

# On the brink

THE CLIMATE CRISIS HAS BEEN FOUND TO HAVE INCHED MEASURABLY FORWARD, WRITES ANANTHANARAYANAN

Of nine factors that contribute to environmental degradation identified by an international team of scientists working with the Stockholm Resilience Centre in 2009, three were found to have passed the limit of the earth's capacity to compensate. In an article in the journal *Science*, a group of 18 scientists has added one more to the list, calling on the world to act decisively before the planet tips over so far that we are not able to adapt.

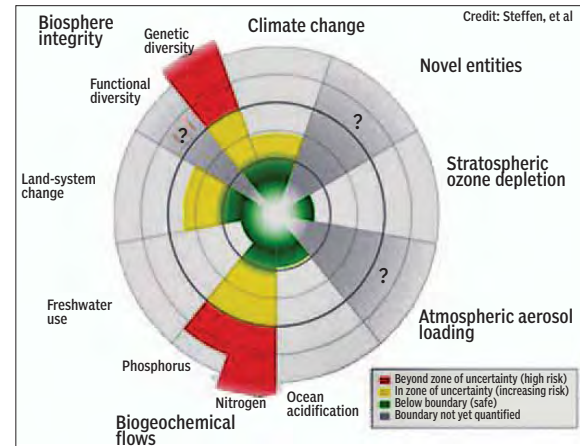
World governments got together in 1992 to think of what to do about global warming. That meeting registered concern, and the Kyoto conference of 1995 planned a course of action — in the form of limiting CO<sub>2</sub> emissions by developed nations, at least, and from 2007 to 2012. But even this has been found to be flawed, with coun-

tries like China and India manufacturing for themselves and others and environmental damage has continued.

While the warning about climate change had been first sounded by environmental scientists, spurring government agencies to move towards containing CO<sub>2</sub> emissions, in the first instance, the Stockholm group went further, to identify the different factors that needed to be controlled, the so-called nine *planetary boundaries*, for the earth not to slide into a different balance of climate and resources, in which human populations may find it difficult to manage. The Stockholm Centre studies the *resilience*, or the capacity of socio-ecological systems to remain stable in the face of disturbances to ecological factors

like climate, land use, pollution of air or water sources, or even human behaviour and exploitation of nature.

While the internationally adopted objectives of the CO<sub>2</sub> cap and how to contain temperature rise to two degrees Celsius were fair enough, the Resilience Centre named another eight environmental factors that also needed to be controlled. These were *biodiversity*, *depletion of the ozone layer*, *ocean acidification*, *pollution by phosphorus and active nitrogen*, *reduction of forest cover*, *depletion of freshwater sources*, *atmospheric aerosol loading* and then *the host of other entities that humans introduce*. It used computer simulation devised at the Potsdam Institute of Climate Impact Research and arrived at a set of just how far damage to these nine parameters could go before the balance would be irreversibly changed.



since 2009 and provides updated analyses and quantification of many of the parameters studied. The study finds that even where some of the boundaries, like freshwater use, have not been crossed at the planetary lev-

el, tolerances at the regional level have been exceeded. The study also notes that boundaries are closely interlinked, leading to control of one resulting in overshooting another. "If irrigation was reduced to stay below the boundary for freshwater use, cropland may have to be expanded as a compensatory measure, leading to further transgression of the boundary for land-system change," says co-author Dieter Gerten of the Potsdam Institute. "Implementing methods to use water more efficiently in agriculture can help sort out this dilemma and at the same time increase global food production," he explains.

#### Value of the study

The content of the study is to be presented by Rockström before the World Economic Forum at Davos on 21-24 January. "In the last four years we have worked closely with policymakers, industry and organisations... to explore how the planetary boundaries approach can be used as a framework for sectors of societies to reduce risk while developing sustainably," said Rockström. "The world has a tremendous opportunity this year to address global risks, and do it more equitably. In September, nations will agree on the UN's Sustainable Development Goals. With the right ambition, this could create the conditions for long-term human prosperity within planetary boundaries," he said.

But, as lead author Steffen said, not to do so would be at the cost of "even wealthy countries". The greatest costs would be to the poorer ones, in Asia and Africa. Can these countries afford to ignore reality and pursue "development" to match other parts of the world? Or can the developed nations delay equal access to resources to the rest of the globe?



Johan Rockström, Will Steffen and Dieter Gerten

#### New study

While the findings first published in 2009 said three of the nine boundaries — climate change, loss of biodiversity and phosphorus-nitrogen pollution — had been breached, a refined and updated study just released finds that one more limit, of land use, has been exceeded.

"Transgressing a boundary increases the risk that human activities could inadvertently drive the Earth System into a much less hospitable state, damaging efforts to reduce poverty and leading to a deterioration of human well-being in many parts of the world, including wealthy countries," says Professor Will Steffen of the Australian National University and lead author of the *Science* paper.

