ALAN DARLING

Farnham Geological Society

(A Local Group within the Geologists' Association)

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The weather has been very variable this year and perhaps it is just as well that our long Field Trip was spent in Malta. Luckily our most recent trip was to Harrow and it was all under cover.

We have to thank Peter Cotton for the second and last part of his article on the Colorado Plateau, and in light hearted mood for his Invitations to his Geologist's Ball, Alan Comer for a thought-provoking article on Mastodon and Mammoth and Jackie Clark for the first of a series of pen-and-ink sketches made during our US trip.

Twenty three members of our society visited the Harrow & Hillingdon Geological Society on its Silver Anniversary on Saturday 19th September. The majority travelled by coach from Farnham, having an easy journey taking just less than an hour. Our destination was the Winston Churchill Hall, Ruislip, a fine brick building whose principal feature was an auditorium capable of seating 300 people in tiered rows of 21 seats. There was a large room adjoining, with benches and tables where the various displays were being held and sundry smaller rooms.

One has to understand that it is people who form geological societies, not geological localities, and at first glance Harrow and Ruislip would appear very unpromising areas, fully built over with merely some old chalkpits a few miles to the NW and extensive wet gravel pits along the River Colne. However this H&HGS is obviously a flourishing society with its President Dr. Robert Symes OBE a former President of the Geologists' Association, no less. An impressive list of names of lecturers included Dr. Monica Grady, Dr. Richard Fortey FRS and Dr. Bob Hutchison and others. Lectures, always illustrated, lasted no longer than 40 minutes each with adequate breaks for refreshment.

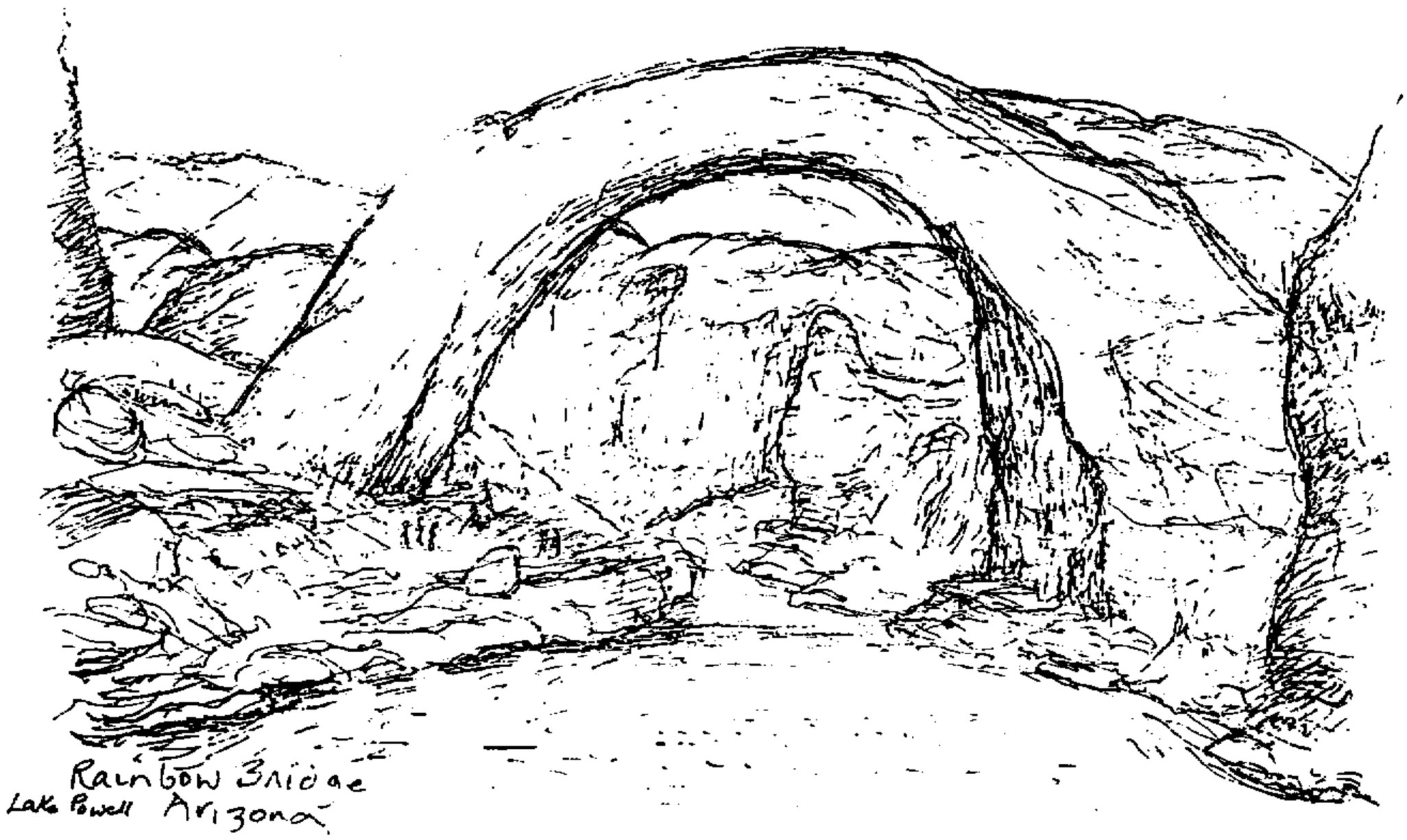
Because of that list of distinguished names many other societies sent visitors and the auditorium soon became filled - probably about 250 people attended.

