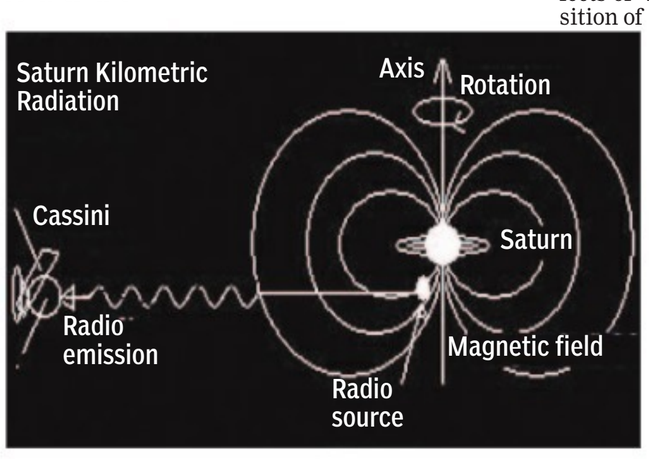
How long is a day on Saturn?

WE CANNOT TELL THAT A MASS OF GAS IS TURNING ROUND JUST BY LOOKING AT IT, WRITES
S ANANTHANARAYANAN

The rotation of planets can generally be made out with a telescope because we see physical features that regularly move out of view at one end and come back into sight from the other. Even of stars, we are able to make out and estimate rotational motion with the help of related effects, like the fact that the star has not collapsed due to gravity, which can be observed. But when it comes to the gas planets, like Jupiter or Saturn, there are neither surface features that can be seen nor other indicators like those of stars.

In Jupiter's case, although what we can see is only gas and clouds there is still a magnetic axis that is inclined to the axis of rotation. The planet's rotation can thus be made out because the direction of the magnetic field is as good as a pointer, or a direction marker, that goes round as it rotates. But in the case of Saturn, the second largest of the four gas planets, its magnetic axis is aligned almost along its axis of rotation. The magnetic field is, thus, not appreciably affected by rotation and it does not serve to make out how fast the planet goes round.

Estimates of the period of Saturn's rotation have, hence, been possible only by listening to low frequency radio signals that come from the planet and this had to wait till the spacecraft *Voyager* and *Cassini* were able to fly past and make close-range observations. The source of radio signals is the movement of charged particles that arise within the planet or in its atmosphere as a result of solar radiation. The planet's magnetic field twists the motion of these particles into spirals and such motion of charged particles leads to radio emission. But as the orientation of the magnetic field itself is changing, the intensity of radio emission rises and falls, in keeping with the changes in the magnetic field. Observation of the *Saturn Kilometric Radiation*, as the radiation from Saturn is called, was hence treated as a reliable method of assessing the rate of rotation.



Except that the rate revealed by *Cassini*, which went into orbit around Saturn in 2003, was both *variable and six to eight minutes slower* than what *Voyager* measured in 1980-81. As the time for a rotation estimated is around 10 hours and 40 minutes, this difference is considered quite large and raises questions about SKR being a suitable method at all. Further estimates based on other data, like wind speeds, dimensions and the measurement of Saturn's gravitational field by *Cassini*, have resulted in lesser rotation time even than the estimate by *Voyager*, and a basic property of a major planet in our own system is still uncertain. But Ravit Helled, Eli Galanti and Yohai Kaspi of Tel-Aviv University and the Weizman Institute of Sciences, Israel, report in the journal *Nature* that they have worked it out with a statistical, opitimisation method, based on *Cassini* data of Saturn's gravitational field and not the orientation of the magnetic field. And when they use the same method, employing gravitational effects to work out the rotation period of Jupiter, which is already known, they find that the answer agrees!

Gravitation data

The principle of using gravitational data to work out the rate of rotation depends on the rotating body not being uniform in all ways. We can readily imagine that the energy of rotation of a wheel that has most of its mass in the centre is not the same as that of a wheel with its mass at the rim. This is the principle of the flywheel and the ballerina, or ice-skater, who pulls her arms in to spin faster. Thus, if the composition of a wheel were not known to us, we could still work it out by measuring what effort it takes to set the wheel spinning. In the case of gravitational forces also, the radial distribution of density, or the oblate shape, which is where the poles are flatter in a sphere, like a planet, have their own effect on the force of gravity as one moves nearer or further away from the sphere. And then there are the effects of variation in density, like the composition of the crust or deeper within the planet, or the presence of mountains or oceans.

