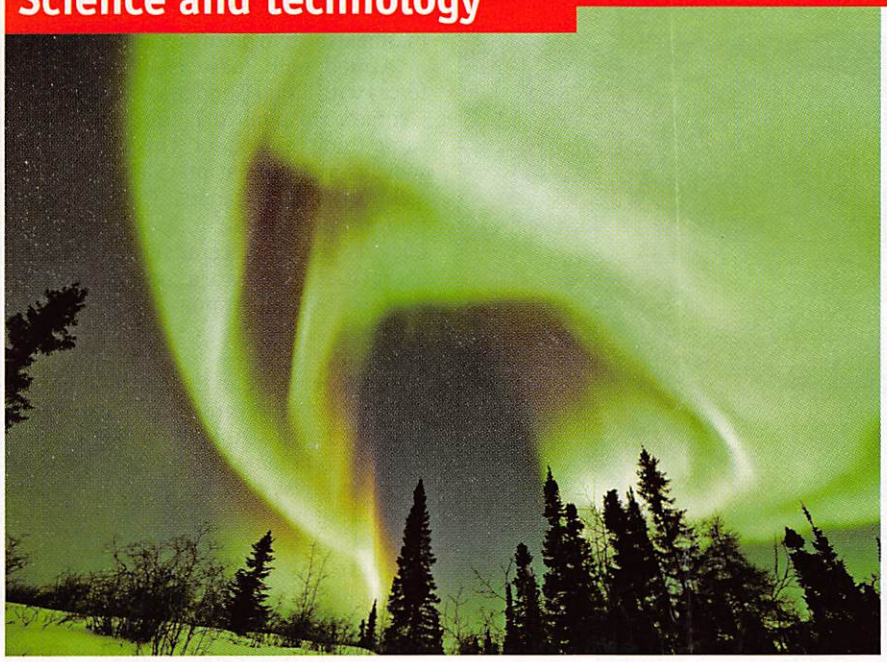

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The American Association for the Advancement of Science

Tales of wonder

BOSTON

This year's meeting of the AAAS looked at space weather, the cause of asthma, submarine mining, mosquito traps and the peopling of the Americas

SOMETIMES the sun burps. It flings off mighty arcs of hot plasma known as coronal mass ejections (CMEs). If one of these hits Earth it plays havoc with the planet's magnetic field. Such storms are among the most spectacular examples of what astronomers call space weather, a subject to which a session at this year's meeting of the American Association for the Advancement of Science (AAAS), in Boston, was devoted. A big CME can have profound effects. In 1859, for instance, a CME subsequently dubbed the Carrington event, after a British astronomer who realised its connection with a powerful solar flare he had observed a few days earlier, generated auroras that could be seen in the tropics. Normally, as the names "northern" and "southern" lights suggest, such auroras (pictured above) are visible only from high latitude. More significant, the Carrington event played havoc with Earth's new telecommunications system, the electric telegraph. Lines and networks failed, and some operators received severe shocks.

Today, the damage would be worse. A study published in 2013 by Lloyd's, a London insurance market, estimated that a Carrington-like event now would cause damage costing between $600bn and $2.6trn in America alone. A year before this report came out the sun had indeed thrown off such an ejection—though not in the direction of Earth. A much smaller storm did, however, do serious damage in 1989, by inducing powerful currents in Quebec's grid, blacking out millions of people. It would therefore be useful, Jonathan Pellish of the Goddard Space Flight Centre, a NASA laboratory, told the meeting, to be able to forecast space weather in much the same way as weather is forecast on Earth. This would permit the most vulnerable equipment to be disconnected, in advance of a CME's arrival, to prevent damaging power surges.

Sturm und drang

It sounds straightforward enough, but is harder than it sounds. Though CMEs are common, they cause problems on Earth only if they score a direct hit. The so-called "empty" interplanetary space of the solar system is, in fact, suffused by a thin soup of charged particles. These particles interact with moving CMEs in ways that are hard to predict. That makes forecasting a storm's track difficult. On top of this, CMEs themselves have magnetic fields, with north and south poles, just as Earth does. The way the poles of a CME line up with those of Earth can affect the intensity of the resulting electrical activity.

