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Vigyan Prasar

# DREAM 2047

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... think scientifically, act scientifically... think scientifically, act scientifically... think scientifically, act...

# We care a damn!!!!. C'mon we are probably too naive to know we harm others in this process ...

Dr. R. Gopichandran

**This is a sarcastic take on our pseudo preparedness at the collective level to secure a better quality of life.** This is also a salute to the compliant and quiet citizens, who more often than not, bear the brunt of callousness of our indifferent other fellow citizens. The latter may however join the chorus for better life. They may want everyone around them to change; but are themselves least prepared to change. I (for a moment!!) identify myself with the indifferent and sarcastically lament over several occasions through any given day when we the indifferent people, really care a damn about anything around us. These remarks are therefore only about the non-compliant.

**We care a damn**. We spit on our roads. We role the window panes of our cars and spit at traffic junctions, because we do not want to soil our interiors. We spit also through racing traffic. Many fellow citizens would stare aghast at us. We care a damn. We speak loudly on the telephone. We don't care for people around us in aeroplanes, trains or buses. We are not bothered about interfering with thinking processes or even headaches of people around us. We jump queues at railway / bus stations / airports / medical shops and pretend to not see others in front of us. When we are reminded of the queue we sarcastically remark that we are in a hurry. Traffic signals or gestures by police men to abide by law mean nothing to us. We conveniently jump signals and often bulldoze abiding vehicles / people with sheer contempt. Even as we disembark from public transport we leave stains on seats. We do not care to inform the caretaker about the nuisance we cause. At office we do not care to maintain silence. We throw tantrums through sheer insolence. We take our children to school in ostentatious vehicles and enter the school premises through the exit gate, just to beat the traffic. Great lessons for children indeed!!!!.

**We are also turncoats**. Yet another peculiar chaos happens at our international airports. We may have been the quintessential disciplinarian when at airports in other countries. Strangely, many of us lose all sense of discipline when we land on our shores. We let loose our arrogance by passing lewd remarks on our people and systems taking the whole country for granted. Even stranger is the tendency to behave well when we land outside our country. The same obstreperous fellow citizens behave as if they are the greatest harbingers of peace and courtesy. What a pity indeed. These are some of the low-hanging misdemeanours that reflect an inner deep seated and recalcitrant malice that probably encrust any glimmer of hope / intent to change.

**Break from routine**. I decided to not cite references about any communication initiative in this editorial. I wanted to rub off some pathos I am inflicted with, watching the turncoats and the indifferent that many of our fellow citizens are. What a shame; we are not suitably prepared to grab the call for collective clean up or shed our inertia to capture newer and more productive niches, much as we can build on our strengths. I lament the fact that we do not act in concert and that the good efforts / impacts by a few will be lost in the din of indifference.

**Any sign of scientific temper????** The larger question is of imbibing scientific temper that should actually pervade all walks and acts of life. Are we prepared enough to comprehend the subtleties of scientific thinking? A snapshot view of the chaos we see around us reduces hope. The acts of misdemeanour I have cited are too very simple, (further compounded by a simplistic narration!!!!! and oversimplified!!!!). These occur in our common space in our daily life. Ulterior motives and hidden agendas are further up the pecking order. Is it too much to expect minimum courtesy as a forerunner to culture? Will it be useful to engage with citizens at all common places where we encounter the stated misdemeanours with loud stark messages that they need to be disciplined and not intrude into others peace? It may be useful to also reward the ones who are shamed into compliance on seeing such starkly presented messages.

The environmental and material benefits of good behaviour through compliance even on these simple entry points cannot be overemphasised. The final aspect on this lamentation is in support of the spontaneously compliant. They enjoy being compliant, but have to often suffer the pressures of seeing the non-compliant creating the chaos and experience all related externalities. What a dampener??? It is the unseen zeal and the enthusiasm of the compliant that is probably responsible for the shine India exhibits. She deserves a much greater deal from the indifferent. This editorial is also a call for ideas about initiatives that can awaken the slumbering insolence. We need large-scale and highly focused programmes to educate and inspire, even as we give the insolent the benefit of doubt that they are not adequately sensitised (an oxymoron for the taking!!!!). Phew!!! Any innovative ideas please!!!!!. We should optimise on the recent rejuvenated call to awake and arise to become clean and stay clean.

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# Nanoscience and its applications

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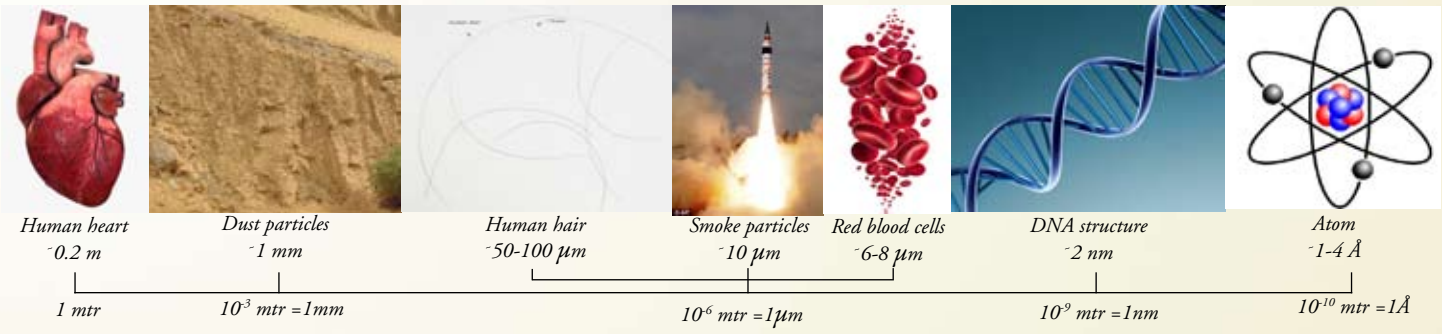
In our day-to-day life, the unit for measurement of length is the metre. We use kilogram as the unit for measurement of mass while for measuring time, second is used. This is known as 'metre, kilogram, second' or MKS system. But if the distance or size involved is too small then we use units much smaller than a metre. Nanometre is a unit of this kind. Very small length is measured in nanometre, miniscule mass is measured in nanogram and extremely small time is measured in nanoseconds. One nanometre is a billionth of a metre. In metric system, it is written as $10^{-9}$ m. Its minuteness may be gauged from the fact that if ten atoms of hydrogen are laid side by side then together they will constitute a length of one nanometre. One thousandth of a metre is one millimetre (1 mm = 1m/1000) and one thousandth of a millimetre is one micrometre (1µm = 1 mm/1000). The chips used in computers are fabricated on this scale. One thousandth of a micrometre is one nanometre (1nm = 1µ/1000). The science related to 'nano' is called nanoscience.

A nanometre can span about 5 to 6 carbon atoms. A DNA molecule is about 2.2-2.6 nanometres in size, and a red blood cell has a size of 6,000 – 8,000 nanometres; whereas a human hair has a thickness of around 80,000 nanometres or 80 microns.




## Is nano indeed a new concept?

Nanoscience is now pervading almost every field of our day-to-day life and day-by-day it is expanding in its scope. However, this field of science based on the measurement, study and application of minuteness is not entirely new. In terms of its application, it is very old. Nevertheless, only research and development carried out during recent years has opened up new vistas in the study of this science. The credit for the very first application of nanoscience goes to Rome. The multi-coloured glass cups made in Rome in fourth century, called Lycurgus cups, look very attractive even today. Gold and silver nanoparticles were used to colour the transparent glass for making of these cups. These cups appear green in reflected light during the daylight due to the presence of nanoparticles. However, when light is transmitted through the glass, the cups appear red.

*Lycurgus cup*

As another ancient application of nanoscience, mention may be made of soot (*kajal*). The use of soot for decorating the eye has been in vogue since ancient times. In villages or rural areas people use traditional method for making soot. They take an earthen lamp (*diya*) containing mustard oil or pure ghee with a wick of cotton wool. When a cold metal plate is kept over the earthen lamp touching the flame, fine particles of unburnt carbon are deposited as soot, a part of which is known to be made up of carbon nanoparticles.

The famous Samurai swords of Japan belonging to medieval period present yet another example of nanotechnology. These Samurai swords had a special significance in ancient Japanese warfare. The 'Forge and fold' technique was used for fabrication of these swords, which were known for their sharpness and strength. The technique involves beating the steel when it is red hot. The beaten steel is then folded. After several repetitions the thickness of the steel surface

*Japanese Samurai sword*

*Gold thread work on Banarasi saree*

or the sword blade becomes extremely thin (about 50 nm) which consequently is endowed with great strength. Analysis has shown that the extreme strength of Samurai swords comes from the presence of carbon nanotubes in the steel.

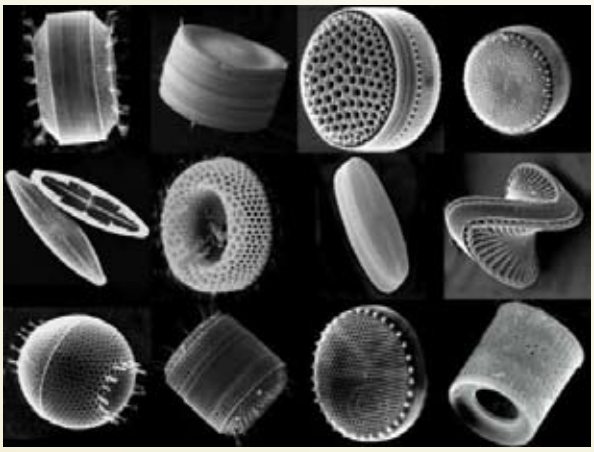
Another promising example of nanotechnology is offered by the traditional sarees of Benaras which have a history dating back a few centuries. As we all know, thread made of gold is used in the making of these sarees. Of all materials on Earth, gold has the maximum ductility. So, just 1 gram of gold can be drawn into about 2-kilometres of thin gold wire. The thickness of these gold threads is about five microns or 5,000 nm. Benaras sarees get their pretty and fabulous look because of the use of these gold wires.

