neglected 'Dark Age' in the geological history of Britain". A joint discussion of geologists and geographers intended to throw light on the problems of this 'Dark Age'—which the radioactive clock tells us was sixty-five or seventy million years long—is therefore greatly to be welcomed, and if the lamps held up at Birmingham cannot be said to have cast their light very far into its depths, it is certain that their beams are turned in the right direction.

Geomorphology offers two contrasted and complementary lines of approach to the problem, namely, by the elucidation of denudation chronology and by the reconstruction of the original pattern of our drainage system. The latter is possible at all only by virtue of the fact that when a new cycle of erosion begins as the result of general uplift, the landscape inherits the rivers of the previous cycle unless these have been extinguished by a marine transgression. Not all the rivers so inherited will survive long, and not all of them belonged to the initial drainage pattern. But some of our present-day rivers may be older than any feature of our present land-surface, and in applying this method to the Midland region of Great Britain (in a very wide sense of that term) Prof. D. L. Linton made this claim for the North Welsh Dee where it crosses the Berwyn Hills, and for the south-flowing streams of the southern Pennines and notably the Derbyshire Derwent. From these and other surviving remnants he reconstructed a Proto-Trent, with headwaters as far west as Snowdonia, which flowed eastwards across the North Midlands receiving the Derwent and its analogues as left-hand tributaries, and the ancestors of the present north-flowing Penk, Tame and Soar from the right, and flowed into the North Sea beyond the site of the Wash. An east–west watershed, he argued, bounded this system from that of a comparable proto-Thames to the south, also carrying Welsh water to the North Sea, while to the north other workers have stressed the importance of the east-flowing element in the original drainage of Yorkshire, Durham and Northumberland, and even beyond the Border.

Later work in many parts of Britain will be necessary to establish such a reconstruction and to give it precision; but if it be allowed that the general pattern of our earliest rivers is being revealed, it becomes clear that the movements that brought it into existence comprised a widespread, though not uncomplicated, tilting from west to east. Prof. Linton would identify this movement with those known to have upraised the Chalk before the deposition of the basal Eocene strata of the London Basin, and if he is correct some new light is thrown on the earliest episodes in our Dark Age.

The later phases are better illumined by tracing the remnants of former valley floors or of base-levelled surfaces of wider extent. Such work must needs be detailed and precise, and therefore local, and the interim results of work being carried on in three widely separated areas—Exmoor, County Clare and the Derby–Staffordshire border—were presented by Mr. W. G. V. Balchin, Dr. Marjorie M. Sweeting and Mr. G. T. Warwick. Each has recognized a series of landscape features corresponding to periods of stillstand and has designated those periods by a non-committal local terminology. The question of correlating the stillstands of one region with those elsewhere had already been taken as far as it can profitably be taken at present by Prof. Wooldridge in his presidential address, and it was therefore not pursued. But a point that was taken up in general discussion concerned the question whether the surfaces at higher levels are marine or sub-aerial. Mr. Warwick's succession of inland stages is wholly sub-aerial, and Dr. Sweeting's partly so; Mr. Balchin's stages at comparable altitudes are all marine and regarded as successive strand-flats cut during the discontinuous emergence of south-western England from the sea. If this emergence is regarded, as it is by Mr. Balchin, as being due to a succession of eustatic drops in sea-level, a somewhat wholesale late-Tertiary submergence of the English lowland would seem to be implied—a conclusion not in accord with the drainage reconstructions so far made. The eustatic hypothesis is attractive, and by its aid some correlations at the lower levels—say, up to 650 ft. or 200 metres—seem to be in sight; but at higher levels the possibility of tilting of the older surfaces must be borne in mind. Prof. Dudley Stamp, in one of his now rare utterances as a geologist, underlined this point and urged the growing band of younger British geomorphologists to supplement the record of their own observed stages of erosion by the depositional record provided by the late-Tertiary succession of Holland. That record is one which implies warping or tilting of the areas to the west and south from which the deposited material came. It was fitting that the last and youngest contributor to the discussion—Miss Alice Coleman—should announce that work she is completing in East Kent displays evidence in the uniclinal shifting of the Stour and, by the discrepancies in altitude between the Kentish succession of stillstands and those worked out for the South Downs by Mr. B. W. Sparks, of eastward tilting during even the latest phases of landscape evolution.

