von Kalkprismen durchsetzt. Der Schädel ist eine einheitliche Kapsel ohne alle Deckknochen. Der Nackenstachel sitzt auf einer Papille der Schädelkapsel und ist mit keiner Flosse in Verbindung. Die Wirbelsäule ist notochord, mit verkalktem centralen Faserstrang; Wirbelkörper kommen nicht zur Entwicklung. Das System der oberen Wirbelbogen ist stark entwickelt und bei zwei Gattungen kommen Intercalaria vor. Es sind sieben Kiemenbogen vorhanden. Der Schultergürtel ist mit einem Kiemenbogen vergleichbar. Die paarigen Flossen entwickelten sich aus einer Reihe ursprünglich neben einander liegender Strahlen. Die Glieder des sogenannten Hauptstrahles entstanden theils durch Verdickung der Glieder eines Strahles, theils durch Verschmelzung mehrerer Nebenstrahlen[2]. Ein Becken ist nicht vorhanden. Das Basalstück der Bauchflosse entstand durch Verschmelzung von Flossenstrahlen. Die Pterygopoden der alten Männchen sind ähnlich gebaut wie die der jetzigen Haie und auch bei den alten Weibchen kamen ähnliche Hilfsorgane für die Begattung zur Ausbildung. Die ovalen Eier sind festschalig.

Der Stammbaum der Haie würde sich mit Berücksichtigung der paarigen Flossen und der Zahl der Kiemenbogen jetzt folgendermaßen entwerfen lassen:

Aus Urfischen, bei denen die Flossen aus neben einander stehenden Strahlen bestanden, entwickelten sich Fische mit Archipterygium; diesen entsprangen einerseits die Dipnoi, andererseits die Xenacanthini mit 7 Paaren Kiemenbogen. Diese erhielten sich bis zum heutigen Tage in der Form des *Heptanchus*.

Von den siebenkiemigen Haien zweigten die sechskiemigen ab, die gegenwärtig durch *Hexanchus* und *Chlamydoselachus* vertreten sind. Von den sechskiemigen Haien zweigten die fünfkiemigen ab, denen fast alle jetzt lebenden Gattungen der Haie angehören.

4. Spermatogenesis in Myxine.

By J. T. Cunningham, M.A., Naturalist to the Marine Biological Association.

eingeg. 25. November 1890.

In the year 1887 when Dr. Fridtjof Nansen left Bergen to carry into execution his brilliant and famous exploit of walking across the ice-fields of Greenland in snow-shoes he left behind him a paper entitled »A Protandric Hermaphrodite amongst the Vertebrates«, which was published in the Bergens Museums Aarsberetning in the following

[2] Das Mesopterygium eines jungen *Scyllium* von etwa 50 cm Länge zeigt gegen das Licht gehalten die Strahlen, aus denen es entstand.

year. This paper dealt with exactly the same points which I had discussed in my memoir on the »Reproductive Elements in *Myxine glutinosa*« published in the Quart. Journ. Micr. Sc. in August, 1886. To a very large extent Dr. Nansen acknowledges his indebtedness to my work, and the priority of my discovery of the facts considered. But as both his title and his summary at the end of the paper seem to imply that the facts described were his own discoveries, it has occurred more than once that writers have referred the discovery of the »protandric« hermaphroditism of *Myxine* to Dr. Nansen. It is not my intention to dwell on this point now, but merely to point out that the only novelty in Dr. Nansen's description of the hermaphroditism of *Myxine* is the adjective »protandric« which did not occur in my paper. At the same time I am very glad that my results should have received full confirmation at the hands of another zoologist.

I have never been able to satisfy myself from reading Dr. Nansen's paper to what extent he himself intended to claim credit in this matter by his title. He quotes my paper correctly and largely in his historical introduction, but when he comes to my description of the spermatozoa he says »The description and illustrations which Cunningham gives of these spermatozoa do not agree with my observations of the real spermatozoa of *Myxine*, which I have found in the greatest abundance. I am afraid that what he has found has been the abnormal product of an, in this respect abnormal specimen«.

My original description was as follows: The spermatozoa possess a pear-shaped head, which is very highly refringent and has a distinct outline; round the posterior, thicker end of the head is a translucent protoplasmic body which is produced into a long tail. In some cases two spermatozoa were connected by their tails, and on the connecting thread thus produced were slight dilatations composed of clear protoplasm. In other cases a cell somewhat spherical in shape gave off two processes, one of which was the tail of a spermatozoon while the other terminated in a point, the head of the spermatozoon belonging to the process having probably become detached in the operation of teasing. — — — It is evident that the cells and spermatozoa described were derived from the spherical cells of the testicular capsules. These cells apparently develope the heads of the spermatozoa which then grow out from the cells trailing a thread of protoplasm which forms the tail. The curious thing about the spermatogenesis observed in *Myxine* is that the spermatozoa are attached to the spermatoblasts by the tails and not by their heads as usually occurs.

