The Generative Organs of the Oyster.

Abstract of a paper by Dr. P. P. C. Hoek.*

By

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With Plates XXII and XXIII.

The following description of the reproductive organs of the oyster cannot well be understood without some acquaintance with the general anatomy of the animal. With the help of Pl. XXII, fig. 1, the most important features of its anatomy may readily be understood. It must be remembered that the valves of the oyster's shell lie right and left of the animal; that the concave valve which lies undermost in the natural position of the animal is the left valve, and the flat upper valve is the right valve. The hinge marks the dorsal border of the animal, and the opposite border is the ventral border. That side which is on the observer's right in fig. 1 is the anterior surface, and that on the left hand is the posterior surface. As the animal is compressed from side to side the anterior and posterior surfaces are very narrow. The great adductor muscle, by which the valves of the shell are closed, is seen lying in the centre of the animal in fig. 1.

If the right mantle lobe is cut through along the anterior and ventral border of the adductor muscle, as in the figure, a finger-shaped process, called by Dr. Hoek the *oral process*, is seen to project from the trunk of the oyster, and to lie closely applied to the ventral border of the muscle. This oral process contains a loop of the intestine and, in addition, a portion of the reproductive organs and of the excretory organ. A large nerve-ganglion, the branchial ganglion, lies between the adductor muscle and the oral process. From this ganglion a number of nerves are given off, the most con-

* Tijdschrift der Nederlandsche Dierkundige Vereeniging, Supplement Deel i, Aflevering i, p. 115. Leiden, 1883. See also Dr. Hoek's prize essay in the Literature of the International Fisheries Exhibition. London: Wm. Clowes and Son.

siderable of which passes forward for a short distance, curves over the oral process, and supplies the posterior part of the gills. It is shown in fig. 1. If this nerve is carefully examined in its course over the oral process, a slit may be distinguished, lying close and parallel to it, on the oral process. This slit—which may be seen on both the right and left sides of the oral process—is the *urogenital aperture.*

Fig. 2 is a diagram to exhibit the relations of the organs which open on each side of the body by the urogenital apertures. The so-called kidney or organ of Bojanus, first discovered and described by Dr. Hoek, is represented in shading. Its structure need not detain us; it is sufficient to say that it is a paired organ, and that it communicates on either side of the body with the pericardial cavity by a canal, marked *Rp.C.* in fig. 2. The generative organs are represented by thick black lines, but are shown smaller than they actually are to avoid encumbrance of the figure.

Like the organ of Bojanus, the reproductive organ is paired, but its branches interlace and anastomose to such an extent that the two members of the pair become confounded with one another, and the paired apertures are the only evidence of the double character of the organs.

Two portions may be distinguished on either side, the reproductive organs properly so called, and the genital duct. There are no accessory organs, such as yolk-glands.

The generative organs may most conveniently be studied in a year-old oyster. The genital duct opens into the anterior part of the slit-like urogenital aperture. At a short distance—half a millemetre, for example—from its opening the duct begins to give off a number of *culs-de-sac,* which are placed perpendicularly to the direction of the duct, and are nothing more than outgrowths of its wall which project into the surrounding connective tissue. The epithelium of the wall of the canal is continued along the walls of the outgrowths, but the cells are not provided with vibratile cilia and are not distinctly marked off from one another. It appears that at a subsequent period they multiply and become metamorphosed into generative products, ova or spermatozoa. If the genital duct is followed further forward to the pericardial cavity, a number of similar canals are seen to originate as outgrowths of the genital duct. These lateral canals penetrate into the connective tissue of the oral process or spread out parallel to the surface of the oyster. In the former case the genital products are developed on both sides of the canals, in the latter case only on that side opposite to the surface of the body. In the latter case the wall of the canal which runs parallel with, and at a little distance from the surface of the

body, is composed of an epithelium provided with vibratile cilia quite similar to that of the genital duct, of which it must be considered as a continuation.

In front of the pericardial cavity it becomes difficult to follow the genital duct. It divides into several branches, which spread on the surface of the body, and, like the outgrowths of the first part of the duct, run for a short distance parallel with the surface of the body. All these canals are oval in section, and their outer and inner walls differ in minute structure; the outer wall is lined with a ciliated epithelium, whilst the epithelial cells of the opposite wall are evidently already in the process of transformation into generative products.

