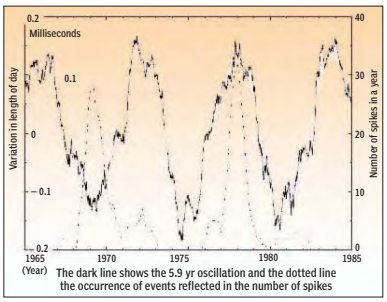
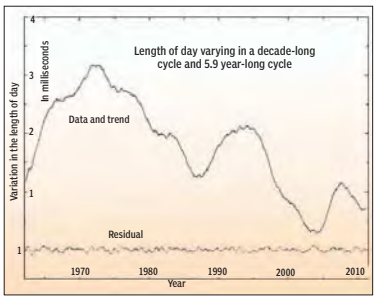
The earth's heartbeat

VARIATION IN THE LENGTH OF THE DAY REVEALS MOVEMENT AT THE EARTH'S CORE, SAYS **S ANANTHANARAYANAN**



The dark line shows the 5.9 yr oscillation and the dotted line the occurrence of events reflected in the number of spikes



The length of a day is regarded as the rock steady and unvarying standard to measure nearly everything else against. This is because we know the earth is a ball that is spinning, once every day, in empty space and there is nothing, but nothing to make it change its speed at all. And yet, there is evidence that the earth once went round much faster than it does today, and it is not any force of friction that has made is slow down.

The slowing, or changing speed has to do with changes in the dimensions of and movements within the earth. It is not really the speed of a spinning ball that stays constant, it is a quantity called the angular momentum, or net result of both how fast parts of an object are spinning around an axis as well as how far from the axis these parts are. And again, if parts of the object move with respect to each other, the whole object would need to spin faster, or slower, to keep the net effect unchanged.

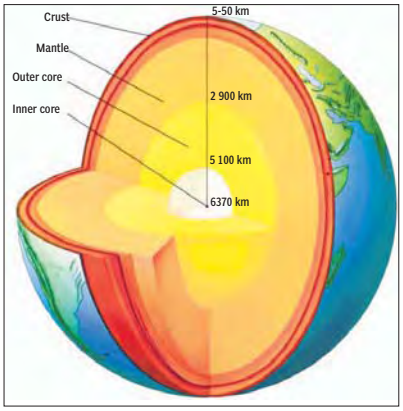
Richard Holme of the School of Environmental Sciences, Liverpool, and Olivier de Viron of the Institute of the Physics of the Earth, Sorbonne, in Paris, report in the journal *Nature* that they have worked out the effect that movement deep within the earth has on its rate of spin. Measuring the length of the day could then help understand the dynamics of the earth's core!


Richard Holme


Olivier de Viron

Size and motion

Spinning objects with the same mass go round faster if their parts are closer together than farther apart. We may have seen this with a spinning ballerina or figure skater, who throws her arms out to slow down or draws them in to speed up. In the same way, if geological or other changes in a planet bring more of the mass of the planet to the surface, then the rotation of the planet would slow down. Such effects are not likely to be of major importance very soon after the planet has formed into a reasonably stable sphere.



But they may be effective at a smaller scale because of seasonal warming of different parts of the planet or changes in the content or extent of the atmosphere.

A more powerful factor is the movement of materials within the spinning object. We can imagine a stationary log of wood starting to turn if the lumberjack standing on it begins to walk. In the same way, a planet would turn one way if the water its surface begins to flow the other way. Ocean currents and winds, driven by differences in temperature or salinity, set huge masses in motion. This motion has to be balanced by movement of other masses or the mass of the earth, which amounts to variations in the speed of rotation.

Just as there is movement of surface water or in the atmosphere, there are also flows within the earth. The structure of the earth is a solid core, under great pressure, surrounded by a molten, liquid region, the mantle, with a solidified crust in the course of stabilising, effectively afloat on the mantle. While we can see evidence of the mantle in the form of volcanic activity through imperfections in the crust, the material of the mantle, being liquid, although very heavy and viscous, is also in motion. There are gradients of temperature and pressure, motion overshooting a point of equilibrium and periodic reverse motion, etc, rather like ocean currents or tides.

These movements deep within the earth also affect the speed of rotation of the earth, although their effects last for longer durations than movements at the surface. In fine, for all these reasons, the length of the day is not constant but shows differences from day to day.

Tidal motion

But the most powerful drivers of movement of the masses in the earth are the tidal forces caused by the gravity of the moon and the sun. We are familiar with the tides in the oceans, where a bulge in the water lines up with the moon, returning to a place on the earth nearly twice every day. This is a very powerful force that moves billions of tones of water and is responsible for recirculating cold water, which sinks to the bottom of the ocean, thereby maintaining the pattern of ocean currents. The same forces also act on the mass of the earth and cause movement of the material in the mantle.

It is these forces, along with the forming of liquid water on the surface of the earth, that have slowed the rotation of the planet from a day of just six hours when it was formed, to 21 hours 400 million years ago and to the 24 hours at present.

