The success of the 'micro-incineration' technique depends on the ability to attain high current densities through the specimen, a condition which was easily satisfied by the use of a cathode-biased electron gun on our R.C.A. Model *EMU* electron microscope. It was observed that unstained myofibrils, when suddenly subjected to a high-intensity beam in the electron microscope, suffered a serious decrease in contrast, presumably resulting from the loss of bound water, organic matter and salts volatile under electron bombardment. The recent observation[6] that the evaporation of potassium salts under high-intensity beams in the electron microscope may not be an entirely thermal phenomenon has led us to believe that our observation was of an essentially similar nature. However, in a few fields containing myofibrils of favourable dimensions, the structure of the residue was particularly clear. Fig. 3 is an electron micrograph of such a field. A striking feature of the phenomenon is the complete disappearance of *Z* and *M* bands. This has been observed to occur in a large number of myofibrils. However, the fine transverse striation was only obtained when the optimum conditions of myofibril dimension and rate of increase of beam intensity were satisfied. The periodicity of these bands of residual crystalline material was again about 400 A., leaving little doubt that they correspond with the striations present in both stained and unstained myofibrils viewed with low beam-intensity (Figs. 1 and 2). The relatively refractory nature of the residual crystalline material suggests that it consists almost entirely of salts of magnesium and calcium, a finding which is supported by the thermal stability and relative resistance to electron bombardment exhibited by crystals of these salts. The ease with which potassium salts may be evaporated under similar conditions justifies the conclusion that all the potassium content of the myofibrils was evaporated under the influence of the beam.

Since we have invariably used suspensions of the fixed material obtained by mechanical agitation and afterwards centrifuged and resuspended several times in distilled water, it must be concluded that the residual mineral content of the myofibrils is either bound by the protein or present in the form of insoluble salts. The disappearance of the *Z* and *M* bands and of the *Q* substance during 'micro-incineration' (Fig. 3) indicates that magnesium and calcium are either absent, or present only in very small amount in these components. Furthermore, their content is distributed periodically throughout the sarcomere.

The distribution of potassium is less definite than that of magnesium and calcium. Macallum[7] obtained a distribution of potassium resembling the distribution of density in Fig. 1. The distribution of mineral ash as demonstrated by Scott[8] was similar, the *J* and *H* bands being almost ash-free, while the *Q* and *Z* bands were represented by deposits of ash. It is to be noted that the thickness variation of the dehydrated myofibrillar fragments, as evident from the shadow in Fig. 2, corresponds exactly with this ash distribution. Preliminary experiments have shown that the myofibrils in our suspensions contain some potassium, amounting to about 0·05 per cent of the dry weight, and apparently firmly bound by the protein. The disappearance of the *Z* and *M* bands and of the *Q* substance during high-intensity electron bombardment then suggests that the mineral content of these components consists largely of potassium and perhaps sodium.

This conclusion is interesting when compared with the affinities for phosphotungstic acid exhibited by the various bands. Although this reagent is used in the analytical determination of potassium[9], it is known to react with proteins and protamines, and cannot be regarded as specific for the localization of potassium. However, the low affinity of the *J* and *H* bands and the high affinity of the *Z*, *M* and *Q* bands for this reagent indicates that at least a part of its 'staining' action on muscle is attributable to combination with potassium held by the protein.

With these observations in mind, the ultrastructure of skeletal muscle begins to assume a concrete form. The myofibril consists of long filaments of actomyosin, aligned parallel in thin sheets, the filaments being held together by the transverse *Z*, *M* and lesser bands and perhaps also by an inter-filamentous matrix substance. A regular fine transverse striation is present arising from a periodic concentration of magnesium and calcium bound to the actomyosin framework, the periodicity being about 400 A. Superimposed on this skeletal framework is the *Q*-substance, which presumably contains protein in globular form, potassium, chloride, phosphate, adenosine triphosphate and other constituents, and which moves in characteristic fashion within the sarcomere during contraction. While it is clear that *Z* and *M* bands exercise a structural function in binding the filaments together, it seems likely that they perform other functions also, possibly connected with innervation of the myofibrils.