Although today we know about these age-old applications of nanotechnology, the people who used these materials did not have any idea of their true nature or scientific significance. We have started getting scientifically acquainted with the world of nano only recently. We have only been seized of the scientific aspects of nanotechnology in the wake of research and scientific developments that have taken place in recent years.

## Examples of nanostructures in nature

Thus far we got familiarised with examples of man-made nano products. However, many unique examples of nano are also found in nature. Mention may be made of a tiny single-celled marine organism called *Emiliania huxleyi* having a shell with a diameter of about 2.5 microns, or 2,500 nm, which is made up of calcium carbonate (calcite) crystals. It has pores and designs of nano size which constitute its unique characteristics. Inspired by these designs and structures, nanocrystals of calcium carbonate were developed artificially in the laboratory. However, these lab-grown crystals were very different from the natural nanocrystals of calcium carbonate. Another example is that of unicellular sea creatures, called diatoms. Their specialty is that they have porous shells made of silicon oxide. These pores may be of nanometre size.

It may be pertinent to refer to the very fine structure of bones as an apt example of nanostructure. Bones are primarily made of hydroxyapatite, which made up of a group of minerals. Pores of nano-size may be seen in the fine minute structure of bones. Due to these pores, bones are spongy inside, which reduces their weight drastically. These structures, which have come into existence after a billion of years of bio-evolution and adaptation are unique examples of nature's artistry.

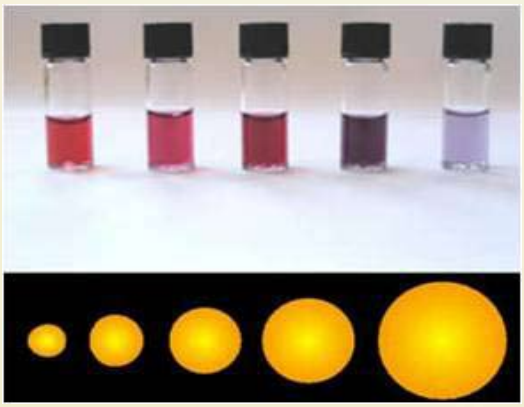


*Diatoms*

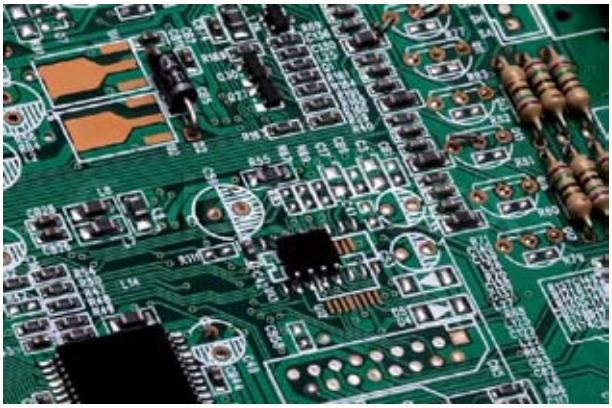
## Properties of matter at nanoscale

There are myriad reasons behind possibilities of the technological applications of nanotechnology. This is because the basic properties of matter undergo sea change at the nano-level. At the nanoscale, remarkable changes are seen in the colour, reactivity, electrical properties, etc., of matter. As these changes are different from the basic properties, they can be used under controlled conditions for development of seemingly unusual applications. These properties of nanomaterials have many unique applications. For instance, turning a opaque material into transparent material (copper); an inert material into a highly reactive material that can be used as a catalyst (platinum, gold); an incombustible material into a combustible material (aluminium); a solid material at normal temperature into a fluid (gold); an insulating material into a conductor (silicon); and many others. The example of colloidal solution of gold may also be given. The normal colour of gold particles is yellow but a colloidal solution of nano-sized gold particles may appear red in colour.

In 1857, Michael Faraday prepared a colloidal solution of gold. This solution comprising nanoparticles of gold was different in many ways. This suspension of gold nanoparticles in solution was totally transparent in some lighting, but in other lighting conditions could produce differently coloured solutions of 'ruby, green, violet or blue'. The most unique characteristic property of this solution is that after passage of so many years it has remained unchanged. This way Faraday proved that it is possible to make permanent colloidal solutions using nanoparticles. In the same vein, by bringing down copper to nanoscale its ductility at room temperature is increased so much that wires with length fifty times as much compared to normal copper can be drawn. At nanoscale, zinc oxide, which is white, becomes transparent; and aluminium when brought to the nanoscale ignites spontaneously. Platinum is chemically a very inert element, but in finely divided nanoparticle form it becomes extremely reactive.



*Gold solutions of different nanosizes. The difference in the size is the cause of difference in colour*



*Integrated circuit*

## Commercial nanomaterials

At present, most of the commercial applications of nanoparticles refer to elements like titanium, silver, etc. These include use of titanium dioxide nanoparticles in cosmetics, use of silver nanoparticles in packaging of food products, use of zinc oxide nanoparticles in textiles, germicides, domestic appliances and cosmetic products, and use of cerium oxide nanoparticles in paints and varnishes for furniture.

The titanium particles present in high quality paint and thermal spray coatings are actually nanoparticles. In the same vein, decorative shapes in glass and ceramic tiles and sanitary products are made up of nanoparticles. Advanced catalysts obtained through nanotechnology are being used in chemical and related industries. The catalysts that are used these days in catalytic converters of vehicles to mitigate pollution are actually nanostructured. Thinking is also going on in the direction of increasing the efficiency of fuel by dissolving nanoliquids in the fuel of automobiles. As initial step in this direction, scientists have used aluminium nanoparticles. Attempts are being made to develop brake fluids made of nanoliquids in place of brake oil. On the basis of preliminary investigations, copper oxide and aluminium oxide nanofluids have been used which have produced good experimental results. Nanoporous materials (zeolites) are being used in the purification of crude oil.

One aspect of nanoscience also encapsulates modern technology. The current age is also known as the 'silicon age'. We are able to witness information revolution through silicon. Silicon is a semiconductor the application of which is seen in all electronic circuits. At present, a single silicon chip contains about a million silicon devices and the size of each of these devices is about 500 nm. It is hoped that in the next two decades this size will be reduced to 1-10 nm. The increase in the computational abilities of computers was achieved by using greater and greater numbers of transistors in an integrated circuit (IC). These days, transistors measuring 200-300 nm can be found in state-of-the-art ICs. In future, computer chips will be made of graphene instead of silicon. This will increase the computational speed of the computers and also reduce their size. Scientists are considering using optical fibres combined with graphene photodetectors to increase the internet speed by up to 100 times. It has been found that when graphene is incorporated into nanostructure made of noble metals it can convert light energy into electrical energy with almost 20 per cent efficiency.

## Applications of nanotechnology in the field of energy

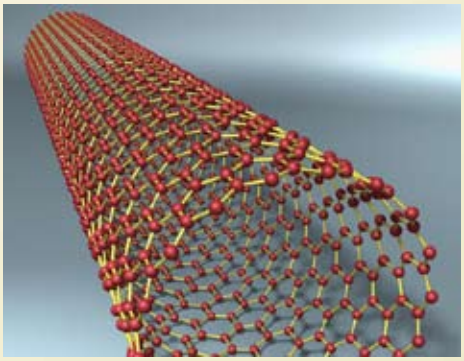
Keeping in view the global energy crisis, nanoparticles of lanthanum, cerium, strontium and manganese are being used in many solid oxide fuel cells. In fuel cells, platinum, which is a very expensive material, is used as a catalyst. Platinum in large quantity is chemically inert, but in nano powder form it becomes reactive. Companies are using platinum nanoparticles with a view to reducing the quantity of this expensive material used without reducing the reactive surface area. Nanoparticles of lithium titanate and tantalum are being used in lithium-ion batteries to produce much advanced next generation batteries.

Nanotechnology has many potential applications in the field of agriculture. For slow absorption of water and fertilisers by plants and for providing sufficient nutrients to plants, zeolites with nanopores can be used. Groundwater has been very heavily polluted due to the rapid industrialisation, use of pesticides in the agriculture, and presence of nitrates, and heavy metals like lead, etc. Recent research has shown that iron nanoparticles can be used for purification of groundwater. Using nanotechnology it will be possible to develop materials in the fabrication of which no waste products will be formed. This will help mitigate environmental pollution.

Research in the field of nanotechnology is being used for making light-weight uniform for the military. It will be possible to endow this uniform with the specialty of changing colour according to the surroundings. In addition, the use of zinc and silver nanoparticles in soaps, textiles and polymers such as plastics, can enhance their quality manifold. The same nanoparticles can be used in anti-microbial, anti-bacterial, antibiotic, and anti-fungal creams. In this way, articles and products of day-to-day use can be made more useful and efficacious.

## Applications in the field of medicine

In the field of medicine and biotechnology too, nanotechnology is helping in the diagnosis of many ailments which was not possible earlier. For instance, using nanocrystals of calcium phosphate, material resembling artificial bone has been developed which has a quality similar to natural bone. Attempts are already going on for the diagnosis and treatment of cancer using nanoparticles. Nano drug-delivery system is being used for which nano-gel and gold plated nanoparticles are employed. These nanoparticles carry different types of biological markers and medicines so that they can straightaway reach the cancerous cells



*Carbon nanotube*

and destroy the ailing cells while keeping the healthy cells intact.

