for normal dogs, as observed from a large series (unpublished) of animals. Obviously, the capacity of the atrophied adrenal cortex to secrete the indispensable hormone, "interrenalin," is not materially altered by hypophysectomy, since animals surviving a relatively long time show no pathognomonic evidence of adrenal insufficiency.

In most instances the rate of blood flow from the adrenals was decidedly lower than is usually found in normal dogs. This might be accounted for by the atrophic changes in the adrenals induced by hypophysectomy. The epinephrine concentration in the adrenal vein blood was correspondingly greater. This can explain the results obtained by Képinov. An increased concentration of epinephrine in the adrenal vein blood, however, does not indicate an increased rate of secretion unless the rate of blood flow from the glands is not diminished.

Our experiments lead to the conclusion that the rate of epinephrine secretion from the adrenals, in dogs, is not significantly altered by hypophysectomy. Certainly, such alterations in the epinephrine output as would correspond with amounts of epinephrine necessary to have an important influence on blood sugar or on blood pressure, did not occur.

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Structure and Function of the Peritoneal Funnels* of the Frog, *Rana pipiens.*

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Heidenhain[1] found no trace of peritoneal funnels in the frog's kidney. Spengel[2] first saw these funnels in such forms as *R. temporaria, B. cinereus, D. pictus,* and Bombinator. He claimed that in the Coecilia and Urodela there was a connection between these

* Since the term "nephrostome" refers specifically to the funnel of a nephridium, the term "peritoneal funnel" is used here to designate the adult structure described without implying its origin, or its tubular connection with either the nephrocoel or hæmocoel. In this way there need be no confusion as to the adult structure found in the Anura or Urodela.

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1 Heidenhain, R., *Arch. f. Mikr. Anat.*, 1874, **10**, 1.

2 Spengel, J. W., *Zentrlblt. f. d. med. Wissensch.*, 1875, No. 2.

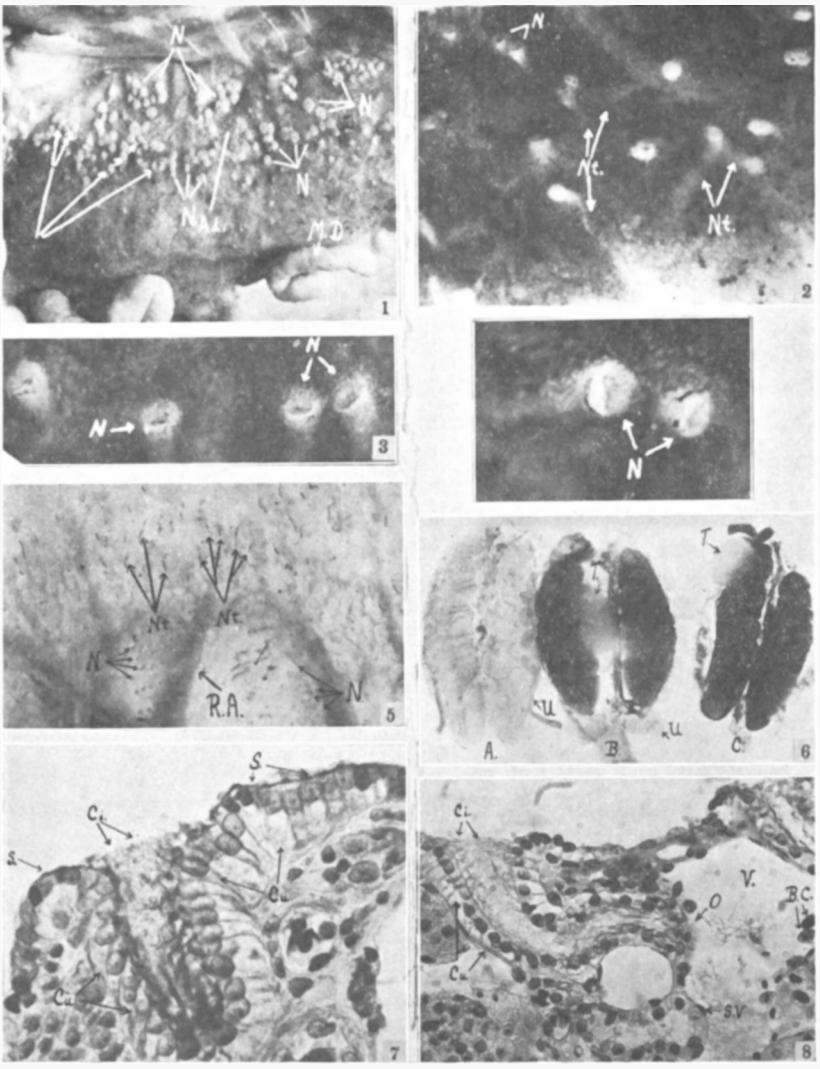

FIG. 1. Surface view of the ventral face of the kidney of an adult male frog, *Rana pipiens*, showing numerous peritoneal funnels (N); adrenal gland tissue (Ad.); and the Mullerian duct (M.D.).

