Sir Andrew Clarke, Bart.
With the Compliments of
J. H. [illegible]
9 west 29th/88
New York

# MALARIA.

BY

JAMES HENRY SALISBURY, A. M., M. D.

*McNAUGHTON PRIZE ESSAY,*

1882.

AWARDED BY THE ALBANY MEDICAL COLLEGE ALUMNI ASSOCIATION.



NEW YORK:
WILLIAM A. KELLOGG.
1885.

*The Riverside Press, Cambridge:*
Electrotyped and Printed by H. O. Houghton & Co.

# MALARIA.

## ABSTRACT OF THE VIEWS OF THE PROFESSION IN PAST AND RECENT TIMES.

It has been observed from remote times that the exhalations from drying marshes and the desiccating beds of ponds, pools, and streams have a noxious influence.

These observations resulted early in vague notions as to the character of these emanations. Such notions were ill-defined down to the time of Sancisi, about two centuries back. He gave to the world a treatise — "De Noxiis Paludum Effluviis" — from which emanated the better defined views of the eighteenth century, which ascribed miasmatic emanations to vegetable decomposition.

During the present century, and especially for the last forty years, these views have been innovated upon by many who have carefully conducted chemical inquiries into the abnormal constituents of the mephitic atmospheres hovering over miasmatic localities.

The meagre and unsatisfactory results thus obtained have created many dissenters from the vegetable decomposition theory; and other hypotheses have been embraced, the most of which have been as intangible as the one rejected.

Some entertain the idea that decay generates a predisposing poison, which, being inhaled, is sufficient of itself to excite disease, while cool nights and hot days may hasten the attack.

Others look upon marsh exhalations as only a cause that may enfeeble health, and thus enable the meteorological changes of the summer and first autumn months to more readily excite disease, which may also result in many instances without any such enfeebling influences.

Others refer all periodical diseases to mere meteorological changes, only regarding marshes as aids in the way of presenting evaporating surfaces by which the air is made colder and damper.

More recent authors, dissatisfied with these theories, have suggested a variety of explanations. The present well-received miasmatic marsh theory is well set forth and sustained by McCulloch.

Cragie, of Edinburgh, has, in his "Practice of Medicine," handled the subject in a more learned and lucid way, and presents both sides of the question. The objections presented by Cragie are: *The low temperature at which these disease-producing changes may take place*, the unaccountable production of them in places where there is no apparent vegetation and often no marsh, the exemption of certain places where all the seeming elements of decomposition occur, the effects of cultivation in eradicating the cause, and the sanitary variation of the same localities during different and similar years.

Professor Dunglison, in his work on hygiene, ably presents the fallacy of the received opinions on the subject of the causation of malarious diseases, of which, he holds, we are yet in total ignorance.

Dr. John Bell is also antagonistic to the entertained views, and refers all such morbid phenomena to the modification of the sensible or appreciable conditions of the atmosphere.[1]

Rammanzani, Daniels, and Gardner believe that malarias originate or consist of sulphurous emanations.

Hoffman, that malarious fevers arise from a lessened elasticity of the air.

Others, that they arise from the gases of decomposing compounds.

Ferguson believes that the only conditions necessary are soil and water.

Others attribute them to electrical and magnetic causes.

Dr. Mitchell believes they are produced by a living organic cause, and that that cause is cryptogamic.

The following list of cases, collected by Dr. Mitchell in his able little treatise on "The Cryptogamic Origin of Malarious and Epidemic Fevers," is interesting in this connection as evidence against the organic decomposition and meteorological theories, and as evidence in support of the true cause of intermittent fevers: —

"1. The canal in St. James' Park, London, was, at the time Dr. McCulloch wrote, notorious for the abundance of its aquatic plants, causing, even in autumn, an intolerable stench; yet he congratulates the inhabitants on their miraculous exemption from malarious fevers.

"2. The town of Kingston, in the Island of St. Vincent, is situated at the bottom of a semicircular bay, and at the foot of a mountain range, with high land on each side. The surrounding soil is thickly covered with decaying vegetable and animal matters. The Deputy Inspector of British Hospitals, Robert Armstrong, says: 'Here, then, we find all the elements necessary for the production of the vegeto-animal poison, — heat, moisture, decayed and decaying vegetable matter, with as

[1] *Medical and Physical Journal*, 1825 and 1826, pp. 274–316.

large a proportion of reptiles, insects, and other animal matters as is found in other tropical countries; yet, strange to say, the town of Kingston is one of the most healthy spots in the West Indies. I was informed by the staff surgeon to the forces, who had long resided there, that it was as healthy as the most favored spots in England.'

"3. Bishop Heber states that the wood tracts of Nepaul and Mulwa, having neither swamps nor perceptible moisture, become in summer and autumn so pestiferous as to cause their abandonment even by the birds and beasts.

"4. Fordyce tells us that in a certain part of Peru, where there is a total absence of water, and of course of ordinary vegetation, fevers and dysenteries render the country almost uninhabitable; and, according to Pringle, the dry, unproductive sandy plains of Brabant excite malarious fevers of great intensity.

"5. New South Wales extends from 10° 5′ to 38° south latitude, embracing a region similarly situated to that of America from the West Indies to the Chesapeake Bay. It is subject to a rainy season, and has bays, streams, estuaries, and extensive swamps. Around some of its towns there lies a deep, black, highly productive vegetable mould. It is liable to extraordinary inundations, which lay the country, as far as the eye can reach, under a sheet of muddy water. The temperature is quite as high as that of any other like latitude. The coast is covered with mangroves, and skirted by rocks, reefs, and islets. Among its products are mahogany, oranges, lemons, and guavas. The mosquito, with myriads of insects and reptiles, parrots, paroquets, and other tropical birds, announce a hot and productive climate, and lead us to look for a tainted air and a pestilential habitude; but, notwithstanding all these threatening conditions, and the usual symbols of a sickly climate, New Holland is remarkable for its healthfulness. Pulmonary diseases, and, in the wet season, dysenteries, are observed, but the fevers incident to warm climates elsewhere are here of rare occurrence.

"6. Mr. Titian Peale, the zealous and successful naturalist who accompanied Captain Wilkes on the exploring expedition to the Southern Ocean, writes to Professor Dunglison that he never saw a case of intermittent fever in either natives or strangers in the Polynesian islands, although the officers and men of the expedition lived and slept in the midst of marsh stenches and mosquitoes, when the days were hot, and the huts open and exposed. Captain Wilkes describes these islands as fertile, moist, hot, but yet as remarkably salubrious.

"7. Captain Wilkes says Tongataboo is an organic island formed by coral; is rich, flat, and luxuriant, and oppressed by a temperature rising 98°, offering a mean, during the sojourn of the expedition, of 79.25° Fahrenheit. There was much rain, and, when clear, there were heavy dews.

"The writer supposes that these phenomena must create sickness, but he sees many old people, and admits that, although ashore at night, the people of the expedition were not sufferers. Mr. Peale also testified to the good health of the place.

"8. Ovolau (Fiji) is a volcanic island, the mean temperature of which for six weeks was 77.81°; maximum, 96°; minimum, 63°. Turnips, radishes, and mustard seeds appeared above ground in twenty-four hours, melons in three days, while marrowfat peas, fit for use, were produced in five weeks. On this island, volcanic as Sardinia, and hot as the Maremma, fevers, whether remittent or intermittent, were unknown.

"9. The island of Soloo, in latitude 6.01° north, enjoys a temperature seldom below 70° or above 90°; that is, about the mean of that of the pestilential western coast of Africa. It is, however, healthy.

"10. 'Menouf, the capital of Menoufzer, in Lower Egypt, is situated on the banks of a canal formerly navigable, but so no longer. This canal bathes the walls of Menouf from south to west. Within a few yards of it lies another canal of stagnant water, the space between forming a road into the town. To the right of the south gate lie basins of water to rot flax in, which give out a disagreeable odor. Here and there is a cemetery, and between these are pools for the same use, some of them broken, neglected, and full of stagnant water. Menouf has no gardens; its streets are narrow and dirty, and its houses small and badly constructed. The people drink the Nile water. The yearly inundation floods the country around Menouf, up to the walls, but it does not continue long under water, to which fact Surgeon Carrie ascribes its healthfulness. In addition to its other defects, the place is surrounded by a second wall, composed of dirt and rubbish transported from the town.' (Degennettes.)

"11. Dr. M. B. Hope says: 'The island of Singapore is, in the main, low and level. The greater part of the island is covered with jungles situated in marshes. These jungles are almost impervious, and infested with tigers and other ferocious wild animals. Here and there the Chinese have cleared and cultivated grounds. The vegetation is incredibly rapid in growth, and equally rapid in decay; the soil is rich; and the mean annual temperature of morning and evening 79.45°, and at noon 84°. Astonishing as it may seem under such circumstances, fevers of any kind are very rare.'

"12. The empire of Brazil extends from the equator to the southern tropics. It is watered by vast rivers and countless streams, abounds in lakes and marshes, and under a burning sun smokes from the vapor of impetuous rains, and boasts a vegetation unsurpassed for abundance, variety, and rapid transition.

"Beyond the coast range of mountains the air is stagnant and hot. Notwithstanding all these conditions, the country and towns are extremely healthy, even in the immediate vicinity of swamps and stagnant waters.

"13. Africa, under the same latitude, is full of fevers. The rains scarcely commence before the constitution begins to sink, even without external exposure. According to Lind, the first rains that fall in Guinea are supposed to be the most unhealthy, and they have been known in forty-eight hours to render the leather of shoes quite mouldy and rotten. Mungo Park mentions that the rain had not commenced three minutes before many of the soldiers were affected with vomiting. Others fell asleep, and seemed as if intoxicated. Twelve of the soldiers were ill the next day. 'The thermometer,' says Boyle, 'is seldom above 81° or below 69°, but the process of decomposition proceeds so rapidly that cloth and animal substances, such as leather, become putrid in a period hardly credible.'

"14. 'On one of the Isles Deloss, at Sierra Leone, a small force was soon destroyed; yet it lies in the sea, only about from half a mile to a mile in diameter, and is formed of granite, which rises to a height of three hundred feet in its centre. It is apparently free from supposed causes of fever. There is but one piece of arable ground, no sulphur, no calcareous rock, no marsh, and very little soil, not a swamp, and the temperature seldom rises above 80° Fahrenheit.' (Boyle.)"

Dr. Mitchell thus remarks, after detailing the foregoing instances: —

"Other examples, almost without number, might be given of the salubrity of places full of decomposing matter, and of the insalubrity of others where scarcely a vegetable is to be seen; so that many reflecting men are now disposed to abandon a theory which cannot be rationally sustained by a reference to facts, and which is shaken the more its pretensions are examined."

Dr. Watson says: "Malaria is a specific poison, producing specific effects on the human body, and is probably gaseous or aeriform. Of its physical or chemical properties we really know nothing."

Dr. Robert Armstrong says: "We are utterly ignorant of the nature of this poison, and no two authors agree respecting its constitution, the circumstances under which it is generated, or its effects on the human body. . . . Of the existence of miasm we have no positive proof. It has never been obtained in an insulated state, and consequently we are totally ignorant of its physical properties."

Caldwell says: "If asked What is malaria? I answer, I do not know."

Tweedie says: "Hence physicians have been reduced to the necessity of inferring the existence of hidden atmospheric influences, as a cloak of ignorance."

## CRYPTOGAMIC ORIGIN OF FEVERS AND OTHER DISEASES.

Dr. Mitchell's theory of the cryptogamic origin of fevers, published in 1849, is the last one, I believe, presented to the public at the time of my writing. It is purely hypothetical, yet arrived at by much careful study and inductive reasoning from collected observations. He deserves much credit for the manner in which he treats his subject, and especially for his apparently reasonable conclusions, in which he points out to future investigators a new field for further careful research.

The cryptogamic origin of fevers is not a theory wholly new. In Spain the populace believe that fungi cause fevers. J. S. Michael Leger, of Vienna, in 1775 published a monograph on mildew, considered as a principal cause of epidemic disease among cattle, etc. He says the mildew producing the disease is that which dries and burns the grass and leaves. It falls usually in the morning, particularly after a thunderstorm. Its poisonous quality, which does not continue above twenty-four hours, never operates but when it is swallowed immediately after its falling.

"Nees von Eisenbeck stated that fungi of the most minute forms have their origin in the higher regions of the air, and descending to the earth produce spots and stains. Should this be confirmed, these signacula would have a much more important connection with epidemics than can be otherwise conceded to them."[1]

[1] Hecker, page 205.

Webster, in describing the malignant fever of 1795, states that sound potatoes for market perished in his cellar in thirty-six hours. He further says, in speaking of the pestilential fever of New York, in 1798, that he saw a cotton garment covered with dark gray-colored spots of mildew in a single night, and that such events were then and there common.

