

A CONTRIBUTION TO THE COMPARATIVE PHYSIOLOGY OF THE  
PITUITARY BODY. By P. T. HERRING. (From the Physiology  
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figures in the text.)

*(Received for publication 21st July 1908.)*

THE researches of Oliver and Schäfer (7), Howell (4), and others have demonstrated the existence in the mammalian pituitary body of active principles which have a specific effect upon the heart and blood-vessels when injected intravenously. Howell, moreover, pointed out that it is the posterior lobe alone which possesses this property. Magnus and Schäfer (5), and more recently Schäfer and Herring (10), showed that extracts of the posterior lobe have the additional characteristic of producing kidney dilatation and diuresis when injected. Their observations were confined to the pituitary body of certain mammals and of the cod, which was found to have a similar action. Osborne and Vincent (8) had previously shown that extracts of the pituitary body of the cod produce effects upon the heart and blood-vessels similar to those of extracts of the mammalian posterior lobe. The question as to the origin of the active principles found in the posterior lobe of the mammalian pituitary has been discussed in a previous paper (3), and the author has given reasons which appear to him to support the view that they are derived from the cells of the *pars intermedia*, which in the mammalian pituitary form so close an investment over the nervous tissue of the posterior lobe. It was thought that an examination of the structure of the pituitary body of other classes of vertebrates, combined with an experimental investigation of the action of extracts of the different parts of each, might furnish some interesting facts bearing upon the physiology of the pituitary body, and at the same time throw light upon the mode of origin of the active material.

The difficulty of obtaining sufficient material for extracts has so far prevented an investigation of the pituitary bodies of reptiles, amphibians, and the lower orders of fishes. The present paper is confined to a description of the general structure of the pituitary body, and the physiological action of its extracts, in birds and in bony and cartilaginous fishes.

#### METHODS.

The pituitary bodies of the types examined were fixed for histological examination in Flemming's fluid. Sections were cut by the paraffin method

in the sagittal plane and mounted serially. In all cases a sufficiently large portion of brain was included to display the immediate relationship which exists between the brain and the pituitary body, a precaution which is of importance.

For the experimental part of the research, extracts of the various structures revealed by the histological investigation were prepared, the lobes of the pituitary being carefully separated from one another, finely minced, and boiled in Ringer's fluid. The animals experimented upon were cats, which were anæsthetised with a mixture of chloroform and alcohol. After a tracheal tube had been introduced, anæsthesia was continued by the administration of the same mixture through Brodie's apparatus, with artificial respiration. Injections of the extracts were made through a tube inserted in the external jugular vein. Blood-pressure was recorded by means of a cannula in the carotid artery. The left kidney was placed in a brass oncometer; its movements were registered by a piston recorder. A tube tied into the bladder drained away the urine, which was allowed to fall drop by drop upon a recorder, an electrical signal marking on the paper the moment of the falling of each drop.

## THE PITUITARY BODY OF BIRDS.

### Histological Features.

The type of bird's pituitary investigated has been that of the common fowl, *Gallus domesticus*. The pituitary body of the adult fowl bears certain general resemblances to that of mammals. It has two well-defined lobes—an anterior or glandular, and a posterior or nervous. The epithelial cleft, which is so prominent a feature of certain mammalian pituitaries, e.g. those of the dog and cat, is absent from all the specimens of fowl's pituitary that I have examined. The anterior lobe is a compact cylindrical body with its long axis in an antero-posterior direction, deeply embedded in the sella turcica. Large blood-vessels enter it at its lower posterior margin and are a prominent feature in the initial dissection. The lobe itself is very vascular, and contains large blood-channels running between solid columns of cells. The cells are for the most part small and finely granular; larger cells containing granules which stain more deeply are occasionally met with, but do not resemble the large deeply staining cells which are so characteristic of the anterior lobe of the mammalian pituitary. The cells have a close resemblance to those of the mammalian parathyroid. The lobe is as a rule well defined, but in its upper part strands of cells frequently pass towards the neck of the posterior lobe and are continuous with narrow columns of cells which encircle this and spread over the adjacent brain-tissue. Fig. 1 (of Plate) shows the general relationship of anterior to posterior lobe and adjacent brain. It is taken from a median sagittal section of a fowl's pituitary body.

The posterior lobe is smaller than the anterior, and overlaps it slightly behind. It is hollow, and its cavity is continuous through a narrow neck with the third ventricle of the brain. The lobe is occasionally much convoluted, and its cavity appears at several points in the same section. Its wall is never very thick, and seems to consist chiefly of long ependyma cells, true nerve-cells being absent from it. Colloid bodies are not infrequently present, and the cavity often contains much debris and occasionally rounded clumps of what resemble epithelial cells. In the extension of its cavity by recesses and the convolutions of its wall the posterior lobe suggests a glandular structure opening into the third ventricle. Like the posterior lobe of the mammalian pituitary, that of the fowl possesses an incomplete covering of epithelial cells, which are constantly found in certain positions. They resemble in structure and in their relationship to nervous tissue the cells of the pars intermedia of the mammalian pituitary, and are probably to be regarded as having the same significance. These cells form layers closely investing the nervous substance of the neck of the posterior lobe, and extending forwards between the anterior lamina of the neck and the optic chiasma (fig. 1 of Plate). The layers are few in number, and well supplied by blood-vessels; in fact, the cells often appear to have extended along the sheaths of the blood-vessels. They spread around the neck of the posterior lobe and for a considerable distance backwards over the thin lamella forming the lower wall of the third ventricle. The body of the posterior lobe lies behind, directly upon the anterior lobe, but is readily separated from it. No epithelial cells are seen on its posterior and upper surface, but they are often found laterally, and extend with the blood-vessels into the spaces between the folds of the lobe. In the fowl, therefore, the cells of the pars intermedia come into close contact with the nervous tissue of the posterior lobe, but are aggregated for the most part in the neighbourhood of its neck and on the thin lamina of nervous tissue forming the floor of the third ventricle. It is easy to separate the anterior lobe from the posterior, but impossible to remove the nervous tissue of the posterior lobe without at the same time including epithelial cells of the pars intermedia and their products.

B. Haller (2) studied the pituitary of *Gallus domesticus* and describes two portions in the anterior lobe, one of which, the superior, is closely applied to the infundibulum. The other portion, or anterior lobe proper, Haller believes to be tubular, and to constitute a gland whose secretion is poured into the subdural space by a small mesial opening. Haller noted the diverticula in the posterior lobe, and states that the arrangement met within it gives the lobe a glandular appearance.

