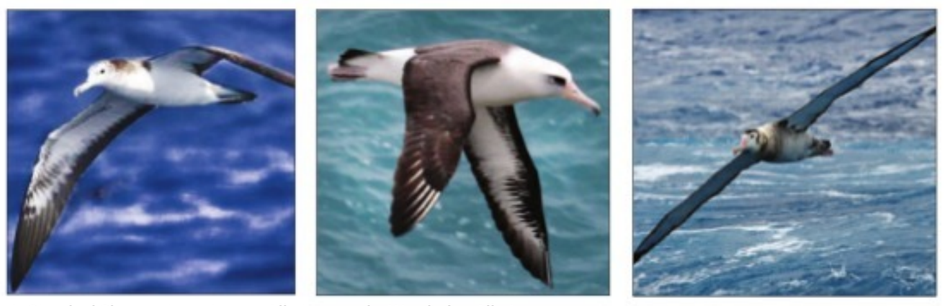
How seabirds track ocean winds

FOLLOWING THEIR FLIGHT PATHS HAS BEEN FOUND TO BE A GOOD WAY TO MAP WINDS ON THE SURFACE OF THE SEA, WRITES **S ANANTHANARAYANAN**



A Streaked Shearwater, a Layson Albatross and a Wandering Albatross

The weathercock and the "single swallow that does not a summer make" represent the role that our feathered friends have traditionally played in climate science. It should not, therefore, come as a surprise that following birds that fly above the sea turns out to be more accurate than satellites or anemometers to get a picture of low altitude winds over the oceans.

Yoshinari Yonehara, Yusuke Goto, Ken Yoda, Yutaka Watanuki, Lindsay C Young, Henri Weimerskirch, Charles-André Bost and Katsufumi Sato from Tokyo University, the Universities of Nagoya and Hokkaido in Japan, in Honolulu, and the Unversité de La Rochelle in France report in the *Proceedings of the National Academy of Sciences* that the flight paths of soaring seabirds can complement existing sea surface wind data by providing very fine-grained and rapid information about wind velocities.

The traditional devices are the windsock that was once a familiar sight at airports — which were called aerodromes — and then the more sophisticated anemometers. While the windsock only showed wind direction, there were other devices to measure its speed. The first was the cup anemometer, which was set spinning by the wind. The next was the vane anemometer, which was a little windmill with a tail. The speed of the spin was converted to wind speed by a counter, or even a dial. And there is the hot wire anemometer, where how much a hot wire cools in the wind is measured by the change in the electrical resistance of the wire.

The weatherman also tracked the changes in wind speed and direction by sending up a hydrogen or helium balloon with a metal plate hanging from it. The plate served to show up on a radar screen and indicate wind speed and direction at different altitudes, as it rose up and up. Much more sophisticated is the laser Doppler anemometer, which depends on the change in frequency of laser light that is reflected by very small particles in the air. This is the method used to survey the wind distribution around a real power generation wind turbine.

The *PNAS* authors explain that these are really methods to only sample wind speed at a few locations that are far apart and the sampling is often not continuous. For recording wind behaviour on the surface of the sea, which is important to understand the climate and also in coastal areas, the only means available was anemometers mounted on buoys that were distributed over a limited area being monitored.

The modern method used to study winds over the surface of the sea is with the help of satellites and a device called a *scatterometer*. In this method, pulses of microwaves, which are very short wavelength radio waves, are sent down to the earth from a satellite and the reflected pulses are detected. Winds create ripples on the surface of water, which can grow into large waves or swell, in the open ocean. While ripples are waves on the surface only, depending on the tendency of the surface not to be pierced by the wind, the weight of the water being displaced also comes into play and the resulting waves are in equilibrium with the wind. The pattern of such waves on the water leads to alternately lower or higher points of reflection and this leads to mutual interference of the reflected radio waves, which can be related to the speed and direction of the wind. As the satellite goes round, it scans the entire earth and in conjunction with data from buoys stationed all over, which helps weather forecasts and the study of ocean dynamics.

