How soon will CO_2 peak?

THE GROWTH OF CARBON DIOXIDE EMISSION HAS BEEN FOUND TO HAVE PAUSED, WRITES **S ANANTHANARAYANAN**

The action in Paris where nations are working out a scheme of acting together to contain global warming involves a mix of dealing with statistics, science, interest groups and political constraints, with the special feature that there can be no separate winners or losers — everyone loses or gains at the same time. The journals *Nature Geoscience* and *Nature Climate Change* have come out, in the same week as the conference, with a collection of papers that comment on and analyse the reality and implications of the problem and the avenues available.

Reto Knutti, Joeri Rogelj, Jan Sedlácek and Erich M Fischer, from Zürich and Laxenburg, Austria define the perspective in *Nature Geoscience* by observing that what matters is not whether we stay within the ceiling of two degrees Celsius or less than that, but the quantity of CO_2 that we send out into the atmosphere. Global temperature, they say, depends on complex factors and while it is certainly linked to CO_2 emission, and two degrees Celsius is a target that governments can easily understand, temperature alone cannot reflect harmful trends of ocean acidification or total heat gain by the planet.

And coming to CO_2 levels, Robert B Jackson, Josep G Canadell, Cori-nne Le Quéré, Robbie M Andrew, Jan Ivar Korsbakken, Glen P Peters and Nebojsa Nakicenovic from Stanford, Canberra, Norwich, Oslo and Laxenburg, Austria, writing in *Nature Climate Change*, find that mitigating efforts, largely steps taken by China, seem to have started the turn of the tide by halting and even reversing the rate of CO_2 growth during 2014 and 2015.

The twenty-three years that have passed since the 1992 Rio de Janeiro conference have seen little progress in holding down emissions, but many "milestones" in the opposite direction have been achieved, they say. Fourteen of the 15 hottest years on record have occurred since 2000, and in 2015 global warming reached one degree Celsius, the halfway mark to the declared limit of two degrees Celsius. In 2015, average monthly atmospheric CO_2 concentrations reached 400 parts per million for the first time in at least 800,000 years and we have now used up two-thirds of the total carbon we can send into the atmosphere before we lose a 66 per cent chance of limiting global temperature increases to below two degrees Celsius.

Dip in emissions

But finally, in contrast, they say there has been a dip in the global increase in emissions with the addition of CO_2 by burning fossil fuels and by industry growing during 2014 only by 0.6 per cent, against the average of 2.4 per cent annually during the preceding decade. And the estimate for 2015, based on data available till October, is a reduction by 0.6 per cent a fall from 35.9 gigatonnes of CO_2 in 2014 to 35.7 gigatonnes in 2015. Not that fall in emissions has not taken place before, it did happen during the breakdown of the Soviet Union and the Asian financial crisis in the late 1990s and 2000s where there was an economic slowdown. But this time round, the paper notes, the decline in emissions is while the world economy has been growing at 3.3-3.4 per cent a year.

The paper notes that the present decline, despite sustained economic activity, is on account of less use of coal, majorly in China, evidently through more intense use of renewables like hydroelectricity, wind and solar energy. The bar chart shows that while coal consumption in China, which is half the worldwide figure, has stayed unchanged during the two years, there is more than compensating increase in renewables, mainly hydroelectric, with a similar trend worldwide.

The world is looking for a total reduction in emissions by about 350 gigatonnes of CO_2 between 2000 and 2050. A handy way of strategising this target is to think of mitigation in terms of "wedges", each of 90 gigatonnes, at least seven of them being required. To qualify as wedges, wind and solar power need to grow and replace fossil fuel use by 2,000 GW each within the 50-year period. Installed capacity for wind power reached 370 GW in 2014, with 51 GW added during the year. Twenty-three GW out of this was added in China, which is now the world's largest producer of wind energy. Power from solar cells also rose from 3.7 GW in 2004 to 178 GW in 2014, with 40 GW added during the last year. With incentives offered by most states to use solar power, the growth is likely to be sustained and wind and solar power seem to be on the way to reaching the 2,000-GW mark by 2050.