Nanoscientists have also been successful in creating fluorescent nanoparticles which glow during diagnostic procedure such as MRI/CT scan. This helps in finding the exact location of cancer in the body. In future, nanomaterial will be used as oxygen carrier like haemoglobin. Nanorobots, called

*Continued on page 28*

# Nutrition for good oral health

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Oral health and hygiene is one of the most neglected aspects of our lifestyle. We often come across people talking of cavities and bad breath, but most of us take our dental health for granted until it becomes a serious problem which forces us to visit that much dreaded place- a dental clinic! We often avoid visiting a dentist because as long as we can chew food and eat normally we don't care about what's happening to our teeth. We forget that small steps to ensure healthy teeth and gums can really help our teeth to last long. Our teeth need much more than regular brushing and flossing to last longer. Good nutrition is a prerequisite for good oral health. By oral health we not only mean absence of tooth decay and gum problems but also mouth ulcers, which cause much pain and discomfort while eating. Mouth ulcers usually form due to nutrient deficiency. Malnutrition is also the root cause of developmental defects in tooth structure and loss of teeth is usually accelerated by neglecting oral hygiene at any stage of life.

Tooth decay and gum problems affect a large section of our population, and people of all ages, especially children and the elderly are more susceptible. When dental problems occur, they affect the health of an individual adversely as oral intake of food is difficult. Several foods need to be restricted, which can result in nutrient deficiencies in the long run. Dental problems are common among the elderly, but children too suffer from dental caries and swollen gums due to unhealthy eating habits. People with long-standing uncontrolled diabetes mellitus, HIV/AIDS patients, chronic alcoholics, malnourished people and cancer patients undergoing chemotherapy also have oral health issues. Getting rid of unhealthy eating habits and adopting healthier lifestyle practices go a long way in ensuring good oral health and hygiene.


*Studies have linked poor dental health to heart disease as well as other systemic disorders like diabetes, stroke alongwith gum disease and tooth decay.*

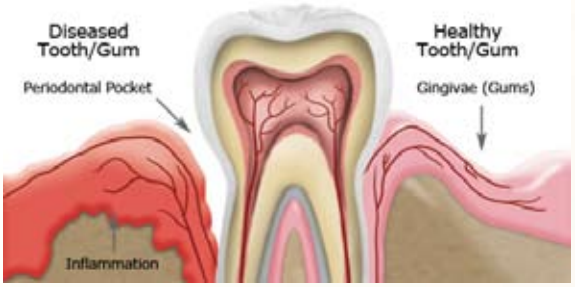
## Mouth ulcers or mouth sores (Aphthous stomatitis)

Mouth ulcers are white or yellowish raised spots surrounded by red and swollen skin anywhere inside the mouth. They appear either singly or in clusters. They are extremely painful and cause a lot of discomfort while eating. They form due to either deficiency of B vitamins such as Vitamin $B_{12}$ and folic acid, iron deficiency anaemia, zinc deficiency; food sensitivities or food allergies, emotional stress and other physical reasons like injury due to sharp teeth, or jagged edges of broken fillings in teeth. Iron deficiency anaemia can result in recurrent mouth ulcers. An infection accompanied by high temperature may also be a cause. Besides, it can appear as a symptom of intestinal disorders like celiac disease (inability to tolerate wheat protein or gluten) or Crohn's disease.

## Nutrition to fight mouth ulcers

In order to prevent mouth ulcers, one must consume foods rich in B vitamins especially folic acid and $B_{12}$, iron and zinc. Foods rich in B vitamins include whole grain cereals particularly wheat bran, lean meat, pulses and legumes. Milk is a good source of B vitamins especially $B_{12}$. Since animal products are particularly rich in vitamin $B_{12}$, vegetarians need to consume more milk and milk products. Folic acid or folate is present abundantly in dark green leafy vegetables like spinach, fenugreek, amaranth leaves, etc., and also in lady's finger (okra). Folic acid is required for maintaining the health of cells lining the mouth. Iron deficiency anaemia can be prevented by cooking in iron pots and vessels, including vitamin C-rich foods like citrus fruits, viz., oranges, limes, lemons, guava, Indian gooseberry or amla and tomatoes along with iron-rich foods like legumes (whole Bengal gram or chana), leafy greens, millets like bajra and dried fruits including dates (khajur) in diet. Vitamin C-rich foods enhance iron absorption from vegetarian sources as iron from vegetarian foods is poorly absorbed by the body. Iron from non-vegetarian sources such as liver, lean meat, chicken, fish, egg-yolk, etc., is easily absorbed by the body. Zinc is present in nuts, seeds, chicken, fish and mutton.

If ulcers form, one must avoid foods which may irritate the sores and cause considerable pain. Foods such as hot beverages like tea, coffee, soups, and warm milk; highly acidic foods like lemon, salty foods like chips, salted biscuits; very spicy foods, chillies, pickles and alcohol must be avoided. Any other foods which may worsen the symptoms like harsh fibrous fruits and vegetables, dry toast, rusk, boiled sweets or



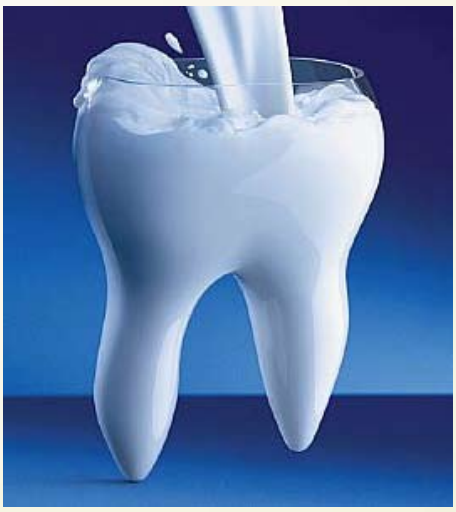

*Accumulation of plaque due to poor oral hygiene can result in inflammation of gums which causes loss of teeth.*

hard candies or any food which may trigger pain or maybe difficult to chew must be avoided. Soft bland foods which are non-spicy and do not irritate the lining of mouth during active ulceration should be preferred. Foods such as poached chicken, eggs (boiled or poached), semolina or suji pudding, yogurt, gelatine desserts, jellies, custard, ice cream, soft cooked rice, boiled and mashed potatoes with light seasoning, fresh curd/cheese, etc., minimise pain and discomfort during eating. In case of multiple ulcers in various locations in the mouth, when chewing solid foods becomes difficult, one can resort to liquid diet. Liquids containing sugar like sherbets, glucose, sweetened beverages including soy milk beverages and milkshakes help in meeting body's energy and protein requirements to some extent. Pureed foods and liquids at room temperature can be sucked through a straw.

## Dental caries and gum disorders

Having a sweet tooth may result in bitter consequences, if teeth and gums are not properly cared for. Dental caries usually begins early in childhood and persists throughout life. Bacteria, the bacterium Streptococcus mutans thrives in dental plaque, a sticky film that coats our teeth after consuming meals, sweet foods and drinks. Colonies of such bacteria are present in our mouth and they require carbohydrates especially sucrose or sugar for their growth and multiplication. Bacteria act on the sugar that sticks to the surface of our teeth by breaking it down and produce acids that erode the surface of our teeth, destroying enamel and dentin. This results in dental cavities. The extent to which tooth enamel and dentin are destroyed depends on the length of time the bacteria have access to sugar and also the frequency with which sugar is made available. Thus, regular and frequent consumption of sweets and sweetened beverages even if taken in small amounts are more likely to be hazardous than taking a large amount of sugar at one time.

If the dental plaque is not removed by regular brushing, it hardens to form tartar which can lead to inflammation of gums or gingivitis. In gingivitis, gums become red, swollen and bleed due to gradual build-up of plaque. Treatment involves good dental hygiene and a visit to a dentist for removal of the plaque. If ignored, it can cause a serious condition called periodontitis, an infection of gums which can eventually cause teeth to loosen and fall off.



*Milk is an excellent source of calcium required for formation of strong teeth.*

## Linking diet with dental health

The foundation for healthy teeth is laid down even before we are born! Yes, a child's dental health also depends on how well-nourished the mother is during pregnancy. So eating healthy during pregnancy ensures that the child gets a good start. During childhood, a good supply of calcium and vitamin D helps in building strong teeth. Other nutrients like phosphorous, protein, vitamin A and vitamin C also play a significant role in building healthy teeth and gums. People generally believe that milk teeth aren't important as they are replaced with permanent teeth later, but the fact is that milk teeth are important and they ought to be strong enough to ensure strong teeth later when they eventually fall off. The best source of calcium in our diet is milk and its products like curd and cottage cheese (paneer). Calcium from vegetarian sources like green leafy vegetables, sesame (til) seeds, drumstick, etc., is poorly absorbed by the body. Calcium supplements do help, but it is best to obtain calcium from natural sources as it is better absorbed by the body and other nutrients are supplied as well. Milk contains lactose sugar which aids in calcium absorption. Also vitamin D present in milk and milk products enhances calcium absorption. The best source of vitamin D is sunlight. Exposure to Sun's rays for as little as 15 minutes in a day helps in the synthesis of vitamin D in the body.

Nutritional deficiencies play a key role in tooth decay and gum problems, though its importance has never been emphasised. Not many people know that minerals like calcium and phosphorous, which are found abundantly in animal foods like milk, meat, fish, chicken and eggs, and fluoride are also important in preventing tooth decay as they strengthen the tooth structure. Drinking fluoridated water helps in preventing tooth decay, especially in young children. But excess of fluoride is bad for health; as it results in a condition called dental fluorosis leading to mottling of teeth.

