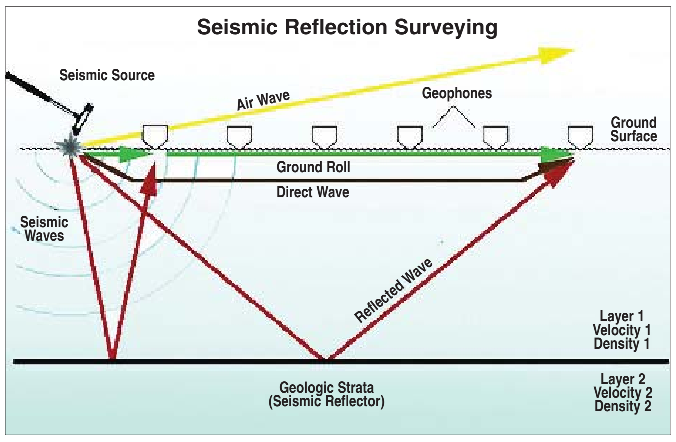
Flows of heat and molten matter

Fingerprints of a period in the sun have been discovered two kilometres beneath the seabed.
s ananthanarayanan **reports**



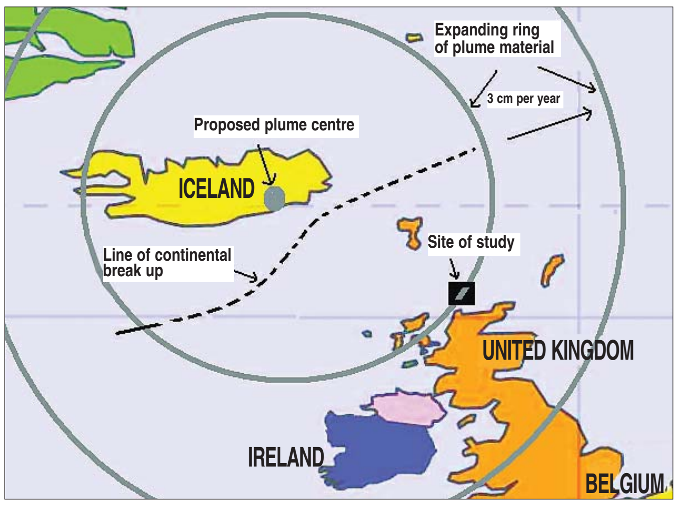
THAT many land masses were formed by the rising of the seabed because of seismic forces is well known. Even the Himalayan range consists largely of rock that was once under water and Mount Everest is made up of marine limestone. The reverse of this process would be that land that was at the surface is now under water. But there are a few instances and they are difficult to observe.

Ross A Hartley, Gareth G Roberts, Nicky White and Chris Richardson at the University of Cambridge report in *Nature* that they have made out the signs of weathered landscape in a tract of land that was once an island crisscrossed by rivers in the North Atlantic, but is now buried two kilometres below the bed of the sea, where the water is up to a kilometre deep.

The earth consists of a rocky and rigid outer surface, with hot and fluid matter deeper down. This was first deduced from studies of the non-uniformity of the earth's gravitational field, The outer layer, which is called the *lithosphere* (litho = rocky), appears to have formed by the cooling of the hot and molten viscous matter below. The fluid part, which is called the *mantle*, has convection currents called *plumes* to transport heat from the centre of the earth and the outer layer is like a conducting lid. But the lithosphere is not an unbroken sphere that envelops the earth – it presents itself as segments, or *tectonic plates*, which are in slow, geological scale, relative motion. When they push against each other, material is pushed both down into the mantle or up, which is the formation of mountains. When they move apart, there is ocean trench formation and earthquakes and volcanic activity arise from both kinds of movements.

With the lithosphere being 50-100 km thick, even under the oceans, the nature of the currents within the mantle, which lies below to carry heat from the core of the earth, is hardly understood. An exception is the *Icelandic plume*, or the upwelling of hot rock that is proposed to have taken place below Iceland. The idea is based on the geological features in this area, which provide a glimpse into its physical history. Apart from the volcanic activity, this area is known to lie in the rift that formed the North Atlantic, as volcanic rock that rose when the land masses parted are found on both sides of the ocean.

