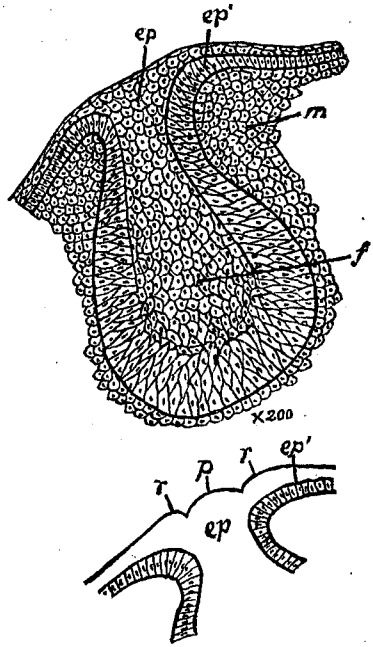
## 28.—ON THE DEVELOPMENT OF THE MAMMARY GLANDS AND GENITALIA OF THE CETACEA.

By JOHN A. RYDER.

The opportunity to dissect a gravid female of *Phocæna communis* having recently presented itself through the great liberality of the Director of the U. S. National Museum, Professor Baird, the dissection being in part conducted by my friends Mr. J. L. Wortman, of the Army Medical Museum, and Mr. F. W. True, curator of the Department of Mammals in the National Museum, I availed myself of the opportunity to make an examination of the structure and condition of the mammary gland of the adult, which contained a fœtus in its uterus about a foot long.

This specimen became of still greater interest when I subsequently happened to be fortunate enough to obtain excellent sections of the




EXPLANATION OF FIGURES.

Upper figure: Vertical section through the rudiment of the mammary gland of *Globiocephalus*, enlarged 200 times. *ep*, outer layer of epidermis; *ep'*, deep or Malpighian layer of the same; *f*, cellular mass in the center of the glandular rudiment derived from the outer layer; *m*, mesoblast or connective tissue.

Lower figure; A similar section, but drawn diagrammatically through the incipient nipple *p* and folds *r r* which inclose the former, finally giving rise to the walls of the mammary fossa and growing up over the nipple so as to conceal it from without at a very early stage.

first traces of the mammary gland in a very young female fœtus of the blackfish, *Globiocephalus melas*, about 2 inches long, the rudiments of

the glands being present on either side of the vulva as simple pyriform involutions or thickenings of the epidermis, as shown in the accompanying cut, drawn from a section passing vertically through the largest portion of the mammary involution and enlarged 200 times.

The primary epiblast, which gives rise to the epidermis *ep*, and the deep layer of the epidermis or *stratum Malpighii ep'*, which forms a solid involution several cells deep at its fundus, is clearly the layer from which in the Cetaceans, as in man, the primary acini, or mammary follicles, are budded off. An involuted mass of cells, *f*, are continuous apparently with the epidermis *ep*, but this mass is not sharply delimited at the fundus of the involution from the *stratum Malpighii*. The latter, however, at the mouth of the involution is quite sharply defined, as indicated in the figure, and differs in this regard from the condition of affairs presented by a section through the mammary gland of a male human fœtus of five months given by Kölliker (11); but Huss (5) figures a stage of the human mammary gland in which the Malpighian stratum is almost as well defined as in my sections of the rudimentary mamma of the embryo of *Globiocephalus*.

The evidence is quite conclusive, so far as the development of the mammæ of *Globiocephalus* afford us any insight into the mode in which these structures are formed in the Cetacea, that the latter differ in no very essential respect in the mode of the early development of these organs from other mammals.

While it is true that I am enabled to figure but one stage, it is unquestionably a fact that that phase is approximately equivalent to the five months' condition of the same organ in a human fœtus. It now presents the form of a simple epiblastic involution or a pyriform proliferation of cellular elements, which have been derived, as shown by their connections, from the epiblast or fœtal epidermis, and this structure has been gradually developed from a simple thickening at *ep*, which has extended downwards into the indifferent surrounding mesoblast *m*, or connective tissue, from the superficial part of which the corium would be formed at a later period.

Of anything like buds from the lower end of this mammary involution, which would represent the future acini or subdivisions of the mature gland, we see nothing, but that such are developed later there can be but little doubt, and in a manner simulating that figured by Kölliker (11) as characteristic of the seven months' human fœtus, the actual terminal subdivision of the ends of the primary acini not occurring in the human species until the time of birth (Langer, 4), when they contain the so-called witch's milk—*Hexenmilch* (D. Barfurth, 10).

