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BY

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Experiments on the Communicability of Cholera to the Lower Animals. By W. LAUDER LINDSAY, M.D., late Resident Physician to the Surgeon Square Cholera Hospital, Edinburgh.[1]

It has often appeared to me surprising, in studying the literature of cholera, that, although the etiology of this dire disease has received a vast,—I might almost say unprecedented, amount of attention from the profession in every part of the civilized world, during the last twenty years, and all the known machinery of science and art has been put into vigorous operation to ascertain its essence or stem its progress, only with the result hitherto of baffling all human ingenuity; and notwithstanding the thousands of volumes that have been published on its etiology, symptomatology, pathology, and treatment, comparatively few attempts have been made, so far as I am aware, to propagate the disease from the human subject to the lower animals,—in them deliberately and experimentally to study all its varied phases. It has been too much the custom among authors, I fear, in the investigation of a subject of such acknowledged difficulty, to prefer the construction of specious and ingenious theories upon supposed or uncorroborated facts, which, perhaps, have been too hastily examined, to throwing aside prejudice and theory of every kind, as fettersome and dangerous, and patiently, silently, and dispassionately observing the workings of nature. It can, however, only be by the careful accumulation of the unprejudiced, simultaneous, and isolated observations of individuals that safe data can be obtained whereon to found just and sound conclusions,—which may be practically acted on and followed out,—as to the nature of a disease about which so little of a specific nature is confessedly known.

Seeing no reason why the same poison which produces or propagates the disease in man should not equally, under similar circumstances, affect creatures so much akin to him in their structure and habits as the dog and cat, it occurred to me to take advantage of my opportunities as Resident Physician to the Surgeon Square Cholera Hospital, Edinburgh, by

[1] The publication of these experiments in their present shape is due to the kindness of Dr Warburton Begbie, visiting physician of the said hospital, to whom I take this opportunity of acknowledging my deep obligations.

endeavouring to communicate the disease to these animals, through the medium of the different excretions of the patients therein treated. This I proposed to myself to do chiefly in three ways, viz :—

I. By feeding them on the evacuations,—dejections, vomit, and urine,—of patients labouring under various stages of the disease.

II. By feeding them on the blood, drawn during life, or taken from the heart and great vessels after death, of man,—or on various of the solids and fluids, *e.g.*, the blood, muscles, and viscera,—of other animals,—affected with the disease.

III. By causing them to inhale the effluvia from these evacuations and blood, and from the clothes worn by, and saturated with the perspiration and breath of, patients.

By the two former modes of procedure, I was led to expect, from what I have seen of cholera, and from the microscopical and chemical examination of the fluids in question,—and I obtained—negative, *i.e. non-specific* results. By the latter I hoped for, and succeeded in producing, *specific* results, viz., what appeared to me to be cholera, which was simultaneously developed in four animals, and was fatal in two of them.

Every one must remember the great importance that was attached by many authors, during the epidemic of 1848-9, to the presence in the cholera evacuations of certain insignificant vegetable cells, which were originally figured and described by Brittan and Swayne under the name of "annular bodies," "cholera corpuscles," "cells," "fungi," &c., and by others to the much more astounding fact that these discharges were found teeming with millions of microscopic animalcules. On the existence of the former, as the supposed poison agents of the disease, was based the very ingenious fungus theory of cholera ; on the presence of the latter, the no less ingenious but more fragile animalcular theory, each having its hosts of supporters. I have seen all the forms of the so-called "annular bodies" described by Brittan and Swayne, in the evacuations of patients under my own charge, and I have also seen the same fluids abounding in minute vibrios in a high state of activity ; but having observed the former only in small quantity, and being able in many instances to trace them back to their original source, the food ; believing moreover, that the latter exist equally in all decomposing animal fluids, I could not look upon either as having any causal relation to the disease, and therefore did not anticipate any specific effects from the administration, to animals,

of fluids, which I knew by microscopical examination, to contain both in abundance. I found that these evacuations, which were given to the animals in all degrees of freshness and putridity, and in all states of concentration and dilution, produced the simple effects of any other irritant or putrid matter, viz., a non-specific diarrhœa, attended, in the case of the more acrid substances, such as concentrated urine, by the secretion from the intestines of an increased amount of mucus to lubricate and defend the canal. The offending matters were speedily thrown off from the system by the stomach or the intestines. This is what, *à priori*, I was lead to expect; for, even supposing the presence in the cholera evacuations of a considerable amount of a volatile poison, it is easy to conceive that while this might immediately generate a specific disease, when entering the system by such an extensive surface as the pulmonary and cutaneous systems, it might be comparatively inert when applied to a surface comparatively so limited as the gastro-intestinal mucous membrane.

By other writers, again, the blood is said to be the recipient and medium of retention and reproduction of the morbific matter of cholera. With regard to this point, I can certify that the blood taken from cholera patients after death and given to animals, was apparently attended by more severe diarrhœa and exhaustion than followed the administration of any of the evacuations. I have reason, however, to look on this effect more as coincident and accidental, than as essentially depending, for its causation, on the blood in question.

During my attendance on cholera patients, I had been constantly struck with the peculiar disagreeable odour given off by their bodies, in the copious clammy perspiration, which is such a common feature of the disease,—the exhalations from one patient being frequently sufficient to taint a large ward. Moreover, I have frequently noticed nurses and attendants suddenly seized with overpowering nausea, accompanied or not by diarrhœa and vomiting, *i.e.* the premonitory symptoms of the disease,—after having accidentally inhaled the effluvia contained in the breath or perspiration of patients for a greater or less space of time; and I have known several fatal cases of cholera occurring in persons who had merely washed the clothes of patients dying of the disease, even at considerable intervals subsequent to their death. One of the washerwomen of the Edinburgh Cholera Hospital, who died of cholera on the 11th October last, after three days' illness, attributed her seizure, and probably with justice, to the exhalations from the clothes of a cholera patient, which she had

occasion to wash ;—and one of the nurses in the same hospital, was more than once seized with very suspicious premonitory symptoms on leaving her duties in the wards for a day to wash patients' clothes in the washing-house. Experience has led cholera nurses to believe that by far the most dangerous part of cholera patients is their breath and sweat and their clothes, which are more or less saturated therewith. I have read of numerous instances, where the clothes of cholera patients, having been dried, packed up and sent to different parts of the country, were unpacked after the lapse of various considerable periods, with the result of instantly generating or rather propagating the disease in individuals previously healthy, and in places where no cholera had until then occurred. From the observation of facts such as these, I was led to believe it extremely probable that by the pulmonary and cutaneous systems the cholera poison is received into and subsequently excreted from the human body ; and a natural deduction from this belief was, that by exposing animals to these supposed poisonous exhalations, *i.e.*, by acting on the skin and lungs, and thereby at once attacking the blood,—and at the same time putting them as much as possible in the same circumstances as the human subject previous to a cholera seizure,—combining ochlesis, damp, filth, poor and innutritious food, deficient ventilation, &c., I was in a manner justified in anticipating some amount of success. By copious dilution with pure air, this noxious effluvium, like all other poisons when diluted, may be comparatively harmless, even when inhaled ; but, if concentrated in a small space, and an animal of any kind be for a length of time compelled to inspire it, surely it is reasonable to expect that a new focus of disease will speedily be produced. If fomites, I thought, were capable of inducing or exciting the disease in a *man* previously predisposed, why should I not be able, by imitating the circumstances, which are well known to predispose to cholera in him, by bringing together the localizing causes of the disease, to excite it in the dog ? It is not sufficient to say, that few or no instances exist of the transmission of disease from man to the lower animals, though examples of the propagation of various diseases peculiar to these animals from them to man are far from being uncommon. One great cause of this may be that the subject has never been properly investigated. I cannot help expressing an opinion, that cholera, as an epizootic or as a sporadic disease among certain genera and species of the lower animals—as the result of the same natural influences, whatever these may be, which produce the disease in man,—is more common than is usually held to be the

case ; but in them the disease may run a much more rapid and insidious course, and not being thus detectable by symptoms during life, can only be found out by an examination of the *post-mortem* appearances. Cases of rapid death, with symptoms of intestinal disease, are so common among many of the lower animals, that *post-mortem* examinations are seldom had recourse to,—a circumstance which is much to be regretted. Every one who has seen cholera must know that even in man rapid cases,—fatal without any of the ordinary symptoms of purging, vomiting, cramps, or lividity,—are by no means rare, and that, were it not for the simultaneous occurrence of other cases of the usual type, and during the presence of an epidemic, such instances would most probably be attributed to some other cause than cholera. It will be found that in the case of the animals which I compelled to inhale the effluvia from the clothes of a cholera patient I had combined the following circumstances :—

The previous habitual use of poor, innutritious, and putrid food, in the form of the various cholera evacuations.

Confinement, to a greater or less extent, in a damp apartment, in an atmosphere charged with the non-specific but still noxious effluvia from their own evacuations,—the probably specific exhalations of the cholera discharges,—besides latterly, the specific volatile poison from the clothes of a human cholera patient.

Ochlesis, or overcrowding.

Heat to a certain extent,—gas being burned in the room, in which the animals were confined, during the night, for the purpose of lighting a dark avenue, which led from the street to the hospital entrance-door.

Filth to a slight degree,—the floor of the apartment being sometimes covered for from one to three days with their own excretions.

Deficient ventilation,—and atmospheric pollution from the various causes above mentioned,—but only to a limited extent, the room being periodically cleaned and ventilated.

I selected the dog as the subject of experiment, from its most nearly approaching man in the structure of his digestive apparatus, and in the nature of his habits and food. Many of the lower animals, which might readily be obtained for experimental purposes, are herbivorous, and could not be made voluntarily to swallow blood and putrid animal fluids : many moreover, have a stomach so organized, that one of the pro-

minent features of cholera, viz., vomiting, could not be exhibited by them.

In consequence of my being otherwise occupied, and my general instructions that the clothes of patients admitted into hospital should immediately be fumigated with various disinfectants, steeped in hot water, and laid aside in the open air, previously to being washed, having been rigidly carried into effect by the hospital nurses, I had not an opportunity of testing the effects of fomites until a comparatively late period of my experiments (21st November);—then only in one case, on account of the stoppage of the disease in Edinburgh, and that case an unfavourable one. The result, however, was, that of four animals seized on the same day, two died with symptoms and pathological appearances exactly resembling those I have myself seen in the fatal cases of cholera which have occurred in the Edinburgh Cholera Hospital during the winter. But, in order that I might not deceive myself as to the production of a result which I was very anxious to obtain, I made the *post-mortem* examination of one of the dogs, in presence of Dr Warburton Begbie, the visiting physician of the Cholera Hospital, and the pathological lesions of both animals were shewn to several other gentlemen of great experience in the pathology of cholera, as observed both in Edinburgh and London,—all of whom, I think, agreed with me as to the similarity or identity of the lesions witnessed in these animals and in the human subject. To guard against another source of fallacy, I shewed the same appearances to a gentleman of acknowledged experience in the anatomy and pathology of the dog and other domesticated animals, and asked him whether they resembled the lesions observed in any disease of the dog with which he was familiar; his reply was in the negative, and I have failed in finding on record any disease of the dog or other animals having the same or similar *post-mortem* appearances, unless in a few cases, which have been avowedly published as cholera.

When I began these investigations I was not aware whether any and what experiments on this subject had previously been made in Britain or on the Continent; but I had not proceeded far when my attention was directed to a paper on "The Communicability of Cholera to Animals,"[1] by Mr Marshall of London, who mentions briefly the aggregate of the attempts at the artificial propagation of the disease hitherto made throughout the world. To that paper I cordially acknowledge my obligations for putting me at once in

[1] Brit. and For. Medico-Chirurgical Review, April 1853.

possession of all that has been, up to the present day, accomplished in this branch of experimental etiology. Still the mode and aims of my own attempts were in no way affected by the information therein contained; for I found that, while the author mentioned scarcely any good instances of the natural influence of cholera in animals, he detailed but very few positive and no conclusive results of direct experiment. In a word, all the experiments hitherto made appear to be either negative in their results, objectionable, or inconclusive. The mode of procedure in almost all cases has been injection into the veins, cellular tissue, or stomach; and the animals chiefly employed in many of the experiments to which he alludes were rabbits, guinea-pigs, goats, and fowls,—animals which, from their dissimilarity in structure and habits to man, we should not expect to be equally subject to the same poisonous influences. Injection into the veins or cellular tissue is, I think, a mode of experimenting exceedingly objectionable, on the ground of its danger, and the liability of its results to fallacy,—the very violence used, especially in the case of a timid animal like the rabbit, of itself, might do irreparable mischief. Its effects have uniformly been unfavourable and unsatisfactory. Injection into the stomach, again, is a most unfair and unnatural means of forcing the introduction of food. It appears to me infinitely preferable, in such experiments, to have it swallowed voluntarily. My anticipations of the effects of the cholera poison on the pulmonary and cutaneous systems of animals were thus nowise affected by the negative or unsatisfactory results referred to in Mr Marshall's paper.

In the detail of my experiments I have been minute—perhaps unwarrantably so—in mentioning the collateral circumstances; but this has arisen from a belief that, in the investigation of such a subject, where the results will be viewed in different lights by the supporters of opposed theories, it is important to state candidly *all* the conditions, however insignificant they may appear,—no less than from a wish that, in future experiments of a similar nature, the errors and omissions of my own rough and hasty essays may be rectified and supplied.

The room in which the following experiments were conducted, was an apartment some ten feet high, thirteen and a half feet long, and eight and a half feet broad, having two small windows looking to the north, and containing a gas-meter and other appurtenances. For the first two or three weeks after the hospital was opened (which was in the end of September last), and prior to the commencement of the ex-

periments, the porter slept in this room, but he was obliged to give it up in consequence of its great dampness and coldness, the floor being slightly sunk below the level of the ground, and the pipes of a cistern above having once or twice burst, and the water percolated through the roof; it had always a damp, musty smell. In this apartment several dogs were shut up for various periods, and allowed to feed, when so inclined, on different evacuations of patients. These were occasionally mixed with milk, porridge, beef, &c., to insure their being swallowed. As was naturally to be supposed, most of the animals shewed a decided aversion to their food, unless impelled by hunger, and some of them refused food for days; but I generally found *every* kind of matter ultimately swallowed voluntarily. One dog licked almost anything; the others were more cautious and capricious in their appetites. It must be obvious that, operating as I did, in an apartment of a cholera hospital, I could only, to a comparatively small extent and for a comparatively short period, produce and maintain such a combination of circumstances as is usually found to predispose to cholera in man. I did not feel myself justified in keeping the animals shut up in the same apartment, in an atmosphere greatly polluted by the exhalations from their own bodies and excreta, and from the putrid matters on which they were feeding, for a longer period than two or three days consecutively, on the ground alone of danger to the inmates of the hospital. I was therefore under the necessity of having the animals let loose and the room well cleaned and ventilated at short intervals. It happened accidentally that a barrel of chloride of lime and a carboy of solution of sulphurous acid were left in the room while the experiments were being made, and these, though they had no appreciable odour, must have in some degree acted as disinfectants.

The animals experimented on were:—

Dog No. 1.—A male; mongrel terrier; comparatively young; weighing about 10 lb., and having the following measurements:—

Length of head[1]	5	inches.
... body[2]	18	...
Greatest girth of thorax	15½	...
... of abdomen	14½	...
... of head	10¾	...

When obtained (on October 24), was very lean and in poor condition; shy, skulking, timorous; ap-

[1] Measuring from the point of the muzzle to the occiput.
[2] ——— the occiput to the base of the tail.

parently quite healthy; after being a few days in hospital became active, lively, and frolicsome.

Dog No. 2.—A female; a mongrel spaniel of the King Charles type; also young; weighing about 6 lb., and having the following measurements:—

Length of head ..... 5½ inches.
... body.....15 ...
Greatest girth of thorax.....11½ ...
... head ..... 8½ ...

A very restless, timorous little animal; appeared healthy, but was very thin and in poor condition on admission (Nov. 7); never seemed to have become naturalized to the house, always meditating and attempting escape;—refused food for considerable periods.

Dog No. 3.—A female; mongrel bull-terrier; comparatively old; weighing about 17 or 18 lb., and having the following measurements:—

Length of head..... ..... 6½ inches.
... body.....23 ...
Greatest girth of thorax.....18 ...
... abdomen.....12½ ...

Well covered with flesh, and in good condition; quiet, shy, crouching apart from other dogs; avoided food, shewed no vivacity, and made no great attempts to escape. (Nov. 19.)

Dog No. 4.—A male; mongrel Skye-terrier; middle-aged; weighing about 14 lb., and having the following measurements:—

Length of head..... 5 inches.
... body.....20 ...
Greatest girth of thorax.....18 ...
... abdomen.....14¾ ...
... head.....12 ...

In good condition; healthy, lively for a few days after admission (Nov. 19th); shy and timorous, taking little food.

No. 5.—A domestic cat of the ordinary kind; female; weighing nearly 4½ lb., and having the following measurements:—

Length of head..... 4 inches.
... body.....14½ ...
Girth of thorax.....11½ ...
... abdomen..... 12 ...
... head..... 8½ ...

Middle-aged; healthy, but in poor condition; lively

and active, constantly attempting escape; immediately after admission (Oct. 24), fighting with dog No. 1. for its share of the viands.

Dogs 1, 2, and 3, and the cat, were stray animals, which frequented the public streets, and probably picked up the scanty means of a miserable existence among the ashes and other refuse of private houses, thrown out for the purpose of removal by the police carts. Dog No. 4 was parted with on account of its master not having the means to feed him; so that all these animals might be considered in a condition exactly analogous to that of the underfed, badly clothed, and worse-housed poor, exposed to similar vicissitudes and subject to similar privations.

Though first in order of time, want of space in the present number of the Journal compels me to postpone the experiments with the evacuations,[1] and merely to detail at present the results of the one with the fomites, *i.e.* the facts of the seizure of the four animals, and the *post-mortem* appearances seen in the two fatal cases formerly alluded to. The whole collateral conditions cannot, of course, be appreciated till the circumstances of the prior experiments have been mentioned, all the animals concerned having been fed on various of the cholera evacuations for greater or less periods. I believe, however, that the nature of their food had no further share in producing the disease in this experiment, than as a powerful predisposing cause; the continued use of fluid food, more or less putrid and sometimes irritant, may have induced a constitutional state highly favourable to the efficient action of the exciting cause, *i.e.* the exhalations from the fomites. This question, however, obviously admits of discussion. Suffice it, meanwhile, to say that, from the 26th October, dog No. 1 and the cat,—from the 7th November, dog No. 2,—and from the 19th November, dog No. 3, were more or less confined in the apartment already referred to, and fed on cholera evacuations,—up to the 21st November, when the experiment with the fomites was begun. As I have before stated, the animals were not constantly shut up; but the room was cleaned at intervals of a few days, and they were let loose to run about the hospital or in some of the empty wards thereof. Dog No. 1 chiefly frequented the kitchen or washing-house; but he was occasionally in the wards, while they contained cholera patients, though never for a longer period than a few

[1] These will appear in the next number of the Journal, and will be accompanied by drawings of the microscopical appearances of the evacuations on which the animals were fed, as well as of the discharges of, and the pathological appearances in, these animals themselves.

minutes consecutively. In them he never had any opportunity of swallowing the evacuations, nor of lying among the clothes of patients; nor did he ever lie or sleep in any part of the wards. The cat, when set at liberty, usually betook herself to the kitchen fireside; but she was also frequently in the wards while tenanted by patients, and often lay in empty beds therein. These wards, which were naturally large and roomy, were well ventilated and fumigated:—they seldom contained at one time more than a single patient, whose clothes were always removed immediately on admission. Dogs 2 and 3 were never in any of the wards while tenanted; they were occasionally, however, allowed to run about in an empty ward.

Between the 24th October and 20th November there were admitted into hospital seven cholera cases, five being in deep collapse, and two passing into the consecutive fever; besides two cases of suspicious premonitory symptoms. Of these, four were fatal—two in collapse, and two in the consecutive fever (or perhaps this should more properly be called the typhoid stage of the cholera fever); the rest made good recoveries. On the blood and evacuations of these cases the animals had been fed from the respective periods of their admission.

On the 21st November, a woman, aged thirty-four, named Macaulay, from Chalmers' Close, High Street, was admitted in a state of collapse, passing into the consecutive fever. She had been seized three days previously in the following way: Having been out washing all day, she returned to her home in the evening much fatigued, swallowed hastily a full meal of potatoes, an article of food she was not much in the habit of using, and was suddenly attacked early the following morning (6 A.M.) with diarrhœa: this was followed by the ordinary symptoms of the disease, viz., severe serous purging, with vomiting and cramps. She had been very intemperate in her habits,—scantily fed and poorly clad,—in consequence of having pawned her clothing, she had been greatly exposed to cold and wet,—appeared to have sustained severe violence, as evidenced by several bruise marks on various parts of her person,—and was four months advanced in utero-gestation. She had had fever seven years previously. On admission (in collapse) she had complete suppression of urine, of two days duration, and was greatly debilitated. The consecutive fever was marked by great injection of the conjunctivæ,—continued, almost complete, suppression of urine,—involuntary evacuations in bed,—a great tendency to coldness of the whole body, and a low typhoid depression, attended by considerable stupor and muttering delirium. She died in the acmé of the fever-delirium on the 24th October. The principal features of the

post-mortem examination were: absence of lividity of any part of the body, which was, however, very pale,—no marked dryness of the muscles nor viscera,—punctuate ecchymosis, to a slight degree, on the posterior surface of the heart,—absence of congestion or ecchymosis of the intestines, which were essentially healthy,—no "psor-enterie," nor undue prominence of Peyer's patches,—liver slightly and kidneys considerably fatty,—lower part of abdomen, up to near the level of the umbilicus, occupied by a gravid uterus. These negative characters of the pathology of cholera I have noticed in all the cases in this hospital which have been fatal during the consecutive fever.

Immediately on admission, her body-clothes, which consisted of a chemise, petticoat, gown, stockings, and neckerchief, were thrown in a heap into a corner of the room occupied by the dogs. They were comparatively new and clean, and had been given to her, I understand, by her sister immediately before she left her home to come to the hospital. The greater part of her own wearing apparel, as well as household furniture, she had pawned to supply herself with whisky. These clothes remained in the room for three days (from the 21st to 24th October), when the patient died; they were then removed and the bedding in which she had just died, soiled by her discharges, was substituted. This was left in the room for a night and then removed.

The effects of feeding the animals on the cholera evacuations up to the 24th was merely the production in most of them of a non-specific diarrhœa; their general health did not appear in any way deteriorated. But though the polluted atmosphere of the apartment, and the nature of their food, did not seem appreciably to affect the health of the dogs, it unfortunately happened that one of the hospital attendants,—a stout, healthy, middle-aged man, was, on several occasions, suddenly seized with nausea on accidentally remaining in the room for a few minutes, while feeding the animals, or otherwise,—nausea, followed by a general feeling of exhaustion sufficiently severe to render him unfit for work for the remainder of the day. On the 23d November, having been two or three times beside the dogs in the course of the morning and forenoon, he was suddenly seized with diarrhœa, while at dinner (1 P.M.), and within a few minutes he had three very fluid stools, which, however, were dark brown, fetid, and feculent. It was followed by considerable languor and nausea, and he felt much exhausted during the evening. This state continued next day; but being sent to bed, and various restoratives had recourse to, he felt comparatively well in the evening. He attributed

his various seizures to the close and noxious atmosphere of the dogs' room; with what justice admits of considerable doubt. Still I consider myself bound to mention the fact, as with some it may have its value. At the same time, I must not omit also to state that, about a week previously, he had been at a Highland ball, after which he probably adjourned to a tavern. The effects of this jubilee undoubtedly had their weight as powerful predisposing causes of his subsequent slight attacks; at all events it was noticed that he had "never been quite well since."

On the 24th, at 6 P.M., one of the nurses of the hospital, who had been in attendance on Macaulay, was seized with sudden diarrhœa, attended with vomiting and nausea. The evacuations were copious, fluid, but dark-coloured, fetid and feculent. There was no prostration, nor any tendency to collapse; on the contrary, the pulse was good and the face flushed. Several days previously she had had an attack of diarrhœa of two days' duration. She attributed her seizure to the breath and exhalations from the body of Macaulay, with whom she had sat up all the preceding night. Such seizures, attributed to similar causes, I have already alluded to as not uncommon among our nurses. She recovered completely in two days.

On the 24th November the floor of the dogs' room was covered by a considerable quantity of urine, and by masses of viscid, feculent matter of a dark brownish-green or tarry colour. There was no discharge of mucus from any of the animals, and none of the fæces were very light in colour, nor fluid in consistence. Of course, the effects of the different matters given as food varied in different animals and at different times. Sometimes the diarrhœa was more severe, the evacuations more fluid, and the animals more or less prostrate and ill; but the average result was the evacuation of urine and fæces having the following characters:—

A specimen of the urine collected from the floor was acid; of a deep amber colour; without sediment; slightly phosphatic; non-albuminous; yielded a claret colour with heat and nitric acid, but no tinge of green or purple; contained abundance of urea, the nitrate crystallizing in beautiful, delicate, colourless plates; became very ammoniacal on standing, and effervesced strongly with nitric acid, after being slightly concentrated.

A portion of the dark viscid fæces, under the microscope, was found to consist of fragments of the epidermis and cellular tissue, and of the spines, hairs, spirals, and isolated cells of various vegetables,—chiefly the elements of broth, &c.,

which had been consumed by patients, and ejected in their vomits or contained in their stools; and having been thus given to the dogs, had passed through their system almost unchanged. I could trace the large ovel cells of the potato,—the smaller cells of the carrot and turnip,—portions of the parenchyma and epidermis of the onion and cabbage,—the epidermis of barley grains,—and starch from bread, barley, &c. All these substances had been copiously supplied a few days before in the vomits of some collapse cases, when the cholera seizure had supervened on a surfeit of potatoes and herring, potatoes and beef, broth, &c. There were also a few entozoon-ova, of a dark brown colour, hairs, "annular bodies," and compound granular cells; the remainder of the field was filled up with molecular debris of a bright greenish-yellow tinge, a few phosphates, and crystals of chloride of sodium. Water agitated with this tarry feculent matter, and filtered, had a rich port-wine colour, was slightly alkaline and albuminous, and had a peculiar mawkish disagreeable smell; the addition of nitric acid slightly decolorized it, but the subsequent application of heat converted the colour into a greenish yellow.

From the 21st to the 26th November the animals were fed chiefly on the reaction and fever stools, and the collapse vomit of Macaulay, as well as on the evacuations of previous patients, without any farther results than have been already described, viz., a continuance of semifluid but dark stools, with a copious discharge of urine. Macaulay's alvine discharges were not consumed for about a week; the vomit was swallowed immediately, chiefly, it appears, by dog No. 1 and the cat.

From the 24th November to the 7th December there were no cholera cases in hospital; nor, so far as I am aware, were there any, during the greater part of that period, in Edinburgh or Leith.

On the morning of the 22d, I found dogs 2 and 3 lying quietly and apparently comfortably among Macaulay's clothes; here they had probably slept all night. In the same position, I frequently saw them subsequently. Dog No. 1 and the cat were lying in different parts of the room, about a yard from the clothes. I never noticed either of them nestling among the clothes as did dogs 2 and 3. Dog 3 seemed very quiet; only rose when called to, and then appeared quite well. Dog 2 rose at once and tried to escape; it was trembling and timorous. Dog 1 and the cat were both quite lively. Little food had been swallowed by any of the animals.

The atmosphere of the apartment was so loaded with

noxious effluvia, on the 25th November, that the animals were turned into a well-aired empty ward for the day, and their room was cleaned and ventilated. No food was meanwhile given, and they were replaced in the same room at night. They all seemed quite as healthy as usual. On the 26th, they were confined all day, and in the afternoon were given about ℥x of dark semiclotted blood taken from the heart and great vessels of Macaulay, at the *post-mortem* examination on the 25th; this was speedily consumed, the greater part of it probably by dog No. 1. They were all healthy and well, so far as I could judge by external appearances, until about 11·30 P.M., when dog No. 2 appears to have been seized with vomiting, purging, and cramps, uttering the most piteous cries and moans, frothing at the mouth, trembling from head to foot, shy, exhausted, and in extreme distress. Her cries continued at intervals for about an hour; but, attributing them to mere restlessness and wish to escape confinement, and occurring, as they did, at so late an hour (midnight), I did not visit the animal, and have consequently to regret exceedingly my not having witnessed the mode of her seizure and death.

Next morning (27th) I found her lying on the top of a barrel, over which her head hung stiffly; her limbs contracted to different degrees, and all quite rigid. On the floor was a small quantity of frothy mucous matter of a pale greenish-yellow tinge, which she had vomited, and a larger quantity of a greenish liquid, having an intermixture of greenish semifluid fæculent matter; its odour was exceedingly disagreeable, though not fœtid. Dog No. 3 was lying apart from the rest, crouched up in a corner of the room, quite apathetic and listless, making no attempt to escape, and scarcely looking up when spoken to; her eyes were heavy and suffused, and her whole appearance denoted great prostration. It was evident that she was dying, but there appeared to be little or no diarrhœal discharge round her; the evacuations were small in quantity, semifluid, fæculent-looking, and green; her tail and hips were not soiled in any way thereby. Dog No. 1 lay trembling in another part of the room, one side of his body, with the tail and hips, being much soiled with his evacuations, which were very fluid, but distinctly green, non-mucous, semifæculent, and mixed with a considerable quantity of urine; his eyes were suffused; he made no attempt to escape, though he rose tremulously when called to: he was evidently greatly debilitated and ill. The cat lay on the top of a cupboard, also quite languid and apathetic, making no attempt to escape; her fur moistened by her dejections, which were like those of the dogs, semifluid,

green, and of a fæculent character. The floor was covered with the vomit, dejections, and urine of the animals; the alvine discharges were all very fluid, but at the same time, distinctly biliary in colour, *i.e.*, of a green tint;—there was a large quantity of urine intermixed. The stench emitted by these and by the bodies of the animals was insupportable; it was not the ordinary odour of any putrid animal matter; I know of no smell with which I could compare it. The animals were therefore again brought out, and the room cleaned and ventilated; it was also fumigated by chlorine evolved from chloride of lime by sulphuric acid. The cat made its way wearily and stealthily to the washing-house; its appearance was quite altered; she had apparently had severe vomiting and purging, attended by great prostration.[1] She lay crouching here the remainder of the day, apathetic and exhausted, but without any vomiting or purging so far as I could see. Dog No. 1 also made its way to the washing-house, to the front of the boiler furnace; there it had severe retching and vomiting, with occasional purging during the afternoon; his mouth was covered with frothy mucus of a light greenish-yellow tint; he seemed much debilitated and quite altered in appearance. With the retching was combined the appearance of an effort on the part of the animal to relieve himself of a feeling of choking, but I did not notice any marked laborious respiration in this or any of the other animals affected. Dog No. 3 retired to a dark coal cellar, where she lay immoveable as if dead, until removed again in the evening to the experiment room. The collapse here appeared extreme; but during the day I observed no vomiting nor purging, and she made no cries nor movements of any kind to lead to the belief that she was cramped. Shortly after being shut up for the night, there was a good deal of whining from dog No. 1, but this probably arose from his being tied up, which in him usually excited demonstrations of this nature.

On the morning of the 28th, dog No. 3 was found lying quite stiff and dead in a corner of the room, in a pool of liquid greenish semi-fæculent matter, which had greatly soiled her right flank, tail, and hips; her limbs were contracted and rigid. Apparently she had partaken of little or none of the food supplied her; there was no appearance of any vomit, nor was the muzzle covered with frothy mucus. Dog No. 1 was again somewhat lively and greatly better; he had eaten

[1] My attention was so engrossed by the dissection of dog No. 2, that I neglected examining the symptoms exhibited by the other animals during life so carefully as I would otherwise have done; on this account I did not note the state of the circulation or heat, &c., in any of them.

a large quantity of the flesh, fat, and blood of dog No. 2, which died on the previous day. The cat was also considerably improved in appearance. There was no diarrhœal discharge from either animal. The cat passed solid dark fæces of tolerably firm consistence, in the course of the afternoon.

Two or three days subsequently, having no further materials for experiment, I let loose the surviving cat and dog, allowing them to run about the hospital and the grounds in front, and giving them abundance of nutritious food in a solid form. Both animals rapidly recovered, and at present (December 10) they appear to enjoy perfect health; the dog, in particular, which has swallowed an immense amount of cholera-blood and evacuations, is very lively and frolicsome—nay, he has even gained flesh, being considerably fatter and heavier than when first admitted.

Dogs Nos. 2 and 3 must have died between midnight and 6 A.M.,—probably about 4 A.M., which appears to be a very critical period in cholera, especially as regards the seizure. The *post-mortem* examination of dog No. 2 was performed at 10 A.M. on the 28th, about six or eight hours after death, and that of dog No. 3 at 1 P.M. on the 29th, about nine or ten hours afterwards; the viscera in the latter case were slightly warm when the body was opened in presence of Dr Begbie.

The following is a note, taken at the time, of the *post-mortem* appearances in dog No. 2.

Body exhales a strong, peculiar, indescribable odour, different, however, from that of the effluvia of the body of the human subject labouring under cholera. Considerable emaciation; limbs appear very fine, their bones and muscles prominent. Legs drawn up towards trunk. *Rigor mortis* well marked. Tail and hair around anus much soiled with the discharges, which, as collected on the floor of the room, are very fluid, of a yellowish-green colour, semi-fæculent, and have the same peculiar odour as the body. A *Tænia* [*solium?*] was found among the evacuations. On examining these more narrowly, the fluid portion is found to contain minute flocculi of mucus; is slightly albuminous and alkaline; yields a deeper greenish-yellow colour on the application of heat and nitric acid; collected in too small quantity to take the specific gravity; sediment contains a few entozoon-ova of a chocolate-brown colour, a few prismatic phosphates, one or two "annular bodies," and a mass of finely granular debris tinged greenish-yellow. On allowing the dejections to stand for a day, the quantity of phosphates becomes greatly increased. About the muzzle there is a quantity of frothy-mucous matter of a light greenish-yellow tinge, corresponding

in appearance with the vomit collected from the floor. It is acid; gives, with heat and nitric acid, a fugitive pinkish-red colour which gradually becomes greenish-yellow. Sediment, consists almost entirely of pavement epithelium; many of the scales are shrunk and atrophied, dark and granular; in the latter case they have a greenish-yellow tinge; if perfect and transparent they are colourless. Besides these there are a number of granular corpuscles nearly equal in size to and resembling pus; they have a light greenish-yellow tinge, and many of them, when acted on by acetic acid, exhibit round them a delicate cell-wall; they are rendered less granular, but there is no appearance of a distinct nucleus or nucle simple or divided. Mucus scraped from the mouth contains healthy pavement epithelium. Eyelids half closed; corneæ glazed. Subcutaneous cellular tissue dry, crackling; fat, when removed, quickly becomes hard and dry like suet; muscles dry, but of natural colour.

On opening *thorax*, contents dry, collapsed.

Lungs considerably overlap pericardium; slightly emphysematous at their anterior margins; flaccid; of light red colour; crepitant throughout; float in water; somewhat congested posteriorly; on making a section dark blood exudes, along with thickened mucus. *Bronchi* quite healthy; weight of lungs $2\frac{3}{4}$ oz.

Mucus taken from the trachea contains normal cylindrical epithelium.

Juice scraped from the lungs contains a quantity of normal epithelium and fatty granules, and a number of hyaline globules.

Pericardium moist, but contains no appreciable amount of serum; no ecchymosis.

Heart weighs $1\frac{1}{4}$ oz., natural in size; cavities, valves, and orifices healthy; organ contains little blood. Left ventricle firmly contracted; no clots in either side of heart; muscular substance firm, of a dull red colour; normal in structure; no ecchymosis. Aorta healthy; no congestion nor ecchymosis.

Blood from great vessels at base of heart, dark, fluid; scarcely any appearance of coagulation. On allowing it to stand in a urine glass, surface becomes bright arterial red, lower stratum continues dark and grumous; the whole mass coagulates feebly into a tremulous jelly; corpuscles normal.

Pharynx, *œsophagus*, and *trachea* healthy; no increased vascularity nor ecchymosis.

On opening *abdomen* there is a very fœtid smell; viscera dry and greatly collapsed. No marked congestion of the peritoneal coat of the intestines, which feel as if covered with mucilage,

thickened, and as if containing very viscid glutinous matter. The *omentum* is shrunk into a few bands of the most delicate areolar tissue, containing in its meshes very little fat. The *mesentery* is quite dry and transparent, resembling silk or tissue paper; its veins full of dark blood. *Stomach* contracted; feels, like the intestines, as if much thickened, and having very viscid contents. Rugæ very thick and prominent, of a dark reddish-purple; whole mucous membrane much congested, copiously lined, like the œsophagus, with very viscid stringy mucus, which, however, does not appear as distinct flocculi. Congestion greatest towards pylorus.

In the stomach and intestines are found about three or four ounces of a very turbid opaque fluid, of a dirty greenish-yellow colour, having a very disagreeable mawkish odour; sediment, which occupies about two-thirds of its bulk, is finely granular and of same colour as fluid portion; resembles very fine pease-meal and water; when filtered, is alkaline and albuminous; yields a deeper greenish-yellow tint, with heat and nitric acid. In the mucus scraped from the stomach is found a quantity of cylindrical and pavement epithelium very dark and granular.

Œsophagus healthy in appearance; considerable increase of its mucous lining; no congestion nor ecchymosis of its plicæ or their interspaces; no softening of the mucous membrane. On scraping some of the mucus from the surface of the gullet, and submitting it to microscopic examination, the epithelium is granular; contains several large "gonidic bodies."[1]

The *small intestines* are copiously lined with a thick, viscid, flocculent mucus, of a very pale greenish-yellow colour,—when this is washed out by means of water, it has precisely the appearance of the "rice-water" stools of cholera, gradually separating into a supernatant liquid, which is whitish, opaque, turbid, whey-like in colour, but somewhat thicker in consistence; and a sediment wholly composed of whitish, opaque, mucous flocculi. The mucous membrane is much thickened, and when the gut is placed under water, it assumes a beautiful velvety or villose appearance. Here

[1] I call these provisionally "gonidic," from their resemblance to the gonidia of the lichens. As generally seen, they appear quite globular, usually larger than pus corpuscles; have a distinct wall, colourless and transparent; frequetnly a distinct central nucleus, also colourless, round which are aggregated a number of rounded granules of a bright greenish-yellow or orange colour, resembling the chlorophylle grains in the cells of plants. These bodies have occurred in greater or less abundance in the evacuations of all the cholera patients under my charge; their precise source I have not had time to ascertain. They pass through the digestive apparatus both of man and the dog, apparently without change. Drawings of their microscopic appearances will appear with the continuation of this paper in the following number of the Journal.

and there, where the mucous coating is thinner, punctuate ecchymosis, with general congestion of the intestine to a slight degree, is observed. But if this thick viscid mucus is removed by washing, the ecchymosis is found to be general, the whole length of the intestine being copiously studded with minute dark points. It appears as if almost all the follicles of the various intestinal glands had become the seat of hemorrhagic extravasation. Peyer's patches are not exempt; they are very distinct, though not perhaps unduly prominent; their margins are thickened, but are not marked by any increase of the general congestion or ecchymosis. There is no marked enlargement of the solitary glands at the lower part of the ilium, but the mucous membrane is greatly thickened, rough, and villous, and the openings of the Lieberkuhnian follicles are very distinct. The increased vascularity is greater in some parts of the intestine than others; it is more a blush of a bright arterial hue than arborescent. The intestinal villi are quite nude.

The same flocculent mucus lines the interior of the *large intestines*, which, however, contains in addition a small quantity of a fluid, yellowish-green, slightly fœtid matter, having, to the eye and under the microscope, the usual characters of fæces; it resembles the evacuations collected on the floor of the room in which the animal died. The ecchymosis is as general and has the same appearance as in the small intestines; the increased vascularity is much better marked. Lower part of *colon* and the whole of the *rectum* are very rugose, in this respect resembling the appearance of the stomach; intensely congested, of a dark purple colour, and thickly covered with a bloody, prune-juice-like viscid mucus. The mucous membrane is much softened and very velvety, but it is much less thickened than in the small intestines. A *lumbricus* was found among the fluid washed from the intestines. On macerating the large intestines, so as to get rid of their mucous coating, the solitary glands are found to be much enlarged and very prominent, especially in the rectum; the surface of the mucous membrane appears as if studded over with pearly sago-grains.

The whole intestines, including the œsophagus and stomach, weigh $9\frac{3}{4}$ oz.

The ricy matter washed from the intestines has a peculiar mawkish smell,—similar to that exhaled by the body of the animal; specific gravity is very low, ranging about 1010,—alkaline—highly albuminous,—gives a greenish-yellow colour, with heat and nitric acid. It is more mucous and viscid, and much more albuminous, than the "rice-water" stools in

man generally are. The flocculi consist of an almost transparent, finely striated, colourless basis, covered by innumerable corpuscles, which are granular, and vary in size from about half to equal that of pus corpuscles, the greater number being somewhat smaller than pus. On the addition of acetic acid, or after boiling with that re-agent, the granularity and haziness of some of these bodies seem in no way affected, while surrounding or attached to them, a delicate cell-wall may be observed; in others, the granules become fewer, darker and larger, and no cell-wall can be detected: while in others, again, a distinct nucleus or nuclei—single or divided, may be rendered visible, and the granular matter partially or completely dissolved. I would avoid giving any decided opinion as to the nature of these bodies; the former may be epithelial or other nuclei, the latter, mucus corpuscles: but I confess my inability at once, under any circumstances, and without difficulty, by microscopic examination alone, to distinguish mucus, pus, lymph, and white blood corpuscles and epithelial nuclei from each other. These corpuscles, though similar in appearance to those found in the flocculi of the "rice-water" stools in man, are much larger, more distinct, and more numerous; this is probably owing to the much earlier period, subsequent to death, at which they were examined. The mucous bands and the corpuscles are rendered much more distinct by acetic acid or tincture of iodine.[1] No intermixture of the debris of food can be noticed.

The yellowish-green fluid taken from the large intestines, and filtered, is highly albuminous, alkaline, and gives a faint and dull brownish-red tinge with heat and nitric acid.

The water, in which the intestines were subsequently macerated for two days (28th and 29th November), likewise presented the appearance of ricy stools, but had a bloody tinge—it was alkaline, and gave a faint greenish-yellow colour with heat and nitric acid,—densely albuminous, the whole coagulable matter falling as a sediment, and carrying with it the greenish-yellow colouring matter produced by heat and nitric acid, leaving the supernatant fluid quite colourless.

Liver weighs 4 oz., of a dark purple colour, much congested with dark fluid blood; otherwise healthy.

Gall-bladder moderately distended, with deep yellowish-green bile, which is quite healthy in appearance. When the

[1] In examining the flocculi of the "rice-water" stools or similar substances, which are exceedingly delicate and almost transparent, I have been in the habit of using iodine, which by communicating to mucus, epithelial cells, &c., a deep brownish-yellow colour, renders them much more easily visible. Bile or any similar dark pigment would answer equally well.

bile is diluted considerably, heated, and a few drops of nitric acid added to it, a dense turbidity is immediately produced, along with a deep bluish-green colour, which quickly passes through purple and pink into brownish-yellow. The biliary sediment, which is scarcely appreciable, consists almost entirely of minute dark globules and granules, resembling oily matter. In the mucus scraped from the gall-bladder, there is found a large quantity of the same dark granular matter, and a few "gonidic" bodies.

Kidneys weigh 1 oz.—firm and congested with dark blood; epithelium fatty (normal state?); capsule tears off readily; surface smooth; Malpighian bodies and tubuli healthy.

Spleen weighs ¾ oz.—flaccid; dark-coloured and congested; otherwise healthy.

Pancreas healthy.

Urinary bladder weighs ¼ oz.—moderately distended, containing about ʒii–iii of urine, healthy in appearance. On opening the organ and drawing off its contents, its fundus is found to be much congested, and covered with a bloody mucus; this was not removed even after three days' steeping in water. On immersion in water, the bladder becomes thick, corrugated, and contracted, and its interior rough and rugose. Its epithelium is hazy, but healthy.

Urine contained in bladder, acid; comparatively clear; non-ammoniacal to the smell; non-albuminous; on heating it and adding nitric acid, an intense dirty green colour is produced, which passes slowly through deep purple into brown. On standing a night after this reaction, continued of a rich chocolate-brown colour, having a scanty granular sediment. The same urine, tested two days afterwards, was non-albuminous, and with heat and nitric acid gave a deep grass-green colour, passing through blue and purple into deep blood red; the latter tint was not destroyed on the addition of a large quantity of acid. On boiling down the urine, to test for urea, it rapidly becomes as dark green as the bile, and exhales a very peculiar and offensive odour, resembling that of putrid fish. On adding nitric acid, great effervescence is produced, and the mass becomes of a dark greenish-brown colour; while in thin layers, on the sides of the evaporating basin, it exhibits various shades of purple, pink, and red. It contains abundance of urea, the nitrate of which, under the microscope, occurs in foliaceous masses of a dark greenish-brown colour, which can be partially removed from it by repeated washing; it also contains a quantity of large prismatic phosphates, and, in smaller amount, dark granular urates.

Uterus and appendages, *per incuriam*, not examined.

Large abdominal veins full of dark, fluid blood; little or no blood in aorta.

Brain and its membranes—skull and scalp healthy; no marked congestion nor venous engorgement in any; ventricles moist, but contain no appreciable amount of serum; choroid plexus congested; cerebral substance firm, normal, no increase of its "puncta vasculosa;" the internal ganglia and the cerebellum normal. [Brain examined 60 hours after rest of body.]

The weight of the body after evisceration is 4 lb.

The following were the *post-mortem* appearances noted, on the 28th November, in dog No. 3.

Exhales a most nauseous odour; *rigor mortis* well marked; eye-lids half closed; corneæ hazy; muzzle firmly closed; stout muscular animal; muscles well developed, dull in colour, very dry; temporal muscles, when removed, appear as rigid as dried ham, and can readily be cut into thin slices; subcutaneous cellular tissue, and fat and cellular tissue of thorax and abdomen also very dry.

On opening *thorax*, viscera are dry and collapsed; cartilages of the ribs ossified.

Lungs weigh 6 oz.; slightly overlap pericardium; of a light reddish colour, covered with bluish-black punctuate mottling; crepitant throughout; congested to a slight degree posteriorly; on being cut into dark blood escapes from numerous points; otherwise healthy.

Bronchi normal; no congestion nor increase of mucus.

Trachea pale; quite healthy.

Pericardium merely moistened with serum; no ecchymosis.

Heart weighs 3½ oz.; normal in all its walls, cavities, orifices, and valves. Both ventricles contain dark, semi-clotted, but comparatively fluid blood, which also fills the auricles and great vessels. No coagula of any kind. Left ventricle firmly contracted; right very flaccid; muscular substance firm, dull in tint; heart appears dilated, especially at its base, probably on account of the quantity of blood contained in the ventricles, no ecchymosis posteriorly; muscular substance normal; aorta quite healthy.

Œsophagus healthy; mucous membrane pale; plicæ distinct, covered with very thick viscid but normal mucus.

On opening *abdomen*, viscera very dry and collapsed; *mesentery* resembles a diaphanous membrane like tissue-paper beautifully ornamented by arborescent lacteals and veins, the latter gorged with dark blood; the *omentum* has the appearance of a lax network of the most delicate silky fibres, covering the intestines, and containing in its areolæ

little or no fat. The fat accumulated around the kidneys and other viscera, when removed from the body, becomes whitish and hard like suet. Peritoneal surface of the intestines feels gluey, but there is no distinct exudation of viscid mucus as there often is in man. Intestines feel doughy and thickened, as if containing pultaceous matter; the surface of the small intestines is marked by a light red blush of general increased vascularity ; thatof the large has somewhat of a slaty colour.

Stomach distended, much thickened throughout, but especially at pyloric extremity; interiorly, its rugæ are very prominent and thick, whole mucous membrane softened and pulpy ; highly congested, having a uniform dark, bloody, purple tinge, which is deepest towards the pylorus ; a small portion of the mucous membrane of the *cul de sac* at the cardiac extremity, along the greater curvature, comparatively smooth and thin. In the interspaces of the rugæ there is found a dark brownish-green frothy fluid, intermixed with a quantity of minute curdy flocculi. From the stomach was squeezed, before it was opened, about ℥ij of a greenish chocolate-coloured fluid, having very little mucus intermixed. When filtered it is found to be slightly alkaline ; has little or no odour ; highly albuminous ; yields with heat and nitric acid a brownish-red colour, which gradually becomes greenish-yellow. Mucus scraped from stomach contains a few "gonidic" bodies. The whole mucous membrane is soft and velvety, and copiously covered by very viscid, ropy mucus.

From the *large intestines* there was squeezed about ℥i, and from the small about ℥ii of a thick, viscid, tenacious mucous matter of a deep brownish-green tinge, containing a scanty admixture of ordinary fæculent debris. This matter exactly resembles, in appearance and consistence, soft soap mixed with a little water ; it is found adhering firmly, as a thin layer, to the whole extent of the canal, and is with difficulty washed off. It has an exceedingly nauseous, though not a fæculent odour, resembling that of the body of the animal ; agitated with water and filtered, it yields a very turbid fluid of a brownish yellowish-green colour, which is slightly alkaline, highly albuminous, and gives with heat and acid an orange-red or brownish-red colour, which ultimately becomes greenish-yellow. Under the microscope the viscid matter is found to consist essentially of delicate striated mucus, entangling a number of granular corpuscles, similar to those mentioned as occurring in the mucous flocculi found in the intestines of dog No. 2, along with a few fragments of vegetable tissues, "annular" and "gonidic" bodies, phosphates in irregular crystals, and a quantity of molecular debris of a bright greenish-yellow colour.

When this viscid muco-fæculent matter is gently removed, the subjacent mucous membrane is found greatly thickened, softened, and velvety; it is copiously lined with a coating of thick whitish or pale brownish-yellow mucus, which, on being scraped off and mixed with water, forms the same rice-watery matter as in dog No. I. It appears as if the mucous membrane had undergone a gelatinous degeneration, there being no line of demarcation between it and its thick covering of gelatinous matter, the one seeming to pass insensibly into the other. This mucus adheres so tenaciously that it is with difficulty removed, even after a lengthened maceration; it does not extend over a number of Peyer's patches, especially in the upper part of the gut, and these consequently appear as if deeply sunk in the mucous membrane, their margins being very thick, puffy, and much congested. There is marked congestion of a bright red hue throughout the canal, but no ecchymosis; it occurs in patches, and is very irregularly distributed.

The *duodenum*, at its commencement, feels much thickened, this thickening being continuous with that of the pyloric extremity of the stomach; the hypertrophy seems seated chiefly in the mucous membrane; it is also somewhat distended; its interior is marked by several patches of deep congestion. This congestion appears only to a slight degree externally, in the form of slightly increased arborescent vascularity of a vivid red hue.

In the lower part of the *ilium*, and throughout the great intestine, the vascularity is much increased, the mucous membrane and its mucous lining having a uniform bloody tinge; the plicæ of the interior of the large intestine appear as dark bloody ridges. The lower part of the *colon* and the whole of the *rectum*, besides being covered with an abundant bloody mucus, has a slaty colour, and the whole appearances of this portion of the intestine exactly resemble those seen in some cases of dysentery. The glands are quite obscured by the thick mucous coating. On being macerated for a few days, the blood and mucus were both gradually washed out, and the surface of the gut was then found studded over with pearl-like grains of sago, *i.e.*, the enlarged solitary glands, as in dog No. 2.

After maceration, Peyer's glands also were rendered much more distinct; their apparently eroded or excavated base and thick congested margins rendering them very prominent.

The whole intestines, including the stomach and part of the œsophagus, weigh 1 lb. 5½ oz.

The water in which the intestines were macerated exactly resembled "rice-water" stools, except that it had a bloody

tinge ; it was very turbid,—alkaline, albuminous,—of specific gravity, about 1005 to 1010, and gave a greenish-yellow colour with nitric acid and heat. The flocculi of the sediment had the same microscopical appearance as those of the "rice-water" stools in man, viz., a delicate striated hyaline mucus, with a greater or less number of granular corpuscles, molecules, and granules, which were colourless, or had a very faint greenish-yellow tint; there were in addition a number of "gonidic" bodies and epithelium scales, and a quantity of dark granular pigment.

The intestinal villi are all nude.

Mucus scraped from any part of the gut is quite pure, unmixed with debris of food or colouring matter of any kind. It appears as a striated hyaline substance, so delicate and transparent that it can scarcely be seen in the field of the microscope. There are few or no granular corpuscles intermixed with it.

Liver weighs 11 oz., large, dark coloured, congested; apparently normal. Hepatic cells fatty to a slight degree. *Gall-bladder* moderately distended with bile of a dark green colour, which is normal also in consistence. When diluted, it gives the usual reaction with heat and nitric acid, the purple, pink, and red tints being very rich and deep. Biliary sediment, which is not appreciable, contains a large quantity of granular matter and oily globules. The mucus scraped from the interior of the gall-bladder contains a quantity of cylindrical epithelium, isolated or in patches, united by a membrane along the apices of the individual cells ; there is also some pavement epithelium and free nuclei, all having a bright greenish-yellow tinge.

Kidneys weigh 3¼ oz., are large, firm, darkly congested ; apparently healthy ; surface quite smooth ; capsule strips easily ; epithelium very fatty.

Spleen weighs 1¼ oz., flaccid, dark coloured ; structure normal.

Urinary bladder greatly thickened and contracted, plicated or rugose, both externally and interiorly. Its exterior is marked laterally by very tortuous veins filled with dark blood. Contains only about half a drachm of very turbid, but non-ammoniacal urine. Interior reticulated, pale ; no congestion nor ecchymosis. Interior of urethra much congested, especially at its commencement. Bladder weighs ¾ oz.

Urine is mixed with a granulo-flocculent whitish matter in small quantity ; is of a deep amber colour, acid, non-albuminous. With heat and nitric acid it gives the same reaction as the bile, *i.e.*, if one or two drops of acid be added to the heated urine, a zone of a bluish-green colour is produced at

the bottom of the fluid; if three or four drops are added, an orange-red zone is developed at the bottom, with blue and green zones immediately superjacent; by agitating, while warm, the whole fluid acquires a deep grass-green colour, which rapidly passes through bluish-green, blue, purple, and orange-red, into a light chocolate tint, which is permanent. It contains a considerable amount of urea. The sediment contains a quantity of minute oil-globules, aggregate or isolated,—exactly similar to those found in the bile.

Uterus is comparatively free from congestion or ecchymosis externally; but vagina is congested internally, and towards its outlet has a somewhat slaty colour. There is also general congestion of the interior of the Fallopian tubes, each of which also contains three patches of punctuate ecchymosis, with surrounding slaty discoloration. Weight of uterus and appendages one ounce. Epithelium from the interior of the uterus, Fallopian tubes, and vagina, healthy.

Brain and its membranes, with the scalp and skull, appear quite healthy. The subcutaneous cellular tissue, and all the muscles of the head, are particularly dry. No marked venous oozing from the scalp nor bone; no marked engorgement of the sinuses of the dura mater, nor of the veins of the cerebral convolutions. On slicing the cerebral matter, the "puncta vasculosa" are normal. Ventricles are moist; small quantity of serum (about ʒss) in the anterior cornu of each; choroid plexus not congested. Internal ganglia and cerebellum healthy. Cerebral substance comparatively firm,—gray matter quite distinct.

Weight of body after evisceration, 14 lb.

The large veins of the abdomen are turgid,—their contents fluid, but not extremely so, and dark.

The *blood* corpuscles are normal. About ʒiii of blood from the heart and great vessels, on standing for a day, exhibited no distinct coagulation, but formed a delicate tremulous jelly; it was of a bright arterial hue on the surface,—dark below.[1]

Crichton Royal Institution,
Dumfries, *March* 1854.

[1] I shall be glad to be favoured by any of the readers of this Journal, or others interested in the subject, with information regarding, or cases illustrative of, the natural influence of cholera on the lower animals, or the results of any experiments, which have been made on the artificial communicability of the disease, during the present or any previous epidemic, in this or other countries.

In addition to the animals already mentioned, the following dogs were employed as the subjects of experiment, viz.:—

Dog No. 5.—A male; black retriever; a large, powerful, healthy, active animal; weighing about 56 lb., and having the following measurements:—

Length of head	9	inches.
... body	34	...
Greatest girth of head	20	...
... thorax	31	...
... abdomen	24	...

Dog No. 6.—A male; mongrel Scotch terrier; 3 months old; lively, healthy, active; weight $8\frac{3}{4}$ lb.; measurements as follow:—

Length of head	5	inches.
... body	19	...
Greatest girth of head	11	...
... thorax	13	...
... abdomen	11	.

Dog No. 7.—A female; mongrel bull terrier; had been previously subjected to several experiments, with puerperal matter injected into the vagina, without effect; weight 18 lb.; measurements as follow:—

Length of head	about $6\frac{1}{2}$	inches.
... body	24	...
Girth of head	14	...
... thorax	19	...
... abdomen	15	..

Dog No. 8.—A male; young mongrel terrier; timorous, quiet; in very poor condition, (apparently starved); weight 7 lb. 11 oz.; measurements as follow:—

Length of head	6	inches.
... body	18	...
Girth of head	$10\frac{1}{2}$	...
... thorax	14	...
... abdomen	$10\frac{1}{2}$	...

The experiments were begun on 24th October, and con-

tinued, with frequent intermissions, according as patients were admitted and discharged, till 16th December. The substances on which the animals were fed during this period were chiefly the stools, vomit, and urine, passed or ejected in all stages of cholera; they were given in all states of freshness and putridity, concentration and dilution. Occasionally I used the blood and various other fluids and solids of fatal cases—removed at the *post mortem* examinations; these also were exhibited in different conditions of freshness, but generally as soon after death as convenient. When the opportunity occurred, I also fed them on the blood and solids of Dogs 2 and 3, which died of cholera, as has been already mentioned; so that all the media usually supposed to contain or convey the cholera poison were thus employed at different times, and to various extents. On one occasion only, did I inject into the cellular tissue, and then with negative results. In order duly to appreciate the effects of these substances on the canine and feline economy, it is necessary not only to give a brief sketch of their chemical and histological characters, but also to glance at the more prominent features—symptomalogical and pathological—of the cases that were thus indirectly made the media of experiment. Reserving comment, I proceed at once with these details, in a greatly abridged form :—

Case I.—I. M., a woman, aged 55; *fatal*, in the "*consecutive fever*," three days after her seizure. Had a previous attack of cholera, which was nearly fatal, during the epidemic of 1848–9. Collapse and reaction were very mild; the fever very insidious and typhoid. The principal *pathological features* were—ecchymoses on the heart, stomach, intestines, the pelvic and lumbar cellular tissue and ovaries; bronchitis; fatty liver; lesions of the aortic and mitral valves and kidneys; absence of any cyanotic condition of the skin.

Collapse vomit resembled bran and water agitated together; was of a dark-brown colour; acid; slightly albuminous; of sp. gr. 1018; had little or no odour; scum consisted of a frothy, flocculent matter. Under the microscope, the vomit-sediment contained a quantity of mucus in the form of delicately striated hyaline bands; epithelium scales; a number of the so-called "cholera corpuscles," or "annular bodies;"[1] a few phosphates; fragments of muscular fibre, and of vegetable tissues; oil globules, and other food-débris.

[1] For a description of the forms which it has occurred to myself to observe in cholera, *vide* "Clinical notes on Cholera," Association Medical Journal, 14th April 1854.

The matter vomited, while *reaction* was passing into *fever*, consisted almost entirely of mucus, and contained a large quantity of pavement epithelium; a few starch granules; cells from the parenchyma, and fragments of the epidermis of various vegetables, and oil globules. It was acid, slightly albuminous, and gave a biliary reaction.

The *collapse stools* had the same characters as those of the diarrhœa, which in this, as in many other cases, preceded the cholera, viz.:—a pea-soup colour and consistence; a bran-like sediment; sp. gr. 1008; they were alkaline and albuminous, and gave no distinctly *biliary* reaction[1] with nitric acid, though they had a biliary colour. Sediment contained a considerable number of "annular bodies;" a few prismatic phosphates; starch cells; and fragments of muscular fibre, and other forms of food-dèbris.

The stools subsequently passed (during *reaction* and *fever*) were of a chocolate colour; and contained, under the microscope, blood corpuscles. On standing, an oily scum soon formed, consisting of oil globules, entangling a few phosphates. They very speedily became fetid.

Case II.—M. R., a woman, aged 37; *recovery*. Admitted in deep *collapse;* passed through all the phases of the disease in a marked form, and was discharged well in sixteen days. Prominent features of the collapse were vomiting and cramps; of the "consecutive fever," (or the typhoid stage), delirium and a tendency to coma; there was suppression of urine for three days after admission. During the convalescence, a scarlatinoid eruption appeared on the face, followed by desquamation of the cuticle as after scarlatina.

Collapse vomit whey-like; somewhat resembled the "rice-water" stools; acid; albuminous; had slight odour of whisky; sediment consisted chiefly of oatmeal, and, under the microscope, showed a large quantity of starch, oil globules, mucus, and mucus-corpuscles; muscular fibre; pavement epithelium; "annular bodies;" compound granular bodies, and various forms of vegetable dèbris.

Collapse stools had the usual characters of the "rice-water" evacuations of cholera; alkaline; albuminous; sp. gr. 1010; devoid of fetor; gave a pink reaction with heat and nitric acid. Flocculent sediment consisted of delicately striated hyaline bands of mucus, covered by mucous and

[1] For my views on the "presence of *bile* in the cholera evacuations," *vide* "Clinical notes on Cholera," Association Medical Journal, March 10, 1854.

other granular corpuscles, which, according as water and reagents were added, resemble pus, lymph, or white blood-corpuscles or free epithelial nuclei.

Case III.—H. H., a woman, æt. 44; *fatal* in *collapse* about eight hours after admission. The most prominent symptoms were cramps, vomiting, and purging; vox cholerica; and complete suppression of urine. Chief *pathological* features were—considerable livor of the body; a sodden condition of the extremities of the fingers; dryness of the muscles and viscera; intestinal and uterine hyperæmia "Psorenterie;" empty, contracted state of bladder; exudation of a glutinous mucus on the peritoneal surface of the intestines; ʒi serum in pericardium; distension of stomach, with thinning, softening, and exuviation of its mucous membrane along the greater curvature; cysts of Fallopian tubes; hemorrhagic extravasation in right ovary; absence of ecchymosis of any of the internal viscera.

Collapse stools had usual characters of "rice-water" evacuations, and contained, in addition, a quantity of pavement epithelium (probably from leucorrhœal matter), a few "annular bodies," and some food-dèbris. They were of sp. gr. 1008; slightly albuminous; and gave a greenish-yellow reaction with heat and nitric acid.

Collapse vomit a brownish-yellow, frothy fluid; acid; of sp. gr. 1005; sediment resembles bran, and contains phosphates, epithelium, oil globules, "annular bodies," and food-dèbris.

Case IV.—A. W., a girl, æt. 7½; *recovery*. Admitted in advanced *collapse*—almost *in articulo mortis*—7½ hours after her seizure; passed through all the stages of the disease, and discharged well in twenty-one days. Collapse was very short, but severe; the typhoid stage tedious, but well marked. During convalescence, or towards the end of the typhoid stage, the "cholera-exanthem," in the form of an urticario-rubeoloid eruption, appeared all over the body; co-existent with its duration there was a considerable deposit of uric acid in the urine.

Collapse stool was "rice-watery," alkaline, albuminous, and gave a pink reaction with heat and nitric acid. Quantity ʒii.

The next stool, passed shortly after, was of a light brownish-yellow colour; slightly fetid; alkaline; had a scanty, branny sediment. The third stool after admission resembled pea-soup in character and consistence; the microscopical differ-

ence consisted in the substitution of food-dèbris for the delicate colourless mucus of the collapse stools.

Collapse vomit was of a dirty grayish-brown colour; very turbid; acid; slightly albuminous; reaction with heat and nitric acid greenish-yellow. Under the microscope, the sediment contained a large quantity of pavement epithelium, and dark granular matter; no appreciable dèbris of food.

First urine passed after admission was sp. gr. 1015; acid; albuminous; loaded with urates; reaction with heat and nitric acid, deep orange-red; with nitric acid, cold, a pink. Sediment contained renal casts, transparent, granular, and oily; dumb-bell oxalates; epithelium; "annular bodies," as in the stools, and compound granular bodies; contained very little urea.

Case V.—A. F., a man, æt. 48. *Fatal* in typhoid stage seven days after admission. Collapse and reaction comparatively mild; typhoid stage insidious and asthenic. Prominent symptoms were—vox cholerica, suppression of urine for two days, frequent but mild hiccup, great restlessness, insomnia, semicoma, low-muttering delirium, involuntary evacuations in bed, picking of the bed-clothes, black sordes on teeth, dry brown tongue, and extreme prostration. *Pathological* features were chiefly *negative*. Absence of marked ecchymosis; hyperæmia, or dryness of the viscera; emphysema and collapse of lungs, with broncho-pneumonia, recent and of a typhoid type; fatty kidneys; firm decolorized clots found in both sides of the heart; bladder contained two or three oz. urine, abounding in epithelium and renal casts; stomach and intestines contained a dark, greenish mucous fluid, having in a most intense degree the peculiar odour exhaled by the sweat and skin of cholera patients; its sediment consisted of mucus, softened mucous membrane and its elements (cylindrical epithelium, &c.), and food-dèbris.

Collapse vomit was of a dark chocolate colour; acid; sp. gr. 1014; had a scanty granular sediment of similar tint, and a frothy scum of a light pinkish tinge; reaction with heat and nitric acid greenish; scum contained a large quantity of *sarcinæ*, besides epithelium, starch, oil globules, and food-dèbris.

Stools passed during the *typhoid stage* were of a pea-soup character; alkaline, albuminous, fetid; of sp. gr. 1010; on standing, a scum collected on the surface, consisting of oil globules entangling a few phosphates.

Urine passed in typhoid stage was acid; sp. gr. 1012; albuminous; reaction with heat and nitric acid greenish-yellow. Sediment contained renal casts, octahedral oxalates

and phosphates; and the evaporated residue consisted chiefly of common salt, in large, irregular cubes, and crystalline masses; plumose and stellate phosphates, globular and amorphous urates, and an oleo-resinous, viscid matter; contained a normal amount of *urea*.

CASE VI.—I. S., a girl, æt. $6\frac{1}{4}$; *cholerine; recovery;* dismissed well on third day after admission; collapse mild, reaction complete; no typhoid stage.

Collapse vomit was of a light brownish-yellow colour; acid; slightly albuminous; sediment bran-like; reaction with heat and nitric acid greenish-yellow. Sediment contained a large quantity of echinus-like fatty bodies;[1] starch; epithelium perfect and shrunk; "annular bodies;" fragments of *acari* and vegetable tissues, phosphates, and oil globules.

CASE VII.—I. W., a woman, æt 38; *recovery;* admitted thirty-eight hours after seizure in deep *collapse;* passed through all the phases of cholera, and dismissed well on the eighteenth day. Prominent symptoms were—protracted and severe retching and vomiting; tendency to coma; delirium; involuntary evacuations in bed; suppression of urine; appearance of the so-called "cholera exanthem," as in Case IV., during the convalescence; and painful distension of the mammæ. She was nursing when seized, and her uterine functions had for some time been disordered.

Collapse stools possessed usual characters (mentioned in Case I.) of the "rice-water" evacuations, but contained a small proportion of "annular bodies" and food-dèbris; reaction of some specimens with heat and nitric acid pink, of others greenish-yellow.

Fever stools (*i.e.* passed during typhoid stage) were of a pea-soup character; alkaline; albuminous; sp. gr. 1010–15; with a dark-brown sediment on the surface; an oily scum collected on standing, containing a few pellets of concrete *fat*,[2] having a deep greenish-yellow tinge.

Collapse vomit first ejected was of the colour and consistence of whey; acid; sp. gr. 1008; slightly albuminous; reaction with heat and acid greenish-yellow. Branny sediment, contained pavement epithelium, *sarcina Goodsirii*, starch, "annular bodies," compound granular bodies, muscular fibre,

[1] For drawings of crystalline and other forms of fatty matter found in the vomit of cholera, *vide* paper by the author in "Medical Times, and Gazette," Aug. 5, 1854.

[2] For examples of the occurrence of fat and oil in cholera fæces, *vide* paper on the subject by the author in the Edinburgh Monthly Medical Journal, Aug. 1854.

potato cells, and other food-dèbris. On standing, an oily scum rapidly collected. Evaporated residue of the filtered fluid contained abundance of phosphates and common salt.

Urine passed early in the *typhoid stage* was acid; albuminous; sp. gr. 1017; had a scanty, white, flocculent sediment, consisting chiefly of pus; but containing also renal casts; epithelium; dumb-bell, and octahedral oxalates; and compound granular bodies (the so-called "exudation corpuscles" of some authors); contained a very small amount of *urea;* reaction with heat and acid deep orange red; with acid alone pink. Evaporated residue contained a considerable quantity of phosphates, urates, and chloride of sodium.

Case VIII.—A. S., a woman, aged 40. *Fatal* in *collapse* 18½ hours after admission. Prominent features were: severe cramps, involving not only the muscles of the feet and legs, but also those of the thigh, abdomen, and thorax; cyanotic condition of body; vox cholerica; and *post mortem* movements, accompanied by a rise in the temperature of the body. (The latter phenomena were comparatively common in the other fatal cases here noted.) Chief *pathological* conditions were: rigor mortis well marked; punctuate ecchymosis of heart and intestines; thickening, softening, and exuviation of the mucous membrane of the large intestines, the separated patches closely resembling in appearance flakes of dysenteric lymph; "Psorenterie" in ilium; muscles, pericardium and viscera dry; latter much collapsed; retrograde tubercle in lungs; recent bronchitis (or, more probably, a hyperæmic condition resembling it in its pathological phenomena); left ventricle of heart firmly contracted, and containing no blood; blood corpuscles normal. Contents of *small intestines*, when filtered, were alkaline, highly albuminous, sp. gr. 1015; reaction with nitric or muriatic acid, in the cold, pink; sediment consisted chiefly of mucus and the disintegrated elements of mucous membrane, but contained also "annular bodies" and blood corpuscles. Contents of *large intestines* were similar in character, but contained a larger amount of blood, and a slight admixture of semifluid fæces, of a dark brownish colour.

Collapse vomit was of a pinkish-red, acid, albuminous; reaction with heat and acid greenish-yellow, with nitric or muriatic acid, cold, pink. Sediment, which occupied three-fourths of the whole bulk of the fluid, consisted of undigested articles of food, chiefly potatoes, beef, and the elements of broth, on which she had dined shortly before admission. The microscope detected, in the finer part of the sediment, the

parenchymatous cells of the potato, carrot, turnip, cabbage, and onion; fragments of the epidermis of these vegetables, and of barley grains; starch from bread, potatoes, &c.; isolated spirals and cells of the same vegetables; epithelium, both pavement and cylindrical; mucus and mucus-corpuscles; *sarcinæ;* fatty and oily matters. Fragments of several *acari*, and several large masses of *concrete fat*, were found in the oily scum. These fatty masses consisted of vesicles, each containing a radiating, crystalline mass of margaric acid.

Collapse stools had the ordinary "rice-water" characters, except that the sediment had a brownish tinge, and contained "annular bodies," starch, muscular fibre, and other food-dèbris; reaction with heat and acid pink. The second and third stools passed were fetid; resembled very thin gruel; alkaline and albuminous; reaction with heat and acid *nil.*

Case IX.—J. W., a man, aged 34. *Recovery;* admitted in mild *collapse;* passed through all the stages of the disease, and dismissed well on the 18th day. The convalescence was marked by the appearance, chiefly on the face, of the "cholera-exanthem," in the form of a scarlatinoid eruption, followed by slight cuticular desquamation.

Fever urine was acid, non-albuminous; sp. gr. 1010; contained a small amount of urea; reaction with heat and acid pinkish-red; evaporated residue contained phosphates, both prismatic, plumose and stellate, and chloride of sodium.

Case X.—M. F., a woman, aged 40. *Fatal* in consecutive fever on the second day. Admitted in deep *collapse* eleven hours after seizure. Collapse stage was short; reaction appeared sthenic and favourable; fever very typhoid, and marked by suppression of urine, great conjunctival injection, stupor and tendency to coma. Chief *pathological phenomena* were: blood contained in the heart and large vessels dark and grumous, showed no tendency to coagulation; alteration of the blood-corpuscles, the red disks being scarcely recognisable as such, but resembling pus, both before and after the addition of acetic acid;[1] bladder contracted, empty; bile healthy; *valvulæ conniventes* of duodenum and jejunum deeply stained with bile; ecchymosis on pericardium and heart, pleuræ, diaphragm, stomach, intestines, broad ligament of uterus and right ovary. Bronchitis, emphysema, and collapse; incipient Bright's disease of kidneys; liver slightly fatty; rugæ of stomach very prominent, and

[1] *Vide* paper in "Monthly Medical Journal" already referred to.

mucous membrane thickened, softened, and pulpy; exuviation of mucous membrane of large intestines in patches of various sizes, resembling in general appearance dysenteric ulcers.

Contents of *small intestines* had the characters of reaction and fever stools; of pea-soup character; fetid; sp. gr. 1012–15; alkaline, albuminous; reaction with heat and acid orange-red. Sediment contained little cylindrical epithelium, but the intestinal villi were all nude.

Contents of *large intestines* were similar in character, but darker in colour, and of a distinctly bloody tinge.

Collapse stools "rice-watery."

Fever Stools of pea-soup character, having a branny sediment; alkaline, fetid, albuminous; sp. gr. 1012; reaction with heat and acid orange-red; the scum, which speedily collected on the surface, contained several masses of concrete *fat*, as in Case VIII., and a few phosphates.

Collapse vomit "rice-watery," alkaline; slightly albuminous; sp. gr. 1008; strong odour of whisky; reaction with heat and acid greenish-yellow. Microscopical character of flocculent sediment resembled that of the "rice-water" stools, with the addition of pavement epithelium, "annular bodies," and food-dèbris.

Case XI.—J. M'G., a man, æt. 45; *fatal* in *collapse* eight hours after admission. Cramps of the muscles of the lower extremities and abdomen, and livor of the body, were marked symptoms. *Pathological* phenomena were: absence of ecchymosis and "psorenterie;" dryness of muscles, pericardium and viscera; general hyperæmia of viscera; contracted and empty state of bladder; abundance of apparently healthy bile in gall bladder; thickening and softening of mucous membrane of stomach and intestines; muscular substance of heart flabby, and of a dull brown colour; left ventricle firmly contracted, right ventricle flaccid and full of grumous blood; firmly intertwined among the *Columnæ carneæ* were a few decolorized clots.

Contents of *small* intestines consisted chiefly of mucous flocculi; had a chocolate or *café au lait* colour from bloody admixture; the fluid portion was slightly fetid; alkaline; densely albuminous, and sp. gr. 1010; a phosphatic scum rapidly formed on the surface on standing. The microscopical characters of the flocculi resembled those of the "rice-water" stools, with the addition of cylindrical epithelium, isolated and in groups connected at their apices by a continuous membrane. Reaction with heat and acid greenish-yellow.

Contents of *large* intestines are similar in character, but darker in colour, from containing a larger amount of blood; there were comparatively few cylindrical epithelium cells, but on the other hand, a considerable quantity of food-dèbris, annular and compound granular bodies; less albuminous; reaction with heat and acid brownish-red.

Collapse stools "rice watery;" sediment contained a few annular and compound granular bodies.

Collapse vomit of a pinkish colour, acid, non-albuminous; sp. gr. 1005-10; reaction with heat and acid, pink, which by prolongation of the heat was converted into greenish-yellow; frothy mucous scum contained a large quantity of *sarcinæ* and epithelium; sediment consists chiefly of undigested masses of potatoes and beef, and their disintegrated elements.

CASE XII.—Caroline Macaulay, a woman, æt. 34; *fatal* in the acme of the "*consecutive fever*," in three days. Admitted in collapse, three days after first seizure; was four months advanced in utero-gestation. Prominent symptoms were: contracted pupils, great conjunctival injection, restless insomnia, tendency to coma, delirium, involuntary evacuations in bed, suppression of urine, laborious respiration, and threatened abortion. Chief *pathological* conditions were: punctuate ecchymosis of heart; absence of marked hyperæmia; stomach and intestines apparently normal, liver slightly, and kidneys very fatty; blood normal.

Contents of intestines resembled the stools passed during life, but were darker in colour, having a bloody tinge.

Reaction and *fever stools* of pea-soup colour and consistence, alkaline, fetid, slightly albuminous; sp. gr. 1015; sediment presents the ordinary microscopic characters of the "rice-water" flocculi, with the addition of a quantity of food-dèbris of a bright greenish-yellow (biliary) tinge. The matters evacuated as the fatal termination approached were darker in colour, of more uniform consistence (no separation of a sediment), more fetid, and contained "annular bodies" and phosphates, in addition to a larger amount of food-dèbris.

Collapse vomits. First was of a grass-green colour, acid, non-albuminous; sp. gr. 1005; clear; sediment, which was scanty and flocculent, contained epithelium, starch, and vegetable dèbris, mucus, and oil globules. Decolorized by nitric acid.

Second and third were of an ale colour, neutral, devoid of odour; sp. gr. 1010; non-albuminous; turbid; reaction with heat and acid brownish-red.

Fourth was of a dark steel-gray colour, slightly acid, devoid

of odour; sediment contained annular bodies, mucus-corpuscles, epithelium, and vegetable dèbris.

Case XIII.—W. L., a man, æt. 42; *fatal* in *consecutive fever* in six days after admission in collapse. Reaction apparently sthenic and favourable; fever insidious and typhoid. Chief *pathological* conditions were: dryness of the muscles and viscera; ecchymosis of the pleura, heart, and intestines; general hyperæmia of the viscera; softening and thickening of the intestinal mucous membrane; red blood corpuscles normal, but there was an increase in the proportion of white corpuscles.

Collapse stools "rice-watery;" reaction with heat and acid pink, passing into greenish-yellow on prolongation of the heat.

Reaction and fever stools chocolate-coloured, alkaline, fetid, albuminous; reaction with heat and acid orange-red.

Collapse vomits acid, of very low density, non-albuminous, of various shades of whey-colour, greenish-yellow, brownish, reddish, and gray; reaction with heat and acid greenish-yellow; addition of acid caused considerable effervescence. Sediment contained mucus and mucus-corpuscles, epithelium, annular bodies; a few phosphates and crystals of chloride of sodium; fatty and oily matters to various extents. In some specimens there was a number of granular corpuscles having single or double nuclei, and otherwise resembling pus.

Case XIV.—J. I., a boy, æt. 2. *Recovery* in ten days after admission. Attack followed protracted convalescence from rubeola. Collapse short; subsequent symptoms more rubeoloid than choleraic in character.

Case XV.—A. B., a man, æt. 49. *Fatal* in four days in the consecutive *fever*, which was very insidious and typhoid. Chief *pathological* features were: softening and exuviation of the mucous membrane, and general arborescent hyperæmia of the intestines; partial ecchymosis of the intestines; first stage of typhoid pneumonia; dilatation and hypertrophy of the heart; lesion of the aortic valves; renal and hepatic epithelium slightly fatty.

Case XVI.—J. B., a woman, æt. 53. *Fatal* in advanced *collapse* three hours and a half after admission. Chief *pathological* conditions were: absence of livor of the surface; marked dryness of the viscera, or ecchymosis in any part of the body; rosy hyperæmia of intestines; thickening and sodden condition of their mucous membrane; their contents "ricy" mu-

cus, slightly tinged with blood; retroverted uterus; mucous polypi of *cervix uteri;* fatty liver.

Contents of *stomach* about ℥iii, of a dirty brownish-yellow colour, turbid, acid, albuminous; reaction (of filtered fluid) with heat and acid light greenish-yellow.

Contents of *large* intestines cream-coloured, having here and there a bloody tinge; alkaline, fetid, densely albuminous; reaction of filtered fluid portion with heat and acid orange-red. Sediment contained cylindrical epithelium, mucus, and mucous and other granular corpuscles.

Contents of *small* intestines similar in character; contained quantities of small shreds of softened mucous membrane.

I now proceed to the detail of the experiments with the solids and fluids of the patients just above referred to; beginning, as I have already stated, on Oct. 24th.

Oct. 24.—Dog No. 1 and the cat were introduced into the experiment room. Both were at first very shy; and, until impelled by hunger, they refused food; they had been starved on the previous day in order to insure some degree of appetite.

No patients in hospital.[1] Case III. had been *fatal* in *collapse* on the 9th; and Case I. in "*consecutive fever*," on the 11th curt. Case II. was dismissed recovered on the 19th curt.

In the morning gave the animals the collapse and reaction vomit, and in the afternoon the collapse and reaction stools of Case I.; the former were chiefly consumed by the cat, the latter by the dog.

Oct. 25.—*No* new cases admitted. The floor of the room was covered by a considerable quantity of fæces; those of the dog being semisolid, and of a dark brownish-green colour; those of the cat more fluid, of a grayish tint on the surface, and brownish-yellow below. Under the microscope they presented the characters of healthy fæces. Both animals were lively and well, and anxious to escape, especially the cat.

In the morning gave the fever vomit, and in the afternoon the fever stools of Case I. Both animals exhibited a better appetite, especially the dog.

Oct. 26.—*No* new cases. Both well and lively. Fæces slightly more fluid and abundant; floor covered with a quantity of urine. Effluvia from the evacuations had a most disagreeable odour. Room cleaned, and animals turned loose for an hour, but allowed no other food.

[1] By this I mean *no* cases of genuine cholera. There were occasionally admitted patients labouring under simple, but excessive, or suspicious diarrhœa, as well as cases simulating cholera in some of their features, *e. g.*, colic, cramps, vomiting, and purging, induced by intoxication and exposure to cold.

In the morning gave the collapse vomit, and in the afternoon the collapse stools of Case II.

Oct. 27.—Cases IV. and IX. admitted in collapse. Both well and lively. Fæces still more fluid, partly from admixture with urine, but not otherwise altered. Dog ate with avidity, and consumed proportionally a much larger quantity than the cat. The stench in the room necessitated its being cleaned and ventilated during the day. The animals were let loose on the ground floor of the hospital.

In the morning gave the collapse stools of Case III.

Oct. 28.—Cases V. and VII. admitted in collapse; Cases IV. and IX, in reaction, passing into fever. Animals well, very anxious to escape.

In the morning gave the collapse vomit of Case III.

Oct. 29.—4 cases under treatment; 1 convalescent from cholerine, and 3 in the "consecutive fever" of cholera.

In the morning gave the collapse stools of Case IV.

Oct. 30.—Case VII. admitted. Animals *in statu quo*, and fæces still very fluid, but, along with urine, comparatively normal.

Gave collapse vomit of Case IV.

Oct. 31.—Case VIII. admitted in collapse. Case V. dismissed recovered. Animals continue well.

Gave collapse vomit of Case VI.

Nov. 1.—Case VIII. fatal in collapse. Four "consecutive fever" cases remain under treatment. Animals well; room cleaned, and animals let loose for the greater part of the day.

Gave collapse vomit of Case V.

Nov. 2.—*No* new cases admitted. Animals well.

Gave collapse stools of Case V.

Nov. 3.—*No* new cases. No perceptible change on the animals; fæces still fluid, and urine abundant.

Gave collapse vomit of Case VII.

Nov. 4.—Case V. fatal in typhoid stage. Three fever[1] cases remain under treatment. Animals well.

Gave collapse vomit of Case VIII.

Nov. 5—*No* new cases. Animals well; fæces frequently differed in colour and consistence; their usual fluidity indicated a slight diarrhœa.

Gave about a pint of blood, removed from the heart and great vessels of Case VIII. at the *post mortem* examination on 2d curt. It was almost wholly consumed by the dog.

[1] In using the words or terms "fever," "consecutive fever," "rice-water," "serous stools," &c., I do not wish to indicate a belief in any particular theory or view of the nature of cholera, or any resemblance which I can trace in the stools. I employ them merely as the phrases ordinarily made use of to signify certain stages or phenomena of the disease.

Nov. 6.—*No* new cases. Both animals very quiet, and evidently ill. Appear to have had severe diarrhœa; fæces of dog tawny in colour and consistence; urine abundant.

In morning, gave contents of *small* intestines of Case VIII., removed at the *sectio cadaveris;* they were chiefly swallowed by the dog.

In afternoon, gave contents of *large* intestines of Case VIII. This was followed by a continuance of severe purging; the fæces of the dog were very fluid, but of a brownish-green (biliary) tint; the microscopical characters did not essentially differ from those of more solid and normal evacuations. The substances detected by the microscope usually consisted of the matters contained in the evacuations on which the animals were fed, many of them passing rapidly through the system of the dog and cat apparently little altered. There was no appearance of mucous flocculi in even the most fluid of the evacuations.

About 11 P.M. ʒii. of the heart-blood of Case VIII., not defibrinated, and partially clotted—removed at the *sectio*—was *injected* by a common syringe into the cellular tissue of the thigh of each of the two animals. Immediately after the operation they scampered away apparently in good health.

Nov. 7.—*No* new cases; 3 cholera convalescents under treatment. Room cleaned and ventilated. In afternoon, dog No. 2 introduced; it was shy and timorous, refusing food, but withal lively and well.

Dog No. 1 and cat better; appeared in perfect health; the former gamboled very friskily, the latter as usual made repeated sly attempts to escape in search of more agreeable food, a warmer lodging, and a more pleasant companion. Floor covered with very liquid but dark coloured fæces, and with limpid urine; stench very strong.

Gave the urine of Cases IV., VII. and IX., concentrated nearly to dryness, mixed with milk and a little porridge.

Nov. 8.—*No* new cases. Milk and greater portion of the porridge had been consumed, but the urine-sediment had scarcely been touched. No appreciable difference in the animals. Gave no other food till the urine should be licked up. In the evening a little had been licked by the dogs, the cat having probably had the lion's share of the porridge and milk. By virtue of her claws, Grimalkin usually managed to have a selection of the viands, keeping the dogs in the background till she herself was served.

Nov. 9.—*No* new cases admitted. Diarrhœa continued in a mitigated form; animals almost *in statu quo*. Dog No. 2 had swallowed very little. Urine not consumed.

Gave the collapse stools of Case VIII., passed on 31st ult. and 1st curt.

Nov. 10.—*No* new cases. Dog No. 2 succeeded in making her escape; all animals apparently well.

Gave the filtered fluid portion of the fever stools of Case V., passed on 28th ult.

Nov. 11.—*No* new case. Animals *in statu quo*.

Gave about oj. of the fluid portion of the collapse stools of Case II., passed on 3d ult., evaporated to dryness, and mixed with some milk and porridge.

Nov. 12.—Case X. admitted. 3 convalescents still remain in hospital. Animals well.

Gave oj. of fluid portion of collapse vomit of Case II. evacuated on 3d and 4th ult., concentrated and mixed with milk.

Nov. 13.—Case XI. admitted, and *fatal* shortly after in collapse; 1 fever case and 3 convalescents remained under treatment. Animals still comparatively well; fæces still fluid.

Gave collapse stools of Case X.

Nov. 14.—Case X. *fatal* in consecutive fever; Case IX. dismissed well; 2 convalescents remain. Dog No. 1 made its escape yesterday afternoon, but was re-captured this morning.[1]

Gave collapse vomit of Case X.

Nov. 15.—*No* new cases.

Gave collapse stools of Case XI.

Nov. 16.—*No* new cases. Dog No. 2 re-captured and re-introduced; still sly and timorous. The semifluid, but still dark-coloured, fæces of the dog No. 1 were again examined by the microscope, and found to contain, in addition to vegetable dèbris, crystals of phosphates and chloride of sodium, grains of siliceous earth, and entozoon-ova (probably of an *ascaris*) in various stages of development.

Gave contents of the intestines of Case XI., removed at the *sectio* 2 days before.

Nov. 17.—Cases IV. and VII. discharged recovered. *No* cases remain in the hospital.

[1] When I do not specially mention the condition of the animals, or the characters of the fæces, it is to be understood that no appreciable or note-worthy alteration from the normal state was observed.

Gave about oj. of the heart-blood of Case XI., removed at the *sectio* 3 days before.

Nov. 18.—*No* new cases. Animals continued well. Fæces resembled soft soap in appearance, others resembled treacle, and were probably passed by dog No. 1, which appeared chiefly to have consumed the blood supplied yesterday. The microscope detected in the latter a considerable quantity of entozoon-ova, hairs, phosphates and chloride of sodium, vegetable dèbris, "annular bodies" such as occur in the cholera evacuations of man, and granular matter of a dark green colour. Most of the so-called "annular bodies," or "cholera corpuscles," appeared to suffer disintegration or great alteration by passing through the intestinal system of the dog and cat; others, however, were discharged unaltered, *e.g.* those I have for convenience sake denominated "gonidic."

Gave about ℥vi. of blood, taken at a *sectio* 2 days before from the heart and lungs of Case X.

In afternoon, gave contents of the intestines of the same case, also removed after death.

Nov. 19.—*No* new cases. Dog No. 3 introduced in good condition, quiet, shy; lay in a corner apart from the others; the cat also avoided canine society; but dogs 1 and 2 generally nestled together in some quiet corner; they all lived together, however, in comparative harmony.

Gave collapse vomit of Case XI., evacuated 6 days before.

Nov. 20.—*No* new cases. Microscopical examination of the fæces revealed no change. Animals all well.

Gave fever stools of Case X., passed 6 days before.

Nov. 21.—Case XII. admitted in collapse; no other cases in hospital. The body-clothes of this case were heaped up in a corner of the experiment room. Animals well; fæces still fluid, but otherwise normal.

In morning, gave about oj. of fluid portion of collapse vomit of Case VIII., concentrated by evaporation.

In afternoon, gave above ℥x. of the fluid portion of the collapse stools of Case XI, also concentrated by evaporation.

Nov. 22.—1 *fever* case in hospital (*i.e.*, a patient in the "consecutive fever," or typhoid *stage* of cholera). The animals were in the condition and positions already described.[1]

Gave reaction and fever stools of Case XII.

Nov. 23.—*No* new cases. Animals well.

[1] *Vide* page 289 *et seq.* of the Journal for the *special* experiments with the fomites, which ought to have been described at this stage of the *general* experiments.

Gave collapse vomit of Case XII.

Nov. 24.—Case XII.—*Fatal* in acme of consecutive fever. Body-clothes removed from experiment-room, and bed-clothes in which the patient had died, and which were saturated by her discharges, were substituted.[1]

Gave fever stools of Case XII.

Nov. 25.—*No* cases in hospital. Animals apparently in good health. Gave contents of the intestines of Case XII., removed at the *sectio* this afternoon. Room cleaned and ventilated during the day.

Nov. 26.—*No* new cases. Animals still well; confined all day. Gave about ℥x. blood, taken from the heart and great vessels of Case XII. at the *sectio* yesterday.

In afternoon, gave about oj. of the fluid portion of the fever stools of Case X., concentrated to one-tenth by evaporation.

Nov. 27.—Dog No. 2 died of cholera; remaining animals all apparently labouring under the disease in different degrees. Fæces, &c., as already described. As the matters supplied yesterday had not been consumed, I gave them no further food.

No new cases admitted.

Nov. 28.—Dog No. 3 died of cholera. Dog No. 1, and cat, still very ill. Cleaned and ventilated the room; turned loose the surviving animals, and gave them a supply of fresh milk and porridge.

Nov. 29.—Dog and cat still very much debilitated, and labouring under diarrhœa; allowed to run at large in the grounds surrounding the hospital, and fed on milk, porridge, bread, meat, &c. Dog No. 4 introduced.

Nov. 30.—*No* new cases. Animals all comparatively well and lively. Again confined them in the experiment-room, and gave them, as food, portions of the blood, fat, flesh, bones, and viscera of dogs Nos. 2 and 3, removed at the *post mortem* examinations on the 27th and 28th current; were chiefly consumed by dog No. 1. Dog No. 5 introduced.

Dec. 1.—*No* new cases. Dog No. 1 very lively; No. 4 trembling, quiet, and timorous; No. 5 lively, *whining and barking* from anxiety to escape. Cat very quiet; all well; none affected with diarrhœa. Most of the fæces were semisolid, and of a dark brownish-green colour; some were semifluid and tarry. Urine was abundant, and normal.

Experiments intermitted till 7th.

Dec. 6.—Cases XIII. and XIV. admitted in *collapse*. Ani-

[1] For characters of the fæces and urine of the animals, *vide* page 288.

mals in good health; had been running about in the hospital grounds daily, and fed on porridge, bread, &c. Dog No. 6 obtained.

Dec. 7.—*No* new cases. Dogs (not the cat) confined in experiment-room in the evening and during the night, and body-clothes of Cases XIII. and XIV. were thrown in a heap in a corner. Dogs Nos. 1 and 4 slept among these clothes, while Nos. 5 and 6 slept at door.

Dec. 8.—All well. Animals let loose during day, and fed on porridge and milk. Room ventilated and cleaned. Fæces and urine normal. Animals were shut up for the night in a damp, dark cellar of an untenanted house a few yards off.

Dec. 9.—*No* new cases. Animals well; confined for a few evenings in an under-ground room of the house above mentioned. In addition to some flesh, porridge, and milk, gave them collapse stools of Case XIII.

Dec. 10.—*No* new cases. All well. Stools had been consumed only partially, and that by dog No. 1. Dogs Nos. 7 and 8 introduced. Gave collapse vomit in the morning, and reaction and fever stools in the afternoon, of Case XIII.

Dec. 11.—Case XV. admitted in collapse; two patients in consecutive fever stage remained under treatment. Animals well; fed on porridge, meat, and general kitchen refuse, and allowed to run about in the open air all day; confined in the room during night, the body-clothes of Case XV. being thrown into a corner thereof.

Dec. 12.—Case XIII. fatal in consecutive fever; two fever cases were still under treatment. Animals well; bed-clothes of Case XIII., in which he died, and soiled by his evacuations, were introduced into the room at night.

Dec. 13.—Case XVI. admitted in collapse, and *fatal* 3½ hours after admission; 1 fever case, and 1 convalescent, remained under treatment. Animals well; body and bed clothes of Case XVI. introduced into room, along with the animals, at night.

Dec. 14.—*No* new cases. Animals well; running loose all day; No. 7 escaped; still feeding on porridge and milk, meat of various kinds, and other kitchen refuse.

Dec. 15.—Case XV. *fatal* in *consecutive fever;* no new cases in hospital. Animals well; bedding in which Case XV. died introduced at night.

Dec. 16.—Case XIV. dismissed recovered; no other cases in hospital. Animals well and lively. Floor covered with fæces; one specimen was perfectly formed, of the colour and consistence of the thicker plastic clay, and appeared as if it had been forcibly extruded through an unyielding sphincter;

a second specimen was also well formed, but of a brownish-yellow colour, soft, and easily broken down; a third was of the consistence of thick porridge, amorphous, of a deep brownish-yellow; it contained a considerable amount of potatoes and other vegetable matters, undigested or only partially so; a fourth was semifluid, amorphous, of a grayish-black colour, and mixed with sand and dust; a fifth was fluid, and of a dark grass-green colour. Their microscopic characters were characteristic of comparatively healthy fæces. Two specimens were agitated with water, and the fluid filtered; both had a greenish-yellow tint, no peculiar odour, and were alkaline and albuminous;—in one the reaction with heat and acid was brownish-red, which speedily changed into brownish-yellow, in the other it was pinkish,—thus showing the decidedly *biliary* nature of these reactions.

Dec. 17.—At this date the experiments were put a stop to by the cessation of the epidemic in Edinburgh. The surviving animals were therefore turned loose, and fed on the kitchen refuse. They continued to enjoy perfect health; some of them even appeared to have gained bulk and weight.

I cannot, in the present paper, make any remarks on the above experiments as bearing on the general question of the *contagion* of cholera; but I would simply beg, in the meanwhile, to call attention to the different effects of the fomites before and after the week between 21st and 28th November. Prior to this period, I endeavoured to concentrate in the animals all the predisposing causes of the disease as we know them in the human subject; subsequently I tried equally to disperse these, by giving the animals nutritious food, exposing them freely to the air, and giving them ample exercise.

Crichton Royal Institution, Dumfries,
April 1854.

With the Authors respectful Compliments.

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ON THE OCCURRENCE OF "CINCHONACEOUS GLANDS" IN GALIACEÆ, AND ON THE RELATIONS OF THAT ORDER TO CINCHONACEÆ.

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[With a Plate.]

A FEW years ago, Dr. Weddell of Paris, in his magnificent monograph of the Cinchonas*, drew attention to a singular feature in these plants, viz. the constant presence of peculiar glands on their interpetiolar stipules; and the attention of this Society was called by Professor Balfour to Dr. Weddell's observations.

The inner faces of the stipules are in many cases firmly glued to the terminal bud, which they embrace, by a gummy or gum-resinous matter exuded by the small sessile glands to which reference has been made. This secretion is stated by Dr. Weddell to be fluid and transparent in Cinchonas and Cascarillas, but solid and opake in several other genera, remarkably so in *Pimentelia glomerata*. In the genus *Rondeletia* it is soft like wax, and of a beautiful green colour. The inhabitants of Peru, who give it the name of *Aceite-Maria* (oil of Mary), carefully collect it, and employ it as an external application in various maladies. It is well known to horticulturists that Cinchonaceous plants under cultivation are very liable to the attacks of *Acaridæ* and other parasites; and Mr. M'Nab has drawn my attention to the fact, that it is invariably in the neighbourhood of the stipules on the young shoots that these pests are most abundant, viz. at the points of the plant where the secretion is most copiously given off.

* Histoire Naturelle des Quinquinas, ou Monographie du genre *Cinchona*, suivie d'une Description du genre Cascarilla et de quelques autres plantes de la même tribu, par M. H.-A. Weddell, M.D. Paris, 1849.

The glands occur at the extreme base of the stipule on its inner or upper surface, and are most plentiful in the immediate vicinage of the nervures of the stipule, where spiral vessels are abundant; but these do not enter the tissue of the gland. In those plants whose stipules early become reflexed (*Rogera* for example) the glands are conspicuously exposed to view; but in those whose stipules remain closely glued to the stem, it requires careful dissection to show them. It is in the young state of the stipule, when it envelopes the terminal bud, that the glands are in best condition for examination; they get quite dried up before the stipule decays.

These stipular glands appear to be of universal occurrence throughout the whole order *Cinchonaceæ*, but as this has not been ascertained from actual observation of all the species, it seems desirable here to record the names of those in which they have been particularly noticed, in order that botanists who have the opportunity may, from time to time, extend the list of observations. These glands have been examined in the following species, viz.—

Cinchona Calisaya, *Wedd.*
—— Condaminea, *Humb. et Bonpl.*
—— lancifolia, *Mutis.*
—— amygdalifolia, *Wedd.*
—— scrobiculata, *Humb. et Bonpl.*
—— australis, *Wedd.*
—— boliviana, *Wedd.*
—— ovata, *Ruiz et Pav.*
—— rufinervis, *Wedd.*
—— Chomeliana, *Wedd.*
—— micrantha, *Ruiz et Pav.*
—— pubescens, *Vahl.*
—— cordifolia, *Mutis.*
—— purpurascens, *Wedd.*
—— carabayensis, *Wedd.*
—— asperifolia, *Wedd.*
Cascarilla Carua, *Wedd.*
Ladenbergia dichotoma, *Kltsch.*
Rondeletia odorata, *Jacq.*
Burchellia capensis, *Brown.*
Cephaëlis Ipecacuanha, *A. Rich.*
Coffea arabica, *Linn.*
Ixora javanica, *DC.*
—— coccinea, *Linn.*
Mussænda frondosa, *Linn.*
Pavetta indica, *Linn.*
Luculia gratissima, *Sweet.*
—— Pinciana, *Hook.*
Pentas carnea, *Benth.*
Gardenia Stanleyana, *Hook.*
Pimentelia glomerata, *Wedd.*
Exostemma longiflorum, *R. & S.*
Rogera Rœgelia.
—— versicolor.
—— elegans.

In all 35 species.

The Cinchonaceous glands are, in general, minute, more or less conical bodies, rising from the surface of the stipule, and are mostly colourless, but in some instances highly coloured, and are then conspicuous objects.

Their plan of structure is perhaps more distinctly seen in *Cinchona Calisaya* than in any other species, and is well illustrated in Dr. Weddell's book. In that plant the gland is sessile, of an oval or lanceolate form, and somewhat pointed at the apex. It consists of a mass of dense tissue of somewhat elongated cells, forming a central nucleus of a conical shape. This axial nucleus

is surrounded by a layer of much more elongated obconical, somewhat prismatic cells, which are closely set around the nucleus in a radiant manner, lying upon it like achenes upon a conical receptacle.

These elongated cells are described by Weddell as having, in the centre of the outer extremity or apex of each, a minute canal or perforation in the cell-wall, communicating with the interior of the cell, and serving to discharge the secreted fluid. This he says is particularly evident in *Cinchona Calisaya*; and the Commission appointed by the Academy of Sciences to report upon Dr. Weddell's investigations (MM. Richard, Gaudichaud and Jussieu) specially drew attention to the circumstance, as of rare occurrence in vegetable glands.

I have not been able as yet to demonstrate the canal satisfactorily, although the glands of *Cinchona Calisaya*, and of other species, have been carefully examined with this view. But, by this expression of my own failure to see what no doubt requires a combination of favourable circumstances, supplemented by patient examination, I do not mean to impute error of observation to so excellent an observer as Dr. Weddell; and refrain, in the meantime, from entering upon a discussion of the point, as it has specially occupied the attention of my friend Dr. John Kirk, whose researches I trust will ere long be laid before the Botanical Society. It may here, however, be remarked, that the secretion is certainly discharged from the apex of the elongated cells forming the outer layer of the gland, and under certain circumstances appears in the form of minute globules on their surface. It is not likely that such globules were taken by Dr. Weddell for canals, but they have sufficiently that appearance to be mistaken by an inexperienced observer.

In size and form the glands vary considerably in different species. In *Cinchona Calisaya* they are of an ovato-lanceolate form, and measure $\frac{1}{40}$th of an inch in length by $\frac{1}{70}$th in breadth; while in *Ixora coccinea* they are very much attenuated, of a linear lanceolate form, and measure $\frac{1}{30}$th of an inch in length by only $\frac{1}{230}$th in breadth.

In occasional cases, though rarely, two glands are found in adhesion.

These stipular glands have been hitherto regarded as quite peculiar to the Natural Order *Cinchonaceæ*, and have been employed as a character whereby to distinguish that order from *Galiaceæ*, in which their presence has not hitherto been suspected, or has rather by implication been denied.

I have recently ascertained, however, that the so-called Cinchonaceous glands are by no means limited to *Cinchonaceæ*. They likewise occur in the *Galiaceæ*, and I believe that the

strong odour (in some agreeable, in others fetid) which many of these plants give off may be found to proceed from the secretions of their glands. It is not in isolated cases merely that I have been able to trace the presence of glands in *Galiaceæ*. In every plant of the order of which I have been able to obtain fresh examples for examination, I have found them to occur; and being quite unable to find a single instance of a Galiaceous plant in which they are absent, I think I am, in the meantime, fairly entitled to presume their general occurrence throughout the order. The plants examined (and found to exhibit these glands) were the following, viz.—

Rubia peregrina, *Linn.*
—— tinctorum, *Linn.*
Asperula taurina, *Linn.*
—— odorata, *Linn.*
—— valantioides.
Crucianella suaveolens.
—— molluginoides, *Bieb.*
—— stylosa, *DC.*
—— aspera, *Bieb.*
Galium Aparine, *Linn.*
—— rubioides, *Linn.*
—— tomentosum, *Thunb.*
—— tauricum, *Rœm. et Schult.*
—— saccharatum, *All.*
Galium Mollugo, *Linn.*
—— Chersonense, *Rœm. et Schult.*
—— glabrum, *Thunb.*
—— cruciatum, *With.*
—— saxatile, *Linn.*
—— rostratum.
—— urceolatum.
—— purpureum, *Linn.*
—— lucidum, *All.*
—— verum, *Linn.*
—— pusillum, *Linn.*
—— boreale, *Linn.*
Sherardia arvensis, *Linn.*

In all 27 species.

In *Galiaceæ* the glands occur apparently in the axils, but in reality on the inner or upper surface of the bases, of the leaves. In structure they bear a considerable resemblance to the stipular glands of many *Cinchonaceæ*, with this difference, however, that they are generally either distinctly stipitate or club-shaped, whereas those of *Cinchonaceæ* are usually thickest at the base, and taper (more or less gradually in different species) towards the apex. When stipitate, the stalk (of the Galiaceous gland) is composed of two or three (sometimes more) series of cells, those running up the centre sometimes containing green chlorophyll granules; none of these, however, being usually exhibited in the body of the gland. In *Rubia tinctorum* each cell of the gland contains a large green central nuclear body. In form the glands of *Galiaceæ* present even greater variety (in different species) than those of *Cinchonaceæ*.

Another feature in which the glands of *Galiaceæ* differ from those of *Cinchonaceæ* is their small size, which is especially observable in some of the dwarf, small-leaved species of *Galium*, as in *Galium saxatile*, for instance, whose glands are not more than $\frac{1}{130}$th of an inch in length by $\frac{1}{800}$th in breadth, whereas I have stated those of *Cinchona Calisaya* (which are not unusually large

for that genus) to average $\frac{1}{40}$th of an inch in length by $\frac{1}{70}$th in breadth.

The *Cinchonaceæ* and *Galiaceæ* form two well-marked groups of plants, abundantly distinct from each other in habit and in geographical distribution; the one consisting of trees, shrubs, and herbs, almost exclusively inhabiting the hotter parts of the world, most of them eminently conspicuous for their œconomical products and the beauty of their broad foliage and flowers, although some of their number are mean weeds; the other composed entirely of straggling herbaceous plants, with weak angular stems and narrow verticillate leaves, inhabiting northern countries, and (if we except the Madder) alike inconspicuous for use and ornament. Unfortunately, however, fructification does not supply any character whereby those two ideally distinct groups of plants can be clearly separated from each other; and in the limitation of natural orders, something more than a difference of habit is considered desirable by all, and by many absolutely requisite. Therefore, although the *Cinchonaceæ* and *Galiaceæ* are kept separate by several of our best systematic writers, there is still a considerable difference of opinion as to the propriety of so doing, notwithstanding the detailed discussion of the subject at different times by some of the most distinguished botanists of Europe.

The principal character whereby these two orders are separated, depends upon the leaves of *Cinchonaceæ* being opposite (sometimes verticillate), and *furnished with interpetiolar stipules*; while *Galiaceæ* have normally verticillate leaves *without stipules*.

DeCandolle, Bentham, and others, who regard *Cinchonaceæ* and *Galiaceæ* as forming only one natural order, *Rubiaceæ*, reduce the distinguishing character above indicated in the following manner. They regard the *Galiaceæ* as opposite-leaved plants, their foliaceous organs being in part true leaves, and in part leaf-like stipules, for the following reasons:—

1. That the foliaceous organs in *Galiaceæ*, if viewed as consisting entirely of leaves, do not bear that relation to the angles of the stem which is usual in Dicotyledons; but that the relation becomes apparent if only two of them are taken as leaves and the rest as stipules. Only two of the apparent leaves have buds in their axils.

2. That in a number of cases, especially in *Asperula*, two opposite leaves are much larger than the others.

3. That in *Spermacoceæ* and other tribes of *Cinchonaceæ*, the stipules are connected with the petiole of the leaf into a sheath, and that this sheath exists in *Galiaceæ*.

4. That the number of parts in each whorl is not necessarily some power of 3, as argued by Dr. Lindley (each leaf having two stipules), but that taking two of the parts for leaves, it is imma-

terial by what number of similar parts those two are separated, because the intermediate processes are analogous to the setæ of *Spermacoceæ*, the number of which is variable*.

Dr. Lindley objects to this line of argument, (1.) that in *Labiatæ* and similar orders the apparent leaves are never opposite the angles of the stem, but are always placed between them, and that the number of angles in the stem of verticillate plants does not necessarily correspond with the number of their leaves, *Dysophylla* for example (a Lamiaceous genus) having whorls of ten parts, while the stem has but four angles; that the non-production of buds in their axils is no proof of bodies not being true leaves, all foliaceous organs, and especially stipules, having that power or not according to circumstances. (2.) That the greater length of two opposite leaves occasionally observed in *Asperula* is to be ascribed to their greater development consequent upon their higher functions. (3.) That the argument derived from the occasional connection of the leaves by a membrane loses weight, when it is remembered that in such cases the intermediate leaves are less like stipules than in those cases where no membrane exists. (4.) That the comparison of the supposed stipules of *Galiaceæ* and the setæ of *Spermacoceæ* is inadmissible, because the former are at all events single simple organs, be they what they may, while the setæ of *Spermacoceæ* are the result of the splitting of two parallel-veined stipules, and therefore will necessarily be uncertain in number.

Dr. Lindley likewise draws attention to the fact, that in *Galiaceæ* the supposed stipules are always what first disappear in the process of reduction in the number of foliaceous appendages; but that in *Cinchonaceæ* it is in many cases the leaves which are first lost when such a reduction takes place, which is illustrated by the capitate Spermacoces, where the bracts are evidently stipules, and especially by *S. calyptera*, in which the leaves are gradually merged in the large membranous cup that subtends the flower, while the stipules suffer no diminution.

From these arguments it will be seen that the principal distinction between the orders *Cinchonaceæ* and *Galiaceæ* depends entirely upon the theoretical notion we adopt of their foliaceous organs, and that from whatever point of view they be regarded, the two orders are structurally closely related to each other.

The observation of the glands now described, in the *Galiaceæ*, establishes another point of relationship between the orders, the presence of stipular glands in the *Cinchonaceæ*, and especially in the arborescent species, having been hitherto looked upon as a singular feature of their structure, serving to remove them from

* Vegetable Kingdom, 3rd edit. p. 769.

the herbaceous *Rubiaceæ* of cold countries. It appears to me that these glands may likewise be instrumental in throwing light on the nature of the foliaceous organs of *Galiaceæ*, as well as on the morphology of those of *Cinchonaceæ*.

In *Cinchonaceæ* the glands are invariably confined to the stipule; and, on observing their occurrence in *Galiaceæ*, it at once occurred to me that if a portion of the foliaceous organs of *Galiaceæ* were in reality leaves and the others stipules, then we had here a key whereby to determine what were leaves and what stipules. With the view of doing so, I have carefully examined the position of the glands of all the *Galiaceæ* within my reach; and, although I came to the subject with a prepossession in favour of the view of DeCandolle, I have been quite unable to find any indication, by the arrangement of the glands, of two kinds of foliaceous organs in these plants. In *Galiaceæ* the stipules occur at the base of the foliaceous organs; they are not limited to a certain number in each whorl, but occur in all, being equally present in those opposite "leaves" which bear branches in their axils, as in those so-called "stipules" that are barren, although more abundant in the latter.

In the *Cinchonaceæ* I have said that the glands constantly occupy the base of the stipule, and are in no case found on a leaf or petiole. Here then the presence of these glands is a certain indication of the stipulary nature of the organ on which they occur, no dubiety whatever having hitherto been expressed respecting the nature of the usual foliaceous organs of *Cinchonaceæ*. I am not sure in how far we are warranted in applying this fact to the case of *Galiaceæ*; but where all other characters have failed, it is not to be entirely overlooked. If then we follow the rule which obtains in *Cinchonaceæ*, that stipules are bodies furnished with glands at their base, we shall come to a conclusion differing essentially from all those that have hitherto been brought forward, viz. that *Galiaceæ* are *leafless plants with whorls of stipules*.

It is worth while to keep in view that this idea, although at first sight sufficiently paradoxical to caution us against its too hasty adoption, is perhaps in reality less liable to objection than either the views of Lindley or of DeCandolle and Bentham. At the same time, even if it were proved to be correct, I do not precisely see in what manner it could help us out of the difficulty.

In organography, as well as in regard to the disposition of these two natural orders, the subject is one of considerable interest in a theoretical point of view.

In viewing the whole question, it appears to me, even admitting (with Lindley) the foliaceous organs of *Galiaceæ* to be true leaves, that the character thus established between the two

orders is not of that great importance with which it seems to be generally regarded. The leaves are truly verticillate in a certain portion of the *Cinchonaceæ*, and, without any violence to truth, they may be regarded as verticillate in the whole of these plants, in this way. All botanists will admit that stipules are merely reduced or rudimentary, partially-developed leaves. In *Galiaceæ* we have plants with leaves in whorls, all equally developed, but in many cases with an undoubted tendency to reduction in part of the whorl. In *Cinchonaceæ* a certain number of the leaves of the whorl are invariably much more fully developed than the others, which assume the character of stipules, but do not appear in the form of ordinary stipules, as appendages to other leaves, but occupy independent positions around the stem like true leaves. If the argument had proceeded in this direction, we should probably have had less discussion upon a point which still remains to be satisfactorily cleared up*.

EXPLANATION OF PLATE IX.

Fig. 1. Stipular gland of *Cinchona Calisaya*. 70 diameters.
Fig. 2. Stipular gland of *Ixora coccinea*. 70 diameters.
Fig. 3. Vertical section of gland of *Cinchona Calisaya* (after Weddell), showing (*a*) central nucleus of compact tissue, and (*b*) outer layer of elongated cells.
Fig. 4. Diagramatic view of two of the cells of the outer layer of the gland (*C. Calisaya*), exhibiting the canals (*c*, *c*) at their apex, as shown by Weddell.
Fig. 5. Stipular gland of *Exostemma longiflora*. 70 diameters.
Fig. 6. Twin gland from stipule of *Luculia Pinceana*, formed by the adhesion of two glands throughout the greater part of their length. This is only of occasional (accidental) occurrence, the usual form of the gland being not unlike that of *Exostemma longiflora*, but of greater size. 70 diameters.
Fig. 7. Glands of *Galium saxatile*. 70 diameters.
Fig. 8. Gland of *Crucianella stylosa*. 70 diameters.
Fig. 9. Glands of *Galium cruciatum*. 70 diameters.
Fig. 10. Gland of *Galium urceolatum*. 70 diameters.
Fig. 11. Gland of *Asperula odorata*. 70 diameters.

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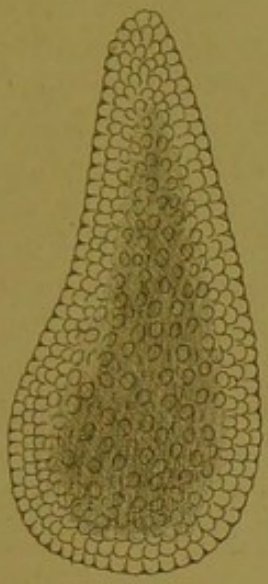
* To Professor Balfour, Mr. M'Nab, and Mr. Evans, my best thanks are due, for the unlimited use of plants from the Royal Botanic and Experimental Gardens, for examination.



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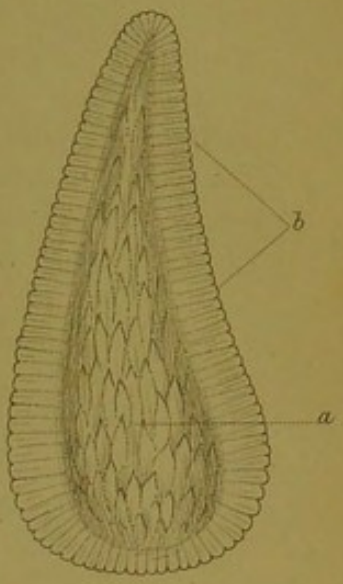

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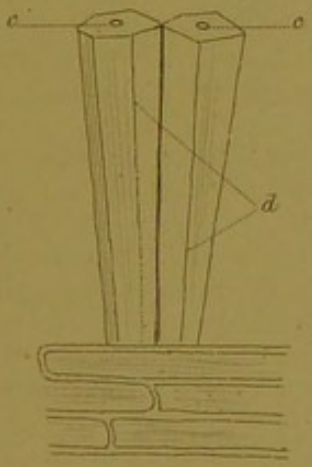

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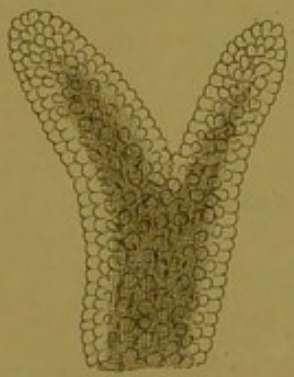

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