The plume also lies under an underwater mountain system, known as a *mid-oceanic ridge*, a formation of ocean floor lifted by pressure from below, with lava filling a rift within the ridge, formed by the movement of



tectonic plates. These telltale signs of mantle activity provide clues to understand the antiquity, the speed and direction of the underlying convection currents.

In their paper in *Nature*, the Cambridge University team studied a 10,000 square-kilometre area in the northwest continental shelf of Europe and a portion which arose by rapid uplift, and later sank, to be buried under the Atlantic, some 57 million years ago. A topographical map of the area, two kilometres under the seabed and as much as a kilometre under the Atlantic, was prepared using data obtained by a technique known as *seismic reflection*. This technique is a form of underground detective work, where shock waves in the earth, like the ones that arise in earthquakes or can be created by explosives, are detected at long distances from their place of origin. The detection is not only of the original waves along the surface but also of waves reflected by changes in the density and elasticity of the rock though which the wave is transmitted, and of different kinds of waves. A topography that lies buried below the seabed would form such a reflecting surface to seismic waves and the shape of the surface can be made out from the reflected waves received at a series of detectors. The intensity of the waves detected also indicate the extent to which waves have been reflected or transmitted, which leads to ideas about the kind of rock that is responsible for the reflection.

To create a map of the irregular target surface, the Cambridge team tracked the surface at different depths and along a crisscross of lines, 150 metres apart. The extent of data considered was good enough to reveal features with a sensitivity of 30 metres. The data was also calibrated using estimates of wave speed at different depths, using boreholes and estimates of the composition at different depths.

The result of the painstaking survey has been a reliable map of the surface as it stood when it sank and was buried. The landscape is found to consist of branching channels, with steep slopes, as may be created through erosion by water flowing over soft sedimentary rock. The elevations are as high as 800 metres and there are drainage ruts along the crests of high formations. The landscape is divided by a meandering valley and it is seen that the valley was fed by a system of tributaries.

The composition of the material, at different depths within the landscape indicates that the formation arose by uplift that lasted some two to three million years and that it had arisen because of a thermal flow under the lithospheric plate. Working out the uplift history of the area could provide a picture of its cause, the underlying flow. Analysis of the network of tributaries provided a picture of the periods of rising levels at different places and a dynamic picture of the uplift process. The result is that the uplift peaked at about 55.5 million years ago, caused by the spreading of a hot ring-shaped plume beneath the lithospheric surface. When the body of the ring went past the uplifted area, the area sank again, to be buried in silt and slime. Mapping of another similarly affected area 240 km away, and the timing of its rise and descent, create a picture of a ring-shaped plume spreading out with a speed of 35 cm in a year!

The study has not only revealed a spectacular landscape, a river valley formation that developed in a piece of land that rose from the sea and then again sank, but has made accessible some clues of what flows of heat and molten matter there may be within the earth's mantle.

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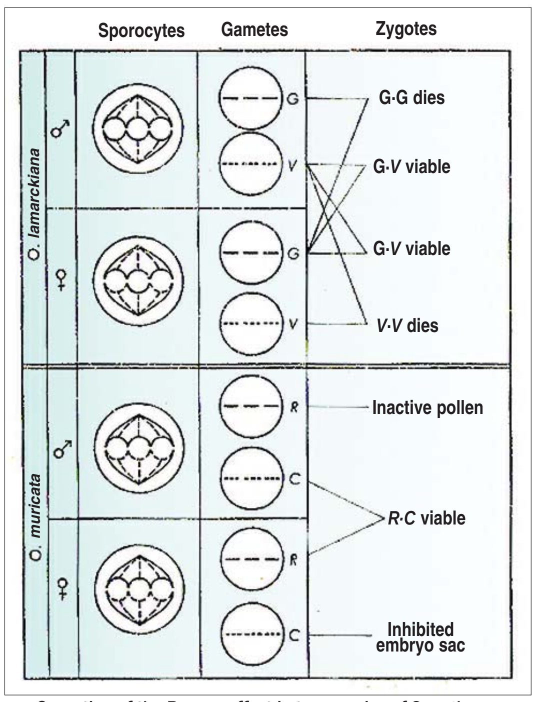
Effects of evolution