Eating plenty of fresh fruits and vegetables, particularly fibrous fruits like apples, and regular munching on raw salads like carrots, cucumbers, radish, etc., help in exercising gums. Vitamin A also plays a role

*Apples are known as natural toothbrushes as they stimulate the gums, increase the saliva flow, reduce the build-up of plaque and help in removing any food particles stuck between teeth.*

in strengthening tooth structures. A lack of vitamin A can cause a reduction in the amount of enamel formation. Yellow and orange coloured fruits and vegetables like mango, oranges, carrots, yellow pumpkin, papaya, etc., contain beta-carotene which gets converted into vitamin A inside the body. Other sources include green leafy vegetables like spinach, coriander, fenugreek, amaranth, drumstick leaves all of which are good sources of beta carotene. Vitamin A is present in animal foods like milk, meat especially organ meats like liver which is the richest source of vitamin A and egg yolk. Apples are known as natural toothbrushes as they stimulate the gums, increase the saliva flow, reduce the build up of plaque and help in removing any food particles stuck between teeth. Fruit juices whether sweetened or unsweetened contribute to tooth decay, as they are highly acidic and have a high concentration of sugars, both added and natural.

Deficiency of vitamin C in the body causes a condition called scurvy characterised by spongy bleeding gums. Hence, one must include plenty of fresh fruits and vegetables in the diet to ensure adequate intake of vitamin C. Even though citrus fruits are acidic in nature and fruits contain sugar, but when they are consumed raw and in whole form, the fibre in them stimulates the secretion of saliva which reduces mouth acidity and washes away food particles lodged between the teeth, thus preventing tooth decay. Only when juices are consumed, they affect the dental health adversely as no chewing is required and chewing causes increased saliva flow.

It is not only sugar-containing foods and beverages that cause tooth decay, but starches in foods like breads, rice, pasta, potatoes and bakery goods like biscuits, cakes, pastries, cookies are also culprits. Food particles containing starch, which lodge between the teeth, are more likely to result in tooth decay, as bacteria has access to them for longer periods of time and starches are converted into sugars in the mouth by the action of salivary amylase enzyme. This makes it easier for cavity-causing bacteria to act upon the sugar from starchy foods and produce acids which erode tooth surfaces.

Other foods which are implicated in causing tooth decay are fizzy or aerated drinks and dried fruits. There is a relation between increased consumption of fizzy/soft drinks and dental caries. Frequent and regular consumption of these carbonated/fizzy drinks has been linked to dental cavities, especially common in young children and adolescents. These drinks have high sugar content along with a high acid content (phosphoric acid) which promotes enamel erosion. The presence of high amounts of phosphorus also disturbs the calcium and phosphorus balance of the body, causing calcium to leach out leading to its deficiency. Increased soft drink consumption among children and teenagers also displaces milk and milk-based beverages from the diet, leading to a low intake of calcium during the most crucial periods of physical development. Dried fruits because of their high sugar content and sticky nature tend to cling to the teeth, increasing the risk for tooth decay. Hence, one must be cautious when consuming dry fruits which should either be eaten along with meals or when taken as snacks, especially before bedtime, teeth must be brushed well to remove any debris that remain on the teeth.

## Strategies to prevent dental and gum disorders

1. The unborn baby could get a good start if the mother eats a healthy diet with adequate vitamins and minerals especially calcium and vitamin D-rich foods during pregnancy.
2. When starting with weaning foods for the baby, adding sugar to foods prepared at home should be avoided.
3. Baby foods sweetened with added sugars should be limited.
4. Infants should never be given any sweetened beverages, diet drinks, or colas.
5. Fruit juices should be diluted adequately with boiled and cooled water in the ratio 1:4 (one part of juice with 4 parts of water) to reduce the acidic and sugar content.
6. Fruit juices should not be sweetened and packed juices should never given to babies.
7. Pacifiers should not be dipped in sugar syrup/honey.
8. Bottle feeding should be avoided and instead the baby should be encouraged to drink from a cup.

   Bottle fed infants are more likely to have tooth decay as their teeth are constantly bathed in milk for long periods.
9. The use of feeding bottle should be discontinued or discouraged by the age of one.
10. The baby's teeth must be wiped with a clean moist cloth after every feed.
11. Sugar-containing drinks and snacks like cream biscuits, wafers, sugar-coated cereals, jams and jellies, cakes, pastries, etc., should be avoided in between meals. Instead, whole fruits, sprouts and other healthy alternatives are better.
12. Bedtime snacking should be avoided. If unavoidable, the mouth should be thoroughly washed or the teeth well-brushed after snacking before going to bed. This is because saliva flow declines during sleep and teeth are more susceptible to decay when food particles remain in the mouth during sleep.
13. The habit of sipping sweetened or acidic drinks for long periods at a stretch like sipping soft drinks through a straw slowly while watching TV or reading should be avoided. Slow and continuous intake of sweetened and acidic juices/drinks has a cariogenic (tooth decaying) effect as they remain in contact with sugar and acid for prolonged periods leading to tooth destruction.
14. Eating sticky sweets, bakery products like biscuits, cakes, cream rolls and chocolates regularly should be avoided. Brushing the teeth after consuming sticky and sugary foods or chewing sugar-less chewing gum can protect the teeth, as it stimulates saliva flow which washes away a lot of acid produced after consuming meals.
15. For elderly people who are more prone to dental and gum problems, having a healthy diet with plenty of fruits and vegetables cut into small pieces/ thin slices to enable easy chewing, and consuming lactose-free calcium-rich foods (unsweetened curd/yogurt) helps in preventing tooth decay.
16. During old age, people often have tooth decay due to dryness of mouth. Since it is difficult to sense dehydration with advancing age, elderly people must drink plenty of fluids including water unless contraindicated due to medical problems.
17. It is important to read food labels for sugar content of foods. Foods

labeled as "sugar free", "sugar less", "no added sugars", etc., maybe misleading, as it only means sucrose is not added to the product. But food ingredients containing sugar include not just sucrose but other names also like "high fructose corn syrup", "invert sugar", "glucose", "dextrose", "maltodextrin", "honey", "molasses", and "lactose", which are commonly used types of sugar in processed foods and have a cariogenic effect too. It is better to avoid foods with high sugar content.

18. The practice of concluding meals with foods that do not promote tooth decay like raw salads, fresh fibrous fruits instead of sweets and rich desserts may help in preventing tooth and gum problems.
19. Chewing gum sweetened with artificial sweetener xylitol actually promotes dental health. Therefore, one must replace regular chewing gum with chewing gum containing xylitol.

Studies have shown a link between gum diseases and heart disease along with other systemic disorders because bleeding gums are likely to serve as an entry port for bacteria and viruses. Women with dental and gum problems are more likely to give birth to premature babies. Since, oral health is linked with other serious disorders, one must adopt healthy eating habits and lifestyle practices to ward off other diseases as well. A healthy well-balanced diet consisting of fresh fruits and vegetables, milk and milk products, pulses, beans and legumes, whole grains, meat, fish and poultry ensures good oral health. Maintaining good oral hygiene by regular brushing of teeth, using fluoride toothpaste or mouthwash, drinking fluoridated water and regular visits to a dentist for removal of dental plaque and any needed repairs keep the teeth and gums healthy and long lasting.

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*Continued from page 32* **(Nanoscience and its applications)**

nanobots, are also being used in the field of medicine. These nanobots are extremely minuscule robots, made up of carbon nanotubes, which have dimensions of 1-100 nm. These nanorobots can easily be made to enter the bloodstream and free the body of pathogens without the aid of antibodies.

In industry, nanoscopic filtration membranes are being used. On a large scale, this is used in the purification of water and air and in various industrial processes which include purification of drugs and enzymes, separation of oil from water and waste removal. In particular, nanotechnology is capable of removing any kind of pollutants from water. Filters made out of nanofibres can be used to remove viruses and other pollutants from water. For removing metal ions, there is plan to develop dendrimer-aided ultrafiltration as a marvellous process of water purification. (Dendrimers are highly branched, star-shaped macromolecules with nanometre-scale dimensions.)

From the aforesaid we can clearly see that the reach of nanoscience and nanotechnology in our life is increasing day-by-day. With their use, myriad devices and methods are likely to be developed in future which on the whole will prove to be very useful for the betterment of human life.

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(Translation: Abhas Mukherjee) ■

# The exotic T-rays

**Dr. P.K. Mukherjee**
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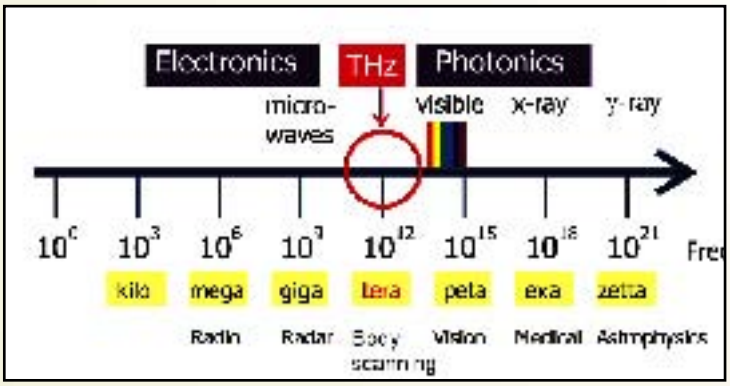
Everyone has heard of X-rays, which are extensively used by doctors to peer beneath the flesh to see the organs or to check for a broken bone. X-rays are also used in other diagnostic methods such as CT scan. The X-ray imaging technology came along in1890s and since then it has had much impact in the field of medical science. X-rays have myriad applications in other fields too. For instance, they are used by scientists to find the precise structure of proteins. X-ray crystallography is an important field where X-rays have promising applications. The potential applications of X-rays are indeed varied and endless.