The effect of these variations is felt by a satellite in orbit around a planet, pulling out away from the planet where the gravity is weaker, or inwards and speeding up if the gravity is stronger. The data of the variations in the gravitational force of Saturn, as measured by *Cassini* over a period, with assumptions about the interior of the planet, can hence be interpreted to provide a measure of the flattening, or the bulge around the equator, and hence the speed of the planet's rotation.

Making use of *Cassini's* gravity data and other data then available, John D Anderson Gerald Schubert of California reported in the journal *Science* in 2007 that they had arrived at the lower limit, which is 10 hours 32 minutes and 35 seconds, which we spoke of earlier. The group from Israel now reports a figure that is very close to this one, based again on the gravitational data and a statistical methodology using 2,000 situations to arrive at the best value of speed of rotation, which fits the other, uncertain models of the internal density distribution.

To check the validity of the procedure used, the group employed the same method based on gravitational data to work out the speed of Jupiter's rotation. As mentioned earlier, in the case of Jupiter we have the clear marker of the magnetic axis well removed from the axis of rotation and we know the speed of rotation with certainty. And the result of the check is that the gravitation data method accurately arrives at the same known value of the speed of Jupiter's rotation.

That two independent determinations of the speed of rotation give results in close agreement thus means we now have the length of a day on Saturn. The Israel group anyway awaits more accurate data from *Cassini* in the course of its extended stay around Saturn till 2017 for a more exact estimate.

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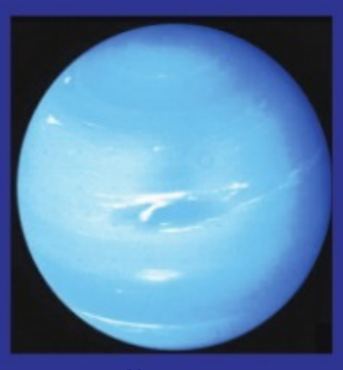
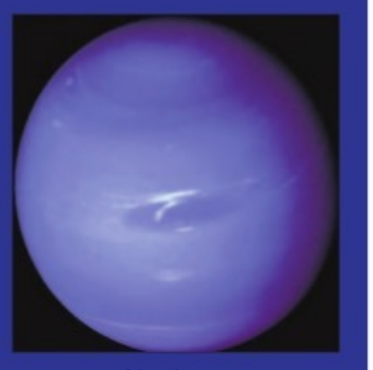
THE PLANETARY GAS GIANTS


Jupiter


Saturn


Uranus


Neptune

INCREDIBLY DANGEROUS

PARTHASARATHI CHAKRABORTY EXPLAINS THE MISCHIEF POTENTIAL OF POLYNUCLEAR AROMATIC HYDROCARBONS

Polynuclear hydrocarbons are organic compounds made up of two or more benzene rings fused in linear or angular arrangement. Naphthalene, anthracene, phenanthrene are the best examples of such compounds. The phenanthrene and anthracene molecule are isomeric in character, ie, their molecular formula is the same though the structures are different — the former with an angular structure, the latter a linear one.

The invention that certain Polynuclear Aromatic Hydrocarbons, with their mischief potential for aggravating cancer or malignancy in animal tissues, opened a completely new field of research into identifying individual carcinogenic hydrocarbons and eventually measuring their toxicity. It was realiSed, probably in the early part of the 20th century, that individuals, especially workers engaged in handling coal tar products, showed an abnormal high rate of cancer, particularly of the skin. This occurs very imperceptibly and the disease develops several years after the body is exposed to coal tar or related chemical products. This was discovered at the Royal Cancer Hospital in London through *in vitro* studies with experimental mice that a particular chemical substance markedly acts as an oncogene activator and is responsible for carcinoma.

