substances". Think about the simple equation of risk: Risk = Hazard x Exposure. Traditional approaches to pollution prevention focus on mitigating the hazard or end-of-pipe pollution prevention controls. These traditional technologies focus on limiting the exposure of a hazardous material. Unfortunately, exposure precautions can and will fail (i.e., gloves can tear, goggles can break, chemical releases can occur). Green Chemistry goes to the root of the problem and aims to eliminate the hazard itself. Green Chemistry is the only science that focusses on the intrinsic hazard of a chemical or chemical process. It seeks to minimise or eliminate that hazard so that we do not have to worry about exposure.

Why Green Chemistry in School?

Green Chemistry is an ideal focus for school science education because it

- presents a modern version of the traditional chemistry curriculum;
- uses less toxic materials, making experiments safer for students;
- teaches critical thinking skills;
- reduces cost with less expensive solvents and equipment and fewer toxic waste disposal fees;
- merges scientific concepts with sustainability and responsible human;
- gives school students opportunities to participate in meaningful science fair and projects.

What is the difference between Environmental Science and Green Chemistry?

Both areas of study seek to make the world a better place. The two are complimentary to each other. Environmental Science identifies sources, elucidates mechanisms and quantifies problems in the earth's environment. Green Chemistry seeks to solve these problems by creating alternative, safe technologies. Green Chemistry is not Environmental Chemistry. Green Chemistry targets pollution prevention at the source, during the design stage of a chemical product or process, and thus prevents pollution before it begins.

Is Green Chemistry more Expensive than Traditional Chemistry?

No. A simplified analysis of the cost structure associated with any chemical process takes into account the cost of materials, equipment and the human resources necessary. But, in reality, disposal, treatment, and regulatory costs associated with the buying, using, and generating hazardous materials involves numerous hidden costs. When you buy and use a hazardous material you are paying for it twice, once when you use it and once when you get rid of it. It makes sense that if you use materials that are non-hazardous and thus have minimal regulatory or disposal costs associated with them, the benefit to the economic bottom line is obvious. The Green Chemistry challenge has provided illustrations of several examples where industry has not only accomplished goals of pollution prevention, but has achieved significant economic benefits simultaneously.

How Chemists are Taught Green Chemistry?

One way that chemists are learning how to do Green Chemistry is by following the 12 principles of Green Chemistry. There are a set of guidelines that chemists use in order to perform chemistry in a better way. As you take a closer look at them, you will find they are very intuitive and simply good to practice.

The 12 Principles of Green Chemistry

1. Prevention

This principle is the most obvious and over- arches the other principles. It goes back to the old adage, "an ounce of prevention is worth a pound of cure". It is better to prevent waste than to clean it up after-the-fact. Throughout the history there have been many cases of environmental disasters that demonstrated this (Bhopal, India; Love Canal; Times Beach; Cuyahoga River).

2. Atom Economy

This principle gets into the actual chemistry of how products are made. As chemists, atoms are assembled to make molecules. The molecules are assembled together to make materials. This principle states that it is best to use all the atoms in a process. And, those atoms that are not used end up as waste. The atom economy is a simple calculation that can be used when teaching stoichiometry and chemical reactions. The calculation is: A.E. = Formula Weight (FW) of product divided by the FW of all of the reactants. It is a simple measure of the amount of waste in a process.

3. Less Hazardous Chemical Synthesis

This principle is focussed on how we make molecules and materials. The goal is to reduce the hazard of the chemicals that are used to make a product (there agents). Throughout the history of how we have invented products and developed the process for making them, chemists have traditionally not thought about what reagents they are using and the hazards that are associated with them. Chemists have traditionally used whatever means necessary. Today, we are finding that less hazardous reagents and chemicals can be used in a process to make products... and, many times they are made in a more efficient manner!

4. Designing Safer Chemicals

The previous principle was focussed on the process. This principle focusses on the product that is made. Everyone wants safe products. Everyone also wants products that do what they are supposed to do (they have to work!). This principle is aimed at designing products that are safe, non-toxic and efficacious. A good example of this is pesticides; which are products that are designed to be toxic. Many researchers are focussed on creating pesticides that are highly specific to the pest organism, but non-toxic to the surrounding wildlife and ecosystems.

5. Safer Solvents and Auxiliaries

Many chemical reactions are done in a solvent. And, traditionally organic solvents have been used that pose hazards and many are highly toxic. They also create volatile organic compounds (VOC's) which add to pollution and can be highly hazardous to humans. This principle focusses on creating products in such a way so that they use less hazardous solvents (such as water). We use solvents regularly in our daily lives (cleaning products, nail polish, cosmetics, etc.) and in the chemistry laboratory. An example that many can relate to, is that of nail polish products. Have you walked by a nail salon and caught a smell of the solvents that are used? The solvents traditionally used have potential toxicity and are certainly not pleasant to smell. A water-based alternative polish would avoid the exposure that goes along with the nail polish and reduce the hazards associated with traditional products.

6. Design for Energy Efficiency

Today, there is a focus on renewable energy and energy conservation. We use energy for transportation purposes and to provide electricity in our homes and businesses. Traditional methods for generating energy have been found to contribute to global environmental problems such as global warming and the energy used can also be a significant cost. This principle focusses on creating products and materials in a highly efficient manner and reducing the energy associated with creating the products, therefore, reducing associated pollution and cost.

7. Use of Renewable Feedstocks

Most of the products we use in our everyday lives are made from petroleum. Our society not only depends on petroleum for transportation and energy, but also for making products. This principle seeks to shift our dependence on petroleum and to make products from renewable materials that can be gathered or harvested locally. Bio-diesel is one example of this where researchers are trying to find alternative fuels that can be used for transportation. Another example is alternative, bio-based plastics. Polylactic Acid is one plastic that is being made from renewable feedstocks such as corn and potato waste.

8. Reduce Derivatives

This principle is perhaps the most abstract principle for a non-chemist. The methods that chemists use to make products are sometimes highly sophisticated. And, many involve the manipulation of molecules in order to shape the molecules into what we want them to look like. This principle aims to simplify that process and to look at natural systems in order to design products in a simplified manner.

9. Catalysis

In a chemical process, catalysts are used in order to reduce energy requirements and to make reactions happen more efficiently (and many times quicker). Another benefit of using a catalyst is that generally small amounts (catalytic amount versus a stoichiometric amount) are required to have an effect. And, if the catalyst is truly a "green" catalyst it will have little to no toxicity and it will be able to be used over-and-over again in the process. Enzymes are wonderful examples of catalysts that have been proven to perform amasing chemistry – our bodies are wonderful examples! Green chemists are investigating using enzymes to perform chemistry in the laboratory in order to obtain the desired product. Many times enzymes will have reduced toxicity, increased specificity and efficiency.

10. Design for Degradation

Not only do we want materials and products to come from renewable resources, but we would also like them not to persist in the environment. There is no question that many products we use in our daily lives are far too persistent. Plastics do not degrade in our landfills and pharmaceutical drugs such as antibiotics build up in our water streams. This principle seeks to design products in such a way, so that they perform their intended function and then, when appropriate, will degrade into safe, innocuous by-products when they are disposed of.

11. Real-time Analysis for Pollution Prevention

Imagine if you have never baked a cake before in your life and you did not have a cookbook to refer to. You mix the ingredients that you believe you need and you place the cake in the oven. But, for how long do you cook it and at what temperature? How will you know when the cake is done? What happens if you cook it too long or for not enough time? This process is similar to what chemists have to do when they make products. How long do they allow the reaction to run for? When do they know that it will be 'done'? If there was a way to see inside the reaction and to know exactly when it would be done, then this would reduce waste in the process and ensure that your product is 'done' and is the right product that you intended to make.

12. Inherently Safer Chemistry for Accident Prevention

This principle focusses on safety for the worker and the surrounding community where an industry resides. It is better to use materials and chemicals that will not explode, light on fire, ignite in air, etc., when making a product. There are many examples where safe chemicals were not used and the result was a disaster. The most widely known and perhaps one of the most devastating disaster was that of Bhopal, India in 1984 where a chemical plant had an accidental release that resulted in thousands of lives lost and many more injuries. The chemical reaction that occurred was an exothermic reaction that went astray and toxic fumes were released to the surrounding community. When creating products, it is best to avoid highly reactive chemicals that have potential to result in accidents. When explosions and fires happen in industry, the result is often devastating.

Teacher's Guide to Activities

The first activity can begin with asking simple questions (that do not have right or wrong answers) to get the students to think about what a chemist does and their role in solving global environmental problems. The questions can be asked at the beginning of class and they can write down their initial answers. The questions can be asked again at the end of the Green Chemistry module to see if their perspectives have changed. After introducing the 12 principles to the students, the second activity can help them to come to a better understanding of the principles. By working alone, or in groups, they can re-write the principles so that they are understandable to them and to their classmates. The activity sheet given below can give them the extended principles that are written so that a chemist can understand them. How will they re-write them so that anyone can understand?

Student Module: An Introduction to Green Chemistry

Activity 1: Questions to think about before we begin

1. What does a chemist do?
2. What are some chemical products?
3. What do you think about when you hear the words "Green Chemistry"?
4. What is environmental science?

5. Do you think our world has environmental problems? What are those problems?

6. How do you think we will go about solving those problems?

Activity 2: The Twelve Principles of Green Chemistry

Now that you have learned about what Green Chemistry is, think about what it means to you. Re-write the 12 principles in your own words so that they are understandable to you and your classmates.

1. Prevention

It is better to prevent waste than to treat or clean up waste after it is formed.

2. Atom Economy

Synthetic methods should be designed to maximise the incorporation of all materials used in the process into the final product.

3. Less Hazardous Chemical Synthesis

Whenever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

4. Designing Safer Chemicals

Chemical products should be designed to preserve efficacy of the function while reducing toxicity.

5. Safer Solvents and Auxiliaries

The use of auxiliary substances (solvents, separation agents, etc.) should be made unnecessary whenever possible and, when used, innocuous.

6. Design for Energy Efficiency

Energy requirements should be recognised for their environmental and economic impacts and should be minimised. Synthetic methods should be conducted at ambient temperature and pressure.

7. Use of Renewable Feedstocks

A raw material or feedstock should be renewable rather than depleting whenever technically and economically practical.

8. Reduce Derivatives

Unnecessary derivatisation (blocking group, protection/ deprotection, temporary modification of physical/ chemical processes) should be avoided whenever possible.

9. Catalysis

Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

10. Design for Degradation

Chemical products should be designed so that at the end of their function they do not persist in the environment and instead break down into innocuous degradation products.

11. Real-time Analysis for Pollution Prevention

Analytical methodologies need to be further developed to allow for real-time in-process monitoring and control prior to the formation of hazardous substances.

12. Inherently Safer Chemistry for Accident Prevention

Substance and the form of a substance used in a chemical process should be chosen so as to minimise the potential for chemical accidents, including releases, explosions and fires.

Green Chemistry experiments use and produce fewer toxic chemicals than traditional chemistry experiments, and they're also safer and less expensive to perform. It is now high time for us to think about (i) the areas of Green Chemistry that were often neglected, (ii) the value of integrating Green Chemistry principles in today's curricula, and (iii) strategies educators might use to incorporate Green Chemistry in their classrooms. We have outlined areas of scientific knowledge that we believe to be of vital importance for the education of future chemists and others. Green Chemistry has the potential to recruit innovative and energetic students, repair a damaged public image, and bolster the long-term prosperity of the chemical sector on the domestic and international scale. We argue that teaching traditional chemistry in a new way is the most effective way to achieve these ends. A new series of teaching principles and tools necessary to implement this change are discussed with emphasis on the long range impacts of a chemistry education that is inherently green. General applications of Green Chemistry, including sustainability, product design, and toxicology should be discussed, while tools such as life-cycle analysis, atom efficiency, structure-activity relationships, and eco-design be emphasised. The goal of the paper is to educate students and enable them to incorporate these concepts into their personal endeavours.

A common belief among us is that our education would have been significantly enhanced with the incorporation of Green Chemistry, beginning at the elementary level and continuing throughout graduate course work. It is unfortunate that Green Chemistry is not addressed to a greater extent in the chemistry curriculum. As the general public, political leadership, and the scientific community continue to recognise the environmental consequences resulting from decades of industrial production, chemists and chemical engineers find themselves uniquely positioned to lead the way to a sustainable future.

The Scientific Context

The science of chemistry is central to address the problems facing the environment. Through the utilisation of various sub-disciplines of chemistry and molecular sciences, there is an increasing appreciation that the emerging area of Green Chemistry is needed in the design and attainment of sustainable development. A central driving force in this increasing awareness is that Green Chemistry accomplishes both economic and environmental goals, simultaneously through the use of sound, fundamental scientific principles.

The International Context

Through the vehicle of Green Chemistry, IUPAC is engaging the international community in issues of global importance to the environment and to industry, through education of young and established scientists, provision of technical tools, governmental engagement, communication to the public and scientific communities, and the pursuit of sustainable development. By virtue of its status as a leading and internationally representative scientific body, IUPAC is collaborating closely in furthering individual national efforts as well as those of multinational entities. In this context, educational opportunities to train chemists in the scientific principles and technical methodologies of Green Chemistry are, of course, of primary importance. To establish and carry out the Green Chemistry educational programmes, there needs to be a partnership among government entities, industry and academic institutions. This partnership should focus on the importance of development and dissemination of new science and technology that form the basis of Green Chemistry and on the related education and training. These target audiences need curriculum materials to be developed and a suitable educational infrastructure in Green Chemistry to be made available to teachers, instructors and professors.

Need for Workshop on Green Chemistry

Existing government and industry programmes (R and D, awards, information, tools, etc.) useful for incorporating Green Chemistry into the education systems should be studied.

Task: We need to develop a survey and collect information among the participants on the existence of programmes and materials on Green Chemistry. Report on existing collaborations among international organisations (educational and industrial communities) for incorporating Green Chemistry concepts into the education system. Identify the existing Awards dedicated to Green Chemistry that stimulate education, information exchange and promotion of Green Chemistry to the public. The outcome will be an account that will illustrate the actions and programmes on Green Chemistry for incorporating these new concepts into the educational system.

Existing Green Chemistry educational material, tools, initiatives and sources should be studied. *Tasks* : Identify (and assess) the existing Green Chemistry educational sources (e.g., university programmes, scientific societies, government programmes, industrial programmes, schools, etc). Identify educational material and tools suitable for scientific faculties belonging to the Universities involved in Green Chemistry programmes.

Outcome: A resource guide of existing Green Chemistry educational materials and tools.

Commitments and recommendations are necessary to carry out Green Chemistry educational programmes should be studied.

Tasks: Recommend future initiatives and programmes on Green Chemistry Education, specifying mechanisms, tasks and tools to implement them.

Outcome: A list of possible recommendations in order to stimulate education communities as well as industrial and governmental interests in the mechanisms that are available or that need to be created to incorporate Green Chemistry effectively into the education systems.

Educational areas that address Green Chemistry Education should be studied.

Tasks: Identify educational areas that address Green Chemistry Education, in particular: Scientific (with a specification of the different levels), industrial (with a specification of the different kinds of training), general public (to improve the awareness of the benefits deriving from the Green Chemistry approach), business (to explain and demonstrate the benefits for the market deriving from the Green Chemistry approach), Government (to identify the appropriate channels to involve government in the adoption of national Green Chemistry educational programmes/projects/activities).

Outcome: An account will illustrate the mechanisms required to promote the incorporation of Green Chemistry concepts into various levels of chemical education.

Elaborating and carrying out the Green Chemistry educational programmes/projects with new educational materials/tools should be studied. *Tasks* : Identify the Green Chemistry educational programmes/projects, such as curriculum materials, teacher training, targeted funding, outreach mechanisms, etc. Identify new materials/ tools for Green Chemistry Education with more emphasis on new types of educational courses on Green Chemistry, such as new e-technologies (i.e., groupware applications, digital libraries, etc.).

Outcome: An account will illustrate the Green Chemistry educational programmes/projects and the benefits of new materials/tools for a faster and wider dissemination of Green Chemistry concepts.

A Guide for Green Chemistry Education should be prepared. As the principal workshop outcome, a background document explaining the barriers, needs, and benefits of Green Chemistry Education will be developed. It will illustrate the scientific and social potential of Green Chemistry. The resulting document will constitute a guide for Green Chemistry Education, a reference for the programmatic future educational initiatives in the context of Green Chemistry.

Green Experiments

- Solvent less Aldol reaction
- A greener bromination of Stilbene
- Synthesis and recrystallisation of adipic acid
- Gas-phase and microwave synthesis and metallation of 5,10,15,20-etraphenylporphyrin
- Thiamine-mediated benzoin condensation of furfural
- Patterning surfaces with molecular films
- Liquid CO_2 extraction of natural products
- A Diels-Alder reaction in water
- The use of supercritical carbon dioxide as a green solvent.
- Aqueous hydrogen peroxide for clean oxidations.
- The use of hydrogen in asymmetric synthesis.

Teacher's View on the Twelve Points

1. Create no waste;
2. Nothing should be left over;
3. No toxicity;
4. Green products as well as non-green products have to work;
5. Get rid of all non-essential additives;
6. Reduce energy usage;
7. Use renewable materials;
8. Get rid of as many steps as possible;
9. Make use of a reusable method to speed up a reaction;
10. Use materials that break down in the environment (biodegradable);

11. Check everything you do against the other principles;
12. Safety first.

Benefits of Green Chemistry in the Curriculum

Future chemists and chemical engineers must be equipped with the tools necessary to support and promote global sustainability. Incorporation of the 12 principles of Green Chemistry into class material is essential for providing a solid basis for "green" approaches that are valid in both theory and practice. The 12 principles can be coupled with specific strategies to enhance and further complement the current chemistry curriculum. They also serve as a reminder that the chemistry we practice has social as well as environmental impacts. An increasing number of institutions are including Green Chemistry concepts in their curriculum, and some even offer degrees in Green Chemistry. The programmes at these institutions should be adopted by others and viewed as inspiration, helping to overcome some of the persistent counter-arguments to Green Chemistry in the classroom. Such arguments include "this is not the way the real world works"; "traditional material is more important than Green Chemistry concepts"; "there is not enough time to cover the traditional concepts and include new ones"; and simple reluctance to change. The benefits resulting from incorporation of Green Chemistry concepts are significant and applicable to all levels of education. Green Chemistry concepts provide a connection between the material taught in class and the students' everyday environment, far beyond pollution, ozone depletion and global warming. Some examples include the feasibility and limitations of recycling, sustainability aspects of consumer product design, energy efficiency, and the ecological impacts of bioaccumulation and endocrine disruption in aquatic wildlife. With the full inclusion of Green Chemistry concepts, students of all disciplines, not just the chemical sciences, will have the ability to relate chemical concepts to the "real world" and to their chosen career path.