Many of us brought packed lunches and I had mine on a convenient lump of brown sandstone about 4' x 2½' x 1½', in the grounds. While I was having my lunch my seat became the subject of a small party being given a lecture - I was actually sitting on a sarsen!

During the lunch interval there was time for looking at the various specimens offered for sale and also for book signing by the lecturers, though sadly not many books were available for this purpose apart from those of Dorling Kindersley which had a display.

After lunch Dr. Fortey kept us enthralled with his account of Life through the Ages while Dr. Symes pointed out that knowledge of the local geology was largely obtained through the study of cored boreholes. The last lecture, which made a great appeal to me was by Jo Crocker on Buildings and Industry. This was accompanies by excellent slides of local churches and the various stones used in their construction. Dr. Symes rounded off the meeting with an *ave atque vale* and we all trooped out into the afternoon sunshine.

David Caddy



Pen and Ink Sketch of Rainbow Bridge Lake Powell by Jackie Clark

Announcements at the Geologists' Ball

Mr. & Mrs. Knight and his mother Gran Knight

Mr. & Mrs. Casite and their son Mark Casite

Mr. & Mrs. Sum and their dog GipSum

Master and Miss Tickle and their father Pa Tickle

Mr. & Mrs. M. Knight and their daughter Bell M. Knight

Mr. and Mrs. Cate and their stupid daughter Silly Cate

Mr. & Mrs. Vine and their son Olly Vine

Mr. & Mrs. Wright and their Son Mike Wright

Mr. & Mrs. G. Dale and their daughter Amy G Dale

Mr. & Mrs. Fluxion and their son Solly Fluxion

Mr. and Mrs Tall and their son Chris Tall

Master and Miss Bull and their mother Ma Bull

Mr. and Mrs. Sed-Beach and their son Ray Sed-Beach

Mr. and Mrs. O'lith and their son Reg O'lith

Mr. & Mrs. Tonite and their son Ben Tonite

Mr. & Mrs. Lith and their daughter Zena Lith

Mr. & Mrs. Matite and their daughter Peg Matite

Monument Valley and Glen Canyon National Parks

Leaving Blanding our final destination that day was Glen Canyon and Lake Powell. Space does not permit anything other than a brief reference to the places we visited en route to the Glen Canyon national park from Bluff where we rejoined the road we had followed on the previous day and continued along the San Juan river route to take us into the famous Monument Valley. We did have a photopportunity at a place above the river called Goosenecks where there is a stretch of entrenched river meander so extreme that successive loops almost meet. The formation of goosenecks is interesting because normally a mature river will cut a new channel between adjoining loops and leave an ox-bow lake. In canyon country, before the major uplift of the Colorado Plateau, rivers had meandered sluggishly over flat, open land. The uplift of the plateau was gradual enough to allow the increased flow of water from the mountains to cut down into these original loops and thus preserve their form in deep canyons. One could call them fossilised meanders!

