Charles Lee is in the Division of Cytogenetics, Department of Pathology, Brigham and Women's Hospital and Harvard Medical School, 20 Shattuck Street, Boston, Massachusetts 02115, USA.
e-mail: clee@rics.bwh.harvard.edu

1. Aitman, T. J. *et al. Nature* **439**, 851–855 (2006).
2. Glazier, A. M., Nadeau, J. H. & Aitman, T. J. *Science* **298**, 2345–2349 (2002).
3. Zhang, Y. *et al. Nature Genet.* **34**, 181–186 (2003).
4. Helgodottir, A. *et al. Nature Genet.* **36**, 233–239 (2004).
5. Noben-Trauth, K. *et al. Nature Genet.* **35**, 108–113 (2003).
6. Mehrabian, M. *et al. Circ. Res.* **91**, 120–126 (2002).
7. Aitman, T. J. *et al. Nature Genet.* **21**, 76–83 (1999).
8. Masugi, M. *Beitr. Pathol. Anat.* **91**, 82 (1933).
9. Iafrate, A. J. *et al. Nature Genet.* **36**, 949–951 (2004).
10. Sebat, J. *et al. Science* **305**, 525–528 (2004).
11. Li, J. *et al. Nature Genet.* **36**, 952–954 (2004).
12. Adams, D. J. *et al. Nature Genet.* **37**, 532–536 (2005).
13. http://projects.tcag.ca/variation
14. Samonte, R. V. & Eichler, E. E. *Nature Rev. Genet.* **3**, 65–72 (2002).
15. Feuk, L., Carson, A. R. & Scherer, S. W. *Nature Rev. Genet.* **7**, 85–97 (2006).
16. Check, E. *Nature* **437**, 1084–1086 (2005).

SPECTROSCOPY

NMR down to Earth

Janez Stepišnik

High-precision nuclear magnetic resonance spectroscopy generally requires the use of powerful magnets. But using Earth's magnetic field allows us to gain some of the same information on the cheap.

Are expensive superconducting magnets necessary to perform high-resolution nuclear magnetic resonance (NMR) spectroscopy? Not absolutely, say Stephan Appelt and his colleagues in the February issue of *Nature Physics*[1]. They use a far less pricey source of magnetism — Earth's own magnetic field — to distinguish the chemical structures of various molecules containing hydrogen, lithium and fluorine. The level of accuracy they achieve is an order of magnitude better than that possible with the most advanced superconducting magnets.

When an external magnetic field is applied to an atomic nucleus, it induces a polarization in the direction of the intrinsic rotation, or 'spin', of that nucleus' constituent protons and neutrons. These spins align either parallel or antiparallel to the field, causing the quantum-mechanically allowed energy levels of the nucleus to split. At a frequency corresponding exactly to the difference between these energy levels, the nucleus can absorb electromagnetic radiation: the phenomenon known as nuclear magnetic resonance or NMR, first observed by Felix Bloch and Edward Mills Purcell in 1946 (for which achievement they won the Nobel Prize in Physics in 1952).

Soon after the initial discovery, it became clear that the effective magnetic field on a nucleus — and consequently the observed NMR frequency — is subtly changed by the effects of both orbiting electrons (the 'chemical shift')[2] and the spins of neighbouring nuclei ('J-coupling')[3]. This was the beginning of the triumphant success of NMR as a spectroscopic tool for exploring the composition and chemical environment of molecules in the liquid state. In the decades since, the need for higher sensitivity and lower spectral dispersion has demanded higher, more homogeneous magnetic fields, fuelling the development of powerful superconducting magnets. Nowadays, the highest-resolution NMR techniques, using magnets producing field strengths of between 1 and 10 tesla, reproduce the hydrogen spectrum with a broadening of spectral lines caused by the instrumentation of less than a tenth of a hertz.

Compared with the fields that can be attained with superconducting magnets, Earth's magnetic field is weak: it varies from about 25 microtesla (μT) at the Equator to 75 μT at the poles, with geomagnetic field lines inclined, in Europe and North America, at an angle of about 60° to the (horizontal) surface. The field is not constant: currents in the ionosphere and disturbances from Earth's interior produce slow daily variations in the field with amplitudes of some 25 nanotesla (nT), and superimposed on these are further oscillations with periods of a few seconds and amplitudes of about 1 nT. Far enough from electric installations and other sources of artificial magnetic perturbation, however, proper shielding can reduce these shorter variations to about 0.1 nT s^{-1}, and local spatial gradients to below 1 nT m^{-1}. These variations are comparable to those found in the fields of artificial magnets.

The first observation of a nuclear magnetic effect in Earth's magnetic field — the free precession of proton spin[4], akin to the precession of a spinning top in Earth's gravitational field — came not long after the discovery of NMR. The weakness of the geomagnetic field is such that it causes only a slight natural polarization in proton and neutron spins. Before an NMR measurement in the Earth field can be made, therefore, these spins generally have to be polarized by a high magnetic field, or polarization has to be transferred from more-readily polarizable electrons using a method known as dynamic nuclear polarization. Such techniques have been used for measurements of the precise 'Larmor' precession frequency for protons, of

50 & 100 YEARS AGO

50 YEARS AGO

...you reveal more than I think you were aware of when writing "a nation using...a minority language cannot escape bilingualism if it desires to attain high standards of scholarship". If the sentence is understood as referring to the use of minor languages for publishing, it is indisputable; but all too frequently it turns the other way — scholars within the major language groups neglecting the literature outside their own language... To illustrate this point I have made a small survey of world scientific literature... That our Soviet colleagues know more about 'Western' literature than the reverse is nothing new, but it is deplorable... That the English and even more the American literature should emerge as the narrowest is scarcely unexpected... It is a waste, and it is also inconsiderate, to publish primary scientific material in a minor language.

From *Nature* 18 February 1956.

100 YEARS AGO

Dr. H. Charlton Bastian re-expounds his well known biological heresies with a vigour and industry worthy of a better cause. The first heresy is that "*archebiosis*" is a present occurrence, that living organisms may here and now arise from non-living materials... we are recommended to take an infusion of turnip or fresh beef, to filter this through two layers of the finest Swedish paper, to let a drop fall on a cleaned microscope slip, to put a cover-glass on, to remove excess of fluid with blotting paper, to allow one or more air bubbles to remain in the film, to seal up with melted paraffin wax...to incubate at blood-heat for two to three hours, and to await events. The expected happens — multitudes of living particles appear... While we must stand aloof from Dr. Bastian's heresies, we cannot but admire his dogged support of what seems to us a lost cause. It is something to stand *unus contra mundum* with no loss of courage or good humour.

From *Nature* 15 February 1906.