1
A much misunderstood man

Georges Cuvier was, in the estimation of Stephen Gould '. . . perhaps the finest intellect in nineteenth century science . . .' (1987, p. 113). He has also been called (by Jane Gregory 1988) 'an unsung champion of science'. Certainly he has always been a hero of mine, so much so that he became a joke in my department (at the University College of Wales, Swansea) and one year my colleague who managed our examinations inserted in the rubric at the beginning of the last paper (which consisted of 100 short questions): 'The answer to one of these questions is Baron Cuvier'.

Cuvier was a remarkable man. He was the 'father' of vertebrate palaeontology, he began the study of comparative anatomy and of functional morphology (that is to say he recognized the close relationship between the detailed anatomy of an animal and its mode of life). He was the first man to observe clearly that species became extinct and, in my opinion, he was the first man to understand the geological record as it really is. After many violent and, one might say, catastrophic changes in the history of France at the end of the eighteenth and beginning of the nineteenth centuries, he became a baron and nearly became president of the republic. He also earned himself a statue outside the Museum of Mankind in London. Yet he became a figure of fun among geologists and was falsely blamed for all the ridiculous excesses of nineteenth century 'catastrophism'.

By all accounts he was a rather dull man, but with much effort and practice he became a brilliant lecturer and writer. After the French Revolution he was one of a team given the task of reorganizing French science. He was successful (as all eminent scientists need to be) in persuading his government to provide funds for research rather than for arms and he was personally responsible for encouraging a great public interest in natural history.

Unfortunately he does not appear to have been a very nice man; thus he poked fun at Lamarck's blindness and at the same time rejected the latter's pioneering ideas about evolution. His reasons for opposing the concept of evolution were simple. Thus he could not see how the giant ground-sloths of the Pleistocene could have given rise to the much

smaller sloths of today. Similarly, the many mammalian fossils he excavated from the Early Tertiary deposits of the Paris Basin (including the gypsiferrous beds that were used to make 'Plaster of Paris') could not, at that time, be seen as possible ancestors of living forms. He could see how they functioned, whether they were carnivores or herbivores, browsers or grazers, swimmers or runners, but he could not connect them, through the great gap of later Tertiary times, with the animals of today. He did not know about the faunas of the 25 million or more years that separated his Palaeogene forms from those already known in the Pleistocene. He described some 300 new species. Many of his battles on behalf of science are sickeningly familiar to us in Britain today. Thus he reminded the authorities of the value of museums and exhibitions which 'speak ceaselessly to the eye, and inspire a taste for science in young people'. He campaigned continuously for the education of the young in science and, although his own research might be regarded as purely academic, he understood that science could be useful to the people and the state. He wrote 'The present era will be reproached if we do not conserve for the future these sources of so many advantages'. Those same arguments are very familiar to many of us today, and yet so little heeded by the government, even when the previous prime minister was herself said to be a scientist!

Nevertheless, in spite of his obvious brilliance and foresightedness, Cuvier became the 'villain of the piece' to most geologists, for proclaiming the 'old-fashioned' ideas of catastrophism in conflict with the 'modern' ideas of uniformitarianism, championed by the 'real scientist' Charles Lyell. But both great men, interpreted in this way, are what Gould rightly calls 'cardboard figures'.

Lyell was a great theorizer. He looked at the modern world and the physical processes that were affecting it. He then deduced that they had functioned in the same way in the geological past. He was what has been called a 'substantive uniformitarian', that is to say that he presumed that these processes had always operated in the same way and at the same rates as they do today. After the publication of the second volume of his great *Principles of Geology*, G. P. Scrope (who had studied the volcanoes of central France) wrote in 1832 to congratulate him in the following terms: 'It is a great treat to have taught our section-hunting quarry men that two thick volumes may be written on geology without once using the word "stratum"'. That sounds to me suspiciously like 'my mind is made up, don't confuse me with facts!' That could never be said of Cuvier or that much humbler man William Smith in England. They were great pragmatists and were wholly concerned with strata and what they contained. It was said of Smith, who first demonstated the succession of strata and their fossils along the sides of his canals and in mines, that he had 'opened the book of earth history'.