The new study makes use of a large number of assessments and research

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In respect of rising CO<sub>2</sub> levels, the current level is 399 parts per million, against the limit that was taken as 350-450. But Johan Rockström, director of the Stockholm Centre, said the

### Planetary boundaries the way forward

"I think one of the most important points is that this is not a doomsday message — quite the opposite actually," says Dr Katherine Richardson from the Centre for Macroecology, Evolution and Climate, University of Copenhagen, and co-author, in a communication.

"We knew already that we had environmental challenges with respect to all nine of these boundaries but we have no mechanism to judge 'how much is too much'. The planetary boundaries framework gives us a tool to work with to identify a 'safe operating space' for societal development. You can think of it like a bank statement.

It tells you how much money you have. You can use that money any way you want, but you cannot use it more than once and you cannot borrow more unless you can pay it back later! Here, we are proposing a mechanism that helps us understand how much we can affect the earth system without greatly increasing the risk of



dramatically changing our own living conditions (for the worse in terms of human living conditions).

"Such a 'bank statement' tool will be necessary when implementing the UN Sustainability Development Goals (coming in 2015) and this represents a new way that science can support societal development."

# rites of passage

TAPAN KUMAR MAITRA EXPLAINS THE TRANSPORTATION OF ESSENTIAL SUBSTANCES INTO AND OUT OF CELLS AND CELL COMPARTMENTS

The selective transportation of molecules and ions across membrane barriers ensures that the necessary substances are moved into and out of cells and cell compartments at the appropriate time and at useful rates. Small, non-polar molecules such as O<sub>2</sub> and ethanol cross the membrane by simple diffusion.

The transportation of all other solutes, including all ions and most molecules of biological relevance, is mediated by specific proteins that provide solute-

specific mechanisms for passage through an otherwise impermeable membrane.

Each such protein has at least one, and frequently several or even many hydrophobic membrane-spanning sequences that embed the protein within the membrane and determine its molecular mechanism of action.

Transport can either be downhill or uphill in relation to a solute's concentration or electrochemical potential. Downhill transport, called

*facilitated diffusion*, is mediated by carrier proteins and channel proteins. The former function by alternating between two conformational states; examples include the glucose transporter and the anion exchange protein found in the plasma membrane of the erythrocyte.

Transport of a single kind of molecule or ion is called *uniport*. The coupled transport of two or more molecules or ions at a time may involve the movement of both solutes in the same direction (*symport*) or in opposite directions (*antiport*).

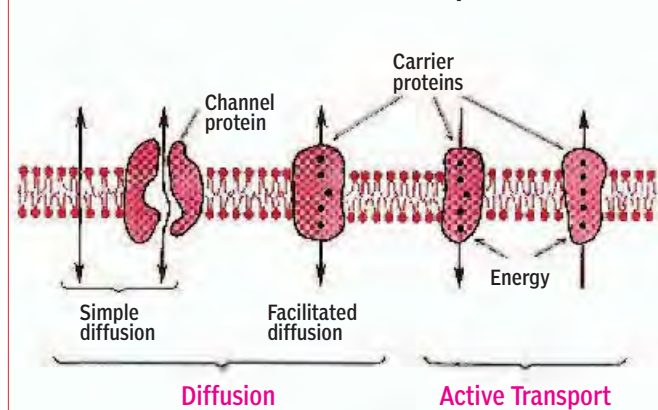
Channel proteins facilitate diffusion by forming hydrophilic transmembrane channels. Three important categories of channel proteins are ion channels (which are used mainly for transport of Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup> and H<sup>+</sup>) as well as porins and aquaporins (which facilitate the rapid movement of various solutes and water, respectively).

Uphill, or active, transport requires energy and may be powered by ATP hydrolysis, the electrochemical potential of an ion gradient, or light. Active transport powered by ATP hydrolysis utilises four major classes of transport proteins called P-type, V-type, F-type, and ABC-type ATPases.

One widely encountered example is the ATP-powered Na<sup>+</sup>/K<sup>+</sup> pump (a P-type ATPase), which maintains electrochemical potentials for sodium and potassium across the plasma membrane of animal cells.

Transport driven by an electrochemical potential usually depends on a gradient of either sodium ions (animal cells) or protons (plant, fungal, and many prokaryotic cells).

## Cell Membrane Transport



- ### Diffusion
- Lipid soluble through phospholipid matrix.
  - Water soluble through protein channels — gated or non-gated.
  - Carrier mediated transport — eg, facilitated diffusion
  - Osmosis of water through protein channels

- ### Active Transport
- Direct active transport — eg, sodium-potassium pump.
  - Indirect active transport — eg, co-transport.

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# Sign of secret worlds?

ROCKS AT THE EDGE OF THE SOLAR SYSTEM ARE MOVING IN ODDS WAYS THAT SEEM TO INDICATE THE PRESENCE OF TWO EARTH-LIKE PLANETS, WRITES ANDREW GRIFFIN

At least two planets that could be bigger than earth might have been hiding at the edge of our solar system, scientists have claimed. These undiscovered planets are thought to be even further from the sun than Neptune and the dwarf planet Pluto. Evidence comes from watching a belt of space rocks known as "extreme trans-Neptunian objects".

Scientists would normally expect the rocks to be randomly distributed, but they are moving in completely unexpected ways, which seem to indicate that they're being pulled by something that can't be seen. Spanish lead

scientist Carlos de la Fuente Marcos, from the Complutense University of Madrid, quoted by the Spanish scientific news service (Sinc), said, "This excess of objects with unexpected orbital parameters makes us believe that some invisible forces are altering the distribution of the orbital elements of the Etno, and we consider that the most probable explanation is that other unknown planets exist beyond Neptune and Pluto."



In 2006, Pluto was reclassified as a "dwarf planet".

Astronomers have spent decades debating whether a hidden planet beyond Pluto remained undiscovered. The new research, published in the journal *Monthly Notices of the Royal Astronomical Society Letters*, is based on analysis of an effect called the "Kozai mech-

anism", by which a large body disturbs the orbit of a smaller and more distant object. The scientists wrote, "In this scenario, a population of stable asteroids may be shepherded by a distant, undiscovered planet larger than the earth..."

One problem is that the theory goes against predictions of computer simulations of the formation of the solar system, which state there are no other planets moving in circular orbits beyond Neptune. But the recent discovery of a planet-forming disk of dust and gas more than 100 astronomical units (AU) from the star HL Tauri suggests planets can form long distances away

from the centre of a solar system. An astronomical unit, the distance between the earth and the sun, is the equivalent of 93 million miles.

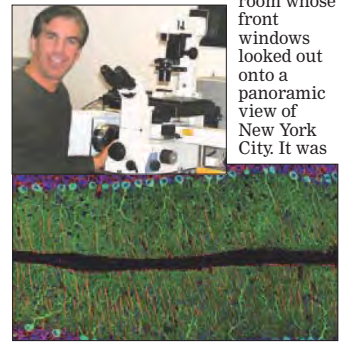
"The exact number is uncertain, given that the data we have is limited, but our calculations suggest that there are at least two planets, and probably more, within the confines of our solar system."

More results based on a larger sample of Etno objects are due to be published in the coming months. "If it is confirmed, our results may be truly revolutionary for astronomy," said Professor Marcos.

### PLUS POINTS

#### Micro master

In October last year, 40 storeys up in 7 World Trade Center, Thomas Deerinck was among the first to check out the winners of the 2014 Nikon Small World Photomicrography Competition, lined up around the perimeter of a room whose front windows looked out onto a panoramic view of New York City. It was



Thomas Deerinck (top) won first place in the 2014 Nikon Small World Photomicrography Competition for this image of a rat cerebellum, captured using a confocal scope and fluorescent proteins.

the photo contest's 40th anniversary, so the location was fitting. "It was pretty spectacular," Deerinck recalls. A slide show of winning entries from the photo competition's four decades featured one of his own works: a 2002 snapshot of a slice of rat cerebellum.

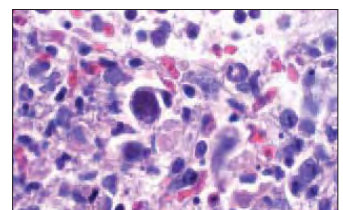
Deerinck has been a microscopist for nearly as long as Nikon has been running the Small World competition. He works at the National Center for Microscopy and Imaging Research, a National Institutes of Health-funded facility at the University of California, San Diego. The 56-year-old is constantly involved in a wide range of research projects that involve taking photographs of the microscopic world. And he's good at his job. In addition to his win in 2002, the first year he entered, he has placed in the Nikon Small World top 20 five times. "Tom Deerinck is what I consider kind of a rock star in the scientific imaging world," says Nikon communications manager Eric Flem.

Deerinck got drawn into microscopy when a researcher from a local college came to his high school in Stockton, California, to speak about a new programme focused on training electron microscopists. "Once she started showing pictures from the scanning electron microscope, I was hooked," he says.

JEF AKST/THE SCIENTIST

#### Environmental Immunity

How humans respond to the pathogens they encounter has less to do with genetics than with their previous exposure to viruses and bacteria, a study of twins published on 15 January 15 in *Cell*



has found. By measuring over 200 immune system parameters — such as blood protein levels or the number of immune cells — in 210 identical or fraternal twins, a team led by Mark Davis of Stanford University found that environmental factors were more influential than genetic ones in determining the variation between twins more than 75 per cent of the time. For over half of the measured parameters, environmental influences accounted for most of the difference. The study participants ranged in age from eight to 82 years old, and the younger twins, likely exposed to the same environment as each other, showed greater similarities in their immune systems than the older ones.

"What we found was that in most cases, including the reaction to a standard influenza vaccine and other types of immune responsiveness, there is little or no genetic influence at work, and most likely the environment and your exposure to innumerable microbes is the major driver," Davis said.

One of the largest environmental causes of immune differences between the twins was the presence of cytomegalovirus, a usually harmless chronic infection harboured by three in five Americans. Sixteen of the 27 pairs of identical twins had one infected and one non-infected twin, and in these cases the researchers found that the cytomegalovirus alone explained over half of the differences between the two siblings' immune systems.

THE INDEPENDENT

JENNY BROWN/THE SCIENTIST