While the work of tidal forces creates movement and heat, the effect of tides is really a slowing down of the opposite rotations of both the bodies involved. The effect of the earth on the moon, for instance, has slowed the rotation to just once a lunar month, which keeps the moon always showing the same face to us. On earth, the slowing action may be imperceptible, but the mix of forces causes small, periodic variation in the length of day, which can be related to the motion of winds, oceans and material in the mantle and the outer core.

The work of Holme and Viron has been to review the collected data of the length of day, as measured by the time for the centre of the sun to reappear on the horizon or along a fixed line of sight, over a 50-year period, from 1962 to 2012. The variations caused by movements in the atmosphere and in the oceans are a rise and fall that has short periods — that is, annual or shorter. Models of circulation were used to assess and factor out these effects so that the data represented only the longer period, typically the variations over periods of decades, which were attributed to movement in the mantle and outer core.

The data showed variations that repeat over a period of a decade and other variations that repeat over 5.9 years, interspersed with spikes that, at times, correspond to geomagnetic events. Analysis of the timing of the spikes, with reference to the stage of the decade-long variation, limits the kind of geomagnetic event that could lead to spikes – and this has led to conclusions about the electrical properties of the lower mantle, which, in turn narrows the possible range of its structure or composition.

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ROLE OF CYTOSKELETAL MOTOR PROTEINS

TAPAN KUMAR MAITRA EXPLAINS THE REVERSAL OF BODY SYMMETRY AND GENETIC DEAFNESS

As it has become easier to isolate genes that are defective in many human genetic disorders, researchers have identified several ailments that are caused by defects in motor proteins. Let us discuss two examples: reversal of body symmetry and genetic deafness.

In at least one in 20,000 live human births, organs in the body cavity are completely reversed left to right. This condition, known as *situs inversum viscerum*, has no medical consequences and is often not recognised until a patient undergoes medical tests for an unrelated condition, at which time the reversed location of organs is discovered. In contrast, when only some organs are reversed (*heterotaxia*) serious health complications result.

In patients suffering from an autosomal recessive condition known as Kartagener's triad, there is a 50 per cent probability of the complete reversal of the left-right location of internal organs. In addition, such patients suffer from male sterility and bronchial problems. The reason for these abnormalities is a defect in the outer dynein arms of cilia and flagella. Recent studies using mutations in a mouse support the idea that microtubule motor proteins are somehow involved in left-right asymmetry in the developing mammalian embryo.

In *inversus viscerum* mutant mice, the internal organs are reversed in half of the newborn homozygotes.

Surprisingly, *iv* encodes an axonernal dynein. Current research is aimed at clarifying the mechanisms underlying the randomisation of the left-right axis in *iv* mutants.


Scanning electron micrograph of epithelial cells of the inner ear showing several rows of stereocilia.

Recently, non-muscle myosins have also been implicated in human genetic disorders. For example, mutations in a myosin VII result in Usher's syndrome, an autosomal recessive disorder characterised by congenital profound hearing loss, problems in the vestibular system (ie, sensing where one is in space), and retinitis pigmentosum, which results in blindness.

In the inner ear, specialised cells known as hair cells contain special action-rich sensory structures known as *stereocilia*. Hair cells carry out auditory and vestibular transduction. A myosin VII is concentrated in the cell body of hair cells and in stereocilia. A myosin VII is also expressed in the retinal pigmented epithelium and photoreceptor cells in the eye, consistent with its role in functions associated with vision.

Ongoing research seeks to clarify the specific role of myosin VII in these processes.

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World's first calendar

AFTER 10,000 YEARS, PITS IN NORTHERN SCOTLAND YIELD THEIR TREASURE, WRITES **DAVID KEYS**

Humans had a sophisticated calendrical system thousands of years earlier than previously thought, according to new research. The discovery is based on a detailed analysis of data from an archaeological site in northern Scotland — a row of ancient pits that archaeologists believe is the world's oldest calendar. It is almost 5,000 years older than its nearest rival — an ancient calendar from Bronze Age Mesopotamia.

Created by Stone Age Britons some 10,000 years ago, archaeologists believe the complex of pits was designed to represent the months of the year and the lunar phases of the month. They believe it also allowed the observation of the mid-winter sunrise – in effect the birth of the new year — so that the lunar calendar could be annually recalibrated to bring it back into line with the solar year.

Remarkably the monument was in use for some 4,000 years — from around 8,000 BC (the early Mesolithic period) to around 4,000 BC (the early Neolithic). The pits were periodically recut — probably dozens of times, possibly hundreds of times — over those four millennia. It is, therefore, impossible to know whether or not they originally held timber posts or standing stones after they were first dug 10,000 years ago. However, variations in the depths of the pits suggest that the arc had a complex design — with each lunar month potentially divided into three roughly 10-day "weeks" — representing the waxing moon, the gibbous/full moon and the waning moon.

The 50-metre long row of 12 main pits was arranged as an arc facing a V-shaped dip in the horizon out of which the sun rose on midwinter's day. There are 12.37 lunar cycles (lunar months) in a solar year — and the archaeologists believe that each pit represented a particular month, with the entire arc representing a year. The 12 pits may also have played a second role by representing the lunar month. Mirroring the phases of the moon, the waxing and the waning of which takes 29 and half days, the succession of pits, arranged in a shallow arc (perhaps symbolising the movement of the moon across the sky), starts small and shallow at one end, grows in diameter and depth towards the middle of the arc and then wanes in size at the other end.

