Histology of the cholera evacuations in man and the lower animals / by W. Lauder Lindsay, M.D.

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HISTOLOGY

OF

THE CHOLERA EVACUATIONS

THE following notes are not intended to embrace the whole subject of the histology of the evacuations passed during life, or of the fluids and solids examined after death, in cases of cholera in man and the lower animals, but refer only to a limited number of observations made by myself in the City Cholera Hospital of Edinburgh, towards the close of the year 1853. These observations have been, in great measure, confirmed by the simultaneous or subsequent labours of various continental observers, who have, since the date above mentioned, published valuable monographs on some hitherto obscure points in the natural history of cholera. In a few minor details only do our respective results differ; but as my object here is simply to enumerate facts, I shall not attempt the explanation of discrepancies, or the solution of difficulties, in regard to the bearing of observations on theories of the nature or cause of cholera. The latter is a subject indeed for which I do not think we have yet obtained sufficient or requisite data whereon to speculate with exactitude or advantage to science. The symptomatology and pathology of the cases upon which the following observations were made, have been already published in various medical journals during the year 1854.[1] It will be convenient to divide the subject-matter into two sections:—

I.—The histology of the vomit, stools and urine passed during life, and of the thoracic and abdominal viscera and their contents, examined after death, in *man*; and

II.—The histology of the same discharges, viscera or fluids in the *dog* and *cat* to which the disease was communicated by artificial means.

I.—*Histology of the cholera evacuations, etc., in man.*

The chief histological elements observed may be shortly tabulated as follows:—

1. *Vomit:* A. Ejected during life.
   - *a. Mucus:* fibrillated bands without or with granular corpuscles.
   - *b. Granular corpuscles:* probably chiefly mucus corpuscles and epithelial nuclei.
   - *c. Epithelium:* tesselated, globular, and cylindrical: perfect, variously abortive, or altered in shape—transparent, hazy, or granular.
   - *d. Debris of food.* 1. *Vegetable* food.
     - *a.* Fragments of epidermis: potato, oats, barley, cabbage, carrot, turnip, onion, sugar-cane, etc.

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[1] Chiefly in the *Association Medical Journal*, March 10, 1854, *et seq.*, *Edinburgh Medical and Surgical Journal*, April and October 1854, and *Edinburgh Monthly Medical Journal*, August 1854.

b. Fragments of parenchyma of several of same vegetables.
c. Isolated cells of epidermis and parenchyma, including, along with starch corpuscles, many of the "annular bodies," and "cholera fungi or corpuscles" of recent authors.
d. Epidermic hairs.
e. Spiral and porous vessels, and uncoiled spirals.
f. Chlorophylle grains—isolated and aggregated.
g. Starch corpuscles of the potato, oats, barley, wheaten bread, etc.
2. *Animal* food.
a. Muscular fibre of beef, etc.
b. Fish scales: Findon haddock, etc.
e. Oily and fatty matters:
a. Fluid: oil globules.
b. Concrete: fat vesicles.
c. Echiniform, or spiculated bodies.
d. Crystalline: filiform bundles—radiating masses.
f. Crystallizable matters, salts, etc.
a. Triple phosphates: chiefly in prismatic form.
b. Chloride of sodium: in broken cubes and irregular tabular masses, etc.
g. Fungi: a. Sarcina ventriculi: entire or partially disintegrated.
b. Mycelium and sporules of various kinds of mould.
h. Animalcules a. Vibrios.
b. Acari.
i. Pus.
k. Compound granular bodies.
l. Molecular and granular debris, variously coloured.
B. Post-mortem contents of stomach.
Epithelium: conoid, fusiform and fibroid, and other elements of disintegrated mucous membrane, in addition to several of the above substances.

II.—*Stools.* A. Passed during life.
a. Mucus: fibrillated bands always associated with granular corpuscles.
b. Granular corpuscles as in the vomit, but larger and more numerous: associated with much granular matter.
c. Epithelium: tesselated and globular, never cylindrical.
d. Debris of vegetable and animal food: as in the vomit, but to a much less extent, and in less variety.
e. Oily and fatty matters: fluid and concrete forms only.
f. Crystallizable matters, salts, etc.: in addition to phosphates and chloride of sodium, as in the vomit,
a. Urates and
b. Siliceous matters.
g. Fungi: Mycelium and sporules of various kind of mould.
h. Animalcules: Vibrios.
i. Compound granular bodies, variously coloured.
k. Blood corpuscles.
l. Hyaline globules: non-oleaginous.
m. Molecular and granular debris, variously coloured.
B. *Post-mortem* contents of intestines. In addition to several of the above histological elements,
a. Epithelium: cylindrical, isolated or in patches, and other disintegrated elements of mucous membrane.
b. Shreds or flocculi of fibrinous false membrane.

III.—*Urine.* A. Passed during life.
a. Mucus: more hyaline than in the vomit and stools, and in less quantity.
b. Granular corpuscles, as in preceding evacuations.
c. Epithelium: tesselated and globular: clavate, fusiform, or otherwise

altered in shape—hazy or granular: in its origin renal, vesical, urethral, vaginal, etc.

d. *Fibrinous casts* of renal tubuli: transparent, granular and oily.

e. *Crystalline matters, salts, etc.:*

a. Uric acid: in lozenges, rhombs, bundles or stellar masses of acicular crystals, etc.

b. Urates: amorphous granular form and in globular masses, with a crystalline radiating texture.

c. Phosphates: prismatic, plumose, stellar, cruciform, etc.

d. Oxalate of lime: octohedral and dumb-bell.

e. Chloride of sodium, in sparing quantity.

f. *Compound granular bodies:* the "exudation corpuscles" of some authors.

g. *Pigmentary matters:* blue and green.

h. *Pus corpuscles.*

i. *Isolated vegetable cells* and other accidental impurities of vegetable origin.

B.—*Post-mortem* contents of bladder. In addition to several of above histological elements, various results of disintegration or mechanical maceration of the mucous membrane of the bladder.

Of the histological elements above noted, several usually occurred in any given specimen of the respective evacuations; seldom or never all of them at once. Some were of very common occurrence, as mucus, granular corpuscles and epithelium; others very rare, as blood corpuscles. A few must be regarded in the light of accidental admixtures or impurities, as urates and siliceous matter in the stools; others were probably the result of incipient decomposition of the fluid evacuated, as vibrios and fungoid mycelium. Let us consider these elements more in detail.

I. *Vomit.*—Vomiting occurred chiefly during the collapse stage, or when collapse was passing into reaction—prior to the development of the fever stage. The fluid ejected varied greatly in quantity and colour. It exhibited various shades and combinations of brown, yellow, green, pink, red, and grey—frequently even in the same case, at different periods of the same day. These colour-changes are probably to be referred to the action of modified bile or blood—more frequently, I think, to the former than the latter. The specific gravity was generally low, varying from 1005 to 1010: the reaction with test-paper was generally acid, though sometimes neutral, or even alkaline in one or two cases; and the application of reagents showed that the fluid was sometimes albuminous—more frequently not. The specific gravity, acidity or alkalinity, odour, amount of sediment, and other characters, necessarily depended, in a great measure, on the nature and amount of the fluid and solid ingesta, and varied accordingly. In the first vomits, were usually discharged quantities of partially digested or undigested food—in some cases, masses or quantities of potatoes, cabbage, onions, barley, oatmeal, beef, herrings, and other articles of diet commonly used among the lower orders of the community, constituting the bulk thereof. In such cases, the sediment greatly preponderated over the fluid element of the vomit; but, in subsequent vomits, the sediment gradually decreased in quantity, becoming more homogeneous, —frequently resembling bran and water intermixed—until it was

present only as a flocculo-granular matter, or as mucous flocculi. In the latter case the fluid was whey-like, or of a very pale straw-yellow colour, the vomit closely resembling the ricy stools of the collapse stage: this, however, was very rare. The histological elements of such a ricy vomit were very similar to those of the ricy stools, with the exception, that in the vomit there was generally a considerable amount of pavement epithelium, and a larger quantity of food debris. The mucous flocculi consisted of hyaline bands or ribbons of mucus, colourless, and very delicately striated, bearing on their surface multitudes of small granular corpuscles, similar in general appearance to, but smaller than, pus corpuscles, and associated with a varying quantity of molecular and granular matter. Both in the vomit and stools—more frequently in the former than in the latter—the mucus occurred in delicate, almost transparent bands, devoid of the corpuscular or molecular element. This I have also observed in other diseases—as in the stools of chronic dysentery—illustrating the proposition, that the corpuscular element is not essential to the composition of mucus.

The granular corpuscles varied much in size. Their appearances under the action of water and acetic acid, separately or combined, also varied greatly. They sometimes remained unaffected, or the granularity was simply diminished, the size of the corpuscles being increased: a single or compound nucleus was sometimes developed, occupying a central or lateral position, the granularity of the cell-walls becoming diminished, or disappearing: or, lastly, a delicate transparent cell-wall became evident, more or less closely enclosing the corpuscles, which now assumed the characters of nuclei. Their histological characters varied to such a degree, as to render it impossible specifically to designate their true nature. In consideration of the reaction on them of acetic acid, they might be denominated mucoid or pyoid—these terms merely implying a general resemblance to mucus or pus corpuscles, without determining their nature or origin. A consideration of the circumstances under which they are developed, as well as of their microscopic characters, leads me to regard them as chiefly mucus corpuscles and epithelial nuclei. It must be remembered, however, that they are presented to us in a very young, or comparatively immature, condition: they are developed with great rapidity, and thrown off in infinite numbers, from the mucous surfaces of the intestinal canal, almost immediately after birth, or at least long prior to maturity. Hence they seldom present the characters of fully matured mucus corpuscles, or epithelial scales. They can be much better studied in the ricy stools than in the vomit of cholera, in consequence of the former frequently containing no other histological elements than mucus bands, and the granular corpuscles in question.

Epithelium was very common, and was most abundant in vomit containing little or no food debris, and having a scanty flocculent sediment. Of such a sediment it frequently constituted the bulk:

and it also occurred, sometimes to a considerable extent, in the frothy mucous scum. It often appeared more abundant in the later than the earlier vomits, and its quantity seemed, to a certain extent, proportionate to the intensity of the retching, or the expulsive or spasmodic efforts of the stomach and œsophagus. The epithelium was almost always of the pavement or tesselated form: it was frequently tinged greenish or brownish by biliary pigment, and it differed much in transparency, haziness, and granularity, being sometimes very dark and granular, or infiltrated to a considerable degree with oleo-albuminous globules. Its form also varied greatly, being sometimes very large, and irregularly hexagonal or polygonal, globular or ellipsoid; or smaller and variously elongated, fusiform or caudate. When small, shrunk, and elongated, it was frequently also hazy or granular. A great proportion of the epithelium was undoubtedly in a young or undeveloped condition. In only one case did I find cylindrical or conoid epithelium. Here the collapse was very severe and rapidly fatal, and the retching intense and protracted.

In the first vomits, I have already stated, that the nature of the food could often be easily distinguished by the naked eye. When the sediment became more homogeneous, and simply granular or granulo-flocculent, the microscope enabled me to detect fragments or isolated cells of the epidermis and parenchyma, epidermic hairs, spiral and porous vessels, and fragments of spirals from the fibrous tissues, starch corpuscles, and chlorophylle grains—the result of the partial disintegration of various culinary vegetables, or articles of diet of vegetable origin. These vegetables, or articles of diet, were chiefly potatoes, bread, oatmeal, and barley, cabbage, onions, carrots, turnips, or other ingredients of Scotch broth, besides sugar cane, and other less familiar substances. Associated with vegetable debris were usually fragments of muscular fibre from beef, mutton, or other forms of animal food; fish scales were found very rarely. Of all the vegetable tissues or cells above referred to, the most constant were the parenchymatous cells of the potato, and starch corpuscles, chiefly from the potato, oats, and barley. The former were large, irregularly globular, oval or oblong cells, usually full of delicate, but comparatively distinct, starch corpuscles: when empty, they appeared as delicate, shrivelled vesicles or sacs, having a slight brownish or greenish tinge. The starch corpuscles varied much in size: on the larger ones the striæ were usually distinct. When ruptured, or emptied of their contents, they frequently resembled entire or broken rings, the inner border having generally a lacerated edge. The peculiar reaction of iodine was observable in some, and not in others.

The isolated or disintegrated individual cells of the tissues above mentioned, probably include many, if not most, of the "annular bodies," the "cholera corpuscles or fungi," which so startled the histological and medical world during the cholera epidemic of 1848–9. At least, the ultimate elements of these tissues or substances, as observed by myself, correspond, in their characters, to those pub-

lished, as delineative of the bodies in question, by their original discoverers. I believe that potatoes, oatmeal, bread, and the vegetables of common broth, will furnish most of the forms of the once famed annular bodies; that they are not, therefore, fungoid in their nature or origin; and that they have no essential or causative relation to cholera. I have found them equally in other diseases—as in the stools of diarrhœa and dysentery. It is unnecessary to specify, in detail, the forms of these cellular bodies, observed by myself.[1] Many of them are simple globular cells, containing chlorophylle granules, aggregated regularly or irregularly round a central nucleus. This is the character of the gonidia of lichens—the green coloured cells lying immediately below the cortical layer of the thallus: hence, in former publications, in order to economise space and words, and to indicate their general appearance, I denominated these bodies *gonidic*. When emptied of their contents, they are delicate hyaline vesicles, and appear often as mere circles or rings, enclosing a free central area. Sometimes there is an inner dotted ring, probably produced by a puckering of the cell wall. This cell wall sometimes disappears, and the chlorophylle grains may then be found aggregated circularly round their nucleus, in regular masses, or free and intermixed with granular debris. Others of these bodies are of larger size, but very irregular shape: their walls are thick, and variously coloured, especially brown. Starch globules, partially broken up, are probably a common form of annular bodies: in this condition they frequently resemble the shrivelled sporangia of ferns. The non-action of iodine is not, I think, a sufficient disproof of such bodies being of an amyloid nature; for I have already mentioned that its usual reaction is sometimes absent, where the corpuscles otherwise bear indubitable marks of being starch. I have never seen annular bodies produced from spiral or annular vessels of plants, as was suggested in the report of the College of Physicians, London, in reference to the bodies described and figured by Brittan and Swayne of Bristol, though such vessels themselves are far from uncommon. Nor have I been able to trace any of them to medicines, for they occurred equally in cases where no medicines were given, or prior to their administration. Moreover, they were comparatively seldom found in the collapse stools, occurring chiefly in those of the reaction and fever stages; and their presence was coincident with the appearance of less equivocal forms of food debris. It will be evident, then, that I can see no satisfactory groundwork for the fungus theory of cholera, which I am not a little surprised to find still possesses powerful advocates.[2] We shall, hereafter, see that there is equally little foun-

[1] Drawings and descriptions will be found in the *Association Med. Journal*, April 14, 1854.

[2] *Vide* Professor Daubeny of Oxford, "On the influence of the lower vegetable organisms in the production of epidemic diseases."—*Edin. New Philosoph. Journal*, July 1855.

dation in fact for the animalcular and other theories of the cause or nature of cholera. We must evidently look elsewhere for a solution of the difficulty,—for as yet we are only on the threshold of the inquiry.

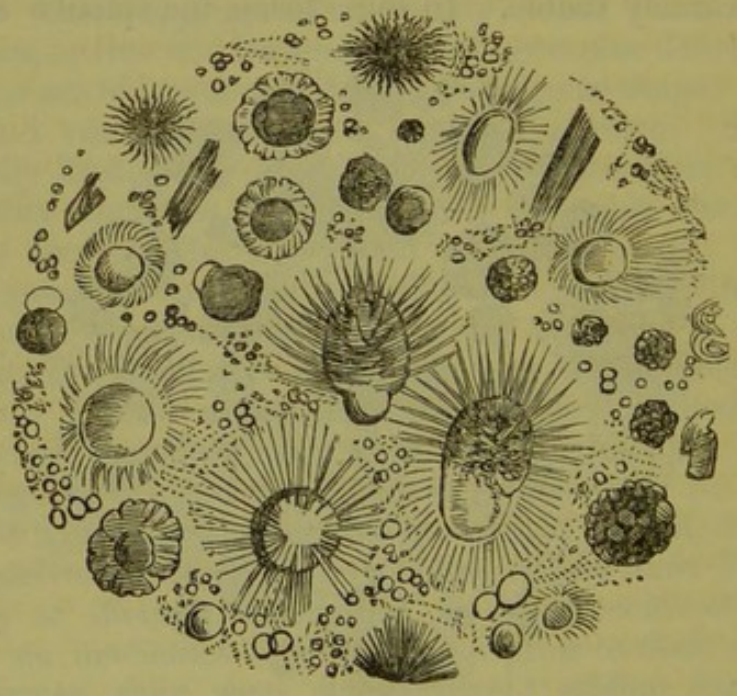
On standing for a short time, a greasy scum usually formed, especially in the earlier vomits; this consisted of oil globules, associated with prismatic phosphates. Occasionally it contained small pellets or masses of concrete fat, resembling pieces of tallow or suet: under the microscope, these sometimes consisted of irregularly oval vesicles, marked by a central stellate radiating mass of delicate acicular or filiform crystals, at other times only oil globules and amorphous granular matter could be observed. The vesicles were also found separately, especially in the earlier vomits, containing a considerable quantity of food debris. The crystals were probably margaric acid, the result of the decomposition of fatty ingredients of the food.[1] Fatty matter also occurred in the earlier vomits containing a considerable amount of undigested food, in the form of irregularly globular, oval or oblong, dark or light, sometimes hazy or granular bodies, surrounded by or bristled over with divergent, acicular spiculæ or crystals, sometimes so delicate that they were scarcely visible. In some forms the spiculæ seemed few,

This engraving represents crystalline and other forms of fatty and oily matters occuring in the vomit of various cholera patients: the vomit having been chiefly ejected in the collapse stage.

short, and thick, and when broken or rubbed from the surface of the nucleus, which was generally light coloured, their roots, or points of origin, gave the latter the appearance of being covered over with

[1] Similar vesicles and crystals are figured in Hassall's "Microscopic anatomy of the human body," plate 19, fig. 5, which is labelled "Human fat vesicles, on the surface of which, crystals, supposed to be those of margaric acid, radiating from a centre, have appeared: their presence is to be regarded as an indication that decomposition has begun to affect the contents of the cells."

wart-like dark points. In other cases, the spiculæ were very numerous, barely visible as fine streaks, and appeared collapsed round or closely embracing the nucleus. The nuclei and crystals were sometimes separate, the latter occurring in irregular raphidian bundles, or in small confused groups. In the scum of the earlier vomits, concentrated by evaporation, the same crystalline matters occurred in the form of stellate radiating masses of thicker crystals, somewhat twisted or tortuous. The application of heat or ether caused the instantaneous disappearance of the crystals, and the agglomeration or fusion of the nuclei into oily masses. The nuclei often appeared compound, or as if made up of an aggregation of fatty globular masses. These curious spiculated bodies, which bear no inconsiderable resemblance to some microscopical insects, I have elsewhere described and figured as "echinus-like," or echiniform fatty bodies.[1] In cholera vomitings, they were frequently associated with sarcina. I have found them more abundantly in accidental vomitings in other diseases; indeed, so common did they appear to be, that I am led to regard them as the results of the natural or healthy digestion of fatty matters in the stomach or intestines. The



The engraving exhibits, by way of comparison, the same bodies as met with in the vomit of a patient labouring under an early stage of general paralysis of the insane. For particulars of the latter case, *vide Medical Times and Gazette*, August 5, 1854.

same or similar bodies have been described by other observers, who apparently regard the crystalline element as stearine—the result of the decomposition of the ordinary fatty matter of the food, by bile and the pancreatic juice, separately or combined.[2]

[1] "On the presence of certain crystalline fatty bodies in the vomit of cholera." —*Medical Times and Gazette*, July 1, 1854. And "Crystalline fats and sarcinæ ventriculi in vomited matters," with plates —*Ibid.*, Aug. 5, 1854.

[2] Dr Leared of London appears to have produced similar bodies by the action

On evaporating down the earlier vomits especially, two crystalline matters were generally found in varying proportions, viz., chloride of sodium and triple phosphates,—the former as irregular or broken cubes or tables, the latter usually as prisms of large size. Common salt was often present in considerable quantity; its source was obviously the ingesta swallowed shortly prior to the cholera seizure. On the other hand, the phosphates, though almost always present, were sometimes so in very small quantity. The same salts occurred, under similar circumstances, in the stools; but their relative proportion was reversed,—the phosphates being generally present in comparatively large quantity, the chlorides only to a small extent. Phosphates were frequently found in the scum or sediment on standing for a short time; but their numbers were greatly increased by evaporating down the fluid portion of the vomits. This process was usually necessary for the detection of the chlorides under the microscope.

In several cases, the vomit had a frothy, yeast-like, copious scum, of a pinkish or brownish red colour, precisely similar to the ejecta in the majority of cases of chronic vomiting, marked by the presence of sarcina. In all these cases, this entophyte was present in considerable numbers, sometimes entire, more frequently partially broken up or disintegrated, often very dark or granular. It was usually associated with epithelium, food debris, and fatty matter. But it also occurred in one or two cases where there was no such scum: in one case the vomit resembled coffee grounds in colour and consistence; in another, it was of a lead grey colour, and the sarcina was associated with undigested food, cylindrical and pavement epithelium, mucus and granular corpuscles. I have found it in five out of ten cases of cholera, where vomiting was a marked symptom; but in none of these cases could I ascertain that there had ever existed gastric symptoms of any kind; and in the fatal cases, where a necropsy was obtained, there was no dilatation of the stomach, or pyloric obstruction, as are stated by some authors almost invariably to exist in cases of sarcenaic vomiting.[1] I did not find it elsewhere than in the vomit. There are two reasons probably for its not being generally found in the stomach and intestines after death, firstly, because it is less seldom looked for in these localities; and, secondly, because it very speedily suffers disintegration. I have found it also in accidental vomitings in other diseases, and in cases where no prior gastric symptoms had existed, or did at the time exist; and I am inclined, therefore, to look upon it as an entophyte

of the pancreatic juice on fat out of the body, *vide* "On the pancreatic juice in relation to the digestion of fat."—*Med. Times and Gazette*, June 3, 1854; and report of the Physiological Society of London.—*Lancet*, May 20, 1854. Robin and Verdeuil also figure and describe similar crystals in their celebrated "Chimie anatomique."

[1] *Vide* "Clinical Lecture on disease of the Stomach and vomiting of Sarcinæ," by Dr Todd of King's College Hospital, London.—*Medical Times and Gazette*, July 1, 1854.

of common occurrence, in states of health deviating but slightly from the normal standard. I believe that it has been hitherto considered too much as a cause, and too little as an accidental result or concomitant of gastric disease; that it cannot be regarded in any other light than as indicative of a vitiated state of the system generally, or of the gastric mucous membrane especially, in virtue whereof the latter becomes the nidus of fungoid growths; and that its presence does not demand the exhibition of special remedies which ought rather to be directed to the amendment of the constitution. The mycelium and sporules of various species of fungi, constituting various forms of vegetable mould, were found in the scum of the vomit, as well as of the stools; but only at some stage of decomposition. They are found, however, under similar circumstances, in the vomit and stools of other diseases, and, indeed, in all decomposing animal fluids, and they are, therefore, far from peculiar to cholera.

The same remark may be made with regard to the presence of *vibrios*, which I have seen in thousands—in a state of very active movement—in vomit, very soon after it was ejected. But the fluid was in a state of incipient decomposition; these animalcules occur abundantly in all animal fluids, under similar circumstances, and their presence in the vomit and stools of cholera, therefore, can have no causal relation to the disease. They were more commonly met with in the stools than in the vomit, for the simple reason, I presume, that the former undergo decomposition more rapidly and readily. In the scum of one vomit, consisting in great measure of partially digested food, I found several acari and their fragments; their presence was evidently quite accidental.

In one case, pus was found in the vomit; but its origin was muco-purulent sputa from a bronchitic lung.

The contents of the stomach, as examined after death, were generally of a greenish, brownish, or chocolate colour, and viscid from copious admixture with mucus. However much mucus they contained, they never had a ricy appearance. In mucus scraped from the interior of the stomach, were found small quantities of the ultimate elements of various vegetable tissues,—in other words, forms of the "annular bodies," already referred to, along with epithelium, conoid, or elongated so as to possess a fusiform or fibroid appearance, generally very dark and granular; fragments of the gastric glands; mucus bands; granular corpuscles; compound granular bodies; and molecular debris coloured by the bile pigment.

II. *The Stools.*—During collapse, these were generally whey-like in colour and consistence, with a sediment of curdy mucous flocculi; sometimes they resembled "potato water," "or sage water," according to the description of the patients themselves. The sp. gr. was usually below 1010: they were alkaline, albuminous, and devoid of odour. As reaction and fever became successively developed, the stools gradually assumed a yellowish

colour, and thicker consistence, becoming like thin pea soup. The specific gravity rose from 1010 to 1015, fœtor was acquired, and a granular sediment occupied about one-third to one-half the bulk of the fluid evacuated. Albuminosity and mucus gradually disappeared,—fœtor, colour, and food debris, being substituted. In advanced fever, the stools became darker and more fœtid, frequently loam coloured, sometimes tarry in colour and consistence. The latter appearance has usually been attributed to an excess of vitiated bile; altered blood pigment, or the secretions of the intestinal canal, may also have a share in its production. In the progress of convalescence, a few scybalæ sometimes appeared, and the fæces gradually acquired their normal consistence and colour.

The mucous flocculi of the ricy or collapse stools consisted almost entirely of delicately striated, hyaline bands of mucus, associated with granular corpuscles, as in similar circumstances in the vomit. The fibrillated and corpuscular elements varied in their relative proportions, but they were always conjoined. Epithelium I very rarely found, unless in the form of epithelial nuclei, the granular corpuscles already described, when speaking of the vomit. In one or two cases, large, irregularly round, or angular scales of pavement epithelium occurred; but the patients were females, and their origin was probably leucorrhœal matter, for they were associated with pus.

Cylindrical epithelium I never observed. This is totally at variance with the statements or observations of Continental pathologists and histologists from Boehm to Professor Buhl of Munich, the latter of whom would appear to have found, in the cholera stools, sometimes "the entire uninjured covering of the intestinal villi."[1] This form of epithelium, however, I found abundant in the *post-mortem* contents of the intestines—especially those of the small intestines. Upon its presence or absence in the stools, hinges another of the fallacious and unstable, but specious and attractive, *theories* of cholera, viz., that its essential nature, or, at least, that an essential lesion is a denudation of the intestinal villi, or desquamation of the intestinal epithelium. Did we speculate on the characters of the contents of the intestines after death, without having regard to the histological elements of the stools passed during life, we should, undoubtedly, be led into the error of supposing that such denudation and desquamation really might or did exist during life; but I think that a dispassionate consideration of the facts of the case must lead to the conclusion, that these phenomena have no claim to be regarded as vital, but are merely the results of *post-mortem* or mechanical maceration. The same desquamation, and even further disintegration of the elements of the mucous membranes, occurs equally, after death, in the stomach and urinary and gall bladders.

Food debris was almost never met with in the collapse or ricy

[1] *Vide* Review in *Edin. Medical Journal*, Oct. 1855, of paper in *Henle's Zeitschrift für Rationelle Medicin, Band VI. Heft I.*

stools; but in those of the reaction and fever stages it was comparatively common, usually stained by altered or normal biliary pigment. I found, in all the cholera stools, including the ricy or whey-like evacuations of collapse, what I considered to be biliary reactions, which led me to regard the prevalent opinion that the bile is wholly deficient in such ricy stools, and that the function of the liver is, therefore, totally suspended during the collapse stage, as very fallacious and erroneous.[1] The histological elements of the food debris present in the stools, were the same in kind as those occurring in the vomit, differing, however, in degree. In the stools, fragments of epidermic and parenchymatous tissues were much less, while isolated and broken up ultimate cells and contents of these tissues were much more, frequent. The reason of this was obvious; in the stools, the food had undergone a much greater disintegration. Hence the forms of altered or partially broken up vegetable cells, which have been by some authors denominated annular bodies, were often more readily discoverable in the stools than in the vomit.

As in the vomit, also, a greasy scum usually formed on the surface of all the stools, on standing, consisting generally, when microscopically examined, of oil globules, prismatic phosphates, and molecular matter. In the fever stools—never in those of the collapse stage—fatty and oily matter occurred in two forms, viz., in pellets or masses of concrete fat, and as a scum of liquid oil. The former condition existed in several cases where the stools were dark and fœtid, resembling in appearance and consistence gruel or porridge. The masses varied from the size of a pea to that of an almond or bean, and floated on the surface of the stools. In some cases they had a very bright, greenish-yellow tinge, from the presence of biliary pigment, which, however, was easily removed by repeated washing in water; they were usually almond shaped masses, somewhat soft and blubber like. Under the microscope, they were resolved wholly into oil globules. Others were of much firmer consistence, and whiter colour; they were irregular in shape, resembled pieces of common suet, and consisted of an aggregation of globular or oval vesicles, each marked by the central radiating masses of filiform crystals, mentioned when speaking of similar fatty masses in the vomit. The interspaces between the individual vesicles seemed made up chiefly of oil globules.[2] In two cases, a scum of fluid oil—of a bright, greenish-yellow colour—occurred; in both cases the stools being those of convalescents from a protracted fever stage. Where fatty or oily matters did occur in the stools, they appeared to bear no relation to the intensity or type of the disease, or to the characters of the matters evacuated. Some authors are inclined to connect all cases of the appearance of fat or

[1] "Clinical notes on Cholera,"—"Presence of bile in the cholera evacuations." *Association Med. Journal*, March 10, 1854.

[2] "Cases of cholera, illustrative of the presence of fat in the fæces, and of certain alterations of the blood."—*Edin. Monthly Med. Journal*, Aug. 1854.

oil in the fæces with the supposed necessary existence of organic disease of the pancreas; but I can neither see the necessity of, nor ground for, such an assumption.

The same salts, also, existed as in the vomit, though, as I have already mentioned, in different degree. Phosphates were almost invariably present, both in scum and sediment, immediately after being voided, increasing in quantity when the stools were allowed to stand, or were concentrated by evaporation. According to the freshness of the evacuations, the period of the disease at which they were voided, the degree of concentration, the rapidity of evaporation, natural or artificial, the nature of reagents added, and similar circumstances, their crystalline form varied considerably. Their most usual and natural form was the prism—perfect or broken, varying greatly in size; but they occurred in an infinity of plumose, stellar, and cruciform conditions. Similar changes in the conditions of examination produced similar modifications in the crystallization of the salts of the urine and vomit. I have found phosphates of similar forms in all fæces I have examined, both healthy and diseased, in similar states of incipient decomposition. Chloride of sodium was only detected on evaporating down the filtered liquid portion of the stools; and, though generally present, it varied greatly in amount in different cases, and in stools at different periods of the disease, in the same case. Its crystalline form appeared to vary in the same way as that of the phosphates, though to a much less degree. In one or two cases—in stools evaporated to dryness—I found large dark brown globular urates of ammonia, similar to those which frequently occurred in like circumstances in the urine; but the patients were females, and I attributed their presence to the accidental intermixture of a small quantity of urine. Siliceous crystalline matter I also found sparingly; but it was evidently present, as an impurity or accidental admixture, its source being probably dust from the floor of the wards.

Blood corpuscles were distinguished only in one case—in a stool passed at, or immediately prior to, death:—it contained a quantity of viscid mucus, deeply stained and streaked with blood, and resembled some of the bloody stools of advanced dysentery. Hyaline bodies, which resisted the action of heat, ether, and other reagents, were also present, in sparing quantity; they were usually considerably larger than pus corpuscles. Fungoid mycelium and vibrios occurred, under the same circumstances as in the vomit.

The *post-mortem* contents of the intestines were sometimes of nearly as low specific gravity as the stools, but they were generally much more viscid from admixture with mucus; had a deep colour, due to altered biliary matter; were alkaline and fœtid, and generally contained some proportion of fluid fæculent matter. They were never ricy, or closely resembling the characters of the whey-like collapse stools; and they were seldom simply mucoid. In one case only, the intestines were lined by pure mucus, no foreign intermix-

ture of any kind being detectable. This mucus, when scraped or washed from the surface of the mucous membrane, agitated with water, and allowed to stand, gave to the fluid quite the appearance of the ricy stools. The mucous flocculi, on being examined by the microscope, differed in this, however, that they contained quantities of cylindrical epithelium, isolated, or in patches of varying size—the apices of the cells being united by a delicate hyaline continuous membrane;—and very rarely a few blood corpuscles. Mucus, scraped from different parts of the canal, always contained cylindrical epithelium, often in process of disintegration; frequently portions of villi, which were always nude; and occasionally shreds of mucous membrane and blood discs. The latter, when present, were most abundant towards the termination of the large intestine, which was generally the chief seat of hyperæmia or ecchymosis, sometimes of a hæmorrhagic oozing. Cylindrical epithelium occurred in much greater quantity in the small than in the large intestines, whose contents also were generally darker and more fœtid. In some cases, flocculi of false membrane, or effused lymph, were found; in others, there appeared to have been an exuviation of the mucous membrane itself.[1] The above histological elements constituted the chief points of difference, microscopically, between the contents of the intestines after death and the evacuations passed during life. The important bearing of this difference on theories founded on the pathology of cholera, I have already pointed out.

III. *Urine* was never obtained during the true collapse stage: it was first passed during the reaction stage, or sometimes not until fever had fairly set in. During these periods, it sometimes became necessary to remove it by the catheter. Whether voided naturally, or artificially drawn off, the urine first passed was generally turbid, acid, pale amber-coloured, devoid of odour, of specific gravity varying from 1010 to 1015, and invariably albuminous: it was, moreover, small in quantity, and contained a scanty flocculent mucous sediment. At subsequent stages of the disease, the density also continued comparatively low, and sometimes the quantity remained small: the albuminosity and mucous sediment gradually disappeared, and gave way to phosphates, urates, and other salts. The histological elements varied greatly from day to day, even in the same case, and especially during the fever and convalescence.

Mucus bands and granular corpuscles, similar to those occurring in the vomit and stools, were frequently present in the mucous sediment of the urine first passed, associated generally with a considerable amount of epithelium. The mucous bands were much more delicate and indistinct—less seldom striated and fibrillated—than in the stools or vomit, and very frequently entangled various crystalline matters. The granular corpuscles were also less frequent, and less

1 *Vide* "Histology and Pathology of Cholera"—"Clinical Notes on Cholera."—*Association Med. Jour.*, April 14 and 21; May 12; and June 16, 1854.

distinct; their nature was also more frequently ambiguous, from their being associated with pus corpuscles: they were sometimes deeply tinged with various urine pigments.

Epithelium, in a multitude of transitionary forms, between the large globular or polygonal pavement cell, and the elongated conoid or fibriform one was generally present, in some shape or degree, in the earlier urine passed. It sometimes occurred in patches, of pentagonal or hexagonal scales, but more generally in the form of isolated scales, which were quite globular, very large, or slightly superior in size to pus corpuscles, or irregularly round, oval, or ellipsoid, presenting sometimes bulgings, occasionally caudate, irregularly square or angular, boat-shaped, crescent-shaped, fusiform, or fibroid. As in the vomit, these scales varied much in their degree of transparency, haziness, or granularity, being sometimes infiltrated with oleo-albuminous granules. The flocculent sediment of the first urine passed, sometimes consisted of little else than pavement epithelium, which had been thrown off abundantly from the surface of the urinary apparatus or passages. Globular epithelium, from the renal tubuli, was generally intermixed with pavement epithelium from the bladder, but to a proportionally small extent—not such, in my opinion, as to justify the idea that desquamation of the epithelial lining of the renal tubuli is a characteristic feature of cholera.

Frequently associated with epithelium, in the first urines, were fibrinous casts or cylinders; sometimes of considerable length, convolute or twisted, and transparent, or faintly striated; at other times in more or less straight fragments, dark or granular, or covered by, or entangling, granular corpuscles, oil globules, and molecular debris. They existed in four out of twelve cases. They gradually disappeared with the epithelium in the later urine, or that passed during fever and convalescence. The histological elements of the first urine, so far as they have been above described, therefore, resemble those of the urine in some cases of Bright's disease; and some authors regard the presence of the large amount of vesical pavement epithelium as the only point of histological diagnosis. The presence of mucus, epithelium, and pus, again cause a manifest similarity to many cases of vesical catarrh.

Of the crystalline ingredients of the urine, uric acid was present in two or three cases, chiefly in the earlier urine passed. In some specimens of the urine, it formed a sparkling crystalline scum; in a few, it covered the sides of the urine jar with a granular coating; in others, it occurred in the sediment entangled among mucus, or associated with other crystalline matters. Its crystalline form varied greatly; most frequently it assumed the shape of lozenges or cubes; sometimes it occurred in oblong bundles or stellate masses of acicular crystals, or as small delicate prisms. The size of the crystals also varied much, and the colour presented various shades of brownish yellow, red, and crimson. In one case, it appeared in the first urine evacuated on the third day of the disease, which was very

mild, terminating in recovery without the intervention of a distinct fever stage. The urine was acid, albuminous, and of specific gravity 1020; containing, in addition, mucus, granular corpuscles, fibrinous casts, epithelium, urates, and dumb-bell oxalates. It occurred either in the scum, sediment, or on the sides of the jar, and in different crystalline forms, for several days. In another case, it appeared during the fever stage, and was coincident with the acmé of an exanthematous eruption on the body of the patient, accompanied by symptomatic fever, on the eighth day of a severe case. The urine was still slightly albuminous, and of sp. gr. 1010. It occurred also in the urine of the ninth day: on allowing this to stand for two days, the whole uric acid was found converted into urate of ammonia. On the 10th day uric acid also appeared in sparing quantity; on the 12th there was no trace; on the 14th it reappeared, along with pavement epithelium. Urate of ammonia was frequently present in its usual amorphous form. When the urine was concentrated by evaporation, however, it assumed the appearance of large irregularly globular masses, of a light or dark brown colour, having a centrifugally radiating crystalline texture, and herein resembling the fibrous concretions of iron pyrites, often found in clay ironstone. When of large size, these masses were very fragile, and hence were frequently found in fragments. In studying the forms of the various crystallizable or saline constituents of the urine, I was in the habit of allowing certain specimens to undergo spontaneous evaporation and decomposition, to limited degrees: other specimens were concentrated by heat, and various reagents applied. The result was, as might be expected, a great variety of crystalline forms—greatest in the case of the phosphates. The triple phosphate occurred frequently—chiefly in the forms mentioned when speaking of their presence in the stools; sometimes alternating with the urates. Oxalate of lime was present in rare cases, but, both in the dumb-bell and octahedral form, chiefly in the earlier urine. In one case, octahedral oxalates were present in the first urine, passed on the third day of the disease, which was mild, terminating speedily in recovery without the intervention of a specific febrile stage. The urine was acid, of sp. gr. 1022, and loaded with urates. The sediment contained, in addition, epithelium, fibrinous casts, pus, and exudation or compound granular corpuscles. In another case, dumb-bell oxalates appeared in the first urine, passed on the third day of the disease, which was very severe. The urine was turbid, acid, albuminous, and of sp. gr. 1015. The next urine passed by the patient, on the sixth day, was phosphatic; while that passed on the eighth day contained a uric acid sediment. Both patients were young females. In a third case—a male—dumb-bell oxalates were associated with uric acid, fibrinous casts, epithelium, and mucus, in the first urine, passed on the third day. These crystalline sediments, as we have seen, frequently alternated with each other, or suddenly appeared and disappeared. One day the urine might be high-

coloured, containing beautiful sparkling crystals of uric acid; on another, it was perhaps turbid, from supersaturation with urates; on a third, it might contain a copious sediment of phosphates or pus; and, on a fourth, only a slight mucous sediment, entangling a few oxalates. Again, epithelium, casts and mucus, on the one hand, and phosphates and urates on the other, appeared sometimes to bear a relation to each other; where the one group was common, the other was rare. The former were met with, chiefly or only in the first specimens of urine passed; the latter, in the urine of fever and convalescence. As in other febrile diseases, there was sometimes observed a sudden and peculiar change in the histological characters of the urine—more particularly its crystallizable or saline constituents—coincident with a crisis, exacerbation, or remission, in the symptoms of the disease—especially during the typhoid or true fever stage. Such changes, however, were not regular or constant; or, in other words, did not bear a specific relation to the phenomena or phases of the disease. Hence, they were of little or no diagnostic value. They consisted most frequently in the appearance, reappearance, and disappearance of the urates, and of uric acid.

In a few exceptional cases, a beautiful Prussian-blue colouring matter was developed in the first urine passed, either after the addition of nitric acid, or simply on concentration by rapid evaporation. In one case the urine was acid, albuminous, of sp. gr. 1015, and contained casts, epithelium, mucus, oxalates, urates, uric acid, and compound granular bodies. Nitric acid, without the previous application of heat, caused the urine to assume a brownish-red colour, and also produced a brownish flocculent precipitate, which, on standing in a test tube, became granular, and of an earth-brown tint. The sides of the tube were at the same time coated sparingly with a greenish-blue granular deposit, which, under the microscope, appeared to consist wholly of bluish granular matter entangled among mucus fibrillæ. Hydrochloric acid produced a similar brownish discoloration and precipitate. Aqua potassæ developed a greenish colour; while aqua ammoniæ produced no change in colour. On standing for some time after the application of heat, and the addition of nitric acid, a yellowish-green colouring matter was found to have tinged certain granular corpuscles, and a cobalt blue pigment certain other corpuscles, along with epithelium scales, cotton tubes, and other debris, occurring in the urine sediment. Some corpuscles were dark-bluish-green and granular; others were light-green, and semi-transparent; while others were also non-granular, and of a fine cobalt blue. In the latter case, the corpuscles were frequently elongated at one extremity or caudate. Within certain limits, the intensity of the colouring matter increased in proportion to the period that had elapsed since the application of heat and nitric acid. It appeared to have a strong affinity for textile fabrics or other vegetable fibre; for I have seen it attached to linen fibres or cotton tubes, when it did not exhibit its presence elsewhere in the urine-

scum, or sediment. On another occasion, in evaporating down several specimens of first urines, when the liquid had arrived at a certain stage of concentration, the scum assumed a deep Prussian-blue colour. These specimens were acid, albuminous, and of sp. gr. 1015 to 1020; nitric acid produced an orange-red or pink reaction, according as heat was previously applied or not. All the specimens were in stages of decomposition, having stood exposed to the air for some days after they were voided. Under the microscope, the scum, when cool, was found to consist chiefly of globular urates, all having a bluish tinge.[1] In all the above cases, the urine in which the discoloration or colouring matter was found, was that first passed after collapse; none were discovered in subsequent urines. Other observers have noticed a violet discoloration, followed by a deposit of a blue colouring matter, after the addition of nitric acid in the urine of convalescence also.[2]

Associated with the epithelium, were sometimes found large roundish or oval cells resembling large epithelium scales, but having nucleolated nuclei, more distinct in outline, and usually darker and more granular. With these, were generally intermixed pus corpuscles, sometimes in great quantity,—the urine sediment being distinctly purulent. Both of these elements occurred in females, and their origin was probably leucorrhœal matter accidentally intermixed with the urine. Compound granular bodies, varying in size, granularity, and colour, frequently resembling the bodies described as "exudation corpuscles," by some authors, were also frequently present, associated sometimes with oily matter in the form of oil globules. Isolated vegetable cells, similar to those already described as occurring in the vomit and stools, likewise existed in a few cases; but they were evidently to be regarded as impurities or accidental admixtures.

The *post-mortem* contents of the bladder, or the urine drawn off by catheter after death, generally resembled that last evacuated prior to death, with the exception that it was always turbid, and contained a more or less copious flocculent sediment. This was made up chiefly of the disintegrated elements of the mucous lining of the urinary bladder and passages,—the result apparently of *post-mortem* or mechanical maceration, as in the analogous cases of the stomach and intestines. It frequently contained greatly elongated forms of epithelium, fusiform, fibroid, and conoidal; the latter sometimes presented two nuclei, the cell wall having a ventricose bulging opposite each. Caudate or horned forms of globular or pavement epithelium were also met with. Associated with epithelium and mucus, oil globules, and non-oleaginous hyaline globules, were also sometimes detected.

[1] "The development of a blue colouring matter in the urine of Cholera."—*Med. Times and Gazette*, May 12, 1855.

[2] Paper by Mr Osborn on the same subject.—*Med. Times and Gazette*, March 31, 1855.

I have still a few remarks to make on the histological characters of the blood, and of some of the abdominal and thoracic viscera. In one case the white corpuscles of the blood appeared to be present in excess. I have found a similar leucocythemic condition in a considerable variety of constitutional affections, especially among the insane;[1] and, I believe it to be a state or symptom—certainly not an independent disease—of comparatively common occurrence. In a few cases, the red discs were hazy or granular. In one case they presented peculiar characters, some having the appearance of a delicate cell wall developed round a single or compound nucleus,—others having the cell wall developed in such a direction as to give the corpuscles caudate or elongated characters, while in others the form was still more irregular. Water rendered these appearances somewhat more distinct, but the subsequent addition of acetic acid made little change.[2] The red discs also sometimes showed a proneness to form rouleaux. Similar structural alterations, or exceptional conditions of the blood have been described by other observers as occurring in cholera. But they are rare—are not peculiar to cholera—have probably existed prior to the development of that disease, and are, therefore, unconnected in a causal relation therewith. Blood changes in cholera, where they exist, are more probably due simply to exosmose, or to pre-existing constitutional conditions, than to structural alterations or morbid conditions essentially related to the disease itself. Some prevalent views on the pathology of the blood in cholera, appear to me to be very limited or very erroneous. I have never seen the tarry viscid condition, formerly so frequently described. I have certainly found it sometimes dull in tint, dark in colour, grumous, and very fluid, showing no tendency to coagulation; but, on the other hand, it more frequently contained abundance of decolorized clots. Both conditions, according to my own limited experience, are equally common in other diseases. I have been able to discover no difference between the blood in cholera, and that in a multitude of affections where pulmonary obstructions of any kind have prevented its due or ordinary oxygenation. The lungs, in cholera, participate in the general hyperæmia of the internal viscera; and, as a consequence, œdema is not an unfrequent pulmonary lesion.

The renal epithelium was sometimes infiltrated with oily globules and granules; but, I do not think that this is sufficient to warrant the conclusion at which some observers have arrived, that the kidneys are hence the seat of fatty degeneration. I think it probable, that had the disease, in some of these cases, progressed towards a favourable, instead of a fatal, termination, this infiltration of oily matter would gradually have disappeared; and that, where it was a permanent state of the epithelium, it probably depended on pre-existing organic disease

[1] "Histology of the Blood in the Insane."—*Journal of Psychological Medicine*, Jan. 1855.

[2] *Edinburgh Monthly Medical Journal*, Aug. 1854, *loc. ol. cit.*

of the kidney, which might have been aggravated, but was not originated or developed, by cholera. In some cases, I found the kidneys presenting the characters of various features or stages of Bright's disease.[1] The epithelium of the liver was also frequently, and that of the gall bladder and bronchi sometimes, infiltrated in a similar way with oily globules and granules; and, we have already seen that the epithelium thrown off from the surface of the gastro-intestinal mucous membrane, and of the urinary bladder and passages, frequently presented like appearances. The hepatic epithelium was sometimes hazy or granular, without exhibiting distinct oil globules. The gall bladder was usually coated with inspissated mucus, abounding in cylindrical epithelium of a very bright greenish-yellow colour, associated sometimes with oil globules and granules. It was usually distended with bile, which appeared healthy, or at least exhibited no marked departure from the normal state. This statement is quite opposed to generally recognised opinions on the conditions of the bile in cholera. I have elsewhere—and in some detail—stated the grounds upon which my own convictions are founded.[2] The very term *cholera* appears to me a misnomer, founded on mistaken views on the pathology of the disease. The presence of cylindrical epithelium in the gall bladder, has given rise to the opinion that here also there has been a vital desquamation of the epithelial lining; but, as in the analogous case of the intestines, the phenomenon is probably a *post-mortem* one. The bloody juice squeezed from a lung in a state of pneumonic consolidation, contained pus corpuscles, but no exudation or compound granular bodies. The cream-like contents of a tubercular cyst about the size of a sixpence situated in the apex of a lung, contained pus and exudation corpuscles, cylindrical ciliated epithelium, and the vague entities denominated by many observers, "Tubercle corpuscles," besides molecular debris—the result of the disintegration of pus.

Before leaving this subject I would remark, that none of the above histological appearances are peculiar to cholera, but, on the contrary, most of them are common in a great variety of diseases. The intestinal evacuations are generally regarded as the most peculiar features of cholera: histologically they are not so, but closely resemble the stools of dysentery and diarrhœa. In ordinary physical characters the difference is generally great; sometimes, however, imperceptible. On the points of resemblance and distinction, however, I cannot here enter.[3] In connection with this subject, I have examined the stools in many cases of simple, acute and chronic diarrhœa, of the diarrhœa of phthisis and of chronic dysentery; and

[1] Pathology of Cholera—"Clinical Notes on Cholera."—*Association Medical Journal*, May 12, 1854.

[2] *Association Med Journal*, March 10, 1854. *Ol. cit.*

[3] They will be found somewhat fully detailed in a paper on the "Histology of Mucoid Evacuations in Diarrhœa, Dysentery, and Cholera."—*Association Medical Journal*, March 16, 1855.

I have found the same albuminosity, the same histological elements, the same excess of salts and of water, or serum; the latter, however, never to the same extent. The stools of the premonitory diarrhœa, and of the reaction and fever stages, closely resembled those of common diarrhœa in ordinary physical, as well as histological and chemical characters. Between those of the collapse stage, the ricy stools, and the purely mucous discharges of dysentery, the resemblance was less close. In rare cases, however, the bloody stools bore an intimate resemblance to those of advanced dysentery. In the latter disease, the proportion of serum is greatly less, and the mucus is more cohesive, viscid, and stringy; when mechanically broken up, however, and agitated in water, a ricy fluid, exactly resembling the rice water discharges of cholera, was produced. The corpuscular element of the mucus in dysentery is generally larger, more distinct, less abundant, and more frequently showing nuclei and nucleoli under the influence of acetic acid; moreover, it is sometimes altogether absent, as it was in one case where the stool was of an apple-green colour and jelly-like. In the same disease, also, pus and blood corpuscles are of frequent occurrence, the reverse being the case in cholera.

II. *Histology of the Cholera Evacuations, etc., in the Dog and Cat.*[1]

To exhibit at once the chief points of resemblance and distinction between the histological characters of the cholera evacuations in man and in the dog and cat, I shall here also shortly tabulate the principal appearances. But, in so doing, it is necessary to state that I had not the same facilities or opportunities for making separate microscopical and chemical examinations of the several evacuations in these animals as in man. The vomit and urine were generally so mixed up with the fæces that I was very seldom able to separate them for examination. The histology of the solids and fluids, after death, was much more fully and satisfactorily examined than that of the evacuations voided during life, the reverse being usually the case in the human subject. Hence the table can only be considered approximative, but it is probably sufficiently accurate to point out the close resemblance between the microscopical characters of the evacuations and the blood and viscera in the cholera of man, and in that of the animals which were the subjects of my experiments. To a certain extent, this resemblance was due to the mode of experiment, for instance, in regard to the nature of the food debris occurring in the stools, the animals having been fed on the evacuations of patients labouring under different stages of

[1] For the circumstances under which these animals were affected with cholera, I must refer the reader to the *Edinburgh Medical and Surgical Journal*, "On the Communicability of Cholera to the Lower Animals," April and October 1854; *Association Medical Journal*, "Clinical Notes on Cholera," September 15 and December 15, 1854; and *Gazette hebdomadaire de Médicine et de Chirurgie* (Paris), November 24, 1854.

cholera, evacuations containing the elements of food which I have already detailed in speaking of the cholera vomit in man. Most of the elements therein mentioned occurred in the stools of the dogs, many of them having passed through their intestinal canal unaltered, others having undergone only further disintegration. The most common of these were the parenchymatous cells of the potato, portions of the epidermis of barley grains, starch corpuscles from the oat and potato, many of the forms of isolated vegetable cells which I have already spoken of as gonidic and annular bodies, with a few hairs and fragments of spirals.

I. *Vomit.*
- *a. Mucus*—fibrillated bands, with or without granular corpuscles.
- *b. Granular corpuscles*—probably chiefly epithelial nuclei.
- *c. Epithelium*—pavement, seldom perfect in form or transparency, more frequently variously elongated or otherwise altered, and hazy, dark, or granular.

II. *Stools.*
- *a. Mucus*—fibrillated bands, with or without granular corpuscles.
- *b. Granular corpuscles*—generally larger and more distinct than in man, probably from earlier period at which they were examined after evacuation or death.
- *c. Debris of vegetable food*—Similar in kind to that mentioned under head of cholera vomit in man.
- *d. Oily matter*—only in form of oil globules.
- *e. Crystalline matters or salts*—phosphates and chloride of sodium, as in man, the former in a less variety of crystalline forms.
- *f. Fungi*—mycelium of various kinds of mould, as in man.
- *g. Ova of intestinal entozoa*—in various stages of development.
- *h. Compound granular bodies*—variously coloured, most frequently greenish-yellow.
- *i. Molecular matter*—similarly coloured.
- *k. Impurities*—
  1. Licked from the surface of their own bodies—
     Hairs.
  2. Licked from the floor—
     Siliceous crystalline matter and other elements of dust.

III. *Urine.*
- *a. Mucus.*
- *b. Granular corpuscles.*
- *c. Crystalline matters or salts*—
  Phosphates.
  Chlorides.
  Urates.
- *d. Oily matter*—only in form of oil globules.

The vomit, when distinguishable from the fæces, was a somewhat viscid, frothy matter, of a pale greenish-yellow tinge, consisting almost entirely of epithelium and granular corpuscles, both having a similar tinge, especially the latter. The epithelium was seldom rounded or broad, but more generally narrow and elongated—fusiform or navicular—sometimes very dark and granular. On the addition of acetic acid, a delicate cell wall became visible round most of the granular corpuscles, whose granularity was sometimes dimi-

nished; they never became compound, nor exhibited nuclei or nucleoli under the action of the acid.

During the earlier stages of the diarrhœa, produced by the nature of the animals' food, the stools were somewhat viscid, sometimes tarry in appearance, more generally of a brownish-green colour, containing much biliary pigment, a considerable amount of food debris, and frequently entozoon ova and phosphates, but little or no mucus. As cholera was developed, the stools became much more copious and watery, but still generally of a brownish-green tint. On minute inspection, however, they were found to abound in small flocculi of mucus. The disease proved fatal prior to the discharge of purely ricy or mucous matter, for the intestines were found, on *post-mortem* examination, lined or loaded with flocculent mucus, sometimes almost pure and colourless, or variously covered by or intermixed with greenish semi-fæculent matter. When the mucus of the intestines, freed from fæculent admixture, where it existed, was washed out by a stream of water, or was scraped from the surface of the mucous membrane, agitated with water, and the fluid allowed to stand, the mixture resulting could not be distinguished by the naked eye from the ricy stools of the collapse stage of human cholera. The flocculi, under the microscope, sometimes presented the appearance of delicately fibrillated bands of mucus, without being associated with or covered by granular corpuscles; the latter, however, were generally present, and varied from the size of pus corpuscles to about half that size. Under the action of acetic acid, alone or aided by boiling, some of these bodies became less granular, others were unaffected; some exhibited one or more nuclei, while around others a delicate cell wall was developed. They were frequently of a greenish-yellow tinge, as were sometimes also the mucus bands themselves. The mucus scraped from the surface of the stomach and intestines consisted sometimes solely of bands of mucus, so delicately striated as to be almost invisible; frequently isolated vegetable cells were adherent or intermixed in more or less abundance. Mucus from the stomach contained cylindrical and pavement epithelium, very dark and granular in one case; that from the œsophagus also contained granular epithelium and a number of isolated vegetable cells.

The urine could not be fully examined. It was generally turbid, having a whitish granulo-flocculent sediment. The vesical epithelium was only hazy; the renal epithelium was infiltrated with oil globules. The blood corpuscles appeared normal. Tracheal mucus contained normal cylindrical epithelium. Fluid squeezed from the lungs and bronchi contained epithelium, sometimes dark and granular, associated with oily granules, and a number of hyaline globules. The hepatic epithelium was slightly filled with oily granules and globules. The mucus of the gall-bladder contained cylindrical epithelium, isolated and in patches, besides a large number of granular corpuscles and oil globules, all of a very bright greenish-yellow colour.

The epithelium of the interior of the vagina, uterus, and fallopian tubes appeared healthy.

EXPLANATION OF PLATES.

Plate I.

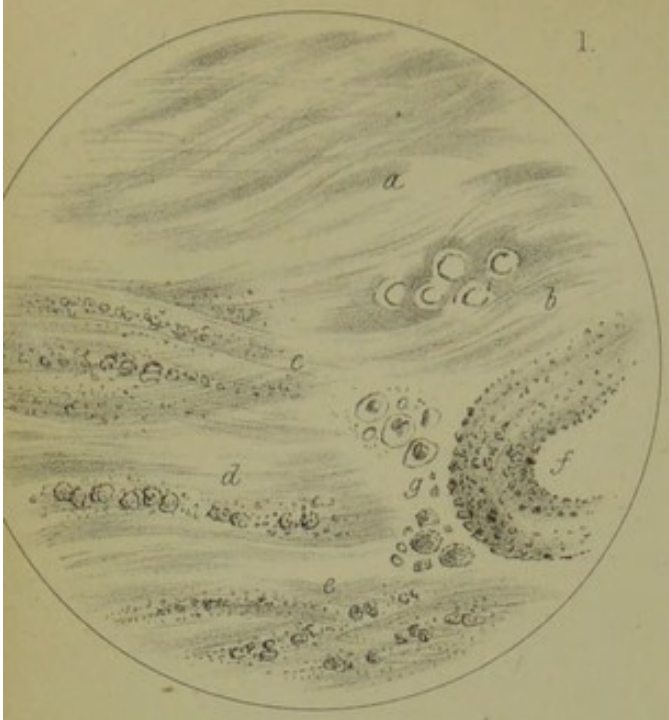
Fig. 1. Mucus-fibrillæ and mucus-corpuscles, etc.
a. From collapse vomit, ejected on first day: fibrillæ unassociated with corpuscles: case recovered.
b. From collapse (rice-water) stools, evacuated on second day: case recovered: fibrillæ entangling hyaline globules.
c. From collapse stools (muco-granular sediment of a dark lead grey colour) passed on first day in same case.
d. f. From collapse (rice-water) stools passed immediately before death: case fatal in eight hours.
g. From same stools: mucus-corpuscles, showing effects of acetic acid.
e. From collapse vomit: case fatal in eighteen and a half hours.

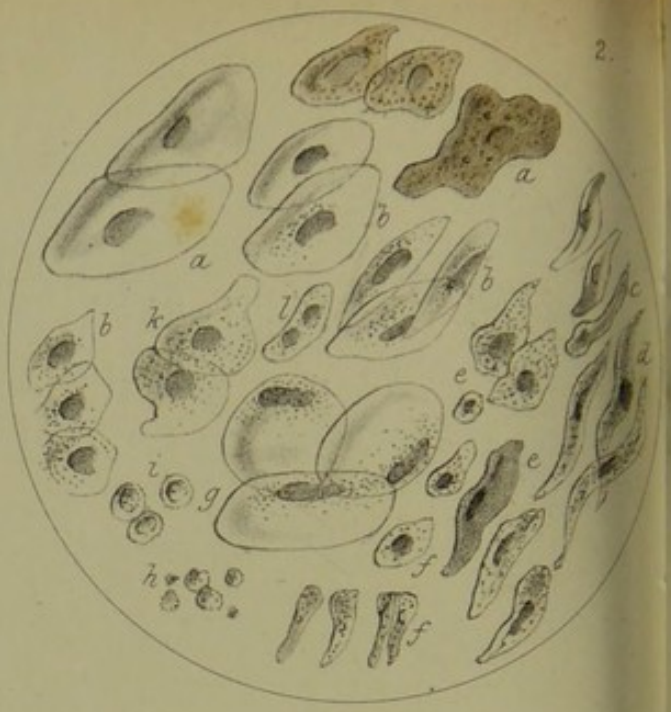
Fig. 2. Forms of epithelium—tesselated, cylindrical, fusiform, caudate, etc., in vomit.
a. From collapse vomit: case recovered.
b. „ case fatal in eight hours.
h. i. „ in same case: *i.* shows effect of acetic acid.
c. k. „ case recovered.
d. „ cholerine: case recovered.
e. „ case fatal in typhoid stage.
f. „ case fatal in eighteen and a half hours.
g. „ case fatal in typhoid stage.
l. „ case fatal in acmé of consecutive fever.

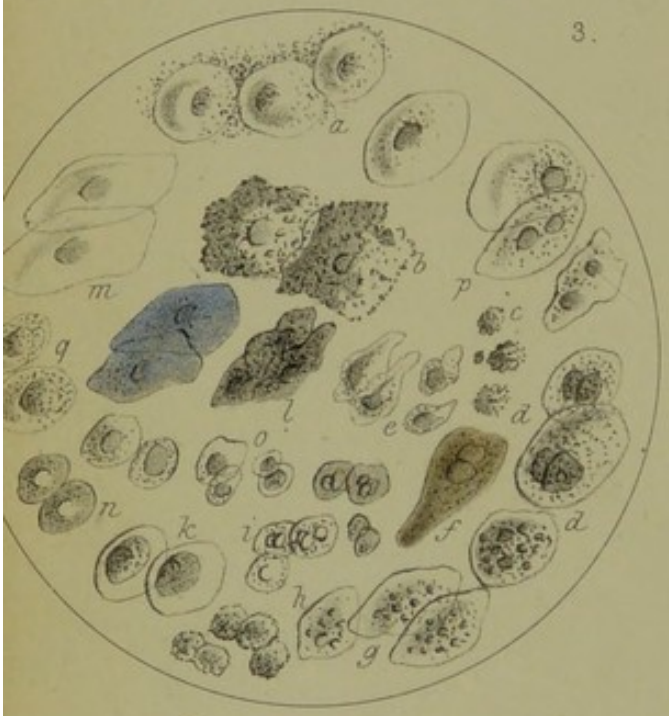
Fig. 3. Forms of epithelium, etc., in urine.
a. c. g. h. i. o. From urine first passed (in fever stage): sediment purulent (probably leucorrhœal): case recovered: *i. o.* show effect of acetic acid.
p. Compound granular bodies from same urine.
b. From collapse urine (first passed): case recovered.
d. f. l. „ case fatal in acmé of consecutive fever.
e. q. From urine first passed (in reaction stage): case recovered.
k. From urine of advanced fever stage: case marked by an urticario-rubeoloid exanthem: recovered.
m. From urine first passed (in reaction stage): cholerine: case recovered.
n. From urine passed during convalescence in same case.

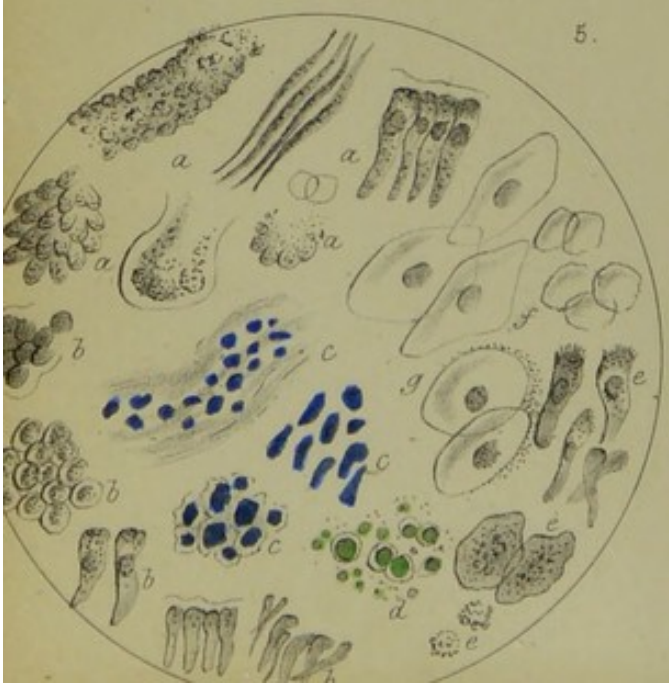
Fig. 4. Forms of epithelium, etc., in urine.
a. From urine drawn by catheter at the autopsy made the day after death: case fatal in typhoid stage.
b. e. From urine passed in reaction stage: cholerine: case recovered. (*Vide* Fig. 3. *m. n.*, and Fig. 5. *c. d.*) *e.* Fibrine cylinders, transparent or granular.
c. From urine passed in collapse: cholerine: case recovered.
d. From urine first passed (in fever stage): case recovered.
f. From urine passed in advanced consecutive fever: case recovered.
g. From urine drawn off by catheter two days after death: case fatal in typhoid stage.

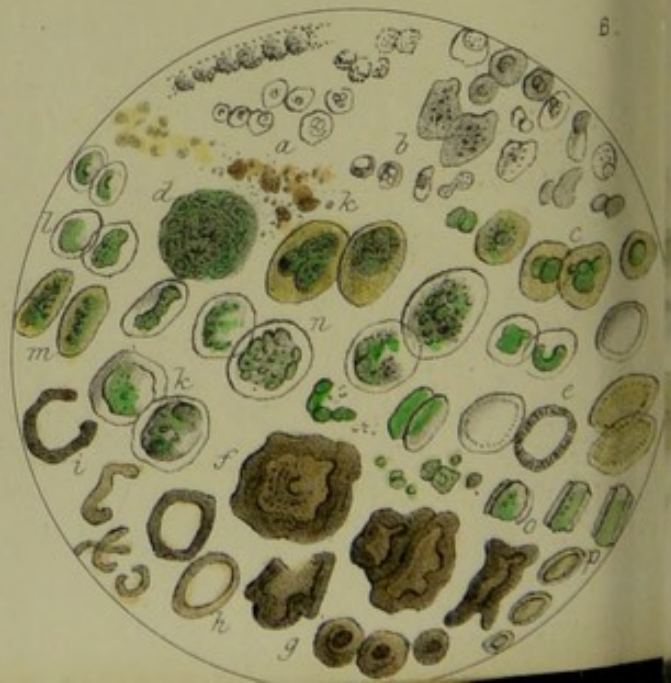
Illustrative of the Histology of the Cholera evacuations in man.











Illustrative of the Histology of the Cholera evacuations in man.

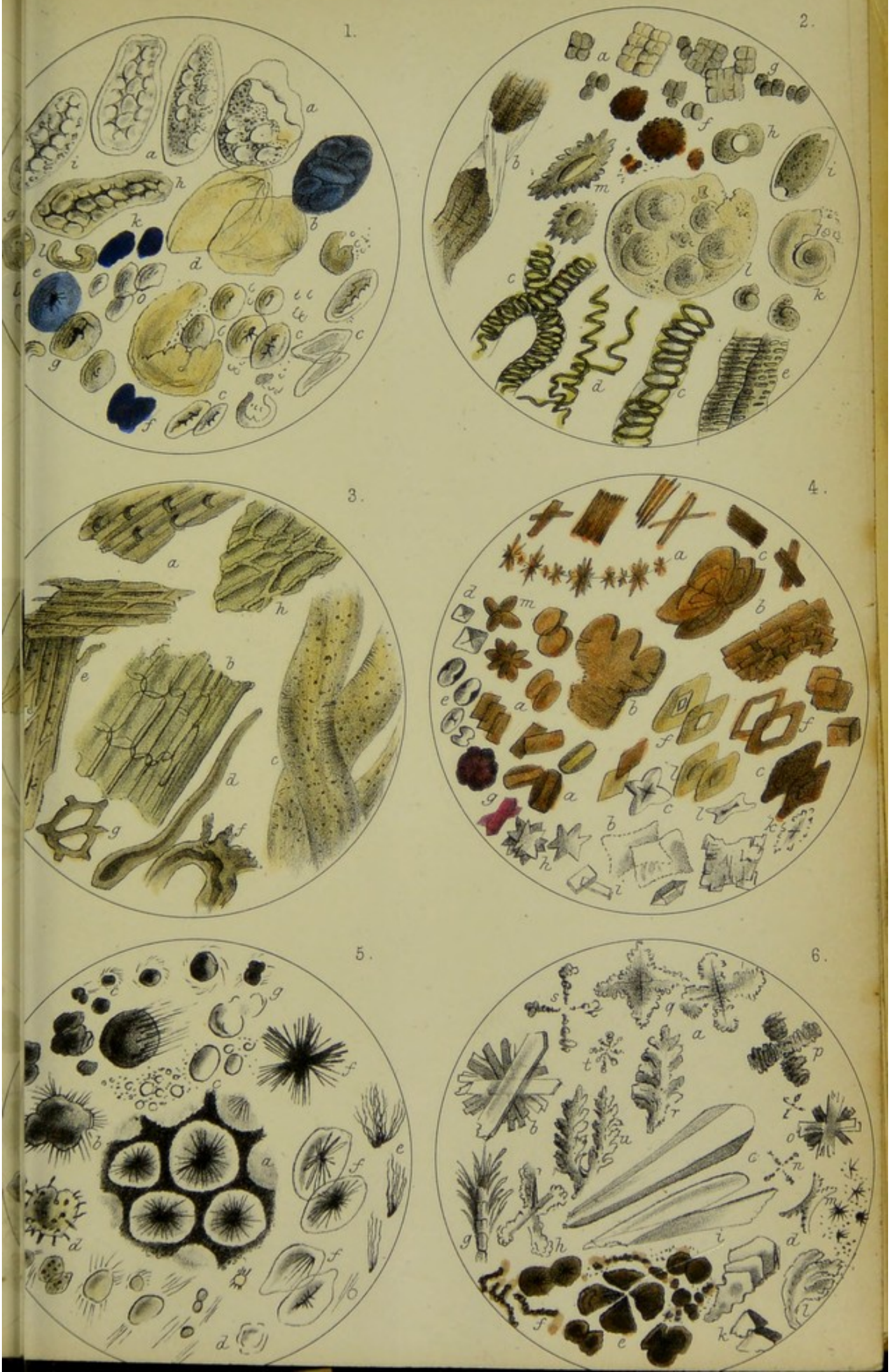


Fig. 5.

a. In fluid removed from stomach at autopsy: case fatal in three and a half hours.

b. In mucous contents of intestines removed at autopsy made the day after death: case fatal in eighteen and a half hours.

c. d. From urine first passed (in reaction): cholerine: case recovered: after addition of nitric acid, and standing for a day, the corpuscles at *c.* assumed a deep cobalt blue, and those at *d.* a Scheele's green colour.

e. Cylindrical ciliated epithelium in juice expressed from a condensed lung at autopsy made day after death: case fatal in consecutive fever.

f. Hyaline bodies in urine, drawn off by catheter at autopsy: case fatal in typhoid stage.

g. Pavement epithelium from collapse (rice-water) stools: case fatal in eight hours: probably from leucorrhœal matter.

Fig. 6.

a. Altered blood corpuscles, in bloody juice expressed from a condensed lung at an autopsy made the day after death: case fatal in consecutive fever: action of acetic acid is exhibited on some.

b. In bloody juice squeezed from the bronchi at the autopsy in the same case.

c. e. h. n. o. Isolated cells of the tissues of various vegetables consumed as food, from collapse (rice-water) stools: case recovered.

d. From stool passed in fever stage: case recovered.

f. From collapse vomit and stools: case fatal in typhoid stage.

g. From collapse (rice-water) stools: case fatal in eight hours.

k. From reaction stools: case recovered.

l. m. „ case fatal in acmé of consecutive fever.

p. From collapse vomit: cholerine: case recovered.

* These cellular bodies probably represent the chief forms of the "cholera corpuscles," "cholera fungi," and "annular bodies" of observers during the epidemic of 1848–9. Some of the forms,—especially *c. k. l. m. n.*—I have elsewhere denominated "gonidic" bodies.

Plate II.

Fig. 1. Parenchymatous cells and starch corpuscles from the potato, oatmeal, barley, etc.

a. Parenchymatous cells of the potato from collapse stools: case recovered.

b. h. Potato cells from collapse stools: case fatal in consecutive fever: at *b.* the starch corpuscles are coloured by iodine.

o. k. Starch corpuscles in collapse stools of same case: *k.* coloured by iodine.

c. g. e. f. l. Starch corpuscles in collapse vomit: case recovered: *e. f.* coloured by iodine.

d. Empty potato cells in collapse vomit: case fatal in eighteen and a half hours.

i. Potato cells, with inclosed starch corpuscles, in collapse vomit of same case.

Fig. 2. Disintegrated elements of the tissues of various vegetables used as food; sarcina; muscular fibre, etc.

a. Sarcina ventriculi (entire) in collapse vomit: case fatal in eighteen and a half hours.

c. d. Spiral and annular vessels and isolated spirals, in same vomit.

f. Compound granular bodies in do.

b. Fragment of muscular fibre in collapse vomit: case fatal in consecutive fever.
e. Porous vessels in collapse vomit: case fatal in eight hours.
g. Sarcina ventriculi (broken up) in collapse vomit: case fatal in typhoid stage.
h. In collapse vomit: fatal in consecutive fever.
i. In collapse stool of same case.
k. *l*. In consecutive fever (pea-soup) stools: case recovered.
m. In collapse vomit: cholerine: case recovered.

Fig. 3. Fragments of the parenchyma, epidermis, and fibrous tissue of various vegetables used as food.
a. In fever stools: case recovered.
b. *c*. In collapse vomit: case fatal in eighteen and a half hours: *c*. is a portion of the fibrous tissue of the turnip.
d. *f*. Vegetable hairs in collapse vomit: case recovered.
e. *h*. In reaction stools of same case.
g. In collapse stool: case fatal in eight hours.

Fig. 4. Crystals occurring in the urine, etc.
a. *m*. Uric acid in sediment of urine first passed (in reaction, on first day) after nitric acid and standing: cholerine: case recovered.
b. Uric acid in scum of same urine.
c. ,, in sediment of same urine: after heat, nitric acid and standing.
e. Dumb-bell oxalates in sediment of same urine.
d. Octohedral oxalates in sediment of urine passed in convalescence: cholerine: case recovered.
f. Uric acid in fever urine (coincident with appearance of cholera exanthem): case recovered.
g. Uric acid in same urine: after concentration and hydrochloric acid.
h. *i*. In collapse stools, after concentration to dryness, the formation of an alcoholic extract and then a watery solution, the addition of ammonia and standing: case recovered.
k. In urine of convalescence: after concentration and the addition of a saturated solution of oxalic acid: case same as *h*. *i*.

l. In collapse vomit after concentration and addition of ammonia: cholerine: case recovered.

Fig. 5. Forms of fatty and oily matters in vomit and stools.
a. Concrete fat, floating in pellets, in stools passed during consecutive fever: case fatal.
g. From last stool passed before death in same case (brought away by injection).
b. Spiculated fatty bodies in sediment of collapse vomit (on standing): case fatal in eighteen and a half hours.
c. From collapse vomit: cholerine: case recovered.
d. From contents of stomach removed at autopsy: case fatal in typhoid stage.
e. Fat-crystals in collapse vomit concentrated to dryness: case recovered.
f. In collapse vomit: case fatal in eight hours.

Fig. 6. Crystalline matters in vomit, stools, and urine.
a. *q*. *s*. Plumose and cruciform phosphates from urine passed in advanced fever stage: case recovered: urine concentrated by evaporation and ammonia added.
b. Stellate group of prismatic phosphates, from stools passed in beginning of consecutive fever: same case: body marked by a scarlatinoid exanthem: stools loam-coloured and somewhat fæculent.
c. In urine passed during convalescence from consecutive fever: same case: urine concentrated by evaporation.

Illustrative of the Histology of the Cholera evacuations in the Dog.

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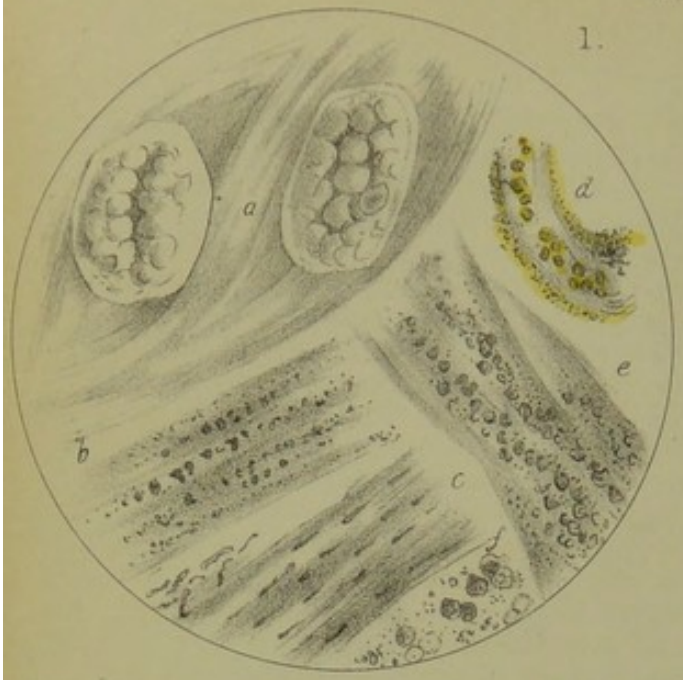

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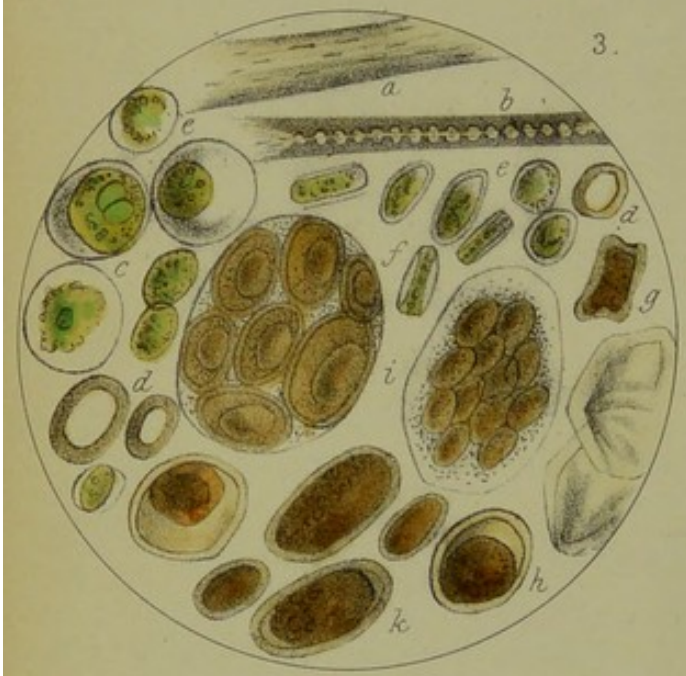

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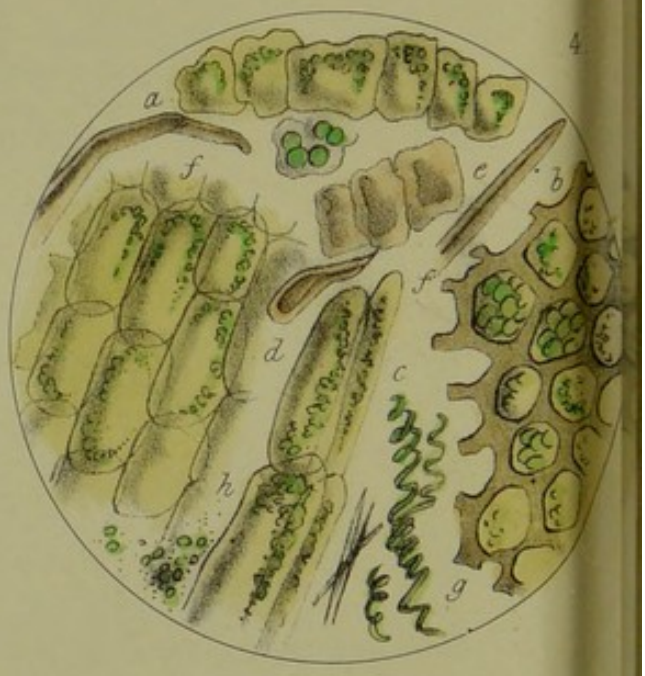

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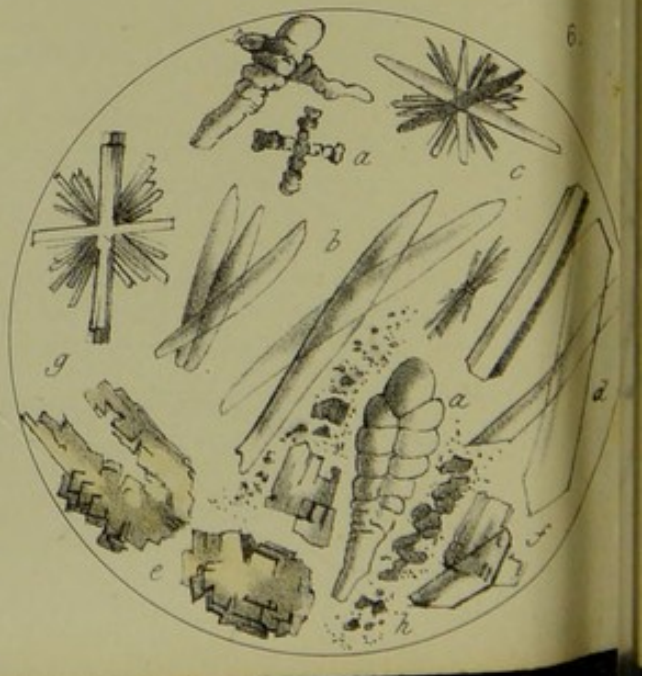

d. From urine passed during advanced fever: same case: after concentration, addition of ammonia and standing two days.
g. o. u. From urine passed during consecutive fever: same case: after boiling, addition of nitric acid, and standing two days.
l. r. From the first and second urine passed at beginning of consecutive fever: same case: after concentration by evaporation on sand bath.
e. f. Urates from collapse urine: case fatal in eight hours: after concentration and standing.
h. From fever (pea-soup) stools on standing: case recovered.
p. From urine passed during consecutive fever: same case: body marked by an exanthem: after concentration and addition of ammonia.
i. From urine passed at beginning of consecutive fever: case recovered: after concentration and addition of ammonia.
n. t. From urine passed during convalescence from consecutive fever: same case: after concentration and addition of aqua potassæ.
k. In collapse vomit after concentration nearly to dryness: case fatal in eight hours.
m. From sediment of urine passed during reaction: cholerine: case recovered.

Plate III.

Illustrative of the Histology of the Cholera Evacuations in the Dog.

Fig. 1. *a.* Mucus, in delicately striated bands, unassociated with granular corpuscles, entangling the parenchymatous cells of the potato, which are full of starch corpuscles. In the cholera stools of man the corpuscular element of mucus is generally present: in the vomit it is sometimes absent.
b. c. Flocculi of mucus, removed from the duodenum after death, boiled in weak acetic acid.
d. Flocculi of mucus from the contents of the large intestines, removed after death, boiled in water. The granular corpuscles and molecular matter were tinged of a greenish-yellow colour from biliary pigment.
e. Ordinary appearance of the mucus flocculi contained in the stools or in the intestines, showing the striated bands of mucus covered by or entangling granular corpuscles and molecular matter. This is also the most usual character of the ricy flocculi in the collapse discharges in man.
f. The corpuscular element separated.

Fig. 2. *a.* Various forms of pavement epithelium from the vomit, all having a light greenish-yellow tinge from biliary colouring matter. The epithelial sediment of the cholera vomit in man generally consists of precisely similar elements, the scales being comparatively seldom perfect in size, form, or transparency, but frequently becoming elongated, navicular, fusiform, fibriform, and dark, hazy, or granular.
b. Granular corpuscles associated with the above and similarly tinged.
c. Action of acetic acid on them, showing the development of a delicate cell wall.
d. In mucus scraped from the gall bladder.
e. Hepatic epithelium, varying in darkness and granularity.
f. Cylindrical and pavement epithelium in mucus scraped from the stomach, very dark and granular.
g. Epithelium and granular corpuscles in mucus scraped from the inner surface of the urinary bladder.
h. Various forms of pavement epithelium in mucus scraped from the lining membrane of the urinary bladder in another dog. It is altered in a similar way to that contained in the vomit. Precisely the same appearances occur in the epithelial sediment of the first urines passed in the cholera of man.
The frequent haziness or granularity of the epithelium in different parts of

the body, and its infiltration with oily globules or granules, are equally common in the cholera of man.

i. In the mucous juice scraped from a section of the lungs.

Fig. 3. *a. b.* Animal hairs, probably accidentally swallowed by the animals, and occurring in the intestinal evacuations.

c. d. e. f. g. Various forms of isolated or partially disintegrated cells of vegetable tissues consumed as food by human cholera patients, and contained in their vomit and stools, especially the former. On these evacuations the dogs were fed. A diarrhœa was induced, during which the vegetable elements of their food frequently passed through the system of the animals almost unchanged. They include various forms of the so-called "annular bodies," "cholera fungi," or "corpuscles" of some authors, as is shown at *d.* *e.* Exhibits the forms which I have elsewhere denominated "gonidic." *f.* Were scraped from the surface of the duodenum, to which they were adherent. Some of these cells were generally to be found adherent to or entangled in the mucus coating of every part of the intestinal tract. The same bodies occur, but in greater abundance and variety, in the stools and intestinal coating in the human subject, not only in cholera, but in other diseases. Their contents possess various tints of yellow or green.

h. Collapsed and empty parenchymatous cells of the potato, of a light brownish colour. They become blue under the action of iodine.

i. k. Entozoon ova in various stages of development, aggregated or free; their colour consists of various shades of brown or brownish-green. In connection with their frequent occurrence in the intestinal evacuations, it may be mentioned that a tænia was found in the discharges of one dog and a lumbricus in the intestines of another.

Fig 4. *a. b. c. d. e.* Fragments of the parenchyma of various vegetables consumed as food, chiefly in the form of broth, and contained in the first vomits of human cholera patients. On these evacuations the animals had been fed, and the contained vegetable tissues had passed almost unaltered through their intestinal system. Most of the cells will be seen to be full of chlorophylle grains or starch corpuscles; at *e* they are empty.

f. Fragments of epidermic hairs of various vegetables generally used as food by man. Such hairs occur in ordinary wheaten bread.

g. Uncoiled spirals from the fibrous tissue of vegetables, also used as food by man, such as the turnip and carrot.

h. Isolated chlorophylle grains which have escaped by the rupture or disintegration of the parenchymatous cells above figured and described.

Fig. 5. *a. b. c. d.* Fragments of the epidermis of various vegetables generally used as food by man, chiefly the ingredients of broth; they possess various shades of green. Fragments like *a* occur in coarse bread.

e. f. Fragments of the parenchyma of similar vegetables, similarly coloured.

g. Starch corpuscles, entire, variously ruptured or otherwise altered, from the contents of the large intestines. They strike no blue colour on the addition of iodine, even with the aid of mineral acids. Hence the non-action of iodine cannot be considered a sufficient proof of the non-amylaceous nature of such corpuscles or cells. In other cases, the same corpuscles, and apparently under the same circumstances, exhibit the usual reaction of starch with iodine. I have noticed the same phenomenon in the cholera of man. When partially broken up, starch corpuscles probably include some of the forms of "annular bodies" already alluded to.

h. Starch corpuscles adherent to the mucous membrane of the intestines or intermixed with the mucus thereof.

i. Compound granular bodies of a deep greenish-yellow colour.

k. Isolated chlorophylle grains and molecular debris of a similar tinge.

The histological elements exhibited in Figures 3, 4, and 5, occurred in the

intestinal discharges and *post-mortem* contents in the cholera of the dog. The vegetable tissues, and their disintegrated cells, are the same as those occurring in the cholera stools of man. The animal hairs and entozoic ova are alone peculiar to the dog.

Fig. 6. *a. b. c. d.* Crystals contained in various specimens of the urine, when concentrated by evaporation.

e. In the semi-fæculent contents of the large intestines.

f. Ordinary prismatic phosphates appearing in the scum of the intestinal evacuations on standing for a short time. Along with and in similar circumstances to the phosphates, chloride of sodium occurred sparingly in broken tables.

g. Stellate groups of acicular phosphates occurring in similar circumstances.

h. Siliceous crystalline and granular matter, probably licked by the dogs from the floor of the room in which they were confined.

The crystallizable constituents of the urine were fewer in number, and presented less variety in crystalline form than those of the cholera urine in man.

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