observers. Spores of most species will germinate over fairly wide ranges of temperature (2°–36° C.) and of hydrogen ion concentration (*p*H 4·0–8·0), although the optimum values vary with the species.

Results obtained by different workers in experiments on the effect of nutrient solutions on germination are often contradictory. Many of these investigators took no particular care to exclude bacteria from their spore suspensions, and it has been shown that many species germinate more readily in the presence of suitable bacteria. Moreover, spores of *Reticularia lycoperdon* which fail to germinate in single-spore culture, germinate readily in the presence of other spores or in filtered liquid in which others have germinated. It is likely, therefore, that some growth-substance is required which is present in natural substrates or can be produced by certain bacteria and which does not normally reach a sufficiently high concentration in pure suspensions of only a few myxomycete spores.

Early workers recognized that solid food particles, such as cells of bacteria and yeasts, or certain fungal spores, are engulfed by both plasmodia and swarm cells and digested within the vacuoles. Unsuitable particles may be engulfed but are discharged unaltered.

Exact work on nutrition, however, has scarcely begun, since it is only comparatively recently that these organisms have been grown successfully in pure culture. Several successful attempts to grow them in 'two-membered' cultures, that is, in the presence of one other type of organism (bacterium, yeast or mould), have been made, among which that of Pinoy[2] is one of the earliest to be described. The important studies of Raper[3] on *Dictyostelium discoideum*, a member of the related group, Acrasiales, in which this organism was grown in 'two-membered' culture with various bacteria, have yielded interesting results. Raper has established that the initial composition of the medium influences the slime mould indirectly through influencing the bacteria on which it feeds. The maintenance of a suitably acid reaction is shown to be of importance. The true Myxomycetes have also been grown in 'two-membered' culture with other micro-organisms by a number of investigators. It is not until the work of Cohen[4], however, that we have a report of pure cultures which have successfully passed the stringent tests for purity which this author considered necessary. Cohen obtained pure cultures by migration of the plasmodia over a series of plates of plain agar or by transfer of the plasmodia to such plates after being allowed to feed on a suitable yeast colony when, in the absence of further food supply, the remaining yeast cells were consumed. The work of Sobels[5] is the first attempt to apply exact methods to the study of the nutrition of slime moulds. She showed that *Licea flexuosa* and some other species grew well in pure culture with an autoclaved suspension of the cells of certain yeasts or on gelatine to which peptone or asparagine were added. The addition of sugars (of which trehalose gave the best results) to an asparagine medium led to improved growth. Asparagine could not be replaced by ammonium salts.

The factors leading to a change from the active vegetative, or plasmodial, phase to the resting or sclerotial stage or to the initiation of spore production have not been precisely determined. Camp[6], however, showed that when *Physarum polycephalum* was grown on moist filter paper or gauze sprinkled with rolled oats, cessation of feeding led to sporulation. It is also clear, from the work of Raper[3] and others, that an acid reaction of the medium is essential for spore production.

The creeping movements of plasmodia and swarm cells are probably the result of a number of varied external stimuli, the relative importance of which has yet to be determined. Various observers have claimed, for example, that movement is controlled by light, gravity, temperature gradients, direction of flow of water or by gradients in moisture content and chemical composition of the substrates.

Thus it is clear that while advances have recently been made towards a clearer understanding of the relations between the slime moulds and their environment, much remains to be done. Moreover, the mechanism of the response of these organisms to environmental stimuli is entirely unknown. The study of the physiology of the Myxomycetes is a promising field for research, and investigations on the lines of those of Raper and Sobels would undoubtedly yield important results. A revival of interest in this subject would be the best memorial to the devoted work of the Listers, father and daughter.

[1] Lister, A., "The Mycetozoa" (London, 1894; 3rd edition 1925).
[2] Pinoy, E., *Ann. Inst. Pasteur*, **21**, 622, 686 (1907).
[3] Raper, K. B., *J. Agric. Res.*, **58**, 157 (1939).
[4] Cohen, A. L., *Bot. Gaz.*, **101**, 243 (1939).
[5] Sobels, J. C., thesis, Utrecht (1950).
[6] Camp, W. G., *Amer. J. Bot.*, **24**, 300 (1937).

MAN AND THE ZEBRA

THE past and present position of the zebra in Africa has recently been described by J. I. Menzies (*Oryx* (Journal of the Fauna Preservation Society), 1, No. 3; September 1951).

Zebras include those species of Equidæ more or less marked with alternate dark and light bands, and fall into three groups. The first group is made up of two species, *Equus quagga* (the quagga) and *Equus burchelli* (Burchell's zebra). The second and third group each include only one species, *Equus zebra* (mountain zebra) and *Equus grevyi* (Grevy's zebra). Separate genera have been proposed for these species (*Hippotigris* and *Dolichohippus*); but these are usually regarded as sub-genera.

Equus quagga and *Equus burchelli* were both plains-dwelling species, often associating in immense herds with gnu and ostrich, but keeping separate in the overlapping portions of their ranges. Commencing with *Equus quagga* (striped only on the anterior portion of the body) and passing through the several sub-species of *Equus burchelli*, a gradual extension of the striping can be traced, culminating in the fully striped northern races.

The range of *Equus quagga* was fairly well defined, from the Kei River west at least as far as Swellendam and north to the Orange Free State and Griqualand West. *Equus burchelli* shows a great variation in striping; but, of all the numerous sub-species that have been proposed, only four are recognized as valid. The southernmost is *Equus burchelli burchelli*, which was found in the Orange Free State and Southern Bechuanaland but not south of the Orange River. The whole of the body was striped but not the legs, the haunch being more or less distinctly marked. Towards the posterior, broad shadow stripes appear between the dark stripes. The second sub-species is *antiquorum*, with the legs incompletely striped and the shadow stripes less distinct than in *burchelli*. This race once inhabited Southern Angola, South-West Africa, eastwards to Southern Rhodesia and Zululand.