Monument Valley lies at the southern end of the uplifted plateau area associated with the Monument Uplift mentioned earlier as one of the mountain building events of the Laramide in Tertiary times. Massive jointing caused by the uplift has helped shape the harder DeChelly Sandstone into a wonderland of soaring spurs and buttes, many of them regarded by the Navajo as sacred monuments. Most of the monuments are preserved by a caprock of Shinarump which is part of the Chinle Formation of late Triassic age. The San Juan river cuts deeply across the Uplift exposing some of the oldest rock in Canyon country. Monument Valley was adopted by Hollywood as the setting for many Western movies. John Wayne has been here and got the T-shirt!

Arriving in Glen Canyon park we stopped to visit the massive power station by the dam that was built in the 1960's across the Colorado river. It is the lake created behind this dam that is the major feature of the Glen Canyon Recreation Area. Lake Powell is the second largest man-made lake in the world, it is 186 miles long with a shoreline of nearly 2,000 miles, longer than that of the Pacific coast of California. Into this lake flows the Colorado, already augmented by the waters of the Green River, and the San Juan river. The lake is a major attraction for boating, fishing and water sports.

The following day we took a cruise on the lake in a powerful and large speedboat. Before the lake was created it was a very arduous trek to get to what is now the head of the lake and the site of the world's highest natural stone bridge, Rainbow Bridge. The Navajo Indians regarded this as a sacred shrine - a rainbow turned to stone.

Our visit to Glen Canyon had little geological input and most of our geological observation was from the deck of the speedboat as it raced up the lake past towering cliffs of Jurassic sandstones such as Navajo, Wingate and Entrada.

Grand Canyon

On July 7th we travelled to the north rim of the Grand Canyon. In sheer scale the Grand Canyon surpasses all the other canyons we had visited. To quote form one of the excellent illustrated booklets produced for each national park; describing the Grand Canyon it says:-

"Nowhere else on earth has nature produced so striking an example of the power of running water -and, in doing so, exposed so much of the early history of the North American continent."

It is impossible to see from the ground, whether from the north or south rims or from the canyon bottom anything other than a small section of the whole. The canyon is 300 miles long and the natural park around it extends, over 1892 square miles. Put into the context of the whole Colorado river system, from the source of the main river in the Rocky Mountains to the Gulf of California it is 1450 miles, during the course of which it traverses most of the south western USA, draining 140,000 square miles and dropping 10,000 feet from source to mouth.

Rock exposures in the canyon range from pre-Cambrian up to Permian and the cumulative thickness of the strata represented in different sections of the river is 20,000 feet, a unique exposure of continental crust. Our views were from the North Rim Lodge where we stayed for 2 nights and from Cape Royal, the highest Grand Canyon viewpoint. One cannot see the river itself from these viewpoints for the reason that the Kailab Plateau through which the canyon is carved slopes southward on the north rim towards the river. This slope allows the rain and snow - some 25 inches per annum on the north side - to drain into the canyon and erode at a much greater pace than on the southern side where the plateau slopes away from the valley and, in any case, has only 50% of the precipitation received on the northern side. This enhanced erosion on the northern side has produced many side canyons so that it is difficult to work out the topography although one can easily observe that the level of the southern rim is appreciably lower than the north. Palaeozoic rocks from the bulk of the canyon walls ranging in age from Cambrian to Permo-Triassic. During this long period of time the western ocean transgressed over the continent on many occasions leaving marine sediments followed by freshwater and desert layers. Although the Jurassic and Cretaceous seas, together with the inter-marine periods of desert conditions, left similar strata to that in other parts of the Colorado Plateau, all of these layers above the Permo-Triassic have been removed by erosion.

A very important event took place whilst we were staying at the North Rim Lodge. Veronica Kilgour achieved quaternary age: that is to say she had her 80th birthday. What a splendid birthday party we had in the grand dining room where tourists from all over joined in the "Happy Birthday to You."

