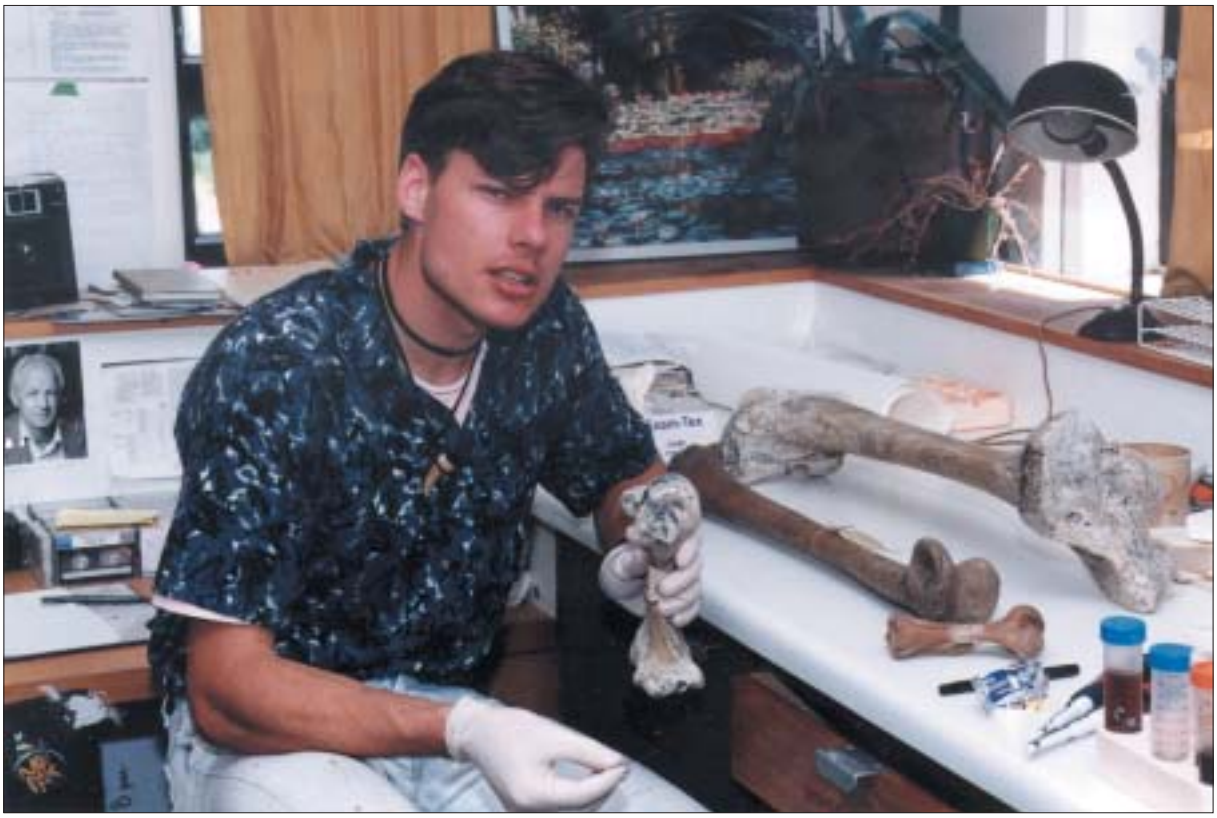
Alan Cooper – explorer and scientist

Alan Cooper is a Professor at Oxford University, where he directs research at the Henry Wellcome Ancient Biomolecules Centre. He travels the world in search of ancient bones so that he can study evolution and past environments. Alan is recognised as a world leader for his work with ancient bones and DNA research.



Alan at Victoria University doing research for his PhD thesis.

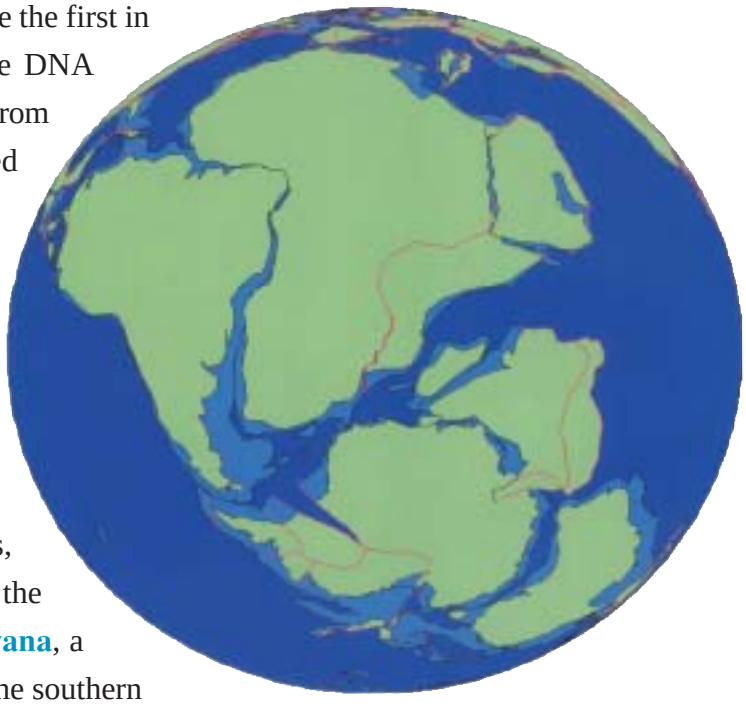
Alan Cooper – explorer and scientist

Alan Cooper stopped for a moment to pry his boots out of the deep sticky mud. He was high up on a freshly exposed bank overlooking a gold mine in the remote Yukon Territory of north-west Canada. Far below, a member of his research team yelled in excitement, as she identified a bone jutting out from the partially melted permafrost. It was probably from a bison 30–50,000 years old. These ancient bones could provide Alan with detailed information about the evolution of the animals and the environment in which they lived, if he could extract **DNA** – the genetic blueprint of the animal – back in the laboratory.

Top: Alan inspects the discovery.
Centre: Excavation and inspection, Alan and Beth.
Bottom: Dr Paul Matheus (University of Alaska, Fairbanks) and Beth Shapiro (Alan's DPhil student, Oxford) with mammoth femur aboard, Colville River, North Slope, Alaska.

His interest began on field trips in our New Zealand bush with his parents in Nelson – Alan was almost brought up in a backpack! Later, as a student at Naenae College in Lower Hutt, he became a keen member of the caving club. As well as the adventure and excitement of discovering and exploring new caves, this brought him into contact with the remains of past animals, including giant moa bones which he used as tools to dig through rock falls which blocked passages!

Alan's research centre made headlines shortly after it was set up in 1999. Early in 2001 it became the first in the world to determine the complete DNA sequence of a **mitochondrial genome** from an extinct species. Alan had returned home to New Zealand for the raw materials – bones from extinct moa. The genomic sequences provided a window on past evolutionary events within a group of flightless birds called **ratites**, which include the moa. This allowed the researchers to link the evolution of the different ratite species, such as the emu, kiwi, and ostrich to the separation of continents from **Gondwana**, a huge land mass that stretched across the southern hemisphere 140–180 million years ago.



Model of Gondwana c. 100 million years ago. Source: Institute of Geological and Nuclear Sciences (GNS). (Atlas Software, Cambridge Paleomap Services Ltd, Cambridge, UK.)

Great spotted kiwi, Mt Bruce Wildlife Centre 1986. Photo – Rod Morris. © DOC

Ratite species: rhea and cassowary. Photos – Colin Walker.

More research was to quickly follow, with studies of Ice Age mammals (using bones preserved in permafrost from Siberia and Alaska), and the evolutionary history of the **dodo** and its relationship to living pigeons. Recently, the centre reported that a group of moa formerly recognised as three different species were, in fact, one species with enormous **sexual dimorphism** – the females were up to 3 m in height while the males were only about 1 m. Animals such as the dodo and moa, isolated on islands, often show extraordinary **morphological** evolution and are therefore difficult to relate to their living relatives.

Alan has had many mentors to help him reach his present position. Techniques to extract mitochondrial DNA from the bones of extinct animals were developed in the laboratory of another New Zealand scientist, Allan Wilson, at the **University of California, Berkeley**. In the late 1960s and 1970s, he and Dr Vincent Sarich were amongst the first to show the genetic similarities between African apes (chimpanzees and gorillas) and humans. This study laid the groundwork for the **Mitochondrial Eve Hypothesis**. Allan Wilson was a pioneer in the field of **molecular evolution**, and a research centre for molecular evolution and ecology has been established in New Zealand in his memory.

Allan Wilson's work in cloning ancient DNA not only inspired the film Jurassic Park, but also inspired a young Alan Cooper to think about studying the genetics of bits of moa skin and tendon that had been found in New Zealand caves. He decided to do a BSc Honours degree in Molecular Biology at Victoria University in Wellington, with Dr Geoff Chambers. During this time he had many discussions with Professor Harold Wellman, the geologist who discovered New Zealand's Alpine Fault (see Alpha 104).

Alan and Professor Harold Wellman in Mr Wellman's home.

Alan's family and growing up

Alan's choice of career was influenced by many people. His father, Roger, was a geologist, while his mother, Dorothy, had a keen interest in botany. Alan was born in 1966 in Dunedin where his father was studying limestone resources for agriculture. The family moved back to Wellington, where Roger worked for the former DSIR. He liked to have his family with him during fieldwork and when Alan was just a few weeks old he was taken with his parents to Nelson, where his father was studying the **Palaeozoic** rocks of the area.

Baby Alan was put in a seat strapped to his Dad's back, as Roger tramped through bush and scrub to get to the creek beds. Luckily Alan was a placid baby and adapted well to the family's mobile lifestyle. He got used to sleeping anywhere then, and reckons he still can today. When Roger stopped to collect fossils from creek beds he would tie the seat, complete with Alan, to an overhanging branch. Between 1968 and 1990, Roger went on field trips to Nelson at least once a year, and usually Alan, Dorothy, and later his sister Julie, would go with him.

Alan at home in Avalon where, some years later, he built a skate park in the garden.

Alan being carried by his Mum while out on a field trip.

Alan on a family holiday in Hamner, 1974.

A primitive worker's cottage in north-west Nelson became their summer home. Alan and his sister Julie grew to love the bush as much as their parents did. It was there, in the hills and caves around Nelson, that young Alan's first fossil-hunting expeditions began. As he grew up, Alan watched his mother and father exploring, making discoveries, and enjoying their work. Dorothy studied native orchids and Roger searched for evidence of how New Zealand had changed during its geological history. They loved their work and it continued at night, in the weekends and through the summer holidays. Microscopes, torches and Tilley lamps were always on the bench with books, tins of food and kitchen utensils. There was no escaping it – Alan could not help catching their enthusiasm for exploring and field research.

Moa fossil bones, Honeycomb Caves, Karamea. Photo – Lloyd Homer, GNS.

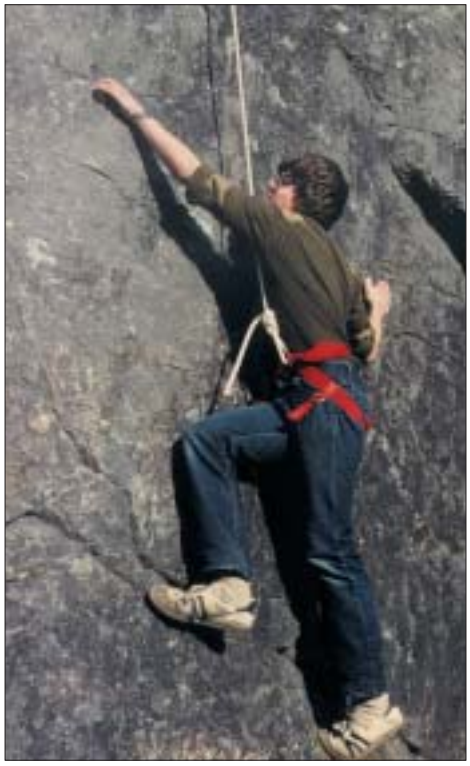
School and study

Back at school in Wellington, away from the excitement of fieldwork, Alan was a normal teenager. He was not so interested in study or doing homework and instead preferred playing soccer or frisbee with friends.

When Alan was 13 years old his family went to England for 18 months – his father had been awarded a Nuffield Science Foundation Fellowship. They spent time in Cambridge and London during the height of the punk era, and Alan says that the social upheavals of the time strongly influenced his subsequent attitude to authority.

Returning to New Zealand, Alan went to Naenae College for his School Certificate year. He enjoyed both sports and study, but an important new interest was also about to begin. A special teacher in Alan's life was Adrian Bulford, who taught him chemistry. Adrian had started a Civil Defence club at Naenae College in order to get the ropes, helmets, and equipment to allow him to take students on caving trips. Alan and the other students valued these trips which allowed them to see their teachers as normal people, by interacting with them outside the classroom. Alan's respect for Adrian as a caver made him enthusiastic to learn about chemistry, Adrian's other passion. "Alan told me later that he appreciated ease of access to the chemical cupboard, which I thought I'd locked, to enhance his research in interesting chemical reactions," jokes Adrian.

Adrian took Alan on many caving expeditions to places like Makuri and Waitomo over the next two years. Alan says the excitement of his first caving trip with Adrian converted him instantly, and from that point he knew what he wanted to do. "He took to caving like a duck to water," Adrian says.



Top: Setting out on a caving expedition at Waitomo. Alan Cooper and Adrian Bulford. Their motto: In emergencies, don't call us!
Bottom: Alan rock climbing at Baring Head, Pencarrow.

Years 12 and 13 were particularly good for Alan, both socially and academically, and he still keeps in touch with the friends he made that year. Alan and many of his school friends went on to Victoria University (where they started a caving club). The exciting university social life distracted Alan from his courses in life sciences, chemistry, mathematics, and physics and he admits his marks were not too good. Alan managed to pass his exams, although he says it was probably only the good teachers and helpful friends that got him through. He remembers skipping many less-exciting classes to spend time talking with Trevor Worthy, one of his course demonstrators and a leading New Zealand caver, about new underground discoveries. They still work together closely as Trevor is an expert in the study of extinct New Zealand birds, including the moa.

Alan was studying for a BSc in biochemistry when he saw Allan Wilson's work on ancient DNA. It seemed a natural way to combine his passion for caving with genetic research, and he applied to do an Honours degree in **molecular biology** at Victoria University. Given his average academic record, Alan is still not sure how he got accepted for the course, but he is extremely grateful they gave him the opportunity.

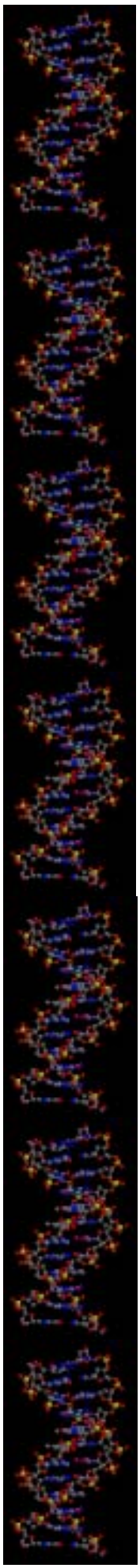
Top left: Alan squeezing through "organ grinder", Waitomo.
Above: Waitomo trip 1983; "lucky strike" cave.
Left: Naenae College summer trip to Makuri 1983.

DNA studies

The field of molecular biology advanced in the late 1980s when a technique called the **Polymerase Chain Reaction** (PCR) made the amplification of DNA routine. Former students of Allan Wilson were involved in the initial development of PCR, and provided the technique to his laboratory at the University of California. PCR made ancient DNA research much easier, and researchers at the Wilson laboratory quickly established new techniques. In 1988, Allan Wilson visited New Zealand to give a series of lectures about the mitochondrial eve research. While he was at Victoria University Alan showed him the results of his initial moa research and, as a result, Alan was invited to study for a year with Svante Pääbo, the world leader in ancient DNA research, in Allan Wilson's laboratory at the University of California.

The year in Berkeley changed Alan's life completely. He adapted well to the American work ethic, working long hours seven days a week, and throwing himself 100 per cent into both research and the San Francisco social life. He learnt to roller-blade and was often seen dodging traffic on his way home from the laboratory in the early hours of the morning. This was Alan's first major overseas experience, and hooked him onto the excitement of cutting-edge research, travel, and living in a different culture. His research went well, and the DNA he retrieved from five moa species clearly showed that the New Zealand ratites, moa and kiwi, represented two different invasions. Strangely, the kiwi appeared closely related to the Australasian emu and cassowary, and probably originated in Australia. When asked about this later in a New Zealand television interview, Alan commented that the kiwi had showed good sense, "and got out of Australia as soon as it could". This comment was broadcast worldwide by *Newsweek* as a quote of the week.

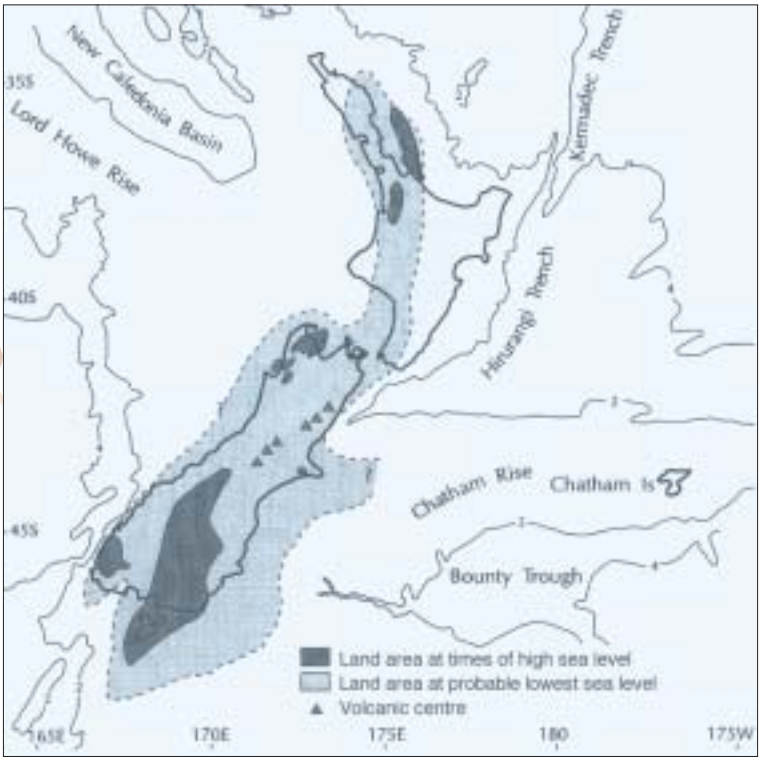
Alan brought the DNA research techniques he learned back to New Zealand in 1990, and continued to work on his PhD. The research went well, and Alan remembers many early morning trips blading up the hills back to his Northland flat after a long night in the laboratory. His study of the moa, kiwi, and the New Zealand wrens (bush wren, rock wren and rifleman) revealed that species within each group seemed to start diverging only within the past 20 million years. This was puzzling because New Zealand had been isolated from other continents for around 80 million years, and therefore each group should have been evolving since that time. Alan wondered what happened to the diversity within each group prior to 20 million years ago and discussed this with his father.



New Zealand's geological history looks like this:

- 20 million years ago New Zealand was about the same size as it is today;
- 28 million years ago New Zealand's land area was about the size that Canterbury is today – it consisted of a number of islands in the Otago, Nelson, and Northland areas;
- approximately 80% of New Zealand as we know it today was under water.

How do geologists know this? Drowning or **transgression** of land occurs when the sea rises through the melting of ice caps or when earth movements change the position of the tectonic plates. The land area remaining above water can be detected by mapping the current distribution of sedimentary rocks formed during this time.



Peak drowning during the Oligocene c. 24 Ma.

With Roger's geological knowledge and the research that Alan had done they concluded that the drowning of New Zealand had wiped out many species. The few surviving species diversified and adapted to new habitats as New Zealand re-emerged from the sea, meaning that much of New Zealand's amazing evolutionary diversity developed in just the past 20 million years. On the other hand, certain groups such as the tuatara, native frogs and some plants like the rimu, kahikatea and totara appear to have survived the drowning relatively unchanged.

Alan (PhD in molecular biology) and Roger (DSc in geology) with Dorothy and Julie at their graduation from Victoria University in 1995.

The history of plants and animals that live in relation to the geography of the time is now known as **paleobiogeography**. Roger and Alan wrote a paper together on New Zealand paleobiogeography in 1995, presenting this idea and calling it the Oligocene Drowning hypothesis.

Following his PhD, Alan returned to the United States for a post-doctoral fellowship. He spent two years at the Smithsonian Institute in Washington DC studying the molecular evolution of extinct Hawaiian birds, which had also evolved in island isolation. It was here he met his future wife, Sarah, at a party at his flat. In 1995, they moved to Oxford University, England, so Sarah could study for an MSc in Refugee Studies. They married in 1997 using the Museum of Natural History (complete with dodo) for part of their wedding. Alan was on a two-year post-doctoral scholarship, where he worked in the **Institute of Biological Anthropology** under the direction of another New Zealand scientist, Ryk Ward[1]. In 1999, he was awarded a five-year NERC (UK Natural Environment Research Council) Advanced Fellowship, and in 2001 he received a Wellcome Trust University Award. More importantly, in 1999 he led a consortium of Oxford researchers in an application to the UK government and the Wellcome Trust to fund a new research centre – the Ancient Biomolecules Centre (ABC) – within Oxford University. Alan was appointed Director of this state-of-the-art research centre, a position he still holds and which takes much of his energy. The ABC serves as the centre of ancient DNA research within the UK, and co-ordinates research activities with laboratories in Europe and the United States.

Above: Sarah Carlson, Alan's wife, with chameleon, Madagascar 1996.
Left: Alan and Sarah on holiday in Lund, Sweden.

[1] Sadly, Ryk Ward died unexpectedly in February 2003 – another New Zealand scientist who has contributed so much to the field of molecular evolution and yet his name is little known here.

Extinction is forever

Jurassic Park, where dinosaurs are returned to life, remains science fiction according to Alan. He is concerned that his team's work might give false hope to people who think that extinct species can be resurrected.

"While we have determined the complete mitochondrial genome of an extinct species (the moa) this approach could not be applied to the nuclear genome because the long stretches of repetitive DNA provide no signposts to allow short sequences to be stitched together.

Jurassic Park is a nice idea, but ultimately it seems that it will be impossible for us to clone extinct species. Therefore it is critical that we do not become complacent in our conservation efforts by assuming that we will be able to bring things back to life if they do become extinct. What would we do with them anyhow – put them in a zoo? Even attempting the process would be incredibly costly, and meanwhile a criminally enormous number of species become extinct each day. It makes far more sense to purchase land to stop it from being logged or developed."

Mammoth tusks, north slope, Alaska.

Alan's work helps us to understand what we have lost already and how ecosystems have changed in response to human impact. It also provides information on the impact of global climate change, and how evolutionary processes produced some of the amazing animals that lived in the Ice Age, or on remote islands.

Dodo head, Museum of Natural History, Oxford University.

"This is how it should be"

Adrian Bulford recollects that by the time Alan left Naenae College as a seventh former (Year 13) he had become a competent caver, leader, and a personal friend. He had developed an independent view of study, sports, and rules, and used this to seize an opportunity provided by another overseas New Zealand scientist, to become a world expert.

"As a teacher it gives me great pleasure to see one of my students do so well, but consider this: what Alan learnt outside the classroom became more important than what he learnt from the blackboard. He started as the student and I the teacher, now I am the student and he is the teacher. This is how it should be."

Alan's research group on a recent holiday in France (nationalities and research projects in brackets). From left to right, back row: Adriana Gravitol (Brazil, golden tamarin conservation), Mike Bunce (New Zealand, moa evolution), Beth Shapiro (USA, permafrost mammals), Jen Jackson (UK, molecular clocks in fish and echinoderms), Tom Gilbert (UK, ancient human DNA); front row: Alan Cooper, Jan Strugnell (Australia, cephalopod evolution/clocks), Shelley Cook (UK, New World flavivirus evolution).

Glossary

Biology: The study of living things.

Biomolecule: A minute particle of matter from a living, or once living, thing.

Chromosomes: Long chains of DNA that carry genes and other genetic information. In eukaryotes (species with nucleus-containing cells) they occur in pairs inside the nucleus of a cell (for example, humans have 46).

DNA: Abbreviation for deoxyribonucleic acid, the molecule that carries the genetic instructions for the way cells develop.

Dodo: A large extinct bird from the Mauritius.

Ecology: Study of the relationship of animals and plants to their surroundings or environment.

Evolution: Process by which a species develops into new and different groups, in response to environmental selection favouring the reproductive success of certain individuals. The fossil record reveals evolutionary history over long periods of time, and shows the modification of species as they have adapted to suit different environments.

Fossils: Buried remains of plants and animals preserved in some form by the Earth. Many fossils have been preserved by being turned into stone, others by being preserved in glaciers, peat bogs, or amber from ancient trees.

Genes: Short sections of DNA that carry instructions for discrete functions or products.

Genome: The full complement of genes carried by a single set of chromosomes. For example, the 'human genome' refers to the range of genes that a human can have.

Geology: Study of the Earth's crust and strata.

Gondwana: Name given to the southern hemisphere 'super-continent' consisting of South America, Africa, Madagascar, India, Arabia, Malaya and the East Indies, New Guinea, Australia, New Zealand, and Antarctica, prior to its break-up under the forces causing continental drift.

Mitochondria: An organelle (a specialised structure) in the cytoplasm of nearly all eukaryotic cells, containing enzymes important for cell metabolism, including those responsible for the conversion of food to usable energy. Mitochondria are thought to once have been bacteria that were incorporated in the ancestral eukaryote cell, and they contain the remnants of a simple bacterial genome.

Mitochondrial Eve Hypothesis: In 1987, a group of scientists working with Allan Wilson claimed that by analysing DNA from mitochondria, they had traced the maternal lineage of all humans back to a single woman who lived in Africa about 200,000 years ago.

Molecular biology: Study of the molecular basis of life, including the biochemistry of molecules such as DNA, RNA, and proteins, and the molecular structure and function of the various parts of living cells.

Molecular evolution: Study of how molecules have changed and evolved as a result of specialisation or selection.

Morphological: Relating to the form or structure of something. In the case of island birds, such as the moa or dodo, the morphological appearance is changed dramatically as they have become giant and flightless.

Palaeontology: Study of life in the geological past, especially through fossils.

Permafrost: Permanently frozen ground – it extends from 2000 to 3500 km south of the North Pole.

Pleistocene: A geological timeframe known as an epoch. It lasted approximately from 1.8 million till 10 thousand years ago, during which at least four major ice ages occurred. Succeeded by the Holocene.

Polymerase Chain Reaction (PCR): A technique developed during the 1980s that uses enzymes to copy short segments of DNA, allowing a few starting molecules to be amplified to enormous quantities, for sequencing or other research.

Ratites: A group of giant flightless birds including the moa and Madagascan elephant-bird (extinct), and the kiwi, ostrich, emu, cassowary, and rhea (living).

Sexual dimorphism: Where two animals in the same species appear dissimilar because of their sex.

Species: A group of organisms that are alike, and that can produce offspring that themselves are capable of producing offspring. There are a number of different biological definitions of a species.

Transgression: Invasion of a large area of land by the sea in a relatively short time (in geological terms).

Internet resources

Allan Wilson Centre for Molecular Ecology and Evolution.
http://awcmee.massey.ac.nz/

Henry Wellcome Ancient Biomolecules Centre (ABC).
http://abc.zoo.ox.ac.uk/

The University of California, Berkeley.
http://www.universityofcalifornia.edu/research/biotech.html

Victoria University of Wellington, School of Biological Science.
http://www.sbs.science.vuw.ac.nz/

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Adams, D. Carwardine, M. 1990: *Last Chance to See*. William Heinemann Ltd.

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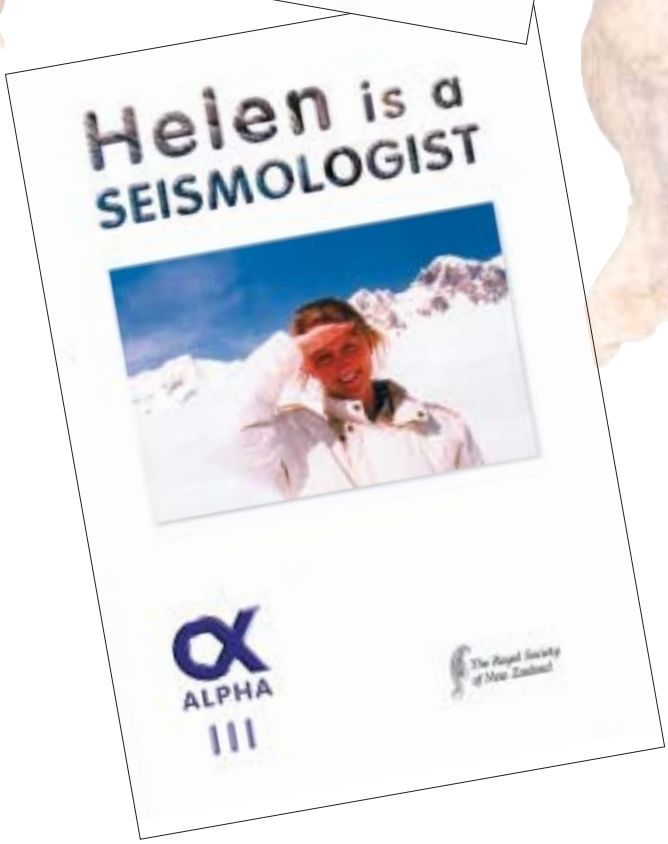
"Bothered by mosquitoes!"



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