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# SCHOOL SCIENCE

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## Contents


# EDITORIAL

The decade (2011-2020) is being celebrated as the International Decade of Biodiversity. In order to present the different issues and concerns related to Biodiversity, we reproduce an article by Thomas-Lovejoil, who is known for coining the term, "Biological Diversity" in 1980 and concept of debt-for-nature-swaps, conceived during his tenure as Director of the World Wildlife Fund's Conservation Programme (1973-1987). The article shows the variety of life forms which we have been sharing for the last four billion years.

This issue also includes Part II and Part III of the series of articles on "Problem Based Learning in Basic Physics", that we started in September 2011. These articles provide the necessary pedagogical processes involved in solving different types of problems. Students and teachers can also learn about design of a problem from these articles.

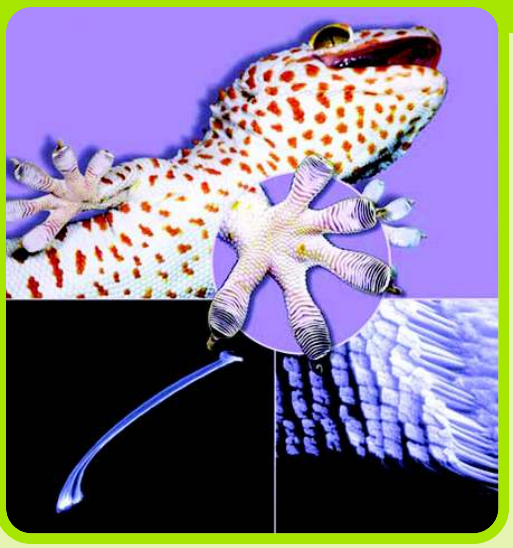
In addition we have articles on Nano Science, Hydroelectric Power and Nature of Science.

We hope that our readers will find the articles, features, and news items, interesting and educative. Your valuable suggestions are welcome.

# WHAT FUTURE FOR BIODIVERSITY *

**Thomas Lovejoy**
Former Director
World Wildlife Fund's Conservation Programme

As UNESCO prepares to publish the proceedings of the scientific meeting which launched the International Year of Biodiversity in January 2010, we take a moment to recall some of the major challenges facing Biodiversity, in an article from the proceedings written by a legend in the field of conservation biology, Thomas Lovejoy, the man who coined the term 'Biological Diversity' back in 1980 and to whom we owe the concept of debt-for-nature-swaps, conceived during his time as Director of the World Wildlife Fund's Conservation Programme (1973–1987).



The paws of a gecko have the best-known adhesive. This small reptile can develop a force of contact of over 100 kg. More and more, scientists are looking to biodiversity for inspiration in developing innovative products, in what is known as biomimicry.

## Introduction

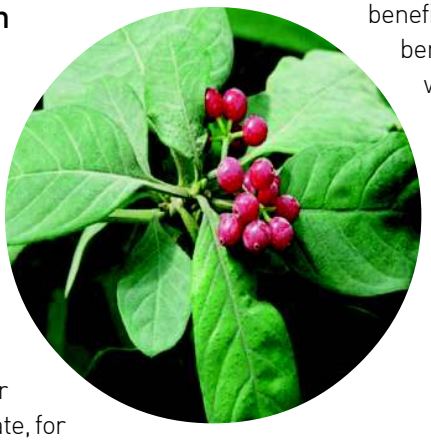
As we embark upon the International Decade of Biodiversity (2011–2020), it is remarkable that we still have such an incomplete overall sense of the variety of life forms with which we share a four billion-year heritage.

Certainly, the outlines of life on Earth have become clearer in recent decades. The two sturdy trunks (plants and animals) of the Tree of Life of my childhood classroom in the 1950s have been replaced in one presentation by something akin to a low spreading bush, with three terminal branches on one side representing plants, fungi and animals. The rest represents a variety of micro-organisms, many deriving from the early history of life. Many have strange appetites and metabolisms that make them potentially useful for industrial purposes and remediation. We now know there are entire biological communities which depend on the primal energy of the Earth (chemosynthesis), rather than on solar energy through photosynthesis, and that organisms live kilometres below the surface of the Earth.

*We do not know the number of species on Earth. There could be ten million, thirty million or one hundred million species.*

* Reproduced from 'A Word of Science', Vol. 10, No. 1, January-March 2012

## The Exploration of Life on Earth: one of the Great Scientific Challenges



This small tree (*Psychotria bacteriophyla*) in *the family of Rubiaceae grows in tropical forests.*

Yet, even the more obvious groups like plants and animals remain only partially explored and described by science. Joppa *et al.*[1] (2011) take a new approach based upon the number of species described per taxonomist per year; they estimate, for example, that about 18 per cent of the Rubiaceae (the family that includes raspberries) remain to be discovered and that, generally for flowering plant families, about 15 per cent remain undescribed. In many cases, this is because the unknowns have small ranges, which means that the number of endangered species per plant family (and in total) is currently underestimated.

Basically, the exploration of life on Earth remains one of the great scientific priorities and challenges: a grand adventure of immense direct and indirect value to society. As US myrmecologist (ant specialist) Edward O. Wilson periodically reminds us, we do not in the end know the number of species on Earth to perhaps even an order of magnitude. There could be ten million, thirty million or one hundred million species, depending on microbial diversity, soil biodiversity and the like.

Clearly, as the 2005 *Millennium Ecosystem Assessment*[2] revealed with greater clarity than understood before, ecosystems and their constituent biodiversity provide multiple human benefits, ranging from direct harvest benefits to flows of benefits like watersheds, pollination and disaster mitigation – such as the protection mangroves offer from storm surges. Most of the benefits are treated as being free and so are undervalued by society.

## The Bushmaster's Venom or the Value of Biodiversity

There is a group of completely unacknowledged services provided by biodiversity: knowledge services. It is useful to think of biological diversity as an enormous library, with each species representing a unique set of solutions to a particular and unique set of biological problems. Humans have a huge stake in flourishing life sciences.

Edward O. Wilson once calculated that the amount of information (as a computer would count) in a single strand of DNA from a chromosome of a species like the domestic mouse was equivalent to the information in all editions of the *Encyclopedia Britannica* combined.

A compelling example of value to the life sciences involves the Bushmaster, a poisonous viper native to the tropical forests of Latin America. Its venom is quite effective and generally ends in death for the prey by driving blood pressure to zero. Scientists at Brazil's Butantan Institute in São Paulo studied the mechanism and uncovered a previously unknown system of blood pressure regulation in mammals,

the angiotensin system. That was interesting but not instantly practical because snake venom taken as an oral medicine is neither poisonous nor practical because the digestive system simply denatures the protein, much as an egg white be comes a solid when cooked. Knowledge of the angiotensin system, however, made it possible for pharmacologists at the Squibb Company to devise a compound to work on it. That was given the brand name Capoten and was the first of the Angiotensin Converting Enzyme (ACE) inhibitors. Today, there are a number of ACE inhibitors and hundreds of millions of people live longer, healthier and more productive lives, oblivious to the benefit conferred by a nasty snake in a far away rainforest.

*Today, hundreds of millions of people live longer, oblivious to the benefit conferred by a nasty snake in a faraway rainforest.*

*Bushmaster snake (Lachesis mutal*

An important footnote to this example is that, in the absence of major pharmaceutical industry research in Brazil at the time, the benefits all flowed to developed country corporations rather than to Butantan. The molecule of the Bushmaster's venom was not the medicine. (Nor does that snake species occur only in Brazil.) Had the venom been usable directly as medicine, there are at least some ways today in which the benefit would flow to Brazilian entities. If Brazilian scientists had teamed with foreign pharmaceutical chemists, the benefit flow would have been shared. The important lesson here is that advances often depend on free sharing of scientific information and that a strong national i industry could have created an opportunity for Brazil to capture benefit nationally more easily.

## Another Example of a Knowledge Service: PCR

In 1993, the American Kary Mullis received the Nobel Prize in Chemistry for conceiving of the Polymerase Chain Reaction (PCR). Known by its acronym of PCR, it is widely included in press stories with almost no reference to what it is or its history. PCR is an extraordinary magnifying reaction that allows tiny amounts of DNA to be multiplied thousands of times over in a very short time. This has revolutionised diagnostic medicine because, in most instances, it is no longer necessary to culture the suspected disease agent until it can be identified. It has revolutionised forensic medicine. It has made all kinds of science dependent on genetic information either possible or more powerful – including the Human Genome Project – with major benefits to humanity. The Indian economist Pavan Sukhdev believes a proper analysis of the benefits from PCR could total a trillion dollars or more.

The reaction has two parts – heat separating the two strands of a chromosome and an enzyme

causing the two separate strands to build their missing partner – repeated over and over again very rapidly. At the time of Kary Mullis's conception, however, there was no known enzyme that could trigger the second part because it had also to be heat-resistant; so, no chain reaction. Eventually, such an enzyme was found in the bacterium *Thermus aquaticus*, recovered from a Yellowstone hot spring in the USA. That was the knowledge service that makes the entire trillion dollar benefit possible.

## Capturing the Value of Biodiversity in Decision-making

Much of the value of the biodiversity library is not captured in the decision-making process; nor, for that matter, does it capture many other contributions of nature. If there is to be a sanguine outlook for the future of biodiversity on our planet, that must change. The Economics of Ecosystems and Biodiversity project[3] addresses that specifically and suggests ways in which a lot of that value can be incorporated in economic decision-making. Led by Pavan Sukhdev, its reports were submitted to the Conference of the Parties to the Convention on Biological Diversity in Nagoya in October 2010.

A classic example is that of whether to clear mangroves to create an opportunity for shrimp aquaculture. In the standard economic analysis, there would be no question about going ahead with the shrimp farm. If, however, the subsidies are subtracted, suddenly the choice would not be clear at all. If, in addition, the benefits the mangroves contribute to fishery productivity were added to the equation, the desirability of leaving the mangroves intact would become abundantly clear. That doesn't even include the protection of coastlines and coastal settlements that mangroves provide.

One of the difficult aspects is the use of discount rates – according to which, the less immediate a benefit, the lower its value – which tend to undervalue benefits to future generations or to the poor, who depend on ecosystems for a significant part of their 'income' (between 39 per cent and 89 per cent of the total, according to studies of specific populations). Another anachronism is that expenditure on disaster relief or medical treatment gets counted in gross domestic product, whereas disaster prevention provided by ecosystems and the benefits of cleaner air or water do not.

I have long been interested in the possible economic analogy to the two forms of biological growth: one whereby the organism simply gets larger and consumes more (such as an alligator) and the other in which the organism does not grow in size, does not consume more but rather grows in complexity [4]. In discussing this with Pavan Sukhdev, I offered the example of a caterpillar becoming a butterfly and the slogan 'an economy like a butterfly' emerged. Perhaps more practical is the notion of moving in that direction from the high consumption growth pattern towards a lower consumption intensity. It would seem wise to do that in a creative fashion before we are left with no choice but to force it upon ourselves.

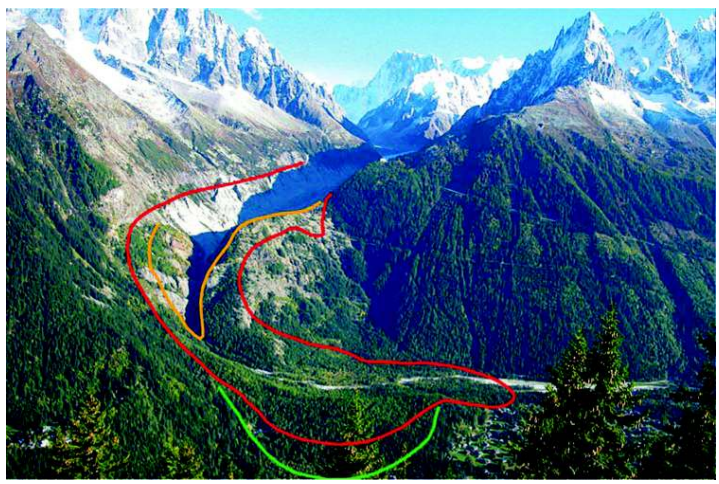
*It would seem wise to move from a high consumption growth pattern towards a lower consumption intensity in a creative fashion before we are left with no choice.*

## Ecosystems have Enjoyed a Stable Climate for 10,000 Years

In 1896, the Swedish scientist Svante Arrhenius addressed an extremely important question: why is the Earth a habitable temperature for humans and other forms of life? Why isn't the Earth too cold? The answer in his famous paper was the greenhouse effect and the heat-trapping capacity of certain gases, most notably carbon dioxide ($CO_2$). It is interesting – in a world that still includes people who deny this venerable and well-tested science – that, with pencil and paper. Arrhenius calculated what the temperature would be for a world with double the pre-industrial levels of $CO_2$. His result came very close to what the modern super-computer models project.

What Arrenhius would not have known was the actual temperature of the planet over the last hundred thousand years and, in particular, that the planet has had a very stable climate for the past 10,000 years. That period includes all recorded human history, plus some unrecorded history, as well as the origins of agriculture and human settlements. In other words, the entire human enterprise is based on the assumption of a stable climate. That is why, in part, people talk so much about the weather. Over that same 10,000-year period, all ecosystems have adjusted to a stable climate. That has begun to change.

Atmospheric concentrations of $CO_2$, which were at 280 parts per million (ppm) in pre-industrial times, are now close to 400 ppm. Despite a brief downturn in emissions because of the global recession, emissions are now climbing faster than the worst-case scenario described in the last report of the Intergovernmental Panel on Climate Change (IPCC, 2007). The planet's climate system is responding with an overall temperature increase of about 0.8°C since 1850.



*The Mer de Glace on Mont Blanc is the longest glacier in France (7 km), even after retreating by 2 km over the past 150 years. In this photograph from 2003, the lines show the area covered by the Mer de Glace in 1644 (green) and 1821 (red), during the Little Ice Age, and in 1895 (orange). Between 1821 and 1895, the glacier* retreated by 1.2 km.

That increase is already causing dramatic, visible changes in physical aspects of nature, most notably between the solid and liquid phases of water. The summer extent of ice on the Arctic Ocean has diminished dramatically in recent years and the first ice-free Arctic Ocean period is projected to be less than 20 years off. Glaciers are retreating in most parts of the world. Soon, the

*Tropical Cyclone Gonu showed up in an unusual place on 4 June 2007. NASA's Aqua satellite captured this image of the cyclone approaching the northeastern shore of Oman, a region better known for hot desert conditions.*

USA's Glacier National Park, a biosphere reserve, will have glaciers only in name. As for France's alpine glacier known as the Mer de Glace, it is the subject of major efforts to slow its melting. All tropical glaciers will be gone in less than 15 years; some, as in Bolivia, are the main source of water for cities, as in the case of, of course have effects on downslope ecosystems.

Sea-level is rising, originally because thermal expansion of water resulting from warmer air temperatures but now because of ice melt, particularly at the poles and in Greenland. The IPCC has consistently underestimated sea-level rise, in part because of its very conservative approach. Sea-level rise, coupled with the natural subsidence of the land, is turning the Blackwater Wildlife Refuge of Maryland's Eastern Shore in the USA into a marine refuge (*see map*). A greater frequency of major storms and intense tropical cyclones is also being experienced around the world.

## Biodiversity is Responding to Climate Change

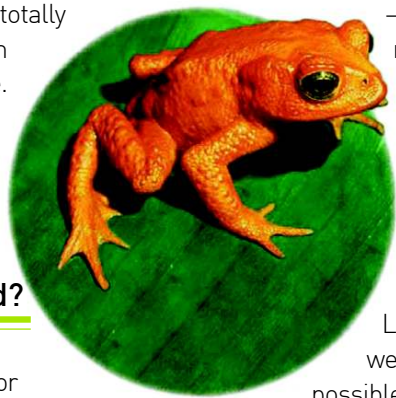
Not surprisingly, the biology of our planet is also responding to climate change. The first signals have been changes in lifecycle timing. Flowering plants are blooming earlier in the spring in the temperate and boreal regions. Animals are changing their annual cycles, with some bird species, such as tree swallows (*Tachycineta bicolor*) in North America, migrating, nesting and laying eggs earlier than before.

Species are also beginning to change the places where they occur. In North America, Edith's Checkerspot (*Euphydryas editha*), an extremely well-studied butterfly species that does normally roam, has clearly moved northward and upslope. Similar shifts have been observed in some other butterfly species. A recent analysis of many cases shows the distributional changes are happening three times faster than previously recognised.

Indeed, it is clear that this is no longer a matter of anecdotal examples; the change and movement in nature is statistically robust.

Virtually everywhere scientists have looked, nature is on the move. It is happening in the oceans with changing plankton and fish distributions. In Chesapeake Bay in the USA, the sea grass habitats so important for blue crabs and other life forms are very sensitive to rising temperatures: the southern boundary of eel grass, a particular type of sea grass, is steadily moving north year after year.

Change is occurring not just in boreal and temperate regions. In Costa Rica's legendary Monteverde cloud forest, change has been detected not so much in temperature but in moisture. Cloud formation is now occurring more frequently at higher altitudes – a very serious change for an ecosystem almost totally dependent on condensation from clouds for its source of moisture. The first terrestrial extinction from climate change may be the Golden Toad of Monteverde ( *Bufo periglenes*).



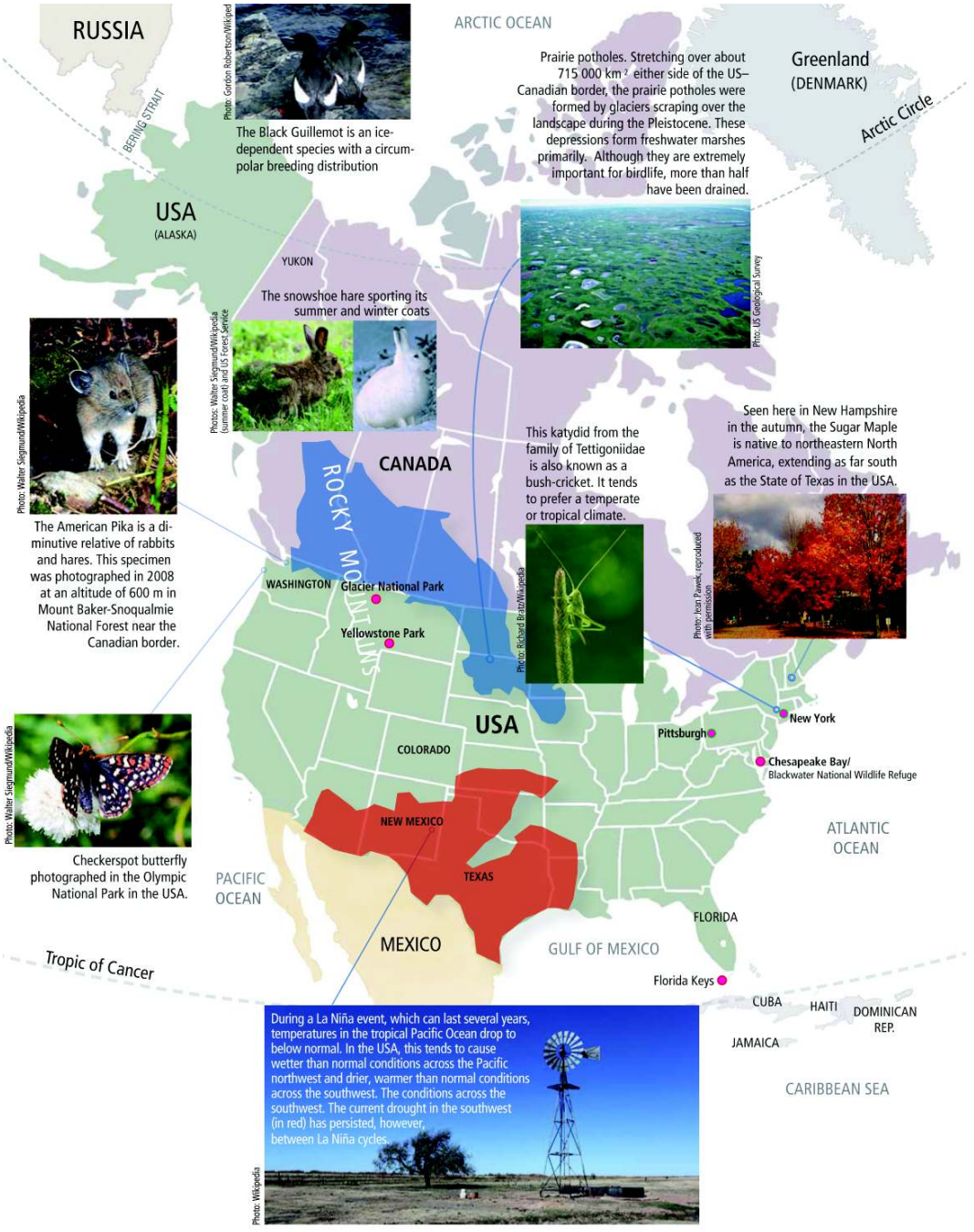
*Endemic to the cloud forests of Monteverde (Costa Rica), this Golden Toad may be the first victim of climate change. The most likely contender for its extinction is an outbreak of a highly pathogenic fungus whose growth was encouraged by climate change.*

## What will the Future Hold?

These changes are relatively minor ripples in the fabric of life on Earth. The more important question is: what does it look like ahead? One thing is clear: change will be not only related to temperature but also to moisture. This is typified by the recurrent drought in the American southwest, which persists despite La Niña cycles, and by drying in the Prairie pothole region in the Midwest – the latter being critical to the great North American flyway for migratory waterfowl (*see map*). Decoupling events are occurring when two linked aspects of nature are responding to different timing mechanisms: daylight versus temperature. While the amount of daylight remains the same, the atmosphere is warming at a faster rate than species can evolve to cope with the consequences. Found only in North America, Snowshoe hare (*Lepus americanus*) are now being caught against a snowless background with their bright white winter pelage – making them totally obvious for predators. Black Guillemots (*Cepphus grille*) nesting on the Arctic Ocean shore of Alaska fly to the edge of the Arctic Ocean ice to feed on Arctic cod. Now, with more of this ice melting in summer than before, they must fly farther on the round trip from their nests – so far, in fact, that at least one nesting colony has failed.