It is evident that in this field of common interest to geologists and geographers a good deal of work is being done, chiefly at the moment by the geographers; and that as the body of evidence derived from the field-work grows, it will demand for its proper interpretation the experience and imagination of some of the best minds in both subjects. This joint discussion made a not inauspicious beginning.

D. L. Linton

## NEW DISCOVERIES OF THE AUSTRALOPITHECINÆ

In 1946 there appeared a memoir of the Transvaal Museum by Dr. R. Broom and Dr. G. W. H. Schepers, in which were described the fossil remains of the Australopithecinæ discovered up to that date at Taungs, Sterkfontein and Kromdraai. In 1947 Dr. Broom, continuing his indefatigable search in the stalagmitic deposits at Sterkfontein, came upon a site which proved to be astonishingly rich in the remains of the Australopithecine group to which he had given the generic name *Plesianthropus*. A further memoir* provides a description of these new discoveries. The description, abundantly illustrated, is not intended to be more than a general account. Indeed, there is now so much material available for study that some years are bound to elapse before it can all be subjected to a complete analysis. Nevertheless, this preliminary

* Transvaal Museum Memoir No. 4. Part 1: Further Evidence of the Structure of the Sterkfontein Ape-Man *Plesianthropus*. Part 2: The Brain Casts of the recently discovered *Plesianthropus* Skulls. By Robert Broom, J. T. Robinson and G. W. H. Schepers. Pp. 117+8 pl. (Pretoria: Transvaal Museum, 1950.)

account, brief though it is, will be welcomed by all those anatomists and palæontologists who are concerned with the problem of human evolution, for it has become abundantly clear that Dr. Broom's discoveries are indeed very relevant to this problem. A ground-plan of the new Sterkfontein locus in the memoir shows that it is of quite limited extent, covering an area of about forty-five square yards. Within this restricted area have been found, closely packed together in the dense limestone matrix, the remains of eight skulls, three mandibles, portions of several limb bones (including a fine specimen of the pelvic skeleton) and very many teeth.

All this new Australopithecine material greatly extends our knowledge of these extinct ape-like creatures and also (it is important to note) vindicates in a remarkable way the provisional conclusions which had already been expressed by Dr. Broom and others on the basis of the earlier, more fragmentary, fossils. Thus, the hominid characters of the auditory region noted in the original Kromdraai skull have also been demonstrated to be present in the new Sterkfontein skulls. The hominid features of the occipital bone which had been observed in the Kromdraai skull and the type skull from Sterkfontein have been found to be consistently present in all the other skulls in which this region is preserved. The reconstruction of the frontal region of the type skull of *Plesianthropus* has been verified by the practically complete skull (No. 5) discovered at Sterkfontein in April 1947. The essentially hominid characters of the dentition are consistently repeated in all the newly discovered specimens of the teeth. The earlier inference (based admittedly on rather incomplete material) that the Australopithecinæ were equipped with limbs approximating very closely to those characteristic of man has received striking confirmation from further discoveries of limb bones and of the pelvic skeleton.

This last specimen deserves particular attention. It was actually found *in situ* in the midst of all the other Australopithecine remains derived from the same locus (and at the same level). It consists of a practically complete right os innominatum and also a portion of the left side. In the low broad ilium, the deep sciatic notch, the strongly developed anterior inferior iliac spine and a number of other features, the bone is essentially of the hominid type and (as Dr. Broom's comparative illustrations demonstrate very effectively) contrasts very strongly with the pelvic bone of anthropoid apes. Indeed, so human is the appearance of this bone, that some critics at first contended that it could not be part of an Australopithecine skeleton. The circumstances of its discovery, however, appear to discount this criticism, as well as the fact that it presents unusual characters which (so far as is known) are not to be found in any variety of *Homo sapiens*. It has further to be added that a second ilium of the same hominid type was later found at an independent site (Makapansgat) which had also yielded a mandible and portions of skulls of *Australopithecus*.