Adaptive capacity is the alpha and omega of biological progress, writes
tapan kumar maitra

THE evolutionary consequences of translocations are intriguing, with *Oenotkera* and *Datura* providing most of the available information. It is clear that in a translocation heterozygote, the chromosome's involved in a ring of four are not inherited independently; the two normal chromosomes are inherited as a group, as are the two trans-located ones, if a full complement of genes is to be transmitted. What were initially two independent linkage groups are now united into one, despite the fact that the chromosomes exist as independent entities. As the translocation complex increases in size, the number of independent linkage groups decreases until, as in many *Oenothera* species, the seven haploid chromosomes behave as one large linkage group. This has the aggregate effect of sharply reducing the component of variability due to independent assortment of chromosomes.

To appreciate the chromosomal situation in *Oenothera* it is necessary to understand the nature of the Renner complex and the Renner effect, so-named after their discoverer. *Oenothera,* has a haploid complement of seven chromosomes with 14 pairing ends. If it is assumed that any particular end can be reciprocally translocated to any other end, then 91 different end combinations are possible (1-2, 1-3, 1-4, 1-5, 1-6, 1-7; 2-3 ... 2-7; . . . 6-7). Most of these have been found in natural populations, a fact that itself indicates either that there is a strong propensity for *Oenothera* chromosomes to undergo transloca-tion or that this is a structural alteration possessing considerable survival value.

Of the known end combinations, seven in particular outnumber the others in frequency and distribution, and for a variety of reasons these 7 chromosomes are believed to constitute the ancestral arrangement from which others arose. A single translocation would give rise to a ring of 4 chromosomes in meiosis. By successive translocations rings of 14 are built up. These would be unstable, however, in a population, for structural homozygosity would result through inbreeding, and individuals with rings of variable size and numbers of bivalents would be expected. Structural heterozygosity becomes enforced only when lethal genes are included in the ring of chromosomes, and the end point is a ring of 14 chromosomes with different lethals in each of the two haploid sets of 7.



Operation of the Renner effect in two species of Oenothera.

Only alternate segregation from the ring leads to the formation of viable gametes; so each group of 7 chromosomes becomes, in essence, a single large linkage group with recombination of genes being confined to the pairing ends of each chromosome. These linkage groups, consisting of 7 separate bat collectively inherited chromosomes, are called Renner complexes, and each individual possessing balanced rings of 14 is actually a dual entity, because each contains two complexes that, because of muta-tions and lack of proximal recombination, may differ appreciably from each other in genetic content. For example, in 0. *lamarckiana,* the two complexes, called gaudens and velans, yield two very different species hybrids when out-crossed to other forms. The individual plants of 0. *lamarckiana,* which are generally self-pollinated, breed true, however, because the incorporated lethals prevent the existence of homozygotes and the breakdown of the complex.

The Renner effect is a further refinement of the system. It is achieved when one of the "Renner complexes is transmitted only through the egg, the opposite complex only through the sperm. Such separation can be accomplished by the establishment of either gametic or zygotic lethals. 0. *lamarckiana* makes use of one method, 0 *muricata* the other. Alternate segregation from a ring of 14 is highly regular in *Oenothera,* and nondisjunction of chromosomes is not frequent enough to affect fertility in a marked manner. Regularity of segregation can be attributed to the fact that all the chromosomes, despite many trans-locations, have median centromeres, a feature that permits greater maneuverability of chromosomes on the metaphase plate. This means that the surviving translocations have been not only reciprocal but also approximately equal in length.

The North American *Oenotheras* provide an overall picture of the manner by which evolution has proceeded via the translocation-complex route. The advantages as well as the limitations of both the system and the goal are fairly evident; indeed, it might be said that the *Oenotheras* have achieved their present evolutionary position and diversity by means of a unique evolutionary unorthodoxy.