Looking ahead for species with well-understood requirements, it is possible to project where those conditions might occur. For the Sugar Maple (*Acer saccharum*), so well known for its autumn foliage (see photo), as well as for maple syrup and sugar, its home will be in Canada once $CO_2$ levels climb to twice that of the pre-industrial area. In fresh waters, cold water species like trout will certainly have their ranges changed, if not reduced or even eliminated.

Species which live at high altitudes, like the American Pika (*Ochotona princeps*), isolated populations of which can be found at high points in the Rocky Mountains, will move upward like the Checkerspot until, finally, there is no further up to go. A projection for endemic vertebrates in the rainforests of Eastern Australia shows a major loss of species with a warming climate; some of the species seem very sensitive to warmer temperatures physiologically.


RUSSIA
BERING STRAIT
ARCTIC OCEAN
Greenland
(DENMARK)
Arctic Circle
USA
(ALASKA)
YUKON
CANADA
ROCKY MOUNTAINS
WASHINGTON
Glacier National Park
Yellowstone Park
USA
COLORADO
NEW MEXICO
TEXAS
MEXICO
Pittsburgh
New York
Chesapeake Bay/
Blackwater National Wildlife Refuge
ATLANTIC
OCEAN
PACIFIC
OCEAN
FLORIDA
GULF OF MEXICO
Florida Keys
CUBA
HAITI
DOMINICAN
REP.
JAMAICA
CARIBBEAN SEA
Tropic of Cancer
Photo: Gordon Robertson/Wikipedia
The Black Guillemot is an ice-dependent species with a circum-polar breeding distribution
Prairie potholes. Stretching over about 715 000 km² either side of the US–Canadian border, the prairie potholes were formed by glaciers scraping over the landscape during the Pleistocene. These depressions form freshwater marshes primarily. Although they are extremely important for birdlife, more than half have been drained.
Photo: US Geological Survey
The snowshoe hare sporting its summer and winter coats
Photos: Walter Siegmund/Wikipedia (summer coat) and US Forest Service
Photo: Walter Siegmund/Wikipedia
The American Pika is a di-minutive relative of rabbits and hares. This specimen was photographed in 2008 at an altitude of 600 m in Mount Baker-Snoqualmie National Forest near the Canadian border.
This katydid from the family of Tettigoniidae is also known as a bush-cricket. It tends to prefer a temperate or tropical climate.
Photo: Richard Bratton/Wikipedia
Seen here in New Hampshire in the autumn, the Sugar Maple is native to northeastern North America, extending as far south as the State of Texas in the USA.
Photo: Jean Pawek; reproduced with permission
Photo: Walter Siegmund/Wikipedia
Checkerspot butterfly photographed in the Olympic National Park in the USA.
During a La Niña event, which can last several years, temperatures in the tropical Pacific Ocean drop to below normal. In the USA, this tends to cause wetter than normal conditions across the Pacific northwest and drier, warmer than normal conditions across the southwest. The conditions across the southwest. The current drought in the southwest (in red) has persisted, however, between La Niña cycles.
Photo: Wikipedia

Coastal species will be affected by sea-level rise but may successfully move in land. Species on low-lying islands, like the Key Deer in the Florida Keys, will have nowhere to go. Those on higher islands may in the end run out of a suitable microclimate and be unable to move on.

*Ecosystem failure is already being recorded. More frequent bleaching events are making the future prospects for tropical reefs quite grim.*

*Ecosystem failure is already being recorded. More frequent bleaching events are making the future prospects for tropical reefs quite grim.*

More worrisome, ecosystem failure is already being recorded. One example concerns tropical coral reefs, which are particularly sensitive to warmer water. That causes the fundamental partnership of the coral ecosystem between the coral animal and an alga to break down. The coral expels the alga, which leads to a 'bleaching event' in which the diversity, productivity and benefits to local communities crash – almost as if the lights go out. Only first recorded in 1983, bleaching events are occurring with greater frequency every year, making the future prospects for tropical reefs quite grim.

## Will Bricks and Mortar Prevent some Specie from Dispersing?

On land, another case of ecosystem failure – or at least major ecosystem transformation – is being observed in the coniferous forests of western North America. From Alaska to Colorado, there is massive coniferous tree mortality from longer summers and milder winters, tipping the balance in favour of the native bark beetles which at high density kill the trees, which feed on dead trees. The growing mass of dry, rotting wood is creating an enormous fire hazard and forest management problem, making it hard to imagine what those ecosystems will become.

Looking ahead, it appears that there will be greater and more complex ecosystem disruption. One cause will be the interaction between species dispersal and human modification of landscapes.

Climate change, of course, has always been a part of life on Earth. Glaciers came and went in the great Pleistocene (*circa* 2.5 million – 11 700 years ago) ice ages, with little apparent loss of biodiversity. Species clearly were able to track their required conditions.

Today, however, landscapes have been highly modified by human use, basically creating obstacle courses to dispersal. The degree to which some human modification acts as a barrier will vary with a species' biology. I once

observed a katydid on the rooftop terrace of a six-storey building in lower Manhattan in New York and, more recently, an invasive species, the Brown Marmorated Stinkbug (*Halyomorpha halys*[5]), on the 20th floor of a Pittsburgh skyscraper but, for others, modified landscapes could prevent dispersal and cause extinction.

*Landscapes have been highly modified by human use, basically creating obstacle courses which could prevent species dispersal in reaction to climate change and cause extinction.*

There is clear evidence from present-day minor shifts, as well as from much greater past change, that biological communities do not move as a unit. Rather, it is the individual species that moves, each at its own rate and in its own direction, as specific conditions are tracked. The result is that, with greater climate change such as could lie ahead, the ecosystems we currently know will disassemble and the surviving species will assemble into ecosystems hard to imagine in advance. The challenge to manage that process would be enormous.

## What if the Climate Changes Abruptly, as in the Past?

It is also clear that whatever change could lie ahead will be more abrupt than that which we have observed in recent decades. That certainly is the case in the climate system.
For example, the southwestern USA, known for citrus fruitgrowing, is already gripped by a drought that is proving exceptional not only in terms of duration but also in its severity and geographical extent.

*Most of the negotiations have focused on 2°C of global warming; 1.5°C seems a much safer target.*

The global 'conveyor belt' that distributes heat around the oceans has been known to shut down in geologic times. The climate 'jumped' most recently at the end of the last ice age about 12,000 years ago, when the melting North American Ice sheets released masses of freshwater into the North Atlantic, causing the conveyor belt to stop and average temperatures in the North Atlantic region to plunge by 5°C within a decade.

## Acid Rain on the Oceans

Major systemic change is already occuring, the most notable sign being the acidification of the oceans. Mostly overlooked until 2005 (although it could be deduced from high school chemistry), the excess $CO_2$ absorbed by the oceans has produced enough carbonic acid in the process to change the pH of the oceans by 0.1 pH unit. That seems a trivial amount, except that the pH scale is logarithmic, so this means the oceans are 30 per cent more acidic than in 1950[6].

The acidification of the oceans is of enormous consequence for all marine organisms that build shells and skeletons of calcium carbonate. The carbonate equilibrium is affected by temperature and pH and is weaker in water that is more acidic or colder. The failure of oyster spawning in the State of Washington in the USA has been attributed to rising acidity. Many of the tiny organisms that exist in astronomical

numbers at the base of foodchains will be imperiled, such as the pteropods – tiny snails with a modified 'foot' that can flap like a wing and maintain the organism at a given level in the water column – and the entire foodchain with them. Acidification is truly a profound change for the oceans that comprise two-thirds of the planet.

*About 50 ppm of $CO_2$ could be sequestered over a 50-year period via reforestation and better forest management, restoration of grassland and degraded pasture lands and agro-ecosystems.*

## Could Amazon Dieback be Around the Corner?

Another major change that may be on the horizon involves the possibility of dieback of the Amazon rainforest in the southern and southeastern part of the Amazon. First projected by the Hadley Centre (UK) model to occur at about 2.5°C of global warming, a revised projection dating from about 2005 indicates it could occur at even 2.0°C.

More recently, the World Bank invested US$1 million in a study that modelled the effects of climate change, deforestation and fire on the Amazon. This was the first time they had been modelled together; the results suggest a tipping point to Amazon Dieback could occur at 20 per cent deforestation, when the current figure is 18 per cent. Disturbingly, what was then the greatest drought in the recorded history of the Amazon occurred in 2005 – only to be followed by an even greater one in 2010. These are perhaps early signals of what could lie ahead.

## Even a Global temperature Rise of 2°C will be Hard on Biodiversity

In the meantime, most of the discussions and negotiations have focused on stopping at an average of 2°C global warming this century. Under current approaches, global emissions will have to peak in 2016 if warming is to stop at 2°C. Yet even this is clearly too much for many of the ice systems and for the ecosystems of the planet. The obvious things to do to assist ecosystem resilience are to restore natural connections in the landscape (such as by creating ecological corridors like that linking Yellowstone Park to the Yukon's Territorial Parks in North America) and to reduce other stresses to avoid negative synergies with climate change. But even these stresses will pale in comparison to the effects of continued global warming.

In sum, a global average temperature rise of 2°C (roughly 450 ppm of $CO_2$) is too much. Something in the order of 350 ppm of $CO_2$ – roughly equivalent to a temperature rise of 1.5°C –seems a much safer target to settle for.

## A lot of Excess Carbon could be Removed by Restoring Ecosystems

The energy agenda is clear and urgent but, in addition, there is a critical need to remove substantial amounts of excess $CO_2$ from the atmosphere to avoid the warming it would otherwise cause. That might seem Quixotic[7] but, in fact, the history of life on Earth shows that twice in the history of the planet, there have been extremely high concentrations of $CO_2$ and, twice, these have been brought down to pre-industrial

levels biologically. The first drawdown occurred with the appearance of plants on land, by their photosynthesis and the accumulation of plant biomass. Simultaneously, soil formation reduced $CO_2$ – not just the physical process but also aided and abetted by the soil biota. The second drawdown occurred with the appearance of modern flowering plants, which performed the same role more efficiently.

Those two major alterations to atmospheric composition took tens of millions of years, which might make biological potential seem irrelevant. It would be, excepted that perhaps 200–250 billion tons of carbon have accumulated in the atmosphere over the past three centuries because of the destruction and degradation of ecosystems via deforestation, the deterioration of grasslands and agricultural practices that lose soil carbon. Greater recourse to crop rotation, for instance, could reduce soil erosion, which releases a lot of stored carbon into the atmosphere. Roughly half of the current excess $CO_2$ is of modern biological origin and a significant portion of it can be removed by ecosystem restoration on a planetary scale. The numbers are approximate but about 50 ppm of $CO_2$ could be sequestered over a 50-year period – the difference between 350 ppm and current levels of close to 400 ppm. That could be achieved by sequestering about half a billion tons of carbon per year in reforestation and better forest management, another half billion per year through restoration of grassland and degraded pasture lands – resulting in better grazing – and a third half billion per year by managing agro-ecosystems to restore soil carbon – resulting in greater soil fertility. Such an approach to managing the planet is obviously more complex than simply making this statement and must take into account the needs of feeding at least another 2 billion people over and above the current population but the potential is clear. Such a solution also has the great advantage of making biodiversity and ecosystems more resilient in the face of the climate change and other stresses that will affect them.

Since this is not enough, given current emission trends, clearly non-biological ways need to be sought to remove $CO_2$ not just from smokestacks but also from the atmosphere. Economically feasible means need developing to this end. For instance, one could imagine a process by which $CO_2$ would combine with other molecules to become an inert substance like concrete.

The reduction of $CO_2$ is infinitely preferable to almost any scheme for geo-engineering aimed at reducing temperature, except locally. Geo-engineering schemes that would reduce the planet's temperature in the end address the symptom, not the cause. They do nothing to combat ocean acidification and, being planetary in scale, their downside will, by definition, also be planetary in consequence. In addition, any time the intervention ceases, the temperature of the planet will go right back up to where it would have been otherwise.

*The reduction of $CO_2$ is infinitely preferable to almost any scheme for geo-engineering. Geo-engineering schemes address the symptom, not the cause.*

Far preferable will be to manage our living planet as just that, a living planet, by using Earth's living systems to regreen it and make it more habitable for all life forms.

Thomas Lovejoy
*Read this article in* Tracking Key Trends in Biodiversity Science and Policy.

***The eruption of Iceland's Eyjafjallajökull volcano in April 2010 paralysed European air traffic for days. As the debris ejected by volcanic eruptions has a cooling effect by blocking the sun's rays, some imagine geoengineering*** the climate system by injecting aerosols into the stratosphere to slow global warming.

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# HYDROPOWER PROJECTS: GENERATORS OF ENERGY AND HARBINGER OF SOCIO-ECONOMIC DEVELOPMENT— A STUDY OF NATIONAL HYDROELECTRIC POWER CORPORATION ,TEESTA V PROJECT IN EAST SIKKIM

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## Introduction

Down the ages, rivers have been the basin of human development. They have provided man water, fertile soil, aquatic flora and fauna, and given them reasons to bind together in a social formation. Several great human civilisations took shape on riverbanks.

The development of hydropower projects on high-gradient rivers has added a new dimension to the virtues of rivers. They have helped in the development and progress of far-flung remote areas in hilly terrain. The bonus, this development has no price attached to it. The energy generated through this mechanism is eco-friendly and extremely reliable. On these scores, hydropower easily outscores other forms of power generation sources, viz., thermal or nuclear power plants.

Wherever a hydropower project is constructed, questions are often raised about the changes in the environment it might bring. Admittedly, any major infrastructural development ushers in a number of changes. While some changes may be detrimental, there are many more of the beneficial kind. The negative changes in the environment brought on by the hectic activity at the

construction site are at worst temporary, whereas the benefits of such projects bring to the well-being of the native people, state and the nation last for several decades.

National Hydroelectric Power Corporation (NHPC) is a major force in hydropower development in India. Formed in 1975 to harness the vast hydro potential of the nation, it has a mission to generate clean, cheap and quality power for the development of the country. It has a clear objective— while aiming at progress, it would not deprave the ecosystem.

Since its inception, this corporation has generated 123153.55 MW of electricity up to March 2005. With the manpower of 13,000 behind an installed capacity of 2755 MW, 10 power stations and 32 generating units, it is committed to provide cheap and clean power for the socio-economic development of the nation.

The corporation has taken up numerous projects in remote, hilly areas of the country and brought about a major development and improvement in socio-economic milieu of these undeveloped areas. In the recent years, it has designed and made operational a number of hydro projects in Sikkim, Arunachal Pradesh, Jammu and Kashmir, Himachal Pradesh and Andaman and Nicobar Islands.

The most obvious limitation of hydropower development is the loss of land—the habitat of people, plants and wildlife due to submergence. However, most modern day projects do not cause any large submergence, as they are run-of-the-river type, which require a small storage, equivalent to a few hours of running.

The advantages of hydropower over other energy sources viz. thermal power and gas-generated power are manifold:

1. Hydropower is renewable and non-polluting source of energy. It helps in conserving scarce fossil fuels.
2. It has an inherent capability for instantaneous starting, stopping, and load variation. It thus helps in improving reliability of power system and optimising the resources.
3. Operates on high efficiency (about 90%) and low operational cost.
4. It makes a sound choice for meeting the peak energy demand.
5. It enjoys a longer useful life.
6. It helps in opening up of avenues for development of remote/ backward areas.

## Role in Socio-economic Development

NHPC is an organisation with assets worth ₹ 70,000 crore and an authorised share capital of ₹ 15,000 crore. It earned a profit of ₹ 694 crore during financial year 2004-05. Apart from generating the cheap and clean hydropower, it has been contributing to the overall socio-economic growth of the undeveloped remote hilly terrains of the nation.

The progress it has brought about in states of Jammu and Kashmir, Himachal Pradesh, Sikkim, Arunachal Pradesh and Uttranchal has been remarkable. Each of its projects brings in a spate of developmental activities for the region, state and nation.

The socio-economic development that ensues in various direct and indirect ways is tabulated here.

## Direct Benefits

1. **Employment Generation**
   The NHPC directly employs 13,000 men and women for construction, operation and management of power stations. It also engages a number of construction agencies to carry out its projects. These, in turn, provide huge employment opportunity to the locals.

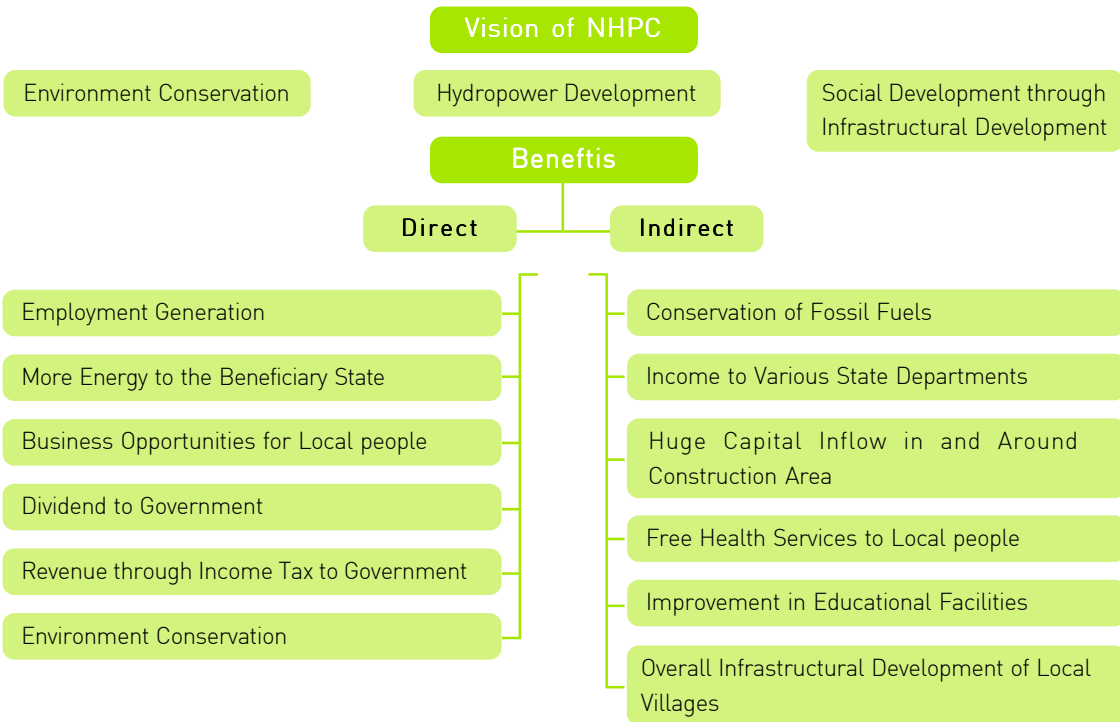
2. **More Energy to the Beneficiary State**
   NHPC has been providing 12 per cent free power to the beneficiary states, which they can use for their consumption or sell it to industries at cheaper rate for encouraging industrial development in the state. Small states like Sikkim and Uttranchal have the potential of becoming the richest states in the country just because of their immense promise to generate hydropower.

3. **Business Opportunities for Local People**

   NHPC has been providing local people opportunities to be a partner in the development by giving them business openings.

4. **Dividend to Government**

   NHPC being Government of India Enterprise pays a considerable dividend to the exchequer



as a part of its profits. During the current year, it has paid ₹ 150 crore as interim dividend to the Government.

### 5. Revenue through Income Tax to Government

NHPC has been contributing to the economy of India by paying huge corporate taxes, which, in turn, are used for the development of the nation.

### 6. Environment Conservation

NHPC, since its inception, has been committed to the sustainable development of the nation by protection of environment along with improvement in environmental quality through comprehensive environment management programmes viz., compensatory afforestation, catchments area treatment, green belt development, reservoir rim treatment, and wildlife and fishery management plan.

## Indirect Benefits

### 1. Conservation of Fossil Fuels

One of the most important indirect benefits of massive hydropower development initiative taken by NHPC has been the huge reduction in use of non-renewable and scarce fossil resources for the production of fossil fuel based energy. The way NHPC has taken up hydropower construction in entire India and successfully completed projects in scheduled time even in the hostile terrain of Andaman and Nicobar, everybody has started to believe now that developing the hydropower is not so difficult. Due to these efforts, even the conventional thermal power developers have forayed into the area of hydropower development. This should go a long way in conserving the scarce fossil fuel resources of the country.

### 2. Income to Various State Departments

States, where NHPC has gone into operation or is constructing hydropower projects, are getting huge revenues because of various state taxes, royalty and developmental boost it gives to the infrastructure. The Sales Tax department, Forest department and Transport department (hiring charges of vehicles) are the major beneficiaries. These revenues come useful in the development of that state.

### 3. Huge Capital Inflow in and Around the Construction Area

During the construction of its hydropower projects, NHPC pumps up huge money in and around the project area. Since hydropower construction is labour intensive, much of the income of the labourers and contractors, and the employees of NHPC is spent in the project area to meet their daily requirements. This leads to an indirect addition to the income of the state.