Another partially successful strategy has been control of land use-based emissions, specifically deforestation. The paper says that emissions from change of land use of about 5.5 gigatonnes per year in the 1990s dropped to four gigatonnes in the 2000s and is at 2.9 gigatonnes in the current decade. The potential of nuclear power is also limited, use in fact is declining as nations are cutting down capacity for safety reasons. Other strategies are the Negative Emission Technologies, like the use of biomass with carbon capture and storage, chemical capture of CO_2 or promoting weathering of minerals to capture CO_2. The journal *Nature Climate Change* has a paper by a multinational group of researchers on the biophysical and economic limits to the effectiveness of these methods.

Which brings us back to the need, basically, to limit the amount of CO_2 getting out there. While China, now the highest emitter of all, after decades of massive industrialisation powered by coal, seems to be showing the way, the European Union has also shown a decline in emissions, and this is after correcting for the element of manufacture that they transfer to other countries.

Despite the marginal dip, however, the actual emission continues at more than 35 gigatonnes a year. India, at 2.4 gigatonnes today, is like China in 1990, but the annual emission per capita is just 1.8 tonnes, against 7.6 in China and 16.7 in the USA. With the need to improve living conditions, including providing basic electricity to 300 million who have none, India's emissions are likely to grow to 4.5 gigatonnes per year by 2030, when the annual emission per capita would still be just three tonnes.

Even China, with a per capita GDP only one-fourth that of the USA, would grow and even with its stated "intended Nationally Determined Contribution" of reduction of emissions per unit GDP by 60-65 per cent, its total emissions are likely to be at 11.3 gigatonnes in 2030, against 9.9 gigatonnes today. The only solution seems to be that China sustains its pace of changeover to renewable sources of energy and other coal-based countries do likewise. In the meantime, the State Council in China has pledged to cut pollutants by the power sector by 60 per cent by 2020. The government has also banned the use of low-grade coal and has set a "bottom line" of 310 gm of coal to generate one Kwh. India, which has only 77 GW of low carbon capacity installed, out of the total of 280 GW, and just four GW of solar power, would need to take dramatic measures to increase the share of renewables in generation. But apart from the source of electricity, India could still make a good showing by revamping its electrical distribution grid, as the country faces record line losses of its scarce and expensive electrical energy.