The new technique has also been successfully applied in the determination of mineral distribution in collagen protofibrils, one of which may be discerned in Fig. 3. The minute residue is concentrated in the narrow portions of the collagen repeating-units.

Further work is proceeding on the localization of mineral content of muscle, collagen and other fibrous protein tissues. A fuller account will be published elsewhere.

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THE TEACHING OF BIOLOGY IN SCHOOLS

TWO "Educational Papers" have recently been published by the British Social Hygiene Council. No. 1 deals with "Biology in the Secondary Modern School" by Frank Tyrer, while No. 2 is concerned with "Social Biology for Sixth Forms", by Eric Lucas. Presumably, coming from such a source, they may be looked upon as propaganda or, more correctly, information of use to those who sympathize with the ideals of the British Social Hygiene Council, and, in this case, are actively concerned with the spread of those ideals, for they are both pamphlets of primary use to teachers. Presumably again, they must have been passed by an editorial board or at least an editor. But what is most puzzling is how two such completely diverse pamphlets could have been approved by the same editor, for, if either one points the good way to teaching the subject then, without any shadow of doubt, the other points in the opposite direction.

The first pamphlet deals in a simple straightforward way with the teaching of biology to pupils during their four years at a secondary modern school. The ground covered by the syllabus is admirable—perhaps this is because there is no particular examination at the end; but in any event it is conceived in a fundamentally sound manner, the object in view being on one hand to give the child a simple idea of how its own body works and on the other to demonstrate its relation to the society in which it lives. Moreover, it deals in a straightforward way with the idea of evolution so that the child comes to realize that this conception is no private concern of biology, but refers to all things which he sees around him. From the practical point of view it rightly insists on building the course on the elementary nature study which it assumes has been done at the elementary school. At the other end it points out how much valuable work can be done by arranging for the children to visit outside institutions—hospitals, sanitary works, factories and so on—to see how the knowledge of biology is applied in the social services. One small point of criticism which is probably due to an oversight on the part of the author is that there is no mention of the use of museums at this stage of education. Museums, properly used, can be of great value to modern school children, especially in cities where it is difficult for children to get out into the country to study some natural history problem at first hand. The study of one particular group of animals or plants can be used as a tree on which to hang all sorts of valuable ideas; thus in the last year in the modern school, the child might take up such a group as fishes or spiders or so on, and here the museum, preferably with a sympathetic curator, can be of very real value. The pamphlet throughout is well planned: the author does not over-emphasize any particular aspect. He clearly has no particular axe to grind, and he knows how to teach.

The second pamphlet, on the other hand, can only be described as fantastic. It purports to deal with the way in which biology, and social biology at that, can be introduced to a sixth form who have done no biology before—"a mixed class of history, classics and mathematics specialists is perhaps the most desirable". The time allowance is two 45-minute periods per week for one whole year. The published syllabus *for the first term alone*, ignoring its more absurd extravagances, contains the fundamental introduction to animal biology, let alone its references to botany, that a professor of zoology would hesitate to deal with in under a complete year, and at the university a professor can reckon on at least three one-hour periods per week backed up by six hours practical work in which the student can clear up his ideas by 'picking the brains' of the demonstrators. The second term's work is devoted very largely to a study of Mendelism, or to be fashionable perhaps we had better call it Neo-Mendelism. The third term continues with even more Mendelism and then goes on to a general consideration of psychology, even including *Gestalt* psychology, and after trifling with such things as intelligence tests and the diagnosis of mental deficiency, is rounded off with a discussion of the validity of psychology and the question of the free will!

