light falls upon the oxide surface the photo-current flows from copper to oxide internally, that is, in the reverse direction, and it may be expected that the magnitude of the current would be related to the reverse characteristic of the rectifier. There is, however, no evidence to support this. The cell has a red and infra-red colour response and the cut-off at the end of the visible spectrum corresponds exactly to the commencement of the light transmission of the cuprous oxide, which, therefore, must be acting as a filter. Maximum colour response is approximately in the middle of the visible spectrum.

SPERMATELEOSIS AND NUCLEINATION

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SINCE the early studies of Miescher[1] followed by those of Steudel and Peiser[2] on the chemical constituents of the sperm-heads, it has been known that these, which represent so far as we know, the consolidated essence of nuclear matter, contain a large percentage of nucleo-proteins which make up much of the chromosomes of the nucleus. In fact, our knowledge of the chemistry of the nucleus has largely been based on these pioneer studies, and as a result, it has now been clear that the chromosomes are in the nature of complex salt-like compounds of proteins and nucleic acids called nucleo-proteins. The two conditions of the nucleus, that of rest and that of division, differ mainly in the polymerization of nucleotides on the protein framework of the chromosomes. It is surmised that most, if not all, nucleic acid of the chromosome comes from the cytoplasm where it exists as isolated nucleotides and which are transferred to the chromosomes at the beginning of every mitosis. In fact, one of the important changes associated with mitosis is the nucleination of the chromosomes, whose fixability, and visibility under the microscope are due to the accumulation of nucleotides on the protein framework of the chromosome, which is the permanent part of the chromosome, the nucleic acid varying in amount at different stages of the mitotic cycle. It has even been suggested that the sudden increase of nucleic acid in the chromosomes at pro-metaphase of mitosis is due to the breaking down of the nuclear membrane at this stage and the free transference of material from the cytoplasm to the chromosomes (White[3]). So the idea has gained ground that the mitotic process is a necessary prerequisite for the organization of the chromosomes in a recognizable form, and for their nucleination. For, at no other stage the chromosome is visible in the nucleus, nor is thymonucleic acid identifiable in the nucleus at any other time.

But that leaves the sperm-head, which has formed the important source of our information on the chemistry of the chromosome, out of the picture. The sperm-head is analogous to the metaphase chromosome in that it represents the synthesis and accumulation of the maximum amount of nucleic acid in relation with the protein; but while in the latter case, this synthesis has been achieved with reference to mitosis, in the former, the synthesis of nucleic acid has taken place without any reference to division and indeed, without any reference to the chromosomes. The sperm-head, therefore, offers the only example of the synthesis and accumulation of desoxyribose nucleic acid outside its relation with the definitive chromosome.

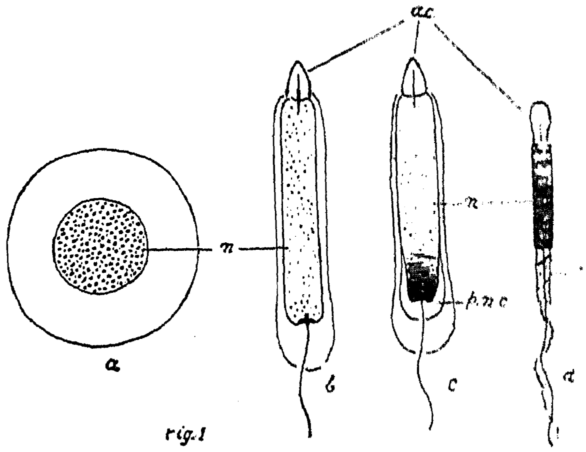

FIG. 1. Four stages in the spermateleosis in *Ichthyophis glutinosus*. × 600.

a. Resting nucleus of the spermatid.

b. Elongation of the nucleus during spermateleosis.

c. Beginning of nucleination from the posterior end.

d. Fully formed spermatozoon.

ac. acrosome; *m.p.* middle piece; *n*. nucleus; *p.n.c.* post-nuclear cavity (which later becomes the middle piece).

The process of spermateleosis confirms this. The animal spermatid has a resting nucleus, and associated with changes* which vary in different animals, this nucleus begins gradually to synthesize nucleic acid within it till in the fully formed sperm, the nucleus is the packed essence of nucleo-protein. If the mitotic cycle involves the transference of cytoplasmic nucleotides into the nucleus and their conversion from ribose to desoxyribose nucleotides, then the same process must take place during spermateleosis also, where, however, without changes associated with mitosis and without the formation of organized visible chromosomes, the essentials of the same process of deposition of desoxyribose nucleic acid takes place in the nucleus.