Implementation of Green Chemistry in the Curriculum

An important consideration often mentioned when curriculum modifications are proposed is the already overwhelming amount of information incorporated in chemistry education. We believe that Green Chemistry is not meant to replace existing class material or be taught as a separate section altogether. Instead, existing classes should be taught in a new way, incorporating key concepts into the curriculum to make chemistry inherently green. In a series of discussions, we identified a number of concepts that should be used to enhance the chemistry curriculum. Green Chemistry is not intended to be a solo discipline, but rather a means for conducting science in a responsible manner. It is not possible to track the fate of every chemical compound used and generated in a reaction or process. Environmentally benign chemicals are therefore highly desirable. Reactions should not only be evaluated based on conversion and selectivity, but also efficiency, sustainability, recyclability, degradation, and elimination or reduction of hazard. The connection between chemical structure and compound activity should be made clear to students. Chemical functionality (sterics, electronics, hydrophobicity/philicity, toxicity) can provide a basic understanding of how chemicals impact the environment. An enhanced understanding of eco-toxicity and fates and transport of chemicals released to the environment is essential for the overall evaluation of chemical substances.

A curriculum that complements current teachings with the Green Chemistry principles is a first step in promoting the ideal that Green Chemistry is inherent to chemistry. These concepts will enhance the chemistry curriculum, providing understanding of the broader impacts of the chemical sciences, bridging gaps between the classroom and the global environment, and, most importantly, helping to complete the education of future chemists and engineers. Beyond the classroom and the individual, Green Chemistry requires an interdisciplinary awareness. A multidisciplinary approach to Green Chemistry education allows students to develop interdisciplinary communication and contacts early on, thus promoting concerted efforts for attacking problems and developing sustainable technologies with global awareness. The internet is an excellent resource that provides an incredible amount of information for global chemical and environmental news. Educators can utilise this tool to create an interactive classroom that allows students to learn in real time, to develop collaborations with students around the globe, and to teach themselves and others through peer-to-peer networks. We encourage educators to step outside their 'comfort zone' and embark on a mission of teaching these fundamental principles to their students. In doing so, many will find that they too will become students of Green Chemistry, just as we have.

Resources are already available to aid in the incorporation of Green Chemistry concepts into the curriculum, including texts, lab experiments, discussion topics, online resources, etc.

The Impacts

Today's students, and ultimately the scientific community of tomorrow, would significantly benefit from the introduction of Green Chemistry principles into the curriculum. Increasing communication and awareness among chemists, engineers, policy makers, and the general public will lead to a greater responsibility for environmental and global issues. Students will enter the professional world with knowledge of the weaknesses of current industrial processes, coupled with motivation for the development of solutions based on Green Chemistry principles in an international and interdisciplinary environment. Green Chemistry education can provide the required knowledge and awareness to develop the technologies that are necessary to achieve the ultimate goal of a sustainable world. It must be stressed that Green Chemistry should not be considered a discipline in itself but rather an approach for conducting science in a responsible manner so that future generations are not compromised by today's actions. Green Chemistry offers a systematic means to sustainable science based on chemical, environmental, and social responsibility while allowing creativity and innovative research to thrive. Interdisciplinary approaches, outreach programmes, recruitment initiatives, and the creation of a global community of educators are ways in which social perceptions of chemistry can be positively influenced. What we ask is that chemical education be enhanced by incorporating the ideals of Green Chemistry into the curriculum, thus building a foundation that leads to a sustainable chemical enterprise and a sustainable society. With this new way of thinking about chemical education and research, students will be armed with the knowledge needed to effectively address the grand challenges of this twenty-first century.

Model Lesson Plan

Topic: Essentail Oil Extraction Using Supercritical CO_2

Many fruits and vegetables contain essential oils, which are water repellent or hydrophobic liquids that give the fruit or vegetable its distinctive fragrance. These essential oils are often extracted for use in perfume, cosmetics, food, medicine and house cleaning products. Many of these essential oils are extracted through liquid chemical extraction using dangerous chemical solvents, such as methylene chloride. Conventional methods used to extract essential oils include steam distillation or liquid chemical extraction. Steam distillation requires high energy input as energy is required to boil water to produce steam. The energy used combined with the dangers of heating large amounts of matter on an industrial level means that this process does not adhere to the principles of Green Chemistry. This is an important component of teaching students about Green Chemistry as it is not just a concept used in the lab but a concept meant to be used on an industrial scale to make products which are useful to the world. Steam distillation may seem like a benign process until it is evaluated against the 12 principles on an industrial scale.

Scientists have discovered the use of supercritical carbon dioxide (CO_2) at high pressure is an alternative method of extracting essential oils and that is the process which you will discover with your students through this activity. CO_2 is the gas exhaled by humans during respiration, is consumed by plants during photosynthesis and exists in the environment in abundance from human activity such as fossil fuel combustion.

It is important to note that the use of supercritical CO_2 for extraction does not affect the net amount of CO_2 in the environment, thus using supercritical CO_2 for essential oil extraction is not considered to affect climate change in anyway. Instead, the use of supercritical CO_2 is considered a greener way of essential oil extraction, since it reduces the amount of energy input and eliminates the need for dangerous solvents. Because supercritical CO_2 does not have high reactivity with essential oils, which can lead to the breakdown of the essential oil, its use in essential oil extraction is gaining popularity. Currently, supercritical CO_2 is used to remove caffeine from coffee beans to produce decaffeinated coffee and as a replacement for perchloroethylene in dry cleaning applications.

In this experiment, students will extract the essential oil d-limonene from the rind (skin) of lemon peels using both a steam distillation or simple distillation method and the method of using supercritical CO_2. They will analyse the difference between the two methods and make connections between the laboratory activities they do in the classroom and the industrial chemical processes that are used to make products. D-limonene gives lemons, oranges and limes their citrus-like scent.

Educational Goal: To understand chemical, steam and CO_2 extraction methods and their relationship to green and industrial chemistry practices.

Student Objectives: Students will ...

- extract essential oils from lemons using steam distillation;
- extract essential oils from lemons using supercritical CO_2;
- compute the use of energy in both extractions;
- compare the use of energy in both extractions;
- compare the use of hazardous chemicals in both extractions;
- Learn about phase changes of CO_2;
- Learn about extraction methods based on polarity.

Activities and Experiments: Cleaning up with atom economy

Cleaning up the environment and, more importantly, preventing pollution are important issues in today's world. Chemistry keeps us clean. One of the most fundamental of these solutions is

Extract essential oils from a lemon using steam distillation, supercritical CO_2 and organic solvent like CH_2Cl_2

Principle	*Traditional Solvent Extraction*	*Steam Distillation Extraction*	*Supercritical CO_2 Extraction*
1. Pollution Prevention	Pollution in the final product could be hazardous to human health as well as solvents in the waste stream.	N/A	N/A
2. Atom Economy	Lemon rind without oil is left over, but this is benign waste which can be composted.	Lemon rind without oil is left over, but this is benign waste which can be composted.	Lemon rind without oil is left over, but this is benign waste which can be composted
3. Less Hazardous Synthesis	Hazardous solvents are used, e.g. methylene chloride is a carcinogen. The solvents used in this process are not considered safe.	N/A	N/A
4. Design Safer Chemicals	Final product can be hazardous to human health if there are trace solvents present.	The trace solvent left over will be water, therefore it is benign.	N/A
5. Design Safer Chemicals	The solvents used in this process are not considerded safe	Water is a safer solvent, however the steam might be hazardous to human health especially on an industrial scale	CO_2 is non-toxic to humans. On an industrial scale pressurised gas is used and it is constantly reused.
6. Energy Efficiency	Energy efficient. No use of intense heat.	This process uses a lot of energy in the heating of the water and subsequent cooling of the water when used on an industrial scale.	There is energy used in this process to heat the water but the water does not have to be as hot as in the case of steam distillation. Also on an industrail scale there is no water used but the CO_2 is pressurised and heated although not to extreme temperatures.

7. Renewable Feedstocks	The solvents used are petroleum derivatives. Petroleum is a non-renewable resource.	This process utilised large amounts of water. Although technically water is a renewable resource. On an industrial scale, water is taken from rivers and put back into the watershed at te mperatures that are not consist with the health of the rivers. Although often this water was recycled.	CO_2 is a renewable resource
8. Reduce Derivatives	N/A	N/A	N/A
9. Catalysis	N/A	N/A	N/A
10. Design for Degradation	Methylene chloride and other organic solvents are not readily biodegradable— many will be persistent in the environment	Water naturally degrades and recycles in the environment, so this is a better solvent.	Carbon dioxide is not persistent in the environment. On an industrial scale, the same CO_2 is used over and over again.
11. Real time analysis	N/A This is not applicable because this process is an extraction not a reaction.	N/A This is not applicable because this process is an extraction not a reaction.	N/A This is not applicable because this process is an extraction not a reaction.

the application of the Green Chemistry principle of atom economy to chemical reactions. Atom economy moves the practice of minimising waste to the molecular level. Traditionally, chemists have focussed on maximising yield, minimising the number of steps or synthesising a completely unique chemical. Green Chemistry and atom economy introduce a new goal into reaction chemistry: *designing reactions so that the atoms present in the starting materials end up in the product rather than in the waste stream*. This concept provides a framework for evaluating different chemistries, and an ideal to strive for in new reaction chemistry. Atom economy means maximising the incorporation of material from the starting materials or reagents into the final product. It is essentially pollution prevention at the molecular level, e.g. a chemist practising atom economy would choose to synthesise a needed product by putting together basic building blocks, rather than by breaking down a much larger starting material and discarding most of it as waste. Atom economy is an important development beyond the traditionally taught concept of per cent yield. Atom economy answers the basic question, *How much of what you put into your pot ends up in your product* ?

Associated Chemistry Topics

- Law of conservation of matter;
- Chemical reactions;
- Stoichiometry;
- Per cent yield;

Vocabulary

Atom Economy

1. The mass of desired product divided by the total mass of all reagents, times 100;

   Per cent Atom Economy = (Mass of Desired Product / Total Mass of all Reagents) x 100;

2. The mass of desired product divided by the total mass of all products and byproducts produced, times 100; and

3. A measure of the efficiency of a reaction.

Per cent Yield : Actual yield divided by theoretical yield times 100

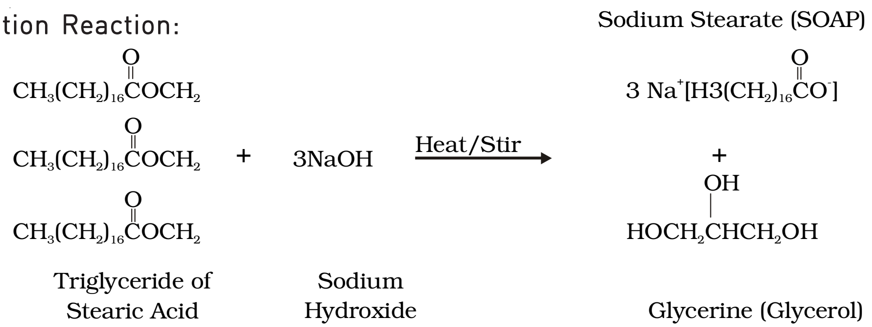
Theoretical Yield : The maximum amount of product that can be produced from the quantities of reactants used; the amount of a given product formed when the limiting reactant is completely consumed.

Stoichiometry – Application of the laws of definite proportions and conservation of mass to chemical processes; quantitative relationship between compounds involved in a reaction.

Saponification, or soap making, is a very old tradition, dating back to 2800 B.C. However, the chemistry was not described until the nineteenth century by the French chemist, Chevereul. Early soap makers used animal fat and wood ash (which contains sodium hydroxide and potassium carbonate). Now a wide variety of materials and methods are available to the soap maker. Today, soap making is not only highly visible in the mainstream manufacturing industry (names like Lifebouy, Dove, Hamam), but many special product industries centre around handmade soaps as well. An excellent resource including the history, chemistry and manufacture of soaps and detergents is available from the Soaps and Detergents Association Web Site: http://www.sdahq.org/cleaning/. Related information including stories about soap and detergent companies can be found at: http://inventors.about.com/library/inventors/blsoap.htm. A brief discussion, with excellent graphical models, of the chemistry of soap making can be found at: http://antoine.frostburg.edu/chem/senese/101/consumer/faq/making-soap.shtml. Clear directions, including pictures, for making soap are available at the Web Site: http://www.soapcrafters.com/makebase.htm.

Now ask the students to calculate the atom economy for the saponification reaction by dividing the total mass of atoms utilised in the product by the total mass of all the reagents and

Saponification Reaction:



multiplying by 100. Since, all the products produced are known, you could instead divide by the total mass of products and byproducts.

Questions

1. What is the atom economy for the saponification reaction, assuming 100 per cent yield (3 soap molecules for every triglyceride used)?
2. What is the atom economy if only two soap molecules were made (66 per cent yield) for every triglyceride molecule reacted (include the third soap molecule in the waste instead of the product).
3. What is the theoretical yield (in grams) of soap, if 500.0 grams of the triglyceride of stearic acid are used?
4. What are some basic characteristics of reactions that have high atom economy?
5. Do you think it is more important to have high per cent yield or high atom economy? Why?
6. Describe modifications you would make to the saponification reaction to increase the atom economy.

Student Worksheet Name___________________________

Stoichiometric Coefficient, Name of Starting Material	Atomic Symbol, Quantity, Atomic Mass of Each Atom	Mass (Quantity Times Atomic Mass) of All Atoms	Atoms Utilised in Product	Mass of Atoms Utilised in Product	Atoms Wasted in Byproducts	Mass of Atoms Wasted in Byproducts

Answers to Questions
Calculated Atom Economy

1. 90.89%, see the following table:

Stoichiometric Coefficient, Name of Starting Material	Atomic Symbol, Quantity, Atomic Mass of Each Atom	Mass (Quantity Times Atomic Mass) of All Atoms	Atoms Utilised in Product	Mass of Atoms Utilised in Product	Atoms wasted in Byproducts	Mass of Atoms Wasted in Byproducts
1 Triglyceride of Stearic Acid	57C, 12.01; 110H, 1.008; 3O, 16.00;	891.45	54,105H 3O	802.38	3C, 5H, 3O	89.07
3 Sodium Hydroride	3H, 1.008; 3O, 16.00; 3Na, 22.99	119.99	3 Na, 3O	116.97	3H	3.02
Totals:	57C, 113H, 3Na, 9O	1011.44	54C, 105H, 3Na, 6O	919.35	3C, 8H, 5O	92.09
Product: 3 Sodium Stearate	54C, 105H, 3Na, 6O	919.35			Atom Economy:	90.89%

2. 60.60%, see the following table:

Stoichiometric Coefficient, Name of Starting Material	Atomic Symbol, Quantity, Atomic Mass of Each Atom	Mass (Quantity Times Atomic Mass) of All Atoms	Atoms Utilised in Product	Mass of Atoms Utilised in Product	Atoms Wasted in Byproducts	Mass of Atoms Wasted in Byproducts
1 Triglyceride of Stearic Acid	57C, 12.01; 110H, 1.008; 6O, 16.00	891.45	36,70H, 2O	534.92	21C, 40H, 4O	356.53
3 Sodium Hydroride	3H, 1.008; 3O, 16.00; 3Na, 22.99	119.99	2Na, 2O	77.98		42.01
Totals:	57C, 113H, 3Na, 9O	1011.44	36C, 70H, 2Na, 4O	612.90		398.54
Product: 2 Sodium Stearate	36C, 70H, 2Na, 4O	612.90			Atom Economy:	60.60%

3. 500.0 g SM / 891.45 g/mol SM = 0.5602 mol SM , 0.5602 mol SM 3 mol soap/1 mol SM = 1.681 mol soap, 1.681 mol soap 919.35 g soap/3 mol soap = 515.1 g soap

4. High atom economy characteristically involves rearrangement or addition (e.g. Diels-Alder, Claisen) rather than substitution or elimination processes (e.g. Wittig, Grignard), and makes use of catalytic rather than stoichoimetric reagents. Atom economical reactions incorporate as much of the starting materials as possible into the product, so solvent-free systems are another characteristic feature.

5. Open-ended question— Possibilities include:

   High atom economy might be preferred over high yield because it is more efficient and less waste is produced. High per cent yield might be preferred over high atom economy because more of the product is produced. High yield with low atom economy might be preferred if a recyclable byproduct is formed.

6. Suggested answers, any logical reasoning is acceptable. Using a lower molecular weight base and/or a higher molecular weight triglyceride would reduce the mass of waste and/or increase the mass of the product, thus increasing the atom economy. Considering glycerol (glycerine) a product, rather than a byproduct would remove it from the waste accounting. Making soap directly from the fatty acid rather than the triglyceride would reduce the waste for this reaction, but where does the fatty acid come from?.

In an organic class, the atom economy could be calculated for all of the basic reaction types. Selectivity, per cent conversion, productivity, rates, catalysis and electrochemistry are all chemistry topics that would enhance this discussion of atom economy.

We have integrated several Green Chemistry experiments into the curriculum. The experiments themselves were just safer for the kids, and they got more out of it. They related to the concepts a lot easier than some of the other experiments we've tried in class, e.g. instead of creating or observing an obscure chemical reaction, students doing a Green Chemistry experiment in our class turned vegetable oil into bio-diesel fuel. Bio-diesel fuel is a concept that students understand. That really helps them connect what they're doing in the classroom with real life application, so they understand chemistry concepts faster and can remember them better. Providing high school teachers with experiments and resources is one of many ways we are spreading the word about Green Chemistry. And, curriculum development projects enhance the school's growing reputation as a leader in sustainable sciences.