Zion and Bryce National Parks

Leaving the Grand Canyon we headed north for two days of visits to Zion and Bryce National parks. The drive northwards from Grand Canyon is along the line of what is known as the Grand Staircase. On the rim of the Grand Canyon the rocks exposed on the Kaibab Plateau are of Permain age as mentioned earlier in the text. But climbing from around 3,000 feet above sea level to over 9,000 feet successive layers of Triassic, Jurassic, Cretaceous and Tertiary are reached; there are in fact five giant steps in this geological sequence.

The first step from the Permian is up to a Triassic layer called the Chinle Formation, a shale and mudstone group forming what are known as the "chocolate cliffs." This is succeeded by colourful Jurassic sandstone layers with exotic name like Moenave and Kayenta, which form the "vermilion cliffs." Up higher to the "white cliffs" composed most of Navajo sandstone which is, in this area, a whitish colour. At this level, some 120 miles north west of the Grand Canyon lies Zion. Finally up to the top layer of the Grand Staircase and the "pink cliffs" of Tertiary age.

It is on this formation, the Claron limestone, that Bryce is found. At this point it is as well to pint out that Zion, lying mainly on Navajo sandstone, and Bryce carved out of the softer Claron limestone, present very different aspects. Zion is massive with sheer walls of hard sandstone whilst Bryce is an intricately carved and delicate fairyland on the very edge of the Paunsaugunt Plateau.

Zion

Zion is a gem and, when I use this endearing term, I am aware that this may be a very personal assessment amongst all the wondrous scenery we observed. It has the dramatic rock formations of the other parks but, being in the canyon of the Virgin river, there is much more vegetation which was indeed a welcome change from arid rock landscapes. Although the Navajo sandstone predominates in Zion - sometimes reddish, sometimes whitish -, where the river has cut its way beneath the Navajo layers into the softer Kayenta, this causes massive rock fall creating a much wider canyon. This widening and narrowing along the valley is very dramatic at a point while the river passes through the "narrows of Zion" before opening out into a wide valley. For those trekking along the river valley it is essential to listen to the local weather forecast before venturing through the slit of the "narrows" because rainfall in the surrounding mountains can rapidly lead to flash floods in the Virgin river which will sweep away everything in its way.

As well as these exposures of the Kayenta underlying the Navajo there is also in the park a lot of the lighter coloured Carmel formation which overlies the Navajo. AT this point, however, it is necessary to caution the use of colour of rocks for the purpose of identification. Iron in the form of oxides can produce varying colours depending on its concentration; many of the massive white cliffs are the result of iron leaching from the Navajo sandstone rather than exposures of Carmel. Whilst on the subject of coloration it must also be mentioned that a common feature throughout all our visits was what is referred to as "desert varnish". This is the dark, lustrous coating often seen on rock

surfaces in desert areas as a result of the leaching of either manganese or iron oxides. These varnished surfaces have been used by prehistoric Indians for etching out the designs depicting humans, animals and plants known as petroglyphs.

Another geological feature of Zion is the way in which the Navajo sandstone has weathered in both vertical and horizontal planes creating a checkerboard effect. Near to the East entrance to the park there is a large mass of Navajo sandstone called the "checkerboard mesa" which is the result of the weathering of planes of weakness, the vertical line following strain cracks and the horizontal lines etching out the layered beds of dune sandstone.

Finally a word about the Mormon settlers in Zion in the mid 19th century. The Indian name for this area was Mukuntuweap and it was by this somewhat tongue-twister of a name that it was known until 1918. Mormons were still not free from persecution even though the State of Utah was becoming very much a Mormon State. Zion was seen as a place of refuge and rest and in 1908 President Taft declared it as a national Monument. Although many of the prominent features of Zion have religious titles such as The Three Patriarchs, Angels Landing and the Great White Throne these did not get their names from the Mormon settlers but from a visiting Methodist Minister Frederick Vining Fisher!

We stayed in the bustling town of St. George on the night of the 9th July and it was from here that three of our group flew back to the UK, Joan Prosser needing to be back for attending the post graduate ceremony for her son. St. George has no relationship to he of the dragon-slaying fame; this St. George was one George Smith who was a prominent Mormon who was therefore a member of the Latter Day Saints! In fact St. George was the place where many of the 19th century settlers came to found the Cotton Mission, again bearing no connection with a similar named member of our group.