### 4. Free Health Services to Local People

NHPC has been making its medical facilities available to the local people living in the surrounding area free of cost. Even the medicines are distributed free of cost to the extent possible. This becomes a major benefit, since most of the areas where the projects are coming up are in such remote areas that regular medical facilities are not available in routine to the locals. In places like East Sikkim where Teesta-V Project is being constructed,

NHPC is providing on an average free medical services to more than 1,500 local people each month.

5. **Improvement in Educational Facilities**
   Similar to the health facilities, NHPC has been developing the educational facilities in the project areas and local children are also getting benefited from this. The ladies welfare associations of NHPC have been opening and running various *anganbari* and adult education schools in project areas.
6. **Overall Infrastructural Development of Local Villages**
   Due to the massive shift of man and material that hydropower projects require, development of infrastructure like roads, bridges, communication facilities become a necessity. This has become a boon for the native people. It has permitted a better connectivity of the remote areas, and as a result, local people are getting an opportunity to join the mainstream of development.

The activities related to development and operation of hydropower projects benefit the locals in a number of ways, while boosting the economy of the region, state and the nation. This can be explained easily if the activities of the hydropower development are listed vis-à-vis the benefits and overall impact (see table).

## How Hydropower Projects Benefit People and Society

| | Activities | Beneficiary | Impact |
|---|---|---|---|
| When the hydropower project is under construction | Employment generation | Local people (primarily in unskilled and semi-skilled category) | Enhancement of local economy |
| | Business opportunities | Local people (due to increase in demand of man and materials) | Enhancement of local economy |
| | Revenue to the state departments | Local people (since the funds shall be invested in the State) | Development of the State |
| | Dairy and Poultry development | Local people (to cater to the requirement of NHPC employees, labourers and contractors' staff) | Expansion of local economy |
| | Vegetable farming | Local people (to cater to the requirement of NHPC employees, labourers and contractors' staff) | Expansion of local economy |
| | Infrastructure development viz., roads, bridges, communication facilities, etc. | Local people | Better connectivity leading to socio-economic development of the region |

| | | | |
|---|---|---|---|
| | Development of medical facilities | Local people | Improvement in the health status of the society |
| | Better educational facilities | Local people | Improvement in the literacy levels |
| When the project becomes operational and begins to generate power | Power generation | Several states connected to the grid which receives the power from the project | Industrial development in the neighbouring states |
| | Free power | State where the hydropower project is constructed | Boosts state economy through industrial development |

## Social Impacts

Social impacts due to the projects are mainly positive and beneficial. The negative impact is displacement of people due to acquisition of land for submergence and project components. However, this impact is compensated by the comprehensive rehabilitation and resettlement plan, which is formulated after due consultation with the affected people and the state government. Various benefits provided to the affected people are: employment, education, medical facility at project dispensaries, vocational training, protected water supply, housing, etc. The main objective of this plan is to provide for better living conditions to the displaced.

The number of families displaced per MW of installed capacity of power is 0.47 and number of families displaced per hectare of submerged area is 1.1.

| Sl.No. | Project | Installed Capacity (MW) | Submergence Area (ha) | Displaced Families |
|---|---|---|---|---|
| 1. | Chamera-I (HP) | 540 | 975 | 1174 |
| 2. | Tanakpur (UP) | 120 | 140 | 60 |
| 3. | Uri (J&K) | 480 | 0 | 121 |
| 4. | Rangit (Sikkim) | 60 | 13 | 19 |
| 5. | Dhauliganga-I (UP) | 280 | 29 | 33 |
| 6. | Chamera-II (HP) | 300 | 25 | 30 |
| 7. | Teesta-V (Sikkim) | 510 | 68 | 46 |
| 8. | Loktak d/s (Manipur) | 90 | 87 | 42 |
| 9. | Parbati-II (HP) | 800 | 27 | 0 |
| | **Total** | 3180 | 1364 | 1525 |

## Impact on Local People

### 1. Cultural Impact

The people living in proscribed area have strong cultural heritage and have been protected for a long time. In the other areas, there is dilution of culture. Hence, cultural impact is likely only in the Dzongu area. Labour population would bring in different cultures into the area. However, impact is expected to be marginal since most of the labour population comprises of local people. Only skilled and semi- skilled people will be brought into the area from outside. Further, most of the project components are outside the proscribed area and only diversion tunnels of project are in the adjoining Dzongu area. Submergence area shall be used only after project completion and will be non-approachable, hence no impact on population in proscribed area is anticipated. Further, it has been ensured that no labour population is living in the prescribed area and no one can go there without the prior permission of concerned District Collector.

### 2. Economic Impact

Positive impact is visible on economic front. More opportunities have opened up for the Lepchas and Bhutia population living in the project area as they are getting employment as labourers, petty work contracts and many individuals have been taken in the NHPC on deputation from state government. This has opened new avenues and new source of income to the people.

### 3. Etiological Impact

Health surveys have indicated that the locals in the area suffer from a variety of diseases including malaria, gastro intestinal disorders, skin and respiratory problems. Until now, they relied on traditional medicine, which was not very useful. With the development of the Teesta project, however, better medical facilities are now available to the native people including tribals. They are being provided free medical check ups, medicines, vaccines and ambulance facilities. This has helped improve their health status. The facility of protected water supply has reduced the burden of water borne diseases.

## Development in the Community

### 1. Development through Direct Benefits

The direct benefits to the local and ethnic communities are in the form of employment with NHPC or due to the employees and family of NHPC and its contractors. This has improved the socio-economic conditions of the people living near the project area and has encouraged people to take up higher education.

### 2. Development through Indirect Benefits

The indirect benefits to the local and ethnic communities are through indirect employment or benefits from the activities of NHPC and its contractors.

### 3. Rehabilitation and Resettlement Plan

As this is a run-of-the-river scheme, the submergence due to the reservoir is very small. In fact, most of the affected people are those whose lands have been acquired for the construction of various components of the project. The number of those displaced is 46 and partly affected 125 as per the detail obtained from the office of District

Collector. Most of the affected families are small farmers with meagre land holdings. Each of them is being rehabilitated suitably.

## Conclusion

Hydroelectric power projects set up in far-flung difficult hilly areas are contributing to the socio-economic as well-being of the native people and the region by improving their economy, infrastructure, connectivity, health status, education facilities and job opportunities while providing a fillip to the development of the state and the nation by offering cheap, efficient and reliable energy source that does not corrupt the environment.

# INTRODUCING NANO SCIENCE EDUCATION AT PRE-UNIVERSITY LEVEL

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The dynamics of education is also changing in this fast-changing world. Knowledge and curriculum especially of science and technology are becoming obsolete at a faster rate now. To keep the future open, the students must be taught not only what to learn, but also how to learn. Nano science and Nanotechnology is one such emerging technology which is readically different when compared with traditional technological systems. In this paper, the current status of the progress and developments in nanotechnology and nano education is briefly reviewed. Strategies for teaching nano science and technology at secondary and higher secondary levels are also presented.

## Introduction

Nanotechnology covers all aspects of the production of materials, devices and systems by manipulating matter at nano scale (one-billionth of a meter). The transition from bulk to atomic properties occurs at this scale. The atoms combine to form clusters, the property of which is different from atoms or bulk materials. The size of the cluster usually ranges from 1-100 nanometers. A combination of classical and quantum mechanics is required to explain properties of matter at nano scale (Mukherjee, 2007). Materials when reduced to nano dimensions show drastic change in physical, chemical, magnetic, optical, mechanical and electrical properties. The increase in surface area to volume ratio results in a change in mechanical, thermal and catalytic properties. When reduced to nano dimensions, opaque substance become transparent, inert materials become catalyst, stable materials turn combustible, solid turn into liquid at room temperature and insulators become conductors. The electrical and thermal conductivities are quantised at nano level. This change in properties promises exciting applications in electronics, bioscience, medical science, environment, textile technology, cosmetics, security and variety of other fields. The range of possible applications include semiconductor laser, sensitive electromagnetic detectors, nano-scale motors, super catalysts, drug delivery systems, micro and nano-electromechanical devices, etc. From consumer goods, electronics, computers, information and biotechnology, to aerospace defense, energy,

environment, finance and medicine, all sectors of the economy are to be profoundly impacted by nanotechnology. This impact creates a challenge for the academic community to educate science and engineering students with the necessary knowledge, understanding and skills to interact and provide leadership in the emerging world of nanotechnology (Uddin, M. and Chowdhury, A.R., 2001). Realising the vast scope of nanotechnology, this paper examines the trend of nano education in India.

## Scope of Nanotechnology Education and Research

Nanotechnology is a highly multidisciplinary subject which combines physics, supramolecular chemistry, material science, interface and colloid science, engineering, biotechnology, self–replicating machines and robotics, information technology, etc. It is the engineering of functional systems at molecular scale. Examples of nanotechnology are the manufacture of polymers based on molecular structure and the design of computer chip layouts based on surface science. Nanotechnology application is being classified into three types: incremental, evolutionary and radical. The current industrial applications of nanotechnology restricted to use of colloidal nanoparticle in bulk form, such as suntan lotion, cosmetics, protective coatings and stain resistant fibres comes under purview of incremental category. Nano-scale sensors exploiting quantum dots and carbon nanotubes representing evolutionary nanotechnology are in the research and development stage. Taken together, incremental and evolutionary nanotechnology is driving the recent interest in industry and academia for all things nano-scale. Radical nanotechnology is currently at science fiction stage only.

The various sub and related fields of nanotechnology are nanomaterials, nanomedicine, nanorobotics, nanoelectronics, nanosensors, etc. Though the field is at infancy stage, the country is making dedicated efforts to develop a strong research and development base on nanotechnology. Further development of the field requires changes in the laboratory and human resource infrastructure in universities and in their educational pattern. Department of Science and Technology, Government of India has launched National Nano Science and Technology Initiative in 2001 to expedite research and development efforts in this area. Many scientific institutions have already taken a lead in research and development in nanotechnology. Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore is a pioneer in nano science and nanotechnology education in India. All Indian Institutes of Technology and many other premier research organisations of the country like Indian Institute of Technology and Science (IIS), Bangalore, National Physical Laboratory and National Chemical Laboratory conduct research in various aspects of nanotechnology. In addition, faculty members in various institutions conduct and manage research programmes in the areas of nanotechnology and nanoscience supported by funding organisations such as the DST (SERC/ Nanomission), DAE, CSIR, DRDO, DBT, UGC, etc. Department of Biotechnology and DST have funded many organisations for establishing specialised centres (Central characterisation Facilities) for Nanotechnology research in advanced areas like Nanosensors, Nanodevices and Drug delivery. With the help of DST support

Technology Transfer and Marketing divisions has also started in some organisations like ARCI for marketing of Nanoproducts and new technologies.

## Nano Education Curriculum

Many Indian universities have begun to offer nanotechnology courses and modules which are mostly designed for science and engineering students. Department of Science and Technology, Government of India has funded more than 15 universities to start master degree programmes (M.Sc./M. Tech.) in the area of Nanoscience, Nanotechnology and Nanobiomedical technology under Nanoscience and Technology initiative (NSTI-Nanomission). Generally nanotechnology education involves a multidisciplinary natural science education with courses in nanotechnology, physics, chemistry, mathematics and molecular biology. Presently most Indian universities offer masters programme in nanotechnology. Some universities offer Master of Science in nanotechnology while others offer Master of Technology degree. Very few universities have started graduate programme in nanotechnology. However, a masters degree in basic science, preferably in Physics, followed by an M.Tech. in nanotechnology is an ideal preparation for a career in nanotechnology. There is an elective paper on 'Physics of Nanomaterials' in the model curriculum of Masters in Physics developed by University Grants Commission in 2001. The paper broadly covers free electron theory, quantum size effect, quantum confinement and different methods of preparation of nanomaterials. It is another matter that very few of the universities offer this paper to their students. There could be several reasons for this reluctance but the most important is lack of trained human resource to teach this subject. Presently several Indian universities offer masters programme in nanotechnology. Some universities offer Master of Science in nanotechnology while others offer Master of Technology degree. Some of the universities offer M.Tech. dual degree in nanoscience and nanotechnology. Few offer M.Sc. in Nanomaterials.

## Nano Education at Graduation Level

Very few universities have started graduate programme in nanotechnology. Surprisingly the model curriculum of Bachelor of Science developed by University Grants Commission does not contain any elective paper or module on either nano science or nanotechnology. Only, a private university offers five years integrated B.Tech. plus M.Tech. degree in nanotechnology. Most of the technical institutions offer nano related module or paper in its various branches. Physics is taught as cumpulsory to first and second semester students of all branches of engineering and technology in India. Few engineering Institutes including National Institute of Technology, Srinagar offer a module on nanotechnology in its second semester Physics curriculum. Few organisations have started management programmes with specialisation in Nanotechnology business opportunities.

## Nano Education at Secondary and Higher Secondary Level

In India, Nanotechnology education is yet to reach schools. Pre-university educational institutions cater to a wide variety of students with differing interests and levels of motivation. The scope of nanotechnology is so vast that relevant education must be imparted to virtually all students. Successful education in nanotechnology at pre-university level requires supplementation of current educational practices by a different instructional approach (Lakhtakia, 2006). Students may be encouraged to take study projects on various aspects of nanotechnology including history, ethics, politics and application of nanotechnology depending upon their aptitude and motivation. They may be given an orientation on the many facets of nanotechnology by experts from nearby institutes of higher learning. In case of non-availability of experts, the teachers of concerned schools themselves may deliver lecture by consulting the various resources. Apart from the science and technological aspects, the other aspects to be discussed could be ethical, legal and political issues surrounding nanotechnology. Little data exists on the health hazards of nanotechnology. The convergence of biotechnology, information technology and nanotechnology is going to create significant social, legal, political and ethical issues. These issues have to be addressed concurrently with techno-scientific developments. The groups of students may be given brief handouts and should be encouraged to gather more information from various sources like textbooks, supplementary readers, web and field visits to nearby laboratories and research institutes. Each group has to study one aspect of nanotechnology. Then they may be directed to submit a journal of their activities and ideas at the end of the project. This supplementation of curriculum however, requires that the teachers have to be sensitised in this new approach known as 'Just in time Teaching' (web-physics.iupui.edu/jitt/ccjitt.html). Moreover a resource base of materials should be made available in the school libraries so that students can read topics of their aptitude and liking.

## Building a Resource Base on Nano Science in Schools

The books and other learning resources for school levels should be simple, interesting, semi-technical and affordable. The books like *Fullerene* by Sivakamusundary and *Nano: The Next Revolution* by M.Sunderrajan published by National Book Trust and *The Quest for New Materials* by S.T. Lakshmikumar published by Vigyan Prasar are a must for every school. Resources on self-assembly and lithography also make good background learning material for nanoscience. Books on investigating techniques such as *Scanning Electron Microscopy and Atomic Force Microscopy* should also be a part of school library. All school libraries must subscribe Science Magazines and Journals like *Science Reporter* (CSIR), *Dream* 2047 (Vigyan Prasar), *School Science* (NCERT) and *Resonance* (Indian Academy of Sciences). If internet access is available, the UNESCO Brochure *The Ethics and Politics of Nanotechnology* may also be

downloaded with other relevant resources. In fact the models of geodesic domes or buckyballs may be very helpful in initiating students towards fullerenes and carbon nanotubes. Students may be encouraged to make geodesic domes themselves with the help of toothpicks, straw pipes, paper or iron rod. The web site www.sci-toys.com will be helpful in this regard.

## Faculty Training in Nano Education

Supplementation of current educational practices however, requires that the in-service teachers would have to be trained in new instructional approach. Curriculum in colleges of education shall have to be restructured and revised. Faculty needs to be trained in *Just in Time Education* pedagogy. School teachers should be sensitised towards self-learning. Since Nano science is interdisciplinary, teachers may join Indian Association of Physics Teachers and Indian Association of Chemistry Teachers, etc., for lifelong skill enhancement. They will regularly get bulletins of these associations and will become aware about various short term courses, seminars and symposia related with nanotechnology. Faculty can look to web for educational resources. Teachers looking for help in Nano science and technology curriculum can find assistance on the portals NanoEd Resouce, Nanotechnology Now, Understanding Nano, etc.

## Conclusion

The potential impact of nanotechnology makes it imperative to introduce nanotechnology at pre-university level. The topic, coverage and the pedagogy however, should be different from conventional approach. The teaching should be student-focused i.e., the students with similar aptitude should be put in a group and topics of their aptitude may be assigned to them for self-learning and to promote peer group interaction and team spirit.

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# PROBLEM BASED LEARNING IN BASIC PHYSICS - II

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In this article (second in the series of articles) we present problems for a problem based learning course from the area of mechanics based on Newton's laws, conservation principles, static equilibrium and rotational motion. We present the learning objectives in this area of basic physics and what each problem tries to achieve with its solution.

## Introduction

In this article, second in the series of Problem Based Learning in Basic Physics, we present a problem on collision which is based on conservation laws accompanied by auxiliary problems and problems baed on Newton's laws of motion, static equilibrium and rotational motion. Methodology and philosophy of selecting these problems are already discussed (Pradhan, 2009; Mody, 2011.) This article deals with problems where cause of motion has to be understood to be able to predict the motion which is in terms of conservation laws and Newton's laws of motion for force as well as torque.

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

### B: Problems on Collision

### 4. Collision

A neutron of kinetic energy 65 eV collides inelastically with a singly ionized helium atom at rest. It is scattered at an angle of $90^0$ with respect of its original direction. (i) Find the allowed values of the energy of the neutron and that of the atom after collision. (ii) If the atom gets de-excited subsequently by emitting radiation, find the frequencies of the emitted radiation. [Given: mass of He atom = 4 × mass of neutron, ionization energy of H-atom = 13.6eV] [JEE, 1993].

- This problem creates a scene where students are expected to think about a collision process at an atomic level and subsequent processes involving emission of radiation.

**Tasks involved** in this problem are:

1. To understand it as an inelastic collision.
2. To understand how energy and momentum are exchanged in such a collision.
3. To apply conservation of momentum to an inelastic process.
4. To realise that conservation of energy can be applied to inelastic processes if it can be accounted for.
5. To realise that energy levels of $He^+$ are identical to H-atom.
6. To see all possible paths of returning to ground state.

The following are the **smaller problems** used :

**A 4.1*** A paricle of mass m undergoes an elastic collission with a stationary particle of mass M. What is the fraction of kinetic energy lost by the striking particle if

(a) it moves at right angles to its original direction after the collission;

(b) the collission is head-on one?

This problem allows students to work through one as well as two-dimensional elastic collisions and thereby become familiar with some of the tasks involved. Here students work with conservation of momentum and kinetic energy, as this is elastic collision.

**A 4.2** A bullet of mass 0.012 kg and horizontal speed 70 m/s strikes a block of a wood of mass 0.4 kg, and instantly comes to rest with respect to the block. The block is suspended from the ceiling by means of thin wires. Calculate the height to which the block rises. Also, estimate the amount of heat produced in the block [NCERT 2006].

This problem allows students to work through a one-dimensional collision and realise what may happen to energy if the collision is inelastic. At the same time it needs application of conservation total energy as block plus bullet system moves in gravitational field.

1. In addition students have to be guided to understand inelastic process at an atomic level through relevant questions.
2. Work out energy levels of $He^+$ using Bohr model. This also needed to review Bohr model for Hydrogen like atoms.

### C: Problems on Newton's Laws

**5.** Two masses $M_1$ = 1 kg and $M_2$ = 3 kg are connected with a light string. The system is placed on an inclined plane of inclination $30^0$, such that the connecting string is parallel to the plane. The system slides down with $M_2$ pulling $M_1$. The coefficient of friction between $M_1$ and the plane is 0.2 while between $M_2$ and the plane is 0.1. Calculate the tension in the connecting string and the acceleration of the system? [JEE 1979]

**6.** In above problem (5) what if $M_1$ and $M_2$ are interchanged?

**Tasks involved** in these problems (5 and 6) are:

1. To identify the body in motion and forces acting on it.

2. To resolving these forces into rectangular components, one parallel and other perpendicular to motion.
3. To applying Newton's 3rd law for reaction forces.
4. To find net force in the direction of motion and applying Newton's 2nd law of motion.
5. To draw free body diagram (Halliday 2005).

The following is the **smaller problem** used.

A 5.1 A block kept on a simple inclined plane: (i) without; and (ii) with friction. This is a standard problem to find acceleration of the block depending on angle of inclination.

These simple problems teach students the method of applying Newton's laws of motion to simple system to study motion.

**7.*** A small ball is suspended from point A by a thread of length *l*. A nail is driven into the wall at a distance *l/2* vertically below A at O. The ball is drawn aside so that the thread takes up a horizontal position and then released. At what point in the ball's trajectory, will the tension in the thread disappear? What will be the highest point to which it will rise?

- This problem deals with motion in a vertical circle. This is also an application of Newton's law of motion, for motion which is along circular path. The problem also includes gravity. This problem illustrates how centripetal force is responsible for motion specially in this case when it is not constant and the agency responsible for it.

* Source unknown.

**Tasks involved** in this problem are:

(a) To draw a free body diagram for a particle moving along circular path.

(b) To apply condition for particle to continue along circular track. In this case, it is the conservation of energy.

(c) To work out mathematical condition in part (b).

(d) To understand how motion in a vertical circular track is different from uniform circular motion.

(e) To find subsequent motion, after the condition stops being satisfied?

The following are the **smaller problems** used.

