the dentate gyrus induce dramatic changes in the expression of many neurotrophic factors[16]. The lesion-induced induction of key signalling molecules might represent the re-emergence of a programme that controls cortical development. To use this response to neuronal death in reconstructing functional neuronal circuits, we need to know much more about the sequence of signals that guide the migration, differentiation, integration and connections of neural progenitors.

These results raise the enticing possibility that the brain has a latent capacity for self-repair. However, the neurogenic response observed by Magavi *et al.*[1] was limited, and it is inconceivable that the small fraction of damaged neurons that appeared to be replaced by new neurons would allow significant functional recovery. We do not even know whether the new cells — even though they seemed to form appropriate connections — can take on the function of the cells they replace. There is a long way to go, but learning how to boost and guide neurogenesis from the stem-cell pool might eventually lead to a powerful tool for brain repair in human disorders of the central nervous system. ■

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Ecology

Shrimp-eat-shrimp

In 1683, the Ottoman Turks' advance up the Danube was turned back at Vienna. A contemporary crustacean invader, however, is having more success. Jaimie Dick and Dirk Platvoet have discovered that, in the freshwater ecosystems of the Netherlands, the native shrimp *Gammarus duebeni* is being wiped out by a menace from the east, *Dikerogammarus villosus* (*Proc. R. Soc. Lond. B* **267,** 977–983; 2000).

D. PLATVOET/J. DICK/I. EWART

This species is native to eastern Europe and the Ukraine. But *D. villosus* has spread to Western Europe through the Danube–Main canal (which opened in 1992) and appeared in the Netherlands about five years ago. Females, shown here on zebra mussels, are about 15 mm long, males being twice that size.

The alien's method of takeover is nothing if not direct — it eats the natives. In particular, male *D. villosus* consume female *G. duebeni*, which are smaller than males of the same species and less able to resist attack. The invader is especially destructive because it can feed on its prey between moults, when the exoskeleton is tough, and not just on soft-skinned, recently moulted shrimps.

In some places, *G. duebeni* has already been displaced by a fast-breeding North American species, *G. tigrinus*, which probably reached Europe in ship ballast-water. To an extent it could withstand this assault, because the two species prefer different habitats and salinities which helps to keep them apart. But *D. villosus* can tolerate a wide range of different conditions, and it is also thought to be responsible for the recent sharp declines in populations of *G. tigrinus*.

As it becomes ever easier for human beings to traverse the globe, exotic animals and plants will be introduced into new environments, both on purpose and as unseen hitchhikers. We face the prospect that ecosystems will become increasingly drab and homogeneous, dominated by a few super-competitive species. **John Whitfield**

Chemistry

Chirality, magnetism and light

Laurence D. Barron

A tortuous quest involving physicists, chemists and biologists that has endured for over 150 years has finally ended with a paper by Rikken and Raupach[1] on page 932 of this issue. They report the first unequivocal use of a static magnetic field to bias a chemical process in favour of one of two mirror-image products (left- or right-handed enantiomers). The chemistry of life is homochiral, being based almost exclusively on L-amino acids and D-sugars, and the ability of biological molecules to discriminate between enantiomers is vital for living systems. The importance of handedness in nature is such that scientists have long wondered about its origin, and the process demonstrated by Rikken and Raupach may provide a new clue.

The quest began in 1846 when Faraday made the plane of polarization of a linearly polarized light beam rotate by applying a magnetic field parallel to the beam. This discovery was of fundamental importance because it demonstrated conclusively the intimate connection between electromagnetism and light. But it also became a source of confusion to many scientists who failed to appreciate that there is a distinction between Faraday's magnetic optical rotation and the natural optical rotation discovered three decades earlier by Arago and Biot in certain crystals and fluids. Such natural optical activity is due to the handedness within the microstructure of the crystals and fluids, as Fresnel later showed.

The first to be misled was Pasteur, who in 1848 separated crystals of sodium ammonium tartrate into right- and left-handed forms, which gave equal and opposite natural optical rotations in solution. Following on from this epochal discovery, he attempted to induce handedness in crystals by growing them in a magnetic field[2], which he mistakenly thought, following Faraday's discovery, to be a source of handedness. But Lord Kelvin, who first introduced the word 'chirality' into science, was under no such misapprehension, and stated quite firmly that "the magnetic rotation has neither left-handed nor right-handed quality, that is to say, no chirality. This was perfectly understood by Faraday, and made clear in

