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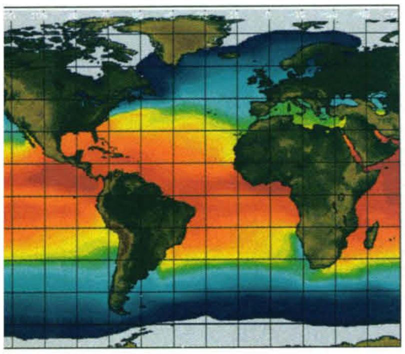

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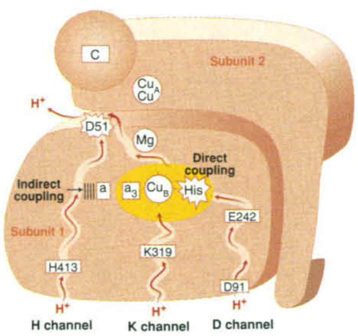
Global change research under scrutiny



1712 & 1723
Proton wires in cytochrome c oxidase

NEWS & COMMENT

RESEARCH NEWS

SCIENCE'S COMPASS

DEPARTMENTS

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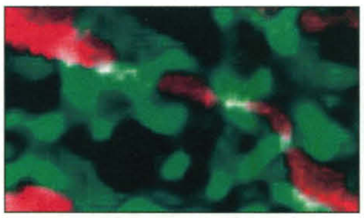
COVER

By creating a "virtual endocast" of this 2.8- to 2.6-million-year-old early hominid cranium from Sterkfontein, South Africa, researchers have determined the endocranial capacity (red) to be ~515 cubic centimeters. This is the largest endocranial capacity known for any early hominid dated to such antiquity, but it is less than earlier reports and suggests that endocranial estimates for other early hominids may need reevaluation. See p. 1730 and the Commentary on p. 1714. [Images: Courtesy of Gerhard Weber, Institute of Human Biology, University of Vienna]

RESEARCH ARTICLE

REPORTS

1763
Endoplasmic reticulum associated with mitochondrial network



1690 & 1735
Seeing a way to better fuel cells

◩ Indicates accompanying feature

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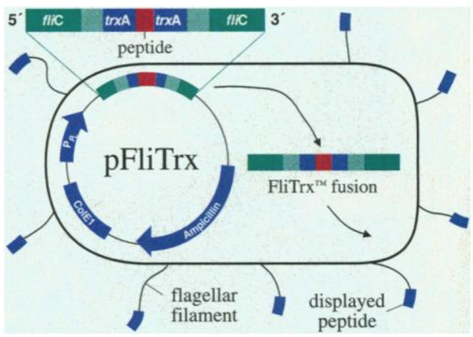

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THIS WEEK IN SCIENCE

edited by PHIL SZUROMI

Proton routes through cytochrome c oxidase

Mitchondrial cytochrome c oxidase catalyzes a central reaction in aerobic metabolism. It uses four protons and four electrons to reduce a molecule of dioxygen to water and couples this reaction to the active transport of protons across the membrane. The gradient of protons is used to synthesize adenosine triphosphate in a separate reaction. Yoshikawa *et al.* (p. 1723; see the commentary by Gennis, p. 1712) provide four high-resolution structures of the cytochrome c oxidase complex in two oxidation states. These structures delineate the path taken by the transported protons, reveal the unusual arrangement of ligands at the heme-copper site where the oxygen binds and is reduced, and suggest a spatial separation between these two regions of the complex. The implications are that the pumped protons do not travel via the redox site and that conformational coupling between the two reactions occurs.

Tolerating defects in computer architecture

Perfection of components underlies modern computer hardware—single defects can send chips to the crushers. Heath *et al.* (p. 1716) discuss a different, defect-tolerant approach to computing that may impact on strategies for creating nanoscale devices. They discuss the Teramac computer, which was constructed at Hewlett-Packard with large numbers of defective memory chips (about 200,000 defects in all) and yet could run in some of its configurations 100 times faster than a single-processor workstation. The Teramac architecture made use of much redundant wiring of these chips so that the main field programmable array chips could locate the defects and wire around them. For nanotechnologists, this approach suggests that successful strategies may not require complete elimination of defects in ever smaller devices but the fabrication of a high yield of working circuitry.