A 7.1 A bob of mass *m* is suspended by a light string of length *L*. It is imparted horizontal velocity $v_o$ at the lowest point A such that it completes a semi-circular trajectory in the vertical plane with the string becoming slack only on reaching the top most point C. (i) Obtain an expression for $v_o$; (ii) the speed at points B when string is horizontal and point C; (iii) the ratio of the kinetic energies $(K_B/K_C)$ at B and C. Comment on the nature of the trajectory of the bob after it reaches the point C [NCERT, 2006].

**8.** In Atwood's machine, one block has a mass of 500 g and the other a mass of 460 g. The pulley, which is mounted in horizontal frictionless bearings, has a radius of 5.0 cm. When released from rest, the heavier block is observed to fall 75 cm in 5.0 s. What is the rotational inertia of the pulley? (Halliday 2005)

- Traditionally inclined plane and a pulley have always been treated as touchstone problems (Redish, 1994) as this is where students learn

resolution of forces, appropriate direction, use of Newton's 2nd law, use of force of friction, how to handle tension and reaction forces. This problem lays foundation of application of Newton's laws of motion.

**Tasks involved** in this problem are:

6. To identify the body in motion and forces acting on it.
7. To resolving these forces into rectangular components, one parallel and other perpendicular to motion.
8. To applying Newton's 3rd law for reaction forces.
9. To find net force and torque in the direction of motion and applying Newton's 2nd law of motion.
10. To draw free body diagram.

The following is the **smaller problem** used:

**A 8.1** An ideal pulley with two masses hanging at the end of an ideal string. How would the system move if the two masses are unequal? This too is a standard problem.

**9.** A ladder is resting equally inclined between a rough vertical wall and ground. If a man whose weight is half that of the ladder starts ascending it, show that the man can climb up to 71.4 per cent of the length of the ladder before it just starts slipping. Also show that this man can just make it to the top of the ladder if a boy of weight 1/4th that of the ladder stands against the ground end of the ladder. Take the coefficient of friction between the ladder and (i) the ground and (ii) wall as 1/2 and 1/3 respectively*.

This is a problem of static equilibrium and students need to identify and balance all the forces and torques.

**Tasks involved** in this problem are:

(a) Identify the forces and torques acting on various parts of the bodies involved.

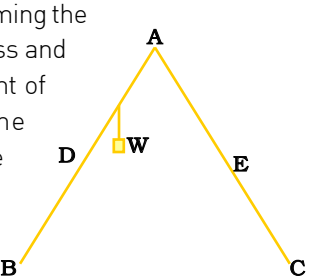
(b) Resolve forces into horizontal and vertical components.

(c) Identify clockwise and anti-clockwise moments.

(d) In equilibrium net force and net moment should be zero to get the desired information.

The following is the **smaller problem** that may be used.

**A 9.1** As shown in figure below, the two sides of a step ladder BA and CA are 1.6 m long and hinged at A. A rope DE, 0.5 m is tied half way up. A weight 40 kg is suspended from a point F, 1.2 m from B along the ladder BA. Assuming the floor to be frictionless and neglecting the weight of the ladder, find the tension in the rope and forces exerted by floor on the ladder. [Hint: Consider the equilibrium of each side of the ladder separately] [NCERT, 2006].




**10.** A rod of mass M and length L is suspended horizontally by means of two massless strings of equal lengths attached at its end points. Find the tension in one of the strings at the moment the other is just cut*.

* Source unknown.

- This is also a touchstone problem in the same sense as inclined plane as it is a first exposure to deal with rotational motion and application of Newton's laws to rotational motion.

**Tasks involved** in this problem are:

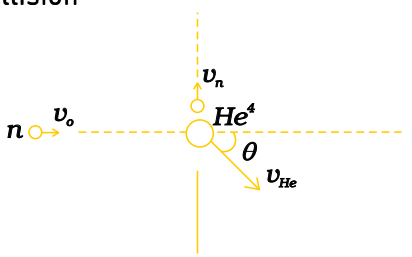
(a) To draw diagram representing all the forces.

(b) To resolve forces in to components to apply conditions for translational and rotational motion.

(c) To find mathematical condition using Newton's laws and solve the equation to get desired result.

***Solutions***

**4. Collision**




(i) $p_n = \sqrt{2mE} = m_n v_o$

Conservation of momentum :

In x-direction :

$m_n v_o = m_{He} v_{He} \cos\theta \Rightarrow v_o = 4 v_{He} \cos\theta$

In y-direction :

$m_n v_n = m_{He} v_{He} \sin\theta \Rightarrow v_n = 4 v_{He} \sin\theta$

Conservation of energy :

$\frac{1}{2} m_n v_o^2 = \frac{1}{2} m_n v_n^2 + \frac{1}{2} m_{He} v_{He}^2 + (E_n^{(He+)} - E_1^{(He+)})$

Where last term in the bracket indicate excitation of helium due to inelastic nature of the process. This also indicates that K.E. is not conserved in the process.

Here $E_n^{(He+)} = 4 E_n^{(H)} = -54.4/n^2$ eV

Solving these equations we get :

$\frac{1}{2} m_n v_n^2 = -4.52 + 43.52/n^2$ eV

Thus, allowed K.E. of neutrons are :

$\frac{1}{2} m_n v_n^2 = 39$ eV (for elastic collision-no excitation),

6.36 eV (1st excitation of $He^+$)

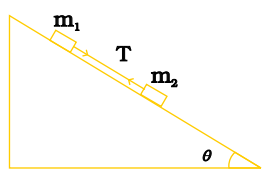
0.3156 (2nd excitation $He^+$)

(ii) Energy levels of $He^+$ are G.S. $E_1 = -54.4$ eV, (1st excited state) $E_2 = -13.6$ eV and

(2nd excited state) $E_2 = -6.04$ eV

Corresponding frequencies that can be emitted are $9.846 \times 10^{15}$ Hz, $1.167 \times 10^{16}$ Hz and $1.823 \times 10^{15}$ Hz ($\nu_{21}$, $\nu_{31}$ and $\nu_{32}$ respectively).

**5. Newton's law**




$m_2 g \sin\theta - \mu m_2 g \cos\theta - T = m_2 a$

$m_1 g \sin\theta + T - \mu m_1 g \cos\theta = m_1 a$

Solving which we get,

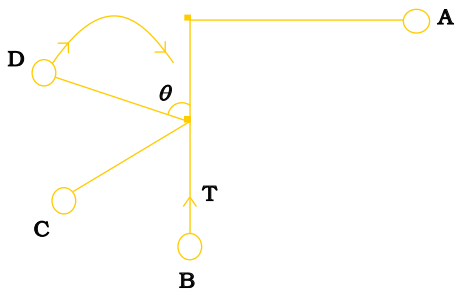
$$a = g\frac{(m_1 + m_2)\sin\theta - (\mu_1 m_1 + \mu_2 m_2)\cos\theta}{m_1 + m_2}$$

and $T = \left(\frac{m_1 m_2}{m_1 + m_2}\right)(\mu_1 - \mu_2) g \cos\theta$

**6. Newton's law**

In problem 5, if masses are interchanged, they come in contact and T gets replaced by R, contact force between the blocks.

## 7. Newton's law




Total energy at A : $mgl$ (where $l$ is length of the string). Height measured w.r.t. B.

At D where tension becomes zero : total energy : $\frac{1}{2}mv^2 + \frac{1}{2}mgl(1+\cos\theta)$

At D condition for tension becoming zero :

$\frac{mv^2}{l/2} = mg\cos\theta$ : centripetal force

Applying energy conservation and solving above equations we get $\theta = \cos^{-1}\left(\frac{2}{3}\right)$

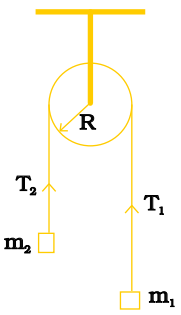
At D particle becomes like a projectile projected at an angle $\theta$ to the horizontal with speed $v = \sqrt{\frac{gl}{3}}$ that we get by substituting $\cos\theta$ in centripetal force equation.

The maximum height reached by the ball above D will therefore be $H = \frac{v^2\sin^2\theta}{2g} = \frac{5}{54}l$.

Thus the highest point reached by the ball is at $h = l/2 + l\cos\theta + H = 5l/6 + 5l/54$

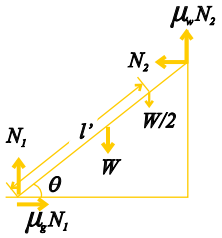
$= \frac{25}{27}l$ above B (or $\frac{2}{27}l$ below A).

## 8. Newton's law




$m_1g - T_1 = m_1a$, $T_2 - m_2g = m_2a$ and $R(T_1 - T_2) = I\alpha$ with $a = R\alpha = 2S/t^2$ gives the needed answer.

## 9. Static equillibrium




Given: $\mu_g = 1/2$ and $\mu_w = 1/3$.

Since ladder is equally inclined, $\theta = 45^o$, let length of the ladder be $l$ and let the man climb up to $l'$ before ladder starts slipping.

In equilibrium, net force in any direction and net moment of force is zero.

Since no net horizontal force: $N_1 + \mu_w N_2 = 3W/2$

Since no net vertical force: $N_2 = \mu_g N_1$

Solving which we get $N_1 = 9W/7$ and $N_2 = 9W/14$

(i) Just before the ladder slips: no net moment:

$[W(l/2) + (W/2)l'] \cos\theta = N_2 (1 + \mu_w) l \sin\theta$

Solving which we get $l' = (5/7)l = (0.7143)\, l$

(ii) If the boy of weight W/4 is added at the ground end, the equation for vertical force changes to $N_1 + \mu_w N_2 = 7W/4$ and this gives $N_1 = 3W/2$ and $N_2 = 3W/4$

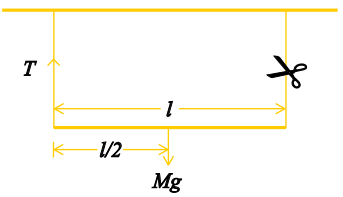
With new value of $N_2$ we get $l' = l$

### 10. Rotational motion

The moment at which scissor cuts one of the string,

net downward force produces acceleration of centre of mass :

$(Mg - T) = M a$ )




Net torque produces rotational acceleration $\alpha$ around the other end of the rod

here $\alpha = \dfrac{a}{l/2}$

$\therefore \quad Mg(l/2) = I\alpha$

where $I = \dfrac{1}{3} Ml^2$ is MI of rod around one end.

Solving this we get : $a = \dfrac{3}{4} g$ and $T = \dfrac{1}{4} Mg$ .

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# PROBLEM BASED LEARNING IN BASIC PHYSICS - III

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In this article (third in the series of articles) we present problems for a problem based learning course from the area of mechanics based on simple harmonic motion, rotational motion, gravitation and waves. We present the learning objectives in this area of basic physics and what each problem tries to achieve with its solution.

## Introduction

In this article, third in the series of Problem Based Learning in Basic Physics, we present problems on simple harmonic motion, rotational motion, gravitation and waves. Methodology and philosophy of selecting these problems are already discussed. (Pradhan, 2009; Mody. 2011).

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

## Problems

### D: Simple Harmonic Motion

11. A cylindrical log of wood of height $h$ and area of cross-section A floats in water. It is pressed and then released. Show that the log would execute SHM with a time period $T = 2\pi\sqrt{\frac{m}{A\rho g}}$ where $m$ is the mass and $\rho$ is the density of the liquid [NCERT EP XI].

**Tasks involved** in this problem are:

1. To understand the balance of forces when the log is in equilibrium.
2. To find the net force that would try to restore the log back to equilibrium and realise that it is proportional to displacement.

3. The constant of proportionality should be identified and its relation with time period would lead to the expression for time period.

*Many such motions are equivalent and has simple behaviour, examples are liquid in a U-tube, magnets in magnetic field, marble in a hemispherical bowl, etc...* . Treatment presented here helps understand such motion or any simple deviation that may be possible.

## E : Rotational Motion

**12.** A carpet of mass $M$, made of inextensible material, is rolled along its length in the form of a cylinder of radius $R$ and is kept on a rough floor. The carpet starts unrolling without sliding on the floor when a negligibly small push is given to it. Calculate the horizontal velocity of the axis of the cylindrical part when its radius reduces to $R/2$ [JEE, 1990].

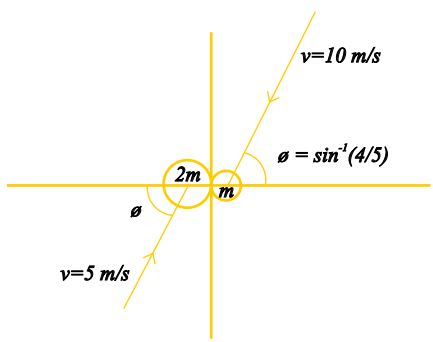
**Tasks involved** in this problem are:

1. To realise that mass of cylinder here changes as $R^2$ and keeps on changing as the carpet unrolls.
2. The unrolling part of carpet (cylindrical part) has linear as well as rotational motion.
3. The deciding factor here is the conservation of energy.

**13.** A uniform disc of mass $m$ and radius $R$ is projected horizontally with velocity $v_0$ on a rough horizontal floor so that it starts off with a purely sliding motion at $t = 0$. After $t_0$ seconds, it acquires a purely rolling motion as shown. (i) Calculate the velocity of the centre of mass of the disc at $t_0$, and (ii) assuming the coefficient of friction to be $\mu$, calculate $t_0$. Also calculate the work done by the frictional force as a function of time and the total work done by it over time $t$ much longer than $t_0$ [JEE, 1997].

**Tasks involved** in this problem are:

1. To identify force that causes sliding disc to rotate and roll.
2. This force causes slowing down (deceleration) of linear motion and torque due to which speeds up rotation of the disc thus to find condition for this.
3. To find the condition when rolling without slipping begins.
4. To identify contribution to kinetic energy initially and finally and hence change in kinetic energy.




**14.** Two smooth spheres made of identical material having masses $m$ and $2m$ collide with an oblique impact as shown in figure above. The initial velocities of the masses are also shown. The impact force is along the line joining their centres. The coefficient of restitution is 5/9. Calculate the velocities of the masses after the impact and the loss in the kinetic energy [Basavraju and Ghosh].

**Tasks involved** in this problem are:

1. To understand that collision is inelastic but $v$-velocity is unaffected.

2. To apply conservation of momentum and find velocities in x- direction.
3. Hence, work out motion after the collision.

## F : Gravitation

**15.** Earth's orbit is an ellipse with eccentricity 0.0167. Thus, earth's distance from the sun and speed as it moves around the sun varies from day-to-day. This means that the length of the solar day is not constant through the year. Assume that earth's spin axis is normal to its orbital plane and find out the length of the shortest and the longest day. A day should be taken from noon to noon. Does this explain the variation of length of the day during the year? [NCERT, EP XI].

**Tasks involved** in this problem are:

1. To understand how planet moves under Kepler's law.
2. To apply Kepler's law and find angular speeds at apogee and perigee.
3. To understand mean rotation and length of the day in terms of angular speed.

**16.** A satellite is in an elliptic orbit around the earth with apehelion of $6R$ and perihelion of $2R$ where $R = 6400$ km is the radius of the earth. Find the eccentricity of the orbit. Find the velocity of the satellite at apogee and perigee. What should be done if this satellite has to be transferred to a circular orbit of radius $6R$? [$G = 6.67\times10^{-11}$ SI units and $M = 6\times10^{24}$ kg] [NCERT EP XI].

**Task involved** in this problem is:

To apply conservation of angular momentum in central force (elliptic orbit) to find out how velocity changes as satellite moves in the orbit .

## G : Waves

### Learning objectives:

1. Becoming familiar with wave propagation and effect of distance ($I \propto 1/r^2$ law) and state of motion of observer or source (Doppler effect) on the observed parameters namely: amplitude, intensity, frequency, wavelength and phase.
2. Superposition of waves leading to beats, resonance and response of detector.
3. To understand mathematical structure dealing with above mentioned points.

**17.** The displacement of the medium in a sound wave is given by the equation $y_1 = A\cos(ax + bt)$, where A, a and b are positive constants. The wave is reflected by an obstacle situated at $x = 0$. The intensity of the reflected wave is 0.64 times that of the incident wave. *

(i) What are the wavelength and frequency of the incident wave?

(ii) Write the equation for reflected wave.

(iii) In the resultant wave formed after reflection, find the maximum and minimum values of the particle speeds in the medium.

- It illustrates what happens when a wave is reflected, how do the incident and reflected waves interact and phase of the reflected wave
- It introduces students to waves and reflection on a surface.

**Tasks involved** in this problem are:

1. To apply principle of superposition.

2. To understand the phase of the reflected wave.
3. To find intensity using the rule that it is proportional to square of the amplitude.
    - No supporting problem. Students are to be guided to achieve the goal.
    - To recognise what the phase of the reflected wave would be they were asked to tell the difference between the waves reflected from the denser and rarer surface and how it gets incorporated mathematically into equation.

**18.** Two radio stations broadcast their programmes at the same amplitude A, and at slightly different frequencies $\nu_1$ and $\nu_2$ respectively, where $\nu_2 - \nu_1 = 10^3$ Hz. A detector receives the signal from the two stations simultaneously. It can only detect signals of intensity $\geq 2A^2$.

(i) Find the time interval between two successive maxima of the intensity of the signal received by the detector.

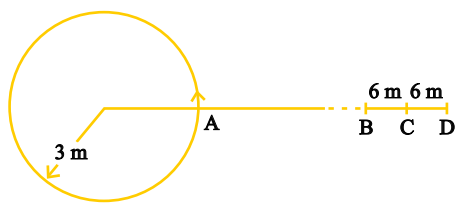
(ii) Find the time for which the detector remains idle in each cycle of intensity of the signal [JEE, 1993].

- This problem illustrates effect of beats on detection of waves.

**Tasks involved** in this problem are:

1. To represent two waves by proper equation.
2. To use the principle of superposition for finding resultant amplitude.
3. To find final intensity proportional to square of the amplitude.
4. To make decision as to when will detector be idle. For this, they may have to plot a graph of intensity v/s time.

**19.** A source of sound is moving along a circular orbit of radius 3 metres with an angular velocity of 10 rad/s. A sound detector located far away from the source is executing linear simple harmonic motion along the line BD with an amplitude BC = CD = 6 m. The frequency of oscillation of the detector is $5/\pi$ per second. The source is at the point A when the detector is at the point B. If the source emits a continuous sound wave of frequency 340 Hz, find the maximum and minimum frequencies recorded by the detector [JEE, 1990].




- This is an example based on Doppler effect. It is interesting as it makes use of symmetric movement of detector due to its simple harmonic motion.

**Tasks involved** in this problem are:

(1) To apply Doppler effect by incorporating relative motion of source and detector.

(2) To see and recognise the symmetry in motion between source and detector.

(3) To recognise the importance of the fact that source and detector are far away.

## Solutions

### D: Simple Harmonic Motion

11. Let the log be pressed and let the vertical displacement at the equilibrium position be $x_0$. At equilibrium $mg$ = buoyant force $= Ax_0\rho g$.

When it is displaced further by $x$, the buoyant force is $A(x + x_0)\rho g$.

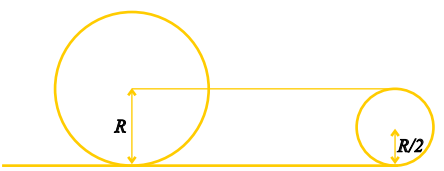
Therefore, the net restoring force = buoyant force - weight = $Ax\rho g$ (proportional to $x$)

Thus $m\omega^2 = A\rho g$ and hence time period

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{A\rho g}}.$$

### E : Rotational Motion

**12.** Mass of the cylindrical part of the carpet is proportional to $R^2$ and as centre of mass (axis) of the carpet gets lowered, its gravitational potential energy decreases and gets converted into kinetic energy of the rolling part.




P.E. lost $= MgR - \left(\frac{M}{4}\right)g\left(\frac{R}{2}\right) = \frac{7}{8}MgR$

K. E. gained = K.E. of axis (CM) + rotational K.E. around axis

$$= \frac{1}{2}\frac{M}{4}v_{CM}^2 + \frac{1}{2}I\omega^2, \quad \text{where} \quad v_{CM} = \omega\frac{R}{2}$$

and $I = \frac{1}{2}\frac{M}{4}\left(\frac{R}{2}\right)^2 = \frac{1}{32}MR^2$

$$= \frac{3}{16}Mv_{CM}^2.$$

Comparing the two we get, $v_{CM} = \sqrt{\frac{14}{3}gR}$.

**13.** (i) Force of friction opposing motion of the disc is $f_r = \mu mg$

which causes acceleration of $a = \mu g$

Torque acting on the disc due to friction is

$\tau = \mu mgR$

and causes angular acceleration

$\alpha = \mu mgR/I$ where $I = \frac{1}{2}mR^2$

at time $t_o$, $v = R\omega \Rightarrow v_o - at_o = R(\omega_o + \alpha t_o)$

$v_o = 3\mu mgt_o \quad t_o = v_o/3\mu mg$

$\omega = at_o = 2v_o/3R$ and $v = R\omega = 2v_o/3$

(ii) $W = \Delta KE = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 - \frac{1}{2}mv_o^2$

$= (3/2)m\mu^2g^2t(t - 2t_o)$

At $t = t_o$: $W = -(3/2)m\mu^2g^2t_o^2 = -(1/6)mv_o^2$ :

work done by friction (decrease in KE).

**14.** denoting velocities for masses $2m$ and $m$ as $u_1$ and $u_2$ before and $v_1$ and $v_2$ after collision,

we have

$u_{2x} = -10\cos\phi = -6$m/s, $u_{1y} = 5\sin\phi = 4$m/s

and $u_{2y} = -10\sin\phi = -8$m/s

Since impact force is only along x- direction, y components of velocities remain unchanged.