The canals themselves are placed at considerable distances from one another. Their interior walls often show the commencement of a number of *culs-de-sac*, which enter the surrounding connective tissue. The *culs-de-sac* seem always to be longest near the genital aperture, and decrease in size and development the further they are from it.

In a ripe oyster several changes have taken place. The growth of the whole body is accompanied by a growth of the lateral branches of the genital duct, both in length and in size. The number of the branches is much increased, and they anastomose to form a network of branches and branchlets on the two sides of the body of the oyster, which is not the case, as far as can be as ascertained, in a yearling oyster. Extending still further, the branches of the two sides of the body unite and anastomose. At this stage the generative organs nearly surround the trunk in front of the adductor muscle. They lie near the surface, but are separated from it by a thin layer of connective tissue, and are continued by the anastomoses of the network of either side, over the anterior and posterior surfaces, but are more conspicuously developed on the posterior than on the anterior surface.

The productiveness of the generative organs is dependent on the increase of their surface. This is attained not only by the multiplication of their branches, but also by the growth of the walls of each branch. That part of the wall of each canal which is opposite to the surface of the oyster increases greatly, and penetrates into the connective tissue. These outgrowths, at first small, grow longer afterwards, but remain comparatively small as long as the genital products are not ripe. Their extent continues to increase, both because they become individually larger and because the number of branches is considerably augmented, until in the breeding season the maximum development is found in oysters of four and five years old, in which the follicles and their ramifications form a layer several

millimetres in thickness, in which very little connective tissue can be distinguished.

The genital ducts are lined by a cubical ciliated epithelium, which is continued into the main branches given off from them, and it may be asserted that the cell-walls of all the ultimate ramifications of the organ are derived from an epithelium continuous with and derived from that lining the ducts.

The genital products are developed from the wall of the follicles, probably at the expense of the epithelial cells which line them. Both ova and spermatozoa are developed in the same follicle.

In the youngest stage observed the ovum of the oyster is a little cell, 20—24 μ in diameter, flattened on the side of the canal-wall, and rounded on its free surface. The protoplasm of the cell-body is feebly granular, the nucleus is large, spherical, and has a highly refringent single nucleolus of a moderate size. The youngest ovules pass by in sensible gradations into the more advanced, and these again into the mature ova. The granulations of the protoplasm become more and more numerous and more distinct, and little refractive granules accumulate in great numbers. The ripe ovarian ovum acquires, as soon as circumstances are favorable, a spherical form, and is rather more than 0·1 mm. in diameter. The manner in which the ova separate from the follicles has not been observed. After their separation there remains a lining of epithelial cells in the follicle, from which new generative products are formed.

It appears to be invariably the case, as will be shown afterwards, that the formation of ova is always followed by the formation of spermatozoa, but the process of spermatogenesis is much more complicated than that of oogenesis. The most favorable preparations for the study of spermatogenesis are procured from follicles which have been previously filled with ova. To procure this one must search in the manner common among ostreiculturists for an oyster with spat in its gills ; when found it must not be opened at once, but must be marked and placed in an aquarium in a current of water. If it is examined a fortnight later the different follicles of the reproductive organ are found to be actively engaged in spermatogenesis. A follicle in this condition is found in Pl. XXIII, fig. 3. In the centre is a loose mass of ripe spermatozoa, and the tissue composing the walls is seen to be in the process of transformation into spermatozoa. The minute mother-cells of the spermatozoa have a diameter of scarcely 8 μ, they stain deeply with alum carmine, and have dark granular contents and a small nucleus. The spermatozoa are developed from them as follows. In each cell after the division of the nucleus the cell-body divides in two portions. Of these one is destined to give rise to numerous spermatozoa, the other seems to

serve only as a provisional connection between the developing spermatozoa and the wall of the follicle. The former cell grows rapidly, and the nucleus subdivides rapidly and repeatedly until a large cell is formed 25—30 μ in diameter, containing 40—50 nuclei. Each nucleus is about 4 μ in length. At this stage the whole structure looks somewhat like a club (Pl. XXIII, fig. 4), of which the swollen part is formed by the large multinucleated cell just described, and the handle is formed by the other derivative of the primitive cell. At this stage the multinuclear cell becomes separated from its peduncle. Its nuclei continue to subdivide and become darker and more opaque. Finally the mother-cell becomes entirely developed into spermatozoa derived from the sub-divided nucleus, but one cannot explain precisely the steps by which the smallest nuclei are transformed into spermatozoa.