Chemistry has been recognised as a scientific discipline for about 150 years, so the concept of Green Chemistry is relatively young by comparison. Because, the field is so new, there's an abundance of projects to work on. Many of those projects have focussed on curriculum development. Green Chemistry may be a relatively young discipline, but it has already gained a foothold in industry, where it is seen as a safer, less expensive, and more environmentally responsible way to conduct research and manufacture products. It's clear that consumers are expecting greener or more sustainable kinds of practices in producing the products they purchase. More importantly, applying the concepts of Green Chemistry can lead to safer, more efficient processes, which is exactly what every industry needs and wants. It's really cutting-edge stuff. It's really a need to know that we're doing something different and something new. The challenge, however, lies in the fact that there are very few Green Chemistry experiments, textbooks, and other teaching materials available at school level.

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Chemistry Education Resources

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Chemists Celebrate Earth Day

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Greener Education Materials for Chemists (GEMs)

University of Scranton's Teaching Green Chemistry Modules

Green Chemistry Network

Featured Books

Handbook of Green Chemistry, ISBN/ISSN: 3527315772

Green Chemistry and Catalysis, ISBN/ISSN: 352730715X

Green Chemistry: An Introductory Text, ISBN/ISSN: 0854046208

Green Chemistry: Theory and Practice, ISBN/ISSN: 0198506988

Advancing Sustainability through Green Chemistry and Engineering, ISBN/ISSN: 0841237786

Green Organic Chemistry, Strategies, Tools, and Laboratory Experiments, ISBN/ISSN: 0534388515

CONSTRUCTION OF KNOWLEDGE AND DEVELOPMENT OF MULTIPLE INTELLIGENCE TEACHING AND ASSESSING THROUGH PBL

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In this paper, we shall discuss constructivist method that is tried successfully to teach students physics using problems. We shall discuss how such a method can help to develop multiple intelligence of students and can also be used for dynamic assessment, that is assessing the students while they learn.

Introduction

In Taxonomy of Educational Objectives, Bloom talks about six major classes:

1. Knowledge;
2. Comprehension;
3. Application;
4. Analysis;
5. Synthesis;
6. Evaluation.

At present, in our academic set up, our teaching-learning and assessment over-emphasises transfer and assessment of surface level knowledge to a great extent. Most of our school/college system has examination which achieves first of Bloom's objective well but higher order objectives are ignored to a great extent due to various reasons in spite of its acceptance as a policy.

In the words of Gardner, "*It is of the utmost importance that we recognise and nurture all of the varied human intelligences, and all of the combinations of intelligences. We are all so different largely because we all have different combinations of intelligences. If we recognise this, I think we will have at least a better chance of dealing appropriately with the many problems that we face in the world.*"

In what follows we suggest one such method which is constructivist, it is based on problem-solving and also enhances intelligence level of student. We show that it is possible to have our assessment based on such a method that is integrated with learning. This method can be easily adopted in our educational set up.

Constructivism and Problem-Based Learning (PBL)

Three ways of constructivist teaching/learning methods are suggested in the literature:

1. Situated learning;
2. Cognitive apprentice;
3. Problem-based learning.

In an educational institutional set up, problem-based learning (PBL) seems to be a good candidate as a remedy for the existing situation. Although need to include problem-solving in science is being realised in India now, none of the efforts made so far has come up with any strategy to actively engage students. It is almost left to students' initiative and interest.

In any case, how much of knowledge that students acquire is needed to be used in real life and needs to be on fingertips? In real life, whatever careers student take up, they would be required to solve problems. These may be from the subject they have learned or otherwise. At the same time, due to explosion in the amount of scientific knowledge, it has become difficult for students to learn everything in their field of interest. It is not possible for any curriculum to cover such a large amount of scientific knowledge. The need is to equip students with necessary skills needed to learn and understand independently. Thus, it is important that education focusses on problem-solving skill and let students learn to construct their knowledge through problems. This way we are teaching learners how to learn. As mentioned earlier problem-solving is also considered as one of the constructivist teaching–learning methodology.

According to Tan, it is not how much content we disseminate in our classrooms, but how we engage students' motivation and independent learning is important. For science teaching he has noted that, *"breakthroughs in science and technology are often the result of fascination with problems. Great learning often begins with preoccupation with a problem, followed by taking ownership of the problem and harnessing of multiple dimensions of thinking. Problems and the questions associated with them when strategically posed can enhance the depth and quality of thinking. What is often lacking in education today is the effective use of inquiry and problem-based learning approaches."*

The problem-solving is an activity which involves stimulating purposeful, reflective thinking in students when they attempt to arrive at rational solution. The teacher creates learning opportunities through properly selected problems and leads the learner through the environment of learning. In the process, which can be termed as cultural mediation, a student internalises and becomes integrated with, the culture of the subject. Thus, teaching students through problem-solving becomes a constructivist activity.

This also involves: (i) guiding students to create appropriate visualisation or mental picture; (ii) pointing to them the precise auxiliary problem/activity; (iii) creating cognitive conflict with their misconception; or (iv) involving them in a reflective metacognitive discussion, so as to arrive at a strategy to solve the problem.

Vygotsky has introduced a concept of Zone of Proximal Development (ZPD) which is an intellectual space where learner and teacher interact. The teacher can gauge intellectual development of the learner and provide the necessary support to advance the learner's thinking. With teacher support, learner can achieve more than they would unaided. More knowledgeable peers can also perform the same function as teachers.

Multiple Intelligence Theory

As mentioned by Armstrong, Gardner provided a means of mapping the broad range of abilities that humans possess by grouping their capabilities into the following comprehensive categories or "intelligences":

Linguistic: The capacity to use words effectively, whether orally or in writing.

Logical-mathematical: The capacity to use numbers effectively and to reason.

Spatial: The ability to perceive the visual-spatial world accurately and to perform transformations upon those perceptions.

Bodily-kinesthetic: Expertise in using one's whole body to express ideas and feelings and facility in using one's hands to produce or transform things.

Musical: The capacity to perceive, discriminate, transform and express musical forms.

Interpersonal: The ability to perceive and make distinctions in the moods, intentions, motivations and feelings of other people.

Intra-personal: Self-knowledge and the ability to act adaptively on the basis of that knowledge.

Naturalist: Expertise in the recognition and classification of the numerous species—the flora and fauna—of an individual's environment.

According to Gardner· "An intelligence is a capacity, with its component processes, that is geared to specific content in the world. A person with high intelligence in my sense of the term is one whose computational capacities are very effective with a particular form of information or content."

In Gardner's words, *"I define understanding as the capacity to take knowledge, skills, concepts, facts learned in one context, usually the school context, and use that knowledge in a new context, in a place where you haven't been forewarned to make use of that knowledge. If you were only asked to use knowledge in the same situation in which it was introduced, you might understand, but you might not; we can't tell. But if something new happens out in the street or in the sky or in the newspaper, and you can draw on your earlier knowing, then I would infer that you understand."*

When we refer to problem/s, they are not merely plug-in numbers but expect them to have one or more of the following characteristics:

(i) A problem which incorporates basic principle/s.

(ii) A problem which is attractive enough or is rich in context.

(iii) The problem should be sufficiently difficult but not too difficult to put students off.

(iv) Should require steps that are not of repetitive pattern and at the same time should involve some decision-making.

(v) The problem should have a reasonable goal.

(vi) The problem should guide students to comprehend the topic and/or application.

In order to design problems for the course, the following is the strategy that has to be adopted:

1. Area of the subject has to be identified keeping in mind students' familiarity with the subject, their background, strengths and weaknesses, e.g. we chose basic physics as weakness of students and thus developed a course based on problems from basic physics.
2. For designing problems from a particular area/sub-area, underlying concepts and key points have to be identified that we need to address and highlight, e.g. we may identify mechanics as sub-area and kinematics of motion as concept and velocity, acceleration, displacement, frames of reference as key points.
3. Once this is done, identify the goal of a problem in accordance with why a particular problem is to be set up (learning objectives) as already discussed. This may involve some application (preferably one that students can relate to) and its interrelation to equation. We may have a problem that involves description of motion involving motion that has these key-points to be addressed and may involve calculation using relevant equations that students have to identify.
4. Problem may involve some goal that may involve concepts from different areas/ sub-areas to highlight interconnection between different areas/sub-areas of the subject.

Care needs to be taken that the goal in the problem should not be too obvious, e.g. as in some plug in problems, that there is no challenge involved in solving the problem.

Example

Let us consider an example from Class VIII, NCERT Science textbook of reflection at a plane surface to illustrate how to employ dynamic assessment.

Students learn about laws of reflection at a plane surface that (i) incident ray, reflected ray and normal to the surface all lie in the same plane, and (ii) angle of incidence is equal to angle of reflection. Teacher can teach this experimentally using pin and mirror and constructing ray diagram. These days, it is easy to demonstrate using simple LASER torch. Having established this, students can be asked or shown construction of position of image due to point object using laws of reflection and two or more rays.

Having done this, following is what can be done for dynamic assessment: Students can be asked to construct (i) image of an extended object, and (ii) image/s of a point object in case of two mirrors inclined at an angle è (say 90^0). These are meaningful activities that can be part of activity or problem-based learning.

Typically, students who know laws of reflection otherwise would have confusion even in constructing image of a point object. They do not know how to start as which should be the incident ray? How does reflected rays lead to position of image? They may not be able to decide that they can construct image for each point on the extended object, etc...

Teacher can help students to construct their knowledge by giving them support in terms of guided intervention, by challenging them through cognitive conflict if they are off the track or auxiliary activities/problems. Students learn by building upon knowledge they already possessed themselves and guided interventions are used to correct errors, which crept in their understanding. Most importantly, there will be effective scaffolding, i.e., students are not given answers to any questions, but are guided (using interventions like auxiliary problems, counter questions, cognitive conflicts) to converge to the right answer themselves.

Our experience and experiment has shown that students not only succeed in solving problem but improve in their cognitive ability. Thus, we can say that they advance in their zone of proximal development and in ability to use their multiple intelligences.

It can be seen that solving problems involve use of multiple intelligence which Gardner has described as capacities. When students try problems obviously as they have to read and understand the information given and challenge posed, which needs linguistic intelligence. When they try employing their resources and techniques to solve, they need math-logical intelligence. If problem involves diagram or some visualisation, they need to use spatio-visual intelligence. If they are dealing with movements that they have to incorporate into equation or convert into diagram they need bodily kinesthetic intelligence. As the course makes them struggle through, they introspect about their own thinking processes, which help develop their intrapersonal intelligence. They also get opportunity to discuss with their peers developing their interpersonal intelligence, which in traditional system would not develop, as all they do is memorising the study material. Since, science deals with nature, it involves naturalist intelligence. When students make progress through problem-solving, obviously many of their intelligences develop. It is not right to talk how these intelligences work individually. In fact a bit of thinking makes it clear that most of them play their role simultaneously during the process of problem solving. Thus though initially students may not display these abilities, their success in solving problem (even with scaffolding provided by instructor) indicate development of multiple intelligence/capabilities.

Such problem-solving activities in class can also be used to integrate teaching-learning and assessment. This is known as *Dynamic Assessment.*

Holt emphasise the concept of dynamic assessment, which is a way of assessing true potential of learners that differ significantly from conventional tests... assessment is a two-way process involving continuous interaction between both instructor and learner... that measures the achievement of the learner, the quality of the learning experience and courseware.

According to Poehner, "Dynamic Assessment (DA) is an approach that takes into account the result of an intervention." In this intervention, the examiner teaches examinee how to perform better on an individual item or on the test as a whole. The final score may be a learning score representing the difference between pre-test (before learning) and post-test (after learning) scores, or it may be the scores on the post-test considered alone....The *interactionist* DA focusses on the development of an individual learner or even a group of learners, regardless of the effort required and without concern for pre-determined endpoint... The result of DA procedures must report the mediating moves as well as the reciprocating behaviours that contribute to the overall performance. Importantly, this information can highlight aspects of development that would likely remain hidden in non-DA, as learners who are not yet ready to perform independently may exhibit changes in the form of mediation they require or in how they respond to mediation.

As Mayer puts it, "If the goal of problem-solving instruction is to improve the cognitive processing of students when they are confronted with a novel problem, then the goal of problem-solving assessment is to describe the cognitive processes they use in their problem-solving."

Students can be assessed while they perform these activities depending upon how well they employ their resources (previous knowledge about laws and geometry). Suppose these activities are to be evaluated on a scale from 0 – 5, then they can be given 5 to start with and can be given – 0.5 (negative marks) each time they need teacher's intervention. Since, they will complete this activity any way and can be made to reflect upon their construct or solution, each would score at least 2 (40%).

A student who succeeds herself/himself without any assistance would have achieved all the educational objectives of Bloom. Others would still be achieving it partially with instructor facilitating their construction of knowledge.

If we allot 50 per cent weightage to such (dynamic) assessment, students definitely become active learner and eventually this helps them to enhance their cognitive capabilities and reduces importance of rote memorisation. We can certainly keep periodic tests (25% weightage) of traditional type but without too much importance to memorisation, i.e., MCQ or small problem type, and final examination (25% weightage) carrying similar activities/problems will generate meaningful grades.

Instead of translating marks to grades as it is done by CBSE (which reduces importance of marks by bunching to some extent but meaningless otherwise), we can assign grades A: B, C, D with following reflection:

A : Have successfully completed and mastered the course.

B : Have satisfactorily completed the course but need to put more efforts.

C : Have completed the course but need to be given remedial coaching before next level of learning.

D : Need to repeat the course before student can be allowed for the next level of learning.

With these strategy (dynamic assessment as discussed) most students would succeed with A and B grades. It may be exceptional case who scores C and extremely rare to score D.

One may justify the grading by statistically grouping students rather than merely translating marks from 0-100 into grades. It is this grading that would not only do justice to students' true potential but also reduce stress level significantly. A lot of work needs to be done to develop this type of grading system. This also demands training teachers to achieve higher objectives.

Conclusion

We have discussed how meaningful problem-solving can be part of teaching-learning process and is useful in helping students to construct their own knowledge of the subject. Such a process involves use and enhancement of students' multiple intelligence. It is possible to integrate assessment with learning with such a methodology that would do justice to students' true potential and learning. However, we recommend traditional testing should also be the part of this assessment, as we do not want to downplay first objective of Bloom's taxonomy.

Grading scheme proposed here truly reduces undue weightage to marking scheme and makes it stress free. Such a grading avoids unnecessary distinction on the marks and reflects genuine learning and not only rote memorisation.

The only hurdle here is, student to teacher ratio. However, if we need to make education stress free and do justice to students' true potential, this ratio have to be brought down to right number. This is the major challenge. Merely stuffing 100 students in a classroom would not achieve 'education for all' and yet keep it 'stress free for all'.

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A COMPARITIVE STUDY OF SCHOLASTIC ACHIEVEMENT IN MATHEMATICS EXAMINATION IN RELATION TO CONCEPTUAL UNDERSTANDING AND MATHEMATICS ABILITY

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The study compares two groups of students of Class VII and Class IX, one group belonging to government schools and the other to private schools. Scholastic achievement in examinations was studied in relation to conceptual understanding and mathematics ability. Conceptual understanding and mathematical ability both exhibited positive relationship with scholastic achievements. It was also seen that conceptual understanding and mathematics ability of the students was at a lower level than scholastic achievement. Some common conceptual errors in mathematics were also discussed.

Introduction

The culture of mathematics education highly values student performance and meaningful learning by students (Gold, A. G. 2003). Problems in mathematics education are universal and not new. They have existed from primary to higher levels of education. Many students cannot understand what was taught in mathematics classrooms because the emphasis is on memorising procedures without any meaningful context.

The process of teaching mathematics in schools include procedural skills as well as conceptual knowledge. Assessments provide a systematic way to inform students, teachers, parents and educationists about student performance. Hence, the need for examinations . However, at the same time, the motivation, commitment and the imaginative faculties of the learner in any discipline cannot be evaluated through a one-shot examination at the end of an academic year. Mathematics is now presented as an interdisciplinary subject. Mathematics knowledge becomes meaningful and powerful in application. This is possible only when there is a thorough understanding of basic concepts.

Based on an understanding of the basic concepts the students construct and develop new ideas and skills, and the processes they learn become richer and more complex. Students then have a better understanding of how topics fit together as well as develop a greater confidence in problem-solving .

There is a long history of research, going back to the 1940s and the work of William Brownell (1945), on the effects of teaching for meaning and understanding in mathematics. Mathematical concepts have to be conveyed to the students by their teachers so that they can apply and retain information through deep understanding. Although students must develop basic mathematical skills, the processes, concepts and understanding should take precedence.

Method

Objectives

The main objectives of this study were:

- to compare the mathematics achievement in examinations, knowledge of basic concepts from syllabus and ability for mathematics of secondary and high school students of undivided Bongaigaon district.
- to compare the above results with respect to government and private schools.
- to determine the relationship among the above three variables.
- to find out some common conceptual errors.

Hypotheses

Keeping in view the objectives stated above the following null hypotheses were proposed for the present study

- H1: There is no significant difference in the mean of variable scholastic achievement and the mean of the variable conceptual understanding for Class IX.
- H2: There is no significant difference in the mean of variable scholastic achievement and the mean of the variable mathematical ability for Class IX.
- H3: There is no significant difference in the mean of variable scholastic achievement and the mean of the variable conceptual understanding for Class VII.
- H4: There is no significant difference in the mean of variable scholastic achievement and the mean of the variable mathematical ability for Class VII.
- H5: There is a significant relationship among the three variables scholastic achievement , conceptual understanding and mathematical ability for Classes IX and VII.

Sample

Bongaigaon district of Assam was the field area for the study. The field area has been divided into Government Schools and Private Schools. In order to cover the different strata of population, a stratified random sampling of schools have been taken .The sampling size was taken as 30. By the proportional allocation method, the number of government schools taken were 24 and the number of private schools taken were 6.The schools were selected with the help of the Fischer Yate's table. For the purposes of this study Classes VII and IX were chosen. A simple random sampling of ten students each from Classes VII and IX have been taken from each school by the lottery method. The total number of samples in Class VII and Class IX being 290 each.

Tools

For the purpose of this study, the following tools were used.

Test for knowledge of mathematical concepts

These were teacher-prepared tests. These tests were developed from contents within school syllabus common to both SEBA and CBSE schools. All items in this test were selected on basis of the contents included in the standard mathematics textbooks used by the schools which were surveyed.

Test of mathematical ability

These were teacher-prepared tests designed to emphasise mathematical ability over achievement.