A windcock and cup anemometer

Vane anemometer and hand-held digital anemometer

But the *PNAS* authors point out that a satellite observes each area only twice a day and the buoys are also far apart. The picture created is, thus, not fine-grained and details of changes in winds could be missed. Another difficulty, they point out, is that in coastal areas, where the wind and circulation features are significant, the topography affects the reliability of satellite data.

Animal-borne data logging

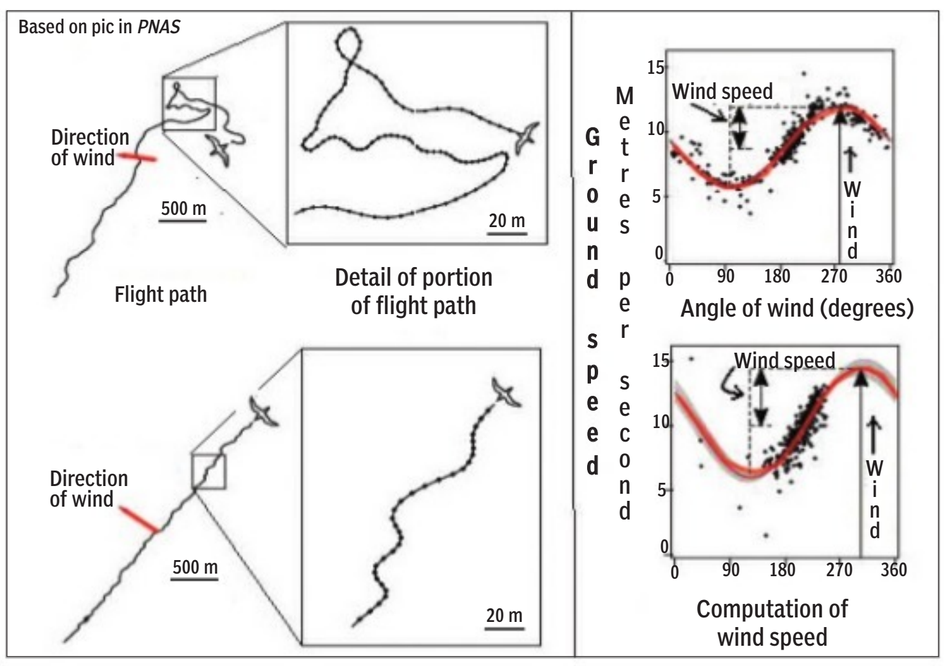
The use of animals that carry miniaturised instrumentation has proved to be a way out in many challenging situations. "The extensive movement range and locomotion ability of marine mammals and seabirds enable observations to be obtained in places and scales unresolved by conventional observations," Yonehara and the others say in the paper. "For example, instrumented seals have been providing temperature and salinity profiles in the Antarctic Ocean for more than 10 years, especially under sea ice coverage that was difficult to measure by conventional methods," they say.

Coming to wind data over the sea, the authors have studied how effective and useful the movement of soaring seabirds can be. Lightweight Global Positioning System units were strapped on to the backs of three species, the Streaked Shearwater (0.6 kg), the Laysan Albatross (3.1 kg), and the Wandering Albatross (9.7 kg). Their flight path was then plotted by recording their position every second. We can see that this is 60 points for every minute of flight and would provide a fine-grained picture of the flight trajectory. As GPS visualises the actual movement with respect to the ground, the speed of the wind that is affecting the birds' flight would be extracted from changes in direction and speed.

The Shearwater and the Albatross are suitable because they carry out soaring flight, which is largely wind-dependent. The estimation of the wind speed is based on the fact that the ground speed is the highest with a tail wind and the least with a head wind, and in between when the wind is in other directions. The various levels of ground speed, in different directions, over a span of soaring would, thus, be distributed in an "up and down" way, as is shown in the chart. And from the shape of the variation of ground speed in terms of direction, the wind speed and the direction of the wind can be worked out.