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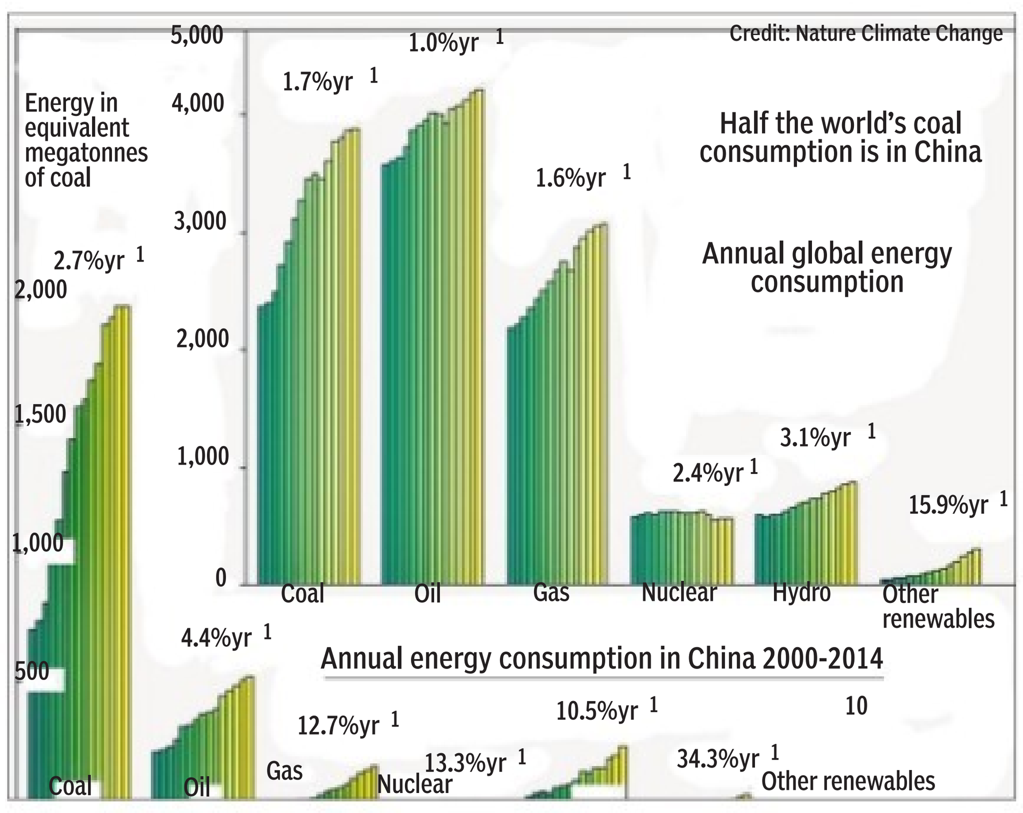
