will be possible to compute quantities such as I_p from first principles in QCD.

One interesting implication of these results concerns attempts to detect cold dark matter (J. Ellis, R.A. Flores and S. Ritz, CERN preprint), essential to some theories of cosmology. Among the candidates for cold dark matter are the massive, weakly-interacting, neutral particles predicted in supersymmetric theories, in particular the photino. It is hoped to detect these particles either directly in the laboratory, by observing their scattering off matter, or indirectly by observing the neutrinos which emerge when these particles annihilate in the Sun. Predictions of the detection rates for these particles will have to be revised because of the EMC results. The rate for photino–proton scattering, for example, is proportional to the square of I_p, and hence is reduced by a factor of about 3.

The EMC measurements are the latest in a series of unexpected results in spin physics. They are perhaps simpler than the previous ones to interpret, in that they involve the wavefunction of only one proton. The results all indicate that our intuitive picture of the origin of the proton's spin, based on the non-relativistic quark model, is wrong. This leaves the following fundamental question: if the quarks carry very little of the proton's spin, then what is the origin of the proton's spin? Does it arise from the orbital angular momenta of the proton's constituents or from the spins of the gluons? □

C. T. Sachrajda is in the Department of Physics, Southampton University, Southampton SO9 5NH, UK.

Vertebrate palaeontology

In search of earliest tetrapods

Alec L. Panchen

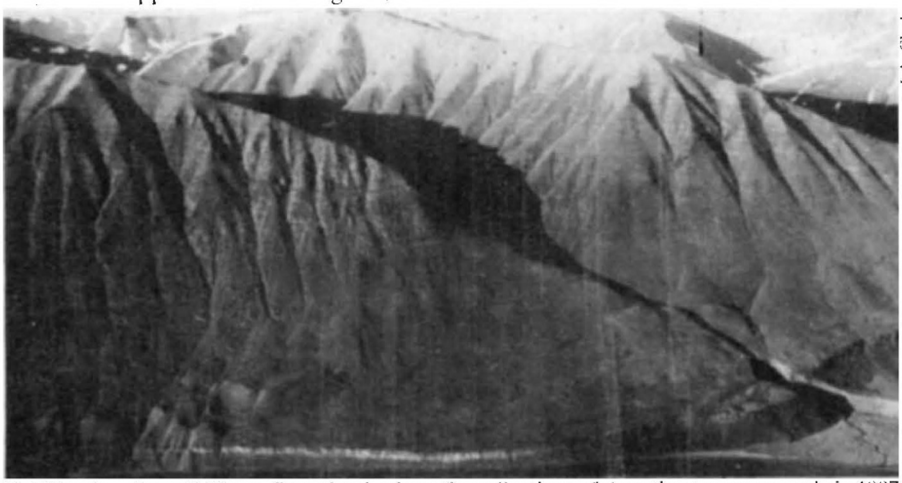
In that period of the Carboniferous which corresponds to the British Coal Measures, there was enormous radiation of land vertebrates, tetrapods, which include the earliest recorded reptiles and even the earliest mammal-like reptiles. But in the period of the Carboniferous before the Coal Measures, roughly corresponding to the Mississippian of North America, and even more in the preceding Devonian period, tetrapod fossils come from very few localities, are rare as specimens and frequently poorly preserved. Two new papers add significantly to our knowledge of the anatomy and distribution of these earliest land vertebrates. On page 768 of this issue[1], Bolt and colleagues describe a new vertebrate locality from Iowa which contains many well-preserved fish and tetrapod fossils. This is the earliest productive tetrapod site in continental North America. In the second paper[2], Clack adds to our knowledge of one of the two principal tetrapod genera from the Devonian of Greenland, preliminary to her successful visit to the localities.

The new site described by Bolt *et al.* is important for three reasons — its early date, its geological location and the nature of its fossils. Before its discovery, tetrapods of Mississippian age were known from three principal areas: the environs of Edinburgh; Nova Scotia; and northern West Virginia and the adjoining part of Pennsylvania[3]. There are Coal Measures sites in Illinois, but the Iowa find is the first Mississippian site to be reported from mid-continental North America and the furthest west yet discovered. It is definitely Lower Carboniferous in date, being of middle Viséan age, and thus corresponds to a horizon in the Edinburgh Oil Shale Group from which the earliest recorded Scottish tetrapods came.

One of the tetrapod fossils from Iowa is a member of the family Colosteidae, whose members are also known from the Edinburgh Oil Shales and above, from the later Mississippian of West Virginia, and from the Coal Measures of Ohio[4]. The other principal tetrapod find represents a new taxon of very considerable interest. Bolt *et al.* refer to it as a 'proto-anthracosaur' and, rightly in my opinion, believe it to be closely related to, but not a member of, the Anthracosauria. The anthracosaurs are a group of primitive tetrapods, ranging in time from the Oil Shales to the early Permian and are thought by some to be closely related to amniotes (reptiles, birds and mammals). The proto-anthracosaur has some of the diagnostic features of the group, but it is primitive in the configuration of the bones of the skull table and in having possibly the most primitive type of tetrapod vertebra. It joins the controversial *Crassigyrinus* from the Scottish localities in showing that anthracosaur characters can co-exist in one animal with extremely primitive features[5].

Clack[2] gives an account of much earlier tetrapods. The material was collected in 1970 by Peter Friend and colleagues from Cambridge while they were exploring the stratigraphic geology of the area in which lie the classic East Greenland Late Devonian tetrapod sites (see figure). The commonest tetrapod from these sites is *Ichthyostega*, but Clack's new account is of three closely associated skulls of *Acanthostega*, known previously from only two incomplete skull roofs. The new specimens yield data on the braincase (typically tetrapod), lower jaw and shoulder girdle. Clack has just made a successful visit to East Greenland and collected about three-quarters of a tonne of Devonian tetrapod specimens.

The expedition on which Clack collected her data[6] was supported by the Greenland Geological Survey. It was an Anglo–Danish initiative led by Svend Bendix-Almgreen (Copenhagen), accompanied by Birger Jorgensen (Copenhagen), Jenny and Rob Clack and Per Ahlberg (Cambridge). The specimens collected seem to be mostly *Acanthostega*, but include *Ichthyostega*, which will supplement data from specimens already in Stockholm[7]. The new material will be described in Cambridge and important specimens then returned to Copenhagen. The material from East Greenland is the only substantial collection of these earliest land vertebrates. □


J.A. Clack

Uphill task — Stensiö Bjerg, Greenland, where the collections of *Acanthostega* were made in 1987.

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Alec L. Panchen is Reader in Vertebrate Zoology in the Department of Biology, University of Newcastle upon Tyne, Newcastle Upon Tyne NE1 7RU, UK.