The last two sub-species, *selousii* and *böhmi*, are fully striped to the hooves with the shadow stripes indistinct or altogether absent. They range from the Limpopo northwards, east of the Rift Valley through Rhodesia, the Congo (Katanga and Ruanda), Nyasaland, Tanganyika, Kenya and Uganda, to Abyssinia and Somaliland.

The second group of zebras (mountain zebras) includes only one species, *Equus zebra*, completely striped with broad black bands. Two sub-species are recognized. *Equus zebra zebra* had a limited range in the mountains of the Cape Colony. *Equus zebra hartmannœ* is now greatly restricted, but was formerly found in South-West Africa along the sub-continuous chain of arid mountains bordering the western edge of the Namib desert. Frequently found on the seashore, it often occurred up to 7,000 ft. and was rarely seen more than thirty miles inland. It ranged from Southern Angola across the Orange River to the Kamiesberg. Both sub-species associated only in small parties.

The third group (Grevy's zebra) also includes only one species, *Equus grevyi*. This became known to science as late as 1882, although the Romans had zebras which may have been of this species. These zebras appear to inhabit open, sparsely-wooded country, avoiding thick bush, and are rather localized throughout Southern Abyssinia and Western Somaliland. Southwards they range into Kenya to the Tana River, westwards to Lake Rudolph and eastwards to the western border of Somaliland. They do not appear to occur farther north than lat. 8°. The species appears to be fairly numerous over its original range and is in no danger of extinction. Of the other two groups, one species (*Equus quagga*) and one sub-species (*Equus b. burchelli*) are extinct and another (*Equus z. zebra*) brought to the verge of extinction.

Being the most southerly of the zebras, *Equus quagga* was the first to suffer from the advance of civilization. Initially, quaggas existed in countless thousands, until the Boers began their systematic exploitation. By the first quarter of the nineteenth century the former herds of thousands had been reduced to herds of thirty to fifty animals. By 1840 they had been driven to the borders of the Cape Colony. North of the Orange River, however, they were still numerous ; but exploitation for their hides continued. In addition, the farmers found the beasts a ready source of cheap meat for their native labour. The last two quaggas in the Cape Colony appear to have been shot on the Tygerberg Mountain, near Aberdeen, in 1850. Quaggas still lingered on, however, in the Orange Free State, possibly as late as 1878.

Several times quaggas have been reported from the Kaokoveld, South-West Africa, but this is almost certainly due to confusion with Hartmann's zebra.

The history of *Equus b. burchelli* followed a similar course. It once existed in immense herds, "but all have long ago been swept away by the rifle". Like its relative south of the Orange, this species provided a cheap supply of meat for the native labour of the progressing colonists.

The other three sub-species of *Equus burchelli* are still numerous ; in some parts the numbers have to be kept under control to avoid damage to crops. In South-West Africa *antiquorum* is common and far outnumbers *hartmannœ*. Some have adapted themselves to the mountain ranges of South-West Africa, occurring alongside but not associating with *hartmannœ*.

Farther to the north and east the races *selousii* and *böhmi* are still found. Where there is little cultivated land they are in no danger of reduction and in the various national parks and reserves provide one of the greatest attractions.

Equus zebra, with its two sub-species, *zebra* and *hartmannœ*, was always a more specialized animal with a very restricted range. With the quagga, the Cape race was early subjected to the onslaught of the colonists, but owing to its inaccessible habitat was not so seriously affected. As did the quagga, it provided cheap meat and leather for the farmers. By 1935 it was estimated that only a hundred were left alive. The species was then accorded complete protection ; but the numbers were still reduced by poachers.

In 1937 the Government voted a sum of £7,600 for the establishment of a reserve to the west of Cradock. By 1949 the stock in the reserve was reduced to two stallions, which have since died. More recently, a new herd has been located in the Outeniqua mountains, and it was suggested that a new reserve be established there. The sum total at that time was between seventy and a hundred. In September 1950, this new reserve was opened and enriched by the generous gift of eleven animals from an African farmer. It is hoped that the future of the mountain zebra is now secure.

THERMAL SWITCH FOR THE ATTAINMENT OF VERY LOW TEMPERATURES

IN a recent issue of the *Proceedings of the Physical Society**, workers at the Clarendon Laboratory, Oxford, described how, by an ingenious method employing a superconducting lead wire as thermal switch in a two-stage adiabatic demagnetization process in which a magnetic field of only 9,000 gauss was used, they have been able to attain an absolute temperature of approximately 0·001° K. and to hold the temperature of the system below 0·01° K. for forty minutes.

In the adiabatic demagnetization method of cooling, the magnetization is usually carried out at a temperature of about 1° K., the lowest temperature attainable by pumping liquid helium. Large water-cooled magnets are required to produce the necessary field, but the use of such large fields can be avoided by using a two-stage process in which the second-stage magnetization is effected at the lower temperature, less than 1° K., reached by the first-stage demagnetization. It is necessary, however, to have a means of making and breaking the thermal contact between the two stages. E. Mendoza, in 1948, used a piece of copper foil which was broken mechanically after magnetization of the second stage, but his apparatus suffered from very rapid reheating of the second stage.

The Oxford method is to use two cylinders of compressed salt, the upper and larger of iron ammonium alum, and the lower a dilute mixture of crystals of potassium aluminium alum and potassium chrome alum, as the two stages, connected by a lead wire

* Darby, J., *et al.*, *Proc. Phys. Soc.*, A, **64**, 861 (1951).