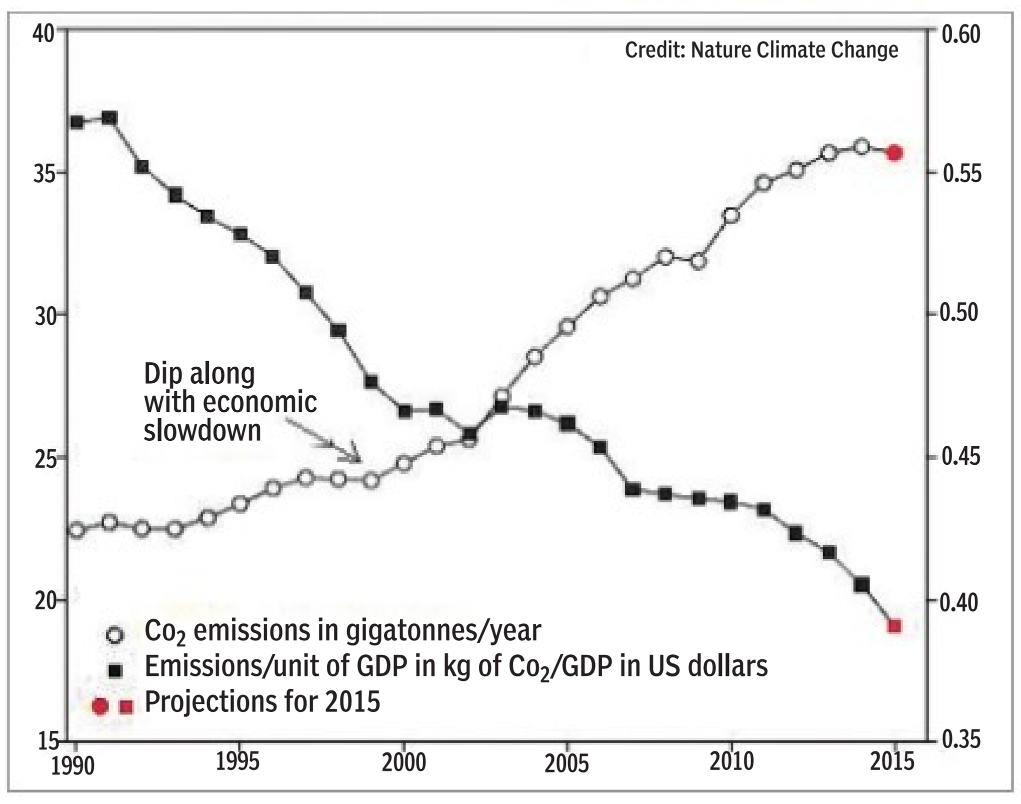
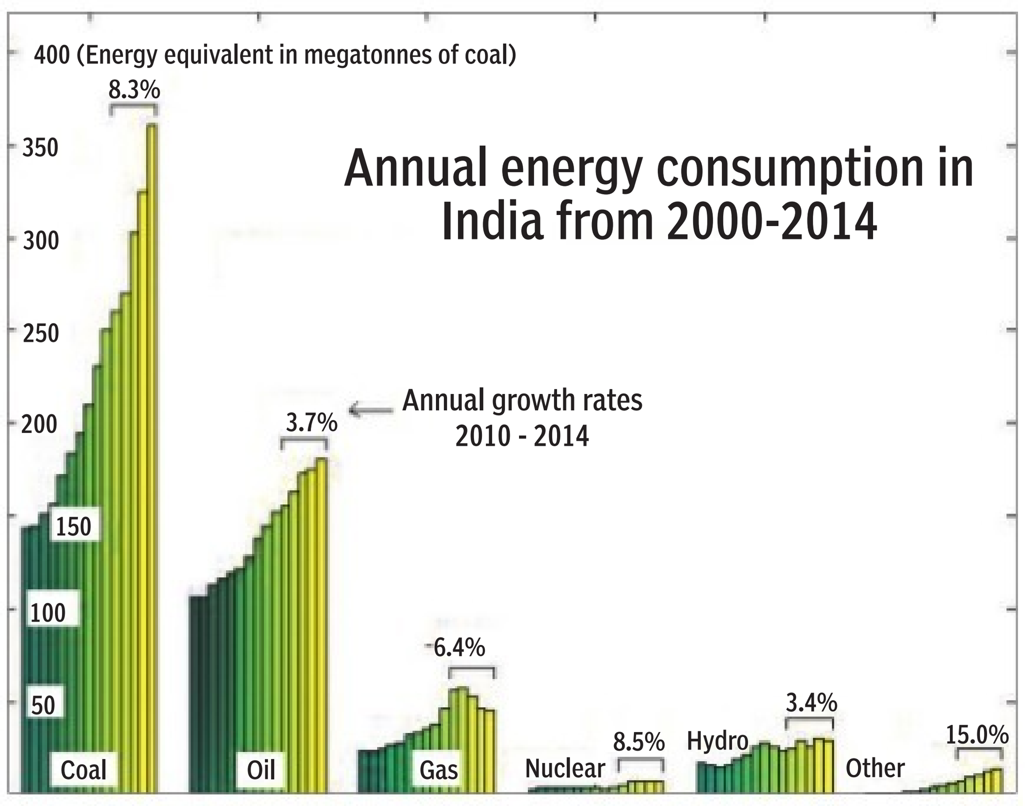
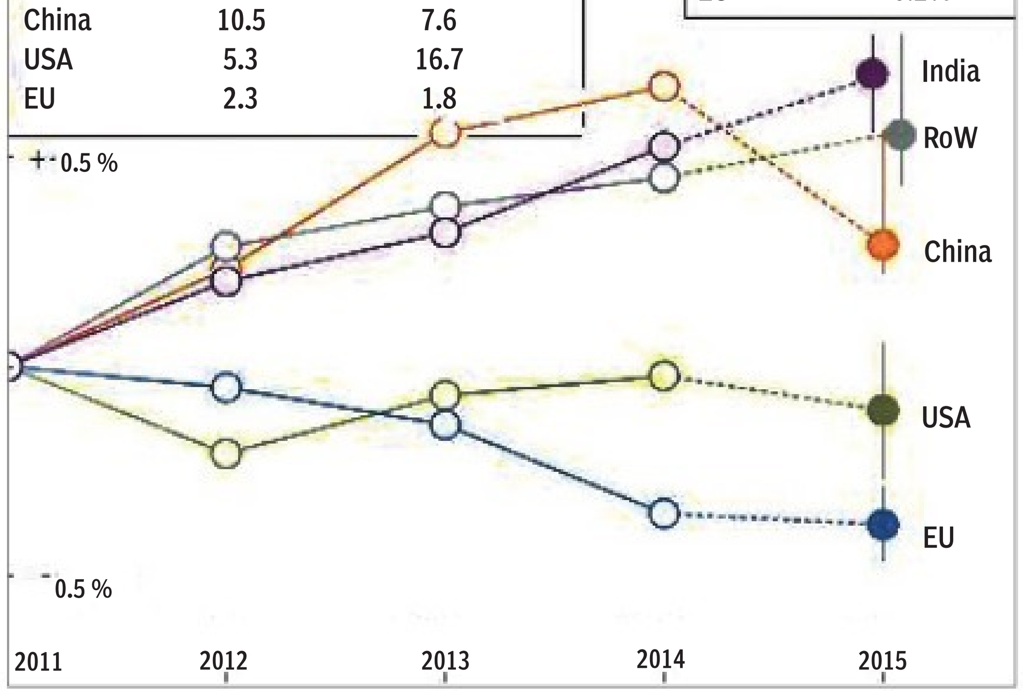






