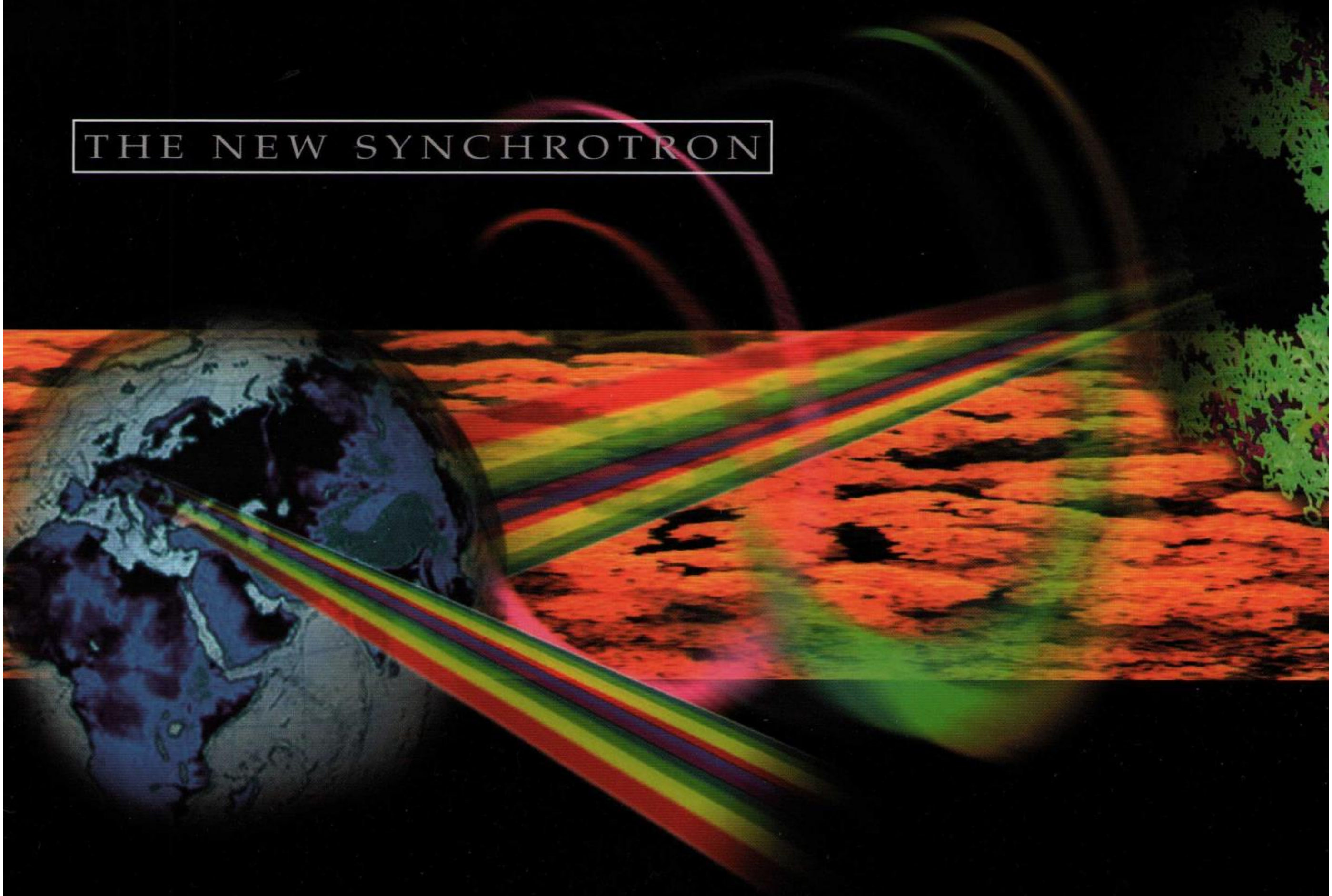
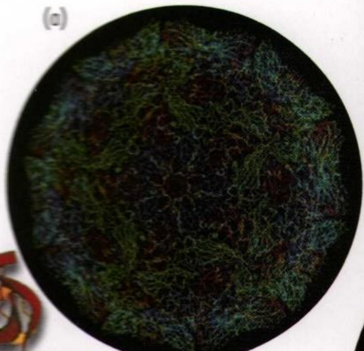
THE NEW SYNCHROTRON



A BRIGHTER LIGHT FOR A BRIGHTER FUTURE...