The Physiology of Generation in the Oyster.

Numerous researches have been made with the view of determining whether the oyster is a functional hermaphrodite, having the power of occasionally or generally fertilising its own ova, or whether it is physiologically unisexual whilst anatomically hermaphrodite. Davaine, de Lacaze Duthiers, and P. J. Van Beneden pronounced in favour of the former view, that the oyster is, potentially at least, a functional hermaphrodite, but subsequent investigators have inclined more and more towards the latter view. Dr. Hoek's researches lead him to the conclusion that, so far from being a functional hermaphrodite, the oyster is a unisexual animal at the moment when it performs the act of generation. He continues:

"It goes without saying, and should not be forgotten, that it is much more difficult to arrive at a certain result in this part of my researches than in the anatomical part. In the latter direct observation is possible, but in the former it is only possible within certain limits. One is obliged, indeed, to make observations from the very first, but one has afterwards to draw conclusions from them, and then everything depends on the greater or less importance which one attributes to each fact observed. A multitude of observations may give more solid grounds for one's conclusion, but cannot exclude the possibility of a fault in reasoning.

"The number of oysters examined was not very large. I call 'examined' those only which gave me satisfactory preparations and in which I could judge with mathematical certainty the condition of the generative organ at the moment of opening. Adult oysters (three years old or more) opened during the breeding season do not

always present the same appearance. Omitting all reference to diseased organs, the condition observed may always be classed under one of the five heads following.

"1. Abundance of ripe spermatozoa and scarcely any ovules. Early stages in spermatogenesis rare. Everything seems to concur in the production of as many spermatozoa as possible. The oyster fat.

"2. Spermatozoa ripe and in course of development. Ovules pretty numerous on the walls of the follicles, but not a single ovum ripe and in a condition to be fertilized. Oyster pretty fat.

"3. Spermatozoa in the course of development everywhere, and here and there a little mass of ripe spermatozoa. A single ovule still remaining on the wall of the follicles. Oyster thin.

"4. Abundance of ripe or nearly ripe ova (in condition to be fertilized) both on the walls of the follicles and free in their cavities. Among the ovules on the walls of the follicles some very small cells whose nature could not easily be distinguished. No spermatozoa. Oyster very fat.

"5. Abundance of ripe or nearly ripe ova. Ripe spermatozoa in the efferent ducts and in the primary lateral ducts leading into it. No younger stages of spermatozoa. Cellular elements among the ova on the walls of the follicles as in the previous case. Oyster very fat."

It should be added that the oysters in the second category show differences both in the number and condition of development of the ovules, but Dr. Hoek never saw ova in a condition for fertilization alongside of ripe spermatozoa, unless indeed Case No. 5 is a question.

As for No. 3, it must be added that the preparations of these oysters corresponded exactly with those made from oysters which were known with certainty to have had brood in their gills from one to four weeks before being opened.

Two facts may here be noticed which are of the greatest importance for the physiology of the organs of generation of the oyster. These are :

1. That the ova of the oyster at the moment of their escape from the genital aperture are already fertilized, and that they have already passed through the earlier stages of segmentation.

2. That on several occasions spermatozoa have been found surrounding the edges of the urogenital aperture as well as in the terminal portion of the genital duct, in the ureter, and even in the renal chamber.