The *Oenotheras* have utilised a number of genetic devices, each deleterious to a certain degree, and have combined them into a single system that functions very well. These devices are as follows: a) reciprocal translocations, which because of irregular segregation lead to a reduction in fertility, and which because of the linkage system established drastically reduce genetic recombination; b) accumulation of lethals and other deleterious mutations; and c) self-pollination, which in itself leads to inbreeding and a lack of vigor. Any one of these three is, in normally open-pollinated species, genetically disadvantageous, yet the translocations lead to the development of diverse linkage groups (the complexes), the lethals enforce structural heterozygosity, and self-pollination prevents outclassing, which tends to break the complex up. On this basis, the course of evolution in the oenotheras is the formation of ring complexes, followed by the in-corporation of lethals and then by the establishment of self-pollina-tion. It is only in this order of occurrence that the system makes evolutionary sense when it is viewed in terms of its adaptive suc-cess.

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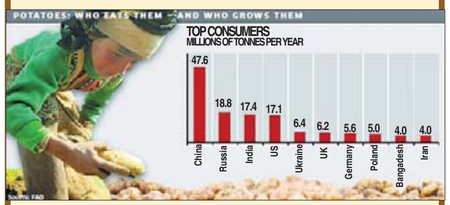
Super spud on the menu

steve connor **on the cracking of the genetic code**

THE full genetic code of the potato plant has been deciphered by scientists who say that it will lead to the rapid development of new disease-resistant varieties of the world's most important non-cereal food crop. An international consortium of research organisations has sequenced the 840 million DNA "base pairs" that make up the 12 chromosomes of the potato genome. The breakthrough should lead to the identification of important genes that confer resistance to potato diseases such as late blight, a fungal infection that triggered the Irish potato famine of 1845.

It takes 10 to 12 years to breed a new variety of potato, but knowing the genome could cut the time by half and improve the end product by targeting the individual genes responsible for the desired traits, the scientists said.



"Anything that allows us to link genes with traits now will improve the rate at which we can produce a whole range of varieties by different methods," said Professor Iain Gordon of the James Hutton Institute in Dundee, which took a lead role in the project. "We now understand, in effect, the book of life of the potato, we understand the genes and we can relate that to the traits that the potato has, to improve its productivity and to reduce the impact of pests and pathogens."

Each year some 200 million tons of potatoes are eaten worldwide and they form the fourth largest staple crop after rice, wheat and maize. The rice genome was completed in 2005 – the first of a crop plant – and a draft sequence of wheat was published last year. Unlike cereals, potatoes are rich in nutrients such as vitamin C and folic acid and are seen as a critical crop in the effort to boost food production for a growing world population – expected to increase from to nine billion in the next 40 years.

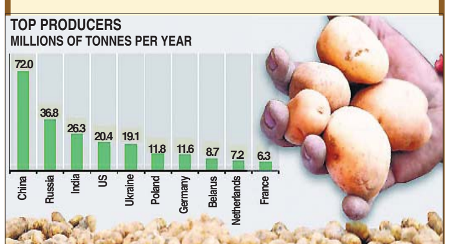
Professor Robbie Waugh, also of the James Hutton Institute, said that cross-breeding domestic potato varieties with wild varieties that grow in South America had improved disease-resistance but success had been limited because these introduced traits tended to break down over time.

"The potato has been bred here for probably less than 400 years," Professor Waugh said. "Despite all the effort, we still grow potato varieties that are over 100 years old. Potato improvement is a very slow process. What the potato genome allows us to do is to identify particular genes that most potatoes have that may have a unique function, such as a resistant gene that is unique to a certain variety to potatoes. It could be transferred using genetic technology to a well-known cultivar grown today."

Short history of the potato

- Domesticated between 7,000 and 10,000 years ago by the natives of southern Peru in South America, where the potato grows in the wild on the slopes of the Andes.

- In 1536, Spanish conquistadors take potatoes grown by the Inca back to Europe to impress royalty.



- The word "potato" is derived from the Spanish "patata", which is a compound of the native words "batata" and "papa".

- In 1538, Sir Francis Drake and astronomer Thomas Harriot were credited with bringing the potato from the Americas to Britain, where it was quickly found to grow well in the cool, damp climate. By the 19th century it had established itself as the staple crop that fed the workforce driving the Industrial Revolution.

- French scientist Antoine Parmentier in 1774 discovered the nutritional benefits of the potato, which lead to the plant's promotion in France.

- The potato crop of Ireland was devastated by the late blight fungus in 1845, triggering the great potato famine.

- In 1995, the potato became the first crop plant to be grown in space.

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