

# Longer days in a warmer world

TIMEKEEPING MAY YET WORK AS A GOOD MEASURE OF SEA LEVEL RISE, SAYS S ANANTHANARAYANAN

The redistribution of water on the earth's surface as a result of the melting of polar ice, while the equatorial sea level rises, has been linked to an imperceptible slowing of our planet's rotation for some thousands of years. Sea levels rise due to both water flowing in from melting ice and also because the water is warming. With global warming during the last century, the melting of ice and warming of the sea have increased and so has sea level rise, which now threatens coastal cities worldwide.

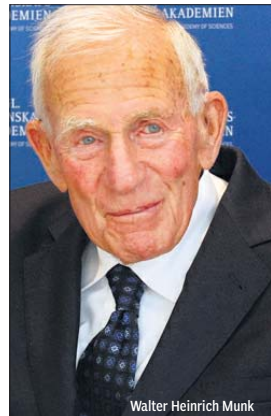
Jerry X Mitrovica, Carling C Hay, Eric Morrow, Robert E Kopp, Mathieu Dumberry and Sabine Stanley, from the universities of Harvard, Rutgers, Alberta, Grenoble and Toronto explain in the journal *Science Advances* that they have refined a way of considering available data so that a serious question about whether the speed of the earth's rotation could be used as a measure of the creeping rise in the sea level is resolved. Getting a correct estimate of how fast the sea level is rising is vital to help coastal cities plan investments for adaptation, from moving coastal structures inland to building dykes and even modifying drainage and sewage treatment according to the changed hydraulics in a warming world.

That the earth's speed of rotation is changing was first noticed by Isaac Newton's contemporary, astronomer Edmund Halley. With the help of Newton's mechanics of planetary motion, Halley made important contributions to the study of eclipses. He created the first *eclipse map* and rediscovered the *Saros cycle*, a pattern of eclipses used by the Chaldeans, Babylonians and later by the Greeks, to foretell the timing of eclipses. With the help of Newton's methods, Halley was then able to calculate the timing of ancient eclipses in historical records. But this is where he found that the timing did not match, in the sense that an eclipse that should have occurred in Babylon occurred, instead,

1,000 miles to the east or west. It seemed that either the orbit of the moon was speeding up or the rotation of the earth was slowing down. Both effects, in fact, were there, and the slowing of the earth was the main reason.

### Reasons for slowing

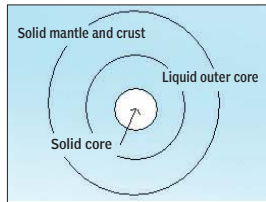
One reason for the earth slowing down is that energy is lost as a result of tides, in the oceans and also in the landmass, caused mainly by the moon. While this lost energy is partly gained by the moon, which then drifts away from the earth by a distance of 3.8 centimetres every year, the length of the day on earth gets longer by about two milliseconds every century. Such gradual slowing also adds up, for two



Walter Heinrich Munk

milliseconds a day is two-thirds of a second in a year, or some 70 seconds in a century. Hence the large differences in the timing of eclipses since the age of the Babylonians. Tides, however, are only one of the reasons that the earth slows down.

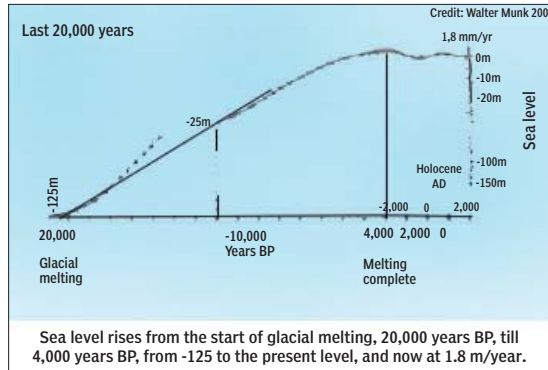
Another reason is when there is warming and ice at the poles melts and moves down towards the equator.