To try to understand all this better a number of satellites already monitor the sun, looking for, among other things, CMEs. These include a fleet of American environment-modelling craft and also the Solar and Heliospheric Observatory, which is a joint European-American venture launched in 1995. Several new sun-watching instruments are planned for the next couple of years. One is the European Space Agency's Solar Orbiter. Another is NASA's Solar Probe Plus. A third is a special telescope, called DKIST, to be built in Hawaii. The eventual goal, said Dr Pellish, is to make space-weather forecasts as easy and routine as terrestrial ones.

Preparing for the extraterrestrial equivalent of hurricanes in this way is surely wise. But space drizzle can cause problems too. Even when the sun is quiet, Earth is bombarded by a steady stream of high-energy subatomic particles. Some come from the sun, which is always shedding matter in small quantities even when it is not throwing off CMEs. Others are cosmic rays, which originate from outside the solar system. Both types, when they smash through the atmosphere, create showers of secondary particles in their wake. And, as Bharat Bhuva, an engineer at Vanderbilt University in Tennessee, described to the meeting, this shrapnel can cause problems with the electronic devices on which people increasingly depend.

If such a particle hits a computer chip, it can inject an electrical charge into the circuit. Since chips work their magic by manipulating packets of charge, that can create all sorts of problems. Dr Bhuva described how, in 2008, the autopilot of a Qantas airliner had been knocked out by a rogue particle. The resulting sudden plunge of about 200 metres injured many of the passengers, a dozen seriously.

Subtler effects can be just as worrying. During a local election in Belgium in 2003, a single scrambled bit of information, almost certainly caused by an errant particle, added 4,096 votes to one candidate's tally. ▸▸

Since this gave an impossibly high total, the mistake was easily spotted. But had the particle hit a different part of the circuit it might have added a smaller number of votes—enough to change the outcome without anyone noticing. Moreover, as the components from which computer chips are built continue to shrink, they become more sensitive, making the problem worse. A modern computer might expect somewhere between a hundred and a thousand space-drizzle-induced errors per billion transistors per billion hours of operation. That sounds low. But modern chips have tens of billions of transistors, and modern data centres have millions of chips—so the numbers quickly add up.

The trick is to design circuits to cope. That is where Christopher Frost, who works at the Rutherford Appleton Laboratory, near Oxford, thinks he can help. He and his team have modified some particle accelerators in a way that offers designers of electronic equipment the ability to test their products—and, crucially, to test them quickly. Dr Frost's particle beams are millions of times more intense than the radiation experienced by real-world devices. They deliver in minutes a dose that would take years to arrive naturally.

This sort of pre-emptive action makes sense. The threats from space drizzle (constant, though low-level) and from CMEs (rare, but potentially catastrophic) are real. Hardening equipment against drizzle, and developing forecasts that tell you when to disconnect it to avoid CME-induced power surges, are merely sensible precautions. ■

Asthma

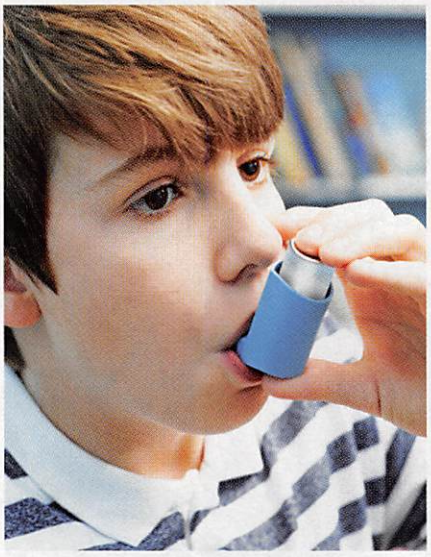
Four good bugs

BOSTON

Certain bacteria protect against a disease that is a growing threat

CAN you be too clean? That is the question posed by the hygiene hypothesis, which seeks to explain why, as many illnesses have become rarer in rich countries, some have become more common. The hygiene hypothesis posits that the rise of several of these diseases, including asthma, eczema and type-1 diabetes (all of which seem associated with malfunctions of the immune system), has been caused by improvements in hygiene of the sort that have helped get rid of other illnesses. Exactly how that might happen is unclear. But at the AAAS meeting Brett Finlay of the University of British Columbia, in Vancouver, persuasively filled in some of the blanks in the case of asthma.