Cuvier studied the stratigraphical succession in the Paris Basin and

recorded stratum by stratum what he saw. In 1822, together with another palaeontologist Brongniart (who described the fossil plants), Cuvier carefully recorded many sections in the Eocene and Oligocene strata around Paris. He did not go in for grand theories about earth history, he simply placed on record what he saw. He saw repeated changes in environment and repeated changes in the faunas in the quarries around Paris. He saw freshwater limestones and marine sands, he saw shell-banks and beds without fossils. There were terrestrial deposits too, of course, such as are seen in the huge quarry at Cormeilles near Paris, with the land mammals that he studied so carefully, and there is the famous *Calcaire grossier*, packed with exotic-looking shells and well seen in the walls along the Seine in the French capital. Cuvier's general section for the Eocene of the Paris Basin is shown in Figure 1.1. This may be translated (from the top down) as follows:

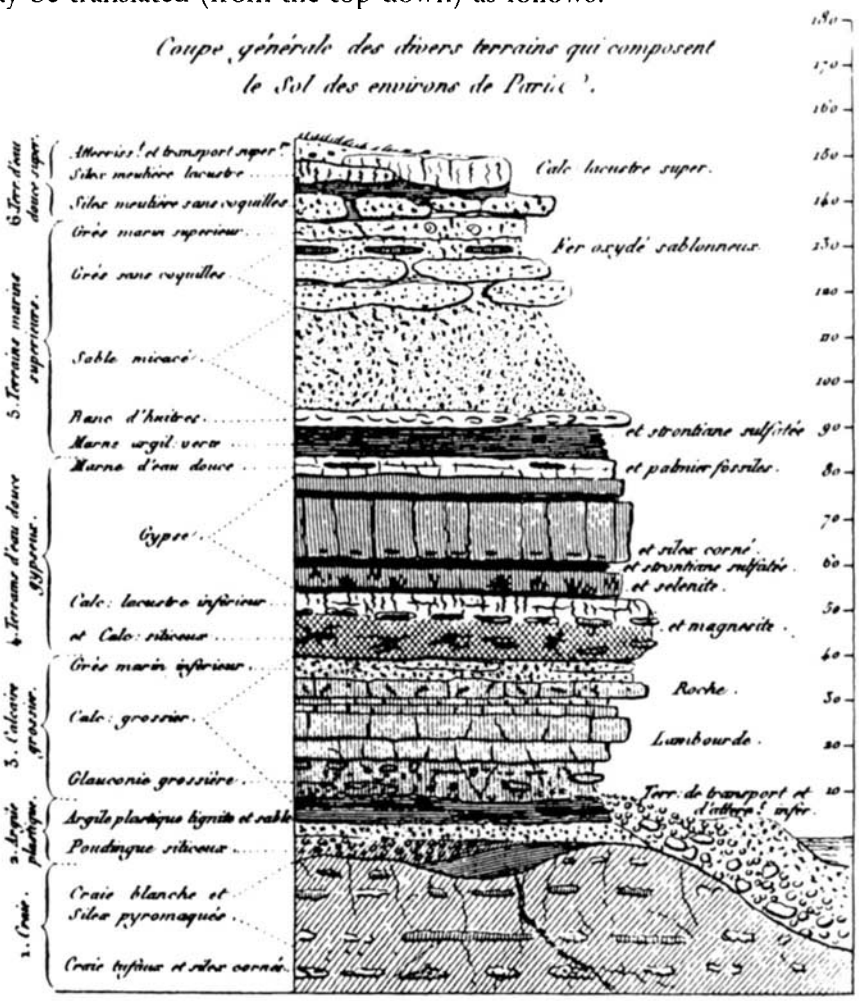

Figure 1.1 General succession in the Paris Basin (France) from Cuvier & Brongniart (1822). Translation in text.

General section of the various beds which form the ground beneath the surroundings of Paris

6. Upper freshwater beds	
Upper lacustrine limestone	
Upper residual and transported material	
Ground lacustrine flint	
Ground flint without shells	
5. Upper marine beds	
Upper marine sandstone	Sandy iron oxide
Sandstone without shells	
Micaceous sands	
Bed of oysters	
Green marly clay	With strontium sulphate
4. Gypsiferous freshwater beds	
Freshwater marl	With fossil palms
Gypsum	With 'horned' flints, strontium sulphate and selenite
Lower lacustrine limestone and siliceous limestone	
3. *Calcaire grossier* (literally common or thick limestone)	
Lower marine sandstone	
Calcaire grossier s.s.	Rock
	Soft, chalky stone
Coarse glauconite	Lower transported and detrital bed
2. Sandy, lignitic plastic clay	
Siliceous conglomerate	
1. Chalk	
White chalk with flints	
Lower chalk with 'horned' flints*	

This seems to me a remarkably detailed work for its time and shows real appreciation of the different environments involved. This is how the stratigraphical record usually is, in my experience, with frequent changes of environments, lithologies and fossils especially, as here, in shallow water and terrestrial deposits.