Boott, in his life of Armstrong, observes that "the most remarkable circumstance connected with the diseases supposed to arise from malaria is their general prevalence in autumn in every country where they occur."

Baron Humboldt remarks that "at Vera Cruz, where May and June are hotter than September and October, the latter months greatly exceed the former in the number and vigor of the fevers."

Professor Mitchell remarks that if mere vegetable decomposition were the cause of such fevers, we should find them most active in May and June, when decay is much more active than in autumn. In all countries the most unhealthy period of the year is when the phanerogams have completed their annual task of growth. This is the period when the microscopic cryptogamous growths develop in the greatest profusion.

In malarial districts the causes of intermittent fever only present themselves at night.

Dr. Mitchell further says: "The most common malarious diseases are not producible by exposure in sickly places during the daytime. Whatever may be their cause, it seems to have activity solely at night. Darkness appears to be essential to either its existence or its power. As this position is not generally acknowledged, it may be well to go into some details on this part of the subject.

"Dr. James Lind cites the following case: —

"'The Phœnix sloop of war, of forty guns, was employed, in 1766, on the coast of Africa, where also was the Hound, on the same duty. Both vessels, after a healthful cruise, put into the African island of St. Thomas, notorious for its pestilential character. Here, of the crew of the Phœnix, slept on shore seven officers and servants, while three midshipmen, five seamen, and one boy were also employed on a watering party which detained them on land at night. Of these sixteen persons, only two survived the malignant fever which followed. The remainder of the crew of two hundred and eighty men were permitted to go ashore in the daytime, where the men rambled about at pleasure, followed field sports, and washed their soiled clothing. Not one of these was attacked with any kind of fever, and before her return home the ship lost only one man, and he died of the effects of a blow on the head. The crew of the Hound were permitted to visit the shore only in the daytime. Of these not one died of the fever.'

"Another equally remarkable case is given by Lind: 'In 1776 some French Protestants settled in a paludal part of Florida, where finally most of them perished. On some business, they were visited by eight gentlemen, more healthfully situated at a considerable distance, who spent one night there. On the following day, seven other persons from the same place paid them a visit, but left their district before nightfall. Of the first party, every one was attacked with intermittent fever, and two died; while of the other party not one individual suffered in the slightest degree.'

"Dr. James Johnson, in treating of this subject, remarks that while cruising or at anchor between Batavia and Malacca, his crew lost but one man by fever among those who had not spent the night on shore; whereas almost every one who slept even a single night at Edam died.

"No ill effects were experienced by going on shore in the daytime. Even being awake during the night, when on land, did not protect the seamen from danger.

"Salter says, when speaking of the danger of exposure to the land air at night, 'Every man who slept ashore died. The rest of the ship's crew remained remarkably healthy.'[1]

"On the authority of Surgeon Allen, we learn that 'at Zanzibar all who slept on board ship escaped. Every victim seen or heard of had passed at least one night on land. The captain and forty men from a French corvette, who passed the night on land, were attacked by the coast fever, and not one survived.'

"Dr. Evans, writing from the unhealthy island of St. Lucia, observes that 'during the day the sportsman wades through the stagnant waters and mangrove bushes which cover the surface of the West India fens, with comparative immunity; but long before the sun has disappeared, he places himself beyond the reach of their poisonous effluvia.'

"Mr. Webb, Inspector of Hospitals, stated before a committee of the British House of Commons that the men who remained on board the ships, in a noxious climate (Walcheren), were extremely healthy, although they went on shore to bathe and exercise daily, but never remained on land at night. Yet it was in that very place that the English army, encamped or lodged on shore, was almost annihilated by malignant intermittent.

"In Major Tulloch's report on the health of the military and naval service, he observes that 'the sickness of the shore very rarely extends to the shipping,

[1] *Medical Naut.*, vol. i., p. 456.

though only a few hundred yards from the land. The visits of the sailors on shore by day could not produce disease. In the Ceylon service the mortality of the marine force, by fever, was three in one thousand; of the military, two hundred and forty-six to the thousand.'" Many other instances could be referred to, to show noxious emanations from certain lands at night, while during the day the emanations are innoxious.

The reasons of this will appear farther on, when we come to speak of the true cause of intermittents.

Dr. Mitchell remarks further that "not only are the fungi generally poisonous to a singular degree, but the phenomena attendant on their introduction into the system are so peculiar as to arrest the attention both of the toxicologist and pathologist. In most cases the poison lies dormant for a time after its ingestion; then excites a morbid action of a febrile character, continued in some instances, remittent or intermittent in others, which is sometimes followed by abscesses or gangrene, as observed in typhoid fever or plague; occasionally by lockjaw or yellow skin, as in yellow fever, even when habitually using fungous food of a slowly poisonous quality, such as rye affected with ergot.

"Females of adult age, and the richer classes of society are, to a remarkable degree, exempted from the disease producing impotency, which exerts itself so disastrously in some parts of France and Switzerland on the poorer and more exposed portions of society."

*Cutaneous Disease caused by Cryptogams.* — "Of late years it has been found that many cutaneous diseases, and at least one mucous disease, are, if not absolutely dependent on, at least closely associated with and aggravated by the growth of minute cryptogams. That these predatory fungi are really causes of the maladies with which they are uniformly connected is made still more probable by the demonstration of the existence in insects, and even many larger animals, of contagious cryptogamous diseases, which, transferred from animals to plants, and from plants to animals, become very destructive, not only to their immediate victims, but to important commercial interests dependent on them."

*Poisonous Properties of Cryptogams.* — So poisonous is the Agaricus muscarius that flies lighting upon it are killed, for which reason it is used as a fly poison.

Burnett quotes several cases where death has arisen in persons who have eaten mouldy bread, mouldy pork, mouldy cheese, mouldy ham, pie, etc.

Burnett quotes one peculiarity of fungoid poisoning as common — that it almost invariably produces fever.

The Agaricus muscarius produces shivering, followed by that kind of delirium which attends an ardent fever.

"The use of potatoes affected with 'potato rot,' caused by and containing Perinospora infestans, produces, in the first place, rigors, heat of skin, accelerated pulse, and abdominal pain; in the second stage, rose-colored spots, migratory and evanescent, and diarrhœa; in the third stage, tumefaction of the muscles of the neck, shoulders, and arms, acute pain there, and, in the worst cases, erysipelas of the face and scalp, and œdema of the eyelids." [1]

Large single doses of ergot produce, first, anorexia, nausea, vomiting, dryness of the throat, and thirst; second, abdominal pain, tumefaction, and diarrhœa; third, weight and pain of head, giddiness and delirium, dilated pupils, somnolency, coma; fourth, distended circulation by increased fullness and frequency or feebleness and slowness of the pulse. Its repeated use not only produces febrile symptoms, but, as in malignant fevers, a disposition to dry gangrene, the fingers, toes,

[1] O'Brien.

and legs often becoming lifeless, dry, and dropping off at the joints.

Ergot then produces symptoms analogous to malignant fevers.

In 1826, Dr. Westerhoff saw two children who had been poisoned by mouldy bread. "Their faces were red and swollen, excited and haggard, tongue dry, inextinguishable thirst, feeble and frequent pulse, abdominal pain, vomiting and purging, vertigo, headache, great depression of mind and body, mental indifference, and somnolency."

"On the 10th of June, 1839, at a musical festival at Aldenfingen, about six hundred persons ate various kinds of meat, which, after being cooked, had been kept in a badly ventilated cellar for nearly three days. Upward of four hundred of them were within ten days attacked by nausea, vomiting, some mental disturbance, colic pains, tenderness of the epigastrium, and diarrhœa. In the progress of the cases, distended circulation, constipation, fetid evacuations, and tympanitis allied the cases to typhoid fever, and nine died with the fever.

"An autopsy revealed inflammation or ulceration of the lower part of the ileum. Those who did not go to the festival, but partook of these cold meats at home, suffered in a similar manner; while those at the festival who dined on bread and cheese escaped all disorders."

"Diseased wheat produced at Wattisham a sickness with sphacelation. Seven persons of one family suffered the loss of one or more of their limbs, and one had blackness of two fingers, but recovered."

"The febrile disease from the use of rye," according to Thompson, "is most prevalent in wet or moist seasons, and in thirty-three years Mr. Newell met with this malady three or four times, and always in rainy or moist seasons. He also says that among fifty patients he did not find one woman; and here he makes the curious statement that only the poor and ill-fed were its victims."

"The famous sweating sickness usually commenced with a short, shivering fit, which in malignant cases convulsed even the extremities. Many experienced at the beginning a disagreeable creeping sensation of formication on the hands and feet, which passed into pricking pains, and an exceedingly painful sensation under the nails. Some persons were afflicted with swollen hands and feet. In many the countenance was bloated and livid, the heart trembled and palpitated, and lividness and rapid decomposition evinced the tendency to sphacelation. The plague, with its symptoms, its abscesses, and its mortification, might be taken for a case of fungus poisoning in its more intense forms."

## PERIODICITY OF SYMPTOMS.

Another curious effect of poisonous fungi on the system is their tendency to produce remittent or intermittent symptoms — the tendency to periodicity. Christison tells us of a whole family, consisting of a woman and four children, who were attacked by a tertian fever occasioned by living exclusively for four months on edible mushrooms. The peculiar cause of the fever was made more manifest by the fact that the husband of the woman, who lived on other fare, escaped all disease; while a cutaneous eruption and subsequent gangrene of the extremities attacked finally those who had the fever. Westerhoff observed in those who were poisoned by mouldy food an intermittent somnolency, which he termed a remarkable feature of the case.

Mr. Gassang saw cases of ergotism, where the sensations either of heat or cold were intermittent.

A young woman who ate a dish of Agaricus clypeatus, and was attacked with nausea, vomiting, bilious stools, and a frequent pulse, had a marked remission on the fourth day. The patient was at ease throughout the night, the skin was moist, and the pulse better. The other symptoms all abated, and the patient slept.

On the fifth day the symptoms returned, with delirium, sighing, anxiety, failing pulse, great dyspnœa, partial yellowness of skin, and even a locked jaw, as in some cases of yellow fever.

A reverend gentleman of New York City, in 1845, went with his family to a place about three miles from the Hudson, near Sing Sing. It was selected because of its reputation for health and its exemption from malarial diseases. In August and September, when mushrooms were very abundant, and when the country people abstained from their use under the impression that they disposed them to fevers, the clergyman's lady, in her frequent drives, collected them daily, and for some time subsisted almost exclusively upon them. The remainder of the family ate them more sparingly and less frequently. About the end of September the lady was attacked by an irregular fever, without periodical chills, but marked by an exacerbation on every second day. Thus the nature of the case was not suspected until the return of the attack in the spring, which became regularly periodical in June, and assumed a distinct tertian form. It was then readily cured by quinine and other intermittent remedies.

Caffort alleges that the Agaricus fimentarius is found in ill-conditioned wounds.[1]

Mery and Lemery cite cases where fungi grew on the skins of animals, even when not wounded or ulcerated.

Schoenlein and Remak observed, and Fuchs and Langenbuch confirmed the observation, that forms apparently vegetable, and of fungiform structure, rooted themselves in the skin of Porrigo favosa. Greeby subsequently determined that the crusts of Porrigo are almost entirely composed of the plants. The vegetable nature of the disease seems to be established by the transfer of it by inoculation to a phanerogamic plant, thus imparting to a vegetable a disease contagious in man.

More recently microscopists have detected vegetations in Porrigo lupinosa, Impetigo scrofulosa, serpiginous ulcers, Sycosis menti, and Porrigo decalvans.

The mucous membrane as well as the skin affords a a nidus for cryptogamous growth — aphthæ.

Dr. Goodsir describes curious vegetable organisms developed in the stomach during indigestion.[2]

Mr. Greeby and Dr. Goodsir have both detected what they call fungoid cells in Pyer's glands in typhoid fever.

Muscardine is a disease in silk-worms in which the whole sebaceous matter is exhausted, the blood greatly

[1] *Annal de Montpellier*, 1808.

[2] Sarcina Ventricula, identical with an alga found in hydrant water.

altered, and the worms destroyed by a species of cryptogamic mould (Botrytis bossiano, Grev.). A few of the spores placed on the back of healthy silk-worms are sufficient to impregnate the whole body. It takes its name from the resemblance of the diseased caterpillar to a peculiar kind of pastile.[1]

Christison says that one of the greatest peculiarities of fungus poisons is the interval before attack, and the difference in that interval. M. Pauler, in his work on mushrooms (1812), says that the extract and alcoholic tincture, and even the juice of the Agaricus bulbosa and vernus, when given to dogs, did not make them sick in less than ten hours after their administration.