When it is considered that autogamy, or the faculty of self-fertilization, is extremely rare in the animal kingdom, and that the nearest allies of the common oyster (*Ostrea virginica* according to Brooks and Ryder, *Ostrea angulata* according to Bouchon Brandely) are

unisexual, one can hardly escape the conclusion, in face of the facts above mentioned, that the oyster is at the moment of propagation a functionally unisexual animal. One could not otherwise explain the different conditions in which the generative organs are found during the breeding season. M. de Lacaze Duthiers, it is true, has found a few ova in oysters filled with semen, and a few spermatozoa in oysters filled with ova, but in the former case the spermatozoa could hardly be destined to fertilize such a very small number of ova, which are besides unripe; and in the latter case the number of spermatozoa found by him are altogether insufficient for the fertilization of the ripe ova contained in the animal. Further, it must be remembered that not only is it impossible that two oysters should copulate, but that it is equally impossible that the generative products of the two sexes should be brought together when floating freely in the sea; for how if this were the case could the development of the brood in the gills of the mother be explained? Nobody has attempted to deny that the brood contained in the gills of an oyster is derived from that oyster. It is impossible to believe that it could collect in its gills a number of ova from the surrounding water, when those ova, being denser than the water, do not float. At the moment of their exclusion the ova are fertilized, and as soon as "white spat" is observed in the gills of an oyster, its generative organs are found on examination to be empty and exhausted. Clearly the white spat in the gills has been produced by the same individual in which it is found. The spermatozoa by which those ova are fertilized might be produced by the mother oyster itself, or might be derived from another oyster. The former supposition is sufficiently refuted by the fact that the reproductive organs of a ripe oyster are either entirely filled with ova, or nearly entirely filled with spermatozoa. The fertilizing spermatozoa must therefore be derived from other oysters.

The only possible conclusion is that during the breeding season a number of oysters produce and emit such a large quantity of spermatozoa that the water passing over an oyster-bed is charged with them, and that a sufficient quantity are able to penetrate into the mantle cavities, and thence into the bodies of the ripe females, and thus fertilize their ova. The number of spermatozoa which are lost must of necessity be much greater than those which are utilised. In the only case in which the two genital products are found side by side and perfectly ripe in the reproductive organs the spermatozoa are all free, none are united into masses, and they are only found in the main genital duct and its principal branches, which is evidently in favour of the view that they have found their way there from without.

Another question remains, Do the reproductive organs of the oyster produce ova and spermatozoa in regular alternation? Robin, on theoretical grounds, and other authors as the result of observation, have asserted that oysters are androgynous hermaphrodites—that is to say, hermaphrodites which function first as fertilizing males, and afterwards as females requiring fertilization. Möbius (Auster und Austernwirthschaft, p. 20) simply states that ova and spermatozoa are not developed at one and the same time in the reproductive organs of the oyster, but successively; that spermatozoa may be formed soon after the ova are laid, and that probably, in the same season, half the oysters in any locality produce ova only, and the other half spermatozoa only. Dr. Hoek agrees entirely with the last-named author. An oyster which contains ripe spermatozoa in the breeding season almost always shows younger stages of spermatozoa in its reproductive organs, whilst, on the contrary, an oyster temporarily acting as a female, and full of ripe or nearly ripe ova, has all its ova in nearly the same condition; it follows, therefore, that it is able to produce spermatozoa for a long period, but that all the ova are laid at nearly the same time. This last point can also be demonstrated by the examination of an oyster which has very young spat in its branchiæ; in this case the reproductive organs are void of ova. In the case of oysters which come under the second category on p. 273, one may well suppose that they have acted and will act as males, but as females only in the following year; nevertheless there is no proof that this must necessarily be the case. But a very simple experiment, which has been several times mentioned, shows that oysters which have acted as females begin immediately to produce spermatozoa, and the latter may very probably serve in the same year for the fertilization of ova produced by other oysters.

Age at which Oysters become Sexually Mature.—Gerbe has examined a great number of young oysters (425, a year old). Of these 35 had spat in their branchiæ, 127 had their ovaries full of ova, and 189 had spermatozoa. It is doubtful, however, whether the oysters on the cultivated grounds of the East Schelde reproduce themselves when only one year old. Of a number of well-developed oysters which were opened at the end of the first year some appeared as though they would function as males in the following summer, others undoubtedly gave the appearance of being about to develop mature ova in the following year. It is impossible to decide whether these latter oysters must necessarily produce ripe spermatozoa first.

