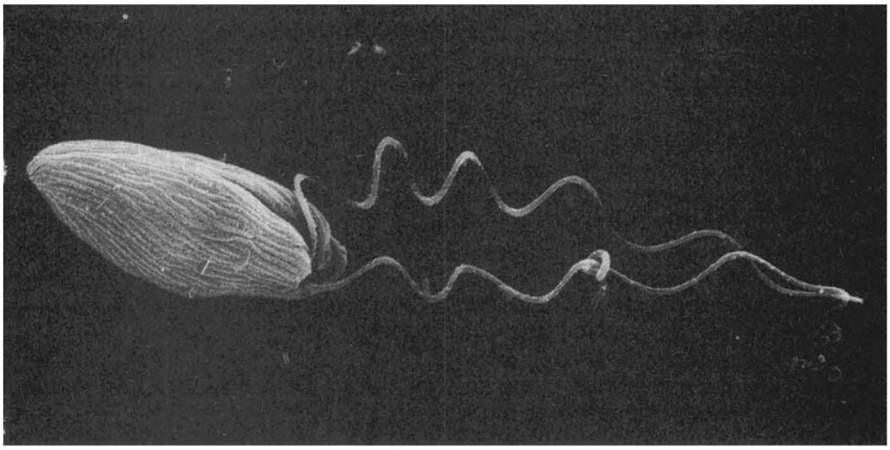

This unusual microorganism was recently found by Mr Harry Burton and Dr Ian Bayly in the course of an Australian Antarctic Division examination of a meromictic lake. These lakes have two well-defined liquid layers below the ice overlay; the top layer has a high oxygen content and low salinity, the lower layer has no oxygen but does have high concentrations of ammonia and hydrogen sulphide. The boundary between the layers is called the chemocline. The microorganism — currently known as Eric — is found only in the 30 cm of water directly below the chemoline. To go with this habitat, it has an unusual lifestyle; its outer surface is covered with bacteria, which appear to cling together with 'wing-like' structures. The bacteria have not been found separately. The little that is known about Eric is reported in *Science News, Fiji;* the Australian team are at present trying to breed from him.

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forces binding quarks together". These speculations that even quarks and leptons may be composite systems can be avoided by assuming that all hadron structure physics is described by QCD just as all condensed matter physics is described by QED. But no one knows how to calculate the properties of a type II superconductor from first principles with QED; similarly there is no clear recipe for the application of QCD to the description of hadron structure and the prediction of experimental results. In both cases the systems and the dynamical equations are too complicated. Theorists use QCD hand-waving arguments to pick a principal or 'leading' contribution for calculating experimental predictions. If a prediction agrees with experiment, they are happy and write a paper. If it disagrees with experiment, they write a paper anyway, and blame the disagreement on nonleading effects. If there are no experimental results available, they publish their result as a QCD prediction. If subsequent experiments disagree with this prediction, experimenters often claim that their results disagree with QCD, rather than with a particular choice of a leading term.

Experiments in the 1970s which scattered high-energy electrons from protons showed that at high momentum transfers the proton behaves like an assembly of free quarks with very weak interactions, even though the interactions between quarks are very strong at low energies. The fact that these interactions become much weaker at high energies has been given the name asymptotic freedom and shown to be predicted by QCD. QCD arguments suggest that experiments at sufficiently high energies can be treated with the use of the leading terms in an expansion called perturbative QCD, because the interaction has become weak enough to be treated by the same perturbation techniques used in QED. But no one has a convincing prescription for where high enough energies begin, and there is a running controversy on this point between different groups of theorists.

The recent polarization experiments are not explained by treatments using any of the obvious leading terms. The first experiments showing nontrivial spin effects motivated new calculations of polarization effects based on perturbative QCD suggesting that these experiments can give useful information after all about hadron structure and QCD dynamics. The simplest leading term predicted that the probability for proton–proton scattering by 90° should be twice as large if the spins of the protons in the beam and in the target were parallel than if they were antiparallel[12,13].

Theorists were delighted when new experiments approached just this factor of two[3] and seemed to level off there, but further experiments at higher energies showed a continued increase to factors as large as four[4]. New models arose, all paying lip-service to QCD, but with different leading terms. The latest result[1] further confuses the theorists by giving the same value for the scattering of protons with parallel and antiparallel spins, implying a sudden disappearance of the large difference which had risen to a factor of four at somewhat lower energies. There are also other experiments showing further disagreements with theory. Single-helicity-flip transitions were observed in 28-GeV proton–proton scattering at high transverse momentum[5], whereas the quark-exchange mechanism with helicity conservation at the quark level cannot produce a single helicity flip. An additional unexpected polarization effect was seen when ρ mesons were produced in collisions between pions and protons[14]. Strange particles producted in proton–proton collisions have long been known to be strongly polarized for reasons still not understood.

All these experiments suggest that there are interesting physics in these spin effects that are not understood in the simple leading terms and which may give clues to the underlying hadron structure and QCD dynamics. It is still an open question whether further experiments and analysis can reveal the relevant nonleading effects and lead to a better understanding. At present the only viable approach seems to be to continue the search for new clues in the data and try to find signals in the noise.

The basic physics and the essential complications of applying QCD to high-energy scattering can be seen by considering a colliding beam experiment in which two proton beams collide, one coming from the left and one coming from the right, and two proton detectors look for protons scattered at an angle of 90° with respect to the incident beams, one scattered upward, say, and one scattered downward. Because each proton consists of three quarks, the collision process begins with three quarks coming in from the left and three from the right, and it ends with three quarks going upward and three going downward. A theory based on QCD must explain how these six quarks get the appropriate kicks to turn their directions of motion by 90°.

There are several possible scenarios (see figure). The direct scattering scenario has all three quarks that came in from the left going out upward, and all three quarks that came in from the right going downward, or vice versa. The exchange scenario has two of the quarks that came in from the left going out upward and one going downward, and two of the quarks that came in from the right going downward and one going upward or vice versa. In the direct scenario, each of the three quarks coming from the left must have its momentum turned by 90° by exchanging one or more gluons with quarks coming in from the right. The exchange scenario makes use of the complicated internal motion of the quarks inside each proton. At the instant before the collision, there is a certain probability that this internal motion inside the proton coming in from the left will already have two of the three quarks moving upward and one moving downward, and that the proton coming in from the right will already have two of the three quarks moving downward and one moving upward. In this case it will be