$v_{1y} = u_{1y} = 4$ m/s and $v_{2y} = u_{2y} = -8$ m/s.

Conservation of momentum in x-direction gives and coefficient of restitution

$v_{1x} = -5/3$ m/s and $v_{2x} = 10/3$ m/s

and $\theta = \tan^{-1}(v_y/v_x) = -12/5$ indicates that

sphere 1 moves at 113° to x-axis and sphere 2 moves at 67° (in 4th quadrant) to x-axis after collision.

## F : Gravitation

**15.** Angular momentum is conserved in motion under central force and as per Kepler's law area velocity is constant, i.e. $r^2\dot{u}$ (at perigee) = $r^2\dot{u}$ (at apogee) = constant

$$\therefore r_p^2\omega_p = r_a^2\omega_a .$$

If *a* is the semi-major axis of earth's orbit, then $r_p = a(1-e)$ and $r_a = a(1+e)$

$$\frac{\omega_p}{\omega_a} = \left(\frac{1+e}{1-e}\right)^2 = 1.0691 \text{ since } e = 0.0167.$$

If $\dot{u}$ is the mean angular speed of the sun (1°) per day) then it corresponds to mean solar day.

$$\therefore \left(\frac{\omega_p}{\omega}\right)\left(\frac{\omega}{\omega_a}\right) = 1.0691$$

$$\therefore \left(\frac{\omega_p}{\omega}\right) = \left(\frac{\omega}{\omega_a}\right) = 1.034$$

$\dot{u}_p = 1.034^o$ per day and $\dot{u}_a = 0.967°$ per day.

If we consider 361° rotation of earth for 1 day then at perigee day is 8.1" longer and at apogee it is 7.9" smaller.

This does not explain the actual variation of length of the day during the year.

**16.** $r_a = a(1+e) = 6R$ *and* $r_p = a(1-e) = 2R$
$\Rightarrow e = ½$

Angular momentum at perigee = Angular momentum at apogee

$mv_p r_p = mv_a r_a \qquad v_a = (1/3)v_p$

Energy at perigee = Energy at apogee

$$\frac{1}{2}mv_p^2 - \frac{GM}{r_p} = \frac{1}{2}mv_a^2 - \frac{GM}{r_a}$$

$$\therefore v_p \frac{2GM\left[\frac{1}{r_p} - \frac{1}{r_a}\right]^{½}}{\left[1-\left(\frac{v_a}{v_p}\right)\right]^2} = \left[\frac{\frac{2GM}{R}\left[\frac{1}{2}-\frac{1}{6}\right]}{\left[1-\frac{1}{9}\right]}\right]^{½}$$

$$\sqrt{\frac{3GM}{4R}} = 6.85 \; km/s$$

$v_a = 2.28$ *km/s*

For $r = 6R$, $\quad V_c = \sqrt{\frac{GM}{6R}} = 3.23 \; km/s$

Thus transfer of orbit requires $\Ä v = 0.95$ *km/s,* can be achieved by firing rockets from the satellite.

## G : Waves

### 17. Stationary Waves

Incident wave : $y_1 = A\cos(ax + bt)$

(i) comparing this with $y = a\cos(2\pi nt - 2\pi x/$

we get, frequency $n = b/2p$ and wavelength $l = 2\pi/a$

(ii) Reflected wave: $y_2 = 0.8A\cos(ax - bt + \pi)$

Intensity of the reflected wave is 0.64 times and hence amplitude is 0.8 times that of the incident wave. Sign change due to reflection and additional phase of $\pi$ due to reflection on denser surface.

(iii) Particle speeds are *dy/dt* and will be maximum at antinodes and minimum at nodes.

### 18. Beats

$w_2 - w_1 = 10^3 Hz$ Beat frequency

(i) $T = (w_2 - w_1)^{-1} = 1$ ms Beat period.

(ii) $y_1 = A \sin 2\pi w_1 t$ and $y_2 = A \sin 2\pi w_2 t$.

Resultant wave $y = y_1 + y_2 = R \cos 2\pi[(w_1 + w_2)/2]\, t$

where $R = 2A \sin \pi(w_2 - w_1)\, t$.

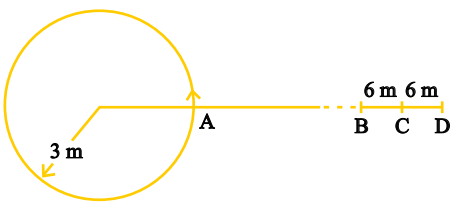
For detector response $I \geq 2A^2$ or $R \geq \pm\sqrt{2}\, A$.

This is when $\sin \pi(w_2 - w_1)\, t = \pm 1/\sqrt{2}$

$\pi(w_2 - w_1)\, t = \pi/4, 3\pi/4, 5\pi/4, \ldots$

Therefore, detector remains idle for $\Delta t = T/2 = 1/2(w_2 - w_1) = 0.5$ ms

**19. Doppler Effect**




Detector is far away from the source and hence radius of the signal becomes insignificant.

Both source frequency of circular motion and detector frequency of SHM are identical.

Source is at A (no longitudinal motion) when detector is at B (at momentary rest) and hence no Doppler shift.

When Detector is at C moving towards D, source is also moving away, hence minimum frequency get recorded: $n_{\min} = n_o \dfrac{(v - u_{\text{detector}})}{(v + u_{source})}$

When Detector is at C moving towards B, source is also moving towards hence maximum frequency get recorded:

$$n_{\max} = n_o \frac{(v + u_{\text{detector}})}{(v - u_{source})}$$

* Source unknown

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# EVOLUTION OF MALARIA PARASITE AND THE EXPANSION OF ANTIGENIC GENE FAMILIES IN THE *PLASMODIUM FALCIPARUM*

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Gene families are groups of homologous genes that are likely to have highly similar functions. Differences in family size due to lineage-specific gene duplication and gene loss may provide clues to the evolutionary forces that have shaped *Plasmodium* genomes. Here, we analyse the antigenic gene families located in the whole genomes of *Plasmodium falciparum*. In total, we have taken three antigenic gene families *Rifin*, *Stevor* and *Var* gene family.

The *var*, *rifin* and *stevor* multigene families are the largest gene families so far identified in *P. falciparum*, these genes of *P. falciparum* play very essential role in host cell modification by expressing on the surface of infected red blood cells. All the three gene families have also been identified to provide virulence of pathogen in disease progression as protein coded by these genes help the parasite to cope up with host immune system. These gene families also responsible for cytoadherence and rosetting mechanism caused by parasite in host blood stream and provide severity to disease. These antigenic gene families are rapidly evolving but the understanding on their evolutionary pattern is still limited. Here, we are trying to find out the pattern of differential evolution of all three gene families by identifying footprints of evolutionary process that have occurred in these gene families. The process may be gene conversion, gene recombination and gene duplication that have taken place in these gene families for their evolution.

## Introduction

Malaria has a massive impact on human health. It is the world's second biggest killer after tuberculosis. Around 300 million clinical cases occur each year resulting in between 1.5 - 2.7 million deaths annually, the majority in sub-saharan Africa. It is estimated that 3,000 children under the age of five years fall victim to malaria each day. Around 40 per cent of the world's population is at risk and it is not known how this might be affected by possible climate change. The societies and economic development of some of the world's poorest nations are severely affected by malaria. Efforts in the direction of its eradication could not achieve much success despite of collective global contributions from scientific research, administration, medical healthcare departments and social activities. The disease progressed as a result of interaction between the three taxa— the host-Human, the vector-Mosquito and the parasite-*Plasmodium* species. Humans can be infected by four species of *Plasmodium* parasites: *Plasmodium falciparum*, *Plasmodium vivax*, *Plasmodium ovale* and *Plasmodium malariae*. Of these, *Plasmodium falciparum* known to cause the most severe form of malaria, can cause cerebral malaria which may lead to death.

This article attempt to develop a scientific and indepth understanding of the expansion of malaria and its parasite. To a certain extent, it will also attempt to answer the question of "Why the researchers are not able to overcome this disease properly?" or "Why the parasite is out of the reach of our medical science at certain stages?". This article is attempts to develop a scientific and indepth understanding of "the expansion of malaria and its parasite", among the biology students.

## Life Cycle of Malaria Parasite

The life cycle of malaria parasite is completed in two phases, sexual phase of its life within the vector and the asexual phase in the host. The whole life cycle of the parasite comprises of four main stages i.e. the sporozoite stage, the trophozoite stage, the merozoite stage and the shizont stage. All types of malaria have almost a similar **Life cycle** (Fig. 1). Sporozoites, the infectious form of the malaria parasite, are injected into a human host through the saliva of an *Anopheles* mosquito. These **sporozoites** enter the liver cells. It takes a new form, and multiply. When the liver cells rupture, blood stage parasites known as **merozoites** are released. Each merozoite invades red blood cell, and multiplies into more merozoites. The red blood cell full of merozoites ruptures to release more merozoites. It is the stage of the life cycle that causes disease. Some merozoites change into the form called **gametocytes,** which do not cause disease but remain in the blood until they are cleared by drugs or the immune system, or taken up by the bite of a mosquito. In the mosquito's stomach a "male" gametocyte fertilizes a "female" to form oocyst, which matures into thousands of sporozoites that swim to the mosquito's salivary glands to be injected into another human at the next bite.

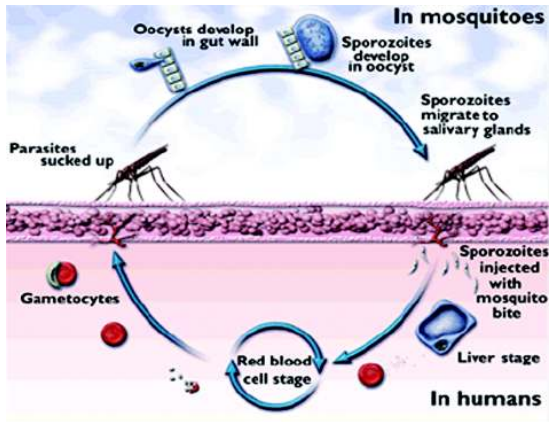


*Fig. 1: Life cycle of* Plasmodium *species*

A sudden uncontrollable attack of fever is the hallmark of malaria. It occurs when infected RBCs rupture and release parasite-derived molecules that stimulate the production of proinflammatory cytokines (it is a protein released by the cells in human immune system that help to regulate our immune response) by the host. After a few cycles, some merozoites develop into sexual stages known as gametocytes. When gametocytes are taken up by feeding *Anopheles* mosquitoes, they mature into male and female gametes and unite to form a zygote in the midgut of the vector. The zygote is the sole diploid stage of malaria parasites; the only meiosis event during this life cycle occurs within a few hours of zygote formation, eventually generating infective sporozoites, which migrate to the salivary glands.

## Evolution of Malaria Parasite

Malaria remains a huge global health burden, infecting hundreds of millions of people each year. Despite a significant immune response by the host, the parasite can establish long-lasting chronic infections. When the parasite is inside the RBC, it has two main functions to serve: one is to reproduce itself and the other is to not get destroyed. Reproducing is relatively easy because the RBC provides all the nutrients (such as amino acids in haemoglobin and other proteins) required for replication. Not being destroyed by the immune system is more difficult. The RBC acts as a shield to any antibody because an antibody cannot recognise the parasite. But when *Plasmodium* parasite enter the RBC, it induces modifications on the surface of the infected Red Blood Cell (RBC) with the help of certain proteins. Due to changes on the surface of RBC, the ability of parasite to avoid host immunity is increased, which may contribute to pathology.

In the human parasite *Plasmodium falciparum*, proteins encoded by parasite which are of three multigene families: var, stevor and rif, have been shown to be exposed on the surface of the RBC. The gene families are the group of genes that code protein of a similar or almost similar function. The proteins coded by these gene families provide the antigenic variation properties to the parasite for successful escape from the host immune system. Thus, these gene families were considered to be rapidly evolving in order to resist with the varying response from host immune system. However, the evolutionary processes responsible for expansion and evolution of these gene families still remain unclear. Understanding the evolutionary pattern of these gene families is very crucial for the development of better antimalarial treatment and intervention strategies.

### 3.1 Antigenic Gene Families of *Plasmodium* Parasite which are Highly Involve in Malaria

Among all the three antigenic gene families, the var genes encode for the *P. falciparum* Erythrocyte Membrane Protein 1 (*PfEMP1*) proteins. The genes are found in the subtelomeric regions of the chromosomes. There exist an estimated 60 var genes within the genome. The proteins encoded by the var genes are ultimately transported to the erythrocyte membrane and cause the infected erythrocytes to adhere to host endothelial receptors. Due to transcriptional switching between var genes, antigenic variation occurs which enables immune evasion by the parasite. The rif genes encode for repetitive interspersed family (rifin) proteins. The genes are found in the subtelomeric regions of the chromosomes. There exist an estimated 149 rif genes within the genome. Rifin proteins are ultimately transported to the erythrocyte membrane. The function of these proteins is currently unknown. The stevor genes encode for the subtelomeric variable open reading frame (stevor) proteins. The genes are found in the subtelomeric regions of the chromosomes. There exist an estimated 28 stevor genes within the genome. The function of the stevor proteins is currently unknown. All these gene families have been expanding and evolving rapidly in the genome of *Plasmodium falciparum*. Although, gene families were considered to be evolved due to the action of several evolutionary forces like gene conversion, recombination and duplication,

the presence of any such evolutionary event have not been detected so far in antigenic gene families of most devastating *Plasmodium falciparum,* which has provided high severity and pathogenecity to *Plasmodium falciparum*.

Now the question arises that how these antigenic gene families are expanding and evolving in the genome of *Plasmodium falciparum*. Thus, it is necessary to understand the evolutionary pattern of these antigenic gene families. The major evolutionary events that are considered to be responsible in expansion and evolution of gene families of *Plasmodium falciparum* are gene conversion, gene recombination, gene duplication, etc. If we know about the pattern of the evolution of these antigenic gene families then we can easily find the solution of the disease at every stage of the parasite's life cycle.

### 3.2 Evolutionary Forces

These are the events which are responsible for the diversification of all organisms from a common ancestor. These events may be gene recombination, gene conversion and gene duplication. So it is necessary to know about gene recombination, gene conversion and gene duplication before going through the study of evolution of antigenic gene family in *Plasmodium falciparum*.

**Genetic recombination** (Fig. 2) is a process by which a molecule of nucleic acid is broken and then joined to a different DNA molecule. Recombination can occur between similar molecules of DNA, as in homologous recombination, or dissimilar molecules of DNA as in non-homologous end joining. Recombination is a common method of DNA repair in both bacteria and eukaryotes. In eukaryotes, recombination occurs in meiosis as a way of facilitating chromosomal crossover. The crossover process leads to offspring having different combinations of genes from their parents and can occasionally produce new chimeric alleles. In organisms with an adaptive immune system, a type of genetic recombination called somatic recombination helps immune cells rapidly diversify and adapt to recognise new pathogen (Stacey, 1994). The similar mechanism of recombination might also have been adopted by *Plasmodium falciparum* in order to produce the diverse antigenic gene families.

The second one evolutionary event responsible for evolution of gene families is the Gene conversion (Fig. 2) which is a non-reciprocal transfer of genetic information. It is a process by which DNA sequence information is transferred from one DNA helix (which remains unchanged) to another DNA helix, whose sequence is altered. It is one of the ways a gene may be mutated. The expression of different rifin, var and stevor changes the antigenic properties of the infected RBC, indicating a potential role of these gene families in antigenic variation.

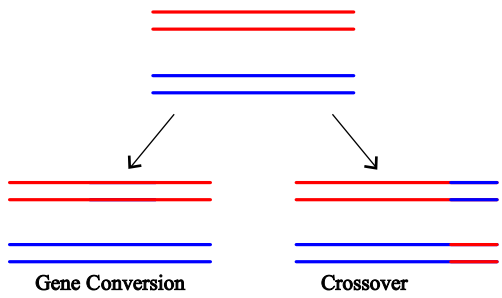


*Fig. 2: Process of Gene conversion and crossover*

The last event is Gene duplication (Fig. 3) which may also be responsible for the expansion of antigenic gene families. Duplication is the opposite of a deletion. Duplications arise from an event termed unequal crossing-over that occurs during meiosis between misaligned homologous chromosomes.

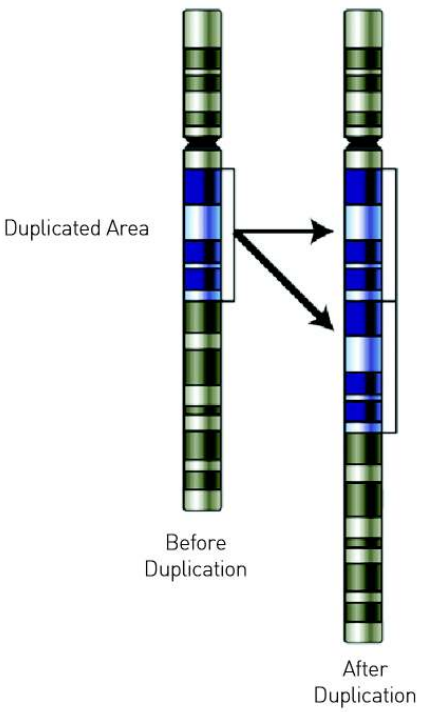


*Fig. 3: Process Gene Duplication*

The chance of this happening is a function of the degree of sharing of repetitive elements between two chromosomes. The product of this recombination is duplication at the site of the exchange and a reciprocal deletion. Duplication of a region of DNA that contains a gene; may occur as an error in homologous recombination, a retro transposition event or duplication of an entire chromosome. Thus it accumulates mutations faster than a functional single-copy gene, over generations of organisms.

## Breaking the Malaria Cycle with the Vaccines

As we know that malaria is caused by parasites of the genus *Plasmodium* that kills an estimated 1–3 million people each year. Among the four *Plasmodium* species that infect humans, *Plasmodium falciparum* causes most malaria mortality. The overwhelming burden of malaria and the appearance and spread of drug-resistant parasites has focused attention on the development of malaria vaccines for this species. Although vaccines targeting all stages of the *Plasmodium* life cycle have been proposed (Fig. 4), the symptoms and pathology of malaria are caused by the erythrocytic stage, during which *Plasmodium* merozoites invade and then develop within erythrocytes, culminating in erythrocyte lysis and the release of daughter merozoites. Merozoite proteins that function in the recognition and invasion of erythrocytes are therefore, being intensively studied as vaccine candidates.

Studies of how erythrocyte invasion proteins diverge between *Plasmodium* isolates is an important step in assessing their utility as vaccine candidates, and can provide evidence of the selection and functional pressures acting on specific sub-domains (Rayner *et al.*, 2005). So it is necessary to know about the evolution of all those gene families which are responsible in pathogenesis.

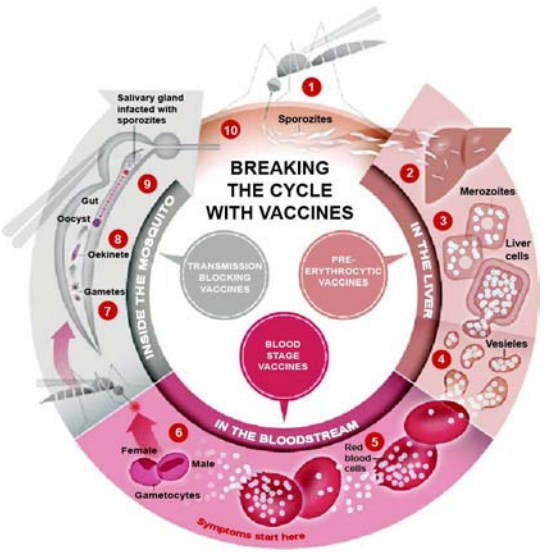


*Fig. 4: Breaking the malaria cycle with the vaccines*

## Parasite Play a Role to Modify the Surface of Red Blood Cells: the Main Cause of Evolution of Antigenic Gene Families

Basically there are var, stevor and rifin, three gene family play the antigenic role. They have the ability to evolve much rapidly. Modifications of the *Plasmodium falciparum*–infected red blood cell surface have been linked to parasite-associated pathology. Such modifications enable the parasite to establish long-lasting chronic infection by evading antibody mediate immune recognition and splenic clearance. With the exception of the well-demonstrated roles of var-encoded *PfEMP1* in virulence and immune evasion, the biological significance of other variant surface antigens (rif and stevor) is largely unknown (Niang *et al.*, 2009).

The asexual stages of *Plasmodium falciparum* modify the surface membrane of the erythrocytes. They infect through insertion of molecules that are highly polymorphic and that undergo clonal antigenic variation. These molecules, termed variant surface antigens (VSA), are immunogenic and induce antibodies that opsonize infected erythrocytes and provide naturally acquired protection against malaria. *Plasmodium falciparum* erythrocyte membrane protein 1 *(PfEMP1),* encoded by the var multigene family, is the best characterised member of the VSA. A larger family of clonally variant molecules expressed by *Plasmodium falciparum* asexual stages, the rifin proteins, has recently been described. Rifins are encoded by the rif (repetitive interspersed family) multigene family and are inserted into the infected erythrocyte surface membrane (Mohmed *et al.*, 2007).

*PfEMP1* and rifin proteins are considered key virulence factors in *Plasmodium Falciparum.* The *PfEMP1*, rifin and stevor proteins are encoded by members of the *var, rif* and *stevor* gene families, respectively. As a measure of the significance of these genes to parasite survival, *Plasmodium falciparum* genome is committed to the expression and generation of diversity of these virulence genes. This includes the genes themselves— a total of 60 *var*, 149 *rif* and 28 *stevor* genes— as well as intergenic (regulatory) regions and non-coding subtelomeric repeat regions thought to contribute to diversity and transcriptional control of the neighbouring virulence genes.

