population substructuring for other loci, it *is* possible, in principle, to predict the likelihoods of various degrees of population substructuring at VNTR loci, to calculate the probabilities that these substructuring patterns will cause a match to an innocent person, and thereby, by the use of a weighted average, to calculate the true probability of a match in any particular case. In practice, however, we will not be able to calculate this true probability, and an estimate has to be adopted. The multiplication rule gives one estimate. Any bias downwards in this estimate as a result of population substructure will be small in almost all cases compared to the sources of conservativeness that are built into the procedure at other points.

Lewontin and Hartl's proposals of new methods have the advantage that the methods are designed to be sufficiently conservative that the probabilities that they calculate will always be equal to or greater than this true probability. This means that discrepancies between the probability quoted in court and the true probability will never lead to false convictions. There are still snags, however. First, although the argument is that they should be used only when we have much greater knowledge of population substructuring, there can be no finite population survey which could demonstrate absolutely that these methods will always be conservative. Second, although such methods consistently produce estimates of probability biased in favour of the suspect, there will be no consistency across cases in the size of this bias, which will probably be affected strongly by the racial structure of the community in which the crime was committed.

The animosities being generated in the current round of exchanges are unhelpful, and indeed surprising given the extent of common ground shared by the protagonists. The human danger implicit in what to many will seem esoteric scientific arguments is the creation of a situation of unreasonable doubt, in which the guilt or innocence of individual suspects is determined in haphazard fashion by the willingness of individual courts to accept DNA evidence as admissable. □

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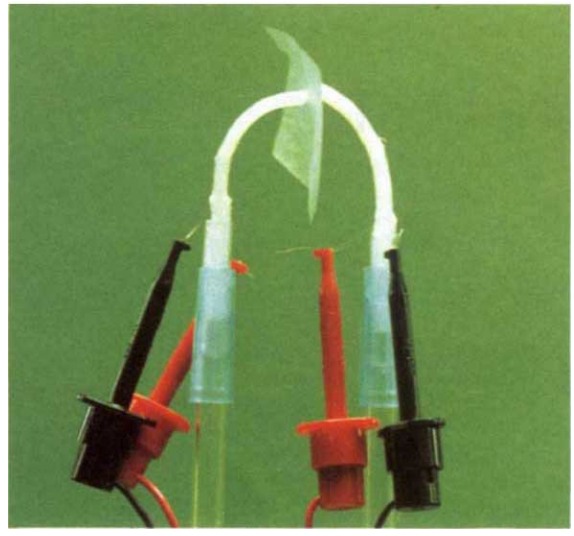
POLYMERS

Synthetic gels on the move

Kanji Kajiwara and Simon B. Ross-Murphy

CERTAIN synthetic polymer gels can be said to be intelligent, that is they can be made to respond to changes in their environment — pH, temperature, voltage and so on — by changing their shape, solubility or their degree of ionization, for example. Such gels are much more than mere curiosities — two meetings have been devoted to them in the past two years; a new journal (*Journal of Intelligent Material Systems and Structures,* Technomic Publishing) has been launched to carry news of developments; and, elsewhere in this issue (*Nature* **355**, 242–244; 1992), Y. Osada and colleagues describe how one such gel can be invested with 'worm-like' motility.



Gripping stuff: the newest polymer-gel fingers grasp a piece of paper at the recent RoboBug Fest.

A thermodynamic system capable of transforming chemical energy directly into mechanical work is known as a chemomechanical system. The history of the materials involved goes back to the early 1950s and such distinguished names in polymer science as W. Kuhn and A. Katchalsky, who described a number of aspects of the chemomechanical response. All living organisms move by the isothermal conversion of chemical energy into mechanical work as exemplified by muscular, flagellar and ciliary movement. Such highly efficient energy conversion systems can now be realized in synthetic polymer gels, which expand and contract upon changing their solubility and/or degree of ionization according to an external stimulus supplied in the form of thermal, chemical and electrical energy. Many artificial chemomechanical systems made of environmentally sensitive polymer gels are being developed for sensor/actuator systems such as controllable membrane separation systems and electronically regulated drug delivery systems. A sophisticated application of such intelligent gels for the second purpose was reported by I. C. Kwon *et al.* only very recently (*Nature* **354**, 291–293; 1991). In their proposed system a mixed poly(acrylic acid)/poly(ethyloxazoline) gel can be dissolved when a current is passed through it, and the authors propose to make this the basis of a long-period, controlled-release device that could, for example, furnish insulin for diabetics.