X-rays belong to a specific category of radiation called electromagnetic radiation. Microwave ovens use microwaves while the remotes for TV and AC use infrared rays, which also form part of the electromagnetic spectrum, as also are ultraviolet rays, gamma rays and radio waves. In terms of wavelength, at one end of the electromagnetic spectrum we have gamma rays having shortest wavelength while at the other end we have radio waves having the longest wavelength.

An underused chunk of the electromagnetic spectrum lies between its microwave and infrared regions covering frequencies between 300 GHz (1 GHz or gigahertz is one billion Hertz) and 10 THz (1 THz or terahertz is one million million Hertz). Electromagnetic waves corresponding to this frequency range are known as terahertz (THz) waves or simply, as T-rays. THz waves have wavelengths hundreds of times longer than visible light.

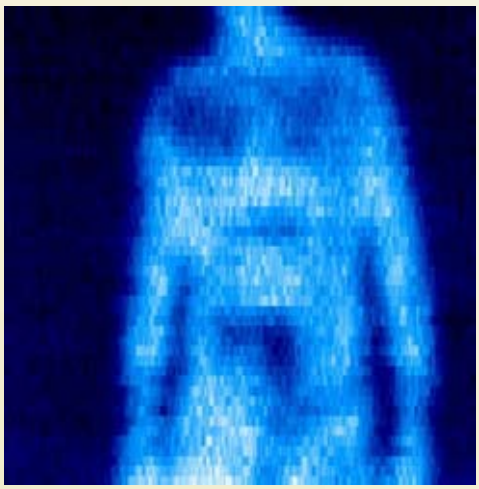
Invisible T-rays bear resemblance with radio waves, microwaves, infrared rays and X-rays. But, unlike these much-used forms of electromagnetic waves, until recently T-rays have not been much exploited, in part because they were difficult to generate. This is because they fall in sort of no man's land, stuck between the world of optics and electronics. It would be appropriate to say that T-rays still constitute a gap between the science of light and energy. They belong to a part of the electromagnetic spectrum that remains to be better understood and much better exploited.

Nevertheless, T-rays are increasingly being used in the full-body security scanners found at the airports around the world. T-rays, like X-rays, can see through most materials. They can pass through clothing, paper, cardboard, wood, masonry, plastics and ceramics. T-rays are of the safe, non-ionising kind unlike X-rays, which due to their ionising nature are harmful.




*The electromagnetic spectrum showing the terahertz region.*

T-rays have led to the emergence of a promising imaging technology which is getting hotter and hotter. Potential applications range from detecting tumours to finding plastic explosives. And since T-rays can penetrate through paper and clothing, a THz camera could readily detect hidden weapons.



*T-ray body scans do not show details of the naked body underneath, but instead just images of explosives, liquids, narcotics, weapons, plastics and ceramics. And because it can see through fabrics from 25m away, concealed objects can be spotted without the usual walk-through scanner.*

## How did interest in T-rays begin?

What was the development that created interest in T-rays? Actually, astronomers wanted to detect THz radiation coming from distant galaxies, which would give information about the evolution of the universe. With this in mind, the European Space Agency (ESA) set up a project in 2002 at the Rutherford Appleton Laboratory near Oxford, UK to build the world's first compact terrestrial camera. Called Star Tiger, the project employed state-of-the-art micro-machining technology to make a novel silicon-based detecting system.

Based on this breakthrough, a UK company named Thru Vision went on to develop passive imaging devices for customs screening that could successfully image guns and explosives concealed under clothing using T-rays. This system was successfully tested for the first time at a UK airport. Currently, this technique is being used in full-body scanners at many airports to detect concealed weapons, drugs and explosives.

## Applications of T-rays

One big advantage of T-rays over X-rays is that they are non-ionising and, therefore, harmless to humans. On the other hand, X-rays are ionising and are known to have the potential of causing damage.

THz waves or T-rays can penetrate through fabrics, cardboards, plastics, wood and even living tissue, but they cannot pass so readily through hard, dense materials such as metals, bones and water. Therefore, T-rays encountering concealed objects such as weapons, drugs and explosives bounce back to the microchips which function as

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# Fireflies: The light out of sight

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Have you ever seen the spectacular show of lights in summer evenings by amazing lightning bugs? Have you ever chased the blinking fireflies through the fields to catch them? If you have not, you have missed nature's most magical, mysterious, wonderful and fascinating light show performed by these tiny creatures commonly known as fireflies or lightning bugs. Thank your luck if you can still find them in the backyard or the lawn of your house. Yes, researchers all over the world are worried that fireflies are disappearing from urban areas as well as from villages where it was found in large numbers not only a decade ago. Let's know more closely about this insect.

## The insect

Fireflies are also known as lightning bugs. But don't be confused, they are neither flies (order: Diptera) nor bugs (order: Hemiptera). They are beetles of the order Coleoptera. The forewings of a firefly are hard and leathery, known as elytra, which distinguish it from Diptera and Hemiptera. The elytra help the insect to keep balance during flying whereas the membranous hind wings are used for movement. The firefly belongs to the family *Lampyridae.* There are about 2,000 species of fireflies all over the world. Most of them can fly, but a few species and most of the female fireflies cannot fly. Although most of the species of fireflies are nocturnal some of them are diurnal too like the genus *Ellychina*, which don't produce light.

The life-span of an adult firefly is very short – about 1 to 3 weeks. The male firefly finds its mate by using specific flashing of light. The female stays on the ground or on the leaf and attracts appropriate male by specific flashing. A particular species of firefly, *Phosphaenus hemipterus*, is diurnal and has large antennae; it uses a pheromone to select mate. After mating the female lays eggs on the ground or just under the ground. After 3 to 4 weeks, the eggs hatch and larvae emerge. The larvae and even the eggs of firefly can glow. So the larva of firefly is also known as 'glow worm'. The larva emits light to warn off predators.

The larvae feed until the end of summer. They are specialised predators and feed on snails, slugs or even other larvae. Larvae of some species have gills so that they can thrive under water and feed on aquatic snails. Firefly larvae hibernate during winter by burrowing into the ground or under the bark of trees. They emerge from hibernating stage during spring and after several weeks of feeding they pupate for 1 to 3 weeks and then emerge as adults. It is not clearly known what the adult fireflies feed on, but researchers assume that adults feed on pollen, nectar or even nothing. Some species of fireflies show cannibalism and feed on other firefly species. This behaviour is most commonly found in the genus of *Photuris*. The female of this particular genus imitates the flashing pattern of the female of the *Photinus* genus. The target male *Photinus* is attracted toward the female *Photuris*, which appear to him as potential mate. But that is actually a trap to catch the male for the sole purpose of predation. This particular mimicking trick of *Photuris* genus is known as '*femme fatale*' (which means fatal woman). Fireflies are distasteful to eat and some of them are poisonous. When attacked by predators, firefly sheds fluid drops, which contain a steroid known as lucibufagins which are bitter in taste and similar to bufadienolides found in some poisonous toads. This process is known as 'reflex bleeding'.

## The light

Fireflies produce light in a specialised organ known as the 'photic organ' which is located in the lower abdomen of the insect. In this organ two chemicals are found – luciferin (a pigment) and luciferase (an enzyme). In presence of oxygen and magnesium, ATP (adenosine triphosphate), which is present in all living cells to provide energy, reacts with the pigment and produces light. The reaction is catalysed by the enzyme. The reaction is known as bioluminescence. Light produced by this chemical reaction is known as 'cool light'. An ordinary tungsten electric bulb wastes 90 per cent of the energy it consumes as heat and uses only 10 per cent to produce light. So, after few minutes of illumination the bulb becomes very hot. A fluorescent tube is much more efficient and turns almost 60 per cent of the energy consumed into light. In comparison, fireflies produce light most efficiently; almost 100 per cent of the energy is converted into light. As no heat is produced, the light is known as cool light. The colour of the light may be green, greenish yellow or pale red and the wavelength may vary from 510 to 670 nanometres.

Fireflies use their flashing light to communicate among themselves. For an adult the main purpose of flashing is to find a suitable mate. Each species produces a specific pattern of light flashes by which a male attracts a receptive female of the same species. They also use the light flashes to define their territory and to warn off enemies. But the larvae and eggs use the light mainly to warn off the predators.

A particular pattern of flashing known as synchronous flashing is observed in some species of firefly such as *Pteroptyx malaccae* in South-east Asia and *Photinus carolinus* in North America. In synchronous flashing, thousands of fireflies blink precisely at the same time and with the same frequency. It is definitely the most wonderful show of nature. The notable synchronous pattern of flashing may be seen in the mangroves forests of South-east Asia round the year,

and Great Smoky Mountains of USA during June. In India, synchronous species of firefly *Photinus pyralis* may be found in Kaziranga National Park in Assam, as reported by Isaac Kehimkar, the general manager of the Bombay Natural History Society.

How the insect synchronises its flashes is still under investigation. Recently two mathematicians R. Mirollo and S. Strogatz have shown that the synchrony follows the rule of mathematical models in which every firefly interacts with each other. It is just like the pacemaking cells of our heart that fire together to produce the heart beats. According to the scientists, when a firefly blinks the neighbouring ones are stimulated to do so and some adjustable pacemaker enables each of the fireflies to fall in line with the rhythm of the group. Synchrony spreads throughout the group until all are flashing together.

## The habitat

Fireflies prefer warm, moist and humid conditions. They can be found in all the continents except Antarctica. Marshy areas where decomposed wood and leaf litters accumulate are the perfect place for the firefly larvae. Adult fireflies thrive around streams, rivers, ponds or standing water. The male insects love to fly around the bushes and canopy of shrubs and small trees as the receptive female stays on the leaves of these plants. The insect does not like dry and harsh areas.