Lastly, yet a third os innominatum, excellently preserved and reproducing the same features of the Sterkfontein pelvis, has now been discovered at Swartkrans. The details of this fine specimen (which was also found *in situ*, within a few feet of two large Australopithecine mandibles) have not yet been published, but a photograph exhibited on behalf of Dr. Broom and Mr. J. T. Robinson at the International Anatomical Congress recently held at Oxford demonstrated very clearly its main features. The fact that three specimens of the Australopithecine pelvis have now been found at these independent sites, and that they are all of a predominantly hominid type, leaves no further room for doubt that the posture of the Australopithecinæ must have approximated quite closely to that characteristic of the Hominidæ. This evidence of the pelvis is consistent with that of the other limb bones the remains of which have been discovered by Dr. Broom, and also with the less direct evidence provided by the basal region of the several skulls now available for study.

Without doubt, the most important result of all the recent discoveries at Sterkfontein and elsewhere is that they eliminate any further need for relying for comparative or statistical study on single, isolated specimens which, it might be argued, are perhaps of an exceptional nature. Attempts have already been made (somewhat prematurely, as it seems to me) to subject to statistical analysis some of the limited and very fragmentary Australopithecine fossils discovered several years ago, and certain inconclusive results (based on measurements taken at second hand or made on plaster casts) have unfortunately led to controversies which the much more abundant evidence since become available now show to have been unnecessary. Thus, well over two hundred teeth of the Australopithecinæ have now been recovered, providing a much more reliable series for the study of variability than the first few specimens which have been used for this purpose. The great accession of new material also makes it possible for the first time to compile satisfactory data regarding the degree of uniformity in the distribution of individual characters, or combinations of characters, in the Australopithecine population. It can now be stated, for example, that nine out of nine palates consistently present evidence of a combination of hominid features in the upper dentition which has not been demonstrated to exist in any anthropoid ape even as an exceptional condition, that four out of four immature jaws with the milk dentition consistently show that the deciduous canines and first molars conform to the human (and not the ape) pattern, that more than a dozen specimens demonstrate that the permanent canines (presumably of both sexes) were consistently small and of human type and associated with no diastema, that seven out of seven anterior lower premolars show the non-sectorial bicuspid form distinctive of the hominid dentition, and so forth. These are a few examples which could well be multiplied.

Thus, it may now be accepted that, in the totality of their morphological features, the Australopithecinæ certainly resembled primitive hominids much more closely than do any of the known anthropoid apes. The significance of this fact is, of course, open to interpretation. Dr. Broom and Mr. Robinson express themselves carefully on this point, but they suggest (and the suggestion is one which seems best to fit the facts so far as these can be assessed at present) that the Australopithecinæ either represent a branch of the ancestral stock from which *Homo* was derived, or are at least rather closely related to this stock. One of the outstanding features of the group is the small size of the brain (as indicated by the study of endocranial casts). There is reason to suppose, as Dr. Schepers points out, that the brain in relation to the size of the body may in some cases have been some-

what larger than that of the anthropoid apes of to-day, but the evidence of the Sterkfontein fossils evidently does not permit a firm statement on this point. On the other hand, the more recent discoveries by Dr. Broom of larger Australopithecine skulls at Swartkrans (photographs of which were also exhibited at the International Anatomical Congress) have raised anew the possibility that the size of the brain extended its range beyond that recorded for the gorilla and chimpanzee, and perhaps even came within the range of primitive hominids of the *Pithecanthropus* group.

W. E. Le Gros Clark

## QUALITY IN GRASSLAND

A DISCUSSION on "Quality in Grassland" in Section M (Agriculture) of the British Association, held on August 31 during the Birmingham meeting of the Association, was opened by Dr. William Davies, director of the Grassland Research Station, Stratford-on-Avon. His remarks were followed by a short paper presented by Dr. D. H. Curnow, of the Courtauld Institute of Biochemistry, London, who dealt with œstrogens in grassland.