The following day we returned to Zion for the morning en route to Bryce National park, some 30 miles to the north east, where we were to spend the night at Ruby's Inn in the middle of the park, perched on the edge of the Paunsaugunt Plateau at an altitude of nearly 8,000 feet.

Bryce

As mentioned earlier, Bryce National park is located at the very top of the Grand Staircase on the edge of the Paunsaugunt plateau. The rock strata up here at 8,000 feet above sea level is of Tertiany age and is called the Claron Formation. This pink limestone is the main constituent of the rocks that form the fantastic pinnacles and spires for which this park is famous. The limestone was laid down in freshwater lakes formed after the retreat of the Cretaceous ocean following the Laramide Orogeny. As mentioned earlier in this article the great seaway had extended from the gulf of Mexico into Canada and left deposits which form the base of the limestone exposures. The river Paria that flows at the foot of the limestone ridge cuts through these more ancient layers and has been the main erosive force in cutting back into the Paunsaugunt plateau and forming the "fins" of rock that were described when discussing the formation of the arches and

windows in Arches National Park. Given the common nature of the erosional forces which creates the Arches landscape and the Bryce Pinnacles, one must ask why such very different features have been created. The answer lies almost exclusively in the different nature of the rock; in the case of the Arches it is the Entrada sandstone whereas Bryce has a combination of the pink limestone and softer siltstone. This siltstone is so soft that it erodes easily and melts into sharp slopes; whilst the limestone, some capped with a layer of erosion resistant shale or sandstone and some exposed, erodes at different rates to form the fluting and fanciful figures which the ancient Indians called Hoodoos. Hoodoo means to cast a spell and the Paiutes believed that the shapes were, "Legend People" turned to stone by Coyote.

Many members of the party descended from the plateau via the Navajo Loop track to the foot of the cliffs 500 feet below the rim of the plateau. On this narrow zigzag path down and back up to the plateau one passes amazing rock formations. Equally amazing is the sight that greets you in the middle of the defile known as Wall Street where two very tall and thin Douglas Firs are growing apparently straight out of the rocky floor. A few members of the party finished the day by taking a flight in a helicopter that skimmed backwards and forwards through the pinnacles and canyons as the setting sun was bathing the pink rocks in its evening glow.

The following morning prior to our departure back to Salt Lake City we paid a brief visit to the Paria Valley below the cliffs,. Our return journey was through spectacular scenery which was a fitting conclusion to this memorable trip prior to flying out to San Francisco en route to Heathrow and home.

Mastodon and Mammoth

Why were the woolly elephants and rhinoceroses so well dressed?

This question is usually dismissed with the reply that their hairy insulating coats evolved as a response to the cold of the ice-ages, but on brief examination this reply is not very satisfactory. The apparent periodicity of a complete cycle of ice-age and interglacial seems to be about 100,000 years, of which about half is considered to be cold and half fairly warm. Thus the hirsute cladding of these creatures must have arisen in less than 50,000 years, a very very short time for such a large evolutionary step, unless the evolving species lived in acute discomfort through earlier interglacials. Indeed this does seem to be the case based on fossil evidence, as the remains of Mastodon, Mammoth, and several Woolly Rhinoceroses dating from the early Pleistocene have been found, apparently extending their development time through several glacials and interglacials. This does not seem to be reasonable. If the development of warm overcoats was really a response to the cold of the ice-ages, why was it not arrested by the intervening interglacials which probably lasted for slightly longer than the ice-ages? Clearly the question is not so easily resolved, and requires that many inherent assumptions are carefully examined.

The original answer to the question depended largely on the observation that the two species of modern elephants and the best known species of rhino live in warm climates, and are hairless, leading to the assumption that any of their kinsfolk not conforming to these patterns must have adapted to special climatic circumstances, which could only have been the ice-ages in view of the localities in which their fossils are found. However even these observations are not strictly true. Modern elephants are not entirely hairless. They normally have tufts of hair at the ends of their tails, useful as fly-swats, and they also have quite elegant eye-lashes, with a few having occasional hairs in their ears. Young Indian elephants are often quite well covered in soft hair for their first year or so, but it becomes sparse and bristly as they grow into adults. It is therefore just as reasonable to suppose that the ancestors of modern elephants were hairy creatures well adapted to a different climate, but their descendants which migrated into hotter, drier parts of the world would find a dense covering of hair detrimental to their comfort, giving advantage in the processes of feeding and breeding to individuals that were less well covered. This is the path of eventual evolution towards hairlessness, with only useful tufts being retained as a legacy of their past. As regards the Rhinos, the largest species now found in Africa is entirely hairless but smaller species have some hair, particularly those in south-east Asia and Indonesia, where there is a type living in swampy rainforests which has quite a luxurious hairy coat.