## Spin-offs from the firefly

This tiny creature helps us in many ways. They are not pests and never attack humans. The two chemicals found in the photic organ of the insect, namely luciferin and luciferase, emit light in the presence of ATP. A normal living cell contains a standard amount of ATP. If the amount varies then it indicates that some abnormality exists in the cell. So these two chemicals may be used in medical science to detect abnormalities in human tissues, such as cancer, cystic fibrosis, etc. These chemicals can be artificially synthesised and used in such applications. Electronic detectors used in space research carrying these chemicals can be used to find out the existence of living organism in space.

Researchers of the Clemson University of South Carolina, USA have used firefly as a bio indicator to assess the environmental health. They found that the health of environment and the firefly population are highly correlated. A good population of fireflies indicates good health of the environment, but if the population of the insect reduces drastically it means something is wrong with the environment.

## Why are fireflies disappearing?

It is now known fact that fireflies are disappearing from our surroundings, but

unfortunately, the insect still does not receive enough attention of the common people. There are many factors responsible for the declining firefly population most of which are related to human activity.

*i. Loss of habitat:* This may be the most significant factor. Due to unplanned development of our towns, cities and villages, without considering the sustainability and conserving the greenery necessary for survival, these insects are losing their habitat. Converting the forest land into agricultural land is another factor which contributes to the loss of habitat for the insect. Farmers in the North-eastern part of India practice *jhum* or shifting cultivation, in which forests along the slope of the hills are completely burnt down for planting crops. This practice destroys the habitat as well as directly kills the larvae hibernating in that place. Fireflies don't migrate. So if their habitat is destroyed then they disappear completely from the area.

*ii. Over-use of chemicals:* Today farmers are using overdose of chemical pesticides and fertilisers to get good crop. These chemicals not only kill the pests of the crop but also harm the fireflies. An adult insect and also the larvae may be killed by these pesticides when they come into the contact with the pesticide residue on plants.

*iii. Light pollution:* Fireflies communicate among themselves through flashing light. Artificial lights in urban areas interfere with the flashing of the fireflies. Lights from traffic, houses, street lights and other bright artificial lights hamper the communication process of the insect and especially make it difficult for them to find suitable mates, which leads to reduced population in successive generations. Professor N. Kumar of Punjab University reported in the *Times of India* in 2011 that the main reason for the loss of fireflies is artificial light which make fireflies' flashes less visible. This leads to breeding failure and disorientation as the male fireflies use flashes to attract females during mating season.

*iv. Drought, pollution and other environmental changes:* As the insect cannot thrive in dry areas, prolong drought may wipe out the insect from the area. Similarly other environmental disturbances such as heavy rain, high wind, and extreme hot and cold may create problem for the survival of the firefly. Along with development, pollution is also increasing in urban areas as well as in villages. Soil and water pollution due to high use of chemicals in the fields, wind pollution due to emission of smokes from various factories or even noise pollution may cause problems to the fireflies.

## What can we do to save the insect?

To save fireflies from becoming extinct some initiatives are necessary. First of all we should use as little external lights as possible. If it is possible, then put off the lights in gardens or lawns at night. As firefly larvae grow and feed on decomposed wood and leaf litters so we should put logs and leaf litter to accumulate in our backyards. Instead of using chemical fertilisers and pesticides we can use organic manures. If using organic material is not feasible then we should use the chemicals at appropriate doses. It is also necessary to create mass awareness among the people to save this beautiful creature.

## National and international initiatives to save firefly

Though scientists all over the world believe that the population of fireflies has drastically reduced in recent times, very little effort has been made by various national and international bodies to conserve them. But their steps towards the conservation

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# Medications and surgeries to rein in glaucoma

**Dr. Yatish Agarwal**
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Glaucoma can't be cured, and damage caused by the disease can't be reversed. Still, the good news is that with regular individualised treatment, glaucoma can be reined in, or controlled. Eye pressure-lowering eye drops, oral medications and surgical procedures can be used to prevent or slow further damage.

If you have glaucoma, you must know that you'll need to continue treatment for the rest of your life. Since the disease can progress or change without a person being aware of the progression, the treatment might need a change over time. Regular checkups and adherence to a treatment plan may seem burdensome, but they're essential to prevent vision loss.


Preventing further damage to the optic nerve and continued loss of visual field may be accomplished by keeping the eye pressure under control. Your eye doctor's focus would be on lowering your intra-ocular pressure to a level that's unlikely to cause further optic nerve damage. This level is often referred to as the target pressure and will probably be a range rather than a single number. Target pressure differs for each person, depending on the extent of the damage and other factors. The target pressure may also change over the course of a person's lifetime.

## Control of glaucoma with special eye drops

The treatment of glaucoma often starts with medicated eye drops. There are several types of drops the doctor may prescribe. It is important to use the drops exactly as prescribed to control your intra-ocular pressure. Skipping even a few doses can cause damage to the optic nerve to worsen. Some drops need to be applied several times each day, and others must be used just once a day. It is also important to inform your doctor of all medications you're currently taking, to avoid any undesirable drug interactions.

As some of the eye drops are absorbed into the bloodstream, you may experience side effects unrelated to your eyes. To minimise this absorption, close your eyes for 1 to 2 minutes after putting the drops in. Press lightly at the corner of your eye near your nose to close the tear duct, and wipe off any unused drops from your eyelid.

### *Types of eye drops*

Your eye doctor may prescribe more than one type of eye drops. If you're using more than one, wait 5 to 10 minutes between applications. The types of eye drop commonly used in glaucoma include the following:

## Beta blocker eye drops

### *How do they work?*

Beta-blocker eye drops reduce the production of aqueous humour and hence help reduce the intra-ocular pressure.

### *Drug names*

Levobunolol, timolol, carteolol, betaxolol, and metipranolol

### *Possible side effects*

Difficulty in breathing, slow pulse, hair loss, decreased blood pressure, impotence, fatigue, weakness, depression and memory loss.

### *Safeguards*

If you have asthma, bronchitis or emphysema, or if you have diabetes and use insulin, beta blockers shouldn't be used unless no alternative is possible, and then only with great care.

### *Alpha-adrenergic agents*

*How do they work? :* Like the beta-blocker eye drops, alpha-adrenergic agents also reduce the production of aqueous humour.

*Drug names:* Apraclonidine, and brimonidine

*Possible side effects :* Increased blood pressure, tremors, headache, anxiety, red and itchy eyes, dry mouth and allergic reactions.

### *Carbonic anhydrase inhibitors*

*How do they work? :* Carbonic anhydrase inhibitors act by reducing the amount of aqueous humour.

*Drug names:* Dorzolamide

*Possible side effects :* A bad taste in the mouth, frequent urination and a tingling sensation in the fingers and the toes are common when a carbonic anhydrase inhibitor is taken orally but rare when it is taken as drops.

### *Safeguards*

If you're allergic to sulfa drugs, this type of medication shouldn't be used unless no alternative is possible, and then only with great care.

### Prostaglandin analogues

*How do they work? :* Prostaglandin analogues increase the outflow of aqueous humour. These hormone-like substances may be used in conjunction with a drug that reduces production of aqueous humour.

*Drug name :* Latanoprost

*Possible side effects :* Mild reddening and stinging of the eyes and darkening of the iris and the eyelid skin.

### Prostamides

*How do they work? :* Prostamides increase the outflow of aqueous humour.

*Drug name :* Bimatoprost

*Possible side effects :* Mild to moderate reddening of the eyes and eyelash growth.

### Miotics

*How do they work? :* Miotic eye drops increase the outflow of aqueous humour. Once extremely popular, they are rarely used today.

*Drug name :* Pilocarpine

*Possible side effects :* Pain around or inside the eyes, brow ache, blurred or dim vision, near-sightedness, allergic reactions, a stuffy nose, sweating, increased salivation and occasional digestive problems.

### Epinephrine compounds

*How do they work? :* Epinephrine compounds increase the outflow of aqueous humour. Once widely used, they are rarely used today.

*Drug name :* Epinephrine

*Possible side effects :* Red eyes, allergic reactions, palpitations, high blood pressure, headache and anxiety.

## Oral medications

If eye drops alone don't bring your eye pressure down to the desired level, your doctor may also prescribe oral medication. The most common oral medications for glaucoma are carbonic anhydrase inhibitors. These pills, which include acetazolamide, dichlorphenamide and methazolamide, should be taken with meals to reduce side effects.

You can help to minimise the potassium loss that these medications can cause by adding bananas and apple juice to your diet.

When you first start taking these oral medications, you may experience a frequent need to urinate and a tingling sensation in the fingers and the toes. These symptoms often disappear after a few days. Other possible side effects of carbonic anhydrase inhibitors include rashes, depression, fatigue, lethargy, stomach upset, a metallic taste in carbonated beverages, impotence and weight loss. Kidney stones also can occur.

The standard practice is to move on to surgery if medications are ineffective. However, many studies support the use of surgery as a safe and effective initial treatment.

## Surgery

Surgery might become necessary for the treatment of glaucoma if medications aren't effective or tolerated. Several different types of surgery are used, including laser surgery and more conventional procedures.

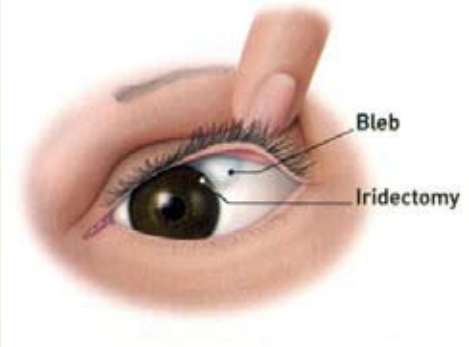
### Laser surgery

In the last couple of decades, a procedure called trabeculoplasty has been used increasingly in the treatment of open-angle glaucoma. The doctor uses a high-energy laser beam to shrink part of the trabecular meshwork, which causes other parts of the meshwork to stretch and open up.