Sterzi (11) examined the pituitary of several species of birds, and describes a division of the anterior lobe into two parts, one of which is made up of chromophobe cells and nearly surrounds the posterior lobe, while the other, more massive, consists of chromophil cells.

Gentes (1) also describes two segments in the anterior lobe. One of

these he designates as the "segment juxta-nerveux," consisting of a few layers of cells which have little affinity for stains, and are applied to the posterior lobe in the middle line only. The other segment is formed by the anterior lobe proper, and consists of chromophil cells. Both Sterzi and Gentes deny the tubular character of the anterior lobe assigned to it by Haller. Gentes found a small cleft—the remains of the sac from which the epithelium of the pituitary is developed—in a young duck.

The "segment juxta-nerveux" of Gentes and the chromophobe cells of Sterzi agree in most respects with the cells which are here described as belonging to the pars intermedia, but in all the specimens I have examined they have a more extensive disposition than is assigned to them by Gentes. The cells of the anterior lobe may be designated chromophil, but they have not the remarkable affinity for stains which is possessed by the larger cells of the anterior lobe of the mammalian pituitary. They certainly do differ from the cells of the pars intermedia in staining property, and occasionally deeply staining granular cells are found among them.

Histological evidence points to the anterior lobe of the fowl's pituitary being, like the mammalian anterior lobe, a gland which secretes directly into the blood-vessels. The posterior lobe has an incomplete covering of cells which are comparable with the cells of the mammalian pars intermedia and are chiefly aggregated around its neck, as in some types of mammals. The nervous tissue of the posterior lobe, with its epithelial investment, may be regarded as forming a distinct organ which has probably a similar function to that exercised by the posterior lobe of the mammalian pituitary. It also resembles the mammalian posterior lobe in the occurrence within its nervous substance of colloid or hyaline bodies. The colloid is, however, confined to the nervous tissue of the lobe, and I have not seen it in or between the cells of the pars intermedia. No colloid is found in the anterior lobe proper.

#### PHYSIOLOGICAL ACTION OF EXTRACTS OF THE LOBES OF THE FOWL'S PITUITARY.

##### Anterior Lobe.

Extracts of the anterior lobe of the pituitary body of the fowl, when injected intravenously, have little effect upon the blood-pressure, kidney volume, and urine secretion. There is no change in the force and frequency of the heart-beats; the blood-pressure may show a very slight rise, as in fig. 2, but is not much altered. Sometimes the pressure falls slightly and quickly recovers, but I have not seen a marked fall after injection of extracts of the fowl's anterior lobe. The kidney volume increases a little, but not more than it does after the injection of a similar amount of Ringer's fluid alone.

The secretion of urine shows no change. Fig. 1 is a typical tracing of

the effects of the injection of 5 c.c. of an extract of anterior lobe in Ringer's solution into the blood-vessels of a cat. The anterior lobe of the fowl's pituitary does not, therefore, contain any active principles exerting an immediate physiological effect upon blood-pressure, kidney volume, or secretion of urine. In this respect it resembles the anterior lobe of the mammalian pituitary body.

#### Posterior Lobe.

The posterior lobe is readily separated from the anterior, and yields a greyish gelatinous material which dissolves to a certain extent in Ringer's solution. When boiled, filtered, and injected intravenously, such extracts produce immediate and well-marked effects. The blood-pressure begins to rise soon after the injection, the heart beats more rapidly, and

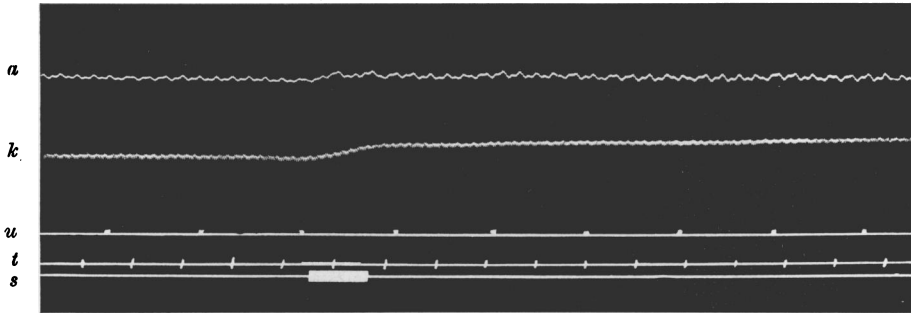


FIG. 1.—Effect of injection into jugular vein of a cat of 5 c.c. of an extract of anterior lobe of the fowl's pituitary in Ringer's fluid.

*a*, blood-pressure; *k*, kidney oncograph; *u*, urine secretion (drops); *t*, time in 5 sec. intervals; *s*, signal. In this and subsequent tracings the line *t* represents the zero of blood-pressure.

the large respiratory waves, when present, are abolished or very much diminished in size. The rise in blood-pressure occurs slowly and attains its maximum about two minutes after the injection. The rise is not a large one, but continues for some time and then gradually falls to normal. The respiratory movements, in spite of the continued supply of air containing the anæsthetic from the air-pump, are sometimes affected. Soon after injection the respiration is increased or inhibited for a short time, and then resumed as before. The kidney volume shows a slight initial increase, followed by a slow and gradual expansion, which, after a 5 c.c. dose (8 glands in 40 c.c. Ringer), attains its maximum in about fifteen minutes, and then falls gradually to what it was before the injection, the whole phase lasting about half an hour. The secretion of the urine increases with the expansion of the kidney, a latent period of one to two minutes usually elapsing before the increase begins.