At this point it is as well to enquire about the function of hair, which most mammals seem to possess in greater or lesser abundance. This is another question that is easily dismissed by the assumption that its purpose is to keep an animal warm, but once again so obvious an answer may not be entirely true. A cottage is thatched not to keep it warm but

to keep it dry, although warmth is a secondary benefit in winter weather. Could this not be a clue towards understanding why the rhinos of tropical swamps and rainforests are unexpectedly hairy, to keep the skin of the animals dry in perpetually wet circumstances where temperatures change very little for weeks and years on end, rendering hair unnecessary as a heat insulator.

It seems that there may well be better answers to some of these fundamental questions. Modern rhinos and elephants are just as likely to be descendants of hairy ancestors that were adapted to wetter but more equable climates than we are experiencing at present.

Where is the evidence to be found?

Palaeontologists tell us that the bones of related elephantine creatures are occasionally found throughout temperate regions all over the world except Australia, showing that for the past two or three million years they were fairly commonplace animals until about twenty thousand years ago, when they became extinct except for their modern relatives in tropical regions. Many of their massive bones and tusks are well preserved in rocks that once were swamps or river gravels from Southern Florida to Alaska, and from North Africa to Northern Europe and Asia, with occasional pygmy forms in isolated places, Malta being a good example. In Alaska and Siberia complete carcasses are occasionally found preserved in retreating ice-cliffs, still quite fresh enough to be eaten by domestic dogs or wolves despite the time they have spent in deep-freeze, showing exactly their appearance and size, and that they were covered in thick dark hair, long on the outside but woolly and thick underneath.

It is this association with the present retreating snowcap that has fostered opinions that Mammoths and Mastodons were creatures of the ice-age, but the reasoning is not particularly sound as it ignores all the bones that were found in regions that were certainly not glaciated, nor does it explain why the animals were there in the first place to be entombed in the ice so quickly that they are so well preserved. They could not have lived on the permanent snowcap, as no food at all would grow there, and even just clear of the permanent snowline it is dubious whether such large hungry herbivorous animals would have been adequately fed if only a tundra type vegetation was available. However it cannot be denied that they were there, so perhaps our concepts of ice-age conditions must be amended to account both for their widespread habitat and for their presence near the ice.

The commonplace view of the ice-ages takes the name at face value. Ice is always cold, at least in human terms although Penguins and Seals might not agree, so that the Earth must have become a much colder place for water to freeze into the distended ice caps of the times. Is this generalization valid? A colder world would have less free energy to drive winds and ocean currents, to evaporate and transport water in the clouds, and to promote the normal processes of erosion throughout the world, and yet there was enough energy in the ice-ages to raise ice-caps three to four kilometres thick, and to grind away the surface of millions of square kilometres of the Earth's crust, carving deep valleys and piling up huge ridges and mounds of pulverized debris over several continents. All this suggests that the ice-ages were times of greater free energy rather than less. Perhaps a different concept is needed.

It seems very unlikely that the polar regions of the Earth are ever entirely clear of snow and ice, even during interglacial times, because the tilt of the Earth's axis ensures that winter darkness at the poles lasts fully six months, without any sunshine at all. Even on the side of Mercury facing away from the Sun there are sub-zero temperatures, so that it is unlikely that any regions of the Earth exposed to empty space without sunshine for six months will be any different. Any water at the poles will freeze, and the temperature of any snow on land will fall well below freezing point in the winter, making it cold enough to survive through the next summer in spite of weak summer sunshine. Surface shade temperature throughout the year in such a region will clearly be below zero, held down by the presence of snow and ice.