In one important respect the later development of the acini of the mammary gland of Cetacea would doubtless differ from that of other mammals, namely, in the rate at which the anterior and posterior acini and the lateral acini would grow, the former being much longer than the latter on account of the elongated, flattened form of the whole gland

(Solley, 3; Owen; Cooper; Hunter, 1; Geoffrey St. Hilaire; Rapp; Rudolphi; Turner). It is therefore likely that the anterior and posterior acini would be developed most rapidly and become longest, and not present nearly so uniform a length and such a pronounced radiated arrangement as in most other Mammalia, in which the gland is discoidal and more or less conical, but resemble to some extent, at one stage of development, the unspecialized condition of the organ seen in *Echidna*.

But the preceding may perhaps be considered pure speculation, and possibly quite out of the way so far as it is intended to describe the mode in which the adult gland is formed. The latter has long ago, as described by Hunter, Cooper, and St. Hilaire, a large ampulla or lacteal sinus, which traverses its center longitudinally along its middle. The involuted rudiment which I have figured may send out two great processes from its enlarged end, an anterior and a posterior one, from the sides of which the secondary acini of the adult gland may bud out laterally on either side. This is the more probable mode of development, for we find that the subsidiary lateral ducts open at intervals into the median lacteal sinus, along the sides of the latter, in the adult organ.

The coarse anatomy of the adult mammary gland of *Phocæna* is pretty well known, and it will therefore be superfluous to enter into a very detailed account of the organ. It is a flat glandular mass nearly 3 inches wide, somewhat over a half inch thick in its center or in the region of the nipple, and nearly or quite a foot in length. Externally or ventrally it is invested by connective tissue, and overlaid first by what are apparently dermal muscles and then by the tough, fibrous, skin which is not underlaid by blubber here or in the vicinity of the vulva. The nipple opens from the mammary sinus and is placed below the hinder half of the gland. As in *Balænoptera* (Turner, 12), there is a single opening in the nipple, the numerous orifices in it described by Owen being apparently the pedunculate bodies at its tip figured by Turner, and, as surmised by Gegenbaur (6), do not indicate the existence of numerous milk ducts opening on its apex.

The apex of the nipple in *Phocæna*, unlike that of *Balænoptera*, is quite smooth, somewhat flattened laterally by compression between the folds of the external mammary fossa, and shows a very distinct single terminal opening in its center, which is continuous by way of a single canal with the wide mammary sinus below.

From the description given by Turner of the enormous mammary gland of a gravid specimen of *Balænoptera*, the inference may be drawn that there is but little difference between the structure of the mammary organs of the *Denticete* and the *Mysticete*.

In both there seems to be good reason for believing, with the editor of the posthumous edition of Hunter's paper (1), that the milk accumulates in the great mammary sinus and is rapidly forced out by the volition of the mother, by compression through the action of the overlying

muscles, while the calf has its mouth to the nipple, for only short intervals between the times when it rises to the surface for air.

The peculiar position of the nipple, which is sunken into a longitudinal fossa which quite covers or incloses the former, is a characteristic feature of the external conformation of these organs in the Cetacea, and may be regarded as a physiological adaptation similar in nature to the extension and flattening of the gland itself, as a result of which the milk-secreting organs do not bulge outwards as in other mammals, but helps the animal to retain its normal fusiform shape, with no portion of these secondary sexual organs projecting outwardly, thus protecting them from injury and not impeding the movement of the parent through the water, as suggested by Owen.

The question now arises, to which category the mammary gland of Cetaceans must be assigned, namely, those with true nipples, such as are found in the Carnivora, or those with pseudo-nipples, such as are found in Ungulata, certain Marsupialia, and Murina. To judge from the structure of the adult nipple, with its single opening, there can, I think, be little doubt of the propriety of classing the mammary gland of Cetacea with that group which has been characterized by Gegenbaur (6) as possessing pseudo-nipples, which are developed by the production of the margin of the primary mammary area of the embryo into a tubular prolongation, and which in all cases is characterized by the possession of a single external opening, as in the cow. By what process of development, however, the great median sinus of the Cetacean mammary gland was produced we do not know, and must wait for the elucidation of this part of the subject through the study of more material.