This helps aqueous humour drain more easily from the eye. This type of laser surgery is an office procedure that takes 10 to 20 minutes. You'll be given an anaesthetic eye drop, seated at a slit lamp and fitted with a special lens on your eye. The doctor aims the laser through the lens at the trabecular meshwork and applies burns to it. You will see bright flashes of light.

After the surgery you can immediately resume normal activities without discomfort. The doctor will check your eye pressure 1 to 2 hours after the procedure and several times in the following weeks. He or she may prescribe anti-inflammatory eye drops for you to use for a few days following trabeculoplasty. It may take a few weeks before the full effect of the surgery becomes apparent.

In almost all cases, laser surgery for glaucoma lowers the intraocular pressure. However, its effects may wear off over time.




### Treating acute angle-closure glaucoma

Acute angle-closure glaucoma is a medical emergency. When you come in with this condition, doctors may administer several medications to reduce eye pressure as quickly as possible.

Once your eye pressure is under control, you'll likely have an operation called iridotomy. In this procedure the doctor uses a laser beam to create a small hole in your iris that allows aqueous humour to flow more freely into the anterior chamber. Many doctors recommend an iridotomy on the other eye at a later date because of the high risk that it too will have an attack within the next few years.

Studies show that eye pressure rises in many people 2 to 5 years after they receive the laser treatment. These patients may need a second treatment.

## Conventional surgery

If eye drops and laser surgery aren't effective in controlling your eye pressure, you may need an operation called a trabeculectomy. This procedure is done in a hospital or an outpatient surgery center.

You'll receive medication to help you relax and eye drops and an injection of anaesthetic to numb your eye. Using delicate instruments under an operating microscope, the surgeon creates an opening in

the sclera and removes a small piece of the trabecular meshwork. The aqueous humour can now freely leave the eye through this hole. As a result your eye pressure will be lowered. The hole is covered by the conjunctiva, so there's not an open hole in your eye.

Your doctor will check your eye in several follow-up visits. You'll use antibiotic and anti-inflammatory eye drops for some time after the operation to fight infection and scarring of the newly created drainage opening. Scarring is a particular problem for young adults, and people who have had cataract surgery. This procedure works best if you haven't had any previous eye surgery.

Although glaucoma surgery may preserve current vision, it can't restore already lost vision. Sometimes a single surgical procedure may not lower eye pressure enough, in which case you'll need to continue using glaucoma drops or have another trabeculectomy operation.

## Drainage implants

Another type of operation, called drainage implant surgery, may be performed on people with secondary glaucoma or children with glaucoma.

Like the trabeculectomy, drainage implant surgery is performed at a hospital or an outpatient clinic. You'll be given medication to help you relax and eye drops and an anaesthetic to numb the eye. Then the doctor inserts a small silicone tube in your eye to help drain aqueous humour.

After the surgery you'll wear an eye patch for 24 hours and use eye drops for several weeks to fight infection and scarring. Your doctor will check your eyes several times in the weeks that follow.

Complications from glaucoma surgery may include infection, bleeding, eye pressure that remains too high or too low and, potentially, loss of vision. Having eye surgery may also speed up the development of cataracts. Most of these complications, however, can be effectively treated.

*Continued from page 27* **(The exotic T-rays)**

a dual transmitter and receiver of T-rays. This "reflectance pattern", with the aid of appropriate software, can at once reveal the identity of the concealed object.

T-rays can also distinguish tissues in the body by their density and the amount of water they contain. These rays can detect biological phenomena such as increased blood flow around tumorous growth, and can also sense molecules such as those present in cancerous tumours and living DNA.

Malignant melanoma, the most serious forms of skin cancer, starts in pigment-producing cells located in the deeper parts of the epidermis – the outer layer of the skin. Biochemical changes that are hallmarks of cancer occur in the melanocytes long before mole-like melanomas appear on the skin. T-rays have the potential for looking underneath human skin to diagnose cancer at the earliest and most treatable stage.

T-rays can also be used for quality control in the pharmaceutical industry to check flaws in pharmaceutical tablet and capsule coatings. These rays can also be used in gas pollution monitoring and non-destructive testing of semiconductor integrated circuit (IC) chips. More importantly, T-rays offer a non-destructive way of probing beneath the top layers of famous paintings and other culturally significant artwork.

Other wide-ranging applications of T-rays include detection of early stages of tooth decay and presence of trace pesticides in food items and drinks. They can also be used for testing the effectiveness of skin cosmetics.

Like infrared radiation, T-rays of specific wavelengths interact with the molecules of a material to give a characteristic chemical signature that could be used to identify that material. The advantage of T-rays is that they are less easily scattered than infrared radiation. So, T-ray spectroscopy is more sensitive than infrared spectroscopy.

The applications of T-rays seem to be enormous. With more advancements made in the field of production and detection of T-rays, many more exotic applications would certainly emerge eventually.

Dr.P.K.Mukherjee is an Associate Professor of Physics, Deshbandhu College, New Delhi and popular science writer.

*Continued from page 25* **(Fireflies: The light out of sight)**

and making people aware of this creature should be appreciated. Researchers do not know much about the insect and so there is a great scope for research in this field. Dr. Nandkumar Kamat of Goa University launched a firefly awareness campaign in Goa in 2011, "Save fireflies of Goa" awareness campaign- SFGAC. He created a blog where videos of local fireflies are there.

Boston Museum of Science along with Tufts University and Fitchburg State University in USA started a 10 year project called 'Firefly Watch' in 2010. Anyone can participate in the project by collecting and uploading data related to fireflies observed in their locality. One can also retrieve the data uploaded by others. The project is running quite successfully and uses volunteers to help in scientific research known as citizen science (scientific research conducted, in whole or in part, by amateur or nonprofessional scientists) – to take advantage of enthusiastic volunteers to provide information that is difficult to get otherwise. The project is also running a web site named firefly.org, which provides tips to the people about how to collect and upload the data.

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# Recent developments in science and technology

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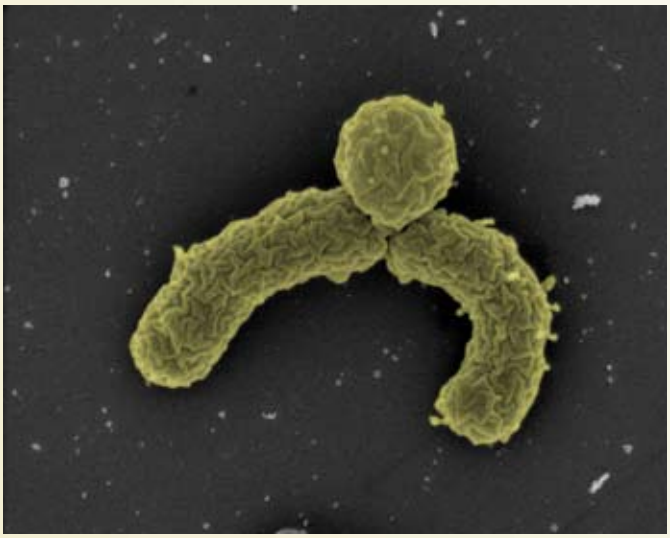
## Teixobactin – the first new antibiotic in 30 years

Ever since the discovery of Penicillin by Alexander Fleming in 1928 several hundred antibiotics have been discovered or synthesised. But the fight against disease-causing bacteria continues. This is because most bacteria have become resistant to even the most powerful antibiotics and antibiotic resistance has been spreading faster than the introduction of new compounds into clinical practice, causing a public health crisis. A large number of antibiotics in use today have become ineffective in treating bacterial infections. The war against drug-resistant bacteria has been a losing battle, with scientists failing to develop any successful new antibiotics in the past three decades. Globally, deaths due to antibiotic resistance are estimated at 700,000 per year. Now comes the good news of the discovery of a new antibiotic – the first to be discovered in more than 30 years – that is said to be as good, or even better, than many existing drugs with the potential to work against a broad range of fatal infections such as pneumonia and tuberculosis (*Nature*, 7 January 2015 | doi:10.1038/nature14098).



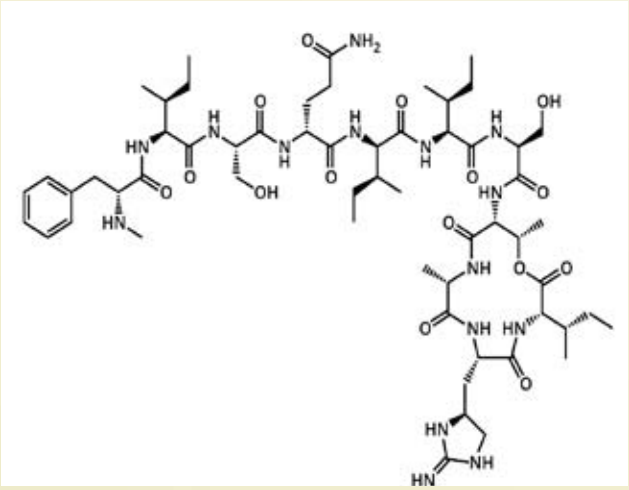
*Eleftheria terrae, the Gram-negative bacterium that produces Teixobactin. (Credit: William Fowle, Northeastern University)*

The new antibiotic, which the scientists have named Teixobactin, is unique not only for its potential to fight new, more dangerous and resistant versions of old bacteria, but also because of the innovative way it was cultivated. Teixobactin was derived from a bacterium grown directly in the soil, not in a Petri dish like many of the traditional antibiotics. Laboratory tests have shown the new antibiotic can kill some bacteria as quickly as established antibiotics and can cure laboratory mice suffering from bacterial infections with no toxic side-effects. According to its discoverers, because Teixobactin targets lipid molecules and prevents cell-wall synthesis in the bacteria, developing resistance to Teixobactin by bacteria would be difficult.