After quoting this description Dr. Nansen says »Those strange statements are completely erroneous as regards the structure of the

normal spermatozoa, as also the process of spermatogenesis; my investigations have led me to no such surprising conclusion, as will subsequently be seen, though the testis and spermatogenesis of *Myxine* is in several respect very remarkable.« In the report of his own observations he writes: »There can thus be no doubt that that portion of the generative organ is a real male organ; it is indeed strange that Cunningham has so little succeeded in finding spermatozoa.« Finally at the conclusion of his own description of the spermatogenesis he says: »As mentioned before, there is, so far as my experience goes, nothing in the spermatogenesis of *Myxine* which serves to indicate a development of the spermatozoa like what is supposed by Mr. Cunningham; that which he has seen in his preparation I cannot distinguish; is it possible that it is spermatozoa which have been artificially changed?«

The latter suggestion I may remark is not probable, for I described the spermatozoa in the fresh condition.

It seems from the above quotations that Dr. Nansen made the extraordinary mistake of believing that I had never seen the real spermatozoa of *Myxine* at all, that he saw them for the first time, and that therefore much of the credit of discovering the hermaphroditism belonged to him.

Dr. Nansen's paper is written in English and I have quoted his very words. But no separate copy of the paper was ever sent to me, and until recently I know its contents only from (a) a summary in the Journal of the Royal Microscopical Society 1889, p. 188, and (b) a French translation of the paper published in Prof. Giard's Bulletin Scientifique de la France et de la Belgique, III. Sér. II. Vol. 1889, p. 315. In the former and in an editorial foot-note to the latter, the discovery of the protandrous hermaphroditism of *Myxine* is attributed to Dr. Nansen, and the editors of these two journals are responsible, even more than Dr. Nansen himself, for having temporarily misled the majority of zoologists into supposing that the intrepid explorer of Greenland was also the discoverer of the curious sexual relations of *Myxine*.

In order to decide the questions at issue between Dr. Nansen and myself as to the spermatogenesis in the hermaphrodite reproductive organ of *Myxine* I visited Norway during the past summer and spent some weeks in Bergen and at Alverströmmen, 20 miles north of that city, where Dr. Nansen carried on his researches. I was enabled to undertake this journey by the aid of a grant from the state-fund administered by the Royal Society, and appliances and facilities for my work were placed freely at my disposal by the Director and staff of the

Bergen Museum to whose kindness and generosity I am deeply indebted.

The questions at issue are essentially two. Dr. Nansen describes and discusses the follicular epithelium of the testicular capsules, of which I in my original paper made no mention. I shall not discuss this point here further than to say that I think it extremely doubtful whether the epithelium referred to is in any way comparable to the follicular epithelium of an ovarian egg. I believe it to be most likely a germinal epithelium homologous with that which lines testicular tubes in other animals, and which in them gives rise to successive crops of spermatocytes.

The second question is more important, and here the difference between my original account and Dr. Nansen's admits of no ambiguity. Both of us have described and figured three principal cellular elements seen in ripe or ripening capsules:

(a) The spermatoblasts (Cunningham) or spermatides (Nansen), large spherical or polygonal cells with a large nucleus,

(b) spindle-shaped cells, bipolar, having a long attenuated process at each end,

(c) ripe spermatozoa.

Dr. Nansen says that these are but three successive stages in the formation of a single spermatozoon out of each spermatide. I stated in my original paper that the spindle shaped cells were the part of the spermatoblast left behind after two spermatozoa had separated from it, each protoplasmic process of the spindle having been previously continuous with the tail of a spermatozoon.

My original account of the spermatogenesis was certainly surprising to myself, and probably to those that read it. But Dr. Nansen though he uncompromisingly contradicts my version of the process gives no evidence of the correctness of his own. He says merely: »By an elongation of the nucleus as well as the whole body of the cell, these spermatides are now gradually transformed into ripe spermatozoa. Fig. 11 *caq* represents part of a capsule containing spermatides and spermatozoa, more or less developed. As to the details of the development of the spermatides into spermatozoa, I will give no circumstantial description here; my investigations of that branch of the subject are not yet finished. From the little I have seen I think however that it is evident that the spermatozoon is formed from the nucleus as well as from the protoplasm of the spermatide, i. e. the whole spermatide is transformed into a spermatozoon. As to the tail, that is perhaps formed partly by an elongation of the nucleus partly by the protoplasm of the spermatide«.