Acceleration or deceleration of the outer portion of a sphere is retarded by a liquid interior which is not rigidly connected with the outer portion. It is like spinning a raw egg. It is difficult to get the egg spinning, and once it is spinning it cannot be easily stopped. But a hard-boiled egg does not behave like this.

The rotating earth can be likened to a spinning figure skater. The mass of a spinning object that is further away from the axis of spin contains more of the spinning momentum than the mass the axis. The spinning figure skater would thus slow down if she stretched her arms out and speed up if she drew them in. In the same way, when part of the mass of the earth in the form of ice at the poles, which is nearer the axis of rotation, moves towards the equator and, hence, away from the axis, the earth has to slow down. Increase in the diameter of the earth by one millimetre can thus slow the planet down by about half a second per year every century. The actual sea level rise during 1900-1990 was 1.8 mm per year, or 18 cm over the century.

Yet another factor affecting the earth's speed of rotation is the flow of the material of the planet itself, as a result of the rotation. The spin tends to throw matter out, away from the axis, which is towards the equator, and the earth has assumed an oval or oblate shape. This squeezing out at the equator is also maintained by the load of ice that has formed at the poles. When this ice begins to melt, the pressure is relieved and the squeezing relaxes, which reduces the bulge at the equator, an effect that would increase the speed of rotation. This is an effect that has been in action since the last major glaciation, which was



Sea level rises from the start of glacial melting, 20,000 years BP, till 4,000 years BP, from -125 to the present level, and now at 1.8 m/year.

20,000 years ago. And a further factor in the picture is the exchange of energy between the molten, fluid outer core of the earth and the surrounding mantle.

### Munk's enigma

With the help of atomic clocks and astronomical observations, scientists are now able to estimate the speed of the earth's rotation with great accuracy. This ability could become a sensitive instrument to monitor the rate of sea level rise, provided the correct relationship could be discovered. Although there are now accurate satellite measurements of sea levels, data for earlier periods, till 1990, comes from tide-gauge readings maintained at many sea ports and harbours. Professor Walter Heinrich Munk, a celebrated US oceanographer, analysed the historical rotation speed of the earth, over the last 3,000 years, as discovered from Babylonian, Chinese, Greek and Arab eclipse records. He found that the variation in the rate of the earth's rotation over the period — after accounting for the effect of expansion due to warming and also the migration of material from the equator to the poles, as a result of the higher latitudes being relieved of the load of glaciers — does not agree with the implied flow of water from melting ice sheets and, hence, the sea

level rise. This discrepancy, which is based on the uncertainty of data and renders the findings of oceanographers and climate experts questionable, has come to be known as *Munk's enigma*.

The group writing in *Science Advances* reports in their paper that the expression of the enigma by Munk itself indicates a correct way to consider the uncertain data that is available. They find that results become more consistent by (i) accepting a lower estimate for the mean sea level rise for the 20<sup>th</sup> century, (ii) using an improved model, based on independent data for the flow of earth material towards the poles and then (iii) by carrying out a computation based on geomagnetic data to account for the interaction of earth's mantle-crust with the liquid outer core.

"Confronting Munk's elegant statement of the enigma has thus improved our understanding of the earth's rotation spanning the last three millennia and the individual sources of sea level rise in the century before the early 1990s. The reconciliation also adds confidence to ongoing efforts to project this rise to the end of the current century and beyond," the authors of the paper say.

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## PLUS POINTS

### The perfect present

A team of scientists have figured out the secret to giving the perfect Christmas present — and fortunately, it isn't about spending as much as possible. In a study recently published in the *Journal of Experimental Social Psychology*, researchers found that those receiving gifts generally like the presents that reflect the personality of the giver the



best. Trying to second-guess or assume what the receiver wants isn't the way to go, the study suggested, as it often causes us to lose an understanding of what they really want and value.