This test was designed to place less emphasis on computational skills and more emphasis on students' visual/spatial skills, pattern recognition, and logical reasoning skills. Instead of questions of the textbook type, the question paper had problems and puzzles which would test the understanding of the students in the areas of reasoning and visualisation.

Test of mathematics achievement

The criteria for measuring the mathematics achievement in examination was taken as the mathematics marks which a student received at the end of the academic year. This was expressed as a percentage with weightage given to unit tests, half yearly examination and annual examination . The marks were collected from the school records of the schools visited.

Statistical Analysis

The data was entered into a SPSS spreadsheet and was analysed accordingly. The mean and standard deviation of the combined scores were calculated. Different cross tabulations were constructed to show the joint distribution of two or more variables. t-test was used to examine the null hypotheses formulated on the basis of objectives. Regression analysis was used to investigate the relationship among the variables.

In order to test the null hypotheses, there exists no significance difference between scholastic achievement , conceptual understanding, and mathematical ability. The mean scores on different tests were calculated and the t-test was applied to find if the differences were statistically significant.

Cross table distribution of mean scores of the tests reveal that a student having both the attributes of very high achievement and very high conceptual knowledge forms only 0.3 per cent from Class IX and 0 per cent from Class VII, while for mathematics ability 0 per cent from Class IX and 0.3 per cent from Class VII.

The results shown in Table 1 reveal that conceptual knowledge and mathematics ability of the students were lower than their scholastic achievement. In all three areas of scholastic achievement, conceptual knowledge and mathematics ability, the pupils from the government schools came behind those of the privately-managed schools.

Table 1: Comparison of means among the different tests

	CLASS VII		CLASS IX	
MEAN SCORES	Government Schools	Private Schools	Government Schools	Private Schools
Scholastic achievement	47.94	68.12	46.03	75.25
Conceptual knowledge	20.73	34.24	20.74	40.77
Mathematics ability	13.24	30.20	16.12	36.67

All t values as seen in Table 2 are greater than the critical value, so the null hypotheses are rejected. This shows that there is significant difference between the means of the above pairs of variables.

Table 2: Paired samples test

	Mean	S.D.	t	Sig
Scholastic achievement Conceptual knowledge (IX)	27.18966	13.3747	34.619	**
Scholastic achievement Mathematical ability (IX)	31.70690	14.7007	36.729	**
Scholastic achievement Conceptual knowledge (VII)	28.59207	12.4244	39.189	**
Scholastic achievement Mathematical ability (VII)	35.37310	12.7454	47.262	**

P←.001

To study the effect of the independent variables on the dependent variable regression analysis has been employed. Here, scholastic achievement for Class IX has been taken as the dependent variable Y1 while conceptual understanding X1 and mathematical ability X2 have been taken as the independent variables. Similarly, scholastic achievement for Class VII has been taken as the dependent variable Y2 while conceptual understanding X3 and mathematical ability X4 have been taken as the independent variables.

The beta coefficients as seen in Table 3 are the estimates which refer to the expected change in the dependent variable, per standard deviation increase in the predictor variable. The positive value of the coefficients for conceptual understanding and mathematical ability indicate positive relationships with scholastic achievements. An increase in the value of each of these predictors will show an increase in the combined scores of the students. The statistics signifies that ß and ß1 are significant at P ← .01 per cent . However ß2 ,the regression coefficient for mathematics ability is significant at P ← .1 per cent .

Table 3: Model summary: Class IX

Co-efficient	Value	Std Error	t	Sig
ß	19.516	1.464	13.329**	.000
ß1	.808	.131	9.535**	.000
ß2	.044	.130	.517	.605

R2 = .721 F = 371.25

F = 371.25 shows that the means of the three variables are significantly different. R2 is the statistical measure of how well a regression line approximates real data points. Here, R2 = 0.721 shows that the regression explains 72 per cent of the variation on Y1 due to X1 and X2 . Thus, knowledge of basic concepts and mathematics ability of the students has a causal effect on the mathematics achievement of the students of Class IX and hypothesis V is accepted.

The regression equation thus is given by Y1 = 19.516 + 0.808 X1 + 0.044 X2, i.e., scholastic achievement =19.516 +.808 knowledge of basic concepts + 0.044 mathematics ability.

Table 4 gives the model summary for Class VII. The positive value of the coefficients for conceptual understanding and mathematical ability indicate positive relationships with scholastic achievements. An increase in the value of each of these predictors will show an increase in the combined scores of the students.

t statistics signifies that ß and ß1 are significant at P ← .01 per cent . However ß2, the regression coefficient for mathematics ability is significant at P← .1 per cent . F =200.475 shows that the means of the three variables are significantly different. R2 = 0.583 shows that the regression explains 58 per cent of the variation on Y2 due to X3 and X4. Thus knowledge of basic concepts and mathematics ability of the students has a causal effect on the mathematics achievement of the students of Class VII and hypothesis V is accepted.

Table 4: Model summary : Class VII

Coefficient	Value	Std. Error	t	Sig
ß	27.789	2.153	12.909**	.000
ß1	0.568	0.181	4.714**	.000
ß2	0.203	0.151	1.681	0.094

R^2 = .583 F = 200.475

The regression equation thus is given by Y2 = 27.789 +. 568 X3 + .203 X4, i.e., scholastic achievement =27.789 +. 568 knowledge of basic concepts +.203 mathematics ability.

Analysis of some common conceptual errors

The students' answers were marked 0 for no response, fractional marks for inadequate responses which contained major computation errors, responses which were attempted partially and responses which focussed entirely on the wrong mathematical idea or procedure and full marks for adequate responses which were clear and unambiguous, communicated effectively and showed mathematical understanding of the problem's ideas and requirements.

CLASS VII

Answer the following questions:

1. Evaluate $(y + x)^x$ when x = 5 and y = 6

Table 5: Student answers to Question 1

Marks (Max. 2)	Government Schools	Private Schools
Not attempted	67	5
0	30	2
0.5	26	6
1	42	13
1.5	25	18
2	30	16
Total	230	60

Students were unable to replace the literals x and y with their numerical values. There were cases where even if the numbers were replaced inside the bracket, the literal x in the exponent was not replaced. Further, there was no proper expansion of the exponent power.

2. Find the values of x, y , z

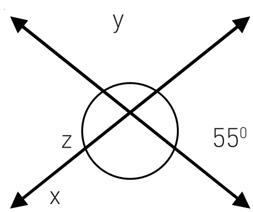

Table 6: Student answers to Question 2

Marks (Max. 3)	Government Schools	Private Schools
Not attempted	23	11
0	28	2
0.5	21	10
1	–	6
1.5	–	8
2	58	23
Total	230	60

A common error being all angles were shown as 55^o. In certain cases, the value of x was found but not the other angles. Thus, the concept of the measure of a straight line being 180 was not known as also the proposition about vertically opposite angles being equal.

3. Find the area of the following figure

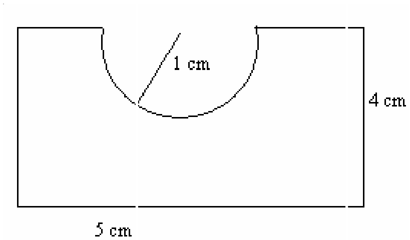

Table 7: Student answers to Question 3

Marks (Max. 3)	Government Schools	Private Schools
Not attempted	110	16
0	21	4
0.5	5	–
1	38	20
1.5	12	6
2	10	4
2.5	24	3
3	10	7
Total	230	60

There was glaring ignorance of the formula for areas of rectangle and circle. In some cases, the wrong formula, i.e., for perimeter of the figures were applied. In the cases, where the students showed the knowledge of the area of the rectangle and semicircle separately, they were unable to apply the concept of difference of two areas for a combined figure .

4. If AB, AC, AD and AE are parallel to line l, what can be said about the points A ,B ,C, D, E.

Table 8: Student answers to Question 4

Marks (Max. 3)	Government Schools	Private Schools
Not attempted	193	47
0	21	9
0.5	16	3
1	0	0
1.5	0	0
2	0	0
2.5	0	0
3	0	1
Total	230	60

In the government schools, 83.91 per cent and 77.96 per cent students of the private schools did not attempt the question showing an immense lack of visualisation skills. Common mistakes were the lines AB, AC, AD and AE being taken as different lines. In some cases, the answer was concurrent points.

5. Three clocks strike after 15, 20 and 30 minutes interval, respectively. If they all ring together at 6pm, when is the next time that they will ring together?

Table 9: Student answers to Question 5

Marks (Max. 3)	Government Schools	Private Schools
Not attempted	113	14
0	55	23
0.5	0	3
1	20	5
1.5	0	–
2	21	2
2.5	0	2
3	21	10
Total	230	59

The application of the concept of LCM was not known to the majority. In some cases, the computation of the LCM was done wrongly. In some cases, the HCF was computed instead of LCM. Common errors included the answer being 12'O clock. In some cases, the sum total of the minutes were added and then added to 6pm making it 7.05 pm.

CLASS IX

Answer the following questions:

1. Factorise $x^4 + y^4$ triangles.

Table 10: Student answers to Question 1

Marks (Max. 3)	Government Schools	Private Schools
Not attempted	30	6
0	172	22
0.5	10	2
1	0	3
1.5	0	–
2	4	2
2.5	14	5
3	0	20
Total	**230**	**60**

2. Divide 4x3 -12x2 +14x -3 by 2x -1.

Table 11: Student answers to Question 2

Marks (Max. 3)	Government Schools	Private Schools
Not attempted	23	5
0	72	4
0.5	17	6
1	118	36
1.5	0	1
2	0	10
Total	**230**	**60**

Errors were seen in the computation of basic operations on algebraic terms. The common error was that the process of division was stopped even though the degree of the remainder remained the same as that of the quotient, because there was the inability to use a fractional remainder in the quotient

3. In an isosceles triangle prove that altitude from vertex bisects the base.

Table 12: Student answers to Question 3

Marks (Max. 3)	Government Schools	Private Schools
Not attempted	36	26
0	10	8
0.5	2	1
1	2	3
1.5	2	1
2	–	2
2.5	2	3
3	1	16
Total	**230**	**60**

The application of the congruence criteria of triangles for solving the problem showed a lack of comprehension of the congruence criteria for only two instead of three identical parts of the triangles could be identified. In some cases, where three parts were identified they were not conformable with the congruence criteria , e.g. the SSA was taken as a criteria.

4. The length and breadth of a rectangular park are in the ratio 8:5. A path 1.5 metres wide running all around the outside of the park has an area of 594m. Find the length and breadth of the park.

Table 13: Student answers to Question 4

Marks (Max. 3)	Government Schools	Private Schools
Not Attempted	187	36
0	623	1
0.5	10	11
1	10	5
1.5	0	2

2	0	2
2.5	2	1
3	0	2
Total	**230**	**60**

Common errors were ignorance of the formula for finding the area of rectangle, using the wrong formula (the perimeter formula), inability to form a simple linear equation, inability to solve the equation. Thus, it was seen that the students lacked the consolidating ability which required combining the different areas of mathematics into a single problem.

5. An electric fan is listed at Rs 350 and is sold at a discount of 8 per cent. During off season, the shopkeeper announces a further discount of 8 per cent. Find the selling price of the fan and how much he would lose if he had announced a single discount of 16 per cent instead of two successive discounts of 8 per cent.

Table 14: Student answers to Question 5

Marks (Max. 3)	Government Schools	Private Schools
Not attempted	104	27
0	5	0
0.5	11	3
1	46	5
1.5	23	7
2	23	2
2.5	4	5
3	14	11
Total	**230**	**60**

There were errors in computation of percentage; instead of successive discount, single discount was taken in both cases. In cases where successive discount was taken, the second percentage for successive discount was calculated on original cost price instead of reduced cost price, operation of addition instead of difference was used to calculate the discount.

Discussion and Conclusion

The above analysis shows that the students failed to develop an understanding of the underlying mathematics concept of a problem. The percentage of all correct responses for the questions was much less than 50 per cent in all the cases. High achievement in mathematics based on examination marks may not reflect knowledge of basic concepts or the mathematics ability of the student. Among the students of this study, it is seen that pupils with high scholastic achievement were able to respond with success to examination questions but were not able to solve conceptual questions with accuracy and understanding. There are a number of common conceptual errors as shown . Not only should students have a fluency in basic computational skills but they must also develop an understanding of mathematical concepts. There is a minimal depth of conceptual understanding, they need in order to continue deepening their understanding in a subsequent course.

This study reveals unequivocally that the ability to memorise facts does not necessarily imply understanding of a concept (Stamovlasis *et al.*, 2004, Mohd. Sahar Sauian, 2002; Parmjit 2002; Reys, R. E. and Yang, D. C. 1998, Yager, 1991). G. K. Mainka (1983) who studied the understanding and the acquisition of mathematical concepts of pupils found that the majority of pupils who were promoted to the next grade did not show acquisition of concepts of the lower grade. Thus, apart from procedural skills which include student's ability to demonstrate appropriate use of procedures, conceptual understanding which includes the students' ability to interpret the problem and select appropriate information to apply a strategy for solution is an area which should be developed in order to improve the quality of mathematics education. Educators should shift from memorisation of facts and algorithms towards instruction that involves students in mathematical concept construction (Mayer and Jones, 2004).

The findings in this research paper also highlight the differences in all three variables among government and private schools. This indicates the existence of other environmental and socio-economic factors which may affect the variables. The factors affecting these should be identified and the disadvantages removed in order that the students are not limited in their achievement of mathematics education. School environment is a vital factor for imparting quality education and equal opportunities for quality education must be available across all sections of the society

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THE ROLE OF INFORMATION TECHNOLOGY (IT) IN RURAL DEVELOPMENT

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There is no gainsaying the fact that the development and progress of all the constituents of a nation are necessary for its overall development. Almost 75 per cent of the population of our country lives in villages. The development of rural areas is, therefore, a must for the overall development of the country.

Even in the present century, people in many rural areas are forced to live in conditions of extreme poverty. Governed by superstitions, they are an ignorant, a lot living under utter inhuman conditions confronted with total lack of medical and other infrastructural facilities. Therefore, besides meeting the fundamental needs of water, food, education, medical facility of the rural people, the socio-economic development of villages is also necessary. Certainly, it can play an important role in fulfilling this task.

In the communication and dissemination of information, the print and electronic media have a definite role. While newspapers and small and big magazines come under the category of print media, radio and television fall under electronic media. In the communication of information, computers and internet have an up role to play. Through e-mail just sitting at home, one can get news and information from any part of the country and even from abroad. The entire informatiion can be obtained through the world wide web (www) at the click of the mouse.

There is no denying that in rural areas, education must be given the first priority. The uneducated rural people not only become easy victims of superstitions but they also remain cut off from the means of development around them which can help emancipate them and improve their quality of life. It is through education that awareness may be created among the masses so that they do not fall prey to superstitions, miracles and mumbo-jumbo. Education has also a role in changing their mindset so that they come out of their age-old views, customs and traditions.

The availability of medical facility and family welfare schemes for the rural people is also a dire necessity. The IT may play an important role in the field of informaton in matters relating to agricultural schemes and crop technology. Through IT, the farmers may be educated about new fertilisers, pesticides and improved agriculture-related tools and artefacts. Also, they can be told about the availability of improved high quality seeds. Through IT, they can also be educated about various crop diseases and the ways and means to safeguard their crops against those diseases. Not only this but updated information about animal husbandry, dairies, sugar and cotton produces etc., can be provided to the farmers through IT.

The market price of crops, vegetables, etc., prevailing in the various parts of the country may also be made available to the farmers through internet so that they are seized of the competitive market and may plan the sale-purchase of agricultural produces accordingly. In the sale and purchase of agricultural produces, there can be extended benefits of e-commerce as well.

Through IT, forecast about weather can also be made available to the farmers so that they can plan the sowing and harvesting of their crops accordingly . Moreover, in times of drought, the information regarding the beneficial crops to be sowed may also be made available to them.

The villagers may also be given the advance warning of the happenings of natural calamities like earthquakes, flood, drought, cyclones, etc., so that timely action may be taken and the avoidable loss to life and property may be averted.

In the social development of villages too, the role of IT may not be undermined. In mass awareness programmes, IT may play an important role. The importance of democracy and the role of franchise may also be highlighted to the villagers through IT.

The IT, therefore, seems to have an important role in the all-round development of villages. But, how can the benefit of IT be passed on to farmers and villagers? In the dissemination of information to its consumers viz., farmers and villagers, internet and multimedia may indeed prove very useful. As is well known, multimedia involves the combination of text, graphics, audio-visual and animation, etc. In fact, multimedia computing has now become an independent branch of IT. Needless to say, in educating rural masses and in mass awareness programmes multimedia has an up role to play.

With a view to taking the benefits of internet and multimedia to the villages, it is necessary that information centres should be opened there. The management of these centres may be done at the village panchayat level. By imparting proper computer training, the rural youth may also be given the responsibility of running these centres. In this way employment opportunities may also be created in the villages.

Thus, through the use of internet and multimedia the e-governance of villages can be started at the panchayat level. Centres at panchayat level may be opened in different villages which may be connected by internet to each other and to the district headquarter. Through these centres, the village folks can send their grievances to the district administration. They can also get any information from the district level at a much faster speed.

Computerisation of land records has, of late, been done in some States including Madhya Pradesh. This has not only facilitated ready collection of revenue by the district administration but has also come as a great help to the village folks. Earlier, the handwritten land records used to be maintained by *patwaris* and other workers. However, timely updating of these records was seldom carried out which created hassles for extending credit to the farmers. But, now the availability of systematic land record in computerised form has come to the rescue of farmers. Indeed, this is a glaring example of the application of IT in rural development.

It is now becoming possible for any villager to get the revenue record from the district administration directly through the village panchayat without even bothering to visit that district. Only some minimum fee amount is required to be paid for availing this facility. Earlier, the farmers had to personally visit the revenue department situated in the district and had to appease the authorities to procure the information needed by him. Besides wastage of time, this procedure entailed lot of unnecessary expenditure too. But now, thanks to IT, the villager can get all the information expeditiously through village panchayats only. Besides saving time and money, this procedure also does away with the practice of corruption.

Thus, the IT may be used to advantage in a variety of ways for rural development. Through information centres at the village level or directly through the centres run by gram panchayat , the village folks may readily get all the necessary information. However, the modern information and communication technology has an edge over the traditional print and electronic media as information can be carried at a much faster speed to its real consumers, e.g., villagers and farmers.