■

Tracing hominid brain evolution

Resolving the course of evolution of brains of hominids has been difficult because sufficiently complete fossils are scarce, so it is often necessary to reconstruct the original brain size. Conroy *et al.* (p. 1730; see the cover) used computerized axial tomography (CAT scans) and computer models to reconstruct the brain size of Stw 505, a skull of a probable australopithecine. They conclude that the cranial capacity is 515 cubic centimeters, much less than the original reports but still the largest size for any australopithecine. Their approach and results suggests that brain sizes of other hominids have also been poorly estimated, as discussed in a commentary by Falk (p. 1714).

■

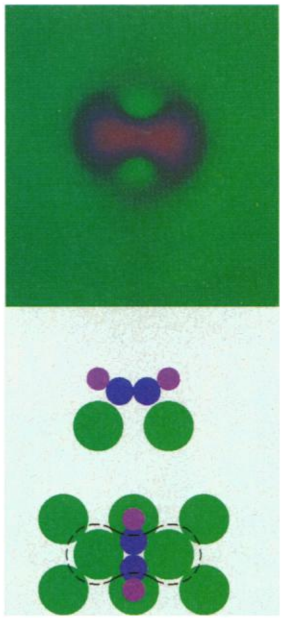
Noble routes to crustal origins

Radiogenic isotopes provide important information not only on dates of rocks, but can also be used to trace geologic processes. Information on melting in the mantle or the amount of crust introduced back into the mantle in subduction zones typically requires knowledge of the distribution of the parent and daughter elements between the important mantle minerals and magmas. Righter and Hauri (p. 1737) examined experimentally the distribution of rhenium and osmium between garnet and a siliceous melt at high pressure. The data imply that garnet is a host for rhenium in the mantle. Thus, oceanic volcanic rocks with low rhenium contents likely come from a part of the mantle that retained garnet.

■

Seeing vibrations of single molecule

Vibrational spectroscopy is usually performed on an ensemble of molecules, and the resulting information is therefore an average. Scanning tunneling microscopy, however, can provide structural information at the single molecule level for molecules adsorbed on a surface. Stipe *et al.* (p. 1732; see the commentary by Pethica, p. 1715) show how the tip in the scanning tunneling microscope can also be used to probe the vibrational characteristics of single molecules on a surface, They observed distinct spectral features characteristic for the C-H bond stretch in acetylene and the C-D stretch in its deuterated form. The method should allow the identification of different functional groups and their chemical transformations at the molecular level.



■

Visualizing better electrocatalysts

Combinatorial discovery of better materials is often limited by how fast a desirable property can be screened. For electrochemical catalysts, current-voltage methods can be time-consuming and difficult to apply to more than a few samples at a time. Reddington *et al.* (p. 1735; see the news story by Service, p. 1690) show that active catalysts can be screened with optical methods by using fluorescent dyes sensitive to the ions generated in redox reactions at the electrode. They screened large arrays of catalysts containing combinations of platinum (Pt), ruthenium (Ru), osmium (Os), iridium (Ir), and rhodium (Rh) for the electro-oxidation of methanol. The arrays used in solution were formed on carbon paper that had been laser-printed with "inks" of different compounds and then reduced to the metals. The most active catalyst, containing Pt, Ru, Os, and Ir, was twice as active in a methanol fuel cell as the commercial Pt-Ru catalyst despite its lower surface area.

■

All-polymer display

Polymer light-emitting diodes (LEDs) are more easily fabricated than their inorganic counterparts, but displays based on polymer LEDs have still needed silicon transistors to drive the individual pixels. Sirringhaus *et al.* (p. 1741; see the news story by Service, p. 1691) show that

(Continued on page 1667)

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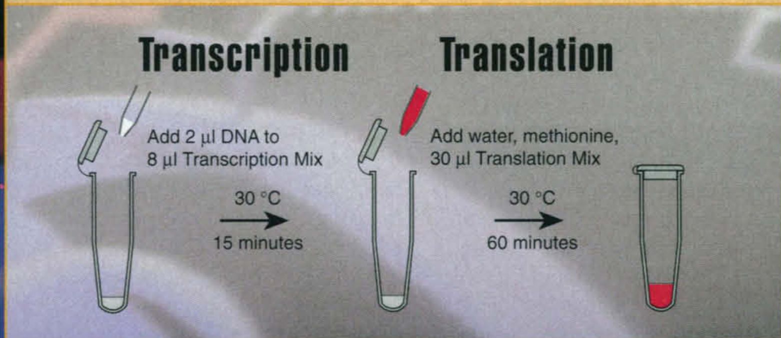