FIG. 2. Enlarged view of surface of frog kidney showing peritoneal funnels (N) and related funnel tubes (Nt).

FIGS. 3 and 4. Enlarged views of peritoneal funnels.

FIG. 5. Ventral face of frog kidney taken from frog which had been injected 5 minutes previously with a solution of india ink. Peritoneal funnel tubes (Nt.) are shown filled with ink, and numerous funnels (N) are seen clustered between the renal arteries (R.A.).

FIG. 6. Urino-genital systems excised from frogs at varying periods after the frogs had been injected with a solution with india ink. Testes (T) and Ureter (U). A. Five minutes after injection into body cavity. B. One hour after injection. C. Five hours after injection.

FIG. 7. Section through peritoneal funnel showing squamous (peritoneal) epithelium (S); cilia (Ci) within the funnel and cuboidal epithelium (Cu.) of the funnel wall, changing to columnar.

FIG. 8. Section through peritoneal funnel and tube showing connection (O) with a blood sinus (V) containing blood corpuscles (B. C.) and surrounded by typical squamous epithelium of the venous system (S.V.).

funnels and the malpighian bodies but that in *B. cinereus* he found a connection with the fourth section of the uriniferous tubule.[3] Simultaneously but independently Meyer,[4] using the silver nitrate method, counted 195 openings on the adult frog's kidney. Nussbaum[5] reported that in larval anura the connections were between the peritoneal tubes and the neck of the malpighian body while this connection was shifted, in the adult anura, to the renal veins. He showed this renal vein connection more conclusively[6] in *R. fusca, R. esculenta, B. calamita,* and *A. obstetricans.* In the same year Hoffman[7] stated that these tubules in the adult anura end blindly. Ecker[8] claimed that the funnels were very difficult to find; that they did not connect any part of the uriniferous tubule with the body cavity; and that their superficial terminations had no cilia. Marshall and Bles[9] described the embryonic formation of these funnels and tubes and showed that in *R. temporaria* they lose their early connections with the malpighian bodies and uriniferous tubules and finally empty into renal veins. Farrington[10] injected carmine into the renal portal veins and found it emerging from the peritoneal funnels but he did not indicate why blood corpuscles were not likewise liberated into the body cavity of untreated frogs. He did state that in the Urodela these tubes opened into the uriniferous tubules but in both *R. catesbiana* and *R. virescens* they opened into branches of the renal portal veins. Hall[11] claimed that the malpighian capsule and the developing funnel formed the short arms of a Y, the long arm of which opens into the archinephric duct, but that subsequently the funnel tube broke away and joined a blood vessel.

3 Spengel, J. W., *Arb. a. d. Zool. Zootom. Inst. der Univ. Wurtemberg,* 1876, **3**, 82.

4 Meyer, Fritz, *Beitrage zur Anatomie des Urogenitalsystems der Selachien und Amphibien,* Leipzig, 1875.

5 Nussbaum, M., *Zool. Anz.,* 1880, **3**, 514.

6 Nussbaum, M., *Arch. f. Mikr. Anat.,* 1886, **27**, 466; *Zool. Anz.,* 1887, **20**.

7 Hoffman, C. K., *Z. f. wissensch. Zool.,* 1886, **44**,

8 Ecker, A., *The Anatomy of the Frog,* translated with numerous annotations and additions by Dr. J. Haslam, Clarendon Press, Oxford, 1889.

9 Marshall, A. M., and Bles, E. J., *Studies from the Biological Laboratories of Owens College, Manchester,* 1890, **11**.

10 Farrington, O. C., *Trans. Conn. Acad. Sc.,* 1892, **8**, 309.

11 Hall, R. W., *Bull. Mus. Comp. Anat. and Zool., Harvard,* 1904, **45**, 32.

Gray[12] showed that during the development of *R. temporaria* the lumina of the peritoneal funnels never form any connection with the lumina of the malpighian capsules but form a direct connection between the coelom and the blood system.