In its role as an annual calendar (covering 12 months — one for each pit), a pattern of alternating pit depths suggests that adjacent months may have been paired in some way, potentially reflecting some sort of dualistic cosmological belief system — known in the ethnographic and historical record in many parts of the world, but not previously detected archaeologically from the Stone Age.

Keeping track of time would have been of immense economic and spiritual use to the hunter-gatherer communities of the Mesolithic period. Their calendar would have helped them to pinpoint the precise time that animal herds could be expected to migrate or the most likely time that salmon might begin to run.

But Stone Age communal leaders — potentially including *Shamans* — may also have used the calendar to give themselves the appearance of being able to predict or control the seasons or the behaviour of the moon and the sun.


Vince Gaffney, professor of landscape and archaeology at the University of Birmingham, stands in Warren Field, Crathes, Aberdeenshire, where the discovery was made.

The site — at Warren Field, Crathes, Aberdeenshire — was excavated in 2004 by the National Trust for Scotland, but the data was only analysed in detail over the past six months using the specially written software that permitted an interactive exploration of the relationship between the 12 pits, the local topography and the movements of the moon and the sun.

The analysis has been carried out by a team of specialists led by Professor Vincent Gaffney of the University of Birmingham. "The research demonstrates that Stone Age society 10,000 years ago was much more sophisticated than we had previously suspected. The site has implications for the way we understand how Mesolithic society developed in economic, social and cosmological terms, " he said.

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PLUS POINTS

The other blue planet

We are not alone. Scientists have discovered a second blue planet in the universe, although this one is decidedly inhospitable and unlikely to support life. HD 189733b, which lies some 63 light years beyond our Solar System in the constellation Vulpecula, is a deep cobalt blue, according to data gathered by the Hubble space telescope, but its azure hue is not due to water but drops of liquid glass raining down horizontally in 7,000 kmph winds. By measuring the wavelengths of light that are lost when the orbiting planet slips behind its star, scientists have been able to calculate the colour that the planet as it would appear if seen by the naked eye.

It is the first time scientists have been able to calculate the visible colour of an "exoplanet" beyond our own Solar System, according to Frederic Pont of the University of Exeter,


Planet HD 189733b,

one of the authors of the study. "This planet has been studied well in the past, both by ourselves and other teams. But measuring its colour is a real first.

"We can actually imagine what this planet would look like if we were able to look at it directly," he said. The planet is a gas giant, similar to Jupiter, and orbits very close to its sun, meaning that its temperatures are a scorching 1,000° Celsius or higher. Extreme winds pelt silicate particles sideways, which scatter blue light. It was technically challenging to work out the colour of the planet because the light from its nearby star swamped any reflected light. However, by measuring the loss of light as the planet disappeared by its sun, the scientists were able to assess the wavelengths reflected by HD 189733b.

"We saw the brightness of the whole system drop in the blue part of the spectrum when the planet passed behind its star. From this, we can gather that it is blue, because the signal remained constant at the other colours we measured," said Tom Evans of Oxford University, lead author of the study.

STEVE CONNOR/THE INDEPENDENT

Microbe secrets

Scientists in the USA have made a breakthrough in microbiology that represents a major step "towards a better understanding of biological evolution on our planet". Their findings, published in the journal *Nature*, involve the genetic sequencing of hitherto almost entirely unexplored branches of the tree of life in an area known as "microbial dark matter".


Phil Hugenholtz

Attempts to research the precise nature of whole swathes of single-celled micro-organisms, the most diverse and abundant variety of species on earth, had been limited by the fact that they wee notoriously difficult to reproduce in a laboratory. And this despite the fact that they were known to thrive in the most hostile environments, including polar ice, the driest parts of deserts and the deepest stretches of the oceans. But scientists have been able to use new technology to work from just a single cell of a microbe and then sequence its complete genetic code.

The report said they had successfully applied the technique to 201 different species of micro-organism and said that "genome sequencing enhances our understanding of the biological world by providing blueprints for the evolutionary and functional diversity that shapes the biosphere".

The California-based team said they were able to "challenge established boundaries between the three domains of life" — made up of single-celled archaea and bacteria, and more complex eukaryota, which include animals, plants and the majority of other organisms we are familiar with. Phil Hugenholtz, a contributor to the research and director of the Australian Centre for Ecogenomics, told the BBC, "For almost 20 years now we have been astonished by how little there is known about massive regions of the tree of life. This project is the first systematic effort to address this enormous knowledge gap."

The scientists said they had found unexpected metabolic features in both archaea and bacteria, which "extend our understanding of biology". They nonetheless acknowledged that the research was just a beginning, given estimates that there are many millions of different microbe species. They said they believed a further 16,000 genomes from all over the world would need to be sequenced if we were to have an understanding of just 50 per cent of the different "phyla" — branches of species — that exist on the planet.

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