The remarks just quoted show that Dr. Nansen had not acquainted himself with the generally accepted facts concerning spermatozoa in general. If he had done so he would have known that in all cases hitherto described the head of a spermatozoon consists almost entirely of a nuclear body (chromatin) and the tail exclusively of extra-nuclear protoplasm. It is certainly not true that nuclear matter can be recognised in the tail of the spermatozoon in *Myxine*, and if it were true it would require to be proved by satisfactory evidence.

An examination of Dr. Nansen's figures shows that he had not sufficiently mastered the histological methods which he employed. He represents the elements as stained with saffranin, but in most cases the staining is diffuse and not selective or differential. I conclude from the figures that he neglected to wash out the stain from his preparations in the proper manner and to the right degree. In his figures of the three kinds of elements I have mentioned, the extra-nuclear protoplasm is stained almost as much as the supposed nuclei. The nuclei are in many of the figures, especially in those of the spindle-shaped cells and the ripe spermatozoa, indefinite and without characteristic structure. The nuclear part of the head in the spermatozoa is almost indistinguishable from the extra-nuclear portion. In the figures of the spindle-shaped cells what are indicated as nuclei are not nuclei at all. I procured plenty of material in Norway, and have made many preparations stained with saffranin, and in all the preparations I find a definite, deeply stained, small nucleus in the larger spindle-shaped cells, which is not represented in Dr. Nansen's figures; while the central elongated deeply stained portion in Dr. Nansen's figures is seen to consist merely of the central protoplasmic strands of the cell which, in consequence of the drawing-out of the poles, run in the direction of the axis of the spindle.

Both in the fresh preparations examined and drawn in Norway, and in sections made since my return, I have seen again and again spermatozoa continuous by their tails with the poles of the spindle-shaped cells. I am inclined to think that spermatozoa are given off from the spindle-shaped cells in succession, each head being formed by a fragment of the nucleus, until no more nucleus is left, when a small spindle of non-nucleated protoplasm is left behind as a useless remnant.

It seems to me therefore certain that each spermatoblast gives rise in *Myxine* as in other animals to a number of spermatozoa, and that the spermatozoa separate from the spermatoblast not tail first as in other animals, but head first. I hope soon to publish full details of my

observations with figures, and thus to supply good evidence that my original statements were correct in every particular, though necessarily somewhat incomplete.

5. An Experiment concerning the Absence of Color from the lower Sides of Flat-fishes.

By J. T. Cunningham, M.A., Naturalist to the Marine Biological Association.

eingeg. 1. December 1890.

One of the most interesting questions which biological research has still to decide is whether adaptations in organisms are due to the natural selection of indefinite variations or to the definite influence of the conditions of life. One school of evolutionists, that of which Weismann is one of the most eminent leaders, maintains that every character in animals is an adaptation and every adaptation is sufficiently explained by indefinite variation and natural selection. Another school believes that many things are not adaptations and that those characters which are adapted are due to the definite influence of conditions. The former school would I suppose maintain that the whiteness of the lower sides of flat-fishes was an adaptation, and was due to selection. What is the especial advantage of this character to flat-fishes I am unable to perceive. But it seems to me more probable that it is due in some way to the fact that little or no light can fall on the lower sides of these fishes, because these sides are generally in contact with the ground.

The following experiment seems to me to support very strongly the latter views; it was carried out in the Plymouth Laboratory of the Marine Biological Association.

At the beginning of last May I received from Mevagissey in Cornwall a large number of young flounders (*Pleuronectes flesus*) in process of metamorphosis. They were very transparent and measured 11·5 to 12·7 mm in length. In a few the metamorphosis was almost complete the left eye having reached the edge of the head but in the majority the left eye though it had commenced its »migration« was still on the lower side. The little fish had already developed the habit of lying on the bottom on the left side. Nearly all the pigment, i. e. the chromatophores had disappeared from the lower side, where only a few scattered black and yellow cells remained: on the upper side the pigmentation was considerable, but not so fully developed as in the adult.

On May 8th I took about 15 or 16 of these small flounders and placed them in a glass vessel without sand. This vessel I placed on a plate of glass supported at the ends by two supports. Beneath the glass plate I arranged a mirror about 15 inches by 12, sloping it at an angle