recognized and targeted[19], and one of them might just cross-react with tetanus toxoid. Or is it possible that a major shift in repertoire has occurred in patients independent of the target autoantigens and before onset of disease? This shift could represent the non-genetic element that explains discordance. Such a shift, if induced by an environmental agent, would require some type of truly super antigen, or several different antigens. Utz *et al.* report only Vα usage, so it is difficult to tell whether a Vβ-specific superantigen, as currently known[6], might be involved.

In all, we now have one more complexity to take into account in studies of autoimmune disease: clearly, the responding TCR repertoire in patients with chronic disease is affected by more than just the genetic background. The next steps will be to examine more sets of twins and more antigens, and to include analysis of Vβ expression. It will also be interesting to see if longitudinal studies in individual patients show TCR repertoire shifts, and if similar phenomena crop up in other chronic autoimmune diseases. □

Brian L. Kotzin is in the Division of Basic Sciences, National Jewish Center for Immunology and Respiratory Medicine, Denver, Colorado 80206, USA.

SEISMOLOGY

Testing the test-ban treaty

Paul G. Richards

As serious efforts to negotiate multilateral limitations on nuclear testing may resume this year after a 12-year hiatus, it is now necessary to look at the progress made on verification, the problems that remain and the plans for explosion monitoring needed to support a new treaty. The first message emerging from two recent meetings* was that seismic methods can be used to monitor nuclear explosions down to yields far smaller than the threshold of 150 kilotonne high explosive equivalent set by the current bilateral treaty between the United States and Russia on nuclear testing.

There remains a grey area between about 1 and 10 kilotonnes where experts disagree on verification capability. And at 1 kilotonne and below (a level at which some weapons designers claim there is a limited capability for testing and development of nuclear weapons or their components), verification cannot be assured with high confidence, even if plans for new seismometers are developed on a global basis. A clash is therefore brewing on a major question of arms control policy between those who advocate a multilateral, comprehensive test-ban treaty both as a restraint on the nuclear states and in furtherance of the goals of the Nonproliferation Treaty, and those who oppose such a treaty on grounds either of a perceived need to continue testing, or as a matter of principle that an unverifiable (comprehensive) treaty is bad policy.

Since nuclear testing went underground in the 1960s, seismology has provided the most important methods for detecting and locating explosions, and distinguishing them from earthquakes. A problem has always been the possibility that a nuclear explosion might be executed in an underground cavity, thus decoupling or muffling the seismic signals to make them look like a much smaller shot carried out under typical (tamped) conditions. In the early 1960s, it was proposed that an explosion as large as 300 kilotonnes could be decoupled to look like a 1-kilotonne tamped explosion. But in fact, decoupled explosions are less of a problem for two reasons (L. R. Sykes, Columbia Univ.): cavities for effective decoupling are too large for practical construction for more than about 10 kilotonnes; and the decoupling is far less efficient than was originally thought. Evidence for this comes from a decoupled explosion carried out by the then Soviet Union on 29 March 1976, when about 10 kilotonne high explosive equivalent was exploded in the cavity of a previous 64-kilotonne shot in a salt dome in West Kazakhstan. Data on this experiment (which was not clandestine) have recently been made available; it was observed teleseismically, both inside and outside the USSR, and had a magnitude of about 4.1 (Sykes). The signal amplitudes were only about a factor of 10 lower than for a tamped shot of similar yield.

But even if decoupling is difficult (because of the challenges of building large, stable underground cavities, and secretly carrying out a sophisticated nuclear test that does not leak radioactive evidence), it still has some influence on assessments of monitoring capability.

With new seismic instrumentation, we can probably be confident that global monitoring would detect any explosion down to about magnitude 4. Without evasion this magnitude corresponds to about 1 kilotonne. With evasion (albeit by methods that some consider impractical, and that would be risky in the light of all the monitoring techniques that could be brought to bear), magnitude 4 might correspond to about 10 kilotonnes.

Below magnitude 4, seismic monitoring becomes difficult. Signal-to-noise ratios are lower; there are typically fewer seismic stations recording each small event; and there are large numbers of natural small earthquakes and chemical explosions, which must be identified as non-nuclear. New ways of discriminating between explosions and earthquakes are being developed (H. Patton, Lawrence Livermore National Laboratory), and spectral techniques can often now distinguish between single shots and the typical ripple-fired chemical blasts used in quarries and mines (B. Stump, Southern Methodist Univ.). But the main improvements in monitoring capability that will be needed to support a new test-ban treaty

US Dept of Energy/SPL

IMAGE
UNAVAILABLE
FOR COPYRIGHT
REASONS

Surface preparations for an underground test of a nuclear bomb at the Nevada test site.

*All-day session at American Geophysical Union meeting, Baltimore, 27 May 1993; and the Fifth Annual Workshop of the IRIS Consortium, Waikoloa, Hawaii, 10–14 June 1993.

© 1993 Nature Publishing Group

Call for extended moratorium

PRESIDENT Clinton on 3 July called on the other nuclear powers to join the United States in a moratorium on nuclear testing that he has ordered to be extended for at least 15 months. Saying that "if these nations will now join us in observing this moratorium, we will be in the strongest possible position to negotiate a comprehensive test ban", he also warned that the United States would move quickly to conduct nuclear tests if there was any resumption of testing by another country before October 1994. British testing in recent years has been conducted only at the main United States test site in Nevada, and President Yeltsin has expressed Russian support for a comprehensive ban, so the main question now is what France and China will do. France has been under a recent moratorium, but has a new government. China carried out two nuclear tests in 1992 (one of them, at about 600 kilotonnes, the largest underground nuclear explosion by far since the mid-1970s). A comprehensive test ban may be closer than at any time since the efforts of Kennedy, Khruschev and Macmillan in the early 1960s — but this Pandora's box will not close easily. P.G.R.

will stem directly from deployment of new seismic instrumentation.

