

THE EARTH'S MAGNETIC FIELD, LOCATION AND MOVEMENT OF THE POLES, ORIGINS OF THE FIELD, AND ITS CONSEQUENCES FOR LIFE ON EARTH.

During the sixteenth century, mariners believed that somewhere in the North was a magnetic mountain that was the source of attraction for compasses, and dangerous to any ship that might stray too close to it. (Note at this point that the North Pole actually has the south polarity of a magnet since opposite poles attract; and correspondingly for the South Pole.) It was not until 1600 that Sir William Gilbert, physician to Queen Elizabeth I, suggested that the Earth itself was a giant magnet, although the origins of its magnetism remained unknown.

Gilbert believed that the North Magnetic Pole coincided with the north geographic pole, i.e. the north point of the Earth's axis of rotation. Magnetic observations made by explorers in subsequent decades showed that this was not true, and by the early nineteenth century, the accumulated observations proved that the pole must be somewhere in Arctic Canada.

Subsequently many expeditions have been mounted to locate the exact position of the North Magnetic Pole. In 1831 James Clark Ross located the Pole at Cape Adelaide on the west coast of Boothia Peninsula.

The next attempt was made some 70 years later by the Norwegian explorer Roald Amundsen. In 1903 he left Norway on his famous voyage through the Northwest Passage, which, in fact, was his secondary objective. His primary goal was to set up a temporary magnetic observatory in the Arctic and to re-locate the North Magnetic Pole.

Shortly after World War II a pole position was next determined by Canadian government scientists at Allen Lake on Prince of Wales Island. This, in conjunction with other observations made in the vicinity, showed that the pole had moved some 250 km northwest since the time of Amundsen's observations. Subsequent observations by Canadian government scientists in 1962, 1973, 1984, and most recently in 1994, showed that the general northwesterly motion of the pole is continuing, and that during this century it has moved on average 10 km per year.

In addition to its trend of movement, the pole also shows a diurnal fluctuation of position. The pole wanders daily in a roughly elliptical path around its average position, and may frequently be as much as 80 km away from this position when the Earth's magnetic field is disturbed.

ORIGINS OF THE EARTH'S MAGNETIC FIELD.

William Gilbert supposed that the Earth rotated because it was magnetic. P.M. Blackett considered the opposite possibility—that the Earth was magnetic because it rotated. This also turned out to be directly correct.

Magnetic fields are produced by the motion of electrical charges. For example, the magnetic field of a bar magnet results from the motion of negatively charged electrons in the magnet. The origin of the Earth's magnetic field is still not completely understood, but is thought to be associated with electrical currents produced by the coupling of convective effects and rotation in the spinning liquid metallic outer core of iron and nickel. This mechanism is termed the dynamo effect.

We are still not sure about what provides the heat in the Earth's core. It might come from some of the iron becoming solid and joining the inner core, or perhaps it is generated by radioactivity, like the heat of the Earth's crust. The flows are very slow, and the energy involved is just a tiny part of the total heat energy contained in the core.

So the molten metal is believed to be circulating. By moving through the existing magnetic field, it creates a system of electric currents, spread out through the core, somewhat like Faraday's disk dynamo.

Because the field generated depends upon any small field of random polarity, it can build up in any direction, and this explains why it is also capable of reversing.

CONSEQUENCES FOR LIFE ON EARTH.

A fundamental property of magnetic fields is that they exert forces on moving electrical charges. Thus, a magnetic field can trap charged particles such as electrons and protons as they are forced to execute a spiraling motion back and forth along the field lines.

One of the first fruits of early space exploration was the discovery in the late 1950s that the Earth is surrounded by two regions of particularly high concentration of charged particles called the Van Allen radiation belts.

The primary source of these charged particles is the stream of particles emanating from the Sun that we call the solar wind. The charged particles trapped in the Earth's magnetic field are also responsible for creating the aurora.