Complex protein structures such as (a) the foot and mouth virus, (b) the bacterial light harvesting complex and (c) the energy enzyme F_1ATPase have been solved at the SRS. The solution of the structure of F_1ATPase played a major part in the work for which the 1997 Nobel Prize in Chemistry was awarded.

(a)



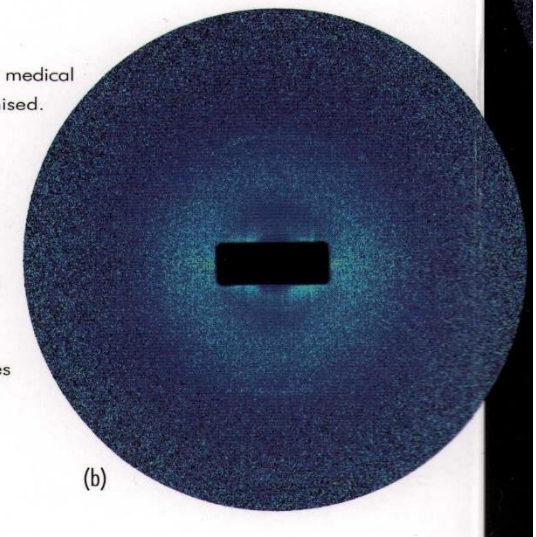
(c)

BIOLOGY AND MEDICINE

The push from the pharmaceutical industry for new drugs, and the various genome projects around the world are creating an enormous requirement for structural information. Powerful X-rays are instrumental in solving the atomic arrangements in highly complex biological molecules such as proteins and nucleic acids. The new synchrotron will produce a much higher flux of X-rays into small biological samples. Data that currently take a day to collect will be collected in a matter of minutes.

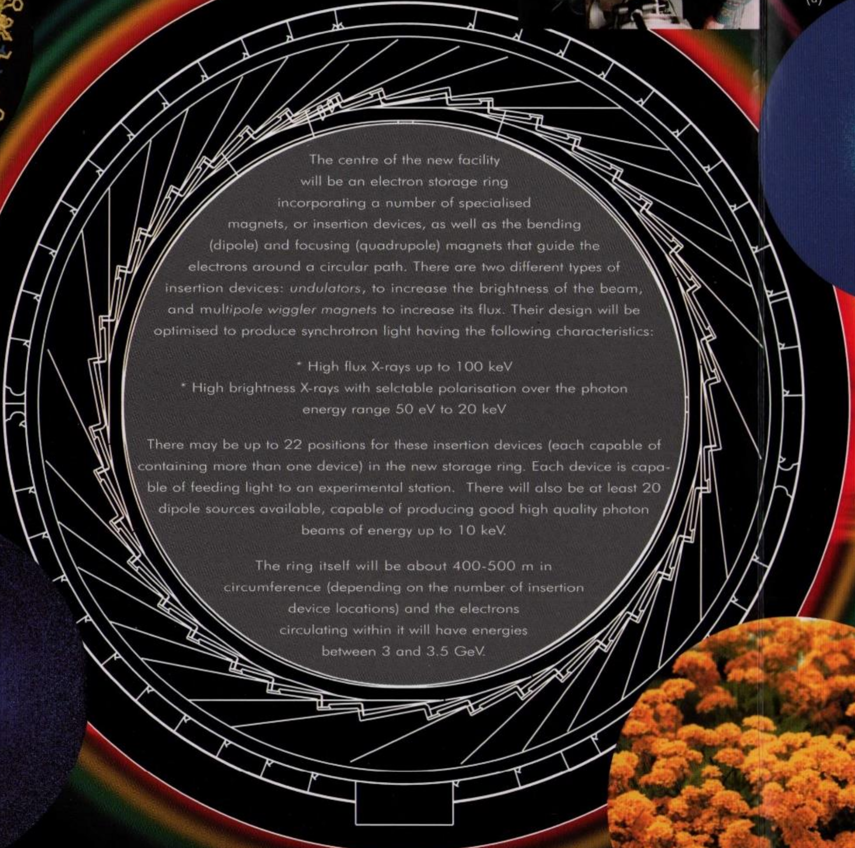
Not only can synchrotron light be used to determine the structure of these huge molecules, it can also reveal how they react to different environments on a sub-millisecond time scale. This is an essential requirement for correlating structure to biological function.