MULTIPLICATION OPERATIONS ON VECTORS AND SOME OF THEIR APPLICATIONS

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Multiplication operations in the forms of scalar and vector products have been dealt with in NCERT textbook for Class XII. In this article, we describe further extension of products and discuss some examples related to some physical situations and some specific problems based on these concepts. We close this article by giving some remarks on crucial concepts of projection and distance between skew lines in vector forms.

1. Introduction

In the case of vectors, we find that two multiplication operations are defined for a pair of vectors. One operation called a scalar product generates a scalar, whereas the other operation called a vector product generates a vector.

Expressions of the form $\vec{a}\cdot\vec{b}\cdot\vec{c}$, $\vec{a}\,.\vec{b}\;\cdot\vec{c}\;\cdot\vec{d}$ are meaningless since the scalar product is only defined between a pair of vectors. The operation of division of vectors is not defined. We may write $\vec{a}\cdot\vec{b} = c$, but it is absurd to write $\vec{a} = \frac{c}{\vec{b}}$ or $\vec{b} = \frac{c}{\vec{a}}$. Another form of product of two vectors is the vector product. We denote the vector products of $\vec{a}$ and $\vec{b}$ by $\vec{a}\times\vec{b}$. With the help of scalar product and vector product, the mixed product of the form $\vec{a}\cdot(\vec{b}\times\vec{c})$ become possible. The next generalisation is the vector product of more than two vectors defined in specified way as $\vec{a}\times(\vec{b}\times\vec{c})$ or $(\vec{a}\times\vec{b})\times\vec{c}$.

For completeness, we elaborate upon scalar triple product and product of more than two vectors as these have not been discussed in NCERT textbook.

1.1 Scalar Triple Product

Let
$$\vec{a} = a_1\hat{i} + a_2\hat{j} + a_3\hat{k}$$
$$\vec{b} = b_1\hat{i} + b_2\hat{j} + b_3\hat{k}$$
$$\vec{c} = c_1\hat{i} + c_2\hat{j} + c_3\hat{k}.$$

Then,

$$\vec{a}\cdot(\vec{b}\times\vec{c}) = \begin{vmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{vmatrix}$$

Reader may verify that, using the properties of determinants, we obtain

$$\vec{a}\cdot(\vec{b}\times\vec{c}) = \vec{b}\cdot(\vec{c}\times\vec{a}) = \vec{c}\cdot(\vec{a}\times\vec{b})$$

or,

$[\vec{a},\vec{b},\vec{c}] = [\vec{b},\vec{c},\vec{a}] = [\vec{c},\vec{a},\vec{b}]$

Geometrically, $|\vec{a}\cdot(\vec{b}\times\vec{c})|$ gives the volume of a parallelopiped whose coterminous edges are represented by vectors $\vec{a},\vec{b}$ and $\vec{c}$, respectively (see Fig.1)

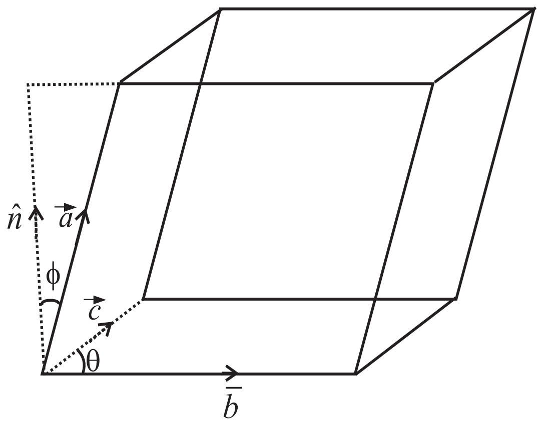

Fig. 1

The area of the parallelogram OBCD is $|\vec{b}\times\vec{c}|$ and the direction of $\vec{b}\times\vec{c}$ is along $\hat{n}$ which is normal to the plane containing $\vec{b}$ and $\vec{c}$. Let *h* denote the height of the terminal point of vector $\vec{a}$ above the parallelogram OBCD. The volume of the parallelepiped

$= h|\vec{b}\times\vec{c}|$ (height × area of parallelogram OBCD)

$$= |\vec{a}\cdot\hat{n}||\vec{b}\times\vec{c}|$$

$$= |\vec{a}\cdot|\vec{b}\times\vec{c}|\hat{n}|$$

$$= |\vec{a}\cdot(\vec{b}\times\vec{c})|$$

1.2 Vector Product of More than Two Vectors

Let,
$$\vec{a} = a_1\hat{i}+a_2\hat{j}+a_3\hat{k}$$
$$\vec{b} = b_1\hat{i}+b_2\hat{j}+b_3\hat{k}$$
$$\vec{c} = c_1\hat{i}+c_2\hat{j}+c_3\hat{k}$$

Using basic definition of vector product of vectors and its representation in determinant form, one can readily deduce that

$$\vec{a}\times(\vec{b}\times\vec{c}) = (\vec{a}\cdot\vec{c})\vec{b}-(\vec{a}\cdot\vec{b})\vec{c}$$

Geometrically, $\vec{b}\times\vec{c}$ is perpendicular to the plane containing $\vec{b}$ and $\vec{c}$, so $\vec{a}\times(\vec{b}\times\vec{c})$ lies in the plane containing $\vec{b}$ and $\vec{c}$.

2. Application in Physical Situations

2.1. Work Done by Force

If force $\vec{F}$ acts on a body causing displacement $\vec{d}$ in the direction of force $\vec{F}$, then the work done by the force $\vec{F}$ is defined as the product of the distance moved and the component of force in the direction of the displacement. Hence,

W (workdone) $= |\vec{F}|\cos\theta|\vec{d}|$

$$= |\vec{F}||\vec{d}|\cos\theta$$

$$= \vec{F}\cdot\vec{d}$$

As W is always positive, so

$$W = |\vec{F}\cdot\vec{d}|$$

Example 1: Let the force $\vec{F}_1$ of magnitude 5 units be in the direction of $2\hat{i}-2\hat{j}+\hat{k}$, force $\vec{F}_2$ of magnitude 4 units in the direction of $\hat{i}+2\hat{j}+2\hat{k}$ and force $\vec{F}_3$ of magnitude 3 units in the direction of $-2\hat{i}+\hat{j}-2\hat{k}$ act on a particle A (6, 2, 3) displacing it to the new position B (9, 7, 5). Find the work done.

Solution: Here

$$\vec{F}_1 = \frac{5}{3}(2\hat{i}-2\hat{j}+\hat{k})$$

$$\vec{F}_2 = \frac{4}{3}(\hat{i}+2\hat{j}+2\hat{k})$$

$$\vec{F}_3 = \frac{3}{3}(-2\hat{i}+\hat{j}-2\hat{k})$$

So, the total force acting on the particle A is

$$\vec{F} = \vec{F}_1+\vec{F}_2+\vec{F}_3$$

$$= \frac{1}{3}[8\hat{i}+\hat{j}+7\hat{k}]$$

Taking **O** as fixed point, we can assign position vector to the point A as $\overrightarrow{OA} = 6\hat{i}+2\hat{j}+3\hat{k}$ and position vector of the point **B** as $\overrightarrow{OB} = 9\hat{i}+7\hat{j}+5\hat{k}$.

Therefore, displacement $\vec{d} = \overrightarrow{OB}-\overrightarrow{OA}$

$$= 3\hat{i}+5\hat{j}+2\hat{k}$$

Hence work done $W = \vec{F}\cdot\vec{d}$

$$= \frac{1}{3}(8\hat{i}+\hat{j}+7\hat{k})\cdot(3\hat{i}+5\hat{j}+2\hat{k})$$

$$= \frac{1}{3}[24+5+14]$$

$$= \frac{43}{3}\text{ units}$$

2.2. Moment (torque) of the Force and the Moment of Momentum

If the force $\vec{F}$ acts on a point P of the body through the point whose position vector is $\vec{r}$ with respect to the specified point O as shown in the Figure 2, then the moment of the force $\vec{F}$ about the point O is defined as

$$\vec{M} = \vec{r}\times\vec{F}$$

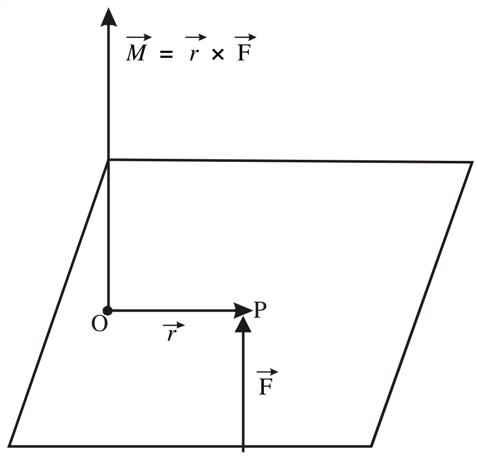

Fig. 2

If $\vec{F}$ is identified with momentum $m\vec{V}$ of the particle of mass *m* at P moving with velocity $\vec{V}$ then the moment of momentum about the fixed point O is expressed as:

$$\vec{M} = \vec{r}\times m\vec{V}$$
$$= m\vec{r}\times\vec{V}$$

It is also called the angular momentum of the particle about O.

Example 2: Find the torque of a force represented by $3\hat{i}+6\hat{j}+\hat{k}$ about the point O given that it acts through the point A (–1, 1, 2) relative to the point O.

Solution: Here, $\vec{F} = 3\hat{i} + 6\hat{j} + \hat{k}$ and the position vector of the point A with respect to O can be expressed as $\vec{r} = -\hat{i} + \hat{j} + 2\hat{k}$. Therefore, torque of the force

$$\vec{M} = \vec{r} \times \vec{F}$$

$$= (-\hat{i} + \hat{j} + 2\hat{k}) \times (3\hat{i} + 6\hat{j} + \hat{k})$$

$$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -1 & 1 & 2 \\ 3 & 6 & 1 \end{vmatrix}$$

$$= \hat{i}(1-12) - \hat{j}(-1-6) + \hat{k}(-6-3)$$

$$= -11\hat{i} + 7\hat{j} - 9\hat{k}$$

2.3 Angular Velocity

Consider a point P on the rigid body rotating about the axis L through the point O with constant spin ω (angular speed).

Let $\vec{d}$ represent the position vector of the point P with respect to O. Since P travels in a circle of radius $d\sin\theta$ (see Fig.3) having centre at C, the instaneous linear velocity $\vec{v}$ along the tangent at P has its magnitude,

$$\omega\,(d\sin\theta) = |\vec{\omega} \times \vec{d}\,|$$

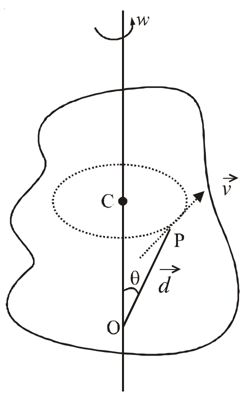

Fig. 3

Also $\vec{v}$ must be perpendicular to both $\vec{\omega}$ and $\vec{d}$ in such a way that $\vec{d}, \vec{\omega}$ and $\vec{v}$ form a right-handed system.

Example 3: A body spins about a line through the origin parallel to the vector $2\hat{i} - \hat{j} + \hat{k}$ at 15 rad/s. Find the angular velocity of the body and also instantaneous linear velocity of a point in the body with position vector $\hat{i} + 2\hat{j} + 3\hat{k}$.

Solution: Angular velocity

$$\vec{\omega} = |\vec{\omega}| \frac{(2\hat{i} - \hat{j} + \hat{k})}{\sqrt{6}}$$

$$= \frac{15}{\sqrt{6}}(2\hat{i} - \hat{j} + \hat{k})$$

Instantaneous linear velocity

$$\vec{v} = \vec{\omega} \times \vec{d}$$

Here, $\vec{d} = \hat{i} + 2\hat{j} + 3\hat{k}$.

Therefore, $\vec{v} = \vec{\omega} \times \vec{d}$

$$= \frac{15}{\sqrt{6}}(2\hat{i} - \hat{j} + \hat{k}) \times (\hat{i} + 2\hat{j} + 3\hat{k})$$

$$= \frac{15}{\sqrt{6}} \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -1 & 1 \\ 1 & 2 & 3 \end{vmatrix}$$

$$= \frac{15}{\sqrt{6}}[\hat{i}(-3-2) - \hat{j}(6-1) + \hat{k}(4+1)]$$

$$= \frac{75}{\sqrt{6}}(-\hat{i} - \hat{j} + \hat{k}).$$

3. Some Specific Problems Based on Product of Vectors

Problem 1: From a given point and a given line, how will you determine the perpendicular distance of the point from the line?.

Problem solving: Let C be the point with position vector $\vec{c}$ and A be the point on the line L with position vector $\vec{a}$ with reference to the fixed point O (see Fig.4). Assume that given line L is parallel to the vector $\vec{b}$, so the equation of the line L can be expressed as

$\vec{r} = \vec{a} + \lambda\vec{b}$ where l is scalar and $\vec{r}$ is the position vector of any arbitrary point P (say) on the line L.

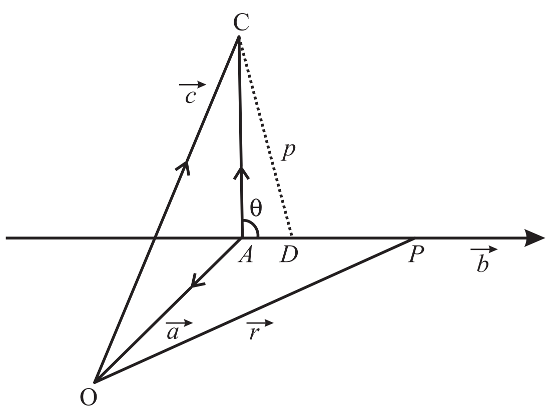

Fig. 4

From Fig.4, p is the perpendicular distance from the given point C to the given line which has to be determined. From the Fig.

$$\overrightarrow{OA} + \overrightarrow{AC} = \overrightarrow{OC}$$

$$\overrightarrow{AC} = \overrightarrow{OC} - \overrightarrow{OA}$$

$$= \vec{c} - \vec{a}$$

From the triangle ACD, we have

$$p^2 = (AC)^2 - (AD)^2$$

$$= \left|\overrightarrow{AC}\right|^2 - \left|\overrightarrow{AD}\right|^2 \qquad (1)$$

Obviously, AD is the projection of AC on the line L, i.e.,

$$\left|\overrightarrow{AD}\right| = AD = AC\cos\theta$$

$$= \overrightarrow{AC}\cdot\frac{\vec{b}}{|\vec{b}|}$$

$$= \frac{(\vec{c}-\vec{a})\cdot\vec{b}}{|\vec{b}|}$$

Hence from (1), we have

$$p^2 = (\vec{c}-\vec{a})^2 - \left(\frac{(\vec{c}-\vec{a})\cdot\vec{b}}{|\vec{b}|}\right)^2.$$

Thus, p can be deduced from the above expression.

Problem 2: Consider a tetrahedron with faces F_1, F_2, F_3 and F_4. Let $\vec{v}_1, \vec{v}_2, \vec{v}_3$ and $\vec{v}_4$ be vectors whose magnitudes are respectively equal to the areas of F_1, F_2, F_3 and F_4 and whose directions are perpendicular to these faces in the outward direction. Then how to determine $\vec{v}_1 + \vec{v}_2 + \vec{v}_3 + \vec{v}_4$?

Problem Solving

Consider the following Fig. 5 representing the tetrahedron OABC with faces F_1, F_2, F_3 and F_4. Let $\vec{a}, \vec{b}, \vec{c}$ represent the position vectors of the vertices A, B and C, respectively.

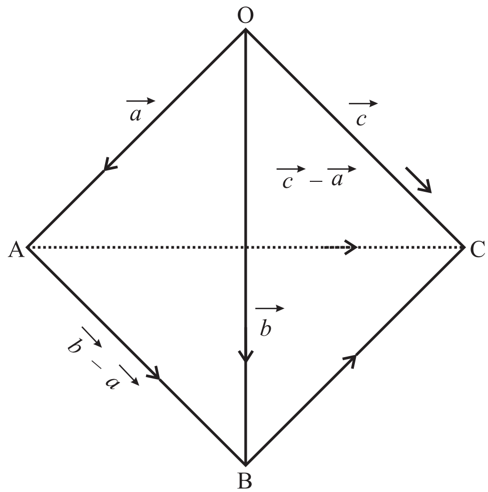

Fig. 5

Again, area of

$$F_1 = \frac{1}{2}\left|\overrightarrow{OA} \times \overrightarrow{OB}\right| = \frac{1}{2}\left|\vec{a} \times \vec{b}\right|$$

area of $F_2 = \frac{1}{2}\left|\overrightarrow{OB} \times \overrightarrow{OC}\right| = \frac{1}{2}\left|\vec{b} \times \vec{c}\right|$

area of $F_3 = \frac{1}{2}\left|\overrightarrow{OC} \times \overrightarrow{OA}\right| = \frac{1}{2}\left|\vec{c} \times \vec{a}\right|$

area of $F_4 = \frac{1}{2}\left|\overrightarrow{AC} \times \overrightarrow{AB}\right| = \frac{1}{2}\left|(\vec{c} - \vec{a}) \times (\vec{b} - \vec{a})\right|$

According to the problem,

$$\vec{v}_1 = \frac{1}{2}(\vec{a} \times \vec{b})$$

$$\vec{v}_2 = \frac{1}{2}(\vec{b} \times \vec{c})$$

$$\vec{v}_3 = \frac{1}{2}(\vec{c} \times \vec{a})$$

and $\vec{v}_4 = \frac{1}{2}\left\{(\vec{c} - \vec{a}) \times (\vec{b} - \vec{a})\right\}$

Again, $\vec{v}_1 + \vec{v}_2 + \vec{v}_3 + \vec{v}_4 =$

$$\frac{1}{2}\left[\vec{a} \times \vec{b} + \vec{b} \times \vec{c} + \vec{c} \times \vec{a} + \vec{c} \times \vec{b} - \vec{c} \times \vec{a} - \vec{a} \times \vec{b}\right]$$

$$= \vec{0}.$$

Problem 3: If $\vec{a} = 2\hat{i} + \hat{k}, \vec{b} = \hat{i} + \hat{j} + \hat{k}$ and $\vec{c} = 4\hat{i} - 3\hat{j} + 7\hat{k}$ and the vector $\vec{r}$ satisfies the relationship $\vec{r} \times \vec{b} = \vec{c} \times \vec{b}$ and $\vec{r} \cdot \vec{a} = 0$, then how to find $\vec{r}$?