The increase of urine is very pronounced. In the example of which fig. 2 is a tracing, the increase is from 12 drops in five minutes before the

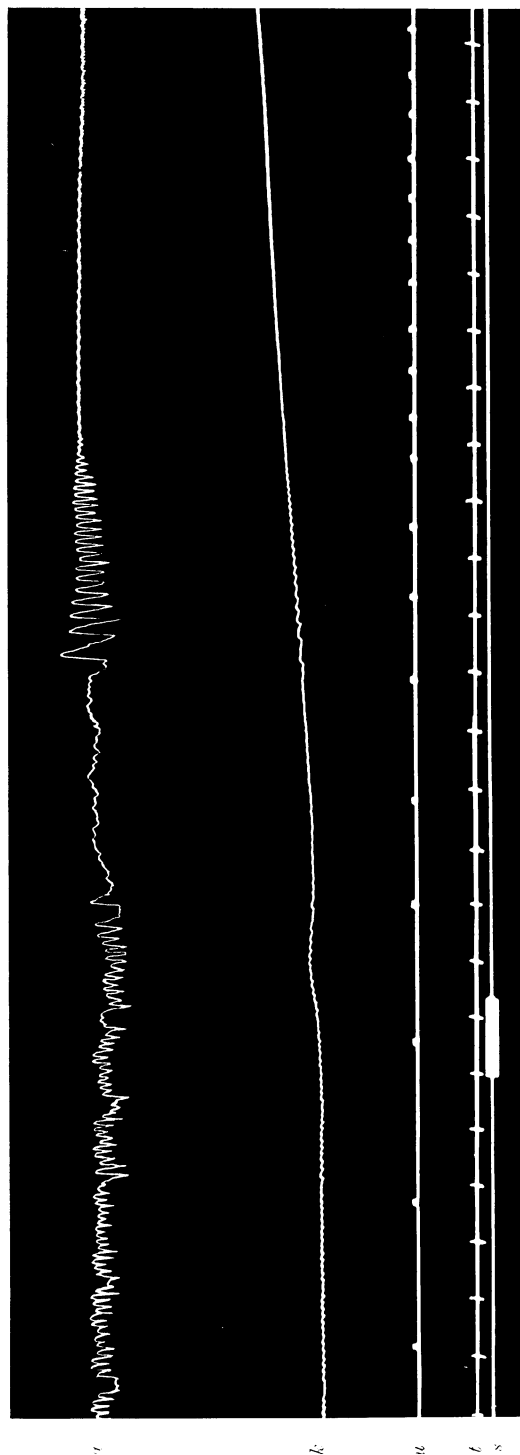


FIG. 2.—Effect of a first injection of 5 c.c. of an extract of posterior lobe of the fowl's pituitary (cat). (8 glands in 40 c.c. Ringier.)  
 Letters as in previous figure. Note slight rise of blood-pressure, marked expansion of kidney, and considerable diuresis.

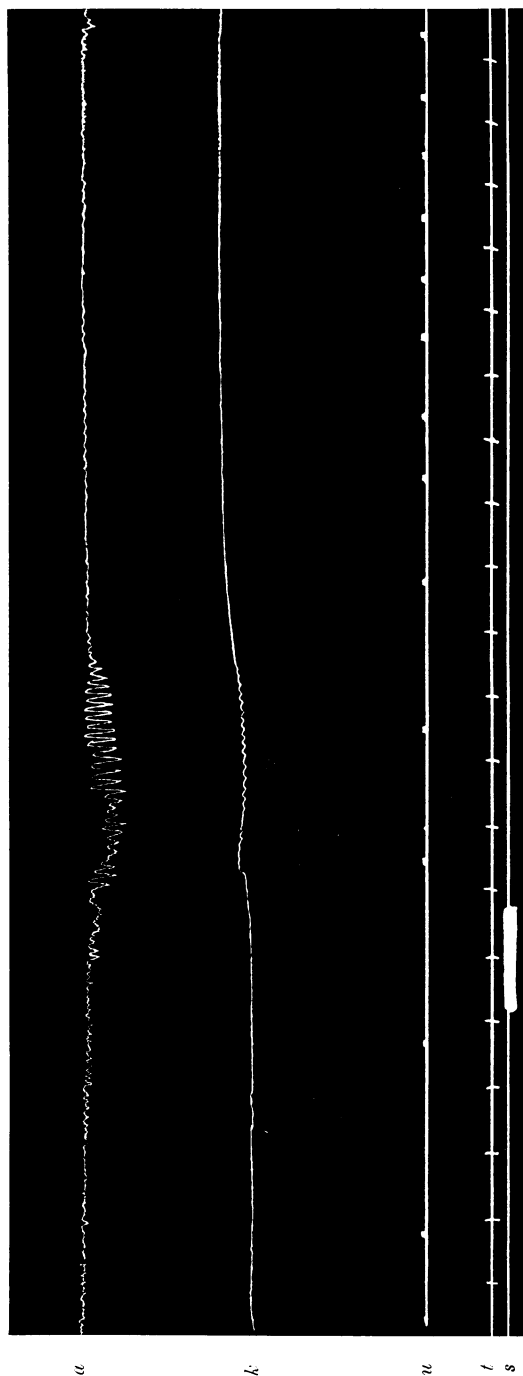


FIG. 3.—Effect of a second injection in the same animal as that used for the last tracing of 5 c.c. of an extract of posterior lobe of fowl's pituitary, administered twenty minutes after the first dose.

Notice the repetition of the above effects.

injection to 42 drops in five minutes afterwards. Where the secretion is very slow to begin with, the subsequent increase may be even more marked. The secretion is independent of the increase of blood-pressure, as was noted by Schäfer and Herring in the case of extracts of the mammalian posterior lobe; it is, however, related to the expansion of the kidney, and decreases when that begins to pass off.

A subsequent dose of the extract in the same animal, if administered after the kidney and urine effect have passed off, is followed by a repetition of the same changes, although there may be an initial fall of blood-pressure, followed by a slow rise (fig. 3).

Extracts of the posterior lobe of the fowl's pituitary have, therefore, an effect on blood-pressure, kidney volume, and urine secretion which is very similar to that produced by extracts of the posterior lobe of the mammalian pituitary. It is impossible to determine whether the active principles in the posterior lobe of the bird's pituitary are products of the epithelial cells of the *pars intermedia* or are formed solely in the nervous substance. The large preponderance of the latter in the bird might be considered as an argument in favour of their nervous derivation; but, on the other hand, if the cells of the *pars intermedia* pour their secretion into the *pars nervosa* of the lobe, it may accumulate there in larger quantities. There is evidence in the mammalian pituitary that the secretion is emptied into the third ventricle of the brain, and is furnished by the cells of the *pars intermedia*. The posterior lobe of the bird's pituitary is so constituted that a similar process may quite well be the normal one in it also.

## THE PITUITARY BODY OF TELEOSTS.

### Histological Features.

The pituitary body of the cod—*Gadus morrhua*—is taken as the type. In this fish the pituitary is a prominent organ lying in front of and below the *lobi inferiores*. The infundibular region is complicated by the presence of a *saccus vasculosus*, which lies immediately behind the pituitary, between the two large *lobi inferiores*. The pituitary body, although forming a single organ, is seen to be composed of two different kinds of tissue, an anterior portion, reddish or white according to the amount of blood in it, and a posterior part, greyish in appearance. The two portions are directly continuous with one another, and the line of division between them can only be recognised by the change of colour in passing from one to the other. On section, the pituitary is found to be a solid organ, and to resemble in general structure the pituitary of mammals and birds; it differs from these, however, in the arrangement of its parts.

In a median sagittal section (fig. 2 of Plate) the general relationship of the different parts is readily appreciated. The pituitary is composed of three varieties of tissue, two of which are epithelial and the third nervous, the



latter being comparatively small in amount. In the anterior part of the pituitary a somewhat quadrilateral or wedge-shaped mass is characterised by the large and deeply staining cells of which it is composed. These cells are almost identical in appearance with the cells found in the anterior lobe of the mammalian pituitary, and the portion containing them is probably the equivalent of the true anterior lobe. The cells are arranged in columns with blood-channels between. There is no trace of tubules, and nothing to support Haller's contention that the anterior lobe of the teleostean pituitary is a tubular gland secreting into the subdural space. This portion of the pituitary of the cod corresponds with that described by Sterzi in other bony fishes as the chromophil segment. Gentes also noted the deeply staining cells met with in certain positions in the teleostean pituitary, and showed that they vary in situation and extent in different species. The chromophil portion is aggregated in the cod's pituitary in the position indicated in fig. 2, c, of Plate. It may be regarded as constituting the true anterior lobe, and its similarity to the anterior lobe of the mammalian pituitary suggests that it has a like function.

The other epithelial constituent of the cod's pituitary is widely distributed in the form of small round cells which have little affinity for stains. They surround and invade the nervous tissue of the pituitary, and resemble in this respect the cells of the *pars intermedia* of the mammalian organ. This part of the gland was described by Sterzi as the "chromophobe" portion, and there is little doubt that it corresponds with the *pars intermedia* of mammals and birds. Gentes found it in the types he examined, and states that it surrounds and passes between projections of the nervous substance of the infundibular lobe. The *pars intermedia* in the cod is divided into two main portions, which are continuous with, and separated from one another by, the true anterior lobe. The part which lies in front of the chromophil segment consists of a mass of small cells among which fibres of the nervous substance penetrate. The latter increases in amount towards the junction of the pituitary with the brain substance behind the optic nerves. The thin lamina of nervous tissue connecting the pituitary with the brain in this situation is called by Gentes the *lamina post-optica*. The main mass of the *pars intermedia* lies behind the chromophil portion and makes up the greater part of the lobe. On the surface of the pituitary the epithelial cells form a thick mass and pass deeply inwards among the fibres of the nervous portion.

The *pars nervosa* of the cod's pituitary is small in amount, and appears to be composed of neuroglia and ependyma cells, without any true nerve cells. It is continuous with the brain in front by the *lamina post-optica* or anterior lamina, and at the sides by lateral laminae. A thin layer of nervous tissue separates the chromophil substance from the cavity of the infundibulum. Behind and in the middle line the pituitary is continued into the wall of the *sacculus vasculosus*. The nervous substance of the pituitary closely resembles in structure the *pars nervosa* of the mammalian

pituitary. It is freely invaded by cells of the *pars intermedia*—more so, indeed, than is the case in mammals. It contains, moreover, the colloid or hyaline bodies of mammals and birds, and like them it encloses an infundibular cavity which communicates with the ventricles of the brain. The pituitary of the cod furnishes another example of a brain gland similar in its essential structure and relationships with the brain to the pituitary of mammals and birds. *Pars intermedia*—chromophobe portion of Sterzi—and *pars nervosa* make up a structure strictly comparable to the posterior lobe of mammalian and avine pituitaries. In the cod there is no epithelial cleft, and anterior and posterior lobes are fused together. The fusion is in some cases even more complete than is indicated in fig. 2 of Plate, for it not infrequently happens that some of the chromophil cells of the anterior lobe are found among the cells of the *pars intermedia*, and cells of the latter occur in the true anterior lobe. It is almost impossible, for this reason, to separate one portion from another exactly; but the difference in colour of the two parts is, as a rule, sufficiently obvious to enable one to divide them for the purpose of making extracts.

The *saccus vasculosus* of the cod is single and placed in the middle line. According to Gentes, the *saccus vasculosus* varies considerably in size in different species of teleosts, and may, indeed, be absent altogether, or present only in a rudimentary state. In the cod it is well developed and forms a wide-mouthed sac opening into the infundibulum immediately behind the pituitary recess. It is lined by a single layer of columnar epithelium resting upon a basement membrane. Numerous blood-vessels reach it in the middle line in the interval between the two large *lobi inferiores*. The columnar cells are large, with a nucleus in each situated near the basement membrane, the part of the cell next the lumen of the sac being clear. The epithelium is thrown into numerous folds which are suggestive of an increase of surface for secretory purposes. The arrangement and structure of the *saccus vasculosus* is such as indicates that it is a gland which secretes into the ventricles of the brain. Gentes believes that it is to be looked upon as a ventral choroid plexus, and that its function is to help in the formation of the cerebro-spinal fluid. It was called an infundibular gland by Rabl-Rückhard (9). The *saccus vasculosus* of the cod is attached to the brain behind, and its epithelium is continued for a short distance over the ventricular surface. The brain-tissue above it is remarkable for the large *ependyma* cells which line its internal surface.

#### PHYSIOLOGICAL ACTION OF EXTRACTS OF THE LOBES OF THE PITUITARY AND OF THE SACCUS VASCULOSUS OF THE COD.

##### Anterior Lobe.

Extracts of the anterior lobe proper—chromophil portion of Sterzi and Gentes—have little immediate physiological effect (fig. 4). The blood-

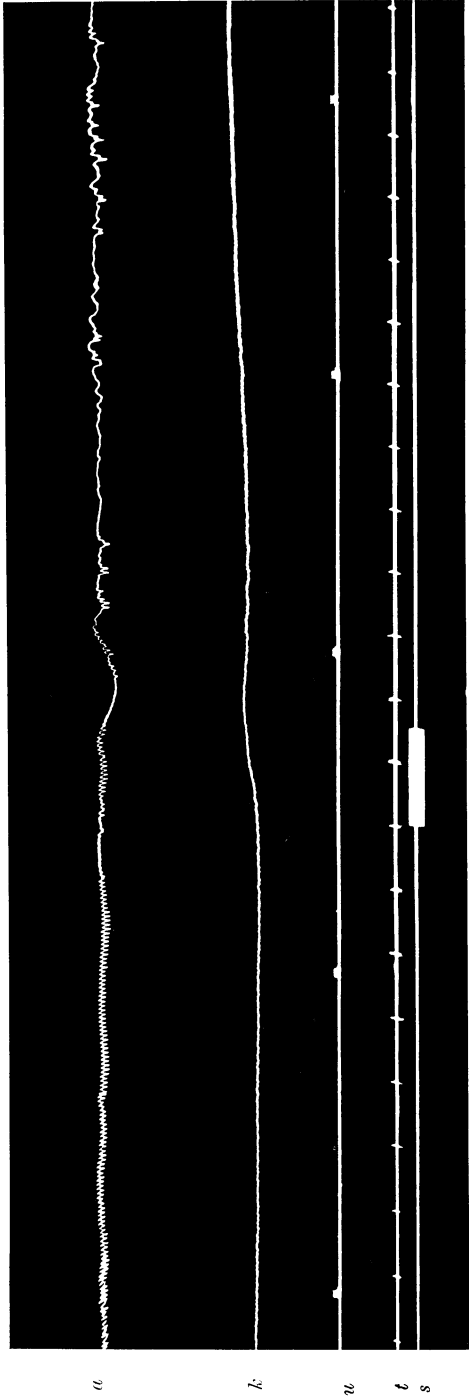


FIG. 4.—Effect of an injection into the jugular of a cat of 5 c.c. of extract of anterior lobe—chromophil cells of Sterzi—of the pituitary of the cod. (12 glands in 40 c.c. Ringer.)

This extract probably contained some of the cells of the pars intermedia in addition to those of the anterior lobe.

pressure may show a temporary slight fall or remain unaltered. The frequency and force of the heart-beat are unaffected.

The kidney frequently shows a slight expansion, but not a continued one. The secretion of urine is unaltered or very slightly increased. The difficulty of isolating completely the proper tissue of the anterior lobe from the elements of the posterior make it probable that any effect obtained by the injection of its extracts is brought about by the inclusion of a little of the posterior lobe. If the dissection be so made as to avoid the junction of the two lobes, extracts of the chromophil portion have practically no action. It seems, therefore, that the anterior lobe or chromophil segment agrees in the inactivity of its extracts as well as in its structure with the anterior lobes of the pituitary of mammals and birds.

### Posterior Lobe.

The general effect of extracts of the posterior lobe is similar to that brought about by extracts of the mammalian and avine posterior lobes.

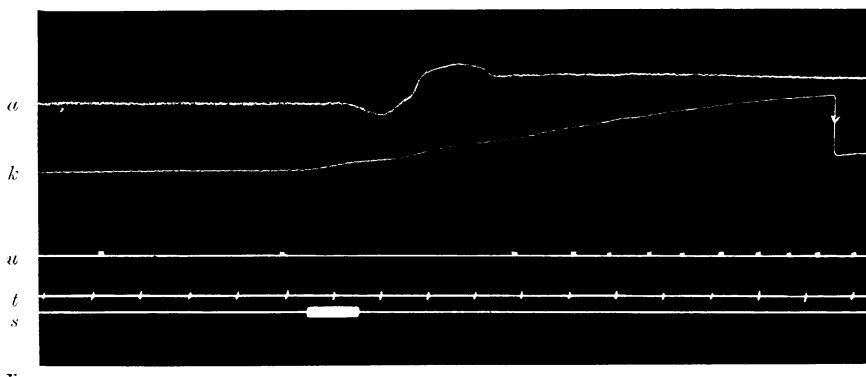


FIG. 5.—Effect of injection into the jugular of a cat of 5 c.c. of an extract of the posterior lobe—pars intermedia and pars nervosa—of the cod's pituitary. (12 glands in 40 c.c. Ringer.)

The arrow on the kidney oncograph indicates an artificial lowering of the writing point. Notice the rise of blood-pressure and rapid expansion of kidney, as well as the well-marked diuresis.

The blood-pressure is almost immediately affected. A considerable rise may take place, preceded sometimes by a slight fall, or the increase of blood-pressure may be only trivial. The same extract frequently produces different results when injected into different cats. In one animal the rise of blood-pressure may be marked, in another very slight, and that notwithstanding that no previous injections of any kind have been made in these animals. Howell pointed out that a repeated dose of pituitary extract does not produce the same results on blood-pressure as are brought about by the first injection, and this observation holds true of extracts of the posterior lobe of the pituitary of avine and teleostean pituitaries as well. The immunity conferred by a first dose does not last very long, and varies with the amount and strength of the injection given; but, in order to obtain

the typical effect, the first injection of extract of posterior lobe can alone be relied upon. Subsequent doses, unless delayed for half an hour, an hour, or longer, according to the amount and strength of the first injection, are followed by a fall of blood-pressure. The same is not the case with regard to the effect upon kidney volume and secretion of urine.

The force and frequency of the heart-beat are scarcely affected, but irregularities in the pressure-tracing due to inhibition of the heart are often abolished for a time.

The kidney expands almost immediately after the injection, and this expansion may be rapid and very considerable, as shown in fig. 5. As was the case after injections of an extract of the posterior lobe of the avine pituitary, the expansion of the kidney may last for twenty minutes or longer and then gradually pass off. The amount of urine secreted begins to increase with the expansion of the kidney, and the increase may be, and usually is, very considerable. In the experiment, of which fig. 5 shows part of the tracing, the increase of urine was from 6 drops in five minutes before the injection to 31 drops in five minutes afterwards, i.e. an increase of five times the amount in a given time. There may be a delay of several minutes after the injection before any increase of urine is detected, and the same extract has different effects in this respect in different cats.

The posterior lobe of the pituitary of the cod has, therefore, an action on blood-pressure, kidney volume, and urinary secretion similar to that of the posterior lobe of the mammalian and avine pituitaries.

Extracts of the posterior lobe of the pituitary of other teleosts, e.g. the ling (*Molva vulgaris*) and the John Dory (*Zeus faber*), have been tried and give the same results. One may conclude, therefore, that the posterior lobe of the teleostean pituitary, corresponding as it does in structure and in the action of its extracts with the posterior lobe of the mammalian and avine pituitary, has a like function. In the case of the teleost the cells of the *pars intermedia* predominate in the posterior lobe and are inseparable from the *pars nervosa*, so that one cannot determine which produces the active material. It seems probable, indeed, that both are concerned; for, wherever cells of *pars intermedia*—chromophobe cells of Sterzi—are bound up with *pars nervosa*, extracts of the resulting tissue produce the effects on blood-pressure, kidney volume, and urine secretion which have been associated with extracts of the posterior lobe of the mammalian pituitary.

#### Saccus Vasculosus.

Extracts of the saccus vasculosus are practically inactive. There is no effect on blood-pressure, and, although there may be some expansion of the kidney, the increase of urine, if any, is very slight (fig. 6). Almost identical effects are produced by rapid injection of a similar amount of Ringer's fluid.

It is of interest to note the observation of Gentes, that in different species of teleosts the saccus vasculosus varies greatly in size and may even

be absent. Gentes further remarks that the presence or absence of the saccus vasculosus brings about no modification of the nervous lobe. It is very probable that the saccus vasculosus has, as Gentes believes, a function similar to that of a choroid plexus.

#### THE PITUITARY BODY OF ELASMOBRANCHS.

##### Histological Features.

The pituitary body of the skate—*Raja batis*—is taken as the type. In the skate the pituitary is a long, club-shaped body which lies for the most part behind the small *lobi inferiores*. Its anterior extremity is thin, and stretches forward to the optic chiasma. Close to it is the large saccus vasculosus which is bilobed. The lobes of the saccus vasculosus appear to arise just above the anterior part of the pituitary by a common origin with it.

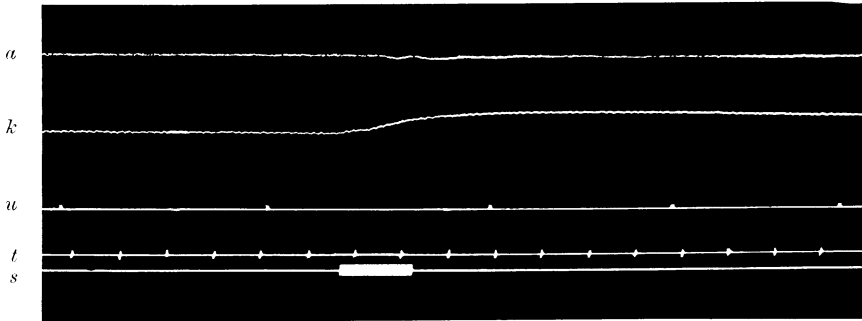


FIG. 6.—Effect of the injection into the jugular of a cat of 5 c.c. of an extract of the saccus vasculosus of the cod. (12 glands in 20 c.c. Ringer.)

The effect upon the kidney is no greater than that produced by rapid injection of 5 c.c. Ringer alone.

Each lobe passes backwards and outwards, and the body of the pituitary lies between them. A fine prolongation of connective tissue passes from the under surface of the pituitary body into the cartilage of the floor of the cranium, binding it closely down to the latter. This is the remnant of the neck of Rathke's pouch, from which the pituitary is developed, and was described by Miclucho-Maclay (6) in the shark. In the skate all connection between buccal mucosa and pituitary body is lost, but a string of connective tissue persists in the cartilage. It is advisable for this reason, in removing the pituitary body, to expose it by cutting away the cartilage of the floor of the cranial cavity.

On making a sagittal section through the pituitary, it is seen to extend for a long distance backwards from the optic chiasma, and to be quite different in structure from the pituitary bodies of mammals, birds, and teleosts. The main body of the organ lies posteriorly, and is the part which Haller designates as the head of the pituitary. It at first sight appears to be composed of tubules lined by large columnar cells, but on careful examination

the tubules are found to consist of columns of cells surrounding blood spaces. The lumen is a blood channel. This feature has been emphasised by Gentes, who states that the elasmobranch pituitary is a typical example of a gland whose secretion is poured directly into the blood-vessels. The epithelial cells surrounding the blood channels are columnar, with nuclei situated at their bases, the part of the cell bordering on the blood-vessel being clear. Outside the columnar cells and separating the vascular tubules from one another is a small amount of what appears to be a very vascular connective tissue. The vascular tubules and this connective tissue make up the body of the lobe. There are no deeply staining granular cells resembling the chromophil cells of the anterior lobe of the pituitary of mammals and teleosts, nor are there any cells exactly resembling those of the *pars intermedia*.

The anterior extremity of the skate's pituitary consists of a comparatively thin prolongation of epithelium enclosing a cavity (fig. 3, *b*, of Plate) which is stated by Gentes to be the remains of the cavity of the original sac from which the pituitary develops. It is lined by columnar epithelium very similar in appearance to that surrounding the blood-vessels in the body of the lobe. The cavity appears to be completely closed, and is much sacculated by convolutions of its wall. Outside this sac are numerous blood-vessels.

There is no differentiation of the pituitary gland of the skate into anterior and posterior lobes. An infundibular cavity is present which runs backwards and downwards to the body of the pituitary. It does not penetrate into the pituitary, but ends in the middle line, as shown in the figure. When followed laterally, however, the infundibular cavity is found to pass on either side into the *saccus vasculosus*. The nearest approach to anything resembling a posterior lobe is seen in the thin lamina of nervous tissue which bounds the infundibular cavity and passes into the tissue of the pituitary. Whether the fine vascular tissue that lies between the epithelial tubules in the body of the pituitary is of nervous origin or not is uncertain, but it is continuous with the lamina of nerve tissue that forms the lower wall of the infundibular cavity. If this tissue really belongs to the posterior lobe, then we have in the skate a very complete intermixture of elements derived from the brain and from buccal epithelium. Gentes states that the posterior lobe is completely absent in elasmobranchs. It is probable, however, that some representative of the *processus infundibuli* exists even in adult life, and that the general plan of development of the pituitary in elasmobranchs does not differ from that of other vertebrates. The nerve tissue in the anterior wall of the infundibulum must be regarded as a representative, in part at least, of the posterior lobe. But its constitution is altered by the large development of the *saccus vasculosus*, and the extension of the epithelium of the *saccus* over the lining wall of the infundibulum.

The *saccus vasculosus* is extremely well developed in the skate, and is a

prominent bilobed organ with a deep red colour due to the amount of blood contained in its vessels. Its wall is thin and convoluted, and consists of one or more layers of epithelial cells outside which are numerous and large thin-walled blood-vessels. The epithelium is continued forwards into the infundibulum, and in median sagittal section the common opening of the two sacs is seen lying above and in front of the body of the pituitary.

The pituitary body of the skate is, then, an example of a type which is entirely different from those of mammals, birds, and bony fishes. There is no differentiation into anterior and posterior lobes, and the characteristics of the cell elements of these are missing. The pituitary body itself furnishes, as Gentes says, a schematic type of gland secreting into blood-vessels. The posterior lobe is not distinct, but is represented to some extent; its infundibular surface appears to be largely devoted to the same purposes as the saccus vasculosus. There are no colloid bodies present in the thin layer of nervous substance, and no cells clearly resembling those of the *pars intermedia*.

#### PHYSIOLOGICAL ACTION OF EXTRACTS OF THE PITUITARY AND OF THE SACCUS VASCULOSUS OF THE SKATE.

##### The Pituitary Body.

Extracts of the whole pituitary body of the skate have little effect upon blood-pressure, kidney volume, or secretion of urine. Strong extracts produce a temporary fall of blood-pressure, but not a marked one (fig. 7). Kidney volume is slightly increased, but there is no continuous expansion, and the effect is merely that of the injection of Ringer's fluid.

Kidney secretion is unaltered or very slightly increased. It is doubtful if this increase is a specific one: it may be solely caused by the rapid injection of so much fluid. The pituitary body of the skate apparently contains none of the active principles which are found in the *pars nervosa* and *pars intermedia* of mammals, birds, and teleosts. If any of these are present, it is only in very small amount; there is no clear evidence of a histological character for the presence of these active principles, and it is probable that they do not exist in the elasmobranch pituitary.

##### The Saccus Vasculosus.

Extracts of the saccus vasculosus, even when very concentrated, have little effect. There may be, as in fig. 8, a temporary fall of blood-pressure, but with weaker solutions there is no change.

Kidney volume and urinary secretion may show a slight temporary increase, but, as was the case with extracts of the saccus vasculosus of the cod, it is not a specific effect, but merely the result of the rapid injection of so much Ringer's fluid.

Extracts of portions of the brain adjacent to the pituitary body and



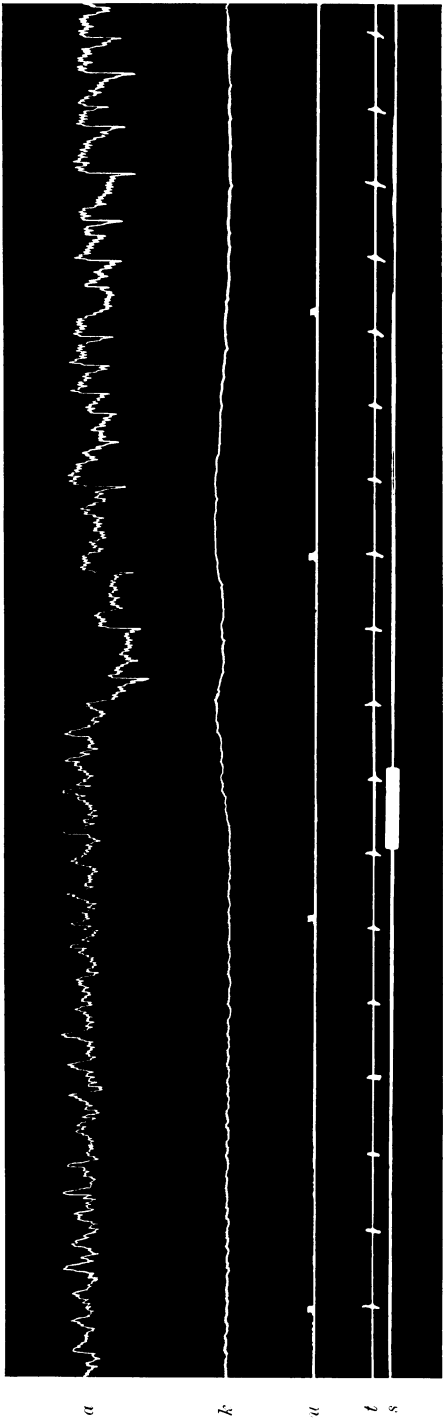


FIG. 7.—Effect of the injection into the jugular of a cat of 5 c.c. of an extract of the pituitary body of the skate. (5 glands in 20 c.c. Ringer.)

There is a transient fall of blood-pressure, accompanied by expansion of kidney, but no diuresis.

saccus vasculosus, and extracts of the lobi inferiores, bring about a large fall of blood-pressure; the effects are similar to those seen after injection of extracts of central nervous system in general. There seems to be nothing in the infundibular region of the brain of the skate which is comparable in the action of its extract with the posterior lobe of the pituitary body of mammals, birds, and bony fishes.

### Conclusions and Summary.

In mammals, birds, and bony fishes the pituitary body consists of two lobes, an anterior or epithelial which has the structure of a gland secreting into blood-vessels, and a posterior composed of nervous tissue more or less surrounded and invaded by epithelial cells of the pars intermedia. The posterior lobe may also furnish secretion into blood-vessels, but its arrange-

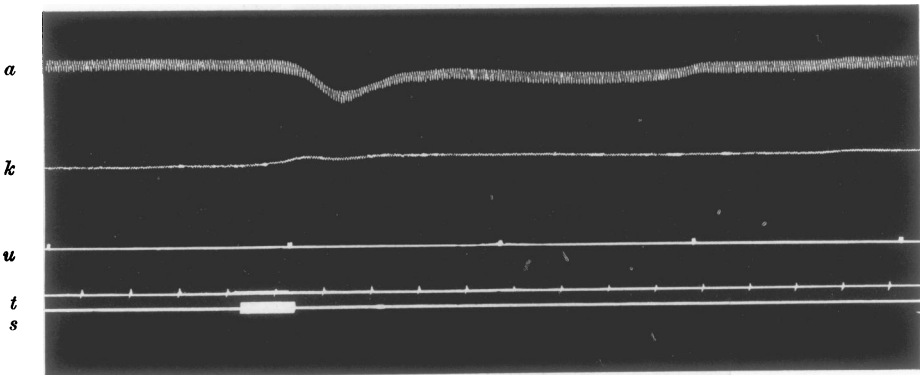


FIG. 8.—Effect of the injection into the jugular of a cat of 5 c.c. of an extract of the saccus vasculosus of the skate. (5 glands in 20 c.c. Ringer.)

There is a transient fall of blood-pressure and slight expansion of kidney, but no diuresis.

ment and histological features suggest a gland which pours its products into the infundibulum, and so into the ventricles of the brain. It may, therefore, be regarded, in part at least, as a special brain gland.

Extracts of the anterior lobe have no immediate physiological action when injected into the blood-vessels.

Extracts of the posterior lobe of birds and bony fishes have an action similar to extracts of the mammalian posterior lobe, bringing about a rise of blood-pressure, expansion of the kidney, and an increase in the secretion of urine. The tissue in which the active principles giving this result are found, contains, when examined histologically, bodies of a colloid nature such as have already been described in mammals in a previous paper. Whether this colloid contains the above-mentioned active principles or not, is undecided; it may possibly be the expression of some other function. The close relationship which exists between pars nervosa and pars intermedia of the posterior lobe renders it probable that the active principles,

and especially the colloid bodies, are furnished by the epithelial cells, but it is possible that the ependyma cells have also a secretory function.

The pituitary body of elasmobranchs differs widely in structure from that of the other classes considered. It is a gland which apparently secretes directly into the blood-vessels, but it contains none of the deeply staining (chromophil) cells which are characteristic of the anterior lobe of mammals and teleosts. Its posterior lobe is absent or merely rudimentary.

Extracts of the pituitary body of elasmobranchs have no immediate physiological activity.

The saccus vasculosus secretes its products into the ventricles of the brain. Its extracts are inactive, and it is probably an auxiliary to the choroid plexus, aiding in the production of the large amount of cerebrospinal fluid which is found in fishes.

I have to thank Mr Richard Muir for the care with which he has executed the accompanying illustrations. The expenses incurred have been assisted by a grant from the Carnegie fund for research-work.

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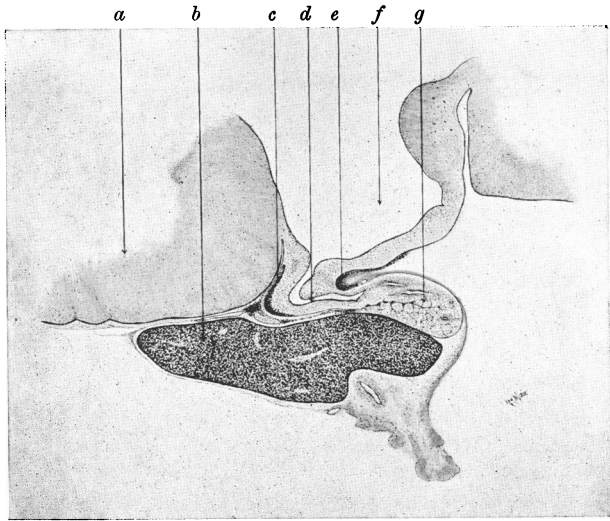
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## DESCRIPTION OF PLATE.

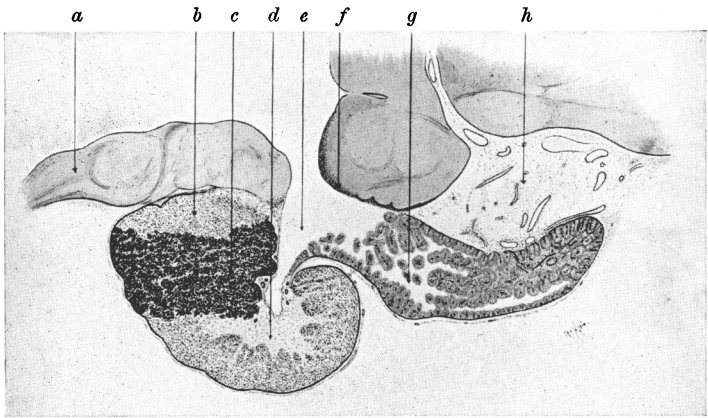
Fig. 1. Median sagittal section through the pituitary body of the fowl—*Gallus domesticus*. *a*, optic chiasma; *b*, anterior lobe of the pituitary—pars glandularis; *c*, cells of the pars intermedia; *d*, neck of the posterior lobe; *e*, cells of the pars intermedia lying behind the neck; *f*, third ventricle; *g*, posterior lobe of the pituitary.

Fig. 2. Median sagittal section through the pituitary body and saccus vasculosus of the cod—*Gadus morrhua*. *a*, optic nerve; *b*, anterior part of pars intermedia—chromophobe cells of Sterzi; *c*, pars glandularis or anterior lobe—chromophil cells of Sterzi; *d*, pars nervosa surrounded by cells of pars intermedia—posterior lobe; *e*, infundibulum; *f*, large ependyma cells; *g*, saccus vasculosus; *h*, space between lobi inferiores occupied by blood-vessels and connective tissue.

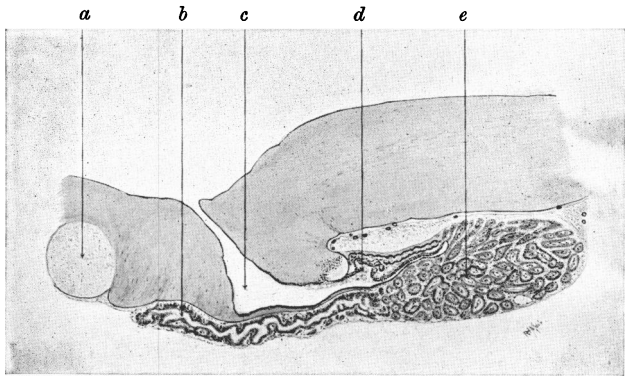
Fig. 3. Median sagittal section through pituitary body of skate—*Raja batis*. *a*, optic chiasma; *b*, anterior part of pituitary enclosing cavity; *c*, infundibulum; *d*, opening of saccus vasculosus on either side into infundibulum; *e*, body of pituitary.



**FIG. 1.**



**FIG. 2.**



**FIG. 3.**