The name of the chemical compound is *1,2,5,6 dibenz anthracene* and Elton S Cook and co-workers, with the help of fluorescence spectroscopy studies, actually isolated from two tons of coal tar pitch a substance known as *3,4 benzopyrene*. It has now been established with absolute certainty that coal tar contains about 1.5 per cent of carcinogenic Pah, which is incredibly dangerous not only for humans but also for animals. It must be attributed that *benzo(a) pyrene* has a marked structural resemblance with *1,2,5,6 dibenz anthracene*. The auto emission from vehicles contains substantial quantities of Pah, some of which are extremely carcinogenic.

Polynuclear Aromatic Hydrocarbons are produced at high temperatures during the incomplete combustion and pyrolysis of fossil fuels. With reduction in the lead content of petrol, the aromatic content is increased to maintain octane levels. Exhaust emissions of Pah further depend on the air:fuel ratio, the type of lubricant and fuel, driving mode, age of vehicle, engine speed, load and torque. It is well known that most of the Pah remain in the absorbed portion of soot particles. In general, Atmospheric Particulate Matter, including Pah, enter a person's body through the respiratory tract. Among these, small particles (0.1 to one micron in size) reach the lungs and are detrimental to health.

Pah toxicity differs considerably – from mild to very acute. A single large dose will not cause immediate adverse effects but continuous low doses will probably induce cancer. For non-smokers, food is normally the main source (over 95 per cent) of carcinogenic Pah (average daily intake being about 3ng).

The position of substituents are extremely important in determining the carcinogenicity of a Pah molecule. These hydrocarbons are commonly classified into two groups based on their molecular structure. Low Molecular Weight Pahs have three or fewer aromatic rings while High Molecular Weight pahs have four or more rings. The differences in the structure and size of individual Pahs result in substantial variability in their physical and chemical properties.

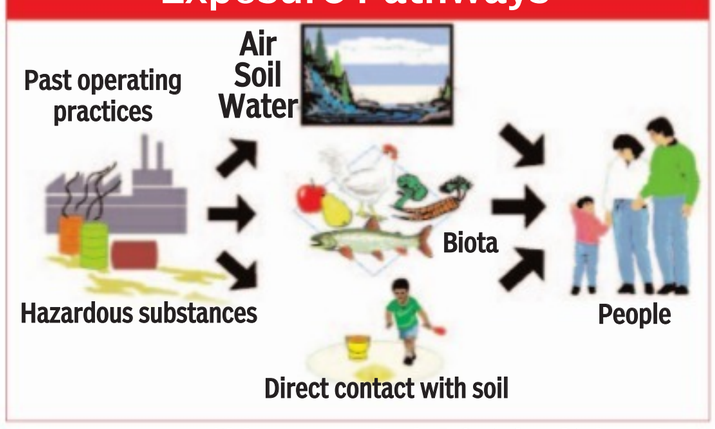
Again, the toxicity dependent on chemical structure.. Isomers can vary from being non-toxic to extremely toxic. One Pah compound, *benzo(o)pyrene*, is known as the first chemical carcinogen to be discovered. The Environment Protection Agency has classified seven Pah compounds as probable human carcinogens, namely: *benzo anthracene*, *benzo pyrene*, *benzo fluoranthene*, *benzo(k)fluoranthene*, *chrysene*, *dibenz anthracene* and *indeno pyrene*. Even *20-methyl cholanthrene*, present in coal tar, has carcinogenic activity.

A Columbia University study on "Environmental Health Perspectives" linked prenatal exposure to pollutants and eventual child behavioural outcomes. It found that exposure to higher Pah levels was associated with a 24 per cent higher score of anxiety or depression for children aged six to seven than those with low exposure levels. Infants found to have elevated Pah levels in their umbilical cord blood were 46 per cent more likely to eventually score highly on the anxiety/depression scale than those with low Pah levels in cord blood.