The paper details how wind speeds derived from bird sensors was verified with reliable instances. The data had been collected at the Funakoshi-Ohshima Island breeding colony in Japan, Ka'ena Point, Oahu Island breeding colony in Hawaii and at Possession Island, Crozet archipelago, in the south Indian Ocean and the areas matched some of the "swathes" covered by the satellite. In the area in the open sea, where the satellite gave good results, there was close agreement with the two sets of results, the paper says.

While wind data from bird-carried sensors could thus supplement that derived from satellites and buoy-mounted sensors, the paper says, birds could be deployed to collect data in areas where satellite data is not possible, as near the coast. The attaching of instruments to birds could also be a powerful instrument to study the wind environments that birds encounter during migratory flights, the paper says. This is a unique platform to study conditions far out at sea and atmospheric and oceanographic data variables can be obtained "by using seabirds as fast-moving, living ocean buoys", the paper says.



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PLUS POINTS

Dealing with mortality

Heavy metal music helps fans deal with the idea of their own death, new research suggests.

According to a study in the *Journal of Psychology of Popular Media*, the sense of identity that the death-themed music creates gives listeners meaning to their lives.

In turn, this feeling helps fans deal with the concept of their own mortality. Yet the researchers found the music does not help those who do not like it.

The psychologist's findings support a psychological idea called "terror management theory" (TMT). According to TMT, cultural values help people manage the prospect of their own death by providing life with value and purpose.

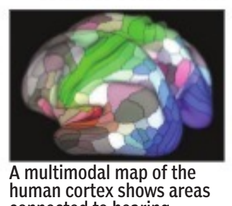
"Heavy metal music is often associated with death and dying by non-fans, whereas members of this subculture report that listening to metal music is their escape from depression and even helpful against death-related thoughts," the psychologists wrote. "Metal music can be seen as cultural good for fans and thereby can form part of their social identity."

The researchers from universities in the Netherlands and Germany carried out the project with 30 participants. They tested how prominent heavy metal culture was in their minds before and after writing about death. To one group they played a song such as Slayer's *Angel of Death* and to the other they played an audio book.
They said the results from these tests showed listening to heavy metal music boosted self-esteem for fans and helped them with the idea of dying.

THE INDEPENDENT

Human Connectome

Since the turn of the 20th century, neuroscientists have been trying to map the human brain. Now, using data from the Human Connectome Project, researchers from Washington University School of Medicine in St Louis have created a multimodal map of the human cortex that combines data from cortical architecture, function, connectivity, and topography. The map, detailed on 20 July in *Nature*, identifies 180 brain areas, 97 of which are new to neuroscience.



A multimodal map of the human cortex shows areas connected to hearing, touch, vision and opposing cognitive systems.

"It's really a breakthrough in mapping the living human brain using (Magnetic Resonance Imaging-based) methods," neuroscientist Katrin Amunts at the University of Düsseldorf, Germany, who was not involved in the work, said. "It's methodically beautiful because it's a multimodal approach, so it integrates different aspects of brain organization."

Washington University's Matthew Glasser, David Van Essen and colleagues decided to create a map that produced a more comprehensive atlas of the human cortex. To generate the map, the team used MRI data from the Human Connectome Project, a five-year National Institutes of Health-funded effort to map the anatomical and functional connectivity of the human brain. They surveyed brain architecture based on structural MRI of cortical myelin content and thickness; cortical function, as measured by functional MRI (fMRI) scans of participants completing seven tasks, ranging from listening comprehension to math problems; and functional connectivity and topography, as measured with resting-state fMRI.

"It's particularly important to find places where you have multiple independent measures changing in the same location," Glasser said. "Up until this point, people were looking at only single modalities."