Problem Solving: Given that,

$$\vec{r} \times \vec{b} = \vec{c} \times \vec{b}$$

$$\Rightarrow \quad \vec{a} \times (\vec{r} \times \vec{b}) = \vec{a} \times (\vec{c} \times \vec{b})$$

$$= (\vec{a} \cdot \vec{b})\vec{r} - (\vec{a} \cdot \vec{r})\vec{b}$$

$$= (\vec{a} \cdot \vec{b})\vec{c} - (\vec{a} \cdot \vec{c})\vec{b}$$

$$= (\vec{a} \cdot \vec{b})\vec{r} = (\vec{a} \cdot \vec{b})\vec{c} - (\vec{a} \cdot \vec{c})\vec{b}$$

(Since $\vec{r} \cdot \vec{a} = 0$)

$$= 3\vec{r} = 3\vec{c} - 15\vec{b}$$

$$= \vec{r} = \vec{c} - 5\vec{b}$$

$$= -\hat{i} - 8\hat{j} + 2\hat{k}.$$

Problem 4: Let $\vec{b} = 4\hat{i} + 3\hat{j}$ and $\vec{c}$ be two vectors perpendicular to each other in *xy*-plane. How to determine a vector in the same plane having projections 1 and 2 along $\vec{b}$ and $\vec{c}$, respectively?

Problem solving: Let $\vec{r}$ represent the vector to be determined in the *xy*-plane containing $\vec{b}$ and $\vec{c}$ respectively, i.e., $\vec{r}$ is coplanar with $\vec{b}$ and $\vec{c}$ and hence $\vec{r}$ can be expressed as

$\vec{r} = \lambda\vec{b} + \mu\vec{c}$ for l, m being some scalar.
$\vec{c}$ is the given vector in the same plane so, we can write $\vec{c} = x\hat{i} + y\hat{j}$ for some scalars *x* and *y*.
Since, $\vec{c}$ and $\vec{b}$ are perpendicular to each other so $\vec{c}\cdot\vec{b} = 0 \Rightarrow 4x + 3y = 0$ which gives $y = -\frac{4}{3}x$.

or $\vec{c} = x\left(\hat{i} - \frac{4}{3}\hat{j}\right)$

Given that projection of $\vec{r}$ along $\vec{b}$ is 1, i.e.,

$$\vec{r}\cdot\frac{\vec{b}}{|\vec{b}|} = 1$$

$$\Rightarrow \quad \frac{(\lambda\vec{b} + \mu\vec{c})\cdot\vec{b}}{|\vec{b}|} = 1$$

$$\Rightarrow \quad 5l = 1$$

or $$l = \frac{1}{5}$$

Similarly, projection of $\vec{r}$ on $\vec{c}$ is 2, i.e.,

$$\vec{r}\cdot\frac{\vec{c}}{|\vec{c}|} = 2 \Rightarrow \mu|\vec{c}| = 2$$

or $$\mu x = \frac{6}{5}$$

Hence $$\vec{r} = \frac{1}{5}(4\hat{i} + 3\hat{j}) + \frac{6}{5}(\hat{i} - \frac{4}{3}\hat{j})$$

$$= 2\hat{i} - \hat{j}.$$

4. Remark's on Projection and Distance between Skew-lines

In NCERT textbook, Class XII, Part II, basic concept on projection of a vector on a line has been explained on page 443 and its important application in finding the distance between the skew lines in space has also been discussed (see page 474). These concepts are crucial and are used in many physical situations besides being used in the study of vectors and three dimensional geometry. Therefore, giving more deeper insight into these concepts as remark's will supplement the textual material on these concepts given in above cited NCERT textbook.

4.1. Projection of a Vector on a Line

Let L be a given line and AB a given directed line segment in three-dimensional space. Intuitively, to make the definition of projection of AB on L, we erect planes passing through points A and B perpendicular to L (see Fig.6). These planes cut the line L at A' and B', respectively. Thus, we obtain the directed line segment A'B' which is called projection of AB onto the line L.

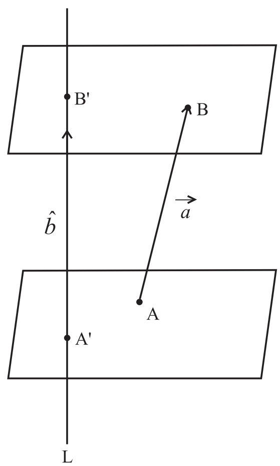

Fig. 6

In Literature, generally projection of a vector on a line is taken in both senses either as a scalar or as a vector. However, projection as a vector is more useful in physical sciences as well as in engineering. Let us distinguish between these two projections.

Consider $\overrightarrow{AB} = \vec{a}$ and suppose $\hat{b}$ is along the line L, then the projection (as vector) of $\vec{a}$ on the line L is given by $\left(\vec{a}\cdot\frac{\vec{b}}{|\vec{b}|}\right)\frac{\vec{b}}{|\vec{b}|}$

$$= \left(\frac{\vec{a}\cdot\vec{b}}{|\vec{b}|^2}\right)\vec{b}.$$

Projection (as scalar) of $\vec{a}$ on L is simply expressed as

$$\vec{a}\cdot\frac{\vec{b}}{|\vec{b}|} = \frac{\vec{a}\cdot\vec{b}}{|\vec{b}|}.$$

It is interesting to exhibit another way of looking at the projection. To this end, let $\vec{a}$ be the given vector whose projection on the line L is to be determined.

Let $\vec{b}$ be the vector along the line L determining its direction and $\vec{p}$ denote the projection vector of $\vec{a}$ on the line L (see Fig.7).

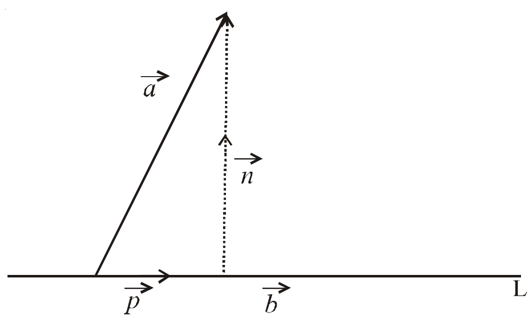

Fig. 7

Clearly, $\vec{n} = \vec{a} - \vec{p}$.

Since $\vec{p}$ and $\vec{b}$ are collinear vectors, so

$\vec{p} = \lambda\vec{b}$ (l is a scalar).

Again $\vec{n}$ is perpendicular to $\vec{b}$, we must have

$$\vec{n}\cdot\vec{b} = \vec{a}\cdot\vec{b} - \lambda\vec{b}\cdot\vec{b}$$

$$0 = \vec{a}\cdot\vec{b} - \lambda|\vec{b}|^2$$

or $$l = \frac{\vec{a}\cdot\vec{b}}{|\vec{b}|^2}.$$

Hence, projection vector $\vec{p} = \left(\frac{\vec{a}\cdot\vec{b}}{|\vec{b}|}\right)\frac{\vec{b}}{|\vec{b}|}$.

Now, we wish to turn to the problem of finding a formula for the distance between the two skew lines. The distance formula has been derived in NCERT textbook, Class XII, Part II on page 474, however, the same is being discussed in more intuitive way so as to strengthen the understanding of shortest distance between the two skew lines in space. Let the line L_1 parallel to the vector $\vec{b}_1$ passing through the point A_1 with position vector $\vec{a}_1$ and the other line L_2 parallel to the vector $\vec{b}_2$ and passing through the point A_2 with position vector $\vec{a}_2$. As these lines are in space, we can think of two different planes containing lines L_1 and L_2, respectively, as shown in Fig. 8.

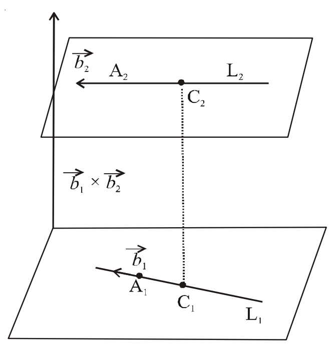

Fig. 8

We can find point C_1 on L_1 and point C_2 on L_2 such that C_1C_2 is perpendicular to both lines. In fact C_1C_2 is the shortest distance between lines L_1 and L_2 which happens to be the distance between the two planes containing lines L_1 and L_2, respectively.

$\vec{b}_1 \times \vec{b}_2$ is also perpendicular to these two planes, i.e., $\overrightarrow{C_1C_2}$ and $\vec{b}_1 \times \vec{b}_2$ are collinear. Thus, we can think of C_1C_2 as the projection of $\overrightarrow{A_1A_2}$ in the direction of $\vec{b}_1 \times \vec{b}_2$ and hence, shortest distance $\left|\overrightarrow{C_1C_2}\right|$ between lines L_1 and L_2 is

$$\left|\frac{\overrightarrow{A_1A_2} \cdot \vec{b}_1 \times \vec{b}_2}{\left|\vec{b}_1 \times \vec{b}_2\right|}\right|$$

$$= \frac{\left|(\vec{a}_2 - \vec{a}_1) \cdot (\vec{b}_1 \times \vec{b}_2)\right|}{\left|\vec{b}_1 \times \vec{b}_2\right|}.$$

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Scientists Use Quantum Mechanics to Show that Glass should Melt Near Absolute Zero

Quantum mechanics, developed in the 1920s, has had an enormous impact in explaining how matter works. The elementary particles that make up different forms of matter — such as electrons, protons, neutrons and photons — are well understood within the model quantum physics provides. Even now, some 90 years later, new scientific principles in quantum physics are being described. The most recent gives the world a glimpse into the seemingly impossible.

Professor Eran Rabani of Tel Aviv University's School of Chemistry and his colleagues at Columbia University have discovered a new quantum mechanical effect with glass-forming liquids. They've determined that it's possible to melt glass — not by heating it, but by cooling it to a temperature near absolute zero.

This new basic science research, to be published in Nature Physics, has limited practical application so far, says Professor Rabani. But knowing why materials behave as they do paves the way for breakthroughs of the future. "The interesting story here," says Professor Rabani, "is that by quantum effect, we can melt glass by cooling it. Normally, we melt glasses with heat."

Turning the thermometer upside-down

Classical physics allowed researchers to be certain about the qualities of physical objects. But at the atomic/molecular level, as a result of the duality principle which describes small objects as waves, it's impossible to determine exact molecular position and speed at any given moment — a fact known as the "Heisenberg Principle." Based on this principle, Professor Rabani and his colleagues were able to demonstrate their surprising natural phenomenon with glass.

Many different materials on earth, like the silica used in windows, can become a glass — at least in theory — if they are cooled fast enough. But the new research by Professor Rabani and his colleagues demonstrates that under very special conditions, a few degrees above absolute zero (459.67° Fahrenheit), a glass might melt.

It all has to do with how molecules in materials are ordered, Professor Rabani explains. At some point in the cooling phase, a material can become glass and then liquid if the right conditions exist.

"We hope that future laboratory experiments will prove our predictions," he says, looking forward to this new basic science paving the way for continued research.

Classical glass

The research was inspired by Nobel Prize winner Philip W. Anderson, who wrote that the understanding of classical glasses was one of the biggest unsolved problems in condensed matter physics. After the challenge was presented, research teams around the world rose to it.

Until now, structural quantum glasses had never been explored, i.e., what happens when you mix the unique properties in glass and add quantum effects. Professor Rabani was challenged to ask, "if we looked at the quantum level, would we still see the hallmarks of a classical glass"?

What the researchers unearthed is a new and unique hallmark, showing that quantum glasses have a unique signature. Many materials he says can form a glass if they are cooled fast enough. Even though their theory is not practical for daily use: few individuals own freezers that dip down nearly 500 degrees below zero.

Professor Rabani is currently on sabbatical at the University of California, Berkeley, as a Miller visiting professor.

(Source: Science Daily Online)

Poor Work ability may Predict Faster Deterioration of Health

Poor work ability in midlife may be associated with an accelerated deterioration of health and functioning in old age, states a study published in Canadian Medical Association Journal (CMAJ).

In a 28-year follow-up population-based study, Finnish researchers studied middle-aged white-collar and blue-collar employees to see if a person's work ability in midlife might predict their risk of death or disability.

In 1981, a total of 5971 employees aged 44-58 reported on their perceived work ability as part of a longitudinal study hosted by the Finnish Institute of Occupational Health. By 2009, altogether 1918 persons had died and the ability to perform daily activities was assessed among 2879 respondents.

"We found that work ability in midlife predicted decline in health and functioning among men and women during the 28-year follow-up even after adjustments for health and lifestyle factors," writes Dr Mikaela von Bonsdorff, Gerontology Research Centre, University of Jyväskylä, Finland with coauthors. "The risks showed similar gradients among blue- and white-collar employees, but the risk of death was generally higher among blue-collar employees."

The authors conclude that, "perceived work ability in midlife correlates with mortality among blue-collar and white-collar employees, and work ability in midlife predicts disability in old age. It is plausible that a person's capacity to perform activities in relation to the demands posed by their age-appropriate role in society tracks through decades. The current work ability of middle-aged employees could, therefore, be considered as an early predictor of functioning in old age."

(Source: Science Daily Online)

Learning Causes Structural Changes in Affected Neurons

When a laboratory rat learns how to reach for and grab a food pellet — a pretty complex and unnatural act for a rodent — the acquired knowledge significantly alters the structure of the specific brain cells involved, which sprout a whopping, of 22 per cent more dendritic spines connecting them to other motor neurons.

The finding, published in the journal proceedings of the National Academy of Sciences by Mark H. Tuszynski, M.D. Ph.D. Professor of Neurosciences and Colleagues at the University of California, San Diego School of Medicine, underscores the brain's remarkable ability to physically change as it learns (not just in rats, but presumably in humans too), but also reveals that the effect is surprisingly restricted to the network of neurons actually involved in the learning.

"I think it's fair to say that in the past it was generally believed that a whole cortical region would change when learning occurred in that region, that a large group of neurons would show a fairly modest change in overall structure," said Tuszynski, who is also director of the Centre, for Neural Repair at the UC San Diego and a neurologist at the Veterans Affairs San Diego Health System.

"Our findings show that this is not the case. Instead, a very small number of neurons specifically activated by learning show an expansion of structure that's both surprisingly extensive — there is a dramatic increase in the size and complexity of the affected neurons — and yet highly restricted to a small subset of cells. And all of this structural plasticity is occurring in the context of normal learning which highlights just how changeable the adult brain is as a part of its normal biology."

Tuszynski said the new work improves science's basic understanding of how the brain learns. "This tells us that learning may be mediated by relatively few cells, but these few cells exhibit a substantial or extensive change in structure." Notably, the impacted cells in the rat study were not clustered together, but widely distributed over the motor cortex of the rat brain, suggesting that learned behaviours create expansive networks of distant cells.

Whether these new connections and changes are permanent, is the subject of continuing research. For a rat, reaching for and grasping food is a learned behaviour that takes time and repetition to master, not unlike a person learning to ride a bike or play the piano. If the behaviour isn't regularly practised, it becomes rusty, though it may be later resumed and remembered.

"This seems to be a 'hard-wired' form of memory," said Tuszynski. We were curious whether we could find evidence of hard-wiring as part of learning in animal brains. We designed this study and our original hypothesis seems to be confirmed.

"Whether this physically represents the formation of long-term memory is hard to say" Tuszynski said, explaining that the data are correlative. "The rats learn, and we know that the learning is mediated by the small set of cells we studied. We know that adjacent cells in the cortex, which are not required to learn the new task, do not show the structural change. So presumably the structural change is occurring only in the learning neurons, and the learning would likely not occur without the structural change."

He added that in order to determine whether the structural change is necessary for the learning to occur, scientists would need to block the expansion in spines and then observe a failure to learn. "Yet the inference is quite strong that structural change is necessary for the learning to occur."

Tuszynski said it remains to be seen how the brain changes in other types of learning, such as language-based knowledge or arithmetic-type learning.

"Types of memory that require much repetition for learning — and that don't fade away easily — likely use this modification of (dendritic) structure to accomplish the learning," he said. "Other forms of memory that are not so hard to establish — and which fade more rapidly — may not involve such extensive structural changes. These are concepts that will be pursued in future studies."

Coauthors of the study are Ling Wang, James M. Conner and Jessica Rickert, all in the Department of Neurosciences, UC San Diego.

The research was supported by National Institutes of Health Grant AG10435 and by Dr Miriam and Sheldon G. Adelson Medical Research Foundation.

(Source: Science Daily Online)

Possible Path to Create Next Generation Computer Chips

University of Maryland researchers have made a breakthrough in the use of visible light for making tiny integrated circuits. Though their advance is probably at least a decade from commercial use, they say it could one day make it possible for companies like Intel to continue their decades long tread of making ever smaller, faster and cheaper computer chips.

For some 50 years, the integrated circuits, or chips, that are at the heart of computers, smart phones, and other high-tech devices have been created through a technique known as photolithography, in which each computer chip is built-up in layers.

In photolithography, each layer of a conductive material (metal, treated silicon, etc., is deposited on a chip and coated with a chemical that hardens when exposed to light. Light shining through a kind of stencil know as a mask projects, a detailed pattern onto the photoresist, which hardens where it's exposed. Then, the unhardened areas of photoresist and underlying metal are etched away with a chemical. Finally, the remaining photoresist is etched away using a different chemical treatment, leaving an underlying layer of metal with the same shape as the mask.

However, fitting more and more circuits on each chip has meant making smaller and smaller circuits. In fact, features of circuits in today's computer chips are significantly smaller than the wavelength of visible light. As a result, manufacturers have gone to using shorter and shorter wavelengths of light (radiation), or even charged particles, to enable them to make these circuits.

University of Maryland chemistry Professor John Fourkas and his research group recently introduced a technique called RAPID lithography that makes it possible to use visible light to attain lithographic resolution comparable to (and potentially even better than) that obtained with shorter wave length radiation.

"Our RAPID technique could offer substantial savings in cost and ease of production," Fourkas said. "Visible light is far less expensive to generate, propagate and manipulate than shorter wavelength forms of electromagnetic radiation, such as vacuum ultraviolet or X-rays. And using visible light would not require the use of the high vacuum conditions needed for current short wavelength technologies."