In *Rana pipiens* the 200-250 peritoneal funnels found on the adult male or female kidney are limited to the four-fifths of the ventral face of the kidney covered by the peritoneum (Fig. 1). The vast majority of these funnels are found clustered between the large renal arteries (Fig. 5), which are found prominently on the ventral face of the kidney. The funnel tubes are directed toward the outer margin of the kidney (Figs. 1 and 5). These tubes are connected ultimately with the posterior vena cava as will be indicated.

The peritoneal funnel openings, which have an average diameter of from 50-80μ are highly ciliated (Figs. 7 and 8). In male frogs these are the only cilia found in the body cavity but in females the peritoneal lining is quite completely covered with cilia which are developed as a secondary sexual character (Rugh[13]). The cilia project slightly from the open end of the funnel (Fig. 7) but their constant and effective strokes are inward toward the funnel tube. The squamous (peritoneal) covering of the kidney disappears at the mouth of the funnel and beneath this epithelium, as the funnel is approached, there appears at first cuboidal and then almost columnar epithelium. The cells of the funnel and related tube bear numerous cilia, not single flagellæ as has been described for other forms. The tubule bends immediately, coursing just beneath the surface of the kidney (Figs. 2 and 8) and empties shortly into a blood sinus.

The function of these funnels and tubes can be easily demonstrated by injecting into the body cavity of each of several frogs 5 cc. of a solution of 1 part Higgins India ink and 2 parts of Holtfreter's[14] modification of amphibian Ringer's solution. This injection may be made at any point into the body cavity and will in no way affect the normal activity of the frog. Within 5 minutes, at ordinary laboratory temperatures of 22-25°C., one of the frogs may be opened, the excess ink in the body cavity washed away, and the entire urino-genital system quickly excised. It will be noted under binocular magnification and direct lighting that the funnels and tubes have already taken up considerable ink (Figs. 5 and 6A), but no trace of ink will yet be found in either the blood or excretory systems. The distribution of the funnel openings and the shape

[12] Gray, P., *Quart. J. Mic. Sc.*, 1930, **73**, 507.

[13] Rugh, R., *J. Exp. Zool.*, 1935, **71**, 163.

[14] Holtfreter, J., *Arch. f. Ent. Mech. der Org.*, 1931, **124**, 404.

and direction of the tubules (Fig. 5) coincide with the observations on the untreated kidney (Fig. 1). If a second frog is similarly examined after a lapse of one hour, it will be noted (Fig. 6B) that the funnels and tubules can no longer be distinguished because the complexly arranged renal blood vessels have become filled with ink particles. Ink will be found in the posterior vena cava, in the liver lobes (which will be black), and toward the anterior part of the body generally. The white testes in Fig. 6B show, as yet, no evidence of ink within their blood vessels. However, after 5 hours (Fig. 6C) there is very little ink left in the body cavity; the kidneys, liver, heart, and lungs are blackened by an accumulation of ink within their blood vessels; and even the arteries of the testes show the presence of pigment. This means that ink particles have been carried through the heart into the arterial system. Much of the ink is retained within the kidney itself, as can be noted by comparing Figs. 6B and 6C.

That the tubule is connected with a blood sinus is also histologically evident (Fig. 8). This connection is seen to be very near the ventral surface of the kidney, a fact which can be confirmed by a study of the living kidney at various intervals after exposure to ink. A study of both dorsal and ventral surfaces of the kidney indicates that these ink particles are limited to the ventral surface. If the tubules had any connection with the excretory units (the malpighian bodies or uriniferous tubules) ink would be seen almost immediately on the dorsal surface of the kidney and in the ureters. These ureters are clear (Fig. 6). In these tests males were used exclusively because the large ovaries of the hibernating female act as partial obstruction to the peritoneal funnels and also because the ostiae could alone rid the body of foreign material (Rugh[13]).

Summary. The peritoneal funnels of the adult frog, *Rana pipiens,* number from 200-250 and have an average diameter of 50-80μ; are confined to the ventral face of the kidney covered by peritoneum; and are clustered near the inner margin of the kidney. These funnels are constantly open to the body cavity and show no variations as to sex. They are highly ciliated and carry material (liquid or particles) from the body cavity, through short tubes just beneath the surface of the kidney, into venous sinuses and hence to the posterior vena cava. In adult frogs there is no connection between these tubules and the excretory units of the kidney (malpighian corpuscles) but they are excretory in the sense that they carry peritoneal contents into the blood system whence such material may be ultimately eliminated through regular excretory channels.