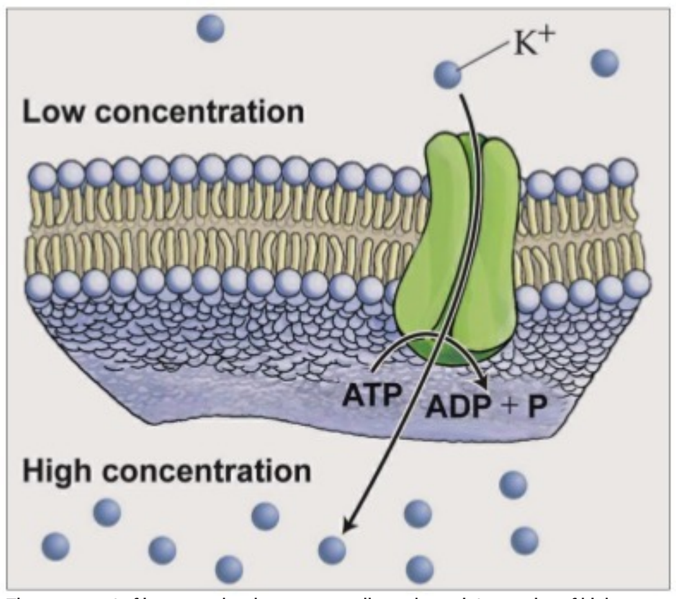
THE SCIENTIST

ACTIVE TRANSPORT

TAPAN KUMAR MAITRA EXPLAINS THE PROCESS BY WHICH SUBSTANCES ARE MOVED UP A CONCENTRATION GRADIENT IN CELLULAR MEMBRANES

Facilitated diffusion is an important mechanism for speeding up the movement of substances across cellular membranes but it only accounts for the transport of molecules toward equilibrium — which means down a concentration or electrochemical gradient.

What happens when a substance needs to be transported against a gradient? Such situations require active transport, a process that differs from facilitated diffusion in one crucial aspect — it makes it possible to move solutes away from thermodynamic equilibrium (that is, up a concentration gradient or against an electrochemical potential), and therefore it always requires an input of energy. In other words, active transport couples a thermodynamically unfavourable (in other words, endergonic) process to an exergonic process. As a result, proteins involved in active transport must provide mechanisms not only for moving desired solute molecules across the membrane but also for coupling such movements to energy-yielding reactions.



The movement of ions or molecules across a cell membrane into a region of higher concentration assisted by enzymes and requiring energy.

Active transport performs three major functions in cells and organelles. First, it makes the uptake of essential nutrients from the environment or surrounding fluid possible, even when their concentrations in the environment are much lower than inside the cell. Second, it allows various substances, such as secretory products and waste materials, to be removed from the cell or organelle even when the concentration outside is greater than that inside. Third, it enables the cell to maintain constant, non-equilibrium intracellular concentrations of specific inorganic ions, notably K^+, Na^+, Ca^{2+}, and H^+.

This ability to create an internal cellular environment whose solute concentrations are far removed from equilibrium is a crucial feature of active transport in terms of its impact on cells. In contrast to simple or facilitated diffusion, which tends to create conditions that are the same on opposite sides of a membrane, active transport is a means of establishing differences in solute concentration and/or electrical potential across membranes. The end result is a non-equilibrium steady state without which life, as we know it, would be impossible.

The membrane proteins involved in active transport are often called pumps, both in scientific literature and textbooks. No functional analogy with mechanical pumps is intended, however. On the contrary, mechanical pumps invariably affect a mass flow of fluid from one location to another, whereas membrane pumps selectively transport specific components-molecules or ions-from one fluid mass to another.

An important distinction between active transport and simple or facilitated diffusion concerns the direction of transport. Simple and facilitated diffusion are both non-directional with respect to the membrane; solute can move in either direction, depending entirely on the prevailing concentration or electrochemical gradient. Active transport, on the other hand, usually has intrinsic directionality. An active transport system that transports a solute across a membrane in one direction will not usually transport that solute actively in the other direction. It is therefore said to be a unidirectional or vectorial process.

Some direct active transport processes are in fact reversible, but in such cases the downhill or exergonic, movement of a solute, which is otherwise pumped against a concentration gradient or an electrochemical potential, is used to drive the formation of the ATP or other high-energy compounds that serves as the energy source in the other direction. For example, an ATPase that transports protons actively in one direction to create a proton electrochemical potential across a membrane can be physiologically reversed to function as an ATP synthase, driven with energy provided by the electrochemical potential. In a similar manner, most anti-porters and symporters can also work in reverse.