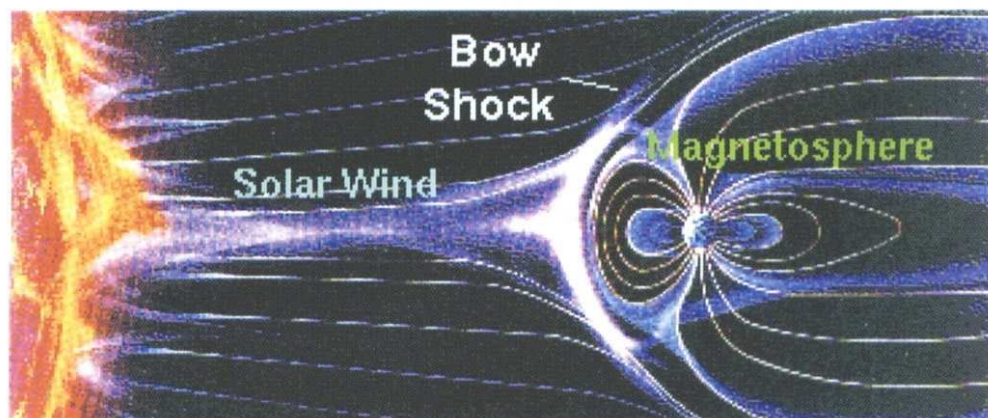
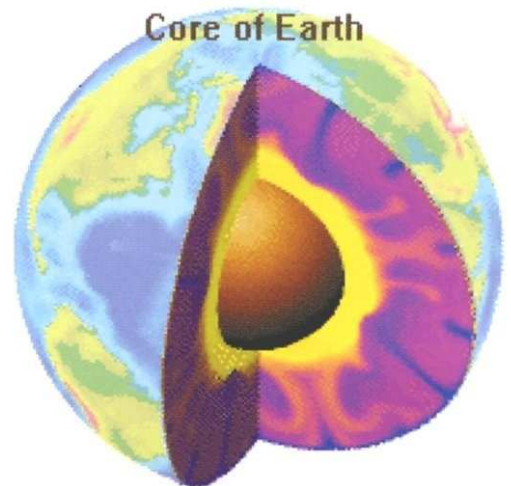
The solar wind is a stream of ionized gases that blows outward from the Sun at about 400 km/second and that varies in intensity with the amount of surface activity on the Sun. The Earth's magnetic field shields it from much of the solar wind. When the solar wind encounters Earth's magnetic field it is deflected like water around the bow of a ship.

The imaginary surface at which the solar wind is first deflected is called the bow shock. The corresponding region of space sitting behind the bow shock and surrounding the Earth is termed the magnetosphere; it represents a region of space dominated by the Earth's magnetic field in the sense that it largely prevents the solar wind from entering. However, some high energy charged particles from the solar wind leak into the magnetosphere and are the source of the charged particles trapped in the Van Allen belts.

Thus, without its magnetic field the Earth would not be so well protected against this blast of ionised gas from the Sun. Of course, it would still be protected by the atmosphere, but the atmosphere itself could perhaps be partially eroded by the solar wind. ■



Movement of Pole.





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For: Edwin



WHAT IS HAPPENING TO THE EARTH'S MAGNETIC FIELD?

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Editor: GORDON CREIGHTON, MA, FRGS, FRAS.

Desktop Publishing and Science Editor:

PHILIP CREIGHTON, BSc.(Hons).

Subscriptions Secretary: HOWARD RAIMBACH, Cert.Ed.

Cover Design: PHILIP CREIGHTON.

Photography: ROBERT RUDGE, LBIPP.

Video Tapes: MALCOLM & SUE WALLER

Electronic Voice Phenomenon (EVP) and Instrumental

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Write to the Editor at:
FSR Publications Ltd,
P.O. Box 162, High Wycombe,
Bucks. HP13 5DZ, UK.
or write to our *NEW* e-mail box at:
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EDITORIAL: OUR NEW SCIENCE SECTION

The current developments in science and technology are becoming ever more extraordinary, and their implications are profound indeed, bringing with them either immense benefits, or catastrophic potential for misuse, or both.

We have therefore started a Science Update section in which we aim to keep a finger on the pulse of the new. There is also an increasingly important legal, social, moral and ethical side to many of these issues, and it is our intention to report on these aspects as attentively as on the scientific developments themselves.

One does not need to be much of a futurologist to envisage discoveries and applications which will have as much human significance to us as the invention of the hydrogen bomb.

I personally think they could feature in our lives within even the next five years or so, and it is therefore very important to promulgate information about such developments in a magazine such as this which is, after all, concerned primarily with a major issue which we

believe can impact the very fate of humankind. I refer, of course, to the alien presence, whose true significance we are still very far from properly understanding.

A lot of the kind of developments I am referring to do *not*, in my opinion, receive adequate coverage in the mainstream media, and in consequence public lay awareness of them is likely to be often hazy.

A major exception to this woeful situation is provided by the magazine *New Scientist*, one of the best popular science magazines in this country. It is therefore from the *New Scientist* that I have drawn much of my material -with thanks that we still have open-minded scientific reporting and debate of this quality.

