Palaeomolecular biology

Raising the dead and buried

from Alec J. Jeffreys

Is the quagga as dead as a dodo? Not entirely, and nor indeed might be the dodo, if the remarkable findings of Russell Higuchi, Allan Wilson and co-workers reported on page 282 of this issue are anything to go by. Because even though the quagga, a curious chimaera of horse and zebra, became extinct just over a century ago, some of its DNA has survived in a museum specimen in a state suitable for molecular cloning.

As a start, Higuchi *et al.* managed to isolate partially degraded DNA from dried quagga tissue and to show that at least some of it is of quagga origin, rather than a contaminant, by virtue of its hybridization with DNA from the closely related zebra. More importantly, it was possible to obtain clones of specific mitochondrial DNA sequences. Comparison of these sequences with those of zebra mitochondrial DNA provided the final proof that they are of quagga origin. Not only are the two species' sequences as closely matched as is expected for congeneric animals but most or all of the differences that do exist (mainly synonymous base transitions at third codon positions) are clearly not due to postmortem changes in DNA that have been subsequently misrepaired during cloning, and so they must reflect the evolutionary history of the quagga. Clearly, the great power of molecular phylogenetic analysis, so far restricted to living animals, can now be brought to bear on at least some extinct species.

The choice of mitochondrial DNA was wise in view of its abundance: there are many mitochondria in each cell. However, to extrapolate from Higuchi *et al.*, it might even be possible to extend such studies to single copy genes of the nucleus. Thus 3 gm of preserved tissue should yield sufficient DNA to produce a library of up to 3×10^7 clones, each containing perhaps 100 base pairs of quagga DNA and together covering most of the genome.

The obvious next question is whether other museum specimens will yield up their molecular secrets. One can only hope that museum curators will be reasonably sympathetic to hordes of molecular biologists eager to dismantle their cherished exhibits. Anthropologists could benefit too — DNA sequences of bog people and Egyptian mummies would no doubt be fascinating, though cloning the latter might prove too nerve-racking a task for the superstitious genetic engineer.

A century or two in a museum is one thing; 40,000 years in a Siberian permafrost bog — the fate of the Magadan mammoth — is another. Nevertheless, Wilson's group (*Fed. Proc.* **43**, 1557; 1984), M. Goodman's (*Acta Zool. Fennica*, in the press) and my own (unpublished) have shown that substantial quantities of DNA can be recovered from preserved mammoth tissue. Unfortunately, almost all of it comes from recent microbial contamination, probably introduced after excavation. Elephant-like DNA sequences are present at vanishingly low levels (less than 1 part in 10^4 of the total DNA) and are severely degraded. Cloning this DNA would indeed be a mammoth task, and any sequence information recovered would probably be seriously distorted by postmortem modification. We know nothing about the chemistry of DNA degradation over geological time periods.

Any hopes that molecular biology and palaeontology can be fused into a grand evolutionary synthesis by studying fossil DNA, still look like nothing more than a glorious dream. However, it is far too early to give up, and it might just be possible that DNA has survived in some fossilized material.

One final point: DNA can easily be purified from animals that have died, and once dried it is stable and should survive for centuries without degradation. It is therefore vital that zoos or museums should start systematically to store DNA from as many species as possible, and certainly from any that face extinction. Friedrich Miescher, who discovered nucleic acid in 1868 (see Vogel, F.C.W. *Die histochemischen und physiologischen Arbeiten von F. Miescher*, Leipzig, 1897), could have saved Higuchi *et al.* a lot of trouble if he had had the foresight to make and store fresh quagga 'nuclein'. □

A quagga mare exhibited at London Zoo from 1851 to 1872. The photograph was taken 13 years before the death of the last captive quagga in Amsterdam in 1883. (Zoological Society of London.)

Alec J. Jeffreys is in the Department of Genetics, University of Leicester, Leicester LE1 7RH, U.K.

Particle accelerators

New concepts for high energies

from J.D. Lawson

SPECTACULAR development of particle accelerators has sustained the progress of elementary particle physics during the last half century. Although current projects, and others yet to be funded, will ensure the progress of particle physics until the end of the century, there is serious concern about what will happen beyond then. We need some new concepts or some radically new technology to continue past trends. Two years ago high energy and accelerator physicists met in Oxford to consider 'The Challenge of Ultra-High Energies'. A few weeks ago they met again, this time in Frascati*, to examine in more depth some of the ideas discussed at Oxford.

The 'colliding beam' concept, first demonstrated twenty years ago, becomes particularly effective when γ, the ratio of total particle energy to rest energy, becomes large. Almost the total energy of $2\gamma m_0 c^2$ is then available for particle creation and excitation, whereas if one of the particles is initially stationary in a target, it

*'The Generation of High Fields for Particle Acceleration to Very High Energies', Frascati, 25 September - 1 October 1984.