Looking at the course as a whole, what strikes one immediately is the over-emphasis which is placed on the study of Mendelian inheritance; but this misguided tendency is nothing new. A glib knowledge of Mendelism is the one thing we can rely on among university scholarship hunters, however ignorant they may be on other matters. It is difficult to see what school teachers find of general educative value in this elaborate study of one particular type of inheritance. It is easy to teach, that is certain; but one hesitates to suggest that this is the reason why such a large proportion of the course is devoted to it.

As regards the detailed items of this syllabus, some are incredible. For example, after suggesting that the course should be introduced by a discussion on "the general characteristics of living matter, assimilation, respiration, irritability, reproduction and so on", which is all right so long as one spends sufficient time over it, it is necessary to point out the difference between animals and plants, and for this purpose, *mirabile dictu*, a discussion of plankton 'indicators' in relation to the herring industry is called for! This, so far as can be assumed from the syllabus, would occur at about the second lesson of the course, and it must be borne in mind it is designed for boys who have done no biology before. However, the cavalier way in which these difficulties of teaching are dealt with can be seen in such sweeping suggestions as "the study of the physiology of the sense organs, nerves, brain and spinal cord . . . dealing particularly in aspects that have philosophical implications". Apparently the philosophical side must be dealt with (whatever this means); but there is no evidence that any time is to be wasted on the *anatomy* of the organs. And then, further on, "Reproductive systems, fertilisation and embryology are described . . . and a simple account of experimental work on amphibian and chick embryos leading to the discovery of organisers is given"—an admirably conceived idea; but I wonder how long the author of this pamphlet takes to demonstrate to these sixth-form pupils the difference between a gastrula of a frog and the blastoderm of a chick.

The clue to this extraordinary pamphlet is probably to be found in the introduction, where it states that it is absolutely essential to be able to pursue at length any particular part of the course with discussions and debate in class; but equally "if the subject seems to be too difficult to hold the interest . . . the teacher must feel free to drop it". The very idea that if a teacher finds a part of the course boring or if his students find it boring then they should drop it and go on to something else is surely something new. An elementary biology course, as T. H. Huxley pointed out, is or should be a continuous whole. It may be possible to teach other elementary subjects by snippets here and snippets there; but this certainly does not apply to biology. What is this type of teaching leading to? It caters for just that type of 'talky-talky' which is becoming so fashionable nowadays under the heading of general knowledge to be given as (at present) a non-examinable subject to sixth forms. It is just the sort of thing for that type of student, so common among scholarship candidates, who can write glibly about any subject under the sun without any real understanding of the subject-matter. So long as this sort of general knowledge is kept, as at present, simply as something to occupy the spare time of the sixth-form pupils outside their specialized subjects and to stimulate them to think, then little harm can be done by the syllabus. But if, as seems likely, this general knowledge is to be included in the new examination as an examination subject, then the syllabus should be condemned outright. Its use would merely intensify the deplorable tendency, which those of us concerned with scholarships and the Higher School Certificate know only too well, of learning whole passages and whole problems by heart on the chance of getting a question on them in the examination. To suggest that there are boys who, not knowing any biology before, could really assimilate in approximately eighty 45-minute periods the contents of this syllabus and retain a coherent idea of its range is asking too much of the imagination.

H. GRAHAM CANNON

STRUCTURE OF THE RESTING NUCLEUS IN *MARASMIUS ANDROSACEUS* FRIES.