The key to RAPID is the use of a special "photoinitiator" that can be excited, or turned on, by one laser beam and deactivated by another. In new work just published online by Nature Chemistry, Fourkas and his group report three broad classes of common dye molecules that can be used for RAPID lithography.

In earlier work, Fourkas and his team used a beam of ultrafast pulses for the excitation step and a continuous laser for deactivation. However, they say that in some of their newly reported materials, deactivation is so efficient that the ultrafast pulses of the excitation beam also deactivate molecules. This phenomenon leads to the surprising result that higher exposures can lead to smaller features, leading to what the researchers call a proportional velocity (PROVE) dependence.

"PROVE behaviour is a simple way to identify photoinitiators that can be deactivated efficiently," says Fourkas, "which is an important step towards being able to use RAPID in an industrial setting."

By combining a PROVE photoinitiator with a photoinitiator that has a conventional exposure dependence, Fourkas and co-workers were also able to demonstrate a photoresist for which the resolution was independent of the exposure over a broad range of exposure times.

"Imagine a photographic film that always gives the right exposure no matter what shutter speed is used," says Fourkas. "You could take perfect pictures every time. By the same token, these new photoresists are extremely fault-tolerant, allowing us to create the exact lithographic pattern we want time after time."

According to Fourkas, he and his team have more research to do before thinking about trying to commercialise their new RAPID technology. "Right now we're using the technique for point-by-point lithography. We need to get it to the stage where we can operate on an entire silicon wafer, which will require more advances in chemistry, materials and optics. If we can make these advances — and we're working hard on it — then we will think about commercialisation."

Another factor in time to application, he explained, is that his team's approach is not a R & D direction that chip manufacturers had been looking at before now. As a result, commercial use of the RAPID approach is probably at least ten years down the road, he said.

Multiphoton photoresists giving nanoscale resolution that is inversely dependent on exposure time was authored by Michael P. Stocker, Linjie Li, Ravael R. Gattass and John T. Fourkas.

The authors acknowledge the support of the Maryland NanoCenter and its NispLab. The NispLab is supported in part by the National Science Foundation (NSF) as a Materials Research Science and Engineering Center (MRSEC) Shared Experimental Facility. This work was supported in part by the UMD-NSF-MRSEC.

(Source: Science Daily Online)

Gestures Provide a Helping Hand in Problem Solving

Talking with your hands can trigger mental images that help to solve complex problems related to spatial visualisation, an important skill for both students and professionals, according to new research published by the American Psychological Association.

Spatial visualisation is the ability to mentally rotate or move an object to a different position or view. An air traffic controller uses spatial visualisation to mentally track planes in the air-based only on a two-dimensional radar screen. An interior decorator needs spatial visualisation to picture how a living room will look with a sofa in different positions without actually moving the sofa.

"Hand gestures are spontaneous and don't need to be taught, but they can improve spatial visualisation," said psychologist Mingyuan Chu, Ph.D., who conducted the research with psychologist Sotaro Kita, Ph.D., at the University of Birmingham in England. "From Galileo and Einstein to daVinci and Picasso, influential scientific discoveries and artistic masterpieces might never have been achieved without extraordinary spatial visualisation skills."

The research findings appear in the February issue of the Journal of Experimental Psychology: General. Three studies examined the relationship between hand gestures and spatial visualisation using various mental rotation tests:

- In the first experiment, 132 students at the University of Birmingham were tested individually. Using a hidden camera, researchers recorded the number of hand gestures and found that spontaneous gestures increased as the problems became more difficult.
- A second experiment divided 66 students into three groups. One group was encouraged to use gestures, the second was given no instructions, and the third had to sit on their hands to prevent any gestures. The gesture-encouraged group performed significantly better on the tests than the other groups and also fared better on later tests where all of the participants had to sit on their hands, showing that the benefits of gestures may become internalised.

In a final experiment with 32 students, a gesture-encouraged group performed better on several tests, which demonstrated that gestures may help solve a range of spatial visualisation problems.

Hand gestures may improve spatial visualisation by helping a person keep track of an object in the mind as it is rotated to a new position. Since our hands are used so much in daily life to manipulate objects, gestures may also provide additional feedback and visual cues by simulating how an object would move if the hand were holding it, said Chu, who now works as a research fellow at the Max Planck Institute for Psycholinguistics in The Netherlands.

Spatial visualisation is important in many scientific fields, including mathematics, physics and engineering. It also helps in any occupation that requires the use of images or diagrams. The research should have practical implications for education, according to Chu and Kita.

Students in a physics class could be encouraged to use hand gestures to help and understand invisible forces such as magnetic fields. Art students could talk with their hands in a still-life class to picture a bowl of fruit or a nude model from a different angle to create a more vivid painting that creates the illusion of three dimensions on a flat canvas.

(Source: Science Daily Online)

New Transistors: An Alternative to Silicon and better than Graphene

Smaller and more energy-efficient electronic chips could be made by using molybdenite. In an article appearing online on 30 January in the journal Nature Nanotechnology, EPFL's Laboratory of Nanoscale Electronics and Structures (LANES) publishes a study showing that this material has distinct advantages over traditional silicon or graphene for use in electronics applications.

A discovery made at EPFL could play an important role in electronics, allowing us to make transistors that are smaller and more energy-efficient. Research carried out in the Laboratory of Nanoscale Electronics and Structures (LANES) has revealed that molybdenite, or MoS_2, is a very effective semiconductor. This mineral, which is abundant in nature, is often used as an element in steel alloys or as an additive in lubricants. But it had not yet been extensively studied for use in electronics.

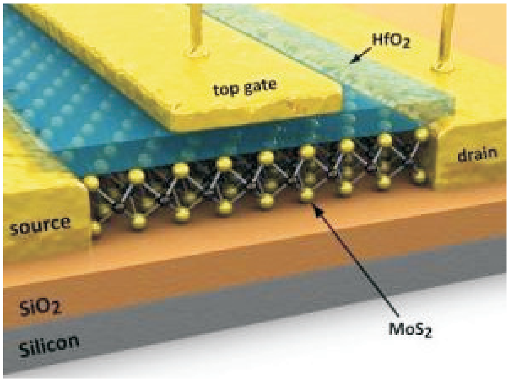
100,000 times less energy

"It's a two-dimensional material, very thin and easy to use in nanotechnology. It has real potential in the fabrication of very small transistors, Light-Emitting Diodes (LEDs) and solar cells," says EPFL Professor Andras Kis, whose LANES colleagues M. Radisavljevic, Professor Radenovic et M. Brivio worked with him on the study. He compares its advantages with two other materials: silicon, currently the primary component used in electronic and computer chips, and graphene, whose discovery in 2004 earned University of Manchester physicists André Geim and Konstantin Novoselov the 2010 Nobel Prize in Physics.

One of molybdenite's advantages is that it is less voluminous than silicon, which is a three-dimensional material. "In a 0.65-nanometre-thick sheet of MoS_2, the electrons can move around as easily as in a 2-nanometre-thick sheet of silicon," explains Kis. "But it's not currently possible to fabricate a sheet of silicon as thin as a monolayer sheet of MoS_2." Another advantage of molybdenite is that it can be used to make transistors that consume 100,000 times less energy in standby state than traditional silicon transistors. A semiconductor with a "gap" must be used to turn a transistor on and off, and molybdenite's 1.8 electron-volt gap is ideal for this purpose.

Better than graphene

In solid-state physics, band theory is a way of representing the energy of electrons in a given material. In semiconductors, electron-free spaces exist between these bands, the so-called "band gaps." If the gap is not too small or too large, certain electrons can hop across the gap. It thus offers a greater level of control over the electrical behaviour of the material, which can be turned on and off easily.



This is a digital model showing how molybdenite can be integrated into a transistor. (Credit: EPFL)

The existence of this gap in molybdenite also gives it an advantage over graphene. Considered today by many scientists as the electronic material of the future, the "semi-metal" graphene doesn't have a gap, and it is very difficult to artificially reproduce one in the material.

(Source: Science Daily Online)

A Clearer Picture of how Rivers and Deltas Develop

By adding information about the subsoil to an existing sedimentation and erosion model, researchers at Delft University of Technology (TU Delft, The Netherlands) have obtained a clearer picture of how rivers and deltas develop over time. A better understanding of the interaction between the subsoil and flow processes in a river-delta system can play a key role not only in civil engineering (delta management), but also in geology (especially in the work of reservoir geologists).
Nathanaël Geleynse et al. recently published in the journals Geophysical Research Letters and Earth and Planetary Science Letters.

Model

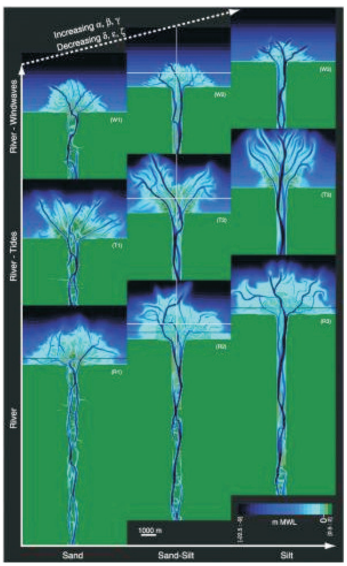
Many factors are involved in how a river behaves and the creation of a river delta. Firstly, of course, there is the river itself. What kind of material does it transport to the delta? Does this material consist of small particles (clay) or larger particles (sand)? But other important factors include the extent of the tidal differences at the coast and the height of the waves whipped-up by the wind. In this study, researchers at TU Delft are working together with Deltares and making use of the institute's computer models (Delft3D software). These models already take a large number of variables into account. Geleynse *et al* have now supplemented them with information on the subsoil. It transpires that this variable also exerts a significant influence on how the river behaves and the closely related process of delta formation.

Room for the River

The extra dimension that Geleynse *et al.* have added to the model is important to delta management, among other things. If — as the Delta Commission recommends — we should be creating "Room for the River," it is important to know what a river will do with that space. Nathanaël Geleynse explains: "Existing data do not enable us to give readymade answers to specific management questions ... nature is not so easily tamed ... but they do offer plausible explanations for the patterns and shapes we see on the surface. The flow system carries the signature of the subsoil, something we were relatively unaware of until now. Our model provides ample scope for further development and for studying various scenarios in the current structure."

Geological information

River management is all about short-term and possible future scenarios. But the model developed by Geleynse *et al.* also offers greater insight into how a river/delta has developed over thousands of years. What might the subsoil have looked like and — a key factor for the oil industry — where might you expect to find oil reserves and what might their geometrical characteristics be? In combination with data from a limited number of core samples and other local measurements, the model can give a more detailed picture of the area in question than was possible until now. The link between the creation of the delta and the structure of the delta subsoil is also of interest to engineers who wish to build there. Hundreds of millions of people across the globe live in deltas and these urban deltas are only expected to grow in the decades to come.



Mapped results from the model for various types of sediment in the subsoil and for various types of water movement, for a given point in time. (Credit: Image courtesy of Delft University of Technology)

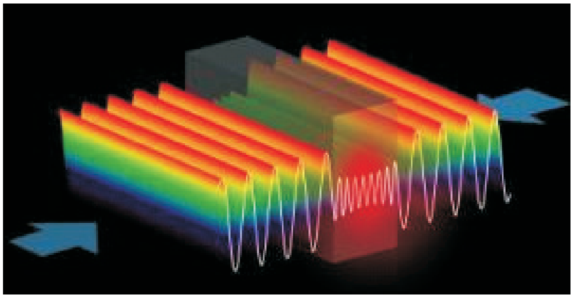
(Source: Science Daily Online)

World's First Anti-Laser Built

More than 50 years after the invention of the laser, scientists at Yale University have built the world's first anti-laser, in which incoming beams of light interfere with one another in such a way as to perfectly cancel each other out. The discovery could pave the way for a number of novel technologies with applications in everything from optical computing to radiology.

Conventional lasers, which were first invented in 1960, use a so-called "gain medium," usually a semiconductor like gallium arsenide, to produce a focussed beam of coherent light — light waves with the same frequency and amplitude that are in step with one another.

Last summer, Yale physicist A. Douglas Stone and his team published a study explaining the theory behind an anti-laser, demonstrating that such a device could be built using silicon, the most common semiconductor material. But it wasn't until now, after joining forces with the experimental group of his colleague Hui Cao, that the team actually built a functioning anti-laser, which they call a coherent perfect absorber (CPA).


In the anti-laser, incoming light waves are trapped in a cavity where they bounce back-and-forth until they are eventually absorbed. Their energy is dissipated as heat (Credit: Yidong Chong/Yale University)

The team, whose results appear in the 18 February issue of the journal *Science*, focussed two laser beams with a specific frequency into a cavity containing a silicon wafer that acted as a "loss medium." The wafer aligned the light waves in such a way that they became perfectly trapped, bouncing back-and-forth indefinitely until they were eventually absorbed and transformed into heat.

Stone believes that CPAs could one day be used as optical switches, detectors and other components in the next generation of computers, called optical computers, which will be powered by light in addition to electrons. Another application might be in radiology, where Stone said the principle of the CPA could be employed to target electromagnetic radiation to a small region within normally opaque human tissue, either for therapeutic or imaging purposes.

Theoretically, the CPA should be able to absorb 99.999 per cent of the incoming light. Due to experimental limitations, the team's current CPA absorbs 99.4 per cent. "But the CPA we built is just a proof of concept," Stone said. "I'm confident we will start to approach the theoretical limit as we build more sophisticated CPAs." Similarly, the team's first CPA is about one centimetre across at the moment, but Stone said that computer simulations have shown how to build one as small as six microns (about one-twentieth the width of an average human hair).

The team that built the CPA, led by Cao and another Yale physicist, Wenjie Wan, demonstrated the effect for near-infrared radiation, which is slightly "redder" than the eye can see and which is the frequency of light that the device naturally absorbs when ordinary silicon is used. But the team expects that, with some tinkering of the cavity and loss medium in future versions, the CPA will be able to absorb visible light as well as the specific infrared frequencies used in fiber optic communications.

It was while explaining the complex physics behind lasers to a visiting professor that Stone first came up with the idea of an anti-laser. When he suggested his colleague to think about a laser working in reverse in order to help him understand how a conventional laser works. Stone began contemplating whether it was possible to actually build a laser that would work backwards, absorbing light at specific frequencies rather than emitting it.

"It went from being a useful thought experiment to having me wondering whether you could really do that," Stone said. "After some research, we found that several physicists had hinted at the concept in books and scientific papers, but no one had ever developed the idea."

(Source: Science Daily Online)

The Green Machine: Algae Clean Wastewater, Convert to Biodiesel

Let algae do the dirty work

Researchers at Rochester Institute of Technology are developing biodiesel from microalgae grown in wastewater. The project is doubly "green" because algae consume nitrates and phosphates and reduce bacteria and toxins in the water. The end result is clean wastewater and stock for a promising biofuel.

The purified wastewater can be channeled back into receiving bodies of water at treatment plants, while the biodiesel can fuel buses, construction vehicles and farm equipment. Algae could replace diesel's telltale black puffs of exhaust with cleaner emissions low in the sulfur and particulates that accompany fossil fuels.

Algae have a lot of advantages. They are cheaper and faster to grow than corn, which requires nutrient-rich soil, fertiliser and insecticide. Factor in the fuel used to harvest and transport corn and ethanol starts to look complicated.

In contrast, algae are much simpler organisms. They use photosynthesis to convert sunlight into energy. They need only water — ponds or tanks to grow in — sunlight and carbon dioxide.

"Algae — as a renewable feedstock — grow a lot quicker than crops of corn or soyabeans," says Eric Lannan, who is working on his master's degree in mechanical engineering at RIT. "We can start a new batch of algae about every seven days. It's a more continuous source that could offset 50 per cent of our total gas use for equipment that uses diesel."

Cold weather is an issue for biodiesel fuels

"The one big drawback is that biodiesel does freeze at a higher temperature," says Jeff Lodge, associate professor of biological sciences at RIT. "It doesn't matter what kind of diesel fuel you have, if it gets too cold, the engine will not start. It gels up. It's possible to blend various types of biodiesel — algae derived with soyabeans or some other type — to generate a biodiesel with a more favourable pour point that flows easily."

Lannan's graduate research in biofuels led him to Lodge's biology lab. With the help of chemistry major Emily Young, they isolated and extracted valuable fats or lipids, algae produce and yielded tiny amounts of a golden-coloured biodiesel. They are growing the alga strain Scenedesmus, a single-cell organism, using wastewater from the Frank E. Van Lare Wastewater Treatment Plant in Irondequoit, N.Y.

"It's key to what we're doing here," Lodge says. "Algae will take out all the ammonia — 99 per cent — 88 per cent of the nitrate and 11 per cent of the phosphate from the wastewater — all those nutrients you worry about dumping into the receiving water. In three to five days, pathogens are gone. We've got data to show that the coliform counts are dramatically reduced below the level that's allowed to go out into Lake Ontario."

Assemblyman Joseph Morelle, whose district includes Irondequoit, applauds RIT's initiative. "Innovations developed at great academic institutions such as RIT will be key to solving many of the challenges we face, from revitalising the upstate economy to the creation of clean, renewable energy sources for the future. Professor Lodge and Eric Lannan's research bridges the gap between cost efficiency and environmental conservation and is a perfect example of how old problems can yield to new and creative solutions."

Lodge and Lannan ramped up their algae production from 30 gallons of wastewater in a lab at RIT to 100 gallons in a 4-foot-by-7-foot long tank at Environmental Energy Technologies, an RIT spinoff. Lannan's graduate thesis advisor Ali Ogut, Professor of Mechanical Engineering, is the company's president and CTO. In the spring, the researchers will build a mobile greenhouse at the Irondequoit Wastewater Treatment Plant and scale up production to as much as 1,000 gallons of wastewater.

Northern Biodiesel, located in Wayne County, will purify the lipids from the algae and convert them into biodiesel for the RIT researchers.

