tion in humans, and have provided important insights into pathogenesis and possible strategies for vaccine and drug development. Analysis of immunogenetic associations with malaria has recently encouraged the development of cytotoxic T-lymphocyte-inducing vaccines against the liver stage of the malaria parasite[14], and has supported intervention studies targeting tumour necrosis factor in cerebral malaria[15]. Whatever the mechanism of protection by α^+-thalassaemia, the unexpected result of Williams *et al.* calls into question some of the assumptions regarding the natural history of the development of severe disease.

We have probably identified only a minority of the genes that influence resistance to malaria. Where the infection is a major cause of mortality, many genetic polymorphisms may be selected. What is needed is a broader approach to evaluate the entire human genome for factors that influence susceptibility or resistance to malaria. Methods for screening the genome for disease susceptibility and resistance genes in general are now well established. To apply them to malaria would require a huge investment in recruiting hundreds of multi-case families in areas where severe malaria is prevalent. But, judging by the lessons that this parasite and its resistance genes have taught us so far, that should be worth the effort. □

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OPTICAL MATERIALS

New stack system for records

Nasser Peyghambarian and Bernard Kippelen

FOR storing huge quantities of information, optical holographic recording is an attractive alternative to the more conventional magnetic technology. The main factor limiting large-scale manufacture of such systems is the lack of a low-cost and easily processed recording medium. With the development of photorefractive crystals, this technology gained some momentum, and, more recently, polymeric materials such as photorefractive polymers[1,2] have emerged that can be easily processed into large-area films at low cost. On page 505 of this issue[3], Berg and colleagues add a new, supramolecular candidate to the list of potential recording media for holographic storage: peptide oligomers.

In holographic storage, an image is recorded in an optically sensitive material as an interference pattern, formed by a laser beam bearing the image and a second reference beam (Fig. 1). The image can be retrieved by diffracting a reading beam off the pattern recorded in the medium. Because all the information is moving in and out in parallel, the access rate is high. Also, by using different wavelengths, polarizations and reference-beam angles, many images can be independently stored in the same volume of material, allowing storage densities of hundreds of gigabits cm^{-3}

The information is usually encoded by light-induced changes in the medium's refractive index. One elegant way to modify the refractive index of a material is to use rod-like molecules as dopants, and control their alignment with a laser beam. That can be done by using the conformational changes of azo dyes: the geometry of the molecule changes when excited by light, until eventually its axis lies perpendicular to the polarization of the light. This effect has been used to store holograms in polymers doped with azo dyes, and the same dyes have been used as molecular rotors to align liquid crystal films[4].

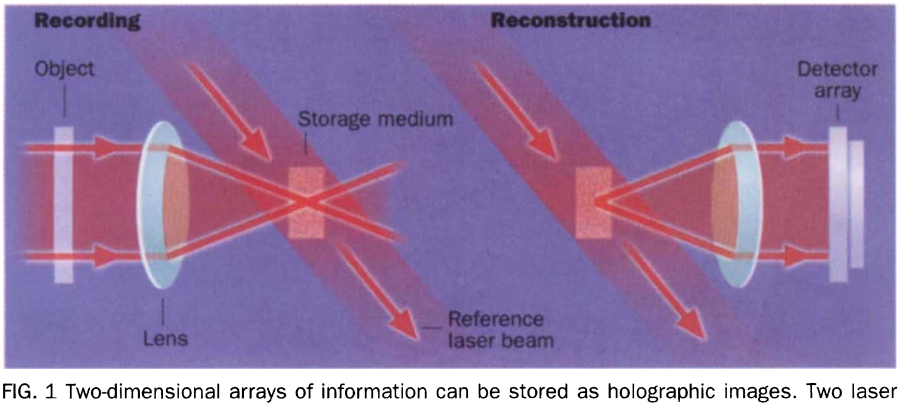

FIG. 1 Two-dimensional arrays of information can be stored as holographic images. Two laser beams are used, one a reference beam, and the other passing through the image to be stored. The beams interfere in the medium, and the pattern formed is optically encoded as variations in refractive index. Information stored in this way can be retrieved by diffracting a laser beam off the pattern, or erased by exposing the medium to a uniform light source.

But Berg *et al.*[3] add a new dimension to the tailoring of organic molecules for photonic applications. They show that by using supramolecular architectures from biology, the performance of such materials can be improved. By linking the functional molecules to a peptide-like backbone, they can impose helical stacking in a manner similar to that in DNA. The planar azo-benzene molecules orientate themselves until their planes are in a direction perpendicular to the light field, as they would do singly, but being coordinated by the backbone they cannot rotate around their long axis (see Fig. 2 on page 506). As a result, the asymmetry achieved in the film is higher than in traditional azo-dye doped polymers, resulting in higher refractive index changes, and consequently a higher storage capacity.

FIG. 2 Dennis Gabor, reconstructed from a 1-mm^2 peptide hologram. Gabor invented holography in 1948 (ref. 5).

At this stage, the practical implications of these new peptides in holographic memories are difficult to predict, as the recording time is still long (several seconds) and we don't know whether they can record information in the thick films (of the order of 1 mm) needed in order to achieve high storage density. They do have the advantage that no electric field is required to write or read the information as in photorefractive polymers.

The high potential of organic molecular materials for optics has been confirmed. Such supramolecular structures will surely produce breakthroughs in the future. □

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