This conclusion was reached during an experiment in which 122 participants bought songs from iTunes as gifts from their friends — when researchers surveyed these friends afterwards, they found they generally liked their gifts more when told they reflected the givers' personal tastes in music.

In more good news for those who have left their Christmas shopping to the last minute, the researchers also identified a few no-nos that people should bear in mind when buying gifts. When receivers were given a bundle of presents comprised of one higher-value gift and a smaller, less expensive one, it was found that they attempted to estimate the value of the set of presents — and when they did that, the cheaper gift tended to lessen the perceived value of the main present in their minds.

Psychology Professor Adrian Furnham from University College London concluded the study by saying that the better people know each other, the more subtle they can be with their gifts, rather than trying to wow the receiver with a flashy present — but, he adds, "a gift still must be carefully and thoughtfully chosen".

DOUG BOLTON/THE INDEPENDENT

### Building a Death Star

The Death Star, the nefarious cosmic entity that is the centre of the evil Galactic Empire's reign in *Star Wars*, has always been thought to be solely a facet of science fiction. But with the approach of the newest film in the monstrously successful franchise, *The Force Awakens*, a chief engineer at the National Aeronautics and Space Administration's Jet Propulsion Laboratory has offered up the idea that one could technically be built in real life — on an asteroid.

In a video released on 10 December on *Wired*, Brian Muirhead, the lab's chief engineer, says the Empire took a



roundabout route in building its self-proclaimed "ultimate weapon". It needn't have shot materials out of a planet and constructed the megastar in space, he says. Instead, it could have just used a pre-existing asteroid. "It could provide the metals. You have organic compounds, you have water — all the building blocks you would need to build your family Death Star," he says in the video.

Muirhead should know, as his latest venture is NASA's Asteroid Redirect Mission, which is attempting to have a robot land on an asteroid in 2023 and gather a boulder from the surface. The boulder is then to be placed in an orbit around the moon, where it will then be tested. May the force be with them.

THE INDEPENDENT

### Sneeze o'clock

It's a common complaint physicians hear from patients suffering from allergic rhinitis: upon waking, uncontrollable



sneezing launches victims into the start of their day, blurry-eyed and itchy-nosed. Studies have confirmed the existence of the phenomenon, says Michael Smolensky, a chronobiologist at the University of Texas at Austin. "Allergic rhinitis starts to exacerbate during the nighttime sleep span," he explains. "If you are not awoken at night, you find the most extreme complaints upon arising."

Part of an allergic reaction has to do with the rhythmicity of allergen exposure, he says. Pollen levels, for instance, will peak at certain times of the day, and we are more likely to encounter outdoor allergens during the day when we're active. But scientists are also now showing that our own circadian clocks have something to do with symptom patterns as well.

THE SCIENTIST

# SPECIFICITY & PRECISION

TAPAN KUMAR MAITRA EXPLAINS THE PART PLAYED BY ENZYMES IN CELLULAR FUNCTION

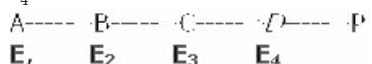
To understand the role of enzymes in cellular function one needs to recognise that it is rarely in the cell's best interest to allow an enzyme to function at an indiscriminately high rate. Instead, the rates of enzyme-catalysed reactions and the biochemical sequences of which they are a part must be continuously adjusted to keep them finely tuned to the needs of the cell. An important aspect of that adjustment lies in the cell's ability to control enzyme activities with specificity and precision.

Regulation that depends directly on the interactions of substrates and products with the enzyme is called *substrate-level regulation*. As the Michaelis-Menten equation makes clear, increases in substrate concentration result in higher reaction rates. Conversely, increases in product concentration reduce the rate at which substrate is converted to product.

Substrate-level regulation is an important control mechanism in cells but it is not sufficient for the regulation of most reactions or reaction sequences. For most pathways, enzymes are regulated by other mechanisms as well, two of the most important being *allosteric regulation* and *covalent modification*. These mechanisms allow cells to turn enzymes on or off or to fine-tune their reaction rates by modulating activities appropriately.