There is yet another parallel between the development of the metaphase chromosome and that of the spermatozoon. In both it is probable that important changes occur in the protein constituents. Miescher[1] himself showed that the metaphase chromosome, like the sperm-head, contains only simple proteins of the histone and protamine types associated with desoxyribose nucleotides, the higher globulin types of proteins breaking up during mitosis and spermateleosis respectively (Miescher,[1] Darlinghon,[4] Caspersson[5]). But this similar end result is achieved in two different ways, in one case by the organization of the chromosome with which the nucleotides are associated, and in the other, without the formation of definitive visible chromosomes.

When we talk of condensation and consolidation of the nucleus during spermateleosis, it implies much more than a mere physical change. It means primarily, a reduction in nuclear volume brought about by an expulsion of water and nuclear sap. This reduction is often considerable as shown in the Apoda (Amphibia) by the author[6] where it may be as much as 95 per cent. But it also means another more important thing. It means the acquisition of nucleotides by the consolidating nucleus from the cytoplasm if they have to come from outside the nucleus; or if they have not, their production inside the nucleus itself. In this matter, whatever the condition in embryonic and meristematic tissues where cytoplasmic ribose nucleotides have been detected (White[3]), in the developing spermatid at any rate, their occurrence in the cytoplasm in any large quantity is highly improbable. The amount of cytoplasm in a developing spermatid (of the Apoda, for instance) is so inconsiderable that the likelihood of there being any appreciable quantity of nucleotides in it to contribute to the sperm-head is very little indeed. Spectroscopic observations in certain tissues have shown the relative paucity of nucleotides in the nuclear sap (White[3]) but in view of the foregoing it would be interesting to examine by spectroscopical analysis, developing spermatids.

Wherever the nucleotides come from, either from the cytoplasm or the nucleus itself,—and the former possibility is very remote,—their original reactions are such that in the early spermatid they are of the ribose type and as in mitosis, they are converted into those of the desoxyribose type in the fully formed sperm-head.

There is yet another curious relationship between the chromosome and the sperm-head to be considered. The reproduction of the chromosome during mitosis (and meiosis) is dependent on the acquisition by the protein framework of a minimal quantity of nucleic acid charge. It is admitted that it is probable that here is involved not only a quantitative relationship between the protein and the associated nucleic acid but also a relationship of *arrangement* of the desoxyribose nucleotides with reference to the protein framework. In any case, assuming that the synthesis of nucleic acid in the nucleus has an important bearing on the reproduction of the protein framework of the chromosome, the synthesis of nucleic acid in the nucleus of the developing spermatid unattended by any attempt at or evidence of reproduction is full of interest. It is highly probable that the whole relationship of the protein and nucleic acid is a different one in the sperm-head from that in the mitotic chromosome. This itself is a matter of considerable interest, for by two essentially different vital processes, the synthesis of nucleic acid can take place in animal cells, (1) by mitosis and (2) by spermateleosis. This would impart a wholly different complexion to the process of spermateleosis and make the spermatozoon a highly specialised cell in more than one respect.

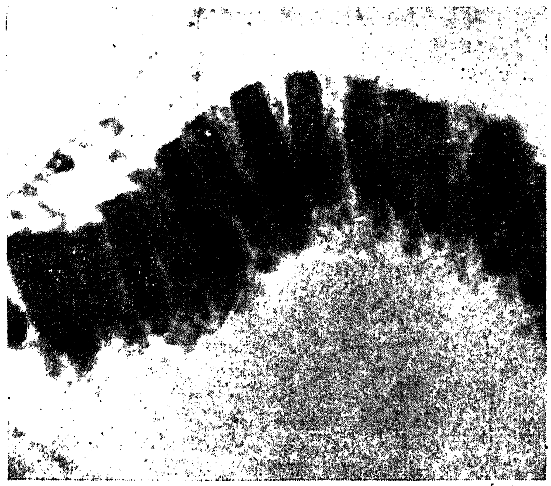

FIG. 2. Microphotograph of the developing spermatids of *Ichthyophis glutinosus*, showing the beginning of nucleination. × 1500.

