ON THE FUNCTION

OF THE

MALPIGHIAN BODIES OF THE KIDNEY.

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READ FEBRUARY 4, 1857.

In March last I read a paper before the Academy of Medicine upon the Structure and Functions of the Kidney. It may, perhaps, be remembered, that at that time I took occasion to dissent from the opinions of Mr. Bowman (whose views have been so generally adopted by the profession), not only with respect to the nature of the venous plexus, &c., but also in regard to the structure and function of the Malpighian coil or tuft. I then concluded, that instead of merely "separating water from the blood, while the urea, lithic acid, salts, &c., are separated by the epithelial lining of the uriniferous tubes from the blood of the venous plexus, which surrounds them," these tufts, on the contrary, were actively engaged in secreting several of the proximate elements of the urine. This view was deduced from the following facts:

1. That the urea, lithic acid, and salts of the urine have been found to exist in the blood of healthy animals. That in various diseases, and especially after extirpation of the kidneys, these substances are found, in large proportion, in the blood. It is, then, proved that they pre-exist in the blood, and are merely separated from it in the kidney.

2. The renal artery which supplies the kidney *must* neces-

sarily contain these proximate elements of the urine, and as the Malpighian tufts are placed upon the terminal twigs of this artery, they *must* consequently enter the tuft. A glance at the structure will lead inevitably to this conclusion.

3. Most diuretics enter the circulation and can be detected in the urine. They can arrive at the kidney only through the renal artery, and consequently must enter the Malpighian tuft. It would be too tedious and unnecessary to mention the various substances which, after having been absorbed, and having entered the circulation, have been found in the urine. I will only refer to a few which have been given by authorities: salts of iodine, bromine, sulphur, arsenic, antimony, mercury, copper, silver, lead, iron, mineral and organic acids and their salts, as the acetates, citrates, tartrates, &c., &c.; the balsams, cubebs, garlic, turpentine, asparagus, &c.; also quinine and morphine, &c., &c. *Urea, when given internally, acts as a powerful diuretic.*

4. According to Mr. Bowman, the Malpighian coil or tuft lies naked in the capsule of the uriniferous tube; which is a proof that it does not separate the complex proximate elements of the urine from the blood, but merely water, the coil or tuft being, as he says, "a bare or naked system of capillaries." Now I have conclusively demonstrated, by various processes, that the Malpighian tuft or coil is covered by oval, nucleated cells, which are differently affected by chemical reagents from those which line the capsule, and consequently have a different organization. The Malpighian tuft is evidently, then, a glandular structure, every way adapted for the separation of the proximate elements of the urine.

5. In opposition to the view that the Malpighian tuft is merely for the separation of water from the blood, it may be stated, that in serpents, alligators, turtles, &c., the Malpighian bodies abound throughout the cortical substance, and in some of these animals, throughout the whole structure of the kidney, yet their urine is secreted in the semi-solid state. It is not easy to reconcile this view with the theory that the Malpighian tuft merely separates water from the blood.

6. In the kidney of a patient who had been jaundiced for

several years I ascertained the presence of the coloring matter of the bile in the capsule of the Malpighian tuft, and in the commencement of the uriniferous tube. By the application of a drop of nitric acid, the Malpighian bodies exhibited the usual changes of color which are seen when this acid is brought in contact with bile. I therefore concluded, that in this case the coloring matter had been separated by the Malpighian tuft, passed into the capsule, and downwards into the uriniferous tube.

7. Within the last three months, I have performed several experiments upon animals by introducing into the stomach and intestines various coloring matters, capable of being absorbed, entering the circulation, and passing into the kidney. My object was to ascertain whether they would be detected in the uriniferous tubes alone, in which case it might be supposed that they were separated by the epithelial cells of the tubes from the blood of the venous plexus, as believed by Mr. Bowman; or whether they would be found in the Malpighian body as well as in the tubes, when there would seem to be no doubt that the Malpighian tuft separated the coloring matter, which had then passed into the capsule, and so on into the uriniferous tubes. Being very anxious then to ascertain what parts of the minute structure of the kidney would be found to be engaged in this process of separation or secretion, I performed the following experiments. In all of them the animals were put under the influence of sulphuric ether, so as to produce insensibility during the operation:

No. 1. I opened the abdomen of a dog, and tied both ureters; a ligature was then placed on the ileum, near its entrance into the cœcum. A small opening was made into the duodenum, about six inches from the stomach, and two ounces of a mixture of finely pulverized indigo and water were injected into the stomach. The tube of the syringe being again placed in the same opening, four ounces of the mixture were injected downwards into the jejunum and ileum. Ligatures were placed on the intestine, above and below the opening, in order to prevent the escape of the injected fluid. The abdomen was then closed by the glover's suture. This animal lived twenty-eight

hours after the operation, and died with the usual symptoms of poisoning, by retention of the urea. On *post-mortem*, there was very little peritonitis. On making thin sections of the kidney, the Malpighian bodies and uriniferous tubes were found very much darkened by the indigo. Both the bodies and the tubes were of various shades of dark blue and black, some being much darker than others.

No. 2. I operated upon a cat in a similar manner, using however a solution of deoxidized indigo, prepared according to the process of the dyers, with sulphate of iron and lime-water. By this process the indigo becomes very soluble, and of a light yellow color, absorbing oxygen, and turning blue on exposure to the air. On dissection, not a trace of indigo could be found in the kidney. I do not know to what cause the failure of this experiment should be attributed.

No. 3. I repeated the operation upon a small white dog of feeble constitution. This animal only lived fourteen hours. No indigo could be detected in the kidney. I think the cause of failure in this case was owing to the fact that the solution was made with cold, instead of warm water, which should always be used, and also to too long exposure of the intestines to the air.

No. 4. I injected the mixture of indigo and water into the stomach and intestines of a very large and ferocious black cat. The ureters were tied. He lived thirty-four hours. There was scarcely any peritonitis. Both the Malpighian bodies and uriniferous tubes were of a light blue, and some of a very dark color.

No. 5. I repeated the same operation on a kitten, which lived fifteen hours. The Malpighian bodies and tubes were of very dark color, as in the preceding experiment.

No. 6. In a large grey cat I removed the left kidney, and tied the right ureter, hoping that the remaining kidney, by receiving more indigo, would show the Malpighian bodies and the tubes more deeply colored. This cat lived twenty hours. Scarcely any peritonitis. The Malpighian bodies and uriniferous tubes were much darker than those of the animals of the preceding experiment. Some of them were nearly as black as

ink. It is from a thin section of the kidney of this cat, under the microscope, that the drawing and diagram have been made by my friend Mr. Benj. Howard, an excellent artist, and a student of medicine in the University of this city.

Plate 47.

No. 7. On the 28th of January I injected six ounces of a mixture of finely pulverized indigo and water into the œsophagus of a small dog. Eighteen hours after, I again injected six ounces more. Twenty-four hours afterwards, I injected six ounces of the mixture. Twenty-one hours after, four ounces were injected; and three hours after this last injection, the animal was killed. I may here mention that a brass pipe with a stop-cock had been left in the œsophagus, and secured in it by a ligature, so that the successive injections were made with great ease and convenience. On examination, only a small number of the tubes and Malpighian bodies were colored. Some of the last were of a light green color, others were slightly darkened; a few were more deeply colored. The tubes were generally uncolored, except here and there in the pyramidal portion of the kidney, where some of the straight tubes were nearly black. I regret that I could not inject the indigo in this animal at such times as I could have wished; could I have done so, the result would probably have been more satisfactory. It will thus be seen that out of seven experiments with indigo, five succeeded, the Malpighian bodies and uriniferous tubes being both colored by it. Berzelius found in indigo a brown, red, and blue pigment. This fact may explain the shades of color which were seen in the Malpighian bodies and uriniferous tubes. These organs may perhaps also produce some slight change in the coloring matter in its passage through them. In some thin sections of the kidney, the Mal-

pighian tuft and capsule seemed to be filled with colored material, which could be traced along the tube, gradually becoming lighter in its progress downwards. In some of these animals the urine in the ureters, above the ligatures, was of a slightly blue color.

No. 8. On the same day I injected a solution of the ferrocyanide of potassium into the stomach and duodenum of a large cat, and then placed a ligature above the opening which had been made into the intestine in order to inject the solution. About ten inches below this point I made another opening into the intestine, and injected downwards into the jejunum and ileum a weak solution of sulphate of iron. A ligature was placed just below this opening, so that the contents of the intestine could not escape. The two solutions were thus separated from each other by ten inches of intestine which contained none of the solution. Ligatures had previously been placed on the ureters. This experiment was performed at 3 P.M. on Saturday, and the animal was found dead on Monday morning, so that it is not known how long she lived after the operation. The Malpighian bodies and uriniferous tubes were of a dark blue color, showing that Prussian blue had been formed in the course of the circulation, and had passed through the Malpighian bodies and uriniferous tubes. The urine was of a slightly blue color.

No. 9. I may also state that I have injected a mixture of Prussian blue and water into the stomach and intestines of a cat, and have found the Malpighian bodies and tubes of a dark blue color; but I regret to say that I have lost the notes of the experiment, although the specimen of the kidney is still in my possession.

No. 10. December 24, at 4 P.M., I tied the ureters of a small dog and injected a solution of madder into the stomach and intestines. This dog was found dead on the 26th. The Malpighian bodies were of a brilliant red color, exhibiting a most beautiful appearance. The tubes were dark red, and some of them very darkly colored. Thin sections of the kidney were placed under the microscope, and then touched with a drop of solution of caustic soda or ammonia, when the Mal-

pighian bodies and tubes became of a still more brilliant red color. The urine which was retained in the ureters, above the ligature, was acted on similarly by the same chemical reagents.

No. 11. On the 22d of January, at 2 P.M., I injected a solution of madder, containing a small quantity of bi-carb. soda, into the stomach and intestines of a dog. This animal died at 8½ P.M. the same day. The ureters had been tied. The Malpighian bodies were of a bright red color. Some of the tubes were simply darkened, others of a dark red color. The fluid in the ureters, above the ligatures, was reddened on the application of carbonate of soda, and also of aqua ammoniæ.

No. 12. I injected a solution of the Brazil wood, *Cæsalpinia Crista*, into the stomach and intestines of a dog, having previously tied the ureters. On examination, sixteen hours after the operation, the Malpighian bodies were of a bright red color; the tubes were darkened. The red coloring matter of Brazil wood is very sensible to the action of alkalies, and on touching thin sections of the kidney, under the microscope, with solution of ammonia or soda, the Malpighian bodies became of a purple color. The tubes exhibited this change only in a slight degree, and many of them not at all.

No. 13. On the 24th of December last, at 12 M., I tied the ureters of a large dog, and injected a solution of cochineal into the stomach and intestines. He was seen alive at 5 P.M., and found dead on the morning of the 26th. The Malpighian bodies were very red; some of the tubes dark red, and a few of them were nearly black.

No. 14. On the same day, at 3 P.M., I tied the ureters in a cat, and injected a mixture of carmine and water into the stomach and intestines. She was seen alive at five P.M., found dead on the 26th. The appearance of the Malpighian bodies and the tubes was the same as in the preceding experiment.

No. 15. I injected into the œsophagus of a dog twelve ounces of a mixture made by rubbing in a mortar two drachms of powdered cochineal with half a drachm of bi-carbonate of soda, to which one ounce of glycerine was added, and afterwards eleven ounces of water. At the end of three hours the animal

was killed. The appearance of thin sections of the kidney, under the microscope, was exceedingly beautiful. The Malpighian bodies were distended, and of a purple and purplish red color. Some of the tubes were light red, others were uncolored. On adding a drop of solution of ammonia, the color of all these parts was changed to a deep red.

No. 16. I injected into the œsophagus of a cat three ounces of a similar mixture of cochineal and three ounces of infusion of madder. At the end of three hours this cat was also killed. The Malpighian bodies and the tubes were of similar, but not as deep color as those of the dog in the last experiment. The same effect was produced on thin sections of the kidney by using ammonia as in the last experiment.

No. 17. January 20th, at 3 P.M., I tied the ureters of a cat, and injected a solution of logwood into the stomach and intestines, having previously fixed a ligature on the upper part of the rectum. This cat was seen living at 9 P.M., and was found dead the next morning. There was no peritonitis, no sign of inflammation or congestion, except at one point, just below the ligature, on the rectum. Thin sections of the kidney showed the Malpighian bodies of a very red color. Under the microscope both these bodies and the tubes were darkened by the solution of the sulphate of iron. The urine retained in the ureters and in the pelvis of the kidney was also slightly darkened by the same reagent.

No. 18. On the 30th of January, at 1½ P.M., I placed a ligature on the duodenum of a cat, and another about the middle of the jejunum. Into this portion of included intestine I threw a solution of logwood. An opening was then made below the lowermost ligature, and a weak solution of sulphate of iron was injected, a ligature having been placed on the ileum just above the ileo-cœcal valve. This cat died at 8 P.M. the same day. The Malpighian bodies were dark red, and much distended; the tubes of a very slightly blue color. Neither were affected by dropping upon them the solution of sulphate of iron. This experiment was unsatisfactory, and the cause of failure is perhaps to be attributed to the fact that too large a quantity of the solution was injected, and the intestines consequently be-

came over distended. Absorption, therefore, did not fully take place.

No. 19. On the 2d February, at 6 P.M., I injected six ounces of a mixture of finely pulverized turmeric and water into the œsophagus of a cat. I repeated this injection several times, and on the 4th, at 4 P.M., she was killed. I could not detect the slightest trace of this coloring matter either in the kidney or the urine, nor even by chemical tests.

No. 20. On the 4th day of February I injected several times into the œsophagus of a cat an infusion of logwood, madder, and Brazil-wood. Four hours after she was killed. The Malpighian bodies were of a faint purplish red. On applying ammonia to thin sections, under the microscope, the color was increased. The bladder was full of a pink-colored urine, which was strongly reddened by ammonia, and also by caustic soda.

No. 21. I procured some of the Persian berries, or berries of Avignon, which are much used by the dyers in coloring cloths of a yellow color. In experimenting with this substance, I found that it contained a yellow coloring matter similar to that of the bile, inasmuch as when acted on by nitric acid it showed a play of colors similar to that which is exhibited when bile is treated with the same reagent. I also ascertained that the yellow coloring matter of Spanish saffron showed a transient green color when acted on by nitric acid. I injected an infusion of equal parts of Spanish saffron and the Persian berries into the œsophagus of a dog, to the amount of eight ounces, and repeated this injection every hour for four hours, at the end of which time the dog was killed. The Malpighian bodies and uriniferous tubes were of a yellow color. On adding a minute quantity of dilute nitric acid to thin slices of the kidney, under the microscope, a play of colors was seen similar to that which was observed when some of the mixed infusion of the Persian berry and saffron was poured on a white plate, then allowed to run off by inverting it, and finally a drop of nitric acid suffered to fall upon the plate, when the rapidly changing colors were instantly perceived.

If we now review the result of the experiments up to this point, it will be seen that of the various coloring matters which

have been detected, both in the Malpighian bodies and in the uriniferous tubes, by means of the microscope and by chemical tests, indigo has been found five times, madder twice, cochineal twice, and Prussian blue also twice. Carmine, the mixture of Persian berry and saffron, logwood and Brazil, have each only once been tried, and have all been detected in the kidney, as has also been the mixture of logwood, Brazil-wood, and madder, and likewise a mixture of madder and cochineal.

I may here state, that in none of my experiments with coloring matters have I ever detected them in the venous plexus of the kidney.

No. 22. On the 20th of December last I injected the stomach and intestines of a cat with a mixture of animal charcoal and water, having previously ligated the ureters. The animal lived twenty hours. Both the Malpighian bodies and the uriniferous tubes were of a very dark color, many of them being intensely black.

No 23. At 4½ P.M., on the 2d of February, I injected six ounces of a mixture of lampblack and water through the œsophagus of a cat. At 10 P.M. I repeated the process; also at 1 P.M. next day, and again at 3 P.M. The animal was killed two hours after. The Malpighian bodies and uriniferous tubes were of various shades of blackness, some being intensely black.

No. 24. At about 4 P.M. on the 2d of February, I injected the œsophagus of a cat with a mixture of animal charcoal and water, to the amount of about eight ounces. By mistake the animal was killed about an hour afterwards. The uriniferous tubes throughout the kidney were very dark, some of them intensely black. Many of the Malpighian bodies were darkened, but generally were not so much so as the tubes.

Nos. 25 and 26. On the 3d of February, I operated upon two cats, injecting the œsophagus of both animals with a mixture of animal charcoal and water, repeating the injection several times at intervals until they were killed, which was about three hours after the operation. In both of these cats the Malpighian bodies and uriniferous tubes were of various shades of blackness, some of them being intensely black.

I should have previously remarked, that in some Malpighian bodies the various coloring substances were sometimes seen in the centre of the capsule, while a clear interval existed between the colored portion and the inner surface of the capsule; thus showing that the coloring matter had not yet left the tuft. In other instances the central portion corresponding to the tuft was only slightly colored, while a deeply colored part was situated between the tuft and the internal surface of the capsule.

I think these experiments conclusively show that the Malpighian tuft can and does separate coloring matters from the blood which have been absorbed from the stomach and intestines, and have thus entered the circulation.

No. 27. On the 19th of January I tied the *ductus communis choledochus*, or common bile-duct, of a large grey cat, with the view of allowing the elements of the bile to remain in the circulation, and the absorption of any which might have been already secreted. I hoped thus to be able to detect it either in the tubes or the Malpighian bodies of the kidney. This cat lived seventy-five hours, and seemed to suffer but little from the operation. On taking off the skin, I observed the under surface of it, in several points, to be of a bright yellow color. The bile-duct was partially ulcerated, so as to allow of the escape of a few drops of bile. There was very slight peritonitis. Thin sections of the kidney exhibited the Malpighian bodies of a light yellow color. Nothing remarkable was observed in the tubes. On adding a portion of a drop of nitric acid to the specimen under the microscope, the Malpighian bodies showed a slight play of colors, among which blue, green, and violet could be most distinctly seen. The same effect was seen in the tubes, but not so clearly. It was observed also on testing the urine. There could then be little doubt of the presence of bile in the Malpighian body and uriniferous tubes.

No. 28. I repeated this experiment on a large yellow dog, and in addition tied the ureters. This animal lived forty-eight hours. The Malpighian bodies were somewhat congested, and of a yellowish red color. I was much disappointed at the result of this experiment, as I could not detect the presence of bile in any part of the kidney, or in the urine, although I used most

carefully and repeatedly all the known tests for bile. I then made comparative tests with the bile from the gall-bladder of this dog, and what was exceedingly surprising, I could not succeed in producing the usual peculiar appearances, either with nitric acid, sulphuric acid and sugar, or any of the usual tests for bile, even after most careful and repeated trials. I know not to what this should be attributed.

I had long been anxious to obtain the kidneys of persons who had been in the habit of passing minute calculi of lithic acid, or whose urine constantly or usually deposited crystals of lithic acid or the lithate of ammonia. It seemed not unreasonable to suppose, that by repeated examinations of such kidneys under the microscope, this acid, or perhaps even its combinations, might there be detected. If found in the tubes alone, its presence could be explained by the theory of Mr. Bowman, viz., that it was separated by the epithelial cells of the tubes from the blood of the venous plexus which surrounds them. On the other hand, if found in the Malpighian tuft and capsule, then we must believe that it was separated by that body. My friend, Dr. F. U. Johnston, jun., has kindly presented me, within a few days past, the kidneys taken from a child three months old. These contained several very small calculi of lithic acid, which were situated in the calyces of the kidney. On making thin sections of the organ, the Malpighian bodies were of a yellow color. Some portions of the tuft were of much deeper color than others, and seemed to contain reddish yellow masses. I endeavored, by using different powers, to ascertain whether these deeper-colored parts were crystalline, or had any determinate form, but could not succeed, after repeated attempts, in resolving this question. The tubes were not remarkable. I added a minute portion of dilute nitric acid to thin sections, under the microscope, and gently heated the specimen over a spirit-lamp, and then exposed it to the vapor of ammonia; then gently heating it again, placed it under the microscope. The Malpighian bodies had become of a deep red, and some of them of a beautiful purple color. I tried these tests repeatedly with the same result. Generally, the tubes were not at first affected; but on further application, many of

them assumed a red or purplish red color. I made comparative tests with sections taken from the kidney of a cat, and also from that of a sheep, testing them in the same manner. In these trials, however, the Malpighian bodies were either rendered of a dirty brown color, or lost their color, being entirely blanched. I made somewhat thinner sections of the child's kidney, and on gently heating them with water and a little nitric acid, effervescence took place, exactly as when lithic acid is heated gently with nitric acid. On then exposing the specimen to the vapor of ammonia, or on adding a few drops of it, and applying heat, a purple or reddish purple was produced. Shall we infer that this was purpurate of ammonia, and if so, that as the lithic acid was thus found in the Malpighian body, it has the power, and does really separate it from the blood? I shall content myself at present by simply stating the facts, and also my conviction that further researches in this direction will probably settle the question.

I removed the kidneys from a subject who had died of aneurism of the aorta, and whose urine had deposited the lithate of ammonia to a very great amount for a few days previous to his death. In examining one of these kidneys, I found the Malpighian bodies greatly congested, and of a dark red color. I then injected the renal artery of the other kidney with two ounces of water to half a drachm of nitric acid. This kidney was then laid aside for twenty-four hours. I examined thin sections of it under the microscope, but could not discover any deposit in the tubes or in the Malpighian bodies. I placed a drop of diluted nitric acid upon a thin section, heated it very gently over a spirit-lamp, and then exposed it to the vapor of ammonia. On placing it under the microscope, the tubes and Malpighian bodies were both of a reddish and reddish purple color. I made comparative tests with thin sections from the fresh kidney of a cat, but in this case the color was entirely destroyed by the application of the above reagents.

I made some experiments to ascertain the effect of highly stimulating diuretics upon the secreting structures of the kidney.

No. 29. On the 24th of January I injected half an ounce

of nitrate of potassa, dissolved in three ounces of water, into the small intestines of a cat. Ligatures were applied as in the preceding experiments. This animal lived thirty-six hours. The mucous membrane of the intestines was very much inflamed. The Malpighian bodies were very red and much congested; many of them were ruptured. The intertubular plexus was greatly congested. The mucous membrane of the bladder was pale.

No. 30. On the 21st of January I injected into the œsophagus of a cat half an ounce of tincture of cantharides, mixed with three ounces of water. This animal lived eighteen hours. There had been no symptoms of excitement of the genito-urinary organs. The Malpighian bodies were intensely reddened, and some of them were ruptured. The venous plexus was very much congested. There was no inflammation of the stomach or intestines; on the contrary, their mucous coat was pale, but that of the bladder was inflamed.

No. 31. January 2nd I injected six grains of phosphorus in three ounces of olive oil, into the duodenum of a cat, a ligature having been placed above the opening into the intestine, and another on the ileum, just above the ileo-cœcal valve. After an hour, there occurred great frequency of respiration and circulation, paroxysmal efforts to bite at objects, and catching and sparring (as it were) with the paws, in the most ferocious manner. Gradually, great prostration and insensibility came on, with dilatation of the pupils. She died three hours and a half after the operation. The mucous membrane of the stomach and intestines was very pale. The Malpighian bodies were greatly congested, and some of them were ruptured. The intertubular plexus was much congested. All these parts were of a most brilliant red color, so that one of my friends remarked that "the specimen of the kidney, under the microscope, seemed to be in a blaze of fire." The kidney had a strong odor of phosphorus.

No. 32. On the 30th of January I injected a grain and a half of phosphorus, dissolved in an ounce and a half of olive oil, into the small intestines of a cat. This animal lived fifteen hours. The Malpighian bodies and venous plexus were very

red and much congested, but not so much as in the subject of the preceding experiment. The bladder was slightly congested. In neither of these animals in which phosphorus was injected was there any symptom of excitement of the genital organs.

No. 33. On the 2d of February, at 6½ P.M., I injected an emulsion of one ounce of spirits of turpentine, beaten up with an egg, and three ounces of warm water, into the œsophagus of a cat. Four hours after, she seemed to be greatly prostrated, and was found dead the next morning. There was no inflammation of the stomach or intestines; the bladder was pale, and contained urine, which had the odor of turpentine. The kidneys were greatly congested; the Malpighian bodies filled with blood, and of a violet red, or rather a purple color. Many of them, as well as the small arterial twigs upon which they are placed, were ruptured. There was also much congestion of the venous plexus.

The foregoing experiments then demonstrate the influence of powerfully stimulating diuretics on the Malpighian bodies and the venous plexus.

Let us now review the facts and arguments which thus far throw light upon the function of the Malpighian tuft:

1. That it is not for the purpose of merely separating water from the blood is proved by its distribution throughout the substance of the kidney in some animals whose urine is semi-solid.

2. The proximate elements of the urine exist ready formed in the blood.

3. These elements can only reach the kidney through the renal artery, upon whose minute terminal branches are placed the Malpighian bodies.

4. It has been shown that the Malpighian tuft is covered by peculiar oval nucleated cells. This glandular structure seems to be, in every respect, well fitted for the separation of these substances.

5. The action of diuretics upon the Malpighian tuft.

6. The actual separation by it of coloring substances, as demonstrated by these experiments.

7. The existence of the coloring matter of the bile in the Malpighian tuft and capsule.

8. The facts here adduced relative to the presence of lithic acid in the Malpighian tuft, and its detection by chemical tests.

9. *From all these considerations, it seems that we are justified in concluding that the Malpighian tuft separates from the blood most of the proximate elements of the urine.*

10. *Any element of the urine which is not secreted by the Malpighian tuft is then probably separated by the epithelial lining of the tubes, as is generally believed. This may also occur with certain foreign substances, which have been introduced into the circulation, and which the Malpighian tuft refuses to separate. It is possible also that certain constituents of the urine may be separated from the blood both by the tubes and the Malpighian bodies. All the facts, however, adduced in this paper, lead to the conclusion that it is to the Malpighian body that we are to attribute the principal agency in the secretion of the urine.*

I may here mention some interesting facts which were observed while making these experiments. The ferrocyanide of iron or Prussian blue, and indigo, are both insoluble substances, and are only held in suspension when mixed with water. Inasmuch, however, as they were absorbed and taken into the circulation, we must either suppose that they were rendered soluble by some substance met with in the intestinal canal; or else, contrary to the general opinion, that it is not necessary for a substance to be soluble in order to be absorbed, pass into the circulation, and then be separated by the kidney. As I had ascertained that animal charcoal, an exceedingly insoluble substance, could be found not only in the kidney, but also in the hepatic cells, and in the minute vessels of the spleen, I determined to try some experiments with other substances well known to be insoluble.

No 34. On the 26th December I removed the left kidney of a cat, and placed a ligature on the right ureter. I then

injected a mixture of very finely pulverized metallic bismuth into the stomach and intestines, using ligatures as usual. The cat died sixteen hours after the operation. The Malpighian bodies and tubes were of a light grey and of a steel grey color, resembling the impalpable powder of metallic bismuth. No chemical tests were employed to ascertain its presence in the kidney.

No. 35. I caused a book of gold-leaf to be very finely ground with sulphate of potassa. This salt was then washed away by water; the finely-powdered gold was then diffused through water by agitation in a vial, and then poured into the small intestine by means of a funnel, passed through the small opening in the duodenum. At the same time the left kidney was removed, and a ligature placed on the right ureter. The dog lived twenty-four hours. There was considerable peritonitis, with effusion of pus and coagulable lymph. There was also some inflammation of the mucous membrane of small intestine, and hemorrhage into the ileum. The Malpighian bodies were of a yellow color, the tube somewhat darkened. I could not satisfy myself that gold existed in the kidney by examination with the microscope. I also tried the method by incineration, both with the kidney and the liver, but could not detect gold in either organ.

No. 36. I ground up a book of gold-leaf with powdered glass into an impalpable powder. This powder was washed repeatedly with water to separate the siliceous portion, and the gold was mixed up with a solution of gum-arabic and injected into the œsophagus of a dog. The animal was killed about six hours after injection, but I could not detect gold in the kidney.

No. 37. On the 5th of January I removed the left kidney of a cat and ligated the right ureter. I then injected finely precipitated copper, in an impalpable powder, into the stomach and intestines, using ligatures in the usual manner. This cat died in three hours. The intestines were slightly, the stomach intensely inflamed. I could not detect the copper in the kidney, either by the microscope, or by the method of incineration in a porcelain crucible.

No. 38. On the 30th of January I injected three drachms

of finely precipitated copper into the œsophagus of a dog, and secured a brass pipe in it with a stopcock. Twenty hours after I injected the same quantity, suspended as before in water. He was killed two hours afterwards. I incinerated one of the kidneys, in a porcelain capsule, with nitric acid; but, testing, could not detect a trace of copper. Neither was I satisfied from the appearances under the microscope that this metal was present in the kidney.

No. 39. On the 2d February, I injected into the œsophagus of a cat three drachms of metallic antimony, ground down to an impalpable powder and well agitated with water at the moment previously to throwing in the injection. The animal was killed five hours afterwards. Many of the tubes were of a steel-grey color. My young friend, Mr. Henry Draper, kindly tested one of the kidneys for me in the laboratory of the University, but could not detect a trace of antimony in the kidney. I therefore consider this experiment as a failure, and also that all the other experiments with metallic substances were unsatisfactory, and that the fact of their absorption and entrance into the kidney has thus far not been demonstrated in these instances.

I may here mention that the introduction of coloring matters into the kidney of animals by means of absorption from the intestines and entrance into the circulation, is a valuable means of facilitating the investigation of the structure of these organs. The effect of stimulating diuretics is also of great assistance in this respect. It seemed to me also that by ligaturing the abdominal aorta a short distance above its bifurcation, a larger amount of blood would thus be thrown upon the kidney, with the effect of congesting the Malpighian bodies and venous plexus. Being unable, from sickness and other causes, to carry out my design, I requested my friend Dr. J. S. Gouley, whose anatomical zeal and acquirements are deserving of the highest praise, to perform this operation, the results of which we examined together. I beg leave here to express my sincere thanks to him for his skillful and valuable assistance in nearly all of my experiments.

Nos. 40, 41, 43. I condense from Dr. Gouley's notes of

three operations upon cats and dogs, in which he ligated the aorta, twice reaching the artery by an incision through the abdomen and once through the lumbar region, without wounding the peritonæum. The symptoms, after tying the aorta, in these three cases, were great acceleration of the heart's action —pulsations so frequent that they could not be counted, no pulsation in the femoral arteries, paralysis and coldness of the inferior extremities, gradually increasing coma and diminished frequency of respiration. On dissection, the heart was distended with coagulated blood; lungs, slightly congested; liver, nearly normal; kidneys, very highly congested. Thin slices of both organs showed, under the microscope, the Malpighian bodies enormously distended with blood; so much so, that on looking at a very thin section with the naked eye, they could be plainly distinguished. Under the microscope, the tortuous vessels of which the tufts are composed could be perceived more beautifully than in an artificial injection. Small vessels could be seen sending branches on each side, terminating in the well known round ball, all filled to their utmost. The venous plexus was also very highly congested. The intertubular vessels were very distinct, being intensely congested. Three or four of these specimens have been preserved.

I may here remark, that the injected state of the vessels resulting from this operation greatly facilitates the investigation of the structure of the kidney. In connection with this congested state of the Malpighian tufts and venous plexus, it may not be uninteresting to refer to the operation of Sir Astley Cooper for ligature of the abdominal aorta, in which case there was suppression of urine for more than twenty-four hours.

In conclusion, it may be well to consider what new facts or deductions have been stated in this paper:

1. It has, I think, been conclusively established, by numerous experiments on animals, by repeated and careful observations under the microscope, and by chemical tests, that colored substances are separated from the blood by the Malpighian body.

2. That the coloring matter of the bile is also separated by it from the blood.

3. From the facts recorded in this paper, it is very probable that it may also separate lithic acid.

4. That a new means of unravelling the structure of the kidney is afforded by such experiments.

5. The peculiar action of excessively stimulating diuretics has been demonstrated by their effect on the minute structures of the kidney.

6. The influence of ligature of the abdominal aorta in throwing an increased afflux of blood upon the kidney, and causing great congestion of its minute vessels and capillaries.

7. Incidentally, some interesting facts have been stated relative to the absorption of substances generally considered to be insoluble.

ADDENDA.

My friend, Dr. Geo. T. Elliot, examined with me this day, March 24th, 1857, the kidneys of a patient who had been under treatment for paralysis from lead for the last seven months in Bellevue Hospital, and who died of tetanus. I made a drawing of the epithelial cells, both of the straight and convoluted tubes, which, under the microscope, exhibited with the greatest clearness and distinctness the same appearances as seen in Plates 1 and 2 of this paper.

I received from my friend, Dr. Geo. A. Peters, the kidneys of a child three months old, who died with convulsions, the urine having been suppressed for fifteen hours. The Malpighian bodies were very much congested, and of a dark red and purple color. The intertubular plexus was also much congested. I have also noticed that the kidneys of other patients who had died from suppression of urine were in a similar condition. This, taken in connection with the influence of stimulating diuretics upon the internal structures of the kidneys of the inferior animals, and the effect of ligature of the abdominal aorta in producing a similar result, would seem to show the importance of local depletion and counter-irritation in cases of suppression of urine and retention of urea in the blood, and the necessity of avoiding diuretics, or at least of using them with great caution.

The successful result of this mode of treatment in such cases is in accordance with the views expressed in this paper relative to the physiology and pathology of the Malpighian bodies and venous plexus.

END OF THE FIRST VOLUME.

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