Almost invariably, an enzyme that is regulated by such a mechanism catalyses the first step of a multi-step sequence. By increasing or reducing the rate at which the first step functions, the whole sequence is effectively controlled. Pathways that are regulated in this way include those required to break down large molecules (such as sugars, fats or amino acids), as well as pathways that lead to the synthesis of substances needed by the cell (such as amino acids and nucleotides).

The single most important control mechanism whereby the rates of enzyme-catalysed reactions are adjusted to meet cellular needs is *allosteric regulation*. To understand this mode of regulation, consider the pathway by which a cell converts precursor A into a final product P via a series of reactions catalysed respectively by enzymes E<sub>1</sub>, E<sub>2</sub>, E<sub>3</sub>, and E<sub>4</sub>:

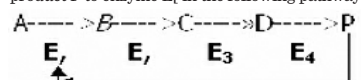


Product P could, for example, be an amino acid needed by the cell for protein synthesis, and A could be some common cellular component that serves as the starting point for the specific reaction sequence leading to P.

If allowed to proceed at a constant, unrestrained rate, the pathway has the capacity to convert large amounts of A to P, with possible adverse effects resulting from a depletion of A or an excessive accumulation of P (or both).

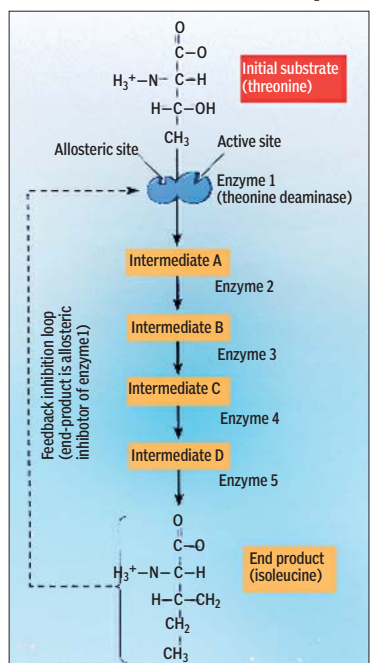
Clearly, the best interests of the cell are served when the pathway is functioning not at its maximum rate or even some constant rate but at a rate that is carefully tuned to the cellular need for P. In our enzyme example, the desired regulation is possible because the product P is a specific inhibitor of E<sub>1</sub>, the enzyme that catalyses the first reaction in the sequence. This phenomenon is called *feedback* (or *end-product*) *inhibition* and is

represented by the dashed arrow that connects the product P to enzyme E<sub>1</sub> in the following pathway:



### Feedback inhibition of E<sub>1</sub> by P

More generally, feedback inhibition occurs whenever a metabolic product inhibits one of the enzymes involved in the pathway by which that product is synthesised. Feedback inhibition is one of the most common mechanisms used by cells to ensure that the activities of reaction sequences



are adjusted to cellular needs.

A specific example of such a pathway is the five-step sequence whereby the amino acid *isoleucine* is synthesised from *threonine*, another amino acid. In this case, the first enzyme in the pathway, *threonine deaminase*, is regulated by the concentration of *isoleucine* within the cell. If *isoleucine* is being used by the cell (in the synthesis of proteins, most likely), the *isoleucine* concentration will be low. Under these conditions, *threonine deaminase* is active and the pathway functions to produce more *isoleucine*, thereby meeting the ongoing need for this amino acid. If the need for *isoleucine* decreases, *isoleucine* will begin to accumulate in the cell, and the increase in its concentration will lead to a decrease in the activity of *threonine deaminase* and, hence, to a reduced rate of *isoleucine* synthesis.