Emissions during 2014		
Country	CO_2 emission Gigatonnes	Emission per capita tonnes
World	35.7	5.0
China	10.5	7.6
USA	5.3	16.7
EU	2.3	1.8

Change since 2013	
Rest of World	= +0.2%
China	= +0.4%
India	= +0.5%
USA	= nil
EU	= -0.2%



GLUCOSE LINKAGES

POLYMERS, WRITES **TAPAN KUMAR MAITRA**, ARE STORAGE AND STRUCTURAL POLYSACCHARIDES

Polysaccharides perform either storage or structural functions in cells. The most familiar storage polysaccharides are the starch of plant cells and the glycogen of animal cells. Both of these polymers consist of a-D-glucose units linked together by a glycosidic bonds. In addition to such bonds linking carbon atoms 1 and 4 of adjacent glucose units, polysaccharides may also contain occasional a (1à6) linkages along the backbone, thereby giving rise to side chains. Storage polysaccharides can therefore be branched or unbranched polymers, depending on the presence or absence of α linkages.

Glycogen is highly branched, with α (1—> 6) linkages occurring every eight to 10 glucose units along the backbone and giving rise to short side chains of about eight to 12 glucose units. Glycogen is stored mainly in the liver, and in muscle tissue. In the liver, it is used as a source of glucose to maintain blood sugar levels while in muscle, it serves as a fuel source to generate the ATP needed for muscle contraction.

Starch occurs both as unbranched amylose and as branched amylopectin. Like glycogen, amylopectin has α(1 —> 6) branches, but these occur less frequently along the backbone (once every 12 to 25 glucose units) and give rise to longer side chains (lengths of 20 to 25 glucose units are common). Starch deposits are usually between 10 and 30 per cent amylose and 70 and 90 per cent amylopectin. It is stored in plant cells as starch grains within the plastids — either within the chloroplasts that are the sites of carbon fixation and sugar synthesis in photosynthetic tissue, or amyloplasts, which are specialised plastids for starch storage. The potato tuber, for example, is filled with starch-laden amyloplasts.

The best-known example of a structural polysaccharide is the cellulose found in plant cell walls. Cellulose is an important polymer quantitatively— more than half the carbon in higher plants is typically present in it. Like starch and glycogen, cellulose is also a polymer of glucose, but the repeating monomer is β-D-glucose and the linkage is therefore β(1 —> 4). This linkage has structural consequences but it also has nutritional implications. Mammals do not possess an enzyme that can hydrolyze a β (1 —> 4) bond, therefore, they cannot utilise cellulose as food. As a result, humans can digest potatoes (starch) but not grass (cellulose). Animals such as cows and sheep might seem to be exceptions because they eat grass and similar plant products. But they cannot cleave β glycosidic bonds either and depend on the population of bacteria and protozoa in their rumen (part of their compound stomach) to do it for them. The micro-organisms digest the cellulose and the host animal then obtains the end-products of microbial digestion, in a form the animal can use.

Although β(1 —> 4) linked cellulose is quantitatively the most significant structural polysaccharide, others are also known. The celluloses of fungal cell walls, for example, contain either β(1 —> 4) or β (1 —>3) linkages depending on the species. The cell wall of many bacteria is somewhat more complex and contains two kinds of sugars, N-acetyl-glucosamine (GlcNAc) and N-acetylmuramic acid (MurNAc). GlcNAc and MurNAc are derivatives of β glucosamine, a glucose molecule with the hydroxyl group on the carbon atom 2 replaced by an amino group. GlcNAc is formed by acetylation of the amino group, and MurNAc requires a further addition of a three-carbon lactyl group to carbon atom 3. The cell wall polysaccharide is then formed by the linking of GlcNAc and MurNAc in a strictly alternating sequence with β(1 —> 4) bonds. The structure of yet another structural polysaccharide, the chitin found in insect exoskeletons and crustacean shells, consists of GlcNAc units only, joined by β(1 —> 4) bonds.