The potential for synchrotron light in medical diagnosis is only just being recognised. Significant advances in tissue imaging have been made in the past two years. Techniques incorporating synchrotron infrared and X-rays are now capable of detecting individual cancer cells in biopsy samples. The new synchrotron will significantly improve the quality of these images and shorten the time needed to collect them.



(b)

(b)



The centre of the new facility will be an electron storage ring incorporating a number of specialised magnets, or insertion devices, as well as the bending (dipole) and focusing (quadrupole) magnets that guide the electrons around a circular path. There are two different types of insertion devices: *undulators*, to increase the brightness of the beam, and multi*pole wiggler magnets* to increase its flux. Their design will be optimised to produce synchrotron light having the following characteristics:

* High flux X-rays up to 100 keV
* High brightness X-rays with selctable polarisation over the photon energy range 50 eV to 20 keV

There may be up to 22 positions for these insertion devices (each capable of containing more than one device) in the new storage ring. Each device is capable of feeding light to an experimental station. There will also be at least 20 dipole sources available, capable of producing good high quality photon beams of energy up to 10 keV.

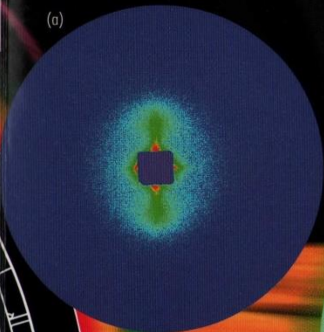
The ring itself will be about 400-500 m in circumference (depending on the number of insertion device locations) and the electrons circulating within it will have energies between 3 and 3.5 GeV.

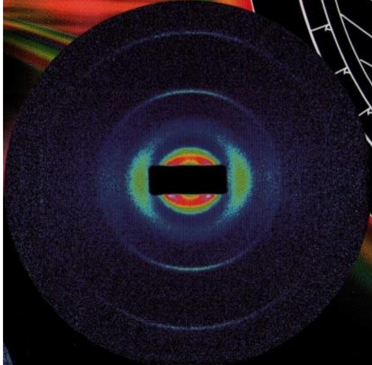
Simultaneously monitoring the small and wide angle scattering patterns from a polymer during the extrusion process has not only enabled scientists to optimise processing parameters to achieve the desired properties of the polymer film but has revealed the true mechanism by which polymers solidify.

(a) Small angle X-ray pattern of polypropylene close to the die head

(b) A wide angle diffraction pattern typical of polypropylene crystals formed further away from the die head.

(a)





(a)

Using a combination of X-ray diffraction and imaging techniques, scientists at the SRS are now capable of detecting the difference between healthy breast tissue, tumours and benign lesions. These are diffraction patterns from (a) healthy and
(b) malignant breast tissue. Effort is now focused on developing this technique so that tumours may be diagnosed with greater certainty.