Hydrogels prepared from polymers which show lower critical-solution-temperature behaviour in aqueous solutions are thermoresponsive, and expand or contract below or above the phase transition temperature. The detailed application of such materials is based upon the studies of T. Tanaka and co-workers at the Massachusetts Institute of Technology over the past dozen years. A gel containing ionic groups can be actuated isothermally by an electric field. When the gel is negatively charged, it swells near the anode and contracts near the cathode, the contraction rate being proportional to the external electrical current.

The absolute change in volume is by no means insignificant — dimensional changes of say 50 per cent are quite usual. Such a gel bar made of polyelectrolytic material can bend backwards and forwards by the application of an alternating electrical field. Here, water and ions migrate towards the electrode bearing a charge opposite in sign to the net charge in the gel, and this coupling of electroosmosis and electrophoresis is thought to be responsible for the observed chemomechanical behaviour. A gel bar prepared from poly(vinyl-alcohol) and poly(acrylic acid) — PVA–PAA — bends towards the anode under a static electric field. A robot hand with four fingers of PVA–PAA gel can be made to grasp a fragile egg in an aqueous Na_2CO_3 solution under an applied field of 50 V. And an artificial fish has been made that swims at a speed of 2 cm s^{-1} by waving its 'tail' as the polarity of the field is alternated. In their paper in this issue, Osada and co-workers describe in detail the behaviour of a hydrogel that can move through a bath of

electrolyte solution. The system consists of a poly(2-acryl-amido-2-methyl propane sulphonic acid) gel doped with *n*-dodecyl pyridinium chloride surfactant. They show how a ratchet-type 'gel looper' can 'crawl' along a bar when a 20 V voltage is supplied.

At the most recent meeting of the Society of Polymer Science of Japan Polymer Gels Group, held last month in the science city of Tsukuba, a number of demonstrations of intelligent gel technology were shown at the so-called 'Robo-Bug Fest'. Examples included a polymer gel finger that works in air (see figure) rather than in solution, a significant advance; a gel beetle that can crawl up an incline; a gel-powered rotational micromotor; a flapping gel wing; and a gel Ferris wheel. A notable aspect of the progress in this area is the powerful synergy of university, government and industrial research, a liaison driven by the Agency of Industrial Science and Technology of the Japanese Ministry of International Trade and Industry.

At the moment the study of externally responsive gels is still in its infancy, and there remain some potential problems before they can be successfully exploited in terms of applications. For example, the gels respond rather slowly, typically over timescales of minutes. But the time required for a spherical gel to shrink is proportional to the square of its radius, so that sufficient speed could be obtained by miniaturization, and the construction of gel microfibres is already being discussed. Applications might then include the construction of devices which can be inserted into muscle to emulate a nerve response. □

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CANCER

Carcinogens leave fingerprints

Bert Vogelstein and Kenneth W. Kinzler

DETECTIVES on the trail of the causes and mechanisms of cancer have been working hard to connect specific environmental agents with particular molecular changes that occur in carcinogenesis. This pursuit has now led[1,2] to the indictment of two suspects who left their fingerprints at the scene of the crime. The suspects, aflatoxin B_1 and ultraviolet light, have long been on the wanted list because of their suspected involvement in liver and skin tumours, respectively.

The new findings are the result of the convergence of two areas of inquiry. First, epidemiology has indicated that certain environmental factors are associated with an increased incidence of cancer; these associations cannot by themselves illuminate mechanism, but because many of the factors concerned are genotoxic it has seemed that induced mutations might be to blame. Second, molecular genetics has identified genes that appear to be responsible for the initiation and/or progression of tumours. Are these oncogenes and tumour suppressor genes the primary targets of environmental factors?

Because oncogenes were identified before tumour suppressor genes, they were the first to be examined in this regard. It has now been exhaustively demonstrated that rodent cancers induced by exposure to a variety of carcinogens often contain mutations in *ras* oncogenes (see any recent issue of the journal *Molecular Carcinogenesis*). Importantly, the base changes in the mutant *ras* genes are generally characteristic of those caused by the carcinogens in simple mutagen assays[3], implying that the carcinogen can interact directly with mammalian genes and produce mutations at the site of interaction. A cell which thereby acquires a mutation in a *ras* gene is endowed with a selective growth advantage and clonally expands to form a tumour.

Similar studies on *ras* genes in human tumours have not been as productive, for two reasons. First, a relatively small number of human tumour types contain *ras* mutations at significant frequency[4]. Second, and more important, there are only a few codons in *ras* which, when mutated, result in oncogenic activation *in vivo*. These facts limit the comparisons that can be made and the conclusions that can be deduced from the examination of mutations in different tumours.

In contrast, some suppressor genes (in particular, p53) are mutated in a significant fraction of many different types of human cancer. Moreover, such genes can be inactivated by mutations at numerous sites, through point mutations, deletions or insertions. The first suggested link between a specific carcinogen and p53 came last year when Harris, Ozturk and their colleagues reported that G→T transversions at codon 249 (arginine to serine) were found in hepatocellular carcinomas (HCC) from southern Africa and east Asia; mutations at this position were rarely found in tumours of the colon, lung, breast or

RÉSUMÉ

Lost and found

To lose a type specimen is unfortunate, but to lose an entire collection might be construed as carelessness — especially if part of it turns up after nearly 200 years under one's very nose. It also causes confusion, as happened after the insect collections of the Swedish entomologist G. J. Billberg were destroyed by fire in 1822. The collections contained many type specimens of important tropical beetle species, and their loss has long inhibited beetle taxonomy. But it has turned out that Billberg's brother-in-law, C. J. Schönherr, was also an entomologist, and that the two had traded specimens. As J. Ferrer discovered (*Annals of the Transvaal Museum* **35**, 279–283; 1991), seven of Billberg's lost type specimens were indeed buried, unrecognized, in Schönherr's own collections, kept at the Naturhistoriska Riksmuseet in Stockholm.

Martian moraines

VAST ice sheets once lay over the poles of Mars, covering as much as one-fifth of the planet's surface, say J. S. Kargel and R. G. Strom (*Geology* **20**, 3–7; 1992). The authors compared Viking pictures of the planet's surface with glacial landforms on Earth. Extensive ridge patterns, they argue, can only be eskers, sand-and-gravel deposits laid down in channels below ice sheets. Drumlins and subglacially eroded tunnel valleys are also identified. From the cratering record, Kargel and Strom suggest that the glaciation (which lasted perhaps 20 million years) may have occurred as little as 250 million years ago. If correct, their interpretation supports the notion that the planet has known periods much warmer than its present CO_2-freezing climate.

Shooting match

THE beginning of the end of the dishonourable history of the Dum-Dum bullet may be marked by a report by R. M. Coupland *et al.* in *The Lancet* (**339**, 35–37; 1992). Dum-Dums and other bullets which fragment easily after hitting their targets, and thereby cause particularly nasty wounds, were outlawed by the Hague Declaration of 1899. But until now there has been no objective way of knowing if such ammunition has been used. Coupland *et al.* looked at 1,287 wound radiographs from four hospitals and show that the extent of bullet break-up and wound severity can be assessed from measurement of degree of bone fracture and of metallic fragments on the radiograph. They were able to identify one hospital with an especially high incidence of wounds caused by bullet fragmentation, and point out that their study has important implications for upholding humanitarian law.