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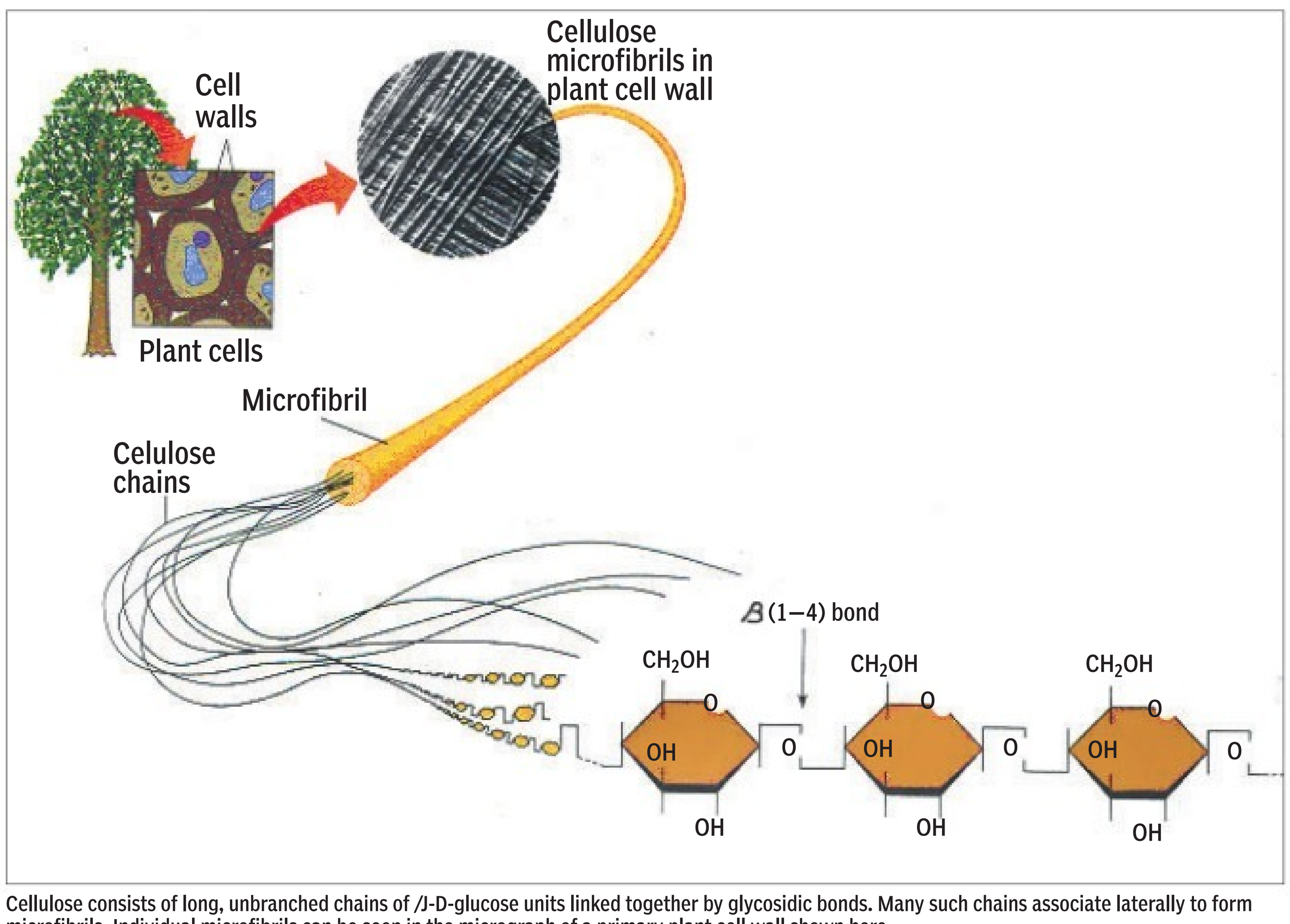
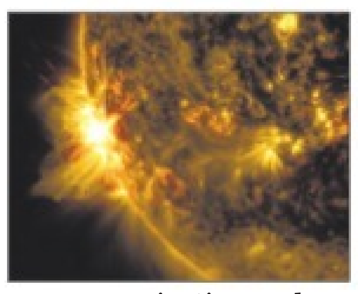