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HOLLANDE[1] considered that living protoplasm in general consisted of filamentous, hyaline tubes with numerous clusters, made up of two punctiform corpuscles, distributed over their surface; and that the nucleus had a comparable structure. Hollande and Hollande[2] made similar findings for Bacteria and Cyanophyceæ. Drennan[3], studying human blood, described granules which moved freely in the serum and which were of different kinds, as they reacted differently to stains and varied in size and degree of motility. Sparrow and Hammond[4] noted Feulgen-positive bodies in the cytoplasm of the meiotic prophase stages of microsporocytes in eleven different flowering plants. These bodies appeared to originate in the nucleus or at the nuclear membrane. They regarded the positive Feulgen reaction together with high absorption at 2537 A. and 2650 A. as proof that the bodies contained desoxyribose nucleic acid, and strong absorption at 2804 A. as an indication that protein also was present. Calvet, Siegel and Stern[5], as a result of electron optical observations, reported that the resting nuclei of calf thymus lymphocytes, treated with lanthanum acetate, showed nucleoprotein ultrafibrils of approximate thickness 80–100 A. These appeared banded. They concluded that the banded appearance was probably due to the coiling of a fine thread to form long helices and that the spirals might be formed by individual desoxyribonucleoprotein molecules in combination with lanthanum ions. Malvesin-Fabre[6] found, in the living nuclei of *Arum italicum*, that there were chromocentres which continuously changed their form and appearance and that the nucleus showed continuous activity in the resting stage. Ritchie[7], working on fixed and stained basidia of *Amanita cæsaria*, found extra-nuclear inclusions, frequently near the base of the basidium, which were readily stained with hæmatoxylin and were Feulgen-positive. He regarded them as chromatic in nature.

The recent papers cited above show that there is an accumulating body of evidence which points to the existence in the cells of many plant and animal groups of: (1) chromatic bodies in the cytoplasm; (2) a fibrillar structure for the protoplasm; (3) a high degree of activity associated with the so-called resting nucleus.

In an account given to Section K at the recent meeting of the British Association at Brighton, I described observations made on the mycelia of *Marasmius androsaceus* Fries. and put forward a theory on the structure of the resting nucleus in this basidiomycete. Many of the general points raised are referred to in a paper to be published elsewhere[8]. In view of the evidence referred to above, it seems desirable to put on record the principal points in my account which refer to nuclear structure.

Growing hyphæ were studied with the use of agar films supported on coverslips[9], using phase-contrast methods. Apparatus of the type recommended by Burch and Stock[10] was used in this laboratory, pending the arrival of the outfit manufactured by Cooke, Troughton and Simms; but observations have been checked on the latter type of instrument at the Strangeways Laboratory, Cambridge, through the courtesy of the director, Dr. Fell, and of Dr. Hughes. Fixed and stained preparations have also been made using half-strength Flemming's fluid[11] and a number of non-osmic fixatives[12,13], of which Belling's modification of Navashin has been the most successful. Heidenhain's hæmatoxylin[11] and the Feulgen stain have been used; the former counterstained with Light Green[11] and the latter with Fast Green[14] when desirable.

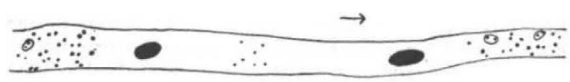

Fig. 1

The living hyphæ contain paired, grey structures, round or oval in outline, corresponding in size and position with the heterokaryotic pairs of nuclei so often seen and figured in stained preparations of basidiomycete mycelium. In addition, there are numerous moving dark granules scattered throughout the cytoplasm. There is an area of marked concentration of these granules nearer the hyphal tip than the more advanced member of the pair of grey bodies and a similar area behind that which is farther away from the tip. Between the two grey bodies there is also a region of concentration of granules, though this is less pronounced than the first two. Some of the granules are associated with cleared areas in the cytoplasm and are paired (Fig. 1). They may move relative to each other, but their association is maintained. In the Basidiomycetæ generally, clamp-connexion formation is associated with the division of the two nuclei of the heterokaryon. In *Marasmius androsaceus* Fr., as a clamp connexion begins to form, the two grey bodies position themselves so that one is in the developing hook of the clamp connexion and the other at or near it in the parent hypha. The cytoplasmic activity in general and that of the granules in particular becomes concentrated very near or on the grey bodies (Fig. 2).

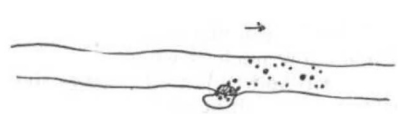

Fig. 2