Teixobactin was discovered by a team of researchers at the Northeastern University in Boston, Massachusetts, USA, after screening more than 10,000 bacterial strains in soil. But the problem was that almost 99% of bacteria found in the soil cannot be cultured in the laboratory in Petri dish. So the researchers had to devise a special technique to culture it – in soil. They call it the 'iChip' in which the bacteria is held within agar in a lattice of tiny wells. The iChip is then covered with a permeable membrane, and placed into the original soil where the bacteria are allowed to grow.

According to the researchers, the team "created a 'subterranean hotel' for bacteria. One bacterium was placed in each 'room' and the whole device was buried in soil. It allowed the unique chemistry of soil to permeate the room, but kept the bacteria in place for study." Using this technique, the research team was able to screen 10,000 bacteria that were previously unculturable and isolate Teixobactin from a bacterium called *Eleftheria terrae*.

In mouse studies, Teixobactin showed 100% efficacy against Methicillin-resistant *Staphylococcus aureus* (MRSA) sepsis, and was very active against *Streptococcus pneumoniae* in lungs. No toxicity was seen against the mammal cells tested. However, Teixobactin does not have activity against Gram negative pathogens such as *E. coli* or Carbapenem-resistant Enterobacteraceae (CRE) or bacteria containing the gene New Delhi metallo-beta-lactamase 1 (NDM-1) that confers 'super resistance' to conventional antibiotics.



*Teixobactin molecule*

## First contracting human muscle grown in laboratory

For the first time, scientists have been able to grow human muscles in the lab that behaves just like muscles in the body and contracts and responds to external stimuli such as electrical pulses and pharmaceuticals. The achievement was reported by researchers from Duke University in Durham, USA led by Nenad Bursac, associate professor of biomedical engineering at Duke University, and Lauran Madden, a postdoctoral researcher in the open-access journal *eLife* (13 January 2015 | doi: 10.7554/eLife.04885).

*iChip in use in the fields (Credit: Slava Epstein/Northeastern University)*

According to the researchers, the lab-grown tissue could become a powerful new tool for studying diseases like muscular dystrophy. In addition, it could facilitate the development of specialised drugs to treat these diseases – and eliminate the need to test the drugs on humans without having to put a patient's heath at risk. It would also allow rapid screening of a large number of drugs on normal and diseased human muscle cells, facilitating development of therapies for neuromuscular diseases. "The beauty of this work is that it can serve as a test bed for clinical trials in a dish," says Bursac.

For their study, Bursac and Madden started with a small sample of human cells called "myogenic precursors", which they had isolated from human muscle biopsies. These are cells that have not yet developed into muscle tissue, but have advanced beyond stem cells. The researchers then multiplied the cells 1,000-fold in a dish full of nutrients. Then they mixed the cells with a nourishing gel and placed them into a 3-D mould, which encouraged the cells to line up and fuse into functioning muscle fibres.

The researchers subsequently subjected the lab-grown muscle to a barrage of tests to determine how closely it resembled native tissue inside a human body. They found that the muscles robustly contracted in response to electrical stimuli – a first for human muscle grown in a laboratory. They also showed that the signalling pathways that allowed nerves to activate the muscle were intact and functional. Further, to see if the muscle could be used as a proxy for medical tests, Bursac and Madden studied its response to a variety of drugs, including statins used to lower cholesterol and clenbuterol, a fat-burning drug known to be used as a performance enhancer for athletes.

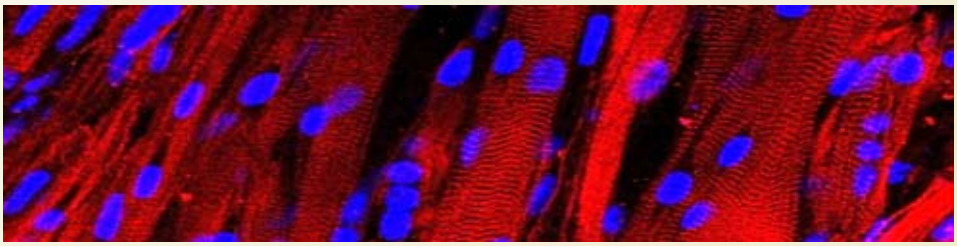
Although cells for the present study were obtained from human biopsies, the researchers are also looking at creating artificial muscle tissue from stem cells taken from skin or blood samples. That would eliminate the need to collect the cells via biopsy, which can be tricky with patients suffering from certain diseases.

## DNA reveals why birds don't have teeth

Birds are known to have evolved from dinosaurs. The earliest known ancestor of birds – the Archaeopteryx – lived about 150 million years ago and is considered a transitional species between dinosaurs and birds. Although the Archaeopteryx had wings, it also had jaws with sharp teeth, but modern birds do not. Evolutionary biologists have long struggled to find out how the lack of teeth came about, and new genetic data may have finally provided the answer: mutant tooth genes. Interestingly, the researchers found, the loss of teeth was not sudden, but gradual. Fossils younger than that of the Archaeopteryx revealed animals with partial beaks, but with teeth in the back of the jaw, meaning that teeth disappeared over a period of time, as the beak evolved in birds (*Science*, 12 December 2014 | doi: 10.1126/science.1254390).

There are roughly 10,000 species of birds spread across dozens of different orders, and they have wildly different body designs. For example, penguins and eagles don't have much in common except their total lack of teeth. Scientists saw two possible ways this could have happened: (i) It could be an example of convergent evolution, where different species around the world independently developed the same feature because it was advantageous, or (ii) the common ancestor of all modern birds had no teeth. The new data suggests it is the second option.

The new data comes from a full genome sequencing project on 48 different species of bird covering nearly all existing bird orders. Researchers also sequenced a representative of the extraordinarily toothy Crocodylia order, which is the closest living relative of birds. They finally narrowed the search down to six genes that are crucial for the formation of tooth enamel (the hard tissue that coats teeth) and dentin (the



*A microscopic view of lab-grown human muscle bundles stained to show patterns made by basic muscle units and their associated proteins (red), which are a hallmark of human muscle. (Credit: Nenad Bursac, Duke University)*

*Birds lost their teeth due to a genetic mutation.*

calcified stuff underneath it) in vertebrates.

The researchers looked for mutations that might inactivate these six genes in the genomes of 48 bird species. A mutation in dentin- and enamel-related genes that was shared among bird species would indicate that their common ancestor had lost the ability to form teeth. And indeed, the researchers concluded after analysis, these six enamel-related genes were disabled in all bird ancestors about 116 million years ago. Interestingly, the researchers also found mutations in the enamel and dentin genes of other vertebrates that don't have teeth or enamel, including turtles, armadillos, sloths, aardvarks and pangolins. However, all the six genes were found to be functional in the alligator, which is the closest living modern reptile relative of birds.

This finding about bird teeth is one of many that came out of a large-scale scientific effort to study the evolution of birds.

## Asteroids, not comets, may have brought water to Earth

After the remarkable feat of landing on a comet, European Space Agency's *Rosetta* spacecraft has now sprung another surprise. Comets are known to be mostly 'dirty snowballs' and so discovery of water vapour on 67P/Churyumov-Gerasimenko by *Rosetta* is not a surprise. But what is surprising is that the water found on this comet is not the kind found on Earth. One of the first scientific studies from the *Rosetta* mission done by a research team led by Kathrin Altwegg of the University of Bern in Switzerland has revealed that the comet's water contains more of a heavier hydrogen isotope called deuterium than water on Earth does. Heavy water has the same physical properties as $H_2O$, but it is heavier in mass (*Science*, 11 December 2014 | doi: 10.1126/science.1261952).

Out of every 10,000 water molecules on Earth, three are not normal water molecules, but instead are so-called heavy water molecules, which contain deuterium or heavy hydrogen in place of hydrogen. This ratio between heavy and light water is very characteristic. It cannot be easily changed and it stays for a long time. The *Rosetta* team found that there was far more heavy water in the ice on Comet 67P than in water found on Earth – it is more than three times higher than found on Earth. According to the scientists, this implies that water on Earth could not have come from comets, as was believed earlier.

One of the leading hypotheses on Earth's formation is that it was so hot when it formed 4.6 billion years ago that any original water content should have boiled off. But, today, two thirds of the surface is covered in water. Where did it come from? Till now it was mostly believed that water was delivered after our planet had cooled down, most likely from collisions with comets and asteroids. But the relative contribution of each class of object to our planet's water supply is still debated. The recent finding from *Rosetta* may settle the issue.

*Water vapour detected on Comet 67P/Churyumov-Gerasimenko was found to be different from water found on Earth, ruling out the possibility that comets brought water to our planet.*

Scientists routinely use data on isotopic ratio to pin down source of substances like water – in this case the proportion of deuterium to normal hydrogen – the D/H ratio. This proportion is an important indicator of the formation and early evolution of the Solar System.

Previous measurements of the D/H ratio in other comets have shown a wide range of values. Of the 11 comets for which measurements have been made, only one comet was found to match the composition of Earth's water. By contrast, meteorites that mostly come from asteroids in the Asteroid Belt match the composition of Earth's water. Thus, according to the scientists, despite the fact that asteroids have a much lower overall water content, impacts by a large number of them could still have resulted in Earth's oceans.

Before *Rosetta* began orbiting Comet 67P in August last year, it was using an instrument known as ROSINA (Rosetta Orbiter Spectrometer for Ion and Neutral Analysis) to analyse the chemical fingerprint of gases in the coma – the comet's fuzzy envelope. Scientists focussed on data from the instrument regarding water to help uncover whether asteroids or comets delivered the water in Earth's oceans. ■