The expression of variant antigens on the surface of infected RBCs is an additional strategy of immune evasion used by all *Plasmodium species*

so far studied. At a first glimpse, the expression of foreign antigens on RBCs, which are devoid of major histocompatibility complex molecules and which thus represent the ideal hideout for intracellular organisms, seems a disadvantage for the parasite's survival in the presence of a competent immune system. However, this may be an intrahost mechanism used to control parasite populations, since rapid parasite multiplication would kill the host in a very short time, decreasing the chances of transmission to mosquitoes (Paget-McNicol *et al.*, 2002). At least two *Plasmodium falciparum* variant antigens are expressed on the surface of infected RBCs: *Plasmodium falciparum Erythrocyte Membrane Protein 1* (PfEMP-1), encoded by var genes, and Repetitive Interspersed Family Proteins (RIFINs), encoded by rif genes. Members of a third family of variant antigens, encoded by stevor (*subtelomeric variant open reading frame*) genes, were recently found to be associated with Maurer's clefts, a parasite-derived tubular network that is present in the cytoplasm of infected RBCs. These clefts are thus not directly exposed on the RBC surface (Kaviratne *et al.*, 2002), although they may become visible at the late schizont stage due to augmented access of antibodies to the cytoplasmic structures of infected RBCs (Hui and Siddiqui, 1988). These three proteins are encoded by multigene families, and most members of each family are located in the subtelomeric regions of chromosomes.

Evolution is commonly observed for gene families which originated a long time ago, however, there are many different types of multigene families, from uniform to diverse. The rate of homogenization by unequal crossing-over, gene conversion, etc., has been evolutionarily adjusted for each gene family. When new functions are needed by organisms, gene families may evolve into superfamilies, in which no further concerted evolution takes place, and each member of the family may acquire an indispensable function (Ohta, 1990). In eukaryote genomes, there are many kinds of gene families. Gene duplication and conversion are sources of the evolution of gene families, including those with uniform members and those with diverse functions. Population genetics theory on identity coefficients among gene members of a gene family shows that the balance between diversification by mutation, and homogenization by unequal crossing-over and gene conversion, is important. Also, evolution of new functions is due to gene duplication followed by differentiation (Ohta, 2000). So it may be possible that antigenic gene families of *Plasmodium falciparum* (most severe form of malaria in human) is evolved by any kind of evolutionary force that may be gene conversion, gene duplication or gene recombination. And for the cure of this disease, it is necessary to study how fast any antigenic gene family is evolved and which kind of evolutionary force is responsible for that evolution.

# TEACHING THE NATURE OF SCIENCE : RESTRUCTURING SCIENCE INSTRUCTION

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## Introduction

In recent past, three important trends in Science Education have been identified. First, research has indicated that all students are capable of learning science and therefore, must be given the opportunities for optional science learning. Science is for All. And curriculum content must be designed to meet the varying abilities, interests, experiences, understanding and knowledge of students (NSES, 1996). An equitable science curriculum is one in which both the content and pedagogy are inclusive to all students. The term inclusive is used to describe curriculum that by its nature and the ways it is offered, includes all students. Contemporary science education is for equity, equality and inclusiveness.

Second, scientists use scientific inquiry to search new knowledge in science. Therefore, understanding the meaning and importance of scientific inquiry is useful for teaching science. Scientific inquiry includes processes of science but it also includes combining these processes with scientific knowledge, nature of science, critical thinking and scientific reasoning. Scientific inquiry also includes knowledge about inquiry. Learning through scientific inquiry involves hands-on and minds-on activities, using processes of science and cognitive processes. Since 1990s science education has been moving

towards an inquiry-based constructivism. Learning is the result of ongoing changes in our mental framework as we attempt to make meaning out of our experience. Inquiry is a fundamental component of effective science teaching and learning. Inquiry-based learning allows students to make connections between the classroom experiences and their personal life which facilitate an understanding of the nature of science.

Third, traditionally school science teaching has ignored exploration of the nature of science. It is considered to be either largely irrelevant to its contemporary practice, or to best acquired *en passant*. Hence, pedagogy of school science has tended to be didactic, authoritarian and non-discursive with little room for active learning or development of critical reasoning. In addition, science teachers, the product of the standard model of science education, often have naive views about the nature of science. Teaching the nature of science rather than teaching science content will require a significant change in its mode of teaching. Research on cognitive learning, neuroscience and constructivist epistemology asserts that learning occurs being active, through senses in the brain. Consequently, the science educators have accepted inquiry-based constructivism as a method of teaching science.

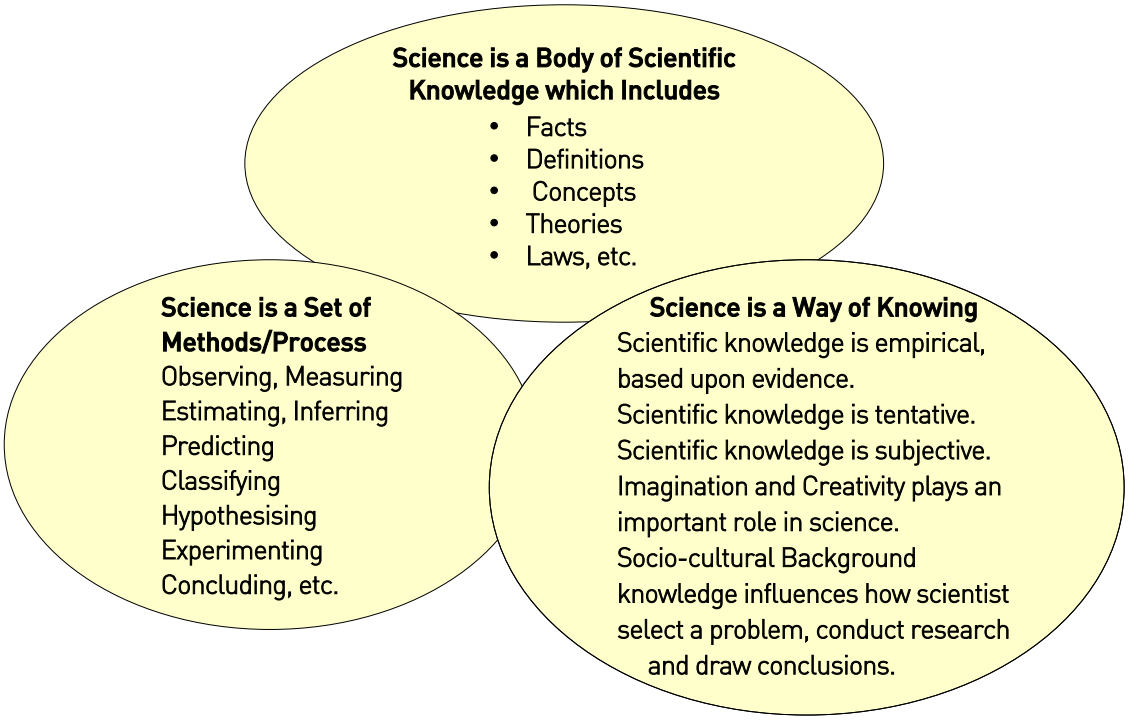
In this paper an attempt has been made to search a relationship among the nature of science, use of scientific inquiry in learning and constructivism. 'Many researchers agree that encouraging students' understanding of the nature of science, its presuppositions, values and aims and limitations of science should be a central goal of science teaching.'

## What is the Nature of Science ?

In the early years of science, the system of acquiring knowledge was viewed as completely objective, rational and empirical. The findings were conclusively based on objective data; this was supposed to be done through 'the scientific method'. People believe that scientists certainly use a universal step-by-step method because they need to get proof for their research from other scientists. The belief that there is a universal scientific method is a misconception. Scientists use multiple methods, such as observing, experimenting and hypothesising. Furthermore, scientists use different ways for the same problem in the same field.

Similarly, science is, however, a human endeavour and subject to personal prejudices, misapprehensions and bias. Scientists are also human beings who live in a society. Therefore, they have their own social and cultural background. And these values certainly affect research they do.

Along with awesome responsibility to teach science content and scientific inquiry comes a responsibility to develop an understanding of the nature of science. Nature of science has been defined in different ways from time to time. In general, nature of science consist of concepts of science, facts, principles of science which comprises a body of knowledge. It also includes processes of science, a way of constructing knowledge about the natural world; including social perspective of science and socio-scientific issues. Finally it includes values of science.




*Diag. 1: Different elements of the nature of science*

## Consensus View Regarding the Nature of Science

It is not easy to arrive on a conclusion regarding defining the nature of science and scientific inquiry. Lederman (1992) notes that the nature of science is neither universal nor stable. 'Typically, nature of science refers to the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge'.

Science education documents have demonstrated that there is a high degree of agreement about the elements of the nature of science that should be communicated to students. First element of nature of science is that scientific knowledge is empirical in nature. It means that science is based on observations of natural world, and validity of scientific claims is provided by referring to observations of nature.

The second element of the nature of science is that scientific knowledge is durable but tentative. It points out the forms of scientific knowledge such as, facts, principles, laws are subject to change. Such changes are based on new evidences, reinterpretation and advances in thinking and changes in cultural and social milieu. 'In addition to all of those factors, logical approaches also lead to changes.'

Third, nature of science necessarily involves human inference, imagination and creativity. The role of creativity and imagination in the construction of scientific knowledge has been acknowledged by most of the researchers. Creativity and imagination are thought to be involved in designing research or experimental procedures and generating new ideas.

Fourth element is the use of a scientific method in research. The scientific method is perceived as a universal step-by-step method, used by scientists in searching new knowledge or solving problems. It is a misconception. No single set and sequence of steps, known as scientific method exists. Scientists use a multitude of procedures and methods. These methods and procedures differ between and within scientific disciplines.

Fifth element is subjectivity in scientific work. Researchers believe that subjectivity plays a major role in the development of scientific ideas. Scientists' beliefs, prior knowledge, training, experiences, and expectations actually influence their work and what they observe, how they make sense of interpretations of their observations means that science is not objective. Sixth element is that science socially and culturally embedded. The social and cultural influences on scientific enterprise are explicitly recognised by researchers. Science is a social enterprise or a form of human, cultural activity. Consequently, society influences science, sometimes funding sources influence science.

## What is Scientific Inquiry?

Scientific inquiry is the process scientists use to learn about the natural world. Students can also learn about the world using inquiry. Although they rarely discover knowledge that is new to mankind. Recent research has indicated that students engaged in inquiry, discover new knowledge.

Scientific inquiry extends beyond science processes such as, observation, measurement, classification, questioning experimentation, analysing data, inferring and predicting. Lederman and Lederman (2006) has observed that scientific inquiry includes traditional science processes, but also refers to the combining these processes with scientific knowledge, scientific reasoning and critical thinking to develop scientific knowledge. In addition to doing inquiry, the phrase scientific inquiry, also refers to knowledge about inquiry. It is expected that all students understand the rationale of an investigation and able to analyse critically the claims gained from such research. Use of scientific inquiry is that the misconception of the use of step-by-step scientific method in research is not an accurate representation of the process of scientific research. As a general approach, scientific inquiry is based on research questions, guides, in searching answers and is varied in approach very widely within and across scientific disciplines.

Inquiry takes different forms but investigations begin with a question, conclusions are based on the analysis of data, obtained to that particular investigation. Inquiry can be perceived in different forms. First, it can be viewed as a set of inquiring skills to be learned by students and combined in the performance of a scientific investigation. Second, inquiry can be viewed as a cognitive outcome that students are to achieve. Third, inquiry can be considered as a teaching model

that places students in situations very similar to those scientists experience during their daily work. In this sense, scientific inquiry communicates scientific knowledge to students or provides situations to students to construct their own knowledge. Together, scientific inquiry and nature of science are intimately related. Scientific inquiry is used to search scientific knowledge about the natural world. The knowledge result from this approach to knowing has certain unavoidable characteristics. These characteristics are what commonly referred to as the Nature of Science (Lederman and Lederman, 2006).

Scientific inquiry refers to methods and activities that leads to the development of scientific knowledge. Further, the idea of 'inquiry based' learning emerges directly from the notion of nature of science (Matson and Parsons, 1998). Since scientists search new ideas by doing 'science', it follows that students should be able to do the same (Martin and Hansen, 2002).

Science is a process of inquiring into the nature of universe. Because the very essence of science is to ask questions, science teaching should be inquiry-based. It is a way to seek information and an understanding of the concepts of science. The student should be the person doing most of the work, that is, inquiry-based teaching should be student-centered (Masson and Parson, 2006). Learner-centered learning is in agreement with the nature of constructivism. Recent reform efforts stress the importance of developing images of science that are consistent with current scientific practices and constructivist perspectives. Similarly, conceptions of nature of science strongly emphasise the use of inquiry in science instruction (NRC, 1996, Schwab, 1962). Scientific inquiry may provide a viable context for discussion and reflection within which learners can develop nature of science conceptions.

Basically, an understanding of the nature of science and an ability to learn through scientific inquiry is a requirement to teach science effectively. Teaching facts of science and memorisation of science knowledge is not sufficient, science teachers need to understand the thinking and behaviour of scientists. They must be able to do science. With a basic background in science and with an ability to carry out processes of science, science teachers can teach science as a conceptually-oriented, hands-on, problem-solving activity which enhances critical thinking among learners. Lederman (1998) has urged that a functional understanding of the nature of science or scientific inquiry is best facilitated through an explicit reflective practice.

## Constructivism in Science Education

It appears that both the nature of science and inquiry-based instruction are part of positivist view of knowledge. But the emergence of constructivism as a view of learning as well as knowing has been accepted as a paradigm shift in science education. Constructivism is a philosophy of learning. It is also an epistemology of knowledge. It is based on the premise that humans construct knowledge to make understanding of their world. What knowledge they construct is influenced by the senses and the mental images they carry in their mind. This is a major conceptual change from objectivist view of

absolute knowledge to the view that knowledge is constructed individually and mediated socially. Constructivist view is potentially more sensitive to the needs of a diverse student population, they need to understand two basic tenets of constructivism. First, constructivism is a philosophical view on how knowledge is acquired or constructed. In this situation nature of science and inquiry-based instruction is pre-adapted to constructivism. Second, knowledge is constructed by individuals to make sense of their world. Knowledge is acquired by our senses and mental images we carry in our mind. These mental images facilitate what and how we learn. Teachers need to bring these two understandings in the classroom. This leads to constructivism-based inquiry.

## Reconstructing Science Instruction

Research has proved that students as well as science teachers possess inadequate understanding of the nature of science. Much cognitive science research has been used to support a new model of learning. This model is called the Constructivist Learning Model. Cognitive science has undertaken the study of mental processes used to acquire, store, process and use of knowledge. Essential to any such theory of learning is cognition. As theory of epistemology, constructivism plays a central role in cognitive science. Starting from constructivism, learning can occur only when the learner is engaged in operating on or mentally processing, incoming stimuli. The interpretation of stimuli depends upon previous knowledge. It means, knowledge is constructed by the learner and prior knowledge impacts the learning process. All learning is dependent upon language and communication. Learning is influenced by social interactions with other humans. It means, learning always takes place in social context.

**Constructivist Learning Model**

Introduction – Engage students in activities: dialogue discussion.
↓

Explore – Students explore through experimentation, questions.
↓

Explain – Search new ideas through interaction and engage in meaning making.
↓

Expand – Expand this knowledge through knowledge construction. Reflection.
↓

Evaluate – Evaluate during the process of learning : formative evaluation.

Instructional design must be based on some theory of learning and cognition. In this paper we have taken inquiry-based constructivism as a theory of learning and relevant pedagogy has been drawn from constructivism, which leads to experiential learning.

## Summary

Recent research has transformed our understanding of science, its relationship with the contemporary socio-scientific issues and environmental concerns, climate change, sustainable development. Further, research on the understanding of nature of science is quite clear that students come to understand the nature of science through explicitly integrating content of science with scientific inquiry using constructivist perspectives of learning. In constructivist science

instruction, the focus is on students and student-centered pedagogy. Since 1990s, science education has been moving towards an inquiry-based constructivism. Learning is the result of ongoing changes in our mental framework as we attempt to make meaning out of our experience.

Inquiry is a fundamental component of effective science teaching and learning. Scientific inquiry-based instruction allows students to make connections between the classroom experiences and the outside world. Research shows that students learn science best by engaging in hands-on and minds-on lessons through an inquiry-based curriculum. Scientific inquiry can be considered as a teaching approach that places students very similar to those of scientists. In this sense, scientific inquiry allow students to construct their own knowledge. Together scientific inquiry and the nature of science are intimately related. Learning about the nature of science involves about the knowledge of science, its goals, methods and values. Understanding of the nature of science as a way of knowing, or values, ideals or beliefs inherent in the development of scientific knowledge reflect several characteristics that are unique to science such as, scientific knowledge is based on empirical evidence. It is a product of both observation and inference, scientific knowledge is tentative, human imagination and creativity are vital in exploring the natural world. Scientific knowledge is culturally and socially embedded, scientific knowledge is subjective and there is no sequential, step-by-step universal single method. Constructivist learning implies an initial concern with what knowledge is and how knowledge is actively constructed by the learner. Understanding of the nature of science can be achieved through the performance of scientific inquiry or investigation or inquiry-based constructivism and reflection.

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# SCIENCE NEWS


## The Future of Plant Science: A Technology Perspective

Plant science is key to addressing the major challenges facing humanity in the 21st Century, according to Carnegie's David Ehrhardt and Wolf Frommer. In a Perspective published in *The Plant Cell*, the two researchers argue that the development of new technology is key to transforming plant biology in order to meet human needs.

Plants serve as the conduit of energy into the biosphere, provide food and materials used by humans and they shape our environment. According to Ehrhardt and Frommer, the three major challenges facing humanity in our time are food, energy and environmental degradation. All three are plant related.

All of our food is produced by plants, either directly or indirectly via animals that eat them. Plants are a source of energy production. And they are intimately involved in climate change and a major factor in a variety of environmental concerns, including agricultural expansion and its impact on habitat destruction and waterway pollution.

What's more, none of these issues are independent of each other. Climate change places additional stresses on the food supply and on various habitats. So plant research is instrumental in addressing all of these problems and moving into the future. For plant research to move significantly forward, Ehrhardt and Frommer say technological development is critical, both to test existing hypotheses and to gain new information and generate fresh hypotheses. If we are to make headway in understanding how these essential organisms function and build the foundation for a sustainable future, then we need to apply the most advanced technologies available to the study of plant life, they say.

They divide the technology into three categories: existing technology that isn't being applied for all

of its potential uses; new, readily envisioned technology and technology we'd like to have, but don't know how to create.

The technological overview includes expanding existing technologies such as DNA sequencing, RNA cataloguing, mass spectroscopy, fluorescence-based microscopy, and electron microscopy, among many others. A key focus is on the advances possible through advanced imaging technologies.

Ehrhardt and Frommer point out that many of the most often-cited academic papers related to the development of new technology, demonstrating the interest of the scientific community. "We certainly expect that new technologies will continue to revolutionise biological research," they say. "Plant science has not often been the driver of innovation but often enough has profited from developments made in other areas."

## Lifestyle Choices Made in your 20s can Impact your Heart Health in your 40s

Maintaining a healthy lifestyle from young adulthood into your 40s is strongly associated with low cardiovascular disease risk in middle age, according to a new Northwestern Medicine study.

"The problem is few adults can maintain ideal cardiovascular health factors as they age," said Kiang Liu, first author of the study. "Many middle-aged adults develop unhealthy diets, gain weight and aren't as physically active. Such lifestyles, of course, lead to high blood pressure and cholesterol, diabetes and elevated cardiovascular risk."

Liu is a professor and the associate chair for research in the department of preventive medicine at Northwestern University Feinberg School of Medicine.

"In this study, even people with a family history of heart problems were able to have a low cardiovascular disease risk profile if they started living a healthy lifestyle when they were young," Liu said. "This supports the notion that lifestyle may play a more prominent role than genetics."

Published in the journal *Circulation*, this is the first study to show the association of a healthy lifestyle maintained throughout young adulthood and middle age with low cardiovascular disease risk in middle age.

The majority of people who maintained five healthy lifestyle factors from young adulthood (including a lean Body Mass Index (BMI), no excess alcohol intake, no smoking, a healthy diet and regular physical activity) were able to remain in this low-risk category in their middle-aged years.

In the first year of the study, when the participants' average age was 24 years old, nearly 44 per cent had a low cardiovascular disease risk profile. Twenty years later, overall, only 24.5 per cent fell into the category of a low cardiovascular disease risk profile.

Sixty per cent of those who maintained all five healthy lifestyles reached middle age with the low cardiovascular risk profile, compared with fewer than 5 per cent who followed none of the healthy lifestyles.

Researchers used data collected over 20 years from the Coronary Artery Risk Development in (Young) Adults (CARDIA) study. It began in 1985

and 1986 with several thousand 18 to 30 years olds and has since followed the same group of participants.

For this study, the researchers analysed data such as blood pressure, cholesterol, blood sugar, BMI, alcohol intake, tobacco use, diet and exercise from more than 3,000 of the CARDIA participants to define a low cardiovascular disease risk profile and healthy lifestyle factors.

If the next generation of young people adopt and maintain healthy lifestyles, they will gain more than heart health, Liu stressed.

"Many studies suggest that people who have low cardiovascular risk in middle age will have a better quality of life, will live longer and will have lower Medicare costs in their older age," he said. "There are a lot of benefits to maintaining a low-risk profile."