Dr. Davies suggested that rather than speak of quality in the singular, we should speak in the plural and discuss the 'qualities' of grass much as we speak of 'qualities' in man. Although most people have a working knowledge of what is meant by quality or qualities, it is, however, extremely difficult to provide a clear and concise definition of either quality or qualities. Among the qualities of grass and of grassland which were discussed were, first, the production of nutrients spread over as long a season of the year as possible; and the point was made that we here deal with quality as it is affected by high production of freely available nutrients. Because of the concentration of digestible nutrients in the leaf, it is clear that one of the first qualities of good grassland is that it is leafy as well as being at high production over a prolonged season of the year. Young actively growing leaf is of better quality than leafage of slower growth, while it may be shown that leaf tip is of better quality than leaf base. Actively growing leafage is usually of better quality than old and mature leafage. Leaf lamina has qualities that are superior to leaf sheath (in the grasses) or petiole. Stem even when immature is of lower quality than leaf.

Evidence from current researches being conducted at the Grassland Research Station and elsewhere in Great Britain shows that herbage can be produced for consumption *in situ*, even in the middle of winter. It is becoming clear, however, that winter grass has qualities which are distinctly different from those of spring-grown grass. These differences may be associated with the high fibre content of winter grass and with a lower energy-value than similar grass grown in spring. The nitrogen content of leaf lamina in winter is frequently higher than in summer. The feeding of pasturage *in situ* during the winter, therefore, may mean that, in the case of the high-production animal, in any event, carbohydrate of low fibre and of high energy-value might well be the sensible supplement. Indeed, there is some evidence to suggest that a carbohydrate supplement might be sensible, even at the height of spring flush.

Grass, using the term as embracing the legume and the herb, as well as the true grasses, is the cheapest and probably the healthiest form of animal feeding-stuff, particularly when grazed *in situ* by the animal itself. The farmer, therefore, is intensely interested in any technique which is practicable and will extend his grazing season. Grazing out of doors during the wet and inclement weather of winter clearly creates new problems for the farmer, but none of these seems to be insoluble. The work of the grassland technician is to examine critically the practical problems associated with the utilization of grass grazed *in situ* during the winter to provide the practising farmer with a technique both of production and of utilization of winter grass.

It is by no means certain that fibre content, energy value and nitrogen-level in the dry matter are the only distinctive differences between summer and winter grasses. Future investigation may indicate other differences, such as, for example, in œstrogen content or in the content of vitamin precursors, mineral value, and so on. There is here a wide and largely uncharted field of study, not only for the agronomist and animal husbandryman, but also for the biochemist and veterinarian.

It is a fairly simple observation that as grass, in its widest context, matures, so its quality deteriorates. Every herbaceous plant goes through a period of maturation from the time it starts growth in spring to the time when it has produced flower and seed. During this period the plant increases in dry weight but decreases in quality as measured by its nitrogen content (which gets lower) and its fibre content (which gets progressively higher). The farmer attempts to prevent this maturation taking its normal course when he grazes his grassland and maintains it in a leafy condition for as long as possible.

The ruminant animal is the largest aggregate consumer of the grass crop. It is abundantly clear that the animal at high production demands grass of high quality. Grass, however, may not be the perfect food for animals at a high level of production, for it may well show deficiencies such as those to be associated with straightforward lack of energy-value. The ruminant animal, however, can deal efficiently with leafage which may have a fibre content of 17 per cent or more. The non-ruminant, on the other hand, such as the pig and the hen, may well be found to show ability to utilize the grass crop. To do this effectively, and for grass to be a major element in its diet, we must provide herbage not only of high nitrogen content and of high energy-value but also especially herbage of low fibre-content. Here we must set the problem not only to the agronomist but to the plant breeder also. It should be possible for the plant breeder to select herbages in which the fibre content of the leaf lamina is as low as 10 per cent of the dry matter, and we should aim at material of even lower fibre content.

Another aspect of quality in the grass crop is that relating to mineral content. We know from the pioneer work of Prof. T. W. Fagan and others that many of the herbs of our pastures are extremely rich in minerals, especially calcium, phosphoric acid and potash. There may be other good attributes in the herbs when compared with the more normal grasses and clovers of Britain. For example, many of the herbs are sought after by the grazing animal, and further, what is true of the major elements mentioned may also be true of the trace elements. In this field, however, there is a great lack of critical evidence in so far as it relates to British herbage plants.