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Just 10 years away

EXCITEMENT IS GROWING ABOUT TWO PLANETS RELATIVELY CLOSE TO OUR SOLAR SYSTEM THAT COULD BE SIMILAR TO EARTH, SAYS **IAN JOHNSTON**

The discovery of life outside our solar system could be just 10 years away, astronomers have said after they found further evidence suggesting two "precious" exoplanets are similar to earth. The planets, which orbit a star called Trappist-1 about 39 light-years away, are in the so-called Goldilocks Zone, suggesting the temperature is "just right" for liquid water to exist — far enough away from the star that it does not evaporate, but close enough that it is not permanently frozen.

Their discovery was revealed in May, but interest has now ramped up with the announcement in the journal *Nature* that astronomers have found they are rocky planets like Mars, Venus or earth, rather than gas giants like Jupiter or Saturn. The next stage is to look for signs of gases that are only given off by living organisms, which can potentially be detected by analysing the light.

One of the researchers, Dr Julien de Wit, of the Massachusetts Institute of Technology, said, "These are the first planets that combine the three key properties we have been looking for for quite a long time: one, they are earth-sized; two, temperature, they could have liquid water; and, third, they are close enough and around the right type of star for us to actually check that out (whether they have life). That's why these planets are really precious. We really hope we are going to find out more about these planets. We can say that these planets are rocky. Now the question is, what kind of atmosphere do they have?"

An artist's impression of the surface of one of the planets.

He said that astronomers should be able to find out more about the planets after the James Webb Space Telescope is launched in 2018. "In five to 10 years we will be able to say if they are habitable, to check if they are the right temperature and with water. And then the next step forward is to assess whether they are inhabited… to look for traces of gas that can only be produced by life. This can be done in the next 10 to 25 years. If there are clear biomarkers, it's feasible we could answer that question (whether there is life)."

However, Dr de Wit cautioned it would "difficult to assess the level of intelligence" of any life on the planets. "The biomass could be a huge amount of bacteria, for example." And, whatever it is, it might well be radically different from life on Earth. The planets are "tidally locked" to their star, meaning the sun would always be in the same position in the sky. One side of the planet would be in eternal daylight, the other in eternal night, much like our moon. And the star, an "ultracool dwarf", produces mostly infrared light, which is outside the spectrum visible to humans. If astronauts were to land on one of the planets, they would barely be able to see with only a "dark" red light. "If there were to be life… it could be exotic," Dr de Wit said.

However, it is this kind of light that allows astronomers to make the observations that allowed them to discover the planets were rocky ones that could have an atmosphere like earth, Venus or Mars. If intelligent life with the same level of technology as we have exists on the planets, they would not be able to make the same observations about earth.

The star was named after the Trappist telescope in Chile that first discovered the planetary system and the researchers are now trying to raise money to build more telescopes to speed up the search and also start scanning the skies in the northern hemisphere.

"It really is an exciting time,' Dr de Wit said. "It's not unlikely we will start to tackle fundamental questions in the next 20 to 25 years."

THE INDEPENDENT

Knowledge economy

The move from hunter-gathering to the age of farming and the dawn of the Industrial Revolution 12,000 years later mark seminal transitions in human history, lifestyle and well-being. Now in the digital age, our civilisation may be in the midst of another equally great transformation — the age of "knowledge economy", a term coined in the 1960s to describe the shift from traditional economies to ones where the production and use of knowledge were paramount.

In a world where fast access to information is vital, Internet availability rules. Governments looking to push their nations towards a knowledge economy put technology development at the heart of their strategies. In this sense, the prize for every country is to have its own Silicon Valley of Internet-based start-ups and innovative small businesses. But in reality the path to a knowledge economy, and the lack of infrastructure in many African countries doesn't help the situation. But there are signs this trend may be changing.

One example is Kenya, where the government hopes to make ICT companies account for 10 per cent of GDP by 2030 through its Kenya Vision 2030, which has given birth to numerous centres for digital innovation around the country and a technology park dedicated to ICTs in the capital. Nairobi's iHub boasts more than 16,000 members and the organisers say more than 150 companies have begun life within its walls.

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