The National Heart, Lung and Blood Institute and the National Institutes of Health funded this research.

## When One Side Does not Know about the Other One: Specialisation and Cooperation of the Brain Hemispheres

Whenever we are doing something, one of our brain hemispheres is more active than the other one. However, some tasks are only solvable with both sides working together. Dr Martina Manns and Juliane Römling of the Ruhr-Universität Bochum are investigating, how such specialisations and co-operations arise. Based on a pigeon-model, they are demonstrating for the first time in an experimental way, that the ability to combine complex impressions from both hemispheres, depends on environmental factors in the embryonic stage.

The results of the study are published online in *Nature Communications*.

### Biased light stimulation

Within the egg bird embryos always turn their head in such a way that one eye is turned close to the eggshell, and the other one is covered by the body. This causes an asymmetrical light stimulation, which influences developmental processes in both brain halves. Dr Manns uses this mechanism for her experiment. One group of embryos hatch in a lighted incubator, another one in complete darkness. Afterwards the scientists analyse the degree of interhemispheric communication in both groups. The results show that information exchange is impaired without light stimulation. This research sheds light on the origin of communication processes in the brain. Developmental disorders like ADHD or autism are characterised by a deviating pattern between the two brain halves. Therefore, there is a possibility that the results may help to understand those disorders and give hints for new therapeutic approaches.

### Classification of colour-pairs

To determine how efficient the animals are able to handle incoming information, Manns and Römling confront the animals with a task that can only be solved with both brain hemispheres working together. For that purpose, the two psychologists use colour-pairs of a transitive line(A→B→C→D→E) at which one of the elements is rewarded with food. First the pigeons

have to learn to discriminate the combinations A/B and B/C with one eye, and C/D and D/E with the other one. Afterwards, they can use both eyes to decide between, for example, the colours B/D. However, only birds with embryonic light experience are able to solve this problem.

## First Computer Model of How Buds Grow into Leaves

Leaves come in all shapes and sizes. Scientists have discovered simple rules that control leaf shape during growth. Using this 'recipe', they have developed the first computer model able to accurately emulate leaf growth from a bud.

"A bud does not grow in all directions at the same rate," said Samantha Fox from the John Innes Centre on Norwich Research Park. "Otherwise leaves would be domed like a bud, not flat with a pointed tip."

By creating a computer model to grow a virtual leaf, the BBSRC-funded scientists managed to discover simple rules of leaf growth.

Similar to the way a compass works, plant cells have an inbuilt orientation system. Instead of a magnetic field, the cells have molecular signals to guide the axis on which they grow. As plant tissues deform during growth, the orientation and axis changes.

The molecular signals become patterned from an early stage within the bud, helping the leaf shape to emerge.

The researchers filmed a growing *Arabidopsis* leaf, a relative of oil seed rape, to help create a model which could simulate the growing process. They were able to film individual cells and track them as the plant grew.

It was also important to unpick the workings behind the visual changes and to test them in normal and mutant plants.

"The model is not just based on drawings of leaf shape at different stages," said Professor Enrico Coen. "To accurately recreate dynamic growth from bud to leaf, we had to establish the mathematical rules governing how leaf shapes are formed."

With this knowledge programmed into the model, developed in collaboration with Professor Andrew Bangham's team at the University of East Anglia, it can run independently to build a virtual but realistic leaf.

*Budding leaves. (Credit: John Innes Centre)*

Professor Douglas Kell, Chief Executive of BBSRC said: "This exciting research highlights the potential of using computer and mathematical models for biological research to help us tackle complex questions and make predictions for the

future. Computational modelling can give us a deeper and more rapid understanding of the biological systems that are vital to life on earth."

The model could now be used to help identify the genes that control leaf shape and whether different genes are behind different shapes.

"This simple model could account for the basic development and growth of all leaf shapes," said Fox. "The more we understand about how plants grow, the better we can prepare for our future — providing food, fuel and preserving diversity."

## Developing Sustainable Power

The invention of a long-lasting incandescent light bulb in the 19th century spurred on the second wave of the industrial revolution, illuminating homes, extending leisure time and bringing us to the point today where many millions of people use a whole range of devices from mood lighting to audiovisual media centres, microwave ovens to fast-freeze ice makers, and allergy-reducing vacuum cleaners to high-speed broadband connected computers in their homes without a second thought.

However, the waves of the industrialisation of the west have merely lapped at the shores of undeveloped regions and it is estimated that about a quarter of the world's population, particularly those in rural parts of the developing world do not have access to electricity in their homes. Indeed, four-fifths of those without domestic electricity live in rural or on the urban margins. In sub-Saharan Africa, the proportion is even more startling where just 8 per cent of the rural population has access to electricity.

Those in the developing countries are thus keen to electrify and need stable sources of power to stimulate development and improve their standard of living. The developed world is gradually recognising the environmental costs of widespread electricity use, yet has neither the right nor the authority to deprive the developing nations of power. There is a need, therefore, to provide 100 per cent off-grid zero-energy solutions that require little or no government involvement and are low maintenance. This would allow the developing world to wade into the technology, the developed world enjoys without making the same woefully polluting mistakes regarding unsustainable power generation that are now a global problem.

Benedict Ilozor and Mohammed Kama of the Eastern Michigan University, in Ypsilanti, USA, suggest that renewable energy is a viable option for electrical power in developing and emerging nations. Writing in the inaugural issue of the *African Journal of Economic and Sustainable Development*, they point out that in most of these nations, the demand for energy far exceeds the generating capacity. They suggests that a rapid response to this huge demand that is informed by social, political, economic, climatic and environmental factors must be put in place so that renewable, sustainable energy supply can be identified.

The researchers have undertaken a case study of Nigeria in West Africa, which is perhaps representative of the situation prevalent in most developing and emerging nations. They suggest that cost is the limiting factor and that communities and governments would be unable to subsidise neither the one-time installation

costs nor the ongoing maintenance however low, for most renewable energy solutions. It is, they say up to the private sector and commercial banks, and perhaps charitable organisations, to fund the installation of wind turbines, solar panels and other renewable energy systems so that wealth-generating development can take place and standards of living raised quickly. They posit the idea of a renewable energy mortgage that would be paid back as the specific region developed and grew economically. There are many approaches to solar power, for instance, that could be implemented by individual households or small communities for domestic electricity as well as on a larger scale, while geothermal systems could be run to provide the power for cooling.

## Predicting Children's Language Development

We depend on a barrage of standardised tests to assess everything from aptitude to intelligence. But do they provide an accurate forecast when it comes to something as complex as language? A study by Diane Pesco, an assistant professor in Concordia's Department of Education, and co-author Daniela O'Neill, published earlier this year in the *Journal of Speech, Language, and Hearing Research*, shows that the Language Use Inventory (LUI) does.

Developed by O'Neill at the University of Waterloo, the LUI assesses the language of children 18 to 47 months old. In answering a series of questions, parents reveal how their children use language in various situations, including interacting with others, playing and communicating about the world around them. Children's scores can then be compared to those of hundreds of other children the same age from across Canada. In fact, the test is currently used in eight provinces in Canada, 30 states in the U.S., as well as in the U.K., Ireland, Australia and New Zealand.

When Pesco and O'Neill began their study, O'Neill had already established that the LUI can accurately assess a child's current language ability, but the measure's relative novelty meant that its ability to accurately predict how toddlers would fare as they blossomed into youngsters could not be assessed until now.

Pesco, who is also a certified speech-language pathologist, was eager to see if the LUI results would hold down the line and perhaps result in fewer false positives than other measures of young children's language.

"False positives," Pesco explains, "means that a measure identifies a child as having a language delay or problem when, in fact, he or she does not. That's a problem, since services for children with true delays are already overtaxed and have long waiting lists. False positives can also lead parents to worry unnecessarily and to incur expenses for private services and can cause stress for children. At the same time, we don't want to miss children who have and may continue to have difficulties."

Finding a measure that can accurately identify children with language issues and that can predict who will continue to have difficulties later in childhood has, therefore, become a common goal for researchers, speech pathologists, paediatricians and parents who want to ensure that their kids develop strong language skills.

In response to this challenge, Pesco and O'Neill analysed data from 348 five- to six-year-olds whose parents had completed the LUI when their child was a toddler or pre-schooler. The two researchers examined the relationship between the children's scores on the LUI and on later language measures.

The results were promising. Children who had scored low on the LUI as toddlers were far more likely to have low scores on language measures when they hit five or six. These same children were also likely to be identified with a language impairment by the time they hit school age.

According to the study's findings, therefore, the LUI can both identify kids who are struggling with language now and provide insight into their future facility with words. Early identification of language delays permits parents to seek help before problems set in, potentially resulting in a brighter future for those children whose language skills need a boost.

## Stress Changes how People Make Decisions

Trying to make a big decision while you're also preparing for a scary presentation? You might want to hold off on that. Feeling stressed changes how people weigh risk and reward. A new article published in *Current Directions in Psychological Science*, a journal of the Association for Psychological Science, reviews how, under stress, people pay more attention to the upside of a possible outcome.

It's a bit surprising that stress makes people focus on the way things could go right, says Mara Mather of the University of Southern California, who cowrote the new review paper with Nichole R. Lighthall. "This is sort of not what people would think right off the bat," Mather says. "Stress is usually associated with negative experiences, so you'd think, maybe I'm going to be more focused on the negative outcomes."

But researchers have found that when people are put under stress — by being told to hold their hand in ice water for a few minutes, for example, or give a speech — they start paying more attention to positive information and discounting negative information. "Stress seems to help people learn from positive feedback and impairs their learning from negative feedback," Mather says.

This means when people under stress are making a difficult decision, they may pay more attention to the upsides of the alternatives they're considering and less to the downsides. So someone who's deciding whether to take a new job and is feeling stressed by the decision might weigh the increase in salary more heavily than the worse commute.

The increased focus on the positive also helps explain why stress plays a role in addictions, and people under stress have a harder time controlling their urges. "The compulsion to get that reward comes stronger and they're less able to resist it," Mather says. So a person who's under stress might think only about the good feelings they'll get from a drug, while the downsides shrink into the distance.

Stress also increases the differences in how men and women think about risk. When men are under stress, they become even more willing to take risks; when women are stressed, they get

more conservative about risk. Mather links this to other research that finds, at difficult times, men are inclined toward fight-or-flight responses, while women try to bond more and improve their relationships.

"We make all sorts of decisions under stress," Mather says. "If your kid has an accident and ends up in the hospital, that's a very stressful situation and decisions need to be made quickly." And, of course, big decisions can be sources of stress all by themselves and just make the situation worse. "It seems likely that how much stress you're experiencing will affect the way you're making the decision."

## How the Brain Responds to Deceptive Advertising

Several specific regions of our brains are activated in a two-part process when we are exposed to deceptive advertising, according to new research conducted by a North Carolina State University professor. The work opens the door to further research that could help us understand how brain injury and aging may affect our susceptibility to fraud or misleading marketing.

The study utilised functional Magnetic Resonance Imaging (fMRI) to capture images of the brain while study participants were shown a series of print advertisements. The fMRI images allowed researchers to determine how consumers' brains respond to potentially deceptive advertising. "We did not instruct participants to evaluate the ads. We wanted to mimic the passive exposure to advertising that we all experience everyday," says Dr Stacy Wood, Langdon Distinguished professor of Marketing at NC State and co-author of a paper describing the research.

Participants were exposed to three pre-tested advertisements that were deemed "highly believable," "moderately deceptive" or "highly deceptive." The ads were also pre-tested to ensure that they were for products that consumers found equally interesting and desirable — leaving the degree of deception as the only significant variable.

"We found that people have a two-stage process they go through when confronted with moderately or highly deceptive ads," Wood says.

During the first stage, researchers saw increased activity in the precuneus — a part of the brain associated with focusing conscious attention. "We found that the more deceptive an advertisement is, the more you are drawn to it," Wood says, "much as our attention is drawn to potential threats in our environment." Specifically, in this study, the more deceptive an ad was, the more precuneus activity was observed.

During the second stage, researchers saw more activity in the Superior Temporal Sulcus (STS) and Tempero-Parietal Junction (TPJ) regions of the brain. This suggests increased "Theory-of-Mind" (ToM) reasoning. ToM is a type of processing that allows us to distinguish our wants and needs from those of others, particularly as this applies to intuiting the intentions of other people. In this case, it appears to indicate that participants were trying to determine the truth behind the claims in the potentially deceptive advertisements.

"What's interesting here is that the moderately deceptive ads cause more activity during this second stage," Wood says. That may be because highly deceptive ads are screened out more quickly and discarded as not meriting further attention.

Overall, when looking at both stages of brain response, researchers found there was greater brain activation when participants were exposed to moderately deceptive ads. But, if moderately deceptive ads stimulate more brain activity, does that make us more susceptible to the sales pitch in ads that trigger just a pinch of skepticism?

Apparently not. In a follow-up, behavioural component of the study, researchers interfered with the ToM stage, making it more difficult for participants to determine the intention behind the ads. As a result, participants more frequently believed moderately deceptive advertising. This suggests that the second stage is an important step that helps protect consumers by allowing them to better discriminate and screen out deceptive ads.

"Now that we've identified these stages of brain response, it may help future researchers identify underlying neural reasons why some populations are more prone to fall prey to deceptive ads," Wood says. "For example, if these regions of the brain are likely to be affected by aging, it may explain why older adults are more vulnerable to fraud or deceptive advertising. Or how might concussive brain injuries, such as those seen in some sports, affect our long-term discrimination in making good consumer choices?"

The paper, "Suspicious Minds: An fMRI Investigation of How Consumers Perceive Deception in the Marketplace," was co-authored by Wood, Dr Adam Craig of USF (lead researcher), Dr Yuliya Loureiro of Fordham and Dr Jennifer Vendemia of USC. The paper is published online in the *Journal of Marketing Research*.

## World's Smallest Radio Stations: Two Molecules Communicate via Single Photons

We know since the dawn of modern physics that although events in our everyday life can be described by classical physics, the interaction of light and matter is down deep governed by the laws of quantum mechanics. Despite this century-old wisdom, accessing truly quantum mechanical situations remains non-trivial, fascinating and noteworthy even in the laboratory. Recently, interest in this area has been boosted beyond academic curiosity because of the potential for more efficient and novel forms of information processing.

In one of the most basic proposals, a single atom or molecule acts as a quantum bit that processes signals that have been delivered via single photons. In the past twenty years, scientists have shown that single molecules can be detected and single photons can be generated. However, excitation of a molecule with a photon had remained elusive because the probability that a molecule sees and absorbs a photon is very small. As a result, billions of photons per second are usually impinged on a molecule to obtain a signal from it.

One common way to get around this difficulty in atomic physics has been to build a cavity around the atom so that a photon remains trapped for long enough times to yield a favourable interaction probability. Scientists at ETH Zurich and Max Planck Institute for the Science of Light in Erlangen have now shown that one can even interact a flying photon with a single molecule.

Among many challenges in the way of performing such an experiment is the realisation of a suitable source of single photons, which have the proper frequency and bandwidth. Although one can purchase lasers at different colours and specifications, sources of single photons are not available on the market.

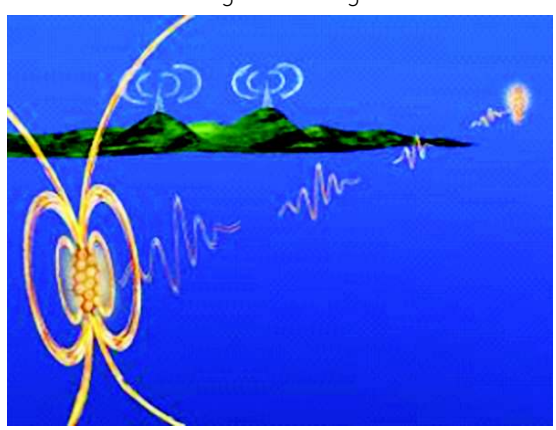
So a team of scientists led by Professor Vahid Sandoghdar made its own. To do this, they took advantage of the fact that when an atom or molecule absorbs a photon it makes a transition to a so-called excited state. After a few nanoseconds (one thousand millionth of a second) this state decays to its initial ground state and emits exactly one photon. In their experiment, the group used two samples containing fluorescent molecules embedded in organic crystals and cooled them to about 1.5 K (-272 °C). Single molecules in each sample were detected by a combination of spectral and spatial selection.

To generate single photons, a single molecule was excited in the "source" sample. When the excited state of the molecule decayed the emitted photons were collected and tightly focused onto the "target" sample at a distance of a few meters. To ensure that a molecule in that sample "sees" the incoming photons, the team had to make sure that they have the same frequency. Furthermore, the precious single photons had to interact with the target molecule in an efficient manner. A molecule is about one nanometer is size (1,00,000 times smaller than the diameter of a human hair) but the focus of a light beam cannot be smaller than a few hundred nanometers.

This usually means that most of the incoming light goes around the molecule, i.e., without them seeing each other. However, if the incoming photons are resonant with the quantum mechanical transition of the molecule, the latter acts as a disk that is comparable to the area of the focused light. In this process, the molecule acts as an antenna that grabs the light waves in its vicinity. The results of the study published in *Physical Review Letters* provide the first example of long-distance communication between two quantum optical antennas in analogy to the 19th century experiments of Hertz and Marconi with radio antennas. In those early efforts, dipolar oscillators were used as transmitting and receiving antennas.

In the current experiment, two single molecules mimic that scenario at optical frequencies and via a non-classical optical channel, namely a single photon stream. This opens many doors for further exciting experiments in which single photons act as carriers of quantum information to be processed by single emitters.

The experimental work was performed at ETH Zurich before the group of Professor Sandoghdar moved to the newly founded Max Planck Institute for the Science of Light in Erlangen in 2011.



*Artist's view of a single molecule sending a stream of single photons to a second molecule at a distance, in quantum analogy to the radio communication between two stations. (Credit: Robert Lettow)*

## Future Smart Phones will Project Images on the Wall

Mobile phones currently on the market are capable of showing high quality images and video, but the phones' small size sets insurmountable limits on screen size, and thus the viewing experience. VTT Technical Research Centre of Finland, EpiCrystals Oy and the Aalto University are developing a better laser light source for projectors that will be integrated into mobile phones, which will enable accurate and efficient projection of, for example, photographs and movies on any surface. Mobile phones equipped with the laser light source can be within the ordinary consumer's reach already in a few years time.

Small-size laser projectors 1-2 centimetres in length can be integrated into many kinds of electronic appliances, such as digital or video cameras, gaming devices and mobile phones. Integrated micro projectors could, in practice, project images the size of an A3 sheet of paper on a wall.

The challenge is to develop a small, energy-efficient and luminous three-colour (RGB) light source, whose manufacturing costs can be kept low, for use in the projectors. Solutions for these challenges are sought in a project combining Finnish know-how, whose parties are VTT, EpiCrystals Inc. and the Aalto University.

"The project has successfully combined multi-technological know-how from VTT and its partners in the project, from manufacturing materials and the accurate focusing of laser chips all the way to production line design. The project was launched last autumn, and we are now entering the stage where we can move from brainstorming and design to building prototypes. It is our goal to prove by next summer that large quantities of the new laser light sources can be manufactured quickly and economically ," says Principal Scientist Timo Aalto from VTT.

EpiCrystals Inc. aims straight for the global market with its product, and it is the company's goal to be the technology and market leader in laser light sources for micro projectors by 2015.

"We are developing an entirely new technology that is currently not in use anywhere else in the world. At the moment, there are stand-alone projectors on the market that can be connected to electronic appliances and early stage integrated projectors, but their quality and price are not competitive enough. Large electronics manufacturers are extremely interested in integrated projectors, and market research shows that demand for these micro projectors will increase strongly in the coming years. Soon, around two billion mobile phones per year will be sold in the world, and if even a couple of per cent of those contain a projector, we are talking about tens of millions of copies, and the hundred million mark is not far either," says Vice President of Business Development Tomi Jouhti of EpiCrystals Oy.

EpiCrystals' laser modules will be mass-produced in Asia, but the research and development will remain in Finland also in the future. The VTT, EpiCrystals and Aalto University project has received funding from the Finnish Funding Agency for Technology and Innovation Tekes, among others.

## Research Offers Insight to how Fructose Causes Obesity and other Illness

A group of scientists from across the world have come together in a just-published study that provides new insights into how fructose consumption results in obesity and metabolic syndrome, which can lead to diabetes. In this study which was performed in lab animals, researchers found that fructose can be metabolised by an enzyme that exists in two forms. One form appears to be responsible for causing how fructose causes fatty liver, obesity, and insulin resistance. The other form may actually protect animals from developing these features in response to sugar.

These studies may provide important insights into the cause of the pre-diabetic condition known as "metabolic syndrome," which currently affects more than one-quarter of adults in the United States.

The study, "Opposing effects of fructokinase C and A isoforms on fructose-induced metabolic syndrome in mice" was just published in the journal *Proceedings of the National Academy of Sciences*. Richard Johnson, MD, the senior author of the study and Chief of the Division of Renal Diseases and Hypertension at the University of Colorado School of Medicine said the findings are significant because we now have a better understanding of how fructose causes obesity and other illnesses.

"These studies provide new insights into how fructose may contribute to the development of obesity and diabetes. In particular, the identification of contrasting roles for two enzymes that are involved in fructose metabolism was surprising and could be important in understanding why some individuals may be more sensitive to the metabolic effects of fructose than others."