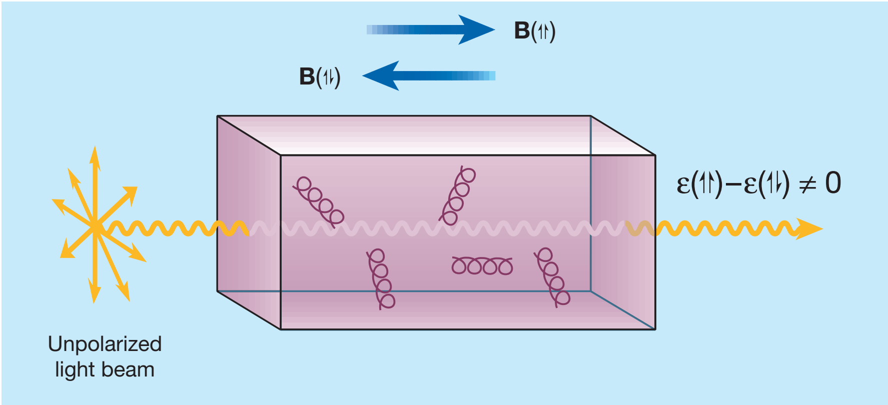

Figure 1 **Favouring a lopsided solution. An unpolarized light beam passes through a solution of resolved chiral molecules (represented by small helices) in a static magnetic field either parallel B(↑↑) or antiparallel B(↑↓) to the propagation direction. The absorption coefficients ε(↑↑) and ε(↑↓) are slightly different owing to magnetochiral dichroism. Rikken and Raupach[1] have now exploited this effect to favour the production of one enantiomer, making it a serious candidate for the source of handedness in nature.**

his writings, yet even to the present day we frequently find the chiral rotation and the magnetic rotation classed together in a manner against which Faraday's original description of his discovery of the magnetic polarization contains ample warning."[3] Lord Kelvin's admonition was largely ignored, and the next hundred years saw many other futile attempts to use magnetic fields to induce chirality in chemical processes[4,5], often motivated, like Pasteur's experiment, to find the source of homochirality in the molecules of life and perhaps even of life's origins.

A new twist to the story appeared in 1982. Wagnière and Meier[6] predicted that light would be absorbed slightly differently by a solution of chiral molecules if the light beam travelled parallel to an external magnetic field, than if it travelled antiparallel to the field. This small difference in absorption is completely independent of the polarization state of the light beam and so should work with unpolarized light (Fig. 1). This effect, subsequently christened 'magnetochiral dichroism'[7], depends on a subtle interplay of chiral and magnetic effects on the molecular optical properties, and was observed in 1997 at the Grenoble High Magnetic Field Laboratory by Rikken and Raupach[8].

Rikken and Raupach[1] have now used magnetochiral dichroism to favour the production of one enantiomer in a photochemical reaction. Their experiment uses the chiral Cr(III)tris-oxalato complex, which is unstable in solution and spontaneously dissociates and re-associates. So at equilibrium there are always equal concentrations of the right- and left-handed enantiomers. This dissociation is accelerated by the absorption of light. The authors show that, in the presence of an unpolarized laser beam travelling parallel to a static magnetic field, a small excess of one enantiomer is produced and maintained, and that, on reversing the magnetic field direction, an equal concentration of the mirror-image enantiomer results. Their experiment finally achieves Pasteur's aim, albeit in a more subtle fashion than originally conceived by the great scientist.

This work confirms the value of a new definition of chirality that goes beyond Lord Kelvin's original definition (based on mirror reflection) to include time reversal[4,5,9], so as to incorporate motion-dependent chirality. This definition provides a rigorous statement of the fundamental symmetry characteristics that external physical fields and forces must have in order to induce absolute enantioselection in all circumstances. Including situations where a chemical reaction has reached thermodynamic equilibrium. According to this new definition, a magnetochiral influence possesses 'true chirality' and so has the same status as circularly polarized light and the electroweak interaction in its ability to induce absolute enantioselection[4,5]. These are currently the most favoured explanations for the homochirality of life, and enantioselective photochemistry with circularly polarized light has already been observed experimentally.

On both experimental and theoretical grounds, we now have to seriously consider magnetochiral photochemistry in discussions of the possible origins of biological homochirality[10]. This is especially pertinent to fashionable theories suggesting that complex organic molecules could evolve in the ice mantles of dust grains in interstellar space[11], because magnetic fields and unpolarized light are more common in the cosmos than circularly polarized light. Furthermore, cosmic magnetic fields lead to partial orientation of the dust grains[12], which may enhance any associated enantioselective chemistry. ■

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Genetics

Reverse gear for *Drosophila*

Barry J. Dickson

These are exciting times for biologists studying the fruitfly *Drosophila melanogaster*. In March came the announcement that the DNA sequence of the fly's genome has been almost completely determined[1]. Now, also in *Science*, comes a paper from Rong and Golic[2] that gives *Drosophila* geneticists the tantalizing prospect of being able to change that DNA sequence almost at will. After nearly a century of classical 'forward' genetics, *Drosophila* now has the necessary gear for 'reverse' genetics as well.

Genetics seeks to bridge the gap between genotype and phenotype. Forward genetics asks which changes in genotype lead to a specific phenotype, while reverse genetics asks how the phenotype responds to specific changes in genotype. Reverse genetics has long been possible in organisms such as yeast and mice. In these systems, researchers can edit the genome specifically with the aid of linear DNA fragments prepared *in vitro*. These fragments contain the desired sequence changes, flanked by 'homologous' regions, which match the targeted genetic site. Once inside the cell, this exogenous DNA triggers the cellular machinery that normally repairs broken chromosomes or recombines them during meiosis (the formation of eggs and sperm). Directed by the regions of homology, the repair machinery 'recombines' the exogenous DNA into the corresponding chromosomal site. The effect of this sequence change on phenotype can then be assessed.

Why has it been possible to exploit this