However, it is not at all impossible that the oysters of the East Schelde may be inferior in this respect to their relatives in a state of nature. If manipulation exercises an unfavorable influence on the number of breeding oysters, it is not at all unlikely that it should

also exercise an unfavorable influence on the age at which the animal begins to breed, so that a considerable number of natural oysters a year old might produce ripe ova and spermatozoa, whilst this might never be the case, or at least might be very exceptional, in cultivated oysters. The question can only be settled by further observation. Particularly it is necessary to compare cultivated and natural oysters. It is probable that it will be found that cultivated oysters differ greatly among themselves, since the brood, fixed in the summer, and usually detached in the spring months, is not always treated in the same manner. If the collectors with the young brood are placed in the sea for the winter, and if afterwards the young are left on the collectors, the oysters are flat and too much crowded; they have a low market value, but in the development of their generative organs they approach much nearer to natural oysters than do cultivated oysters.

The more a cultivator deviates from the course followed by nature the greater the danger of weakening the reproductive capacity of the oyster. It is certainly a considerable deviation to place the collectors in ponds during the winter. To detach the oysters from the collectors is another deviation; a third is the crowding of hundreds of oysters in small reservoirs; a fourth to keep young oysters for a whole year in parcs, &c. Although many of these deviations do not appear to be dangerous to the life of the nurselings, and are even necessary to the advantageous application of culture, one must not lose sight of the fact that they must necessarily exercise an unfavorable influence on the reproductive faculty.

It may be added that among cultivated oysters those of the fourth and fifth year are the most prolific. Oysters six years old still have well-developed reproductive organs, but in oysters of nine or ten years they are always poorly developed, and rarely contain generative products. The liver too, in these last is greatly enlarged, so that the layer of connective tissue between it and the body-wall which contains the follicles of the reproductive organs, is of very slight thickness. Ordinarily the follicles of these aged oysters contain no ova, but a few spermatozoa. The conclusions arrived at by Dr. Hoek in the course of his work are as follows:

A. *Anatomical.**

1. The reproductive organ of the oyster consists of a genital gland and efferent ducts. There are no accessory organs.

* Several of the anatomical conclusions arrived at by Dr. Hoek are omitted, as being beyond the purpose of the present abstract.

2. The genital gland is not a compact organ situated in a definite position. It is spread out superficially so as to cover nearly the whole of the trunk properly so called. At a short distance from the surface of the body, separated from the integument by a thin sheet of connective tissue, the genital gland spreads out as a system of canals which unite secondarily with one another, and their internal walls give rise to follicles placed vertically to the surface of the body and buried in the connective tissue.

3. The generative products are developed from the walls of the follicles. Spermatozoa and ova are developed alongside of one another in the same follicle. The two generative products are developed in all probability from the epithelial cells, which must be considered as the derivatives of the epithelial cells lining the walls of the genital ducts.

4. It is probable that a single epithelial cell is metamorphosed into a single ovum, whilst only a portion of a single epithelial cell becomes the mother-cell of spermatozoa. All the spermatozoa derived from a single mother-cell are united into a bunch of characteristic shape.

5. The ducts of the genital gland communicate directly or indirectly on the two sides of the body with a principal efferent duct, which opens to the exterior at the anterior end of an open groove, running along the muscle of the valves at a short distance from the great posterior branchial nerves.

B. *Physiological.*

1. An oyster with spat in its branchiæ is the mother of that spat.

2. At the moment of extrusion the ova are not only fertilized, but have already passed through the earlier stages of segmentation.

3. The spermatozoa necessary to fertilization do not come from the mother oyster itself.

4. The water which passes over the oysters brings the spermatozoa which have been emitted by other oysters. Some of this enters the mantle cavity, penetrates to the genital aperture, traverses it, and spreads not only into the principal duct of the genital aperture, but also into its larger branches.

5. The oysters of the East Schelde may have spat in their gills when two years old. Ordinarily oysters in spat are older. Oysters of four or five years produce the most spat.

6. Similarly two-year oysters may produce spermatozoa, but the larger part is derived from older oysters. Neither earlier researches nor my own have established with certainty that year-old oysters from the East Schelde emit spermatozoa.

7. The number of oysters producing spermatozoa is, in the East Schelde, greater than those producing ova.

8. The ova of a ripe oyster are laid all at once, excepting a few which are ill developed. The production of spermatozoa probably for a longer period.

9. In every oyster examined the production and emission of ova was followed by a period in which only spermatozoa were formed.