Turner (12) speaks of the sinus as being lined by a mucous membrane, but the question arises, has this endothelial lining of the gland arisen by involutions from the primary epiblastic involution, or has it arisen partly by vacuolization and retrogressive histological processes, as argued by Creighton (7) and Rein (9). To me it seems probable that both processes, as shown by the last-named investigator, are involved, namely, those of involution or proliferation from the primary gland bud, and vacuolization, which latter process probably steps in later, or after the foundations of the principal acini have been laid down by the first process.

In some forms it would seem probable that the mammary glands almost wholly disappear during the intervals between the periods of gestation, as observed by Allen (8) in the bats, to be regenerated again beneath the integument with the progress of the period of gestation. Facts such as these would seem to favor the opinions and suggestions put forward in 7, though there can be no doubt whatever as to the fact that the first traces of these organs exist as thickenings or proliferations at definite regions in the epiblast, and that eventually such a thickening shoves the *stratum Malpighii*, downward before it as a pretty

well defined layer into the mesoblast, as shown in the accompanying figure.

The development of the dermal folds which inclose the nipple of Cetaceans, however, complicates the development of the nipple itself somewhat, so that it is probably impossible at present to reach any very positive conclusions, unless we may assume that the stages of the development represented by an embryo of *Globiocephalus melas* 2 inches long and one of *Rhachianectes glaucus* 5½ inches long will serve to throw some light upon this question.

The sections which were made of the young of *Globiocephalus* of the size mentioned show that the folds which form the wall of the nipple fossa were only in their incipiency or scarcely at all developed during the 2-inch stage, as shown in the second diagrammatic figure, taken from a section at a somewhat different level from the upper more detailed one, this one striking nearly the center of the incipient nipple, which seems to be present as a slight elevation of the epidermis, while on either side of it there are two swellings, *r r*, which seem to me to represent the developing side-walls of the nipple fossa.

What convinces me that the preceding opinion is justified is the external appearance of the nipple fossæ or clefts in the more advanced, female embryo of *Rhachianectes*, 5½ inches long. In this specimen the mammary clefts, without externally visible indications of the nipples, are already formed as a pair of minute longitudinal slit-like depressions, which, without much doubt, represent the proportionally large clefts which open from without into the nipple fossa in the adult. In this last stage these clefts are about .5 millimeter in length, and, on account of the greater proportional size of the clitoris of the embryo, are placed relatively much closer to that organ than in the adult. Were it possible to investigate the condition of the mammary gland in this larger embryo, it might be that light would be thrown upon the steps by which the gland itself is formed; but as the specimen is a unique one, having been figured by Scammon, and unfortunately belongs to a Pacific species which I am told by Mr. Dall is rapidly approaching extinction, great hesitancy has naturally been felt by the Museum authorities as to the desirability of sacrificing it for purposes of anatomical investigation.

There seems to me, therefore, to be but little doubt remaining that the nipple fossa of Cetaceans is developed during a comparatively early stage, or in the interval in the history of the intrauterine growth of the young Cetacean corresponding to that between the fifth and seventh months of the human fœtus.

Turner (12) has described rudimentary mammary fossæ, behind and a little to either side of the base of the penis of an advanced male fœtus of *Balænoptera Sibbaldii* 18 feet long, but in the much younger stages of development of *Phocæna communis*, represented by a male fœtus 3 inches long now in my hands, I cannot find any evidence of such rudimentary mammary clefts or fossæ as are described by Turner.

In a male fœtus of *Delphinus Bairdii* 11 inches long, belonging to the National Museum collection, no traces of mammary fossæ could be found. In another female fœtus in the collection, identified with some doubt by Mr. True as *Phocœna lineata*, and 17¼ inches long, the mammary clefts were 8 millimeters long, the nipples distinctly developed and about 1.5 millimeters in diameter.

In a male fœtus 33½ inches long, referred to *Balænoptera musculus*, (No. 13763) by Mr. True, the rudimentary mammary clefts are about one-eigth of an inch long, and are situated about half way between the anal opening and the proximal part of the preputial membrane covering the base of the penis behind, and seven-eighths of an inch in advance of the anus. The nipples are not nearly so well developed in proportion as in the female fœtus of *Phocœna* 17½ inches long, being only .75 millimeters in their longest and .5 millimeters in their shortest or transverse diameter. The pair of mammary clefts and nipples of opposite sides in this specimen were situated about one-fourth of an inch apart, measured across the middle line of the fœtus.

It is therefore evident that there is an important difference existing between the fœtal males of some of the species of *Denticete* and some of the *Mysticete*, inasmuch as the latter possess rudimentary mammary glands and the former do not. How universally this may be true we will not know until fœtuses of all the farms have been studied.

The sexes of young Cetaceans are already distinguishable when they are about 2 inches long, and when 3 inches long the genital raphe has closed in the male and the perineum is already much longer than in the female fœtus; it is, in fact, more than twice as long in a male 3 inches long than in a female fœtus 2 inches in length. It is therefore evident that the indifferent-stage development of the external genitalia of the embryos of Cetaceans must be passed over before they have reached the length of 2 inches, so that the dimensions reached when the sexes become differentiated externally probably correspond pretty closely with those of the embryos of the human species.

Wyman, in examining an embryo of the great right whale, *Balæna mysticetus*,* found it difficult to discriminate the sex of it externally, although 6 inches in length. In the series of embryos in my possession there does not seem to be any difficulty of this sort, as the single male specimen of *Phocœna*, with its closed raphe between the penis and anus, at once gives the unmistakable outward indication of the sex to which the specimen belongs.

This was an important matter to determine in order to discriminate the specimens used in the preceding discussion of the development of the mammary gland.

The results arrived at in the foregoing paragraphs may be summarized as follows:

1. The mammary gland of Cetaceans develops from a thickening of

* Proc. Bost. Soc. Nat. Hist., iii., 1848–'51, p. 355.

the epidermis of the embryo, which is covered internally by the *stratum Malpighii*, as in other mammals.

2. The acini of the gland probably develop in the same way as in the same organ in other mammals, except that the gland begins to elongate very early and develop a great longitudinal median sinus in its middle portion, which is directly continuous with the duct which opens through the nipple.

3. The folds which surround the nipple fossa and inclose the nipple arise very early, as shown by the condition of the gland in two successive stages represented by an embryo of *Globiocephalus* 2 inches long and one of *Rhachianectes* 5½ inches in length.

4. The gland as found in Cetacea, while displaying peculiar teleological modifications, must, so far as the mature anatomy and early development of the organ is concerned, be included with the type defined by Gegenbaur as possessing pseudo-nipples.

5. The sexes of Cetacean embryos, judging from those of *Globiocephalus* and *Phocæna* may be discriminated from each other externally when somewhat under 2 inches in length, by the differentiation of the external genitalia.*

In conclusion I would express my appreciation of the kindness of the curator of the Department of Mammalia in often, finding for me, I fear, at considerable trouble to himself, the materials, in the way of specimens and literature in the Museum collection, upon which this investigation is based.

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* I have not been able to find any papers dealing with the development of the mammary glands of Cetacea, though a thorough search of the literature may reveal the fact that such investigations have been previously made. The results which I have obtained have seemed to me of sufficient interest to warrant their publication, aiding as they may in giving us some additional light in a department of vertebrate embryology in which it is very difficult to obtain fœtuses young enough for the prosecution of such studies.

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## 29.—THE EFFECTS OF AN ELEVATED TEMPERATURE ON FISHES.

**By FRANCIS DAY.**

In a stream in the Government gardens at Ootacamund, on the Neilgherry Hills, in Madras, in the middle of December, 1866, the average maximum was 72°, the average minimum 50°, the highest point noted 72°, and the lowest 42°, and here Indian carp thrive. In the lake in that station, 7,600 feet above the sea, between May 20 and June 12, 1866, I found the water at 6 a. m. 67½°, at midday 77°, at 4 p. m. 79°, and at 6 p. m. 73°. In the Coonoor Stream the water was from 3° to 6½° colder than in the Ooty Lake, while half way down to the low country, at 4 p. m., it stood at 74°, and 6 p. m. at 75°. In the Bowany River, in the low country, a much higher temperature prevailed, at 6 a. m. it being 79°, at 12 a. m. 92°, at 4 p. m. 86°, and at 6 p. m. 82°. But after the first burst of the monsoon the water may be roughly said to have decreased about 10° in the Ooty Lake, 1° or 2° in Coonoor River, rather more on a lower level, but from 10° to 13° in the Bowany River. All these localities being stocked with fish, it shows that they must become accustomed to a heat which rises to as much as 92° at midday in the low-country river.

In June, 1869, I took sixty-three observations in the Irrawaddi River, in British Burmah, the thermometer being immersed 1 foot below the surface, and the temperature recorded between 6 a. m. and 11 p. m. varied from 82° to 85°, while at the Een-gay-gyee Lake, on June 18, the water at 11 a. m. stood 90°. It is stated in Nature of February 12 that the secretary to the National Fish Culture Association at South Ken-