As Cuvier himself said 'Life on earth has been frequently interrupted by frightful events. Innumerable organisms have been the victims of such catastrophes. Invading waters have swallowed up the inhabitants of dry land. Their species have vanished for ever.' (quoted by Wendt, 1970). Of course, Catholic France put its trust in the church, rather than in the bible and did not go through the agonies of Protestant Britain in relating

* this would not be the 'Lower chalk' as generally understood in Europe (i.e. Cenomanian in age and usually lacking flints).

geological discoveries and evolution to what was regarded as the absolute truth as recorded in holy writ. So much for the false linking of Cuvier with the biblical fundamentalists. He also argued (1827) that geological changes were sudden and that the present continents were in a geological sense very new. Of particular interest is his description of the pillars which form my frontispiece, many years before they were described by Lyell: 'the example of the Temple of Serapis, near Pouzzola [sic] proves that the margins of the sea are, in many places, of such a nature as to be subject to local risings and fallings'. He went on to point out that many other Roman quays, roads etc., from Alexandria to Belgium, were not affected. This was simply because they were not affected by local volcanicity, as was (and is) the Naples area.

When he used the word 'catastrophe', for which he has been so much blamed, he was thinking (as I am) of the repeated comings and goings of the sea, which were not always 'plus ou moins graduelle' (more or less gradual) and could be very general. The land animals obviously perished when their land was flooded. He commented on the remains of land animals and plants in beds which have long disappeared 'au milieu des couches marines' (in the middle of marine beds). He did note, however, that 'lorsque la mer a quitté nos continents pour la dernière fois, ses habitans ne différaient pas beaucoup de ceux qu'elle alimente encore aujourd'hui' (when the sea finally left our continents for the last time, their inhabitants did not differ very much from those which they still support today). So, though he did not accept Lamarckism, one can only wonder what his reaction would have been to Darwin. Unfortunately he died in 1832, just 27 years before the publication of *The Origin of Species*.

2

Magnolias and marigolds; hippos and hiatuses

Magnolias and marigolds

This will be a somewhat paradoxical chapter about what is not there. It will be concerned with preservational potential, that is to say the gamble of whether fossils and rocks are preserved for the geologist of tomorrow.

A magnolia is more likely to be preserved than a marigold, an oak tree than a daisy. This is simply because the magnolia and the oak tree are woody plants, whilst the marigold and the daisy are soft and herbaceous. Is this the only reason for the woody flowering plants having a much longer fossil record than the herbaceous sort? Is this all that lies behind the botanical theory that the woody angiosperms were ancestral to the humbler genera? The most successful flowering plants today are probably the Compositae (the daisy family, including the marigold) and the Umbelliferae (the parsley family). In fact I sometimes think that it is not the triffids (of John Wyndham's science fiction novel) which are taking over the Earth. It is the umbellifers and the sycamores. But I speak from the view-point of a Briton who has seen the beautiful flowery hedgerows of his childhood disappear under the bureaucratic 'weed' killers which seem to favour the boring umbellifers, sycamores and brambles.

I have a private theory that many of the ancient plants that have survived to today are those with a built-in resistance to dangers that affect their later, weaker brethren. Thus while cow-parsley (*Chaerophyllum sylvestre*) seems to be taking over on British road-sides, the member of the ancient fern family, known as bracken (*Pteris aquilina*) with its deep, strong roots, is taking over the moors from the heather (*Erica cinerea*) and its relations, especially after frequent heath fires. Another ancient plant which is clearly able to survive severe burning is the giant redwood (*Sequoiadendron giganteum*, often called *Wellingtonia* in Britain and *Washingtonia* in the States!) Ancient fires in what is now Yosemite National Park have in places burned these trees, often thousands of years old, right through, allowing people and cars to pass right through the blackened arches left in the still very much alive trees. So

TOWN-HALL, NEATH,

(By Permission of the Worshipful the Mayor,)

On Thursday, Friday and Saturday,

JANUARY 30TH and 31ST, and FEBRUARY 1ST, 1851, will be Exhibited an extraordinary Specimen of

THE WONDERS OF NATURE,

Found on Friday, January 17, 1851, Embedded in a Coal Vein at the Kimle, on the Gnall Estate, near Neath.