10. A large portion of the brood which attaches itself every year on the banks of the East Schelde is not, in all probability, derived from the oysters in the establishments.

11. It would appear that cultivation exercises an unfavorable influence on the fertility of oysters.

12. In aged oysters the liver is much more developed than in young. This development is correlated with the retrograde condition of the reproductive organs.

A Comparative Examination of Cultivated and Natural Oysters, made to determine the Number which annually take Part in Reproduction.*

After the publication of his first paper, Dr. Hoek received from Baron Groeninx van Zoelen and Baron G. H. Clifford, oyster culturists of the East Schelde, an offer of a sufficient number of oysters for the continuation and completion of his researches. This offer he willingly accepted, and received towards the end of June, 1883, 200 oysters from an establishment where only cultivated oysters had been laid down, and 200 others from a locality where no cultivated oysters had ever been laid down. The age of every oyster was noted, and also whether it had been growing on a tile, a shell, or a stone. Each individual was numbered, and a piece was taken and preserved in alcohol for further investigation. A thin section was eventually made from each piece, which was stained and treated for microscopical examination.

The oysters examined were opened between June 16th and 28th, and as the pieces removed were immediately placed in spirit, subsequent examination of them gave an exact idea of the condition of the sexual organs on the day on which they were opened. In several cases the examination of these pieces was not wholly satisfactory. Some of the oysters had spat in their beards; these might have been pronounced as functional females for the current year without any further examination: some others contained a great number of ripe

* Dr. P. P. C. Hoek, Tijdschrift der Nederlandsche Dierkundige Vereeniging, Supplement Deel i, Aflevering ii, 1883–4, p. 483.

or nearly ripe ova; these they would have emitted in a few days. Others, again, contained spermatozoa either ripe or nearly ripe—one could see that they would participate in the season's breeding. On the contrary, the oysters which contained young cells producing ova and sperm mother-cells were in a condition in which it was very difficult to determine whether they would participate in the season's breeding, and what would be their function.

According as the male or female elements appeared to predominate they were classed as likely to become males or females. A certain number, though not many oysters remained in which the sexual organs were very feebly developed. It is impossible to say whether these oysters had already bred, or whether they were weak or diseased.

The results of the examination of 190 oysters from each locality are given in the following table:

Condition of reproductive organs.	Cultivated oysters.	Natural oysters.
A. Oysters with white spat	11	19
B. „ with black spat	17	12
C. „ with ripe or nearly ripe ova . . .	21	42
D. „ with ripe or nearly ripe spermatozoa . .	75	94
E. „ which seemed likely to become females . .	11	7
F. „ which seemed likely to become males . .	17	6
G. „ with ill- or non-developed reproductive organs .	38	10
Total number of oysters examined . .	190	190

Of 190 cultivated oysters, there were at least 49 functional females, and of the same number of natural oysters, 73, or 12½ per cent. more, were functional females. But the more numerous examples of cultivated oysters classed under E should probably be classed as females, and thus the difference is made less; and since many of those classed under G had doubtless acted as females, the difference, which looks large at first, loses its importance. The same is the case with the males. The advantage remains with the natural oysters, but the advantage is so small that any conclusions founded on these data would be valueless.

One circumstance shown in the table is remarkable. The cultivated oysters are in advance of the natural oysters in their development at a certain season of the year. Ordinarily the consignments received comprised an equal number of the two kinds, so that they might be considered as having been opened at the same date. If we allow that, of those classed under G, one half had been functional females,

we should have to class the oysters which had already acted or were yet to act as females under the following categories :

Oysters with ripe or nearly ripe ova : cultivated	21,	natural 42.
,, ,, white spat . . . . ,,	11,	,, 19.
Oysters with black spat . . . . ,,	17,	,, 12.
,, which had produced young . ,,	19,	,, 5.

The table shows sufficiently well that, in this particular instance, the cultivated are in advance of the natural oysters. This observation is confirmed by the assertion of oyster breeders, viz. that natural oysters spat after those under cultivation. In the establishments where the mass of spat to be collected is believed to be derived from natural oysters, the tiles are set out some time after they are set out in the cultivated beds.