Previous research has shown that fructose intake in added sugars such as sucrose and high fructose corn syrup is strongly linked to the epidemic rise in obesity and non-alcoholic fatty liver disease. Fructose intake also causes features of metabolic syndrome in laboratory animals and humans. It is known to cause visceral (organ) fat accumulation and insulin resistance compared to starch-based diets even when calories are kept even.

Faculty at the University of Colorado School of Medicine work to advance science and improve care. These faculty members include physicians, educators and scientists at University of Colorado Hospital, Children's Hospital Colorado, Denver Health, National Jewish Health, and the Denver Veterans Affairs Medical Centre. Degrees offered by the CU Denver School of Medicine include doctor of medicine, doctor of physical therapy, and masters of physician assistant studies.

## 60-Year-Old Definition of Surface Tension on Solids Revised

Researchers of VTT Technical Research Centre of Finland have shown that surface tension on a solid material is unconnected to the energy required to create a new surface. Consequently, surface tension on a solid does not exist in its conventional meaning.

It is generally believed that an excess surface tension on a solid material exists, in similar manner to that on a liquid. This tension is described by the Shuttleworth equation, which was presented more than 60 years ago and is considered a fundamental equation of surface thermodynamics. It is believed to provide the connection between surface tension and surface energy.

Three years ago, VTT researchers Lasse Makkonen and Kari Kolari, together with British scientist David Bottomley, revealed in the Surface Science journal that the Shuttleworth equation is incompatible with the thermodynamic theory. This was hard to accept by many and provoked a lively discussion in the scientific literature.

Now Lasse Makkonen has shown mathematically that the disputed equation reduces to the definition of mechanical surface stress and has no connection with the energy of creating a new, unstrained surface. Consequently, the excess surface tension suggested by the Shuttleworth equation does not exist. The existence and nature of surface tension on a solid must, therefore, be sought by molecular dynamics at the surface layer only.

## Liquid-like Materials may Pave Way for New Thermoelectric Devices

In the continual quest for better thermoelectric materials — which convert heat into electricity and vice versa — researchers have identified a liquid-like compound whose properties give it the potential to be even more efficient than traditional thermoelectrics.

Thermoelectric materials have been used to power spacecraft ranging from Apollo to the Curiosity rover now headed for Mars. Recently, however, scientists and engineers have been turning to these materials to use wasted heat — released from automobiles or industrial machinery, for instance — as an efficient energy source. They have also proposed using these materials to create more efficient heating systems in electric cars or even as new ways to exploit solar power.

In identifying this new type of thermoelectric material, the researchers studied a material made from copper and selenium. Although it is physically a solid, it exhibits liquid-like behaviours due to the way its copper atoms flow through the selenium's crystal lattice.

"It's like a wet sponge," explains Jeff Snyder, a faculty associate in applied physics and materials science in the Division of Engineering and Applied Science at the California Institute of Technology (Caltech) and a member of the research team. "If you have a sponge with very fine pores in it, it looks and acts like a solid. But inside, the water molecules are diffusing just as fast as they would if they were a regular liquid. That's how I imagine this material works. It has a solid framework of selenium atoms, but the copper atoms are diffusing around as fast as they would in a liquid."

The research, led by scientists from the Chinese Academy of Science's Shanghai Institute of Ceramics in collaboration with researchers from Brookhaven National Laboratory and the University of Michigan, as well as from Caltech, is described in a paper recently published in the journal *Nature Materials*.

A thermoelectric material generates electricity when there is a temperature difference between one end of the material and the other. For example, if you place a thermoelectric device right next to a heat source — say a laptop battery — then the side closest to the battery will be hotter. The electrons in the hot end will diffuse to the cool end, producing an electric current.

A good thermoelectric material must be good at conducting electricity but bad at conducting heat. If it were good at conducting heat, the heat from the hot end would move to the cool end so fast that the whole material would rapidly reach the same temperature. When that happens, the electrons stop flowing.

One way to improve thermoelectric efficiency, then, is to decrease a material's ability to conduct heat. To that end, researchers have been developing thermoelectric materials with a mix of crystalline and amorphous properties, Snyder says. A crystalline atomic structure allows electrons to flow easily, while an amorphous material, such as glass, has a more irregular atomic structure that hinders heat-carrying vibrations from travelling.

These heat-carrying vibrations travel via two types of waves. The first type is a longitudinal or pressure wave, in which the direction of displacement — in this case, the jiggling of atoms — is the same as the direction of the wave. The second type is a transverse wave, in which the direction of displacement is perpendicular to the direction of the wave, like when you shake a jump rope up and down, resulting in waves that travel horizontally along the rope.

In a solid material, a transverse wave travels because there is friction between the atoms, meaning that when one atom vibrates up and down, an adjacent atom moves with it, and the wave propagates. But in a liquid, there is minimal friction between the atoms, and a vibrating atom just slides up and down next to its neighbour. As a result, transverse waves cannot travel inside a liquid. Ocean waves are different because they have an interface between the liquid and the air.

The team found that because heat-carrying vibrations in a liquid can travel only via longitudinal waves, a material with liquid-like properties is less thermally conductive. Therefore, a liquid-like material that's also good at conducting electrically should be more thermoelectrically efficient than traditional amorphous materials, Snyder says.

In the case of the copper-selenium material that the researchers studied, the crystal structure of the selenium helps conduct electricity, while the free-flowing copper atoms behave like a liquid, damping down thermal conductivity. The efficiency of a thermoelectric material is quantified using a number called a "thermoelectric figure of merit." The copper-selenium material has a thermoelectric figure of merit of 1.5 at 1000 degrees Kelvin, one of the highest values in any bulk material, the researchers say.

NASA engineers first used this copper-selenium material roughly 40 years ago for spacecraft design, Snyder says. But its liquid-like properties — which were not understood at the time — made it difficult to work with. This new research, he says, has identified and explained why this copper-selenium material has such efficient thermoelectric properties, potentially

opening up a whole new class of liquid-like thermoelectric materials for investigation.

"Hopefully, the scientific community now has another strategy to work with when looking for materials with a high thermoelectric figure of merit," Snyder says.

In addition to Snyder, the research group includes Caltech graduate student Tristan Day. The other authors on the *Nature Materials* paper, titled "Copper ion liquid-like thermoelectrics," are Huili Liu, Xun Shi, Lidong Chen, Fangfang Xu,

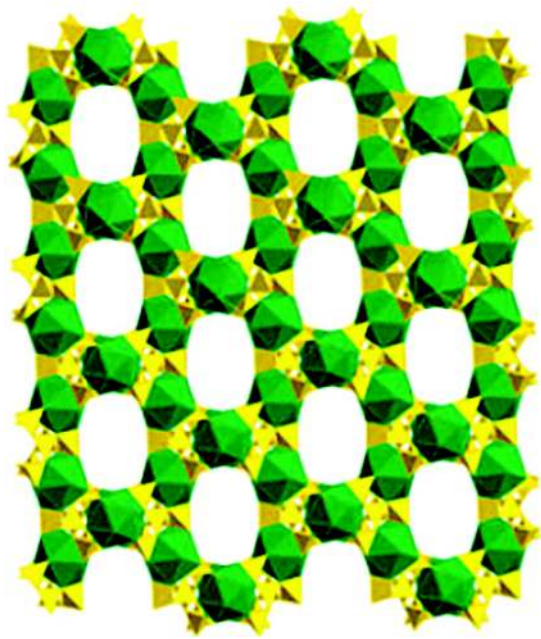
Linlin Zhang, and Wenqing Zhang of the Chinese Academy of Science's Shanghai Institute of Ceramics; Qiang Li of Brookhaven National Laboratory and Citrad Uher of the University of Michigan.

## New Method for Cleaning up Nuclear Waste

While the costs associated with storing nuclear waste and the possibility of it leaching into the environment remain legitimate concerns, they may no longer be obstacles on the road to cleaner energy.

A new paper by researchers at the University of Notre Dame, led by Thomas E. Albrecht-Schmitt, professor of civil engineering and geological sciences and concurrent professor of chemistry and biochemistry, showcases Notre Dame Thorium Borate-1 (NDTB-1) as a crystalline compound that can be tailored to safely absorb radioactive ions from nuclear waste streams. Once captured, the radioactive ions can then be exchanged for higher-charged species of a similar size, recycling the material for re-use.

If one considers that the radionuclide technetium (99Tc) is present in the nuclear waste at most storage sites around the world, the math becomes simple. There are more than 436 nuclear power plants operating in 30 countries; that is a lot of nuclear waste. In fact, approximately 305 metric tons of 99Tc were generated from nuclear reactors and weapons testing from 1943 through 2010. Its safe storage has been an issue for decades.



*(NDTB-1) as a crystalline compound that can be tailored to safely absorb radioactive ions from nuclear waste streams. (Credit: Image courtesy of University of Notre Dame)*

"The framework of the NDTB-1 is key," says Albrecht-Schmitt. "Each crystal contains a framework of channels and cages featuring billions of tiny pores, which allow for the

interchange of anions with a variety of environmental contaminants, especially those used in the nuclear industry, such as chromate and pertechnetate."

Albrecht-Schmitt's team has concluded successful laboratory studies using the NDTB-1 crystals, during which they removed approximately 96 per cent of 99Tc. Additional field tests conducted at the Savannah River National Laboratory in Aiken, S.C., and discussed in the paper have shown that the Notre Dame compound successfully removes 99Tc from nuclear waste and also exhibits positive exchange selectivity for greater efficiency.

## Solving the Mystery of Blood Clotting

How and when our blood clots is one of those incredibly complex and important processes in our body that we rarely think about. If your blood doesn't clot and you cut yourself, you could bleed to death, if your blood clots too much, you could be in line for a heart attack or stroke. Hans Vogel, a professor at the University of Calgary, has thought a lot about blot clotting and recently published research in the *Journal of the American Chemical Society* that helps to better understand the clotting process.

Vogel and his graduate student Hao Huang were able to determine the molecular 3D structure of a protein in blood platelets and a receptor that sticks through the membrane of the cell to the outside. Platelets are tiny cells specialised for clotting reactions. The receptor protein is unique for platelets and directly controls blood clot formation. Other scientists have unsuccessfully attempted to map this structure, but Huang and Vogel were the first to make it work.

"The goal of the research is to provide a molecular level understanding of the blood clot regulatory process," says Vogel of the Department of Biological Sciences in the Faculty of Science. "Eventually the long term goal is to interfere in that, although one has to be extremely careful with such a delicate process. Often times, these molecular structures are useful for pharmaceutical companies and for follow-up research projects that take them as a starting point to develop new drugs."

This particular piece of research is also related to Vogel's lab's larger goal, which is to figure out how our body responds to foreign invasions of bacteria, particularly in relation to superbugs that aren't treatable by antibiotics. "You don't really want to have an infection starting in and around a blood clot," says Vogel. "So once a platelet is lodged into position, it releases all sorts of proteins and then it attracts all these factors that are antimicrobial. Platelets get together with white blood cells and together they orchestrate a really important antimicrobial response."

The next step in Vogel's research is to try to find out more about this antimicrobial response and build on it. "A lot of science is putting pieces into a large puzzle," says Vogel. "I've been involved in active research for 30 years. If you look over your career, then you make many incremental steps forward, but everything together builds a big picture. The paper we recently published proved to be a very important piece of the puzzle." Vogel's research in this area is supported by Alberta Innovates Health Solutions and the Canadian Institutes for Health Research.

## 3-D Microscopy to Aid in Cell Analysis

The understanding of diseases such as Parkinson's and Alzheimer's is set to take a step forward following groundbreaking technology which will enable cell analysis using automated 3D microscopy.

An initiative between the Griffith's School of Information Communication Technology and the Eskitis Institute for Cellular and Molecular Biology, the technology will allow the automated identification, separation and analysis of cells as complex as nerve cells in the brain.

"Scientists and clinicians will be able to superimpose multiple data sets in three dimensions using automated techniques and then conduct detailed analysis of the data in a far improved way from the two-dimensional microscopy that is currently available," said Dr Adrian Meedeniya, manager of Griffith's Imaging and Image Analysis Facility.

Microscopy and image acquisition technology has undergone a recent revolution, with modern microscopes generating huge multi-dimensional data-sets that can easily fill an entire hard drive. Manually analysing these data-sets is incredibly time-consuming and prone to human error and bias.

"One of the main motivations for establishing this collaboration with the School of ICT was to create the technology to efficiently deal with these huge data-sets," Dr Meedeniya said.

"We will be able to use this technology to rapidly increase our understanding of the way neuro-degenerative disorders affect nerve cell function in the brain."

Underpinned by neural network algorithms (artificial intelligence), the cutting-edge technology is expected to be widely used in disease research within a matter of a few years.

*Ph.D. candidate Gervase Tuxworth who is involved with the technology. (Credit: Image courtesy of Griffith University)*

## Right Hand or Left? How the Brain Solves a Perceptual Puzzle

When you see a picture of a hand, how do you know whether it's a right or left hand? This "hand laterality" problem may seem obscure, but it reveals a lot about how the brain sorts out confusing perceptions. Now, a study which will be published in a forthcoming issue of *Psychological Science*, a journal published by the Association for Psychological Science, challenges the long-held consensus about how we solve this problem.

"For decades, the theory was that you use your motor imagination," says Shivakumar Viswanathan, who conducted the study with University of California Santa Barbara colleagues Courtney Fritz and Scott T. Grafton. Judging from response times, psychologists thought we imagine flipping a mental image of each of our own hands to find the one matching the picture. These imagined movements were thought to

recruit the same brain processes used to command muscles to move — a high-level cognitive feat.

The study, however, finds that the brain is adept at decoding a left or right hand without these mental gymnastics. Judging laterality is "a low-level sensory problem that uses processes that bring different senses into register" — a process called binding, says Viswanathan. Seeing a hand of unknown laterality leads the brain to bind the seen hand to the correct felt hand. If they are still out of register because of their conflicting positions, an illusory movement arises from the brain's attempt to bring the seen and felt hand into the same position. But "this feeling of moving only comes after you already know which hand it is."

In the study, participants couldn't see their own hands, which were held palm down. They saw hand shapes tilted at different angles, with a coloured dot on them indicating a palm-up or down posture. One group of participants saw the shape first and then the dot; and the other, the dot first. Participants in both groups put the shape and dot together mentally and indicated which hand it was by pushing a button with that hand. However, when the shape and dot were shown simultaneously, participants in the first group felt movements of their right hands when seeing a left hand and vice versa; the other group always felt a movement of the correct hand. This behavioural difference (which experimenters gleaned from response time) was due to differences in participants' perception of the seen hand — establishing that an earlier sensory process made the decision.

In a second experiment, participants were told which hand it was and had to judge whether its palm was down or up, indicating their answer with one hand only. This time, the illusory hand-movement occurred only when the seen hand-shape matched that of the participant's own palm-down responding hand, but not otherwise. Even though no right/left judgements were required, the response was dominated by an automatic binding of the seen and felt hands, and the illusory movement followed, says Viswanathan.

The study helps us understand the experience of amputees, who sometimes sense an uncontrollable itch or clenching in the "phantom" body part. Showing the opposite hand or leg in a mirror allows the patient to "feel" the absent limb and mentally relieve the discomfort — a "binding" of vision and feeling.

*When you see a picture of a hand, how do you know whether it's a right or left hand? (Credit: © Christian Schwier / Fotolia)*

## Precision Time: A Matter of Atoms, Clocks and Statistics

The ability to accurately measure a second in time is at the heart of many essential technologies; the most recognisable may be the Global Positioning System (GPS). In a paper accepted for publication in the AIP's journal Review of Scientific Instruments, Judah Levine, a researcher at the National Institutes of Standards and

Technology (NIST) and the University of Colorado at Boulder discusses how achieving a stable and coordinated global measure of time requires more than just the world's most accurate timepieces; it also requires approximately 400 atomic clocks working as an ensemble.

According to Levine, however, calculating the average time of an ensemble of clocks is difficult, and complicated statistics are needed to achieve greater accuracy and precision. These statistical calculations are essential to help counter one of the most important challenges in keeping and agreeing on time: distributing data without degrading the performance of the source clocks.

All atomic clocks operate in basically the same way, by comparing an electrical oscillator (a device engineered to keep time) with the transition frequency of an atom (one of nature's intrinsic time keepers). This atomic transition is a "flip" in the spin in the outermost electron of an atom — an event that is predictable with an accuracy of a few parts per ten quadrillion. Comparing the natural and engineered signals produces the incredibly stable "tick" of an atomic clock.

Several algorithms are then used to estimate the time of the reference clock with respect to the ensemble of clocks. These calculations weed out as much error as possible and establish a reliable reference time. Levine notes that there are strengths and weaknesses in each of these statistical steps, but these weaknesses can be mitigated to some extent by also including retrospective data. So in essence, determining the current time relies on understanding how accurately researchers were able to calculate time in the past.

Even the next generation of atomic clocks and frequency standards are unlikely to eliminate the need for these timescale algorithms. However, keeping time and frequency signals and standards the same in all countries is essential and greatly simplifies international cooperation in areas such as navigation, telecommunication and electric power distribution.

# 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.

- **Science News for Kids**
  www.sciencenewsforkids.org

  Science News for Kids is an online publication aimed at the 9-14 age range, although the articles would also appeal to older students. The articles come from the magazine Science News, and each article has a list of key words and definition at the end.

- **Green-planet-solar-energy.com**
  www.green-planet-solar-energy.com/index.html.

  This website offers lots of information on a range of topics easily accessible from the links on the home page. Solar and you has sections on photovoltaics and solar gadgets. The environment leads you to information on the feature of various types of power and reasons for its use, and includes big projects, with information on and images and videos of new and unusual projects using solar energy. Kids stuff has experiments and quizzes. Vehicles has information on transport for the future – hybrid cars and electric cars, motor bikes and scooters. How solar cells, batteries and fuel cells work is explained under same theory. This is an up-to-date and interesting site that will support some of the topical issues to be studied for the new GCSES.

- **Chemistry for Life**
  **American Chemical Society**
  www. acs.org

  In similar fashion to the Royal Society of chemistry website, the American Chemical Society website has a lot of interesting links and resources in the education area. Resources include podcasts and lesson guides including worksheets, web references, questions and answers on topics such as how waste water is recycles and this week is chemical history – a section that contains a summary of science landmarks and discoveries for every day of the year and chemical landmarks by year.

  In the chem matters area you have access to past articles, podcasts and videos on a huge variety of topics, including acids/bases, organic chemistry, thermochemistry and bonding, as well as others such antimatter, using cooking oil for fuel and sustainability.

- **Nanooze**
  www.nanooze.org

  The site has an interesting collection of articles about all things nanotechnology. Topics include nanofood, nanomedicine, self-assembly, the senses and nanobots. There is also a nanotechnology primer and glossary explaining the many terms used.

- **Spectra School**
  www.le.ac.uk/spectraschool

  This site is a link from the Royal Society of Chemistry website (www.rsc.org). It is hosted by the University of Leicester. The site contains a large range of organic molecules for which you can access various kinds of spectra : $^{1}$HNMR, $^{13}$C NMR, IR, mass and UV. The site also includes information about the structures of the molecules, the elemental compositions and the melting points. All the spectra and information can be exported into other programmes. The site is very easy to use and is essential for any A-level chemistry teacher or for students who need to practise analysing spectra.

- **Materials Classroom**
  classroom.materials.ac.uk

  This site presents interactive information on the structure and properties of various materials. In explore, students can investigate the properties of the materials used to make an $MP_3$ player and a camera, an F1 car and a normal on-road car and piezoelctric materials. There are also simulations including tensile strength testing, games case studies on the materials used for heart valves, hip replacements and helicopter blades and quizzes.

Complied and Edited by
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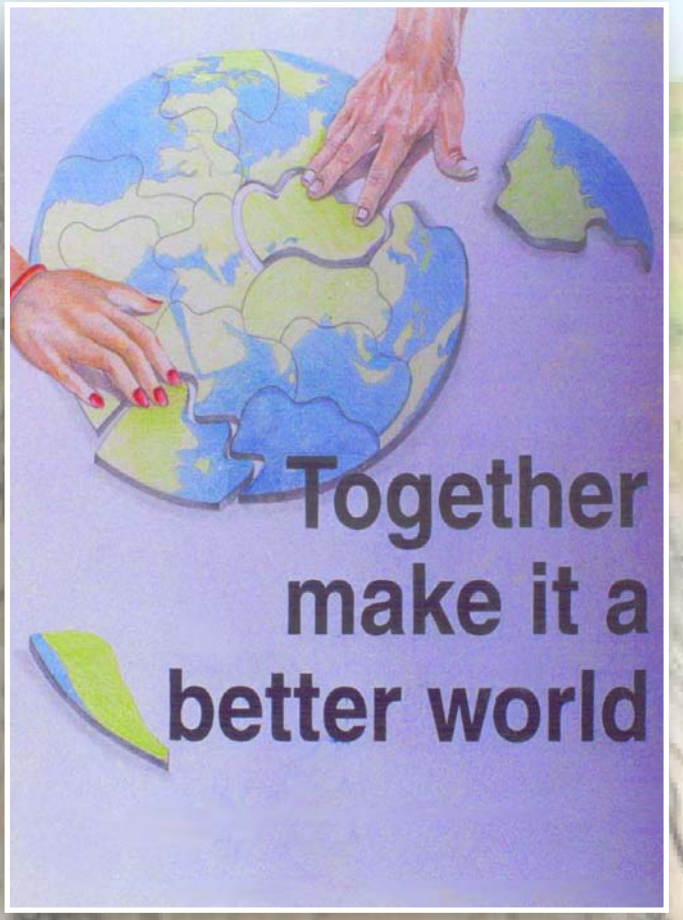
## To Our Contributors

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**

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