It has been inspected by several Gentlemen of great Geological Acquirements, who have not succeeded in arriving at a satisfactory conclusion as to its identity with any of the Fossil Inhabitants of by-gone worlds; but do not hesitate, from the perfect state of the Scales with which it is covered, and the natural coil or twist in the Trunk or Body, to pronounce it a

FOSSIL SERPENT!

It measures 8 feet 3 inches long and 7 inches across, and must have been when alive, (some thousands of years since,) a Reptile of immense strength.

GEOLOGISTS, NATURAL HISTORIANS, and the PUBLIC generally, will find this a most interesting Exhibition.

Admission:---Ladies and Gentlemen, 1s. each; Tradesmen, 6d.; Working Classes, 3d. Open from 11 o'clock in the Morning until 1, & from 2 until 10 o'clock in the Evening.

T. THOMAS, PRINTER AND STATIONER, NEW-STREET, NEATH.

Figure 2.1 Poster displayed in Neath (South Wales) in 1851. The 'serpent' was in fact a *Stigmaria* root, such roots are commonly preserved in the local Upper Carboniferous Coal Measures. Note the prices of admission, which reflect the class consciousness of the time.

far as daisies are concerned, I was surprised to see none in Japan, where the children make chains of clover instead. So geographical distribution comes into it too.

It is not, however, only the sturdy trees and resistant ferns that have survived from ancient times. Certainly the Articulatales have a record going back to massive trees such as *Calamites* in Late Palaeozoic times, but they were already reduced to low marsh-living plants such as *Equisitites* in the Mesozoic and the modern 'horse-tails' (*Equisetum*) look far from sturdy in their usually damp habitats. They are only too easy to pull apart at their nodes, as I find when I try to pull them up in my garden. I well remember, however, returning home after my usual long (working) vacation travels in 1976, following an exceptionally dry summer (even in Wales!) to find my lawns as well as my flower-beds covered with horse-tails. Their secret, of course, like the ferns, lies in their extensive, creeping root-stock, which reminds one of *Stigmaria*, the roots of *Calamites*, which are probably the most common plant fossils in our Upper Carboniferous 'Coal Measures'.

In the middle of the last century a large *Stigmaria* was put on show in Neath, near Swansea, and called a 'Fossil Serpent' (Figure 2.1). Particularly fascinating are the charges for admission: one shilling (five new pence) for ladies and gentlemen, six pence (2½ new pence) for tradesmen and three pence (1¼ new pence) for the working classes. It does not make clear how they were distinguished in those class conscious days. Presumably the gentlemen wore top hats, the workers wore cloth caps and, in my first theory, I thought perhaps the tradesmen wore bowlers, but further research revealed that the bowler had only been invented two years before and I doubt if it had reached Neath by 1851. Fortunately those days are long past. Of course stigmarian roots, buried in the soil, stood a much better chance of preservation than 'serpents', presumably writhing about on the surface. Incidentally it has recently been pointed out by Alan Batten (in *New Scientist*) that since living 'serpents' have rudimentary legs, God's verdict on the serpent in Genesis that 'upon thy belly shalt thou go' indicates an early recognition of evolution.

Closely related to the evolution of land tetrapods is that of grass, probably the most successful group of organisms on Earth at the present day. It positively thrives on being eaten or cut. I like to remember the recipe for the perfect English lawn. One prepares the ground, one plants the seed and then one cuts it every week for 300 years. Such an organism was obviously bound to succeed, though in my own lawns there is strong competition from the Compositae, notably the common daisy (*Bellis perennis*) and the dandelion (*Taraxacum officinale*), together with what is probably a much more ancient stock, the mosses. One presumes its antiquity from the organization of the plant, not from its fossil record, which is virtually non-existent (which is hardly surprising in view of its tender form). The so-called 'club mosses', the lycopods, are very well

known from the Late Palaeozoic simply because they then took the form of large forest trees. None of these modern forms, such as daisies and grass has much in the way of a fossil record, probably simply because of their non-preservability and the 'club mosses' are reduced to insignificance. I shall discuss the grasses again later (in Chapter 13), but I might mention here that their record probably goes back to the Cretaceous. It seems that they are chiefly known in the older rocks by their woody members, the bamboos, which obviously had a better chance of survival than the seemingly fragile forms on which we walk.