Moving away from the poles the annual amount of sunshine received at the Earth's surface increases progressively, to reach a maximum at the equator. This should also progressively increase average surface temperature, but there are several factors such as the presence or absence of the sea, altitude, and local weather, which prevent the increase being completely regular, although the general pattern is fairly accurate. Surrounding the poles there is thus a zone in which seasonal snow is always melted by summer sunshine, so that its average annual temperature must be above zero. Here winters might be cool, but summers would be mild after the snow had gone, circumstances where permafrost could never develop, and fairly abundant vegetation could be expected right up to the edge of the permanent snow of the central region. This would be a suitable environment for woolly elephants, sometimes cool but not too cold in their hairy coats, wet, but with plenty of food for most of the year, even in the winter if they searched underneath the transient snow much as the Bison of Yellowstone Park do today, by shifting it with their long curved tusks.

Now imagine the very slow transition to glacial conditions. In due course the angle of tilt of the Earth's axis would begin to reduce once again, with the effect that slightly less sunshine would be received annually in polar regions, thus widening the zone of continuous freezing, and correspondingly more in the tropics, resulting in slightly more evaporation that would ultimately supply the extra snow needed to increase the size of the snowcap. The process would be imperceptibly slow, but it would have enormous consequences in the long term. However, it would have no immediate effect on the environment in which the woolly elephants lived other than than moving it slowly away from the pole at a rate probably of no consequence to any single generation. The slowly advancing edge of the permanent snow would at all times be controlled along a fairly stable line by the balance between accumulation and melting, probably causing boggy conditions and many streams just beyond its edge, but the advance would be over fertile ground which would remain productive, and the climate would continue to be cool but temperate rather than cold. The woolly elephants would probably enjoy it. There might, however, be some danger to more venturesome animals browsing near the ice-cliff at the edge of the permanent snowcap, which would never be entirely stable in these circumstances. A sudden avalanche could result in burial and very fast freezing of the carcass, which might remain entombed in the ice until it melted in the next interglacial.

There is at present a large measure of agreement that the duration of each glacial/interglacial cycle is about 100.000 years. It follows that the sequence of slow change described above would continue for nearly 50.000 years, when the permanent snowcap would reach maximum size, after which the rate of change of the Earth's angle of tilt must reduce and finally reverse, to begin the slow return over the next 50.000 years to interglacial conditions. In practice the snowcaps would remain close to their maximum dimensions for many thousands of years, but, other than geographic factors that might intrude, the environment occupied by the woolly elephants near the snowcaps would be scarcely changed except that the climate would be much wetter and possibly a little warmer over the course of a year than that experienced by their ancestors many generations earlier. With the angle of tilt of the Earth's axis near its minimum, evaporation from the oceans would be at its greatest, making the whole earth much wetter, reducing deserts to negligible size, but at the same time maintaining the snowcaps against the serious melting that would arise in the summer so far from the poles. Vegetation would clearly thrive in these conditions, and probably the woolly elephants would also prosper, with more territory for their occupation.

But these conditions would not endure. As the angle of tilt began to increase, the Earth would slowly become drier, with re-emerging deserts and local reduction in vegetation, once again reducing the territory available to large herbivores. At the same time the edges of the snowcaps would begin to retreat, but now a very different land surface would be exposed, unfertile, covered in glacial debris, with permafrost a problem where the ground had been thickly covered for thousands of years by glacial ice. It probably took a long time for even a tundra type vegetation to become established, and very much longer for verdant pastures where woolly elephants might prosper. Clearly these hostile conditions might drive the species towards extinction, particularly if a new and active predator had arisen during the easier climate of the last ice-age and was now forced by circumstances to sample a new diet.

The foregoing has shown that there is indeed an ice-age scenario that would accord with the known history of elephants and rhinos during the present glacial epoch, and with other animals including the hippos and mankind itself if enquiries are extended. It does not require catastrophe to initiate either ice-ages or interglacials, nor has the entire earth to cool down or warm up, any of which could be disastrous to far more species than are known to have perished during this time. It also explains why the onset of interglacial conditions rather than glacial might well create difficulty to the point of extinction for large herbivores that needed a lot of food, particularly if another adverse factor should intervene when the species is under stress in its changing environment.