

# The safe and just space

SOCIAL ENGINEERING IS BEING SEEN AS THE WAY ENVIRONMENT SCIENTISTS COULD GET A HOLD ON CLIMATE CHANGE, SAYS S ANANTHANARAYANAN

Defining global boundaries, or physical limits that were dangerous for earth to cross helped fix the specific parameters that needed to be controlled and gave shape to what nations need to do to contain global warming. It is now widely realised that these goals cannot be attained while social inequality persists. The recent International Alliance of Research Universities Congress at Copenhagen forcefully brought home the "need to expand the concept of sustainability beyond the physical sciences". As one business leader asked during the opening session, "Is it not time we developed a concept of social tipping points?"

In mechanics, a tipping point is when a state of equilibrium, like a glass of water leaning to one side as the table is tilted, suddenly changes, with the glass toppling over when the table is tilted beyond a point. Till that point is reached, the glass can be righted by reducing the tilt of the table, but not after the tipping point.

There has been much research into how far physical properties, like the salinity of a water body, or the number of animals in a forest area can rise or fall, after which there cannot be a recovery. And considering the globe as a whole, the Stockholm Resilience Centre had put forward, in 2009, the idea of *planetary boundaries*, or the levels beyond which the planet could not sustain increase in nine specific parameters.

While climate change had been accepted as a grave reality, the community of nations had not defined specifically what they needed to do as measures to slow down the effect human activity had on the environment. The publication of planetary boundaries became a graphic statement of what had to be done and the document has proved useful in fine-tuning what the response of industry and society has to be. But even after the goals were defined, a path of action has not developed and the world is not much better off in containing the indicators of environmental degradation, despite the good intentions of international conventions.

In developed countries, goals like reducing CO<sub>2</sub> emission are being apparently met, but this is by moving the manufacture of many consumerables to other places. And in many parts of the underdeveloped world, opportunity to manufacture for the rest of the world is seen as means to "development" and increasingly non-sustainable living is becoming inevitable. China is the leader and India is striving to follow suit. And in the extremely deprived parts of the world, again, drivers for survival are so urgent that measures to preserve the environment or even to adapt to inescapable climate changes are found politically and socially impractical.

In 2012, Oxfam, the international agency that fights poverty and hunger, published a paper called "A safe and just space for humanity", by Kate Raworth, where the author responded to the ceiling levels set by planetary boundaries, with a set of floor level criteria under 11 heads, as a social threshold. The space, or the doughnut, between the maximum environmental pressure and the minimum social needs was the space within which humanity could operate with social inclusiveness and environmental sustainability. A set of social tipping points, as it were.

### The challenge

While the challenge, on the physical side, is to stay within limits — and in three cases, biodiversity loss, climate change and nitrogen use, we have breached the limits — in the social dimensions we need to attain the



Kate Raworth



Ottomar Edenhofer

base levels. "Deep inequalities of income, gender and power mean that millions of people are living below every dimension of the social foundation. Nearly 900 million people face hunger; 1.4 billion live on less than \$1.25 a day and 2.7 billion have no access to clean cooking facilities," says the paper. These disadvantages need to be speedily remedied, and doing so would have a negligible effect on the environment, the paper says.

In terms of food, it says that providing the additional calories needed by the 13 per cent of the world's population facing hunger would require just one per cent of the current global food supply. For energy, bringing electricity to the 19 per cent of the world's population who currently lack it could be achieved with less than one per cent increase in global CO<sub>2</sub> emissions. In terms of income, it says, ending poverty for the 21 per cent of the global population who live on less than \$1.25 a day would require just 0.2 per cent of global income.

In fact, the biggest source of planetary-boundary stress today is excessive resource consumption by roughly the wealthiest 10 per cent of the world's population, and the production patterns of the companies producing the goods and services that they buy, the paper says.

Around 50 per cent of global carbon emissions are generated by just 11 per cent of people; 57 per cent of global income is in the hands of just 10 per cent of people; and 33 per cent of the world's sustainable nitrogen budget is used to produce meat for people in the European Union — just seven per cent of the world's population.