(Source: Science Daily Online)

'Periodic Table of Shapes' to Give a New Dimension to Mathematics

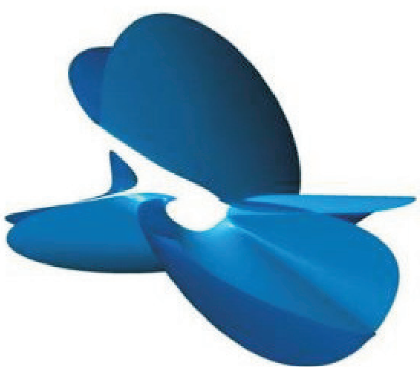
Mathematicians are creating their own version of the periodic table that will provide a vast directory of all the possible shapes in the universe across three, four and five dimensions, linking shapes together in the same way as the periodic table links groups of chemical elements.

The three-year project should provide a resource that mathematicians, physicists and other scientists can use for calculations and research in a range of areas, including computer vision, number theory and theoretical physics.

The researchers from Imperial College, London and institutions in Australia, Japan and Russia, are aiming to identify all the shapes across three, four and five dimensions that cannot be divided into other shapes.

As these building block shapes are revealed, the mathematicians will work out the equations that describe each shape and through this, they expect to develop a better understanding of the shapes' geometric properties and how different shapes are related to one another.

The work is funded by the Engineering and Physical Sciences Research Council, the Leverhulme Trust, the Royal Society and the European Research Council.



Sample shape: this one shows a slice of the cubic threefold (Credit: Imperial College, London)

Project leader, Professor Alessio Corti, from the Department of Mathematics at Imperial College, London, explained, "The periodic table is one of the most important tools in chemistry. It lists the atoms from which everything else is made, and explains their chemical properties. Our work aims to do the same thing for three, four and five-dimensional shapes — to create a directory that lists all the geometric building blocks and breaks down each one's properties using relatively simple equations. We think we may find vast numbers of these shapes, so you probably won't be able to stick our table on your wall, but we expect it to be a very useful tool."

The scientists will be analysing shapes that involve dimensions that cannot be seen in a conventional sense in the physical world. In addition to the three dimensions of length, width and depth found in a three-dimensional shape, the scientists will explore shapes that involve other dimensions, e.g. the space-time described by Einstein's Theory of Relativity has four dimensions — the three spatial dimensions, plus time. String theorists believe that the universe is made up of many additional hidden dimensions that cannot be seen.

Professor Corti's colleague on the project, Dr Tom Coates, has created a computer modelling programme that should enable the researchers to pinpoint the basic building blocks for these multi-dimensional shapes from a pool of hundreds of millions of shapes. The researchers will be using this programme to identify shapes that can be defined by algebraic equations and that cannot be divided any further. They do not yet know how many such shapes there might be. The researchers calculate that there are around 500 million shapes that can be defined algebraically in four dimensions and they anticipate that they will find a few thousand building blocks from which all these shapes are made.

Dr Coates, from the Department of Mathematics at Imperial College, London, added, "Most people are familiar with the idea of three-dimensional shapes, but for those who don't work in our field, it might be hard to get your head around the idea of shapes in four and five-dimensions. However, understanding these kinds of shapes is really important for lots of aspects of science. If you are working in robotics, you might need to work out the equation for a five dimensional shape in order to figure out how to instruct a robot to look at an object and then move its arm to pick that object up. If you are a physicist, you might need to analyse the shapes of hidden dimensions in the universe in order to understand how sub-atomic particles work. We think the work that we're doing in our new project will ultimately help our colleagues in many different branches of science.

"In our project we are looking for the basic building blocks of shapes. You can think of these basic building blocks as 'atoms', and think of larger shapes as 'molecules.' The next challenge is to understand how properties of the larger shapes depend on the 'atoms' that they are made from. In other words, we want to build a theory of chemistry for shapes," added Dr Coates.

Dr Coates has recently won a prestigious Philip Leverhulme Prize worth £ 70,000 from the Leverhulme Trust, providing some of the funding for this project. Philip Leverhulme prizes are awarded to outstanding scholars under the age of 36 who have made a substantial contribution to their particular field of study, recognised at an international level, and where the expectation is that their greatest achievement is yet to come.

(Source: Science Daily Online)

Nanotechnology may Lead to New Treatment of Liver Cancer

Nanotechnology may open a new door on the treatment of liver cancer, according to a team of Penn State College of Medicine researchers. They used molecular-sized bubbles filled with chemotherapy drugs to prevent cell growth and initiate cell death in test tubes and mice.

Researchers evaluated the use of molecular-sized bubbles filled with C6-ceramide, called cerasomes, as an anticancer agent. Ceramide is a lipid molecule naturally present in the cell's plasma membrane and controls cell functions, including cell aging or senescence.

Hepatocellular carcinoma is the fifth most common cancer in the world and is highly aggressive. The chance of surviving five years is less than five per cent, and treatment is typically chemotherapy and surgical management including transplantation.

"The beauty of ceramide is that, it is non-toxic to normal cells, putting them to sleep, while selectively killing cancer cells," said Mark Kester, Ph.D., G. Thomas Passananti, Professor of Pharmacology.

Cerasomes, developed at Penn State College of Medicine, can target cancer cells very specifically and accurately, rather than affecting a larger area that includes healthy cells. The problem with ceramide is that as a lipid, it cannot be delivered effectively as a drug. To solve this limitation, the researchers use nanotechnology, creating the tiny cerasome, to turn the insoluble lipid into a soluble treatment.

"Cerasomes were designed as a therapeutic alternative to common chemotherapeutics," said Kester. "These have been shown to be toxic to cancer cells and not to normal cells, and have already been shown to effectively treat cellular and animal models of breast cancer and melanoma. Cerasomes have also been shown to be essentially free of toxic side-effects normally associated with anticancer agents."

In the test tube and animal models of liver cancer, cerasomes, but not a placebo, selectively induced cell death in the cancer cells.

In mice with liver cancer, cerasomes blocked tumor vascularisation, the forming of blood vessels needed for growth and nutrition. Studies show that lack of nutrition causes cells to create more ceramide and leads to cell death.

"It is plausible that preventing liver tumor vascularisation with cerasome treatment could induce widespread apoptosis, a genetically programme series of events that leads to cell death in tumors," Kester said. "The efficacy of our cerasomes in the treatment of diverse cancers lends significant therapeutic promise as it translates from bench to bedside."

The researchers published their work in the journal *Gut*. A Penn State Dean's Feasibility Grant, Pennsylvania tobacco settlement funds, and the National Institutes of Health supported this work.

In an earlier study published in the journal *Blood*, researchers observed that cerasome use led to complete remission in aggressive, large granular lymphocytic leukemia in rats. In addition, the protein survivin, which prevents cell death, is heavily produced in NK-leukemia cells, but not in normal cells. Cerasome decreased expression of survivin and may lead to a therapeutic approach for fatal leukemia.

Other researchers are Hephzibah Rani S. Tagaram, M.D., Diego Avella, M.D, Eric. T. Kimchi, M.D., Kevin F. Stavely O'Carroll, M.D., Department of Surgery; Nicole A. DiVittore, Brian M. Barth, Ph.D., and James M. Kaiser, Department of Pharmacology; Yixing Jiang, M.D., Ph.D., Department of Medicine; and Harriet C. Isom, Ph.D., Department of Microbiology and Immunology.

(Source: Science Daily Online)

The more Secure you Feel, the less you Value your Stuff

People who feel more secure in receiving love and acceptance from others place less monetary value on their possessions, according to new research from the University of New Hampshire.

The research was conducted by Edward Lemay, Assistant Professor of Psychology at UNH, and colleagues at Yale University. The research is published in the *Journal of Experimental Social Psychology*.

Lemay and his colleagues found that people who had heightened feelings of interpersonal security — a sense of being loved and accepted by others — placed a lower monetary value on their possession than people who did not.

In their experiments, the researchers measured how much people valued specific items, such as a blanket and a pen. In some instances, people who did not feel secure placed a value on an item that was five times greater than the value placed on the same item by more secure people.

"People value possessions, in part, because they afford a sense of protection, insurance and comfort," Lemay says. "But what we found was that if people already have a feeling of being loved and accepted by others, which also can provide a sense of protection, insurance and comfort, those possessions decrease in value."

The researchers theorise that the study results could be used to help people with hoarding disorders.

"These findings seem particularly relevant to understanding why people may hang onto goods that are no longer useful. They may also be relevant to understand why family members often fight over items from estates that they feel are rightfully theirs and to which they are already attached. Inherited items may be especially valued because the associated death threatens a person's sense of personal security," Lemay says.

The research was conducted by Lemay; Margaret Clark, Aaron Greenberg, Emily Hill and David Roosth, all from Yale University and Elizabeth Clark-Polner from Université de Genève, Switzerland.

(Source: Science Daily Online)

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.

- **International Year of Chemistry 2011**
  http://www.chemistry2011.org

  The year 2011 is being celebrated as International Year of Chemistry (IYC–2011) to highlight the achievements of chemistry and its contributions to the well-being of humankind. The theme of the celebration is "Chemistry—our life, our future," it will offer a range of interactive, entertaining and educational activities for all ages. The IYC–2011 is an initiative of the International Union of Pure and Applied Chemistry (IUPAC) and the United Nations Educational, Scientific and Cultural Organisation (UNESCO). It also involves chemical societies, academies, and institutions worldwide, and relies on individual initiatives to organise local and regional activities.

  This site offers information about different types of activities of IYC–2011.

- **Green Chemistry**
  www.epa.gov/gcc

  It introduces the concept of Green Chemistry, also known as sustainable chemistry; provides resources for Green Chemistry education and related links.

- **Green Chemistry Network**
  http://globalwarming.com

  The Green Chemistry Network (GCN) aims to promote awareness and facilitate education, training and practice of Green Chemistry in industry, commerce, government, academia and schools. It was initially launched in 1998 with funding from the Royal Society of Chemistry, U.K. and is now funded on a project-by-project basis.
  The website provides link to educational resources, institutes and organisations and journals in this field.

- **Problem-based Learning**
  http://en.wikipedia.org/wiki/Problem-based_learning

  "**Problem-based Learning** (PBL) is a student-centred pedagogy in which students learn about a subject in the context of complex, multifaceted and realistic problems". This site talks about the concept of PBL, research evidences which supports this approach, cognitive effects of PBL and constructivism and PBL. It also details criticism of PBL.

Compiled and Edited by

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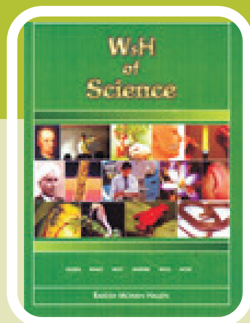
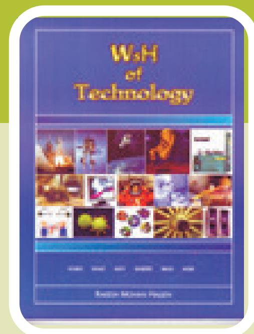
Book Review





Title	**1. W_5H of Science**
	2. W_5H of Technology
Author	**Rakesh Mohan Hallen**
Publisher	**Vigyan Prasar**
	A-50, Institutional Area
	Sector 62, Noida 20107
No. of Pages	**176 and 184**
Price	**₹ 200 each**

The body of knowledge called science is based on certain well-tested principles and technology is nothing but application of these principles in the development of machines, gadgets, etc. for human benefit. Thus, in simple terms, technology is 'science in action'.

Children and students are generally very curious and they have many questions about matters concerning science and technology. These questions often centre around When, What, Why, Where, Who, and How? Of course, there are textbooks which a curious child can always go through. But, textbooks explain things in a manner which is highly technical and hence not easily comprehensible to children. Moreover, many new terms relating to science and technology are frequently used in media. One may, for instance, encounter terms like spam, blog, simputer, GM food, tofu, etc. These days, a lot of reference to trans fats is being made both in electronic and print media.

The two volumes under review have been specially prepared with the objective of presenting the facts in easily comprehensible style. The author has included topics on subjects generally not covered in the conventional books. Over 350 questions on different facets of science and technology are covered in the two volumes.

The first volume W_5H of Science is divided into ten broad topics. The title of some of the topics are: 'About Planets and Animals'; 'About our Body'; 'About Food and Health'; 'About the Sky and the Universe'; 'About Electricity'; 'About Light and Colour' and 'About Sound'. Some of the interesting questions included in this volume are: Do plants excrete? Do ants have any blood? How large is an elephants's heart? Why do we feel itchy? Why do we have two eyes? What is a "funny bone" of our body? What is the evening star? Does the Moon rotate? What are fats? What are GM foods? What is tofu? Can snakes hear? Can we hear sound in outer space? How does water rise up in plants? Why is our blood red?

The second volume W_5H of technology is divided into six broad topics: About 'Inventions'; 'Technology for Communicating Information';

'About Softwares'; 'Technology for Health Care'; 'About Space Exploration', and 'Other Miscellaneous Technologies'.

In the modern IT age, one often hears or reads many technical terms like pen drive, simputer, bluetooth technology, laser printer, inkjet printer, gateway, LAN, web camera, blog, etc. The book discusses these terms in question-answer format.

Another term which is very poorly understood is what is called 'placebo effect' in medicine. In fact, a placebo may be plain or distilled water or just sugar pill which a doctor may give to a patient without her/his knowledge. Even so, the patient may be cured of the disease her/his is suffering from due to her/his belief or faith in the drug.

There is a general misconception about bacteria and viruses which are prevalent among the common masses. The genetic material DNA is now a commonplace term. While the DNA can replicate, i.e., make copies of itself, it is not possible for DNA to directly build a protein which is so essential for carrying out the activities of the cell. The protein-making function is, in fact, performed by the RNA. A class of virus, called retrovirus, has RNA instead of DNA in its core.

Although viruses have been properly explained, bacteria and RNA have not been included as separate questions in the book which obviously leaves some gap.

While dealing with fats although the author has discussed saturated as well as mono and poly-unsaturated fats, he has not included a word about partially hydrogenated fats, also called trans fats. Also, while discussing the colour of blood, it needs to be mentioned that although the colour of the blood of most animals is red, some animals may have blue or green blood.

After India's successful *Chandrayaan*-1 mission, a lot of interest has been generated to know more about Moon. In this scenario, the question 'Does the Moon rotate?' will be read with great interest by the readers. It is due to the rotation period of the Moon about its axis being equal to the period of its revolution around the Earth that we are able to see only one hemisphere of the Moon. However, the orbital velocity of the Moon around the Earth shows slight variation which is known as libration. Thanks to these librations, we are able to see 59 per cent of the lunar surface. The remaining 41 per cent of the lunar surface is never visible from the Earth.

Incidentally, some of the questions listed in the contents do not find inclusion in the text. For example, in the first volume on science, the question 'What is an electric motor; who invented it?' (About electricity) is missing from the text. Similary, the question 'What is a vegetarian egg?' (about food and health) is not answered in the text. There may be many more instances of this kind.

Also, some of the questions not listed in the contents appear in the text, e.g., the question 'Can plants eat animals?' (About food and health), although not listed in the contents is answered in the text. Many more examples may be provided.

Nonetheless, on the whole, the two volumes will prove to be treasure-trove of knowledge for students who will find them very informative and useful. Both school and college libraries can order for these books to serve as ready reference for students.

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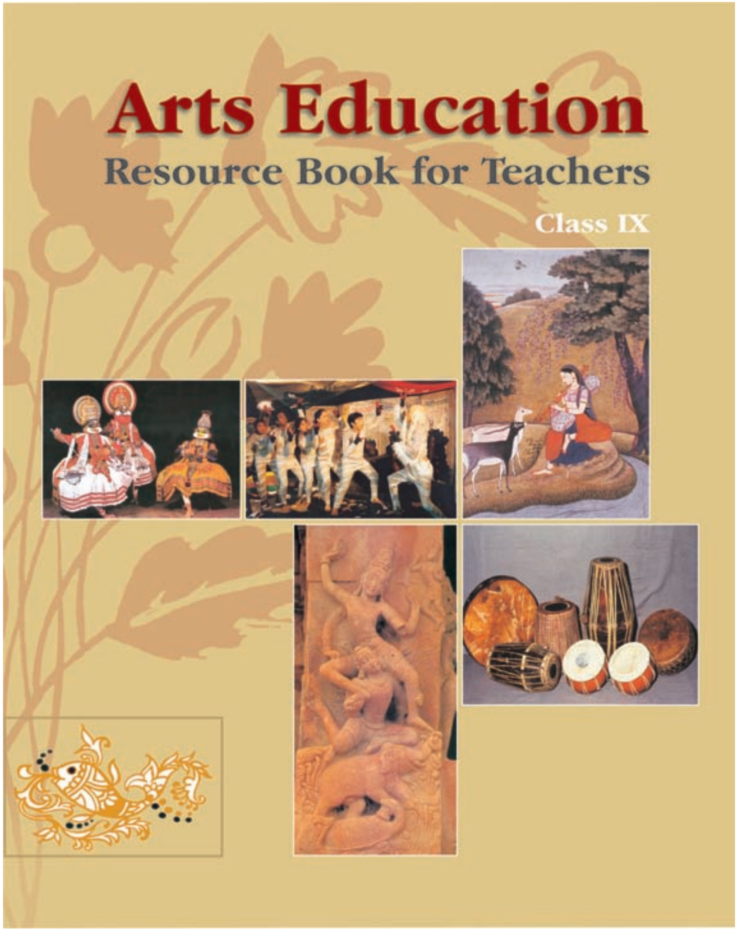
To Our Contributors

School Science is a journal published quarterly by the National Council of Educational Research and Training, New Delhi. It aims at bringing within easy reach of teachers and students the recent developments in science and mathametics and their teaching, and serves as a useful forum for the exchange of readers' views and experiences in science and mathametics education and science projects.

Articles suitable to the objectives mentioned above are invited for publication. An article sent for publication should normally not exceed ten typed pages and it should be exclusive to this journal. A hard copy of the article including illustrations, if any, along with a soft copy should be submitted in CD. Photographs (if not digital) should be at least of postcard size on glossy paper and should be properly packed to avoid damage in transit. The publisher will not take any responsibility or liability for copy right infringement. The contributors, therefore, should provide copy right permission, wherever applicable, and submit the same along with the article.

Manuscripts with illustrations, charts, graphs, etc., along with legends, neatly typed in double space on uniform sized paper, should be sent to Executive Editor, School Science, Department of Education in Science and Mathematics, NCERT, Sri Aurobindo Marg, New Delhi 110 016 or email at **school.science@yahoo.co.in**



Art Education

Resource Book for Teachers

Rs. 225.00/Paperback/166 pp

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