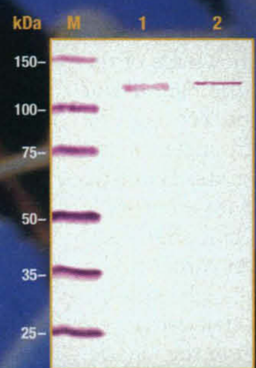

S•Tag Western Blot of crude and affinity-purified STP3 products. A standard STP3 reaction was performed with a pCITE-3 construct encoding β-gal fused with the 15 aa S•Tag peptide (used as an affinity tag for detection and purification due to its high affinity for the 104 aa S-protein). A portion of the reaction was analyzed directly, the remainder combined with S-protein agarose and incubated for 10 min at room temperature. Unbound proteins were washed away and the purified protein was eluted in SDS sample buffer. The western blot was developed with S-protein alkaline phosphatase and NBT/BCIP substrates. Lane M—Perfect Protein™ Markers (5 µl), Lane 1—crude STP3 reaction (3 µl), Lane 2—elution from S-protein agarose (20 µl).

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(Continued from page 1665)

polymeric field-effect transistors can be integrated with polymer LEDs. They optimized the deposition conditions of the polymer that constitutes the field-effect transistor and fabricated a simple integrated device with performance characteristics that rival those of similar silicon devices.

■

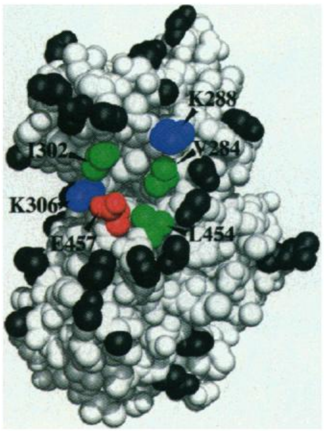
Quantized conductance in carbon nanotubes

Theory predicts that carbon nanotubes should exhibit ballistic conductance of electrons, with the nanotube acting as a waveguide for the electron. The mean free path of the electrons is much longer than the length of the conductor and scattering events should be elastic collisions, so conductivities should jump in multiples of the conductance quantum G_0, or $2e^2/h$, where e is the charge of an electron and h is Planck's constant. Frank *et al.* (p. 1744) have now measured the conductance of multiwall carbon nanotubes (MWNTs) that ranged from 5 to 25 nanometers in diameter and had lengths of 1 to 10 micrometers. A single MWNT protruding from a nanotube bundle, which provided one contact, was slowly lowered into mercury, which provided the other contact and also cleaned the nanotube of adhering material. Although theory has suggested that each shell of a MWNT should contribute $2G_0$ to the conductance, they find that the first main conductance plateau occurred at $0.5G_0$ or G_0 but never at $2G_0$. These smaller values are still unexplained but may arise from spin coupling effects induced by the helicity of the nanotubes. Similar results were seen using other liquid metals. The current densities in these tubes are extremely high under these room-temperature conditions and were estimated to be greater than 10^7 amperes per square centimeter.

■

Thyroid receptor surface

Nuclear receptors contain domains that interact with multiple cellular components, including ligands, other receptor molecules, cofactors, and DNA



binding elements. Feng *et al.* (p. 1747) have used scanning mutagenesis to map the thyroid receptor surface that interacts with coactivators. This interaction domain is found to be a small surface surrounding a hydrophobic cleft. Similar surfaces may be present in other nuclear receptors.

■

Less restricted hypermutation

During an immune response, B cells produce antibodies of increasingly high affinities. Somatic hypermutaion of the variable regions of rearranged immunoglobulin genes produces point mutations that enable higher affinity antibodies to be selected by the antigen. Shen *et al.* (p. 1750) found that a gene mutated in some transformed B cells, *BCL-6*, was a target of hypermutation in normal memory B cells. Other genes, such as c-MYC, did not get mutated. Hypermutation in normal B cells was previously thought to be restricted to immunoglobulin genes; the consistent mutation of a cellular oncogene may provide a clue to tumorigenesis or hypermutation mechanisms in B cells.