The details of the process of nucleination of the spermatid nucleus are full of interest in this connection. In the Apodan spermatid with which the author[7] is particularly well acquainted, the following briefly are the facts: The spermatid nucleus is at first spherical and is in the resting condition. It gradually assumes an elongated cylindrical form and at the same time becomes fainter in its staining capacity. When this elongation has reached its maximum (which varies in the different species of Apoda examined) the nucleus begins to contract in length as well as in girth, and associated with this contraction in size is the beginning of the synthesis of thymonucleic acid. The nucleus, which till now was only very faintly staining, shows posteriorly a positive reaction with Feulgen and the narrowing nucleus gradually shows a deeper staining power. This synthesis of thymonucleic acid as evidenced by the staining reactions extends gradually forward till it pervades the entire nucleus, which now is narrower and shorter but a deeply staining cylinder. If we divide the nuclear history during spermateleosis in Apoda into two phases, the first phase is concerned only in the elongation of the nucleus, while in association with the second phase is a double phenomenon of shortening and consolidation as well as the synthesis of thymonucleic acid. By this time the cytoplasmic equipment of the elongated spermatid is so meagre that, as already observed, it is highly unlikely that any contribution of nucleotides could be made by it. The staining reactions prove this. It is more probable, on the other hand, that the nucleotides in a ribose state exist within the nucleus itself and in the second phase of the nuclear history of the spermatid, are converted into those of the desoxyribose type.

Throughout spermateleosis there is a continuous process of concentration and reduction of the volume of the nucleus but while in the first phase, there is only reduction in volume, in the second, there is in addition, a synthesis of desoxyribose nucleic acid.

Much of the above account of spermateleosis refers to the Apoda (Amphibia) which illustrate the phenomenon admirably, but it is probable that other animals display much the same process.

It is, therefore, clear that nucleination, far from being associated *always* with division, occurs at least in one other condition, *i.e.*, in spermateleosis, but in a fundamentally different relationship and unassociated with the formation of definitive visible chromosomes. Chemically and even quantitatively, the protein and nucleic acid of the metaphase chromosome may resemble those of the ripe sperm-head, but in one case, the protein is a fibrous framework with which at certain localised areas, the nucleic acid becomes associated, while in the other case, no chromosomes are seen. In one case, the synthesis of nucleic acid is associated with division and in the other, it is unattended by division.

The subsequent history of the sperm nucleus is also interesting. After entry into the ovum, it exhibits reactions which fall under two different categories. In the sea-urchin, it becomes converted back again into a resting nucleus and from all existing accounts of the details of fertilization (Wilson[8]) it is in this condition that it fuses with the nucleus of the ovum. On the other hand, in Ascaris, soon after the entry of the sperm the nucleus almost immediately becomes organized into the definitive haploid number of chromosomes characteristic of the species, and in this condition, with the chromosomes distinct within the nuclear membrane, it approaches the female pronucleus. A spindle is soon formed —the spindle of the first cleavage division,— and on it by the dissolution of the nuclear membranes of the sperm and the ovum, the chromosomes are placed; so that in Ascaris no mingling or flowing together of the nuclear material is involved.

The difference between the sea-urchin and Ascaris would appear to lie in the interpolation in the former of a resting stage before the actual fusion of the sperm nucleus with that of the ovum.

The significance of this from our point of view is important. In the sea-urchin processes which are the reverse of what take place during spermateleosis must occur during the early stages of fertilization. Nucleination which occurred during spermateleosis is followed by denucleination during the early stages of fertilization, where the sperm nucleus gets back into the resting condition. Obviously this supports the view expressed earlier that spermateleosis is a remarkably unique phenomenon without parallel in any other aspect of cell life, where nucleination occurs with reference to the resting condition, and unassociated with division of the nucleus.

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THE INDIAN INSTITUTE OF ART IN INDUSTRY

THE Indian Institute of Art in Industry, which has, during the last five years, pioneered the art-in-industry movement, has been registered and invested with an All-India status. The Institute will have a secretariat in Bombay and representatives in other important centres. It aims at becoming "the central guiding force in the country's art applied to industry".

The Institute will develop the art in industry exhibitions and will also build up an annual industrial fair of goods of attractive appearance, and this will greatly stimulate trade in the immediate post-war period. The Institute will engage experts in commercial art and industrial design, and will assist in the training of teachers for government technical institutions. It is intended that as soon as possible a monthly magazine will be published, followed in due course by other types of bulletins. A register of commercial artists and designers will be compiled. The Institute will strive to become as rapidly as possible a valuable complement to industry in matters pertaining to design, packaging, and the various aspects of commercial art. It is understood that a substantial grant from the Central Government is now under consideration and it is hoped that Provincial Governments and Indian States will give generous support to the Institute. It is expected that a revenue of 5 lakhs of rupees will be forthcoming to enable the Institute to carry out its programme, and of this sum, it is estimated that two lakhs will be contributed by industrialists.