Cellulose consists of long, unbranched chains of β-D-glucose units linked together by glycosidic bonds. Many such chains associate laterally to form microfibrils. Individual microfibrils can be seen in the micrograph of a primary plant cell wall shown here.

PLUS POINTS

Lethal superflares

The sun could unleash huge superflares that would destroy much of the things we rely on for life on earth, scientists have warned.



Huge flares of energy with the power of a billion one-megaton nuclear bombs could destroy our communication and energy systems, they have said after seeing a huge superflare erupt from another star that looks alarmingly like our own sun. Occasionally, flares and other solar weather upset communications systems on earth, but the effects are usually relatively limited and can be recovered from. But the new study suggests the lethal effect a potential superflare could cause. Flares happen when magnetic energy that has built up in the solar atmosphere is suddenly released, causing a massive outburst of radiation.

Lead scientist Chloe Pugh, from the University of Warwick, said, "If the sun were to produce a superflare it would be disastrous for life on earth; our GPS and radio communication systems could be severely disrupted and there could be largescale power blackouts as a result of strong electrical currents being induced in power grids. Fortunately, the conditions needed for a superflare are extremely unlikely to occur on the sun, based on previous observations of solar activity."

The superflare studied by the team occurred on the binary star KIC9655129 and its research is reported in the *Astrophysical Journal Letters.*

ANDREW GRIFFIN/THE INDEPENDENT

Chinese tomb find

Chinese archaeologists have uncovered a 2,500-year-old- tomb thought to contain the skeletons of an ancient royal family, in Luoyang city, Henan province. It is

believed to originate from the relatively unknown Luhun Kingdom, which only lasted 113 years between 638 BC-525 BC, according to *People's Daily Online.*

Thought to be the tomb of a Luhun nobleman or royal — copper belts and ceremonial pots were discovered along with a nearby burial pit complete with chariots and whole horse skeletons. The excavation began in 2009 after a spate of grave-robbing in the area, which hosts around 200 different ancient tombs. Due to the tomb's size, which is 21 feet long, 17 feet wide and 28 feet deep, experts believe it to be the resting place of a royal family who wielded little political power. The site had suffered from damage caused by water and grave-robbers, but the interior coffin was protected by plaster and a coffin board. The horse burial pit contained the skeletons of 13 horses and six chariots. The animals had been carefully arranged on their sides, with decorations placed on their carcasses.

MATT PAYTON/THE INDEPENDENT

Rattan wood transplants

Rattan wood — the stems of a climbing palm that grows in Southeast Asian and West African forests — could be the source of next-generation bone implants, with the first products planned for release in 2019. Italian firm GreenBone announced last month that trials on sheep proved that its technology worked. It found that rattan could be used to build a scaffold to support damaged bones by turning it into a material with the same strength, flexibility and porosity as bones.

The chemical process that turns rattan

into a bone-like material was developed by a team at the Institute of Science and Technology for Ceramics of the Italian National Research Council. Through this process, plant materials such as lignin and cellulose are removed from pieces of rattan wood, which are then treated to create hydroxyapatite, the same mineral that makes up human bones.

"The advantages offered by rattan-derived bone-like material over other bone substitutes like ceramics, polymers and titanium are great," says Anna Tampieri, a researcher with the Istec project and chief scientist at GreenBone. GreenBone is producing a development plan for the new technology, based on the *Calamus rotang* species of rattan palm which is grown in southern India and Sri Lanka. The company aims to bring rattan bones to the market by the beginning of 2019.

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