For humans, heavy occupational exposure to Pah entails a formidable risk of lung, skin or blood cancer. The acute and lethal effects of these hydrocarbons in a freshwater environment have been studied in detail and the result is indeed alarming. However, their effect on human health will depend largely on the concentration of Pah, the length and route of exposure and the toxicity involved. The genotoxic effects of some Pahs have also been demonstrated both in rodents and from *in vitro* tests using mammals, so it is absolutely imperative to control and prudently the carcinogenic mischief potentials these hydrocarbons, formulate standards of exposure in the work place and the environment.

THE WRITER, A FORMER READER IN CHEMISTRY, PRESIDENCY COLLEGE, KOLKATA, WAS ASSOCIATED WITH THE UNIVERSITY GRANTS COMMISSION

Exposure Pathways



Roadside 'bioreactors'

STEVE CONNOR REPORTS ON A BREAKTHROUGH IN HYDROGEN-POWERED CARS THAT COULD SPELL THE END FOR PETROL STATIONS

Scientists have dramatically increased the efficiency of producing clean hydrogen fuel from plant waste in a breakthrough that could one day lead to petrol stations being replaced by a network of roadside "bioreactors" for refuelling cars. A study funded by Shell Oil has shown it is possible to convert all 100 per cent of the sugar stored in corn stover — the stalks, cobs and husks left over in a harvested maize field — into hydrogen gas with no overall increase in carbon dioxide emissions to the atmosphere.

The researchers perfected the process by mixing the raw biomass with a watery solution containing a cocktail of 10 enzymes that turned the plant sugars xylose and glucose into hydrogen and carbon dioxide, said Professor Percival Zhang of Virginia Tech in Blacksburg, Virginia. Previously, it has only been possible to convert between 30-60 per cent of the plant's sugars into hydrogen using either fermenting microbes or industrial catalysts. The latest technique, however, converts every percentage of the plant sugars into hydrogen, he said.

Producing pure hydrogen gas from crop waste and biomass is seen as one of the most important goals of the green economy because of the need to produce clean alternatives to petrol. However, existing methods are inefficient, costly and are dogged by the problem of how to distribute the hydrogen once it is made. "All the products produced by the process are gases so they can be separated and collected easily from the biomass substrate.

Over its lifecycle, the process is carbon neutral and we have achieved a 17-fold increase in the rate of the reaction which makes it economically viable," said Zhang. "This means we have demonstrated the most important step toward a hydrogen economy — producing distributed and affordable green hydrogen from local biomass resources."

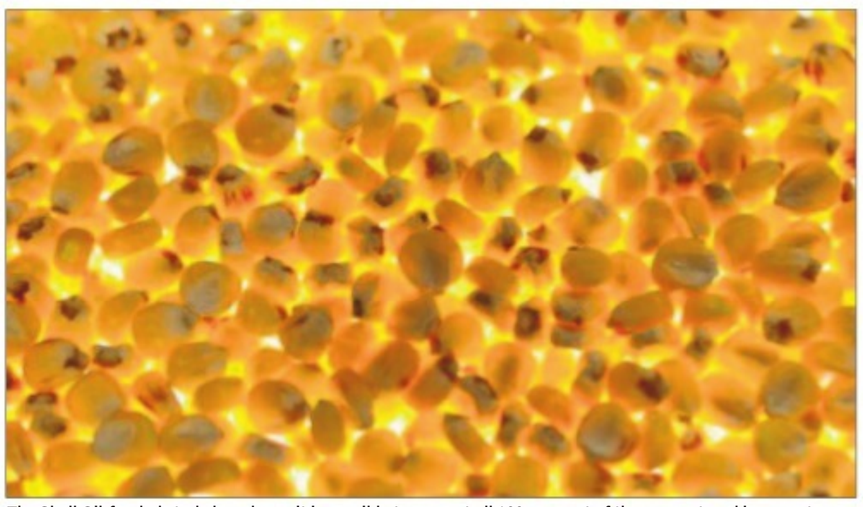
One of the critical developments in the process is being able to directly use "dirty" biomass as the fuel rather than relying on highly processed sugars as the source of hydrogen. In addition to being more efficient, this means it should also be possible to build large bioreactors the size of petrol stations near to sources of biomass, thereby leading to a network of green refuelling stations distributed around the country, Zhang explained.