So I have been going through my back issues and indexing items which I find particularly important and interesting. Quite arbitrarily I will start this Science Update section with material derived from the *New Scientist* issue dated 20th April 2002. -Philip Creighton. ■

SCIENCE UPDATE

MORE ON SCHRÖDINGER'S CAT.

In our last issue we reported on proposals to end, by experiment, the major controversy in quantum physics as to whether the phenomenon of so-called superposition -something being in two states at once, a hybrid reality - can translate or carry over from the level of the very small of particles and atoms to the macroscopic world we ourselves perceive. (See Schrödinger's Cat, page 3, FSR volume 47/1)

The problem with the proposed experiment mentioned there is that, because it would involve very long path lengths for X-ray beams, it could only be conducted in outer space, and would not be feasible for a long time.

However, now Keith Schwab (Laboratory for Physical Sciences in College Park, Maryland) and co-workers have come up with a proposed lab experiment which they believe may resolve the issue within 18 months.

To recapitulate, it has been demonstrated to date that even largish molecules, like the spherical 60-carbon-atom buckyball molecule, can exist in a state of superposition. This has been shown by the observation that a single molecule can pass through two adjacent parallel slits at the same time, and so produce an interference pattern, in a way entirely analogous to the famous Young's slits experiment which was used to reveal the wave nature of light.

The issue is: How large an object can be shown to exist in a state of superposition, and for how long before that state "collapses" or opts for one or other of the two states that make up the superposition?

Schwab and colleagues have built an apparatus which should enable the superposed state of "tunnelling" electrons to be transferred to the state of a flexible silicon beam whose thickness is 1/40 of that of a human hair - small, but still a macroscopic object.

Tunnelling is a quantum effect whereby electrons can pass through a material barrier despite the fact that they ostensibly do not have enough energy to do so. Essentially Schwab's apparatus consists of a superconducting aluminium loop attached by insulating contacts to an aluminium strip, referred to as a Cooper pair box; and adjacent to the latter is mounted the thin silicon beam, with the end next to the box free to bend if attracted to it.

Because the tunnelling is a quantum effect, electrons can be both in the superconducting loop, and in the Cooper pair box, at the same time, which means that it can have two different charges simultaneously - a state of superposition. Electrons, of course, are negatively electrically charged, and so they will attract and bend the silicon beam, which is made positively charged.

When the box is in two charge states at once, this should force the beam to be in two positions at once. Observation of the beam over a detailed time course should reveal if this indeed happens, and if so, for how long before the beam opts for one position or the other.

If this experiment does indeed succeed, it will end a controversy which has been raging for years, and explain

why large objects do not appear to be able to exist in two states simultaneously. See New Scientist, 20 April 2002, page 7, and 9 March 2002, page 26.

ORGANIC OPTICAL CONTROL.

The search is on for ways to use light to control light. The reason for this need is that our existing communications systems often use both light and electricity, and signals have to be constantly converted between these two forms - which slows them down, and is costly and wasteful.

A group in Florida has found a way of using organic molecules to achieve optical path switching - using light. The device consists of two quartz cells.

The first splits the light beam into three beams of distinctly different wavelengths (colours). Each wavelength can, for example, carry a separate phone call. The splitting is achieved using three different fluorescent organic molecules: anthracene, naphthalene, and tetracene. (Fluorescent substances shine with different colours when irradiated with light of a shorter wavelength.)

The second quartz cell holds a solution of spiropyran, an unusual organic molecule which changes shape according to the wavelength of the light to which it is exposed. The differently shaped forms of the molecule absorb a different one of the three wavelengths. Thus the second cell either blocks or absorbs one or more of the three beams from the first cell, according to the kind of light with which it is illuminated.

Eventually it is hoped that it will be possible to build all-optical miniature switches. These would revolutionise our existing ones which rely upon a hybrid of fibre optics and electronics. See New Scientist, 20 April 2002, page 23.

SCARY SCIENCE: THE THREAT FROM PHARMACOLOGY.

Do we really need all those mind-altering drugs which the pharmaceutical industry is constantly dreaming up and finding justification for - with financial motive certainly - but also ethical?

I remember being shocked, when as a biochemistry student in the seventies, I read a monograph brought out by Roche, entitled *Pathophysiology of the Emotions*. The opening page carries these words:

LIBRIUM is now a well-established therapeutic principle which the majority of doctors would not be without. That it is so frequently and unhesitatingly prescribed today is due to the recognition that it possesses in high degree the two basic qualities of reliability and safety. Both these features are amply attested in more than 1,000 scientific publications and have been confirmed by several years' experience in millions of patients.