■

A gene underlying sight and sound

Usher syndrome is a disease that causes loss of both hearing and sight. Eudy *et al.* (p. 1753) have found that Usher syndrome type IIa is associated with mutations in a gene on chromosome 1, which has sequence motifs that suggest it may be a novel extracellular matrix protein or cell adhesion molecule. Further study of this gene, which is expressed in the fetal cochlea eye and in adult retina, may provide insights into links between these developmental pathways.

■

Protein origins

Although both prokaryotes and eukaryotes begin protein synthesis with the initiation codon for methionine in the new polypeptide sequence, very different mechanisms and factors are involved in accomplishing this event. However, evidence now shows that translation in the two systems may be more conserved than previously thought. A yeast homolog has been found for the bacterial translation factor IF2. Choi *et al.* (p. 1757) show that, like bacterial IF2, yeast IF2 is a general translation factor that can deliver the initiator transfer RNA charged with methionine to the ribosome. Yeast IF2 may perform this role in conjunction with the yeast factor eIF2.

■

From auxin to ubiquitin

How plants respond to auxin, a hormone in plants that directs a variety of developmental and cellular processes, is yielding to investigation. Del Pozo *et al.* (p. 1760) show that in *Arabidopsis*, the AXR1 protein, which mediates certain responses to auxin, forms a complex with a newly identified protein, ECR1. Together these proteins then activate RUB, a close relative of ubiquitin. RUB may then go on to direct localization or degradation of a target protein, as do other relatives in the ubiquitin family.

■

Calcium, mitochondria, and the ER

Simultaneous imaging of the endoplasmic reticulum (ER) and the mitochondria revealed that these organelles have regions that are in close physical contact. Rizzuto *et al.* (p. 1763), using a high-speed, high-resolution imaging system, observed that the mitochondria appear as an interconnected tubular network that undergoes constant reorganization. Consistent with this physical association of the ER and mitochondria, release of calcium from the ER exposed a Ca^{2+}-sensitive photoprobe located on the outer face of the inner mitochondrial membrane to high concentrations of Ca^{2+}. The authors conclude that the structural organization of these organelles is likely to have functional consequences for control of Ca^{2+} signals both in the mitochondria and the surrounding cytoplasm.

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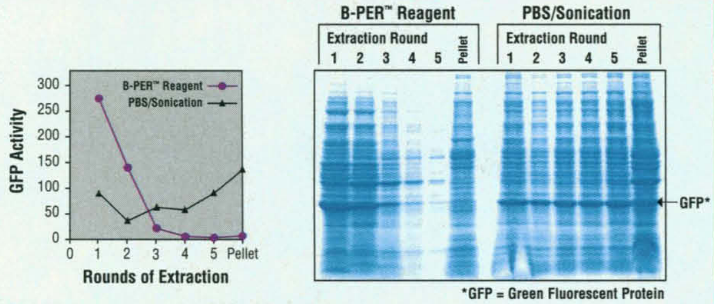

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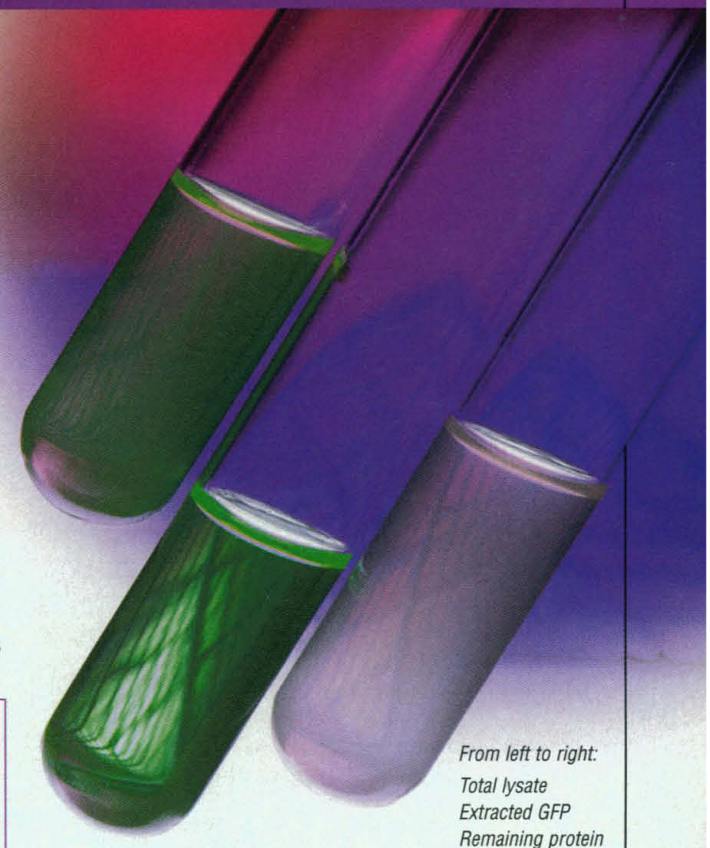