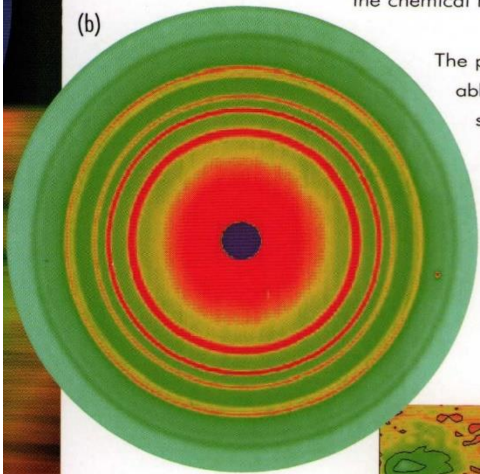
Alyssum lesbiacum, a plant native to the Greek island of Lesbos, can store large amount of nickel. Recent experiments at the SRS have enabled scientists to identify the soluble complex responsible for transporting nickel in this plant.

PHYSICAL AND CHEMICAL SCIENCES

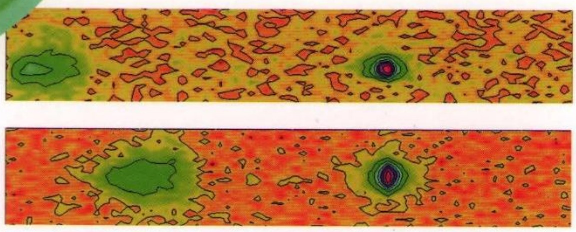
The strength of a plastic can vary enormously depending on the degree of alignment of its molecular chains. The new synchrotron will enable the factors that govern chain alignment to be studied in greater detail, leading to industrial processes that offer a improved control over the properties of the finished article.

In many industrial processes, control of a solid's internal structure is the key processing parameter, as it is this that governs the physical properties of the product. For catalysts, however, it is not just the internal structure that is important but also the surface structure. Catalysts are used in the manufacture of over 80% of world's industrial chemicals. They are designed to increase the yield and eliminate unwanted side products. Their success lies in the ability of molecules to stick onto their surface in the correct conformation for a reaction to take place. The high intensity X-rays from the new synchrotron will be able to determine the structure of both the catalysts and the active molecules as well as monitor the chemical reactions taking place.

(b)



The performance of electronic devices relies on being able to construct tiny transistors containing layers of semiconducting material, such as silicon and gallium arsenide, that are only a few atoms thick. Any defect in the atomic arrangement within these layers can seriously affect performance. Experiments using the high intensity X-rays available on the new synchrotron will highlight these defects.



In gallium arsenide, a substitutional defect, EL2, can occupy two distinct electronic states. Shining a light on the material causes it to move from one state to another inducing a lattice relaxation which can be monitored using high resolution X-ray diffraction. The signal to the gallium arsenide overlayer (left on the upper image) shifts closer to the gallium arsenide substrate peak when the sample is illuminated (lower image).

ENVIRONMENTAL AND EARTH SCIENCES

Synchrotron light is now being used to study a range of natural minerals, soils, plant and animal matter and the extent to which they have been affected by contaminants at the molecular level. Such investigations can clarify the source of contamination, the mechanism by which it was transported and the effect it has on its surroundings.

Perfluorocarbons are increasingly being used as replacements for the banned CFCs. Unfortunately, while their use helps minimise ozone depletion, they are in fact greenhouse gases and may contribute to global warming. Their removal from the atmosphere is controlled by vacuum ultraviolet photodissociation or photoionisation processes occurring in the mesosphere. Synchrotron light provides the perfect way to study these molecules, as well as many other atmospheric pollutants, in conditions they would encounter in the Earth's upper atmosphere. The new synchrotron will allow the chemistry of these molecules to be studied in much more detail and lead to more effective ways of conteracting pollution.

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THE LOCATION

The new synchrotron will be built at CLRC Rutherford Appleton Laboratory near Didcot in Oxfordshire to sit alongside CLRC's major neutron, muon, neutrino and laser research facilities.

The site is situated close to main motorway and rail networks and within easy reach of London Heathrow airport.

The new facility will enhance the appearance of the existing site, and will be a modern construction specifically designed to blend in with its countryside setting and the existing buildings on the site. The facility is quiet and clean in operation and, being a light source, presents no radiation impact. All in all, the new buildings will be a positive addition to the science campus at Chilton.

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