As to the age necessary for reproduction, these researches give no certain information, since all the oysters received were nearly of the same age. The majority were three or four years old, some few two or five years. Even if the ages had varied more, the number of specimens examined would have been too small to give decisive results on this point.

To arrive at a definite conclusion it would be necessary to begin investigations in March, and to continue them till October. Each month, at nearly the same date, at least 100 specimens both of cultivated and natural oysters should be opened. The oysters should be two, three, and four years old. A section of each individual which would leave no doubt as to the actual condition of the reproductive organs should be made. With such materials one could arrive at numbers admitting of a comparison.

Suppose that the result still showed scarcely any difference in the number of females in the two kinds of oysters, it would be rash to conclude that the greater part of the free spat is not produced by natural oysters. Their spat might be hardier than that of cultivated oysters, and it might reasonably be admitted that the spat produced by a natural oyster is larger in amount than that produced by a cultivated oyster.

DESCRIPTION OF PLATES XXII, XXIII,

Illustrating the abstract of Dr. Hoek's paper on "The Generative Organs of the Oyster."

All the figures after Dr. P. P. C. Hoek.

FIG. 1.—View of a freshly opened oyster lying in the left valve after removal of the right valve. A portion of the mantle has been removed to show the oral process situated in the suprabranchial chamber.

FIG. 2.—Diagram of an oyster of which a part of the branchiæ and mantle have been removed to show the general arrangement of the generative organs and organ of Bojanus. The black lines represent the canals and ducts of the generative organ; the organ of Bojanus is shown in shading. To avoid encumbrance of the figure the genital ducts and canals are made to appear much smaller than they are in reality. *U. A.* Urogenital aperture. *Rp. C.* Renopericardial canal.

FIG. 3.—Section of a follicle of the generative organ of an oyster which has laid ova. *s'*. Mother cells of spermatozoa in division with numerous nuclei. *s''*. Ripe spermatozoa (× 190).

FIG. 4.—A portion of the preceding figure more highly magnified (× 900). *a*. Epithelium. *b*. First stage of division of mother-cell. *B*. Numerous nuclei derived from the primitive nucleus. *A*. Stage previous to the separation of the swollen multinuclear mass from its pedicle. *y.y.* Blood-corpuscles.

FIG. 5.—Mass of ripe spermatozoa (× 575).

FIG. 6.—Ovules on the wall of a follicle. *e*. Epithelium of the follicle (× 190).

Fig. 1

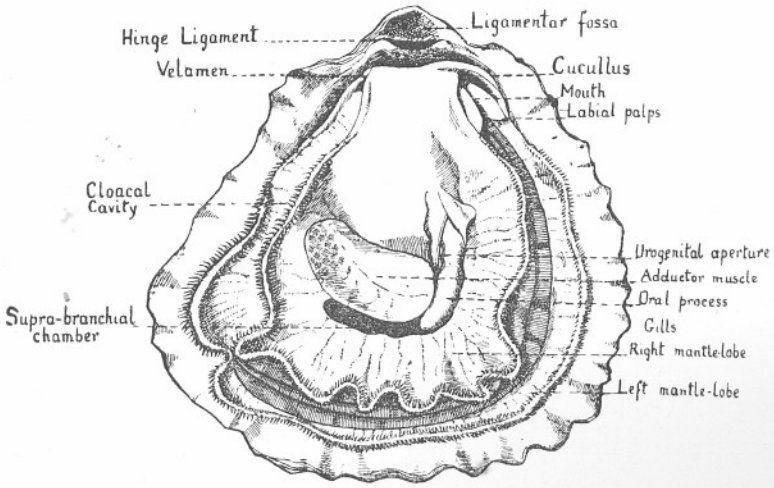
Hinge Ligament
Ligamentar fossa
Velamen
Cucullus
Mouth
Labial palps
Cloacal Cavity
Urogenital aperture
Adductor muscle
Oral process
Supra-branchial chamber
Gills
Right mantle-lobe
Left mantle-lobe