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# Let there be light

A HYDROGEN TRANSMISSION NETWORK CAN PROVE TO BE A GAME-CHANGER WHEN IT COMES TO PROVIDING ELECTRICITY TO OFF-GRID AREAS, WRITES ARINDAM BANERJEE

Even as the world pontificates on the consequences of climate change and energy nothing specific has ever been done to provide electricity to impoverished people living in remote off-grid areas. Despite the availability of the high-voltage grid, uninterrupted, full-voltage supply of electricity remains a dream because of frequent breakdowns due to poor maintenance, pilferage or natural calamities.

A solution that is crying out to be tried is a Hydrogen Transmission Network. Zero-pollution HV grid-grade electricity can be produced from hydrogen derived from electrolysis of saline water using renewable energy such as photovoltaic solar cells and fuel-cell/inverters. The technology would enable people in remote regions to use power tools, pumps and motors and produce ancillary or traditional items, using machinery, welding and small furnace among other things. Compressed hydrogen may be used in place of petrol/diesel for fuel-cell vehicles and reduce the production of greenhouse gases too.

Hydrogen need no longer remain in a compressed condition because HTN is a flow process without problems of storage or transport. In any case, most of the hydrogen generated is used up soon after generation. It is not carried in tanks but sent from the source to the destination using special non-corrosive thin but rugged pipes and the storage facilities act as buffers for continuous load balancing.

At the destination, the hydrogen will be converted into electricity (direct current) using the relatively new but now proven technology of fuel cells. A fuel cell takes in hydrogen as input, oxygen from the air, and converts the hydrogen into water and electric power. The fuel cell has no moving parts, and does not require constant maintenance like batteries. The direct current from the fuel cell can be converted into normal 220 volt AC with inverters, and this could be distributed in, say, a remote village beyond the scope of the electric grid.

Hydrogen can be generated by utilising solar power or other forms of renewable non-fossil energy sources such as nuclear, wind, tidal, biomass or geothermal, with electrolysis of the sea or brackish water. People in power-deprived areas will get elec-

tric power and pure water, plus hydrogen as fuel. It is an alternative or extension to high voltage transmission of energy.

Thus, instead of electricity it would use hydrogen as energy carrier through lossless piping. HTN primarily acts as an alternative to high voltage transmission, in distant and remote areas. Its main role is to carry power with pure water as a by-product in a cheap, efficient and pilfer-proof manner. The labour costs are low as is the carbon footprint.

Other by-products are oxygen at the initial stage if electrolysis is used, and hydrogen as a direct fuel for say, moving buses and trucks, or welding. The key components of the system are non-renewable or renewable energy sources such as PV solar cell panels, fuel cells, the methods of electrolysis, hydrogen compressors and special non-corrosive pipes, alarming and monitoring systems, pumps and hydrogen storage containers, condensers — all these have existed for decades. The invention brings them all together, in a new energy transport system that will be bottom-up, need-based, and have organic growth like in telephony or internet.

A project report for setting up a 150kw by-day/5kw by-night pilot plant was prepared at the request of the West Bengal Renewable Energy Development Agency of the ministry of power. However, the cost of Rs 2 crore was found prohibitive. The proposed project would be the first-in-the-world, from electrolysis of saline/brackish water, using solar cells (or any renewable energy) and the fuel-cell/inverter technology for conversion to electricity at the destination.

Such pilfer-proof, lossless, 24x7 uninterrupted supply of HV grid-grade electricity derived from piped supply of hydrogen would be of immense value to marginalised people living in areas outside the power grid. HTN can also supply compressed hydrogen as substitute for petrol/diesel as zero-pollution fuel for fuel-cell vehicles and industrial purposes such as welding, small furnace or for making fertilizers, apart from pure water/oxygen as bonus.

THE WRITER HOLDS A PATENT FOR HTN, IS DIRECTOR OF HTN RESEARCH PVT LTD, MELBOURNE, AND CAN BE CONTACTED AT http://www.htnresearch.com/ banerjeadda1234@gmail.com