"The next problem is to work on how to scale it up. But if we receive further funding I think in three to five years we should be able to build a bioreactor that is something like a gas station which can produce 200 kilos of hydrogen fuel a day. This would be enough to refuel about 40-50 cars."

The key step in the study was to identify the precise combination of enzymes that would work together on the plant waste to convert all of its xylose and glucose — which together account for 90 per cent of the sugars in plant waste — into hydrogen and carbon dioxide, which can be collected separately.

These 10 enzymes were initially made in microbial fermenters using genetically engineered bacteria. The separated enzymes were then added to the solution of plant waste where they continued to work for several weeks. However, the aim eventually is for these enzymes to continue working for months or years without being replaced, said Zhang.

THE INDEPENDENT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PLUS POINTS


A model of a corpse flower, which attracts carrion flies by producing an odour like that of rotting flesh.

Extremophiles on show

Despite the odds, life inhabits practically every inch of earth and "that's the marvelous thing", says ichthyologist John Sparks, who along with parasitologist Mark Siddall co-curated the exhibit, "Life at the Limits: Stories of Amazing Species", on display at the American Museum of Natural History in New York City.

"Life is so tenacious; it's resilient; it's resourceful, and every place it can live, it does, basically. Every habitat we've looked at, from the top of the Himalayas to the bottom of the ocean trenches, from boiling hot springs to deep sea vents — there's life there." The exhibit opened on 4 April in the museum's LeFrak Family Gallery and explores the diversity of life at earth's extremes of temperature, pressure, wetness, and aridity — and everywhere in between. It also highlights the range of adaptations that creatures have experienced in order to thrive in myriad conditions.

While most creatures featured in the exhibit have adapted to one extreme or another, the tardigrade, a tiny animal whose scaled-up models hang from the ceiling at the gallery's entrance, can withstand environmental extremes of all sorts.

This creature, called the water bear, is about the size of a poppy seed and has a round body, eight legs and a round protruding snout that makes it look like a caterpillar in a gas mask. When conditions are unfavourable, the water bear forms a spore-like state that can survive boiling, freezing, high pressure, and the vacuum conditions and radiation levels of outer space. When conditions improve, it reanimates itself. This astounding creature, the exhibit's poster child, may have been missed without the aid of rigourous research (and microscopy).

ASHLEY P TAYLOR/THE SCIENTIST

Genetics service

With only a bit of your saliva, Ancestry.com can send you a list of people you're related to, even cousins that lived and died 200 years ago. Or so claims the consumer genetics company in a new ad campaign, touting the genealogical power of its new "Ancestry DNA" test. The move is the latest in a big push from such firms to get the general public genotyped and excited about their genetic heritage.


A simple DNA test is all it takes, says Tim Sullivan.

"Now, through a simple DNA test, AncestryDNA is fundamentally revolutionising the way to discover your family history, transforming the experience by making it faster and easier to go further into your family's past and instantly discover new ancestors you never knew you had," said CEO Tim Sullivan.

AncestryDNA obviates the need for intensive genealogical research and relies solely on the mighty bulk of genetic databases and "new patent-pending algorithms" to match individuals to other people with genetic similarities that indicate familial relatedness. It boasts more than 800,000 genotyped members in its database, and the company claims that a new DNA testing technology, which reads a person's genetic code at "more than 700,000 DNA markers", makes to possible to dig up relatives that lived centuries ago.

But some experts are cautioning that the prospects of unearthing 200 years worth of genetic relatedness might be trickier than the company is making it sound. "Going back three or four generations, it's going to be hard for a researcher to know whether you are descended from George Smith, the oldest of the family, or any of the other sons," Hank Greely, a director at the Center for Law and Biosciences at Stanford University, said. "The company is going to need an awful lot of family members' DNA to determine with a high degree of probability how closely you're related to a distant ancestor."

Alexandre Bolze, a geneticist and postdoctoral researcher at the University of California, San Francisco, said, "A couple of other labs have already tried to make these huge family trees using big databases. This is useful to understanding how genetics influenced certain traits, like height. Not everything is caused by genetics."

BOB GRANT/THE SCIENTIST