One important aspect of the problem of preservation or non-preservation is what is called the study of taphonomy. This is, strictly speaking, the study of burial, from the Greak word ταφος (taphos) – a tomb (as in cenotaph = empty tomb). So we must always consider the way our fossils are buried, whether they had been transported after death and whether they had changed or disappeared as the result of burial. This makes it all the more likely that the exhibit at Neath (Figure 2.1) was a root and not a reptile. I have noted the selectivity of preservation, even among single groups such as the molluscs, in the Pliocene and Pleistocene shelly sands or 'crags' of eastern England (where I found my first fossil when digging a slit trench in the expectation of an invasion in the Second World War). Some of the many molluscs there (such as my first, still cared-for *Aequipecten opercularis*) have clearly survived fossilization better than others and some fossils have been derived from elsewhere (such as rare Mesozoic brachiopods which occasionally turn up in the same deposits and which I am sent to identify). It is well known that gastropods, nearly all with aragonitic shells, are much less likely to be preserved than other fossils with calcitic shells.

I always think of the first grave-digger in *Hamlet* as a pioneer taphonomist who recorded his observations. His scientific communication to the prince was to the effect that a human corpse, if it were not rotten before he died would last eight years in the earth before it rotted or nine years in the case of a tanner whose 'hide is so tanned with his trade, that he will keep out water a great while'. In the case of poor Yorick, who had been in the ground 23 years, only the skull was recorded so we may presume selective preservation even within a single specimen. So fossilization is a highly discriminating process and I may turn now to the second part of the title of this chapter: 'hippos and hiatuses'.

Hippos and hiatuses

I once met a charming lady who turned out to be a world authority on fossil hippopotamuses (or hippopotami – before the reader criticizes me, I must record that both plurals are permissible). In my usual frivolous way I made a facetious remark about the likelihood of the average geologist finding such things. I was surprised to be told that they and their

predecessors, the anthracotheres, are in fact very common so far as vertebrate fossils are concerned. In fact they are so common that many vertebrate palaeontologists almost kick them aside as many specialists in fossil invertebrates tend to disregard oysters. Then it suddenly struck me that, though I have no pretensions to be a vertebrate palaeontologist, I had actually found two myself, one in the Oligocene of the Isle of Wight in southern England, and one in the Miocene of eastern Libya.

Then I suddenly remembered that famous hippo song of Flanders and Swann about 'Mud, mud glorious mud' in which the hippos delighted as their favourite habitat. I also remembered T. S. Eliot's lines:

The broad-backed hippopotamus
Rests on his belly in the mud;

obviously therefore their preservational potential is high. They simply ask to be fossilized. They have only to die to sink into their beloved mud and to await the palaeontologist of the future.

My hero, Georges Cuvier (see Chapter 1) commented on the abundance of fossil hippos. Thus in his research on fossil bones (1820, p. 313) he wrote (my translation): 'On my first journey in Tuscany, in 1809 and 1810, I found, either in the collection at Florence or in that of the Academy of the valley of Arno at Figline, such an abundance of fossil bones of hippopotami . . . a considerable quantity I have bought from the homes of peasants.' He went on to compare hippos with other vertebrate fossils and made the point about their different modes of life.

Then I considered the other non-marine vertebrate fossils that I have found in a long career of grave-robbing. There were turtles, for example in the uppermost Jurassic of the Dorset coast in south-west England. There were crocodile scutes in various places, such as the Eocene of the Isle of Sheppey in the Thames estuary and again in the Miocene of eastern Libya. Obviously these animals also lived in an environment where they stood a very good chance of preservation.

I have only seen living hippos outside a zoo in repeated visits to East Africa, where they are common snorting away in their special environment, as are turtles and crocodiles. I saw as many as seven hippos together high up in the Tsavo River of Kenya and lower down that river I saw the same number of crocodiles. I photographed a sign which said 'Beware of crocodiles'. Three years later that sign had changed to '*Vorsicht Krokodilen*', presumably indicating a change in the tourist population.

The land fauna in East Africa, however, is vastly more abundant, notably the great columns of wildebeest or gnu that sound at night like motor-cycle rallies, the zebra, the many kinds of antelope and the sadly depleted herds of elephants (though my wife and I saw more than 40 in one place). Land mammals, however, have left a far poorer fossil record than freshwater hippos and reptiles because their skeletons just lie on the land surface and rot away. The birds too are very common and diverse