Librium is, of course, the first of the family of tranquillisers known collectively as benzodiazepines. The monograph then goes on to describe the supposed mechanism of action of Librium. It contains an illustration which particularly struck me. The caption reads: *Fig. 7. European lynx, "vicious, snarling, dangerous" before treatment... and two hours after Librium was administered.*

Many years later I found myself working in the department of Pharmacology at the Institute of Psychiatry in London, and lo and behold, one of the main projects of that department was an exhaustive study of benzodiazepine addiction!

So the blandishments of the drug company were *not true*. It is now widely recognised that benzodiazepine tranquillisers and sleeping pills are extremely addictive, probably harder to get off than heroin, and have incapacitating side-effects like impairing short-term memory. Doctors are now not supposed to prescribe them for more than a few weeks, but I have known people who have been on them for decades.

Francis Fukuyama wrote an excellent article entitled *Life, but not as we know it*. In it he says:

"The bright line that formerly fenced off humans from the rest of the animal world, and allowed us to believe in our own higher dignity, has been steadily eroded.

"I believe that it is possible to defend the existence of a Factor X -a human essence- on secular grounds that are compatible with what we know of modern science. Factor X has to do with the evolved complexity of the human whole that can only superficially be understood by reductionist scientific methods.

"The most important component of that whole is the gamut of emotions that every human being is capable of subjectively experiencing. We do not understand the provenance or proper functioning of that gamut, or the subjective consciousness within which it is embedded.

"Biotechnology poses a fundamental threat to human dignity because of its ability to manipulate our natures in ways that will ultimately simplify that complexity and reduce us to something that is less than human. But let me explain.

"It has been understood in the natural sciences for some time now that the behaviour of complex wholes cannot be understood as the aggregated behaviour of their parts.

"The inability of reductionist materialist science to explain observable phenomena is most glaringly evident in the question of human consciousness, that is, the realm of subjective mental states. In the words of the philosopher John Searle, 'The most striking feature is how much of mainstream philosophy of mind of the past 50 years seems obviously false', beginning with the almost routine denial among researchers in this field that subjective mental states actually exist.... The fact of the matter is that we do not have the faintest inkling of how consciousness and the full range of our subjectively experienced mental states are produced by the brain."

He goes on to say:

"The problem with modern biomedicine is that it

constantly tempts us to reduce the natural complexity of the human whole in the name of much simpler utilitarian ends such as the relief of suffering or the prolongation of human life.

"The aspect of our complex natures most under threat has to do with our emotional gamut. We will be tempted to think that we understand what 'good' and 'bad' emotions are, and can go one better than nature by suppressing the latter: by trying to make people less aggressive, more sociable, more compliant, less depressed."

He then goes on to discuss the drug Ritalin, now prescribed to millions of children around the world to cure a disease known as attention deficit hyperactivity disorder. He points out -and I agree with him- that this is not a disease at all, and the child might just as easily be treated with greater adult attention, interesting work, or new challenges.

I quote from Francis Fukuyama further:

"There is a disconcerting symmetry between Prozac and Ritalin. The former is prescribed heavily for depressed women lacking in self-esteem; Ritalin on the other hand is prescribed largely for young boys who do not want to sit in class because nature never designed them to behave that way. Together, the two sexes are gently nudged toward that androgynous, median personality, self-satisfied and socially compliant, that is the current politically correct outcome in modern societies. The human emotional gamut is narrowed: we eliminate severe depression and hyperactivity, as well as a range of more nuanced feelings of discontent and discomfort that may be the source of creativity, wonder, innovation and struggle."

And finally he concludes in dire warning:

"The current debate over the ethics of biotechnology has become sidetracked, especially in the US, into a debate over the moral status of embryos. Yet real threats to human dignity are waiting in the wings. Neuropharmacology today is just a precursor to powerful technologies of the future, both pharmacological and genetic, that will allow us to alter the natural forms of human behaviour that have shaped us as a species, and eventually to redesign human nature itself.

"Given that we scarcely understand the provenance and functioning of consciousness, emotion, and the complex human whole out of which they spring, it behoves us to proceed down this road very cautiously, if we should want to go down it at all." See *New Scientist*, 20 April 2002, page 42.

Francis Fukuyama is professor of international political economy at John Hopkins University. His book *Our Posthumous Future* was published by Profile Books on May 20th.

Well, Francis, I found your article extremely interesting, and I have to say that I entirely agree with you. As one who worked for a psychiatrist in a research unit, and heard him one day blithely pontificate to the assembled company over lunch that "if you do not have consensus with at least six other people, you are by definition insane", I share all these misgivings about the

trend to shoe-horn us into uniformity, conformity, and compliance, whether through the use of psychoactive drugs or any other means.

I also think that the nightmare has only just begun. The lid of Pandora's Box is already creaking open... I will be following more scary science in later Science Updates. I think we have far more to worry about than a mouse with a human ear growing out of its back, a condition described by some, I think appropriately, as an "ultimate blasphemy".

Some scientists do indeed wish to not only indulge in genetic engineering, but to create life *de novo*. The plan is to start with a simple organism, and design it from scratch. The obvious candidate is a bacterium. And what if this creature, probably named *bacillus arrogans*, climbs out of its petri dish?

I *know* these people -I have worked with their ilk. I gave up a career in medical research because I was not prepared to engage in vivisection. I *know* that they would have much preferred to do their experiments on human beings than on cats, dogs and monkeys, because they *told* me so -down at the pub over lunch.

Hubris is the word which comes to mind: the extraordinary arrogance and incaution of which some scientists are capable.

HOPEFUL SCIENCE: A CONTRACEPTIVE FOR MEN

Take a styrene maleic polymer, dissolve it in dimethyl

sulphoxide, and inject it into the vas deferens, the tubes that carry sperm from the testicles to the urethra. Simple as that. It appears that the way it works is that the substance coats the walls of the tubes, but does not occlude them. Further than that the exact mechanism of action is believed to be that complexes of charge on the tube walls rupture the membranes of spermatozoa as they pass through.

Named RISUG, for Reversible Inhibition of Sperm under Guidance, the method has been developed by the Indian Council of Medical Research, and has been tested successfully on 500 men.

Apart from temporary tenderness and swelling there appear to be no adverse side-effects. The contraceptive is believed to be effective for about 10 years, and the procedure is completely reversible. The polymer can be flushed out with a solution of sodium bicarbonate or by manipulation.

Historically India has had a major problem with attitudes towards male contraception. Indira Gandhi's government enforced mass sterilisations of men in 1976. The result was hundreds of deaths through infections following botched operations. Consequently vasectomy remained extremely unpopular, and at present 97 percent of all sterilisation operations in India are on women. With this new male contraceptive it is to be hoped that this trend can be reversed. Maybe one of the Four Horsemen of the Apocalypse can be slowed to a canter... See *New Scientist*, 8th June, 2002, page 5. ■

AN ELECTROMAGNETIC GYROSCOPIC PROPULSION SYSTEM. © BY KEN MORTIMER, FSR Consultant and Amateur Astronomer.

Ken Mortimer prefaces his article with a letter containing the following words:

I mentioned on the phone that electromagnetic fields of energy possess mass. They may also be arranged in lines of force, like those of the magnetic fields of the Sun, Earth, or Jupiter for example.

A few years ago an article appeared in *Astronomy Now*, if my memory serves me correctly. It explained how meteorites caused the electromagnetic lines of force to 'twang' when they pass through the Earth's magnetic field. The meteorites build up a plasma ahead of them which stretches the Earth's lines of force. They then snap back into place. Clearly there is a force concerned that could be utilised for different modes of transport.

It is articles like this that provide the clues and indirect evidence that I, and the likes of Sandy Kidd, are on the right tracks. There are other areas of information in astronomy that provide yet further clues.

Nobody is breaking any current laws of physics with these ideas. It is simply a case of new theories,

new understandings of physics, and new ways to utilise energy. There are no free lunches being had by anyone, so to speak.

On the 17th of December 2003, the United States of America in particular, and the rest of the world, will celebrate 100 hundred years of manned powered flight. Many previous attempts at manned powered flight ended in failure, and on both sides of the Atlantic mathematicians claimed that it couldn't be done. Heavier-than-air machines simply could not fly.

The triumph of Orville and Wilbur Wright on the 17th of December 1903 at Kitty Hawk in the USA was achieved by determination and vision, and since that historic date many other breakthroughs have been accomplished in spite of the negative predictions of mathematical experts. And indeed, manned flight has now evolved into manned Moon landings and space shuttles.

Now there is a desire to develop more advanced methods of propulsion away from what are nothing more than sophisticated giant firecrackers. They are launched from Cape Canaveral and elsewhere and place spacecraft