Asthma is caused by chronic inflammation of the airways, and inflammation is an immune response. The thinking behind the hygiene hypothesis is that a lack of exposure to parasites and pathogens in what has become an unnaturally clean environment means a child's immune system does not develop appropriately. Evidence that asthma is a consequence of overcleanliness includes the facts that farm-raised children are less prone to it than city-raised ones (farms are full of bacteria and other critters that provoke immune responses), that those born by Caesarean section are more prone than others (they do not receive an initial bacterial inoculation from maternal faeces and vaginal fluids), and that those treated with antibiotics as babies are also more prone. Dr Finlay therefore wondered if he could find bacteria which might be involved in asthma protection in the guts of children.



A bit of muck might have helped

To this end he got in touch with the organisers of the Canadian Healthy Infant Longitudinal Development (CHILD) study, which looks at the development of children from birth to the age of five. He asked if the study's organisers could include the regular collection of faeces as part of their protocol and he thus obtained stool samples taken at the ages of three months, 12 months and annually thereafter, the bacterial contents of which he analysed.

Asthma does not normally manifest itself before a child is five, but a tendency to wheeze and a reaction to a particular skin-prick test are good indicators that the child in question will eventually become asthmatic. Recording both of these are routine parts of CHILD. Dr Finlay was therefore able to correlate the composition of an infant's gut flora with the presence or absence of these indicators. When he did so he found that children deficient, at the age of three months, in four relatively rare bacteria, *Faecalibacterium*, *Lachnospira*, *Rothia* and *Veillonella*, were 20 times more likely than those playing host to these species to manifest the two predictive indicators.

Armed with these results he joined forces with Philip Cooper, a researcher at St George's Hospital in London, to try the same thing in Ecuador. This is a country which has a similar prevalence (20%) of asthma to that in Canada. The researchers found that in Ecuador, too, infantile gut bacteria predict susceptibility to asthma—except that in this case a completely different set of bugs are responsible.

Bug hunt

How the presence in three-month-olds of particular microorganisms protects against asthma remains unknown. But the fact that two different sets of them can do so provides a way to investigate further. It is all a question of finding out what the various bugs have in common.

These discoveries, moreover, offer the possibility of treatment. If a newborn is found to be deficient in the relevant bacteria, an inoculation of them into that child's gut, perhaps in the form of an oral probiotic, might put matters right. Testing this idea would, naturally, require clinical trials, but it is a promising line of inquiry. Meanwhile, Dr Finlay's advice to parents of young children is that, though cleanliness may be next to godliness, it is possible to go too far. ■

Oceanography

Fruits de mer

BOSTON

Plucking minerals from the seabed is back on the agenda

IN THE 1960s and 1970s, amid worries about dwindling natural resources, several big companies looked into the idea of mining the ocean floor. They proved the principle by collecting hundreds of tonnes of manganese nodules—potato-sized mineral agglomerations that litter vast tracts of Davy Jones's locker. At first sight, these nodules are attractive targets for mining because, besides manganese, they are rich in cobalt, copper and nickel. As a commercial proposition, though, the idea never caught on. Working underwater proved too expensive and prospectors discovered new mines on dry land. Worries about shortages went away, and ocean mining returned whence it had come, to the pages of science-fiction novels.

Now it is back. As Mark Hannington of the GEOMAR-Helmholtz Centre for Ocean Research, in Germany, explained to the AAAS, prototype mining machines are already being tested, exploration rights divvied up between interested parties, and the legal framework put in place. Next ▸▸