Adding to the pressure created by the world's wealthiest consumers is a growing global "middle class" as-

ternalities" but as the ceiling and the floor that form the guide rails for economic activity. The objective is no longer economic growth alone, but steering humanity into the safe and just place and then maximising well-being within that space. The Oxfam report stresses that ensuring social justice may be just as essential as physical sustainability, in the developed world, for containing warming. Poverty has the effect, through inefficient use of resources, like burning biomass as cooking fuel, of increasing environmental stress. And the effects of climate change would rapidly multiply the numbers that live in this way, leading to a spiral.

Global forums have begun to stress that it is in the interest of the developed world to work for moving humanity into the just space, and also to re-examine its own way of living, to stay in the safe zone. The Inter-



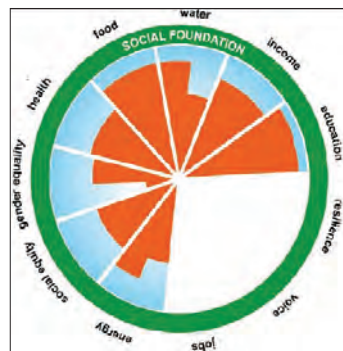
piring to emulate today's high-income lifestyles. By 2030, global demand for water is expected to rise by 30 per cent and demand for food and energy both by 50 per cent. In addition, the inefficiency with which natural resources are currently used to meet human needs — for example, through wasted food, leaky irrigation, fuel inefficient vehicles — further compounds the pressure, the paper says.

### Integrated approach

The significant point the paper makes is that the environment and social stresses are not viewed as "ex-

governmental Panel on Climate Change completed its fifth assessment report on 2 November 2014 in Copenhagen. "There is no doubt that climate policy has its costs, but it does not cost the earth to save the planet for our children," said Ottomar Edenhofer, chief economist of the Potsdam Institute for Climate Impact Research and co-chair of the IPCC Working Group III's "Mitigation of Climate Change".

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The blue space is the shortfall to be made good

## TRANSDUCTION PATHWAYS

THE RELEASE OF CALCIUM IONS, WRITES TAPAN KUMAR MAITRA, IS A KEY EVENT IN MANY SIGNALLING PROCESSES

How do we know that the sequence of events, especially the link between IP<sub>3</sub> signalling and the release of calcium within cells, actually occurs in cells? The answer begins with the observation that a specific physiological phenomenon — salivary secretion, in this case — could be activated by the products of phospholipase action: IP<sub>3</sub> and DAG.

Evidence for the role of calcium was provided by an experimental approach involving the injection of a calcium-dependent fluorescent dye, such as fura-2, into a target cell. Because the fluorescence of the dye varies with the calcium concentration, it is a sensitive indicator of the intracellular calcium concentration. Such dyes are typically referred to as *calcium indicators*.

By measuring the increase in fluorescence in response to activation by a ligand or by IP<sub>3</sub> directly, investigators were able to establish that ligand binding leads to an increase in IP<sub>3</sub> concentration which, in turn, triggers an increase in cytosolic calcium concentration. More recently, genetically engineered proteins called "cameleons", which increase their fluorescence in response to elevated calcium, have been used to monitor cytosolic calcium levels.

To complete the sequence of events, the increase in calcium concentration had to be linked to the actual physiological response of the target cell. This link was established by treating target

cells with a *calcium ionophore* (such as the drugs ionomycin or A23187) in the absence of extracellular calcium. The ionophore renders membranes permeable to calcium, thereby releasing intracellular stores of calcium in the absence of a physiological stimulus.

Treatment with the calcium ionophore mimicked the effect of IP<sub>3</sub>, thus implicating calcium as an intermediary in the IP<sub>3</sub> signal transduction pathway.

Calcium ions (Ca<sup>2+</sup>) play an essential role in regulating a variety of cellular functions. The concentration of calcium is normally maintained at very low levels in the cytosol because of the presence of calcium.

Calcium ATPases in the plasma membrane transport calcium out of the cell, whereas the same in the ER sequester calcium ions in the lumen of the ER. In addition, some cells have sodium-calcium exchangers that further reduce the cytosolic calcium concentration. Finally, mitochondria can transport calcium into the mitochondrial matrix. For most cells in their resting state, the action of calcium ATPases maintains the calcium concentration in the cytosol at about 1 x 10<sup>-7</sup> M.

One of a number of different ways that various stimuli can cause cytosolic calcium concentrations to increase is by the opening of calcium channels in the plasma membrane.

The calcium concentration in the ex-

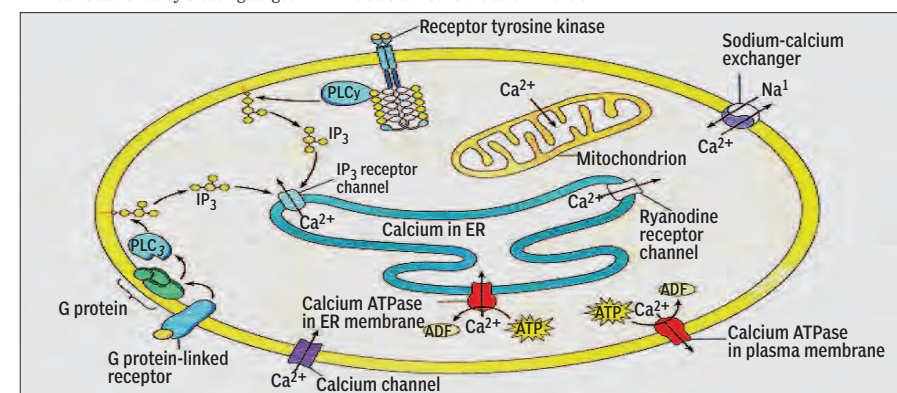
tracellular fluid and the blood is about 1.2 mM, more than 10,000 times as high as that of the cytosol. As a result, when calcium channels open, calcium ions rush into the cell.

Calcium levels can also be elevated by the release of calcium from intracellular stores. Calcium ions sequestered in the ER can be released through the IP<sub>3</sub> receptor channel, discussed earlier, and through the ryanodine receptor channel. The latter, so named because it is sensitive to the plant alkaloid ryanodine, is particularly important for calcium release from the sarcoplasmic reticulum of cardiac and skeletal muscle but nonmuscle cells such as neurons also have ryanodine calcium-release channels.

Surprisingly, both the ryanodine receptor channel and IP<sub>3</sub> receptors are sensitive to calcium itself.

When a neuron is depolarised, for example, calcium channels in the plasma membrane open and allow some calcium to enter the cytosol. Upon exposure to a rapid increase in calcium ions, the ryanodine receptor channel opens, allowing calcium to escape from the ER into the cytosol. This phenomenon has been aptly named calcium-induced calcium release.

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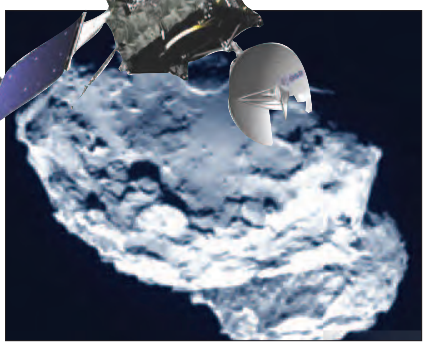


An overview of calcium regulation in cells: Cytosolic calcium concentration is lowered by the actions of the ER calcium ATPase, the plasma membrane calcium ATPase, sodium calcium exchangers, and mitochondria. Calcium concentration increases in the cytosol because of the opening of calcium channels in the plasma membrane and the release of calcium through the IP<sub>3</sub> or ryanodine receptor channels in the ER membrane.

## A cosmic rubber duck

EUROPE'S UNMANNED MISSION TO A COMET THAT HOLDS THE VERY ELIXIR OF LIFE SHOULD ANSWER TWO OF THE MOST IMPORTANT QUESTIONS IN SCIENCE, SAY HEATHER COUPER AND NIGEL HENBEST

Imagine travelling through space for 11 years, hibernating for months in the depths of the solar system until you finally



awaken as you home in on your goal. And then, when you arrive, you discover it's totally rancid. It smells of rotten eggs and horse manure, coupled with the acid-sharp tang of sulphur dioxide. The stench is alleviated only by the reek of bitter almonds: but that's a sign of deadly cyanide, which is mixed with scentless but poisonous carbon monoxide.

Disappointed? Want to go home? Not so, say the scientists behind *Rosetta*, Europe's unmanned mission to a comet. They are elated. For this mix of chemicals — sniffed out for the first time at Comet Churyumov-Gerasimenko — is the very elixir of life. It's probably the original material from which all living things have been made.

*Rosetta* arrived at Churyumov-Gerasimenko in August. As well as sniffing the gas that's erupting as the frozen comet feels the increasing heat of the sun, the spacecraft has been sending back stunning postcards of its target. The comet looks like a rubber duck — in shape, though not in colour. It's as black as coal. Even the experts aren't sure how the comet came to be this shape. The "head" and the "body" were, perhaps, separate icy objects that stuck together long ago, when the solar system was born. Alternatively, the comet may have been a single object all along, with a layer of volatile material through its middle that's evaporating until only a thin "neck" is left. *Rosetta's* cameras are already show-

ing steam boiling away from the neck region, so it's only a matter of time till the duck's head parts company from its body.

On 12 November, *Rosetta* will drop a small lander on to the "head". Here it will measure what the comet is made of — as well as take snapshots of the eruptions all around it, as Churyumov-Gerasimenko heads for its closest encounter with the sun next year. Between them, *Rosetta* and the *Philae* lander should answer two of the most important questions in science: where did earth's water come from and — ditto — the carbon atoms that make up living things?

Most astronomers think earth was baked dry billions of years ago, when a wayward planet impacted it, splashing out the rocks that made up the moon — and leaving earth as a ball of molten lava. After our planet cooled, perhaps the water we see in the oceans today deluged down from space, delivered by countless comets hitting earth — along with the smelly molecules that are now getting up *Rosetta's* scientific nose.

By checking out the blackened cosmic duck, we'll be able to tell if it's comets that we can thank for our existence on earth.

THE INDEPENDENT

### PLUS POINTS



Professor Howard Wiseman, director of Griffith University's Centre for Quantum Dynamics.

### Parallel universes

Griffith University academics are challenging the foundations of quantum science with a radical new theory based on the existence of, and interactions between, parallel universes. In a paper published in the journal *Physical Review X*, Professor Howard Wiseman and Dr Michael Hall from Griffith's Centre for Quantum Dynamics, and Dr Dirk-Andre Deckert from the University of California, take interacting parallel worlds out of the realm of science fiction and into that of hard science.

The team proposes that parallel universes really exist, and that they interact. That is, rather than evolving independently, nearby worlds influence one another by a subtle force of repulsion. They show that such an interaction could explain everything that is bizarre about quantum mechanics. Quantum theory is needed to explain how the universe works at the microscopic scale, and is believed to apply to all matter. But it is notoriously difficult to fathom, exhibiting weird phenomena that seem to violate the laws of cause and effect.

As eminent American theoretical physicist Richard Feynman once noted, "I think I can safely say that nobody understands quantum mechanics." However, the "Many-Interacting Worlds" approach developed at Griffith University provides a new and daring perspective on this baffling field.

"The idea of parallel universes in quantum mechanics has been around since 1957," says Professor Wiseman.

"In the well-known 'Many-Worlds Interpretation', each universe branches into a bunch of new universes every time a quantum measurement is made. All possibilities are therefore realised — in some universes the dinosaur-killing asteroid missed earth. In others, Australia was colonised by the Portuguese.

"But critics question the reality of these other universes, since they do not influence our universe at all. On this score, our 'Many Interacting Worlds' approach is completely different, as its name implies," he says.

### Bionic app

Other primates have opposable thumbs, sure, but only we have an app for them. It comes with this new prosthetic hand, unveiled recently by developer Touch Bionics. The powered thumb is



controlled by signals from the user's arm muscles or — in a first for upper limb prostheses — via a smartphone app: a tap of the screen and the hand automatically arranges itself into a preset grip. The thumb can move into 24 different positions and new, extra-sensitive fingertip electrodes also give improved dexterity.



### Eye on space

The Thirty Meter Telescope — set to be the world's widest eye on space — has gotten the go-ahead for construction on the summit of Mauna Kea in Hawaii. The TMT will join 13 others on the extinct volcano but will dwarf them all: the biggest now are the twin 10-metre Keck telescopes. The summit is a perfect location as it offers clear skies for 300 days of the year.