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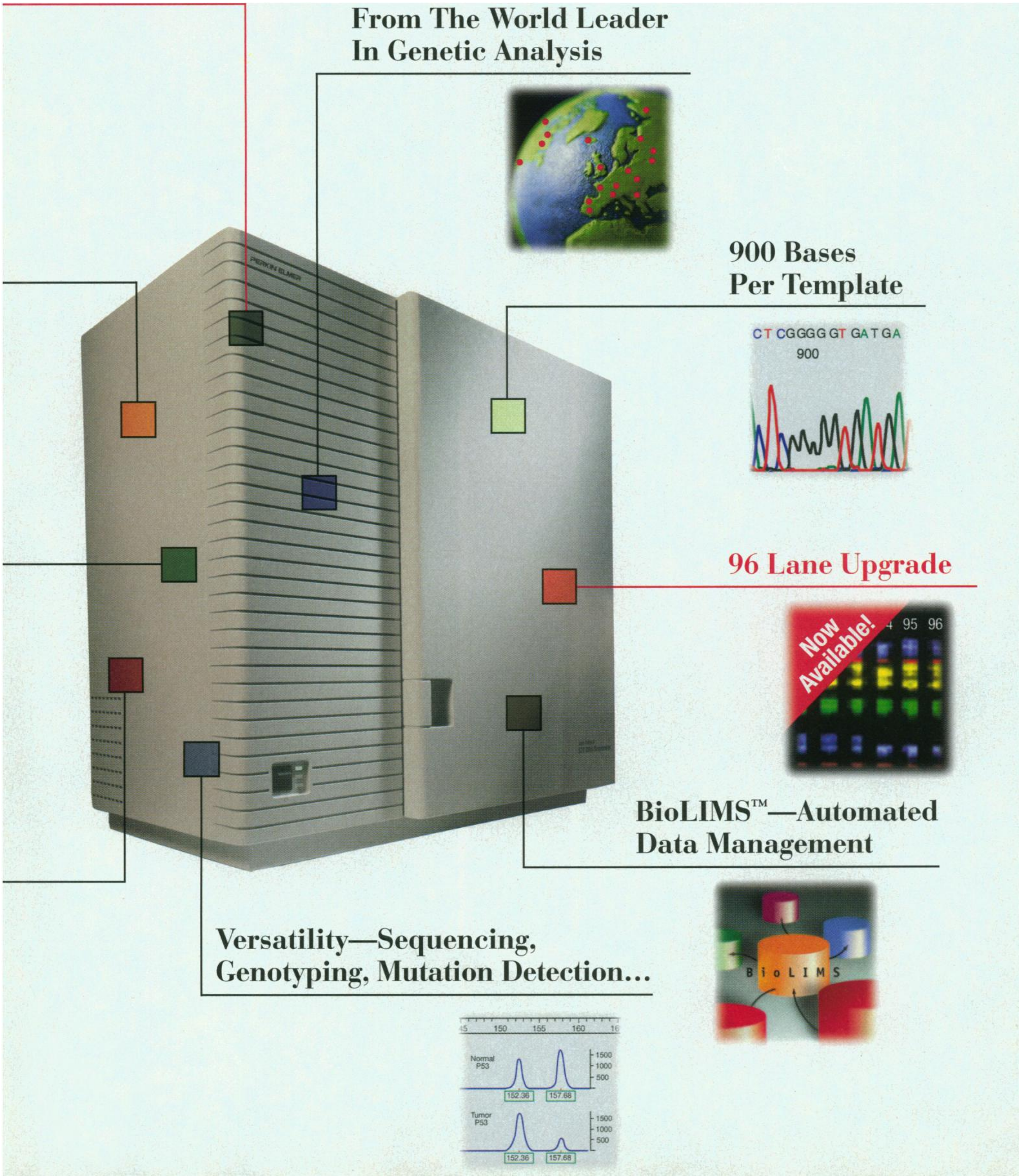

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