In recent years, seismic stations of a new type have been installed around the world for purposes of geophysical research (G. van der Vink, IRIS consortium). Their distinguishing characteristics include broadband digital recording, and the ability to send data from remote sites, by modem and/or Internet connection, on request from any interested user. The global network has been a major effort of the international seismological research community, and its performance will, it is hoped, continue to improve. By combining the data from current and planned stations, it is estimated that all seismic events in Eurasia above about magnitude 3.8 could be detected with high confidence (J. Claassen, Sandia National Laboratory). The network performs even better than this in Central Asia, in large part because IRIS (a group of about 80 research institutions) has recently installed state-of-the-art seismometers and recording systems on territory of the former Soviet Union.

But the research community's network alone should not bear the burden of monitoring compliance with a weighty new treaty. If an event such as a nuclear test by a new state is very unlikely — but would lead to sweeping policy changes if it occurred — then the United States government, for one, would need a very reliable monitoring system (L. Turnbull, Central Intelligence Agency). The Advanced Research Projects Agency (ARPA) of the United States Defense Department in 1992 proposed the need to monitor all countries of high interest for signals of magnitude 2.5 and above (representing 1 kilotonne fully decoupled); to monitor globally to about magnitude 3–3.5 (about 10 kilotonnes fully decoupled); and to be able to locate seismic sources to within 10 kilometres "in order to bring other assets to bear" (Turnbull). These are demanding requirements, and some might say unattainable, as more than 50,000 earthquakes and several thousand chemical explosions each year give signals above magnitude 3. In practice, monitoring below magnitude 3.5 is needed only in regions within which decoupling is plausible. Which are these regions? This question will influence the new effort needed in building a monitoring network. ARPA has been a strong proponent of building arrays of seismometers (typically 10 or more instruments deployed in an area a few kilometres across) to achieve better signal-to-noise ratios than single stations. A subcommittee of the United Nations in Geneva, known as the Group of Scientific Experts (GSE), has conducted technical tests funded extensively by ARPA to exchange seismic data between arrays and single stations in different countries. The GSE has plans (R. Alewine, ARPA) for a new international seismic centre that would continuously receive data from a global network of about 50 stations and arrays, backed up by a secondary network of stations from which data could be requested as needed, for detection and location of earthquakes and explosions.

The Clinton administration has yet to decide whether the GSE approach should receive support. It would be rational first for a decision to be made on the monitoring capability required for various countries, as a basis for negotiating new limitations on nuclear testing. If an effective end to nuclear testing is desired, but a comprehensive ban is deemed unachievable because small explosions might go undetected, then one approach would be a treaty banning all explosions at and above a certain size, together with an indefinite moratorium on all nuclear explosions below that size. Such an approach was developed in 1960–62 by the United States and the Soviet Union; with a treaty threshold set initially at, say, magnitude 4, perhaps it can succeed in the 1990s. □

Paul G. Richards is at the Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York 10964, USA.

RÉSUMÉ

Chiral practice

CARBON chemistry developed a new twist when the fullerene C_{76} turned out to exist in two enantiomeric forms (R. Ettl *et al.* *Nature* **353**, 149–153; 1991). But how might one separate the two? Lacking a nanoscale equivalent of Pasteur's tweezers, J. M. Hawkins and A. Meyer (*Science* **260**, 1918–1920; 1993) have taken the chemical approach of tagging the two twisted carbon cages with a chiral ligand. Each enantiomer of the ligand has a preference for just one of the two C_{76} stereoisomers. So separating the tagged and untagged products, and then removing the ligand from the tagged variant, yields 97 per cent pure, optically active C_{76} fullerenes.

Blood and guts

To reproduce its kind the female mosquito needs to drink blood: two blood meals suffice to fuel oogenesis. But the blood proteins must first be broken down by gut enzymes, among which, as H.-M. Müller *et al.* (*EMBO J.* **12**, 2891–2900; 1993) have now shown, a pair of serine proteases, with the sequence attributes of trypsins, are prominent. Other trypsin-like sequences could be identified in the genome, but the two that Müller *et al.* have expressed in *Escherichia coli* do indeed digest blood proteins *in vitro*. Moreover their messenger RNAs appear in the mosquito gut only after the second blood meal. The interesting questions now are how feeding provokes transcription of the trypsin genes, and whether an antitrypsin for example, administered to the host, could spell death to the mosquito with more certitude than a folded newspaper.

Looking back

SOME people just have to be different. Flouting the custom of using a microscope to investigate a sample, L. Montelius and J. O. Tegenfeldt have employed a cleverly designed sample surface to gaze at the tip of their atomic force microscope (*Appl. Phys. Lett.* **62**, 2628–2630; 1993). In scanning force microscopy, the shape of the tip is convoluted with that of the sample surface in the image, and the effects can be hard to remove. Montelius and Tegenfeldt get around this by etching an indium phosphide surface into tiny columns which look, in the scanning electron microscope, like an army of miniature villi. Being so much thinner than the tip, the columns act in effect as an array of delta functions. The image produced is a corresponding array of pyramidal tip shapes, one for each column, and broadened only slightly by their 40–50 nm diameter. Molecules attached to the microscope tip itself could, say the authors, be imaged simultaneously by dozens of the columns, giving a painless increase in the statistical significance of each scan.

© 1993 Nature Publishing Group