Fig. 2

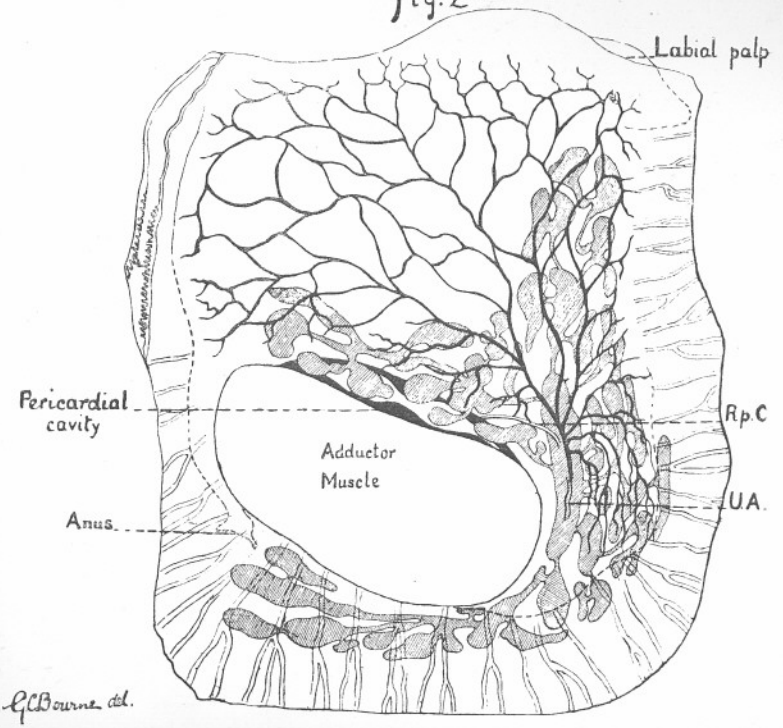
Labial palp
Pericardial cavity
Rp.C
Adductor Muscle
UA.
Anus.
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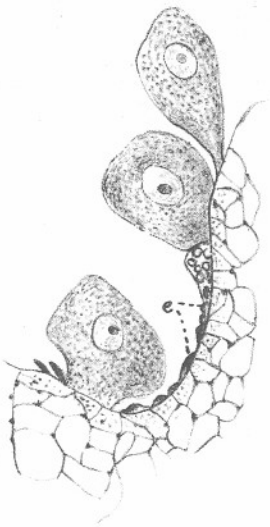
Fig. 3

Fig. 6



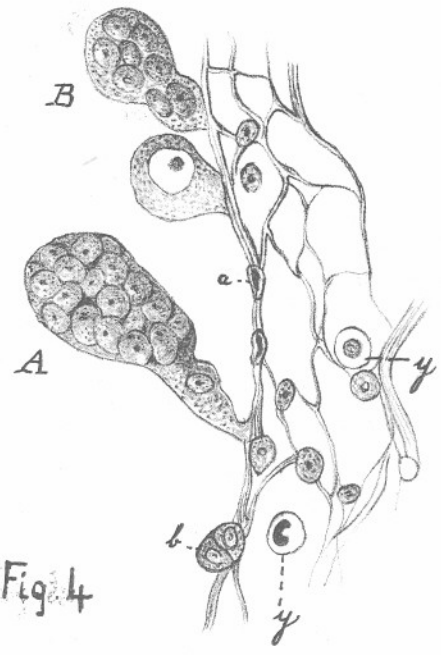


Fig. 4

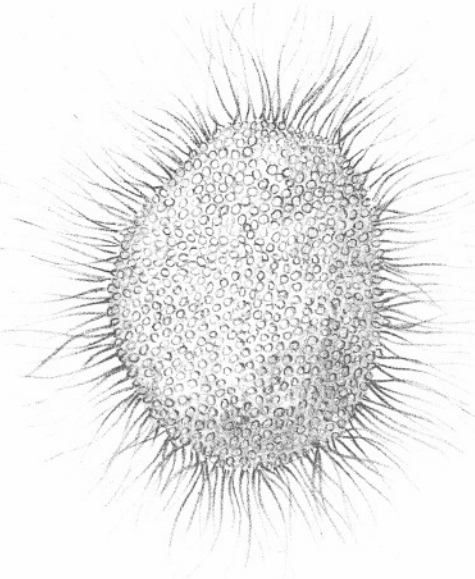


Fig. 5

G. C. Bourne. autogr.