Christison mentions the poisoning of six persons by the Hypophyllum sanguineum, or toadstool, in Scotland, most of whom were attacked after the lapse of twelve hours, one after twenty hours, one after twenty-four hours, and the last in thirty hours.

Gmelin quotes seventeen cases which did not exhibit symptoms of intoxication until the expiration of a day and a half after the meal at which the poison was swallowed.

Corvisart's journal relates that, of some soldiers who ate of the Agaricus muscarius, a part were attacked with gastric symptoms almost immediately, but that others were indisposed only after the lapse of more than six hours, of whom four died.

Malarial poisons do not seem to be transported usually for any great distance from the point of their origin. It is stated by authors entitled to credit that the wearing of a gauze veil, or the stretching of a gauze screen across an open window, adds much to the security of the wearer or the occupant of the chamber in even the most miasmatic localities. It is believed

[1] *Mic. Dictionary,* third edition.

to be very unhealthy to sleep in damp, mouldy sheets. The dust from old books that have been long packed away often excites coryza, and inflammation of the Schneiderian membrane, and local fever of throat and air passages.

There is abundant evidence that miasmatic poisons of certain kinds, as that of yellow fever, etc., may be transported for long distances in trunks of clothing, in the holds of ships, etc. Dr. Rush mentions one trunk case in detail, and says that he heard of two other instances, in all of which only those suffered who opened the packages. According to William Stevens, of Santa Cruz, " the poison is made more intense by being confined in clothes and bedding."

In 1747, the trunk of a young supercargo, who died at Barbadoes, was opened in Philadelphia in the presence of Mr. Powell, Mr. Halton, three Welshmen, a cooper, and a boy of Mr. Powell's; all sickened and died of yellow fever within a few days.

Hassock says: " I have seen the cases of some servants attacked by yellow fever, upon receiving the clothing of a relative who had died of that disease in the West Indies, at a time when there was no yellow fever in New York." He also further says that "after the death by yellow fever of the late Gardner Baker, while on a visit to Boston when it prevailed epidemically, his clothes were sent home to his wife, then a resident of Long Island. The opening of the trunk was followed by yellow fever, of which Mrs. B. died. No disease of the kind existed in New York or its vicinity at that time."

That the poison of yellow fever is thus transported, there can be no longer any doubt. It is only thus that we can comprehend how a perfectly healthy crew may bring with them, in the close hold of their ship, the germs of disease, which after their dismissal may pestilentially affect the stevedores who discharge her, or only the laborers who disturb the ballast. We can thus explain the usual pause between the first set of cases caught by visitors to, or laborers on board the ship, and the attack upon the inhabitants of the vicinity. This curious interval, noticed by almost every writer, occupies from about ten to fifteen days, while the period of incubation after exposure to a known source of infection is only about five days. (Vachi.) This interval is only to be explained by the supposition that germs of some kind have gained a footing on shore, have grown, and become more numerous. It is the crop in the hold which produces the first set of cases. It is the crop on land that causes the second.

Different fungi affect different animal organisms differently. The Agaricus clypeatus of the west of Europe poisons in one way, the Amanita muscarius of Siberia in another. One irritates, and the other intoxicates.

So a certain kind of Mucor produces dysentery, another typhoid symptoms, and a third excessive vomiting.

The ergot of rye excites formication, fever, and sphacelation; the ergot of maize, fever, loss of hair and nails, etc.

So far as known, the effects produced by the introduction of poisonous cryptogams into the system are interesting and peculiar. In most cases no abnormal symptoms present themselves for some little time after the reception into the body.

This dormant period may be called the incubative period. After this period, which may be longer or shorter, a train of abnormal symptoms is ushered in, which is of a febrile character. These are sometimes continued, sometimes remittent, and at other times intermittent. These are always accompanied by abnormal conditions of the epithelial tissues. Sometimes the epithelial derangements are confined to the glandular tissues internally, and at others they are confined to the cutaneous and mucous surfaces. The same cryptogamic poison always produces the same or similar abnormal states. The eating of mouldy food, such as meat, pies, bread, and cheese, has been known to produce severe sickness and even death. The symptoms, so far as noted, are those of a febrile character, often preceded or accompanied by algid symptoms. The Agaricus muscarius produces, after an interval, rigors followed by a train of symptoms resembling febrile intoxication.

In diphtheria I have found the mycelium of a Mucor resembling somewhat the Perinospora infestans, growing in the exudations, and in the subjacent epithelial tissues. I have called this the *Mucor malignans*.

In a lengthy series of experiments connected with the cause and prevention of camp measles, published in the July number of the "American Journal of the Medical Sciences" of 1862, there appeared the strongest evidence for the belief that the minute cryptogams growing upon old straw under certain states of the atmosphere, and under peculiar circumstances, may produce measles, etc. In erysipelas, so far as my investigations have gone, there appears to be developing in the capillary vessels of the parts affected the mycelium of a beautiful species of Penicillium. The developing mycelium clogs up the capillary vessels, and the tumefaction and redness keep pace with the extending filaments of the fungus. It requires much care and experience in microscopic manipulations, as well as a thorough knowledge of the appearance of fungoid filaments developing in animal tissues, to determine the presence of fungoid mycelium in the blood of the capillary vessels in erysipelas.

Inexperience and the want of knowledge of these organic forms subject one to constant error. Such observations require time, patience, and skill.

In the early settlement of Ohio and other portions of the Western country, there appeared a disease known as the "wheat sickness." The eating of the flour of wheat from certain localities would always produce rigors, febrile symptoms, nausea, and vomiting. The wheat from which such flour was made always had a small reddish spot about the size of the head of a pin situated on the chit. There is no doubt that this was a fungus developing in the grain.

In certain glycogenic states of the system a species of Penicillium (Torula) develops in the secretions of the mucous membranes so rapidly that a white curdy crust is formed on the tongue, throat, fauces, œsophagus, and sometimes dips down into the trachea. This growth resembles the diphtheritic exudation, and is usually taken for such. The microscope readily settles this question. This growth is very apt to occur in low states of the system in all such as feed too exclusively upon farinaceous and saccharine food. Such patients are subject to flatulence, prickling, or paralytic sensations in hands, feet, and legs, with a mixed up, confused feeling in the head, a partial loss of memory, etc. Exhausting diarrhœa frequently follows, which often proves fatal. In these states the patients are frequently affected with rigors, small pulse, and great anxiety, followed by febrile symptoms.

The use of rye containing a parasitic fungus often results in febrile symptoms, accompanied and followed by a congestive state of the capillary vessels, which frequently results in gangrene of the extremities, etc.

Similar symptoms have been observed from the use of diseased wheat.

The above is deemed sufficient to show the cryptogamic tendencies of modern writers, of whom the late Dr. Mitchell, of Philadelphia, stands the most prominent. Dr. Drake, of Cincinnati, published a paper on this subject about the same time, in which he advanced about the same views, without any knowledge of Professor Mitchell's publication. Further on we shall allude to the researches of still later times.

## MORPHOLOGY OF THE SECRETIONS OF AGUE CASES — MORPHOLOGY OF THE AIR AND SOIL OF AGUE DISTRICTS.

We now proceed to the subject proper of this paper, a brief description of a series of investigations connected with the cause of intermittent fever. What I have to say may be embraced under two heads: —

First, *The investigations connected with the sputum, the urine, the blood, the sweat of persons suffering under what is called intermittent fever.*

Second, *The investigations connected with the bodies suspended in the night air of the malarious levels, and inhaled; and also the investigations connected with the study of the soils of malarious districts. These divisions may become somewhat mixed in the account, from natural causes; still I shall try to be as explicit as possible.*

### HOW THE OBSERVATIONS CAME TO BE MADE.

During a lengthy series of careful experiments, connected with camp diseases and those affecting vegetation, as the curl in peach leaves and the blight in apple, pear, and quince trees, etc., and in studying the causes and consequences of fermentation, gangrene, decay, and the changes going on in diseased tissues, I was led by some of the experiments connected with bodies suspended in the atmosphere in the direction of causes of fevers, and especially those of an intermittent type.

Intermittent fever began to show itself in the rich malarial districts of the Ohio and Mississippi valleys in

1862, during the month of May. It did not, however, prevail to any great extent till the months of July and August. The weather had been unusually damp up to about the first of July. During the months of July, August, and September there was scarcely any rain. Springs and streams became very low; swamps and humid grounds became dry; vegetation almost entirely ceased to grow, and the country presented all the signs of a severe drought. The disease, which became quite general during the month of July in ague districts, increased rapidly till about the 20th of August, when, in the vicinity of places above named, the disease had invaded nearly every family.

The examinations connected with this inquiry were begun during the month of June. Through the kindness of Drs. Boestler and Effinger and several other friends I obtained, for microscopical examination, blood, urine, sweat, and sputum from numerous patients laboring under various types of the disease.

The blood was drawn either just before the chill, during it, during the febrile stage, or the period of sweating.

The urine was obtained at all stages of the paroxysm and during the interval.

*Sputum Examination.* — My first step was to examine microscopically the sputum of those laboring under intermittent fever, and exposed during the evening, night, and morning to the cool, heavy vapors rising from stagnant pools and low, humid grounds. The morning sputum was that used. In this occurred uniformly, and usually in considerable abundance, minute oblong cells, either single or aggregated, and with them a variety of other large cells, mostly algæ, but none of which were so abundant and uniformly present as the peculiar, minute, oblong cells just mentioned.

SEARCH TO FIND OUT WHERE THESE CELLS CAME FROM.

I began suspending rectangular plates of glass, sixteen by twenty-two inches, about one foot above the surface of stagnant pools and marshy grounds that were partially submerged. The plates were placed horizontally, each resting on four pegs, a single peg supporting each corner of a plate. The plates were placed in position at dusk, and secured in the morning before sunrise. Invariably the under surface of the plates would be covered thickly with large drops of water. This condensed vapor was subjected to careful microscopical examinations. I found many of the unicellular algæ that I had previously found in the sputa above named. But the oblong algæ so uniformly present in the sputa were rare. I repeated these experiments for many nights, varying widely the localities, with the same results.

In going to the stagnant pools and swampy grounds southeast of the city of Lancaster, Ohio, to suspend the glass plates, I had to pass over a rich, peaty, prairie bog, where the water had become mostly dried off, and the surface broken by the tread of cattle. I had noticed that in walking over this ground a peculiar, dry, feverish sensation was always produced in the throat and fauces, often extending to the pulmonary mucous surfaces; and that my sputum was, after returning, uniformly filled with the minute, oblong cells, above described. This drew my attention to the partially desiccated, peaty bog, where the surface had been broken by the tread of cattle. I discovered on the recently exposed earth what appeared to be a whitish mould, or more closely the incrustation of some salts.

I here suspended the plates of glass, and the following morning, much to my delight, found the inferior surface of the plates covered with the minute unicellular algæ which I was in pursuit of. I immediately returned to the bog and secured samples of fresh earth that were covered with the incrustation and some that were not, and also portions of the boggy turf. On placing a fragment of the incrustation under the microscope, it was at once discovered to be made up of aggregated masses of the minute unicellular algæ so uniformly met with in the sputa of those exposed to the influence of cool vapors of the ague districts. It was further seen that there were several species of palmellæ, and that the larger ones were infested with parasitic fungi.

The locality from which these first results were obtained is situated on the southeast side of the city of Lancaster, Ohio, between the canal and railroad, just east of the starch factory.

Here stretches out to the southeast along the canal, a low, peaty, prairie bog (and in its vicinity the grounds are low and humid), containing from seventy-five to one hundred acres. The portion of the town (Third Ward) adjoining this bog is all of it situated below the line about thirty-five feet above the bog; has always been a fertile field for intermittents. Those living immediately on the edge of the bog are frequently subjects of ague yearly, from May to November. August and September are usually the worst months.

Having progressed so far with the experiments, and having arrived at results which appeared to throw some light upon the cause of intermittent fevers, I continued the investigations with renewed zeal.

## MODE OF COLLECTING BODIES IN THE AIR ELEVATED BY THE NIGHT VAPORS.

A glass screen standing perpendicularly, and in front of it a large funnel with a broad open end pointing from the screen and the small end terminating within one half inch of it.

This was arranged on a pivot so constructed that the force of the currents of air kept the broad mouth of the funnel toward the wind. When an observation was to be made, the screen was covered with glycerine and the apparatus suspended at the desired height, and left for one or two hours. The wind passing through the funnel and falling upon the coating of glycerine would deposit the small particles upon the smeared, suspended screen, while the air would pass out at either side. This was my "*aspirator*."

On examining under the microscope the glycerine on the screen, after an hour's suspension, all the bodies floating in the atmosphere would naturally be expected to be found in it.

By suspending the aspirator at different heights above the low, ague lands, at all hours of the day and night, the following facts were ascertained: —

1st. That cryptogamic and other minute organic bodies are mainly elevated above the surface during the night. That they rise and are suspended in the cold, damp exhalations from the soil after the sun has set; and that they fall again to the earth soon after the sun rises.

2d. That in the latitude of Ohio these bodies seldom rise above from thirty to sixty feet over the low lands. That in the northern and central portions of the State they rise from thirty-five to forty-five feet, while in the southern from forty to sixty feet.

3d. That at Nashville, Tenn., and Memphis, and farther south, they rise from sixty to one hundred and more feet above the surface.

4th. That above the summit plains of the cool night soil exhalations these bodies do not rise, and intermittents do not extend.

5th. That the day air of malarious districts is quite free from these palmellæ and from causes that produce intermittents.

## LOCAL SYMPTOMS.

To trace more carefully the symptoms of the local fever produced in the mouth, fauces, throat and air passages by inhaling the emanations from the incrustations of the rich, freshly exposed soil of bogs and humid grounds, on September 2, 1862, I visited the bog above referred to, and spent some time in wandering over its surface, examining the incrustation, and in collecting samples for further microscopical examinations. In less than ten minutes after my arrival on the bog, I began to feel a dry, feverish, constricted feeling in the mouth, fauces, and throat. This feeling increased till the fauces and throat became very unpleasantly parched and feverish. The opposite walls in swallowing adhered together, and the normal mucous secretions were entirely checked. There was a constant desire to swallow and hawk and spit without being able to raise much of anything, or to relieve in the least the dry, feverish, constricted sensation. This feeling soon extended downward to the bronchial and pulmonary surfaces, which became dry, feverish, and constricted, with a heavy, congestive feeling and dull pain. These peculiar symptoms lasted about two hours before they had entirely disappeared. The malarious matters inhaled appeared to be poisonous to the surfaces with which they came in contact, and there seemed to be an effort on the part of the exposed mucous surfaces to close up their absorbent and secreting organs until this poisonous matter could be dislodged by the swallowing and hawking and spitting which they excited.

On the morning of the 3d of September I again visited the bog to obtain more specimens for examination, and to study still further the symptoms produced by inhaling the malarious matters of ague bogs. I remained walking over the surface for about one half hour. The same train of symptoms manifested themselves that I experienced on the previous day; being quite as severe, and lasting quite as long.

On the evening of the 3d, just at dusk, I again visited the bog to suspend plates of glass. I remained only from ten to fifteen minutes. I had scarcely left the ground when the dry, constricted, feverish feeling of the air passages began, and I experienced the same train of symptoms as on previous occasions. Between this and the last of October I daily visited this and other like bogs, always with the same result.

On September 18th, Dr. Effinger, at my request, accompanied me over the bogs, with the view of determining whether he would be affected with the same train of symptoms as myself. In a very few minutes after our arrival the symptoms began in his case, as in my own; and he described them precisely as they have been already stated.

On September 20th, Dr. Boestler walked over the bog with me, and experienced the same symptoms. He remarked that he had often experienced the same or like sensations before without knowing the cause. He also stated that mouldy straw and hay had frequently excited like symptoms in his case.

Numerous other persons who visited ague bogs with me, and grounds where the palmellæ were growing (of the oblong type already described), were invariably affected with the same train of symptoms.

The only constant foreign bodies found in the expectoration of those affected with above local symptoms, excited by walking over ague bogs, and those exposed to damp, heavy night air of ague districts, are those found in the peculiar plants previously mentioned, growing upon the broken soil of low, rich grounds. It is hence inferred that the minute unicellular algæ are capable of exciting local fever in the mucous surfaces with which they come in contact; further, that there is strong presumptive evidence, from what has been previously determined, that by repeated and continuous exposure to them, they may cause general fever of an intermittent or remittent type.

On the northwest side of Lancaster, in the vicinity of the old canal mill, is another district of considerable extent, where the people are universally subject to ague. With the view of exploring for the local cause, I visited the locality September 12th. Immediately west of this is a wide, low, rich prairie. A few rods south of the mill, and also west of it, I found the ague plants growing luxuriantly, covering the surface of the soil recently thrown up by moles and exposed by the traveling of cattle. While collecting samples of these plants, I became affected with all the peculiar symptoms of local fever previously described.

On the north side of the town of Lancaster, immediately on the west and south side of Mount Pleasant, is another locality where ague prevails in its worst forms, often running into fever of a continued type.

There is a low belt of ground running through this locality, along which are stagnant pools of water. Around these pools and in the rich, humid, broken soil of the vicinity, I found the ague plants growing in profusion. While gathering them I experienced all the symptoms of local fever as above described.

On the Columbus road, about one mile northwest of the city of Lancaster, on the farm adjoining, on the north, the old Tallmadge farm, occurred suddenly, about the middle of September, a severe case of ague in a strong, healthy young man. This locality had been previously exempt from the disease. I visited the point in connection with Dr. Effinger, who was attending this patient.

About fifteen rods south of the house we discovered a new ditch, about ten rods long, running through a piece of low, black, humid ground. The freshly thrown out earth and the sides of the ditch were covered with ague plants; and while procuring some for examination, I experienced all the local febrile symptoms above described. This ditch was dug about two weeks previous to the occurrence of this case of ague.

On September 21st, in company with Dr. Effinger, I visited Mr. C. and family, who reside five miles northwest of Lancaster, in a locality previously exempt from ague. Mr. C. was attacked with a severe form of the tertian type of intermittent fever on September 1st, and his wife on September 3d. The paroxysms were arrested on the fourth day of the disease, with quinine, by Dr. E., their attending physician. Relapse on the 15th, arrested after the second paroxysm. Both Mr. C. and wife, on September 21st, were much debilitated, pale, and sallow. Mr. C.'s house stands upon the edge of a low terrace, elevated about twenty feet above the prairie bottom, which approaches within about fifteen rods of it on the south and southwest sides. About fifty poles southwest of the house, a small creek running through the prairie bottom empties into the canal. This creek, during rains, washes in sediment, and makes a troublesome bar across the canal.

The lessees of the canal had purchased, a short time previous, of Mr. C., an acre of ground at the mouth of this creek, for the purpose of excavating there a reservoir to receive the sediment of the creek. About the middle of August, workmen began the excavation. The soil removed was a rich, peaty loam, with some black and blue clay. Very soon after the work was begun the workmen began to be taken down with ague. In September, Mr. C. was also taken down.

September 21st, we found excavated soil covered with ague plants, and collected some. We contracted the local fever as above mentioned. Mr. C., who went with us, was obliged to retire. He said that he and Mrs. C. slept in a room in the southeast corner of the house, on the lower floor; while their children, seven in number, from two to fourteen years of age, slept on the second floor, above them. They escaped the fever. That the fog early every morning rose about two thirds up the first story, entering his own apartment freely through the open windows; and that it had the same odor as the soil excavated, and produced the same local febrile symptoms of the air passages. That he never had known the fog to rise as far as the windows of the story where the children slept. That the fog dissipated soon after sunrise and before his children were up. That he had lived there over forty years; had not had the ague before; that all his neighbors on the same and lower levels were now suffering from the disease. I mention this case particularly as it is of peculiar interest, showing in a striking manner a quite uniform and marked line, indicating the summit plane of invasion, above which the malarious causes do not extend.

In the east half of the city of Lancaster stands a hill containing fifty or more acres, upon the sides and summit of which the finest portion of the town is built. It rises to the height of sixty feet above the ague bog, lying near its base, and on its south and southeast sides heavy, cold, night vapors emanating from these bogs rise within about fifteen feet of its summit. The upper surface of these vapors in the morning before sunrise is seen from the surrounding hills to be a broad, level plain, limited by its contact with the adjacent hills. The line described around this hill by the upper surface of these vapors is a horizontal one, and defines distinctly the ague line. All of those living on the hill above this line are exempt; all below are subject to this disease. If any cases occur above the line, they are found to be in such persons as frequent lower levels during the evening or early morning.

During the summer of 1862, and especially during the months of August and September, intermittent fever prevailed to a remarkable extent in the town of Carroll, situated on the canal, eight miles northwest of Lancaster, Ohio. The site of the town and much of the surrounding country is low, and many boggy places occur along the canal. In these months, old and young of almost every family, including physicians, were down with the disease. I visited this locality several times, and found the ague plants growing abundantly on the partially desiccated soil, along the canal, through the town and vicinity.

The sputa of all examined were found to be filled with the ague palmellæ.

Numerous other localities were visited where intermittent fevers prevailed, and in every instance, without a solitary exception, the ague plants were found growing in the immediate vicinity. In no instance were they found where the disease did not occur.

An interesting instance of the readiness with which the emanation from these ague plants produced the disease presented itself the last of September, one mile west of the city of Lancaster. Here, a few poles south of the pike and fifty poles west of Judge Van Tromp's residence, is a little pond that affords water to a small flouring mill. In September and August the water was low in this pond, and ague plants made their appearance in abundance on the drying, peaty mud from which the water had retired. The wind was south. There being no buildings on the north side of the pond, the disease did not appear. Near the last of September the weather became cool, the wind changed, and blew briskly from the north and northwest. About thirty poles, a little southeast of the pond, twenty-five to thirty feet above it, on the side hill, resided a strong, healthy, laboring family, who, up to now, had been entirely free from ague. The wind blew over the pond directly to this house. About the fourth day several members of the family were taken down with the disease. The wind now suddenly changed to the southeast, blowing across the pond, directly toward the toll-gate, about forty rods distant, where a family resided in which were four small children. This family had been up to this time also exempt from the disease. The third or fourth day two cases of intermittent fever appeared among the children, and soon after the father was attacked. Here is an interesting instance of the transmission of the malarious influence by the wind. These families had lived for nearly two months in the vicinity of an abundant crop of ague plants without taking the disease. The pond being small, banks abrupt, and soil around dry, no fog or night vapors emanated from the place to diffuse the poison. What malarious matters there were emanating from this point were borne north by the prevailing south wind. As soon, however, as the wind changed and blew over the pond toward the neighboring abodes, the disease in a few days appeared.

Another interesting instance came under my observation in the city of Columbus, Ohio. On a visit to this place during the last of September, 1863, I met Mr. T. H. Tallmadge, who said to me that his children were all coming down with ague. He stated that his family had been spending a few weeks at White Sulphur Springs, and that about two weeks before they had returned home all hearty and well. In a few days after their return, one of his children came down with ague, and soon after another. This surprised him, as ague had not previously been known to occur at his residence on Broadway. Feeling satisfied that there must be some local cause, I on the following morning repaired to his house and examined his grounds. I immediately discovered a prolific crop of palmellæ just back of his house, in some new, peaty soil he had drawn there a few weeks previous, to level off the surface. I directed him to sprinkle the surface of this new soil thickly over with caustic lime, after which he had no more attacks in his family.

On the rich, low limestone lands of the Maumee and Miami bottoms in Ohio, the black alluvial land of the Wabash and its tributaries in Illinois and Indiana, the fertile prairie lands of these States, and Missouri and Iowa, and on the rich, low limestone and alluvial lands of Kentucky, Tennessee, and Mississippi, ague plants develop in great luxuriance, especially during the months of July, August, and September. For the most part, wherever the soil is free from lime and the water soft, the ague palmellæ developed are mostly white, or slightly tinged with yellow or green, and the intermittents are comparatively free from congestive tendencies, and the types better marked. The eliminating organs are much less liable to become badly deranged, and the paroxysms more readily yield to the tonic influence of quinine and iron, and the disease usually is quite promptly and easily controlled unless the system be exposed to continued and constant accessions. In limestone regions, however, where the water is hard and the soil highly calcareous, there is a remarkable tendency during the months of July, August, and September, for the soil to become covered with a greenish, brick-colored, or plumbous-hued dust or film — numerous palmelloid cells (plants), usually of a pink, brick-dust, greenish, or yellowish color, with which are confervoid filaments, frequently variously colored. The brick-dust and greenish-colored cells are the most abundant.

Where the brick-dust and greenish plants prevail, the intermittents are apt to assume a congestive type; the functions of the eliminating organs (epidermic and mucous surfaces and portal and renal glands) become much deranged and partially suppressed. Oxaluria is almost constantly found, and in this state of the system quinine does but little if any good, and often, in old and bad cases, aggravates the paroxysms. If, however, in these severe forms the functions of the eliminating organs be restored to their normal or to increased activity by the proper diuretics, diaphoretics, expectorants, and alteratives, the paroxysms readily yield to the tonic influence of quinine and iron.

## COLLEGE HILL, NASHVILLE, TENNESSEE.

This hill rises from seventy-five to one hundred feet above the level of the Cumberland, which flows around its northern and eastern base. Upon its summit is an area of six to ten acres. Upon this area stood the University of Tennessee, and the residences of several of the Faculty.

When the Federal forces drove the Confederates from Nashville, all the eminences in and around the city were fortified for the better defense of the place. This hill was strengthened by a ditch six feet wide and four feet deep, with the excavated earth thrown on the outside, and running around on the eastern and southern fronts, which face the adjacent country. Soon after the University buildings were appropriated for hospital purposes. This high point was supposed to be peculiarly healthy, from its elevated and airy position, overlooking most of the city and surrounding country. As soon, however, as the warm weather of May and June set in, it was found that this high ground was quite malarious, giving rise to a peculiar type of congestive intermittent that was very severe, producing in some instances death. The attendants were more subject to the disease than the inmates of the wards. This probably arose from the fact that the former often exposed themselves to the evening vapors and exhalations outside, while the latter were mostly confined to the wards. This peculiar type of intermittent became much more severe during the months of July, August, and September. The surgeon in charge (Dr. Lynde) was under the impression that this malarious influence came from the low grounds to the east of the hill, which bordered the river and which were half a mile distant, and one hundred feet below. This, on careful inquiry, was found to be highly improbable, as the malarial influence was much less marked on this low ground than on College Hill.

On carefully examining the soil on the perpendicular sides of the ditch which was dug to strengthen the place, it was found covered completely with cryptogamic vegetation, forming in places a greenish and in others a brick-red film on the surface. Samples of this soil were preserved in tin boxes for microscopical examination.

On my arrival at Cincinnati three days after, this vegetation was carefully examined under the microscope, and found to be composed of green confervoid filamentous algæ and the unicellular palmellæ, having mostly a pale green or a brick-dust color. This vegetation was very prolific and abundant. The palmellæ were of a different species from those met with on non-calcareous soils, and were like those that are found in all districts where intermittents are of a congestive type. The outside cell wall of the red palmellæ is not readily made out, from its high transparency and entire absence of any perceptible contents outside of the central portion. This vegetation was collected on the ninth of October, and examined on the twelfth. Occasionally the soil on the surface of the hill where it had not been disturbed was covered slightly with this same vegetation. This was noticed all through the city and surrounding country, wherever there was any indication of a malarious tendency. It was not, however, noticed in any great abundance except where the fresh soil had been thrown up to a depth below where it had been usually disturbed in cultivation.

The city of Nashville stands on a series of small, conical, limestone eminences, which rise from fifty to one hundred feet above the river. The limestone comes to the surface or nearly so. This is so much the case that the rock is perfectly bare and denuded of soil over at least one fourth of the surface, while the balance has a covering ranging from two inches to four feet in thickness. Wherever a cellar is dug, it is sunk into the solid rock. The same may be said of all subdrains and sewers. The limestone is either massive, porous, or shaly, and is rich in fossil remains. The soil on College Hill is rather deeper than on most of the surrounding eminences; and this hill has a larger and more level summit area. The digging of this defensive ditch changed the health of the locality, so that instead of being the healthiest locality in and around Nashville, it had become decidedly the most malarious and sickly.

### LOUISVILLE AND VICINITY.

On the limestone soil surrounding Louisville, Kentucky, and in Jeffersonville, opposite, like species of confervoid and unicellular algæ are developed from the soil to those found at Nashville. All the low limestone lands appeared to be more or less malarious. Those just above Jeffersonville, where was being erected the new Jeffersonville U. S. Hospital, on the Chestnut Hill plan, are very malarious. This site is on a low terrace, about seventy rods back from the river, and rising about twenty feet above the river bottom. Immediately upon the brow of this terrace is located the hospital. The grounds had several sink holes which held water, now filled up. Around the base of the terrace, springs, for nearly a mile in length, make out, forming a boggy or swampy strip of ground from ten to twenty rods wide. The south winds blew over this directly to the hospital. The soil is black, sandy muck, underlaid with stiff clay, and produces during July, August, and September abundant crops of the plants I have called ague plants. Hence the hospital is unfortunately located.

## CINCINNATI AND VICINITY.

On the low grounds in and around the city and along the river and canal, the soil in August, September, and October is covered with a greenish film of cryptogamic vegetation. This is made up of confervoid and unicellular algæ in piles and aggregations massed together, developed by successive duplicated segmentation and fructification. The palmellæ are either green or red. They are represented at H, I, and K, Plate I., Fig. 1. The confervoid algæ are species of the Oscillatoriaceæ.

They are the same as found in other places, but the palmellæ are the algæ that I have invariably found in all places where I have studied the vegetation that grows in malarious districts.

Camp Dennison is located about sixteen miles from Cincinnati, on the Little Miami bottoms, twenty-five feet above the river bed on a calcareous limestone soil. The hospital inclosure contains one hundred and eighty acres of bottom land. Through it runs a shallow ravine forming a draining from the adjacent hills to the river. The northern fifth of the grounds, previous to draining them with open ditches, was damp, the water standing till evaporated. The wards on this soil were found to be unhealthy; the patients were very subject to intermittent fever. Since drainage the wards have been empty. Wherever the soil is exposed by eave-drains, ditches, etc., it is, during August, September, and October, covered with green algæ, which in some places become of a black ink color. They belong to the Oscillatoriaceæ; mixed with them are numerous palmellæ, one green and the other a red species. When mature, these plants send forth minute spores, which are elevated in the night vapors.

There is also met with in calcareous malarious soil another species, which occurs in irregular patches, giving to the surface a metallic, lead-colored appearance. By transmitted light they have a dirty, brownish green color. By reflected light they have a metallic, plumbous hue.

## CONSPECTUS OF MALARIA PLANTS.

The following conspectus exhibits more systematically the plants which I have found in their *natural habitat on the soil and in the night air of malarious districts, and which I have also found in the blood, sputum, urine, and sweat of persons suffering under ague.*

*Gemiasma.* — Unicellular plants, each consisting of a thin outside wall, inclosing an inside cell filled with minute microspores, either single or aggregated. Multiply by duplicative or segmentative division, within a parent membrane, and also developed from spores. Colors red, green, yellow, plumbous, etc. There are several species which seem to act as malarial poison. The brick-red, green, and plumbous plants are principally found upon rich, calcareous soils; while the greenish yellow and white varieties are found mostly on non-calcareous grounds.

*Gemiasma rubra.* — Color, brick-red; gives the soil the appearance of having been sprinkled over with brick dust; produces intermittent of a congestive type.

*Gemiasma verdans.* — Color, green.

*Gemiasma paludis.* — Color, greenish yellow. Found mostly on non-calcareous soils.

*Gemiasma plumba.* — Color, plumbous by reflected, and a dirty brownish green by transmitted light.

*Gemiasma alba.* — Color, greenish or yellowish white.

In all these species the mass of the visible dust or incrustation of the soil is usually made up of incalculable multitudes of minute spores that have escaped from the plants beneath them. These most minute of all organisms are elevated in the night earth exhalations. Another type consists of jelly-like protuberances, single or in groups, made up of a thin external membrane inclosing a highly transparent, gelatinous material filled with minute double-walled spores. This type has received the generic name of Protuberans. (Ag. gave the name to this species.) A, T, Fig. 2, Plate I.

In these the double-walled spores are developed in a highly transparent, jelly-like frond, surrounded by a delicate membrane. These are of various shades of green, yellow, brown, and perhaps other colors.

Another type of plants seems to multiply by the extending laterally of a thin lamina or gelatinous layer, which, like the protuberant variety, consists of an outside parent membrane, within which is a gelatinous matter, filled with a multitude of minute double-walled spores, which escape in vast numbers as the lamina dries. This type has received the generic name Lamella. B, Fig. 2, Plate I. All these genera have spores of a like structure. They are more or less oval or oblong, and have double walls.

## EXPERIMENTS CONNECTED WITH THE PRODUCTION OF INTERMITTENT FEVER, BY INHALING THE NIGHT EXHALATIONS FROM SMALL BOXES OF DEVELOPING AGUE PLANTS.

To obtain more positive evidence of the intimate relation between the cause of intermittent fever and the algæ grown on dry, humid soils, I filled six tin Seidlitz powder boxes with the surface earth from a decidedly malarious, drying prairie bog, which was covered with the palmellæ above described. Cakes of the surface soil were cut out the size and depth of the boxes, and fitted carefully in, without disturbing more than needful the surface vegetation. The covers were then placed on, and the boxes transported to a high, hilly country, five miles distant from any malarious locality, and where a case of ague had never been known to occur.

It was over three hundred feet above the stream levels, was dry, sandy, and rocky. I here placed the six boxes of ague plants on the sill of an open second story window, opening into the sleeping apartment of two young men. I removed the covers and gave particular directions that the boxes should not be disturbed, and the windows left up. Suspending a plate of glass over the boxes, on the fourth day I found the under surface completely covered with the palmellæ (Gemiasmas); on other plates suspended in the room at the same time, I found numerous gemiasmas adhering to the chloride of calcium solution.

On the twelfth day, one of the young men had a well marked paroxysm of ague, and on the fourteenth the other was taken down with the disease. They both began to feel unnatural and dull about the sixth day. All three stages of the paroxysms were well marked. The type in both was tertian. It was readily controlled with quinine and iron and acetate of potash, with warm diaphoretic drinks on retiring. Four members of the family slept on the lower floor of the house, but none of them were affected.

The experiment was repeated at another point in the same neighborhood, where one young man and two boys were exposed in the same way as described in the previous cases. In this instance, the two boys were taken down with the disease, one on the tenth, and the other on the thirteenth day of exposure, while the young man escaped. On account of other duties, and the difficulty of obtaining the consent of parties for experiment, I have been unable to conduct this part of the examination further. The experiments thus far, however, are highly satisfactory, and confirmatory of the previous observations and results of this extended inquiry, on which nearly three years of almost constant labor have been bestowed.

Later, in November, 1866, I placed a large pan of the ague soil in Dr. House's office. Dr. House at that time was my assistant. It was loosely covered with a newspaper, and forgotten. In a few days the doctor began to have pains in the back and limbs. These symptoms were followed by a well marked paroxysm of ague. As soon as this occurred, the pan of plants was removed. His wife and daughter, who had spent part of their evenings in his office, were in a few days after taken down with the same disease. Dr. E. Sterling, of Cleveland, Ohio, treated these cases, and can testify to this statement. I may state here, that this occurred after the ground had frozen up, and all danger in taking the disease outside had ceased.

## CASES WHERE THE PLANTS' HABITAT WAS HUMAN.

I will now introduce some cases where the gemiasmas were found in the urine of patients. In such positive evidence the presence of the plants in either the blood, sputa, sweat, or urine of an ague case must go to sustain our position. It is only in the old cases that the plants are found in the urine.

*Case* 1. — November 15, 1863: Orville Ames, private, Co. L., 3d U. S. Artillery, New York, was attacked with intermittent fever the 4th of August, at Snyder's Bluff, below Vicksburg. Paroxysms came on every other day, between 9 and 10 A. M., and were very severe, with intense pain in head and lungs. He came up the river soon after the attack and went to Seminary Hospital, Covington, Ky. Thence he was sent to the Dennison. Has had chills from the 4th of August up to the present time, except during now and then a short interval of a few days when the paroxysms seemed to yield to quinine. Had been taking it and arsenic daily. November 15: Found the patient pale and anæmic, yellow, hypochondriacal; spleen enlarged; skin and mucous membranes dry; renal functions partially suppressed; tongue considerably furred; appetite poor, nausea; fæces pale, plastic, and scant; bowels rather constipated; dull pains in joints and bones.

*Microscopic examination of urine.* — The urine that was passed on the morning following the paroxysm (November 16) was clear, normal in color and odor; and in it were floating a number of small white flocks and scales that were scarcely large enough to be perceptible by the naked eye. These were made up of pale reddish palmellæ (plants). With these were many mucous cells.

In many of these flocks were masses of from twenty-five to fifty plants, all adhering to each other. Oxalates abundant.

*Case* 2. — Daniel Chase, Co. C, 51st N. Y. V. I., private, was seized about the middle of July at Snyder's Bluff, below Vicksburg. A great many were attacked about the same time. Had chills every day coming on about 10 A. M. Had a great deal of pain in head and chest. Has had paroxysms most of the time since the attack up to the present, except occasionally during an interval of a few days, when the paroxysms were suspended with quinine. Has taken quinine or arsenic almost daily since the attack, and is now in a worse condition than at any time previous. Produces pain to lie long on either side. Remained in the field till the 7th of September, when he was sent to Seminary Hospital, Covington. Came to Dennison Hospital, October 3. I found the patient pale, anæmic, yellow, hypochondriacal; spleen enlarged; hepatic derangement; skin and mucous membranes dry; renal functions partially suppressed; pains in back and limbs; constricted feeling about chest; great muscular and nervous debility; tongue furred; appetite poor; indisposition to physical and mental activity; fæces pale, plastic, scanty; and bowels rather constipated.

*Microscopic examination of urine.* — Urine clear, and normal in color and odor. It contained no sediment, but had floating in it numerous small flocks of a whitish color. These were made up of palmellæ (O, P, and Q, Plate IV.). In some of the flocks were noticed a species of penicillium. The palmellæ cells were all of a pale brick-dust color (Q, Plate IV.). Oxalate of lime abundant in urine.

*Case* 3. — Michael Torpy, age 35, private, Company G, 9th New Hampshire V. I., was attacked on the Mississippi River, four miles below Vicksburg, July 1. When first seized, had a paroxysm every day. Commenced generally from 10 A. M. to 2 P. M. Had severe pain and vertigo during the paroxysms. Has had all along severe pain in back and limbs. Came to Camp Dennison Hospital, September 14. Has had paroxysms almost daily since first attacked. November 15: Found the patient pale, anæmic, yellow, hypochondriacal; the skin dry; urine partially suppressed; spleen somewhat enlarged, and liver deranged in its functions. Has had chronic diarrhœa with intermittent fever. Diarrhœa nearly well. Oxaluria severe.

*Microscopic examination of urine.* — Clear, and normal in color. Quantity small. Many crystals of oxalate of lime. Floating through it were numerous small flocks, which under the microscope were resolved into masses of gemiasmas of a pale brick-dust color (like O and P, Plate IV.). Examination made immediately after voiding. Morning secretion.

*Case* 4. — William F. Caswell, private, Co. A, 11th N. H. V. I., was attacked by intermittent fever at Snyder's Bluff, below Vicksburg, June 21, 1863. Had chronic diarrhœa at this time. When first attacked had two paroxysms daily, one in the forenoon and one in the afternoon, accompanied with severe pain in head and chest. Arrived at Dennison's Hospital, August 26. Since arrival has had paroxysms nearly every other day, save occasionally at short intervals. November 15: Pale, anæmic, yellow, hypochondriacal; spleen enlarged; hepatic derangement; skin and mucous membranes dry; urine partially suppressed; pains in joints and bones; small appetite, and tongue furred.

*Microscopic examination of urine.* — Color natural.

Clear, and frothed much on agitation. It contained a few floating flocks, composed mostly of gemiasmas (O and P, Plate IV.). Numerous crystals of oxalate of lime.

*Case* 5. — John Simms, private, Co. D, 36th Ohio V. I., was attacked on the 22d of August with intermittent fever, at the barracks of Camp Dennison. Paroxysms nearly every day since. Severe pain in head during paroxysms. Dysentery for the last two weeks. November 13, nearly well. November 15: Found him pale, yellow, anæmic, hypochondriacal, skin and mucous membrane dry, and urine partially suppressed. Spleen somewhat enlarged and some hepatic derangement.

*Microscopic examination of urine.* — Clear and natural in color. Froths like beer when shaken. Contains numerous crystals of oxalate of lime, also a few yeast cells; quite a number of small flocks of gemiasmas (O and P, Plate IV.); also an entozoön, like the Anguillula aceti in size and shape.

*Case* 6. — Charles Derby, private, Co. A, 36th Mass. V. I., was attacked about the 1st of August with intermittent fever, on the Yazoo River. Had been there about one month before the attack. Was engaged in digging rifle-pits and clearing away timber. Many were attacked about the same time. Left the Yazoo River August 5, and arrived at Dennison U. S. A. Hospital August 17. When first attacked had chills every other day. Paroxysms have continued up to the present time, with the exception of now and then a few days, when controlled temporarily by quinine. Recently, part of the time has had paroxysms daily. During them had severe pain in head and epigastrium.

November 15: Pale, anæmic, yellow, tongue furred, hypochrondriacal; spleen enlarged; considerable hepatic derangement; skin dry; renal secretions scanty;

stools small and plastic; bowels constipated; pains in limbs and general torpor of mind and body.

*Microscopic examination of urine.* — Clear and normal in color. Contains floating through it many small flocks composed of palmellæ (O and P, Plate IV.). With them were found a few mucous cells. Small crystals of oxalate of lime were quite numerous.

*Case* 7. — Charles Newell, private, Co. L, 3d U. S. Artil., R. I., was attacked with intermittent fever at Vicksburg about the 1st of August, 1863. Remained five or six days after he was attacked, and then came to Cincinnati. Had a paroxysm every day. It came on from 10 A.M. to 12 M. Had a severe pain in stomach and chest during the paroxysms, with cough. Came to Camp Dennison August 15, at which time he was having a paroxysm daily. For some time back had chills for four or five days daily, and then an interval of about the same length of time, when the paroxysms would again occur.

November 15: Pale, anæmic, yellow; tongue furred; appetite poor; hypochondriacal; spleen enlarged; liver deranged in its functions; skin dry; renal secretions small; and general torpor of mind and body.

*Microscopic examination of urine.* — Clear and natural in color. Contains a few small octahedral crystals of oxalate of lime. Floating through the urine are many small flocks made up of palmellæ, resembling O, P, and Q, Plate IV. Occasionally a yeast plant is met with.

## THERAPEUTICAL REMARKS ON THESE CASES.

On November 15 these seven cases were put on the diuretic and diaphoretic treatment which is detailed further on, with the most marked and beneficial results. They all at once began to improve; eyes became bright; the pale, sallow, anæmic condition rapidly passed away;

the languor and debility and pains in limbs disappeared; appetite improved, the paroxysms were broken, and in less than two weeks the patients moved about with elastic step and renewed strength, entirely free from those debilitating influences which had been hanging over them for months.

For twenty years I have had the same experience in finding the ague palmellæ in the urine of persons suffering from the ague. *The fact of the parasitic life out of its natural habitat and in the urine, is one that is positive and undeniable. It should be noticed that the mature plants were found in the urine, and not merely the microspores or seeds. This shows the full development of the plants from the seeds or spores in the unnatural habitat, to wit, the urine.*

MORE OBSERVATIONS. — PLANTS IN THE URINE OF AGUE.

The urine of over *one hundred cases* of intermittent fever has been subjected to careful microscopic examination, with the view of arriving at general results as to the abnormal bodies present. The urine was in some cases voided before treatment had been commenced; in others after treatment had been continued for some days without breaking the paroxysm; and in others the paroxysm had been broken for the time with quinine, while the fever poison still remained in the system. The urine was voided either in the algid, febrile, or sweating stage of the disease, between the paroxysms or after the paroxysms had ceased for some days. The results of the examinations are highly interesting. *They establish the fact that ague plants, the same as grown upon the ague soil previously described, are constantly developing in the system of the intermittent fever patients, and that the urinary organs constitute one great and important outlet for the elimination of this fever vegetation;*

*that the urinary organs, with the perspiratory apparatus, are the important channels through which Nature strives to rid the organism of the exciting cause, and through which the physician should operate by all the medicinal means at his disposal to eradicate the disease.*

They explain to us the important reason why it is that quinine breaks the continued recurrence of the paroxysms, while it does not eradicate the poison; and why diuretics and diaphoretics and expectorants are such all-important aids in eliminating from the system the ge-miasmas. While quinine braces up the system by its powerful tonic action upon the organizing processes of the epithelial tissues, and through this imparts such tonicity to the nervous system as to enable it to resist the paroxysm, it is well known not to exterminate the exciting cause, though it may control for the time its further development, in the same way that it checks the multiplication of yeast plants in fermentation. This exciting cause must be carried out of the organism through those excreting channels which Nature has provided for the elimination of effete and abnormal products. The principal of these are the perspiratory apparatus, the mucous surfaces, and urinary organs. That the perspiratory apparatus performs, in this disease, an important office in this eliminating process, we should long ago have understood, from the fact that through this excretory system Nature so powerfully acts in her efforts to eliminate the disease. *The sweating stage of the paroxysm is essentially a curative one.*

These examinations have also established the fact that in intermittent fever conditions yeast cells are constantly and uniformly present, indicating the presence of sugar in the urine. Cholesterine is also uniformly found in this excretion in ague. This points us to diabetic tendencies, as these bodies are the great abnormal products of diabetic urine. Both cholesterine and sugar are found in the spleen and liver.

The spleen is a great manufacturing organ of cholesterine, and at the same time manufactures some sugar, as is evident from the development of yeast spores in the spleen when it is removed from the body and allowed to ferment. The liver is the apparatus for organizing sugar. The kidneys never normally organize or excrete these bodies. In intermittent fever, we see, then, that the functions of the liver and spleen, of secreting sugar and cholesterine, are in part taken on by the kidneys, perhaps indicating something like metastasis or vicariousness of function, and pointing us to these organs for disturbances that are excited by the vegetable poison of ague.

There are also found quite uniformly in the urine the spores or embryonal forms of a species of fungus, generally vegetating, belonging to the genus Sphærotheca, which is almost uniformly found growing on and in the ague plants, as well as in localities where ague plants do not grow, and where ague is not known.

I do not know that the plant produces any abnormal influence upon the system, as it is often met with in the urine of healthy persons. The ague plants occur in the urine in the form of little flocks, so small that they are scarcely noticeable to the unaided eye, and too few in number to communicate turbidity to the excretion. They vary greatly in the amount present in different cases. They are uniformly more abundant when the disease is severe and has continued for some time. They appear to be developed in the bladder, and perhaps in the renal pelves and ureters, often in great numbers. In some cases of ague of long standing the yeast plant — penicillium — is also found developing in large numbers, mycelium often rising to the surface a short time after the urine is voided, and producing fertile threads and fruit. These plants were found largely developing in the urine of several patients — in the month of September — who had been laboring under the disease most of the summer. In several instances of this kind I have known the intermittent to merge after some weeks into a continued fever of a typhoid type. In all cases of this kind the patients have been receiving constant accessions to the disease by being exposed daily to the exciting cause.

Plate V., and Z, Plate III., represent the abnormal bodies found in the urine of patients laboring under intermittent fever. In some cases the plants appear as seen at A, and in others as seen at E; in others as seen at B, C, D, and G; and in still others as represented at K, P, Q, R, U, and V, Plate V., and at Z, Plate III.; and sometimes nothing is found in the urine but the minute oblong cells or spores of these plants, which are seen scattered at the right of the figure Z, Plate III.

Occasionally a severe, continued case is found where all the forms are met with in abundance in the same patient. A, B, C, D, and E, Plate V., are ague palmellæ that have been developed in the bladder. There are but few cases that I have met with where the brown spore cases, D C, were found. Where the plants are developed in the system they are very frail and transparent, readily yielding to pressure, and very friable. They seldom have much color till after being exposed to light.

Occasionally flocks of these plants with fungoid filaments vegetating from them are met with in the urine of ague patients, as seen at Z, Plate III., and at K, Plate V. These flocks in the freshly voided urine are white, minute, and scarcely visible to the unaided eye. They are light, and float in the urine, and would be overlooked save by the careful observer, as they are slow to be deposited with any sediment that may subside by the urine standing or otherwise. The fungoid filaments vegetating from these flocks belong to the genus Sphærotheca, and are the same plants as are represented farther advanced at O and L, L, L, Plate V.

The peculiar bodies having the appearance of being made up of acicular crystals radiating from a single point, and represented at W, Q, and R, Plate V., are sometimes found in ague urine. These bodies are identical with those found on the bogs among the developing gemiasmas, which are represented at D and J, J, J, Plate III.

In the urine of a patient aged thirteen, with the tertian type of ague, were found abundantly the bodies represented at Q, R, S, T, U, V, Plate V. He had his first paroxysm September 15. The urine examined was voided September 21, during the subsidence of the fever of the fourth paroxysm. He had taken no medicine. Urine of high color, quite free from sediment, containing many minute flocks floating through it. These flocks were examined a few hours after the urine was voided, and were found to be composed of the bodies above referred to. Several flocks like that represented at R were left between the slides and covers of the microscope over night, floating in urine. In the morning the urine was quite evaporated, and growing from these flocks were the variously sized pedunculated sacs, S, S, Plate V. On applying moisture the elongating of the peduncle was so rapid that they could be seen to extend in length and the cells to recede. At length the cells would be disengaged from the foot stalks and become spherical and granulated, as represented at T, Plate V. Some of these would become nucleated, while others would remain transparent. They gradually enlarged, and finally each cell formed a new plant, as represented at U and V, Plate V. Here is a mode of plant formation resembling strikingly the development of some protozoa, as the amœba, also one of the early stages of development in the cell products of the spleen. In the flocks were also noticed the radiating bodies which are represented at Q and W, Plate V. These are identical with the peculiar bodies, D, J, J, J, Plate III., found among developing ague plants. The peculiar growth seen at X, Plate V., was frequently met with in the urine of ague when the patients were exposed to the continued cause, and had been for some time afflicted with the disease, and whose systems were debilitated.

It occurred in small, flat, white, curd-like scales or masses, scarcely visible to the unaided eye, floating in the urine. These masses, as is seen in the figure, are composed of closely packed, short fibres or threads, running at right angles to the flat, scale-like mass. Among the threads or fibres are masses of spores, and on the upper ends of the fibres are minute cells, which have the appearance of being spermatia. These masses resemble a growth often found growing among ague plants on boggy grounds. One of these is represented at I′, Plate III. The growth is, so far as my observations have gone, uniformly present in the urine of typhoid fever, and may have something to do with the cause of this disease. The cells represented at P, Plate V., are sometimes met with in ague urine, and appear to belong also to the palmellæ, resembling somewhat the plants, A and A′, Plate III.

The cells, F, Plate V., are also palmelloid, and are frequently met with in ague urine. They are developed upon wet, low bogs, when drying off during the warm summer months. The cells, I, H, and G, Plate

V., are embryonal plants and are constantly present in the urine, perspiration, and blood of intermittent fever. The more severe the case, and the longer its standing, and the greater the systemic derangement, the more abundant generally are these bodies, which most writers call bacteria.

### MODE OF INQUIRY.

In every sample of urine all the abnormal bodies were carefully figured and described as they were met with, with statements as to their frequency, etc. This mode of inquiry involved the labor of many hundred drawings, which made the investigation slow and laborious. This was done to avoid trusting at all to the memory for the details of so extended a series of observations, and to have accurate representations of the bodies all before me at once, after the examinations were completed. This involved a great amount of repetition in the drawings, but afforded valuable material for general conclusions. It would be interesting to give the detailed results, in order to exhibit the constancy of the presence, in some form, of the ague plants. This, however, would involve far too great expense in engraving, and too extended, detailed description for a paper of this kind. I have therefore so condensed and generalized as to give those bodies only which are either constant or frequent accompaniments of the disease. There was a variety of other abnormal bodies present, but these varied in different cases and were by no means constant. In all congestive types of ague, I have found in the urine the reddish plants represented at O, P, and Q, Plate IV.

As corroborative evidence that these peculiar palmellæ are the true source of ague, as I observed it, I refer to the preceding description. I may also add that I have never met with these plants abundantly in any locality but that intermittent fever was already present as an accompaniment, or soon made its appearance. Sometimes the mere digging of a well or a few rods of ditch through new, humid, black, or rich ground, or the spading or the turning up of a few feet of new, rich, humid soil, is sufficient to generate locally the disease, during the usually dry, warm months of July, August, and September. Those in the immediate vicinity of the palmellæ vegetation are the first to be affected; especially if they are situated on the side toward which the wind blows. This was beautifully illustrated in the cases previously described.

## MORPHOLOGY OF NIGHT AIR IN OHIO AGUE DISTRICTS.

*Active and inactive cells and bodies that are elevated and suspended in the night vapors from stagnant pools and bogs partially submerged.*

These observations were made during the months of June, July, August, and September, in the ague districts of central Ohio. The exhalations from bogs partially submerged and from stagnant pools were collected for examination by suspending glass plates (sixteen by twenty-two inches) in a horizontal position, about one foot above the surface. Each plate was supported by four pegs, one at each corner. They were placed in position at dusk, and secured in the morning before sunrise. Invariably the under surface of the plates was found covered thickly with large drops of water, formed by the condensation of the rising vapors. In this condensed water occurred the bodies represented from A to P, Fig. 1, Plate I.

The plates suspended over the partially submerged bogs were more thickly covered with these bodies than the plates over the stagnant pools.

At A, Fig. 1, Plate I., is represented an oblong, subquadrangular, oval cell, of a dark brown color, which was active, having a revolving, progressive movement. It occurred much more frequently on the plates over the stagnant pools than on those over the partially submerged bogs. They are probably algoid cells in the zoösporoid stage of development.

At B, D, F, G, and H, Fig. 1, Plate I., are represented active zoösporoid cells, having a zigzag, oscillatory, or undulatory progressive movement, rotating or rolling from side to side on their longest axis as they progress. This motion, during the last stages of their active existence, resolves itself into a rhythmical, pulsatory movement, during which the cells have a tendency to assume a spherical form. These are very abundant, both on the plates suspended over the partially submerged bogs and stagnant pools.

At C, Fig. 1, Plate I., are active bodies composed of minute cells, joined end to end. They have a squirming, progressive movement. Similar bodies are found in all fermenting and decaying matters, and are known as vibriones. They appear to be confervoid.

At E, Fig. 1, Plate I., are transparent cells with cilia and without any cell contents. They are seldom met with on the plates.

At I, Fig. 1, Plate I., are represented large granular appearing cells filled with small ones. They are quite numerous on the plates over the bogs, and sometimes appear to have a pulsating or jerking motion, but are generally stationary.

At K′, Fig. 1, Plate I., are large inactive cells containing nuclei. They occur on the plates over the bogs.

At M, Fig. 1, Plate I., are represented algoid cells, attached to a filament, and adhering to the same filament are two diatoms. These with other diatoms are quite frequently met with on the plates over the stagnant pools. O, a diatom. N, a portion of an algoid filament.

At P, Fig. 1, Plate I., are represented the minute oblong cells occurring so constantly in the expectoration of ague. They occur also on the plates over the boggy grounds. These are cells from peculiar, minute palmelloid plants growing upon the soil of desiccating bogs, and the dry, freshly exposed, new soil of humid, rich, low grounds.

The mode of collecting these bodies, elevated and suspended in the heavy night vapors, has been previously described. They are represented from *a* to *w*, Fig. 2, Plate I. Those represented at O, R, K, K′, V, S, T, and U, Fig. 2, Plate I., are universally met with in the heavy, humid, cool exhalations rising both from desiccating, peaty bogs, and from the recently exposed, drying soil of rich, humid, low ground. Whether the fresh new soil be exposed to the desiccating influence of the sun by ploughing, excavations, or by other means, the result is the same.

The other bodies represented under Fig. 2, Plate I., are confined mostly to the plates suspended over desiccated, peaty bogs, that have been partially covered with water during a portion of the year. In these exhalations there are no active or zoösporoid cells found, unless there happens to be a small pool of water under the suspended plate.

The cells, C and C′, Fig. 2, Plate I., were always found in abundance attached to the plates where they were suspended over desiccating peaty bogs. They are sporoid cells from species of large palmellæ growing abundantly upon such bogs, and described in figure farther on. With the cell, C, were met the masses of spores represented at M, M′, D, D′, and B, same figure and plate. These are from a species of Sphærotheca which develops abundantly in the larger species of palmellæ. Their color is a beautiful brownish yellow.

N, N′, F, and I, Fig. 2, Plate I., are young palmelloid plants. E, and E′, Fig. 2, Plate I., represent cells of palmellæ that occur frequently on the plates suspended over the peaty bogs. Their color is usually a light orange yellow.

G and L, Fig. 2, Plate I., are greenish cells, having granular contents, often occurring aggregated in the substance of palmelloid plants, in the hymeneal tissue, near their inferior surface.

V and W, Fig. 2, Plate I., are greenish granular bodies, having externally a tuberculated appearance, and filled with minute oval or spherical cells. These are frequently met with on the plates suspended over the bogs.

Of all the bodies found adhering to the plates suspended over the low, humid grounds of ague districts, those represented at O, K, K′, Fig. 2, R, S, T, U, V, Fig. 3, Plate I., are the most constant. These are universally present. They belong to a minute and peculiar species of palmellæ that rapidly develops on desiccating, peaty soil, and upon freshly exposed, rich soil from new, humid, low grounds. They are constant accompaniments of ague in all ague districts, and are found invariably in the morning expectoration of all such as are exposed to the heavy, humid, night exhalations of ague localities.

Low calcareous lands in malarious regions produce several other species of palmellæ, one of which has a pink or brickdust color, another is green, while a third is brownish green. This last species is more rare than others, and produces glistening, metallic, plumbous patches on the surface of humid calcareous soil where the new earth has been recently exposed.

These several species are represented at A, B, C, D, E, G, H, I, K, and N, Plate IV, and at A, A′, B, B′, C, C′, D, Plate III. They are the plants which produce intermittent fever of a congestive type. This congestive form of ague has a much stronger tendency to suppress and otherwise derange the functions of elimination and assimilation than those that are developed upon non-calcareous soils. These latter are white or slightly tinged with green and yellow, and are represented on the Plates I. and II., and produce the ordinary mild forms of ague — those which generally yield quite readily to the tonic and anti-fermentative or cryptogamic influence of quinine.

## MORPHOLOGY OF SPUTA OF PEOPLE EXPOSED TO THE NIGHT AIR OF AGUE LANDS.

*Bodies found in the morning expectoration of all such as are exposed to the night exhalations from the desiccating soils of peaty bogs and humid, low grounds of ague localities.*

By walking for half an hour or even for a less time over an ague bog or over a calcareous soil producing malarial palmellæ, during the evening or early morning, the mucous lining of the fauces and bronchi become thickly covered with the bodies elevated and suspended in the heavy night vapors of such localities. These are readily dislodged with the expectoration. They were found in the experiments on myself and many others to be essentially the same as the bodies that become attached to the under side of the glass plates suspended during the night over ague soils and bogs, and which are represented under Fig. 2, Plate I., and at A, B, C, D, E, G, H, I, K, and N, Plate IV.

By microscopic examination of the condensed vapors upon glass plates suspended upon both low and higher levels, during the same night, and examination of the expectoration of persons occupying the same planes during the same time, it was determined that there was always a correspondence on the same level and locality between the bodies inhaled and those adhering to the glass plates; and further, that the bodies elevated from the low, humid, ague lands did not usually rise to exceed thirty-five feet above such levels, and never above the upper line of the visible vapors; that up to the summit level of these vapors the atmosphere was always cool and damp, while above it was much warmer and drier. This was found to be so marked that in ascending elevated ground during the evening the line of demarcation between the ague vapors and the superincumbent dry air was readily indicated by the difference in humidity and temperature.

In examining the expectoration of persons upon levels above the reach of ague, almost always were found the spores (single or in masses) and broken filaments of the Sphærotheca pyrus (M, M′, B, and D, Fig. 2, Plate I.). These occur abundantly upon fruit trees and decaying fruit at all elevations. There will always be also found algoid cells from stagnant waters similar to those represented at Fig. 1, Plate I. The peculiar cells of the palmellæ (O, K, K′, Fig. 2, R, S, P, and U, Fig. 3, Plate I.) are not found save in the atmospheric zone of ague.

### MORPHOLOGY OF SPUTA OF AGUE PATIENTS.

For evidence that the ague plants have been found in the expectoration and nasal discharges of ague patients, I refer to the histories of cases related in the former part of this essay.

### AGUE PLANTS IN THE BLOOD.

Ague plants are found in the blood and secretions of patients exposed to malarial influences. When the plants develop in the human organism, they are perfectly colorless and somewhat larger than those growing on the soil. It is impossible to distinguish between the species of a genus, but the spores of different genera are distinguishable. They are frequently found of different sizes in different persons, and even in the same individual. The spores are usually larger when the plants are developed in the body than when they develop on the soil. To find these plants in the blood and secretions requires great care and patience. No casual observation will accomplish any satisfactory result. Drop after drop of the blood should be patiently explored. Hours should be taken instead of a few minutes. When a case is worked up in this way, the physician feels that he has obtained some positive knowledge. In my observations upon the ague plants in the blood, I have noticed an interesting fact that seems to explain the agency of quinine in intermittent fevers. It is this: Where patients have taken this agent largely for some time, keeping the system under its influence, the plants in the blood seem almost entirely empty of spores. It appears to destroy their power to organize the reproductive elements. This is precisely what might have been expected; as we well know that it has a remarkable tendency to check the growth of yeast plants, and is a powerful agent in preventing other cryptogamic development — N, Plate VIII.

## PLANTS IN THE PERSPIRATION OF AGUE.

These are the same that occur on ague bogs, and have been previously described. They vary greatly in quantity in different individuals, and often with the severity of the disease. There is, however, a constancy and sameness in these bodies in the perspiration of all the ague patients I have examined. These bodies are represented at L, L′, M, M′, N, O, and P, Plate III. Sometimes they occur aggregated in considerable masses, as at O, with fungoid filaments vegetating from them. At others they are smaller, as at P, Plate III., and at others the minute cells are scattered loosely, as at L and L′, same plate. Occasionally the perfect plants in their simple form occur as at M and M′, Plate III.

At N and S, Plate III., are cells of the Torula cerevisiæ, which occur uniformly in the perspiration, urine, and blood of ague, indicating the presence of sugar undergoing fermentative changes. They vary greatly in different cases, but are always present, according to my observations embracing over one hundred cases.

At Q, Q′, and R, Plate III., are represented the asci of a species of puccinia, resembling that which attacks wheat, and produces so much injury to this grain. These were found abundantly in the perspiration of a baker who was laboring under ague. This is interesting; but whether they produce any derangement of the perspiratory apparatus, or of the system, I am unable to say. At Q′ one of these asci has ruptured and is shedding its spores.

## PATHOLOGY OF INTERMITTENT FEVER.

The lesions in intermittent fever are confined mostly to epithelial structures, showing quite conclusively that the exciting cause acts primarily upon the parent epithelial cells, or those cells that either organize the products that nourish the several tissues, or disorganize those of interstitial decay, so as to prepare them for ready elimination. These derangements consist in the altering and enlarging of glandular structures, and in inflammations and alterations in structure and function of the mucous, epidermic, and serous surfaces. All other abnormal manifestations are either symptomatic of these, or are the result of previous disease in the organism.

All the glands in the body belong strictly to epithelial tissue, and are made up mostly of parent epithelial cells. These structures are affected in time and extent apparently in proportion to their importance in organizing and assimilating products for nutrition, or disorganizing those destined for elimination.

## LESIONS OF THE SPLEEN.

Of all the lesions met with in fatal cases, those of the spleen and liver — most important organs of the body — are the most frequent. The spleen increases in bulk and consistence; its structure is easily torn; its interior often being found to be broken down, and composed of a blackish red pulpy mass, with which are mingled fibrinous portions of a lighter color. Morgagni gives one case where the spleen weighed eight pounds; and another is mentioned by Bailly that weighed nearly ten pounds, the structure being entirely converted into a pulp. The spleen has been occasionally ruptured, and the broken down and altered tissue emptied into the abdominal cavity. This indicates an altered condition in the organizing processes of the parent epithelial cells of the organ, by which the fibrinous matters and other products of the blood formed become deposited in the splenic tissue, thus producing enlargement, so-called "ague cake," which often, if the patient is not removed from constant accessions to the disease, and the exciting cause not eliminated from the organism, results sooner or later in disorganization and frequently in disintegration of the gland.

## LIVER.

The liver is also in some cases found greatly enlarged, and altered but little in structure. In others it is softened, or filled with black blood, or tuberculated, or containing purulent deposits.

## PANCREAS AND INTESTINES.

The pancreas is also frequently hardened, so as almost to resemble scirrhus. The mucous membrane of the stomach, duodenum, and small intestines is likewise sometimes involved.

The mesenteric glands are frequently enlarged, and are subject to very nearly the same derangements in function and structure as the spleen.

## RATIONALE OF INVASION.

The exciting cause inhaled, taken into the system in the food and drinks, and absorbed by the skin and mucous surfaces comes into direct contact with the epithelial cells, spreading over and covering the entire body, both internally and externally, wherever there are any ways by which external bodies may enter the organism. The epithelial cells, hence, make up the first tissue of the system with which these poisonous bodies come in contact. These cells they have to pass through before they can enter the systemic circulation and reach the vascular tissues. In passing through these cells, they derange them so as to poison the products they organize. In this way the other tissues, including the ganglionic and cerebro-spinal systems, become involved. As the epithelial cells of the glands, especially those of the spleen, mesentery, and liver, are the most largely engaged of any in organizing nutrient products for the other tissues, these glands are the most severely taxed, and are the first to suffer extensively from the poisonous palmellæ, and hence it is that in these we find so frequently grave lesions. When the tissues have become poisoned to a certain extent, there is a reaction on the part of the system, an effort of nature to eliminate the poisonous products already in the body. This effort is the paroxysm which constitutes what we call the disease.

We can readily see how it is that the blood of the body should become thin — deficient in fibrin — as soon as the functions of the spleen are partially or wholly suspended. This being the gland which organizes fibrin more largely than any other, if its function in this respect be suspended by the blocking up of the oval splenic bodies with partially organized fibrin, one great source of this product would be cut off from the blood. The fibrin already in the blood becomes deposited in the tissues, and one important source being cut off, the blood becomes thin and deficient in the body. This thin blood fills up all portions of the organ not occupied by masses of fibrin, and hence the ease with which the blood contents of the spleen may be washed out. Wherever the whole mass of the blood of the body becomes very abnormally thin, we may look to the spleen for the primary lesion.

Some of the interesting symptoms of intermittent fever, where the spleen is involved (Dr. Tweedie), are depression of spirits, torpor of mind, inactivity of body, with much muscular debility, deadly paleness, or a yellowish hue tending to black or green more than in ordinary hepatic disease. There is great liability to hemorrhage from various regions of the body, to dropsy, dysentery, and to ulcers of the legs. The spleen is liable to take on a morbid condition in continued fevers, as well as in intermittents.

Diseases of the heart, stomach, and liver are liable to be accompanied by diseases of the spleen. The spleen is more liable to be affected with diseases in damp, wet, marshy localities than in other situations. In intermittent fevers there is a diminution of red blood globules and fibrin.

Softening and the breaking down of the spleen is found in intermittent and continued fevers, in scurvy, and in some varieties of malignant dysentery. By understanding the true functions of the spleen, these symptoms and lesions are all traceable to their true cause.

Depression of spirits and torpor of mind may arise from either oxaluric or phosphatic states, or from a defective supply of fibrin to muscular tissue. The yellowish hue may be due to a defective supply of red globules. The great liability to hemorrhage in different parts of the body, dropsy, and dysentery, may be due to an enervated condition of the heart, to thinness of the blood, and the defective supply to it of its normal products.

The probable reason why the spleen is so liable to take on a morbid condition in continued fevers as well as in intermittents is that the exciting causes of both affect primarily the epithelial tissue, and have a tendency to derange those portions most which are the most actively engaged in organizing nutrient products, the reason of which appears to be that the exciting causes exist alike in the materials we eat, drink, inhale, and absorb through the skin.

The reason why the skin and spleen are more liable to be affected in damp, marshy localities than in other situations is that in the former districts miasmatic poisons impregnate more or less the air, the water, and the food. The reason of the diminution of fibrin and red globules in the blood in intermittent fever is a greater or less suppression of the normal functions of the spleen and the mesenteric glands.

## PLANTS THAT EXCITE FERMENTATION IN THE URINE OF AGUE.

In the urine of all cases of intermittent fever the spores of penicillia are found, indicating the presence of glycogenous matter undergoing fermentative changes. These cells are generally more abundant in obstinate types and in cases of long standing than in the milder forms and recent cases. These observations apply equally well to the blood of this disease.

In several instances in my observations, where the patients had been laboring under severe and obstinate forms of the disease, such as were exposed to constant accessions for many weeks, tending to typhoid conditions of the system, the urine was found containing numerous vegetating fungoid filaments, which were the developing mycelia of penicillia, aspergilli, or sphærothecæ. The filamentous growth of the same fungus produces the so-called *torula cells* during the vinous fermentation in the urine of ague. In these obstinate cases of the disease, the urine passes rapidly to the acetous fermentation, even before it is voided, ushering in filamentous development in the cryptogams present, or the development of the mycelia in yeast plants. This fermentation progresses so rapidly that in a few hours after the urine is voided putrefactive fermentation begins, and small, white, cottony flocks or tufts of fertile threads appear above the surface. These soon bear fruit, when the plants are discovered to belong either to the genus Penicillium, or to the genus Aspergillus, or the genus Sphærotheca, and sometimes all.

The torula cells of the vinous fermentation in urine are exhibited in their early stages at D and G, Plate VI., and at N, Plate VII. The filamentous developments accompanying the acetous or acid fermentation are exhibited at A and E, Plate VI. The mature plant, bearing fruit, is represented at C, Plate VI. The vegetating spores of the mature plant are represented at B and F, Plate VI. There is a beautiful species of penicillium often present, having symmetrical heads; the stem dividing first into four equal pedicels, which ascend close together a short distance, then abruptly diverge from each other, and soon subdivide, each into four pedicelets, each one of which bears a long moniliform line of spherical spores.

I do not know that this fungus is at all injurious of itself in the urine, but it indicates the presence of glycogenic matter, and rapid fermentative changes, which are abnormal.

The mycelia exhibited at A and E appear to belong to two different species of penicillium. That at E is the mycelium of the mature plant represented at C, Plate VI. The mycelium, E, was beautifully developed in a boy (James Scott), aged thirteen, who resided immediately on the northwest margin of the "ague bog" on the southeast side of the city of Lancaster, Ohio. The whole family have been constant sufferers from ague every year since they moved to this point, from May till November. The water used comes from a spring at the edge of the bog.

This boy (James) had been laboring under ague (type quotidian) from the preceding May up to the time of this observation (October 1), when this sample of urine was voided during the sweating stage; boy pale, emaciated, and puny, indisposed to mental or physical action.

In this sample of urine also occurred abundantly the spores of a species of sphærotheca that grows upon the ague bogs, with the ague palmellæ. These are represented at Q, R, S, K, L, and M, Plate VI. These occur more or less in the urine of most cases of ague, and often in that of health. There were also found in this sample of urine crystals of oxalate of lime, which are seen at N, Plate VI., O, Plate VI., empty amyloid cells, P, Plate VI., and epithelial cells.

The mycelium represented at A, Plate VI., is from the urine of a young man, aged twenty-six, who resides immediately on the east margin of low, humid, rich ground, which is covered with ague plants. He was attacked with obstinate intermittent fever in the early part of the season, which during the month of August gradually passed into typhoid conditions, from which he recovered about the 1st of September. On the 20th of September intermittent fever again set in. On the 28th this sample of urine was voided, during the sweating stage of a paroxysm. It had a deep reddish amber color, and in the bottom was a reddish brown sediment, made up of the echinated bodies, known as lithates of the alkalies, represented in Plate VII., and which will soon be described. Scattered through the urine were flocks of the mycelium represented at E. In a few hours white cottony tufts of fertile threads began to appear on the surface. These soon bore fruit, when a beautiful species of penicillium was exhibited.

In another case this fungus appeared in the urine of a little girl aged two and a half years, after she had been laboring under the quotidian type of the disease for several weeks. This type gradually passed into remittent and then into a continued typhoid type of fever, which finally resulted fatally. Several other cases of this character have fallen under my observation during these inquiries. The above three will, however, suffice to give a general idea of the peculiar form of the disease which tends to this rapid fungoid development in the urine.

These growths are undoubtedly but the consequence of particular pathological states, and not the cause. Their presence is indicative of rapid fermentative changes in the system, and in this respect they are valuable aids in diagnosis, and useful in directing our attention to such medicinal means as may counteract this abnormal fermentative condition.

## THE FORMS OF CRYSTALLINE MATTER MOST USUALLY MET WITH IN THE URINE OF INTERMITTENT FEVER.

The crystalline sediments of intermittent fever are somewhat peculiar, and by no means as common as those of the urine of typhoid and other continued types of fever. The rhomboidal plates and prisms of lithic acid, so common to all typhoid types of disease, are seldom met with; and when they are, they are in small quantity and occur in those cases having a typhoid tendency.

What are known as lithates of the alkalies — lithates of soda, potassa, and ammonia — and the hour-glass and octahedral crystals of oxalate of lime, and the hour-glass type of crystals supposed to be one form of lithic acid, are frequently met with in obstinate and continued and neglected cases of the disease. They are also found occasionally in what appear to be mild types of intermittents. Crystals of the triple phosphates are also accompaniments often of the more obstinate forms. The peculiar crystalline forms represented from O to Z, Plate VII., are met with in some cases in great abundance. The crystals represented at O′ and N′ are regarded by Hassall and Golding Bird as belonging to the oxalate of lime group, while those represented at O, Q, R, Y, S, etc., are regarded by them as one form of lithic acid. There is, however, but little doubt that both of these varieties in form are the same type of crystal and are made up essentially of the same proximate body.

All these crystalline forms are represented in Plate VII. The rhomboidal crystals of lithic acid represented at H′ are seldom met with, save where there is a tendency to typhoid conditions. The same may be said of the forms exhibited at C′, D″, E″, F′, G′, and H″.

The other forms represented, excluding the crystals of phosphates and octahedra of oxalate of lime, are those to which we wish to direct special attention, from the fact that they are peculiar in form, not well understood, and from the interesting consideration that their form appears to be to some extent determined by an organizing process. These crystals are all deposited in developing cells. These cells are from the epithelial lining of the urinary organs. What are known as lithates of the alkalies are cells in which the filamentous metamorphosis has commenced, giving sharp prominences and spinous projections to the cell walls. At this stage acicular crystalline matter begins to be deposited in the cells, the crystals radiating from the centre, and shooting into the cell prominences and spinous prolongations. When the cells become filled with crystalline matter, they appear yellowish and opaque, and have no longer any of the apparent characteristics of a cell. Cells filled with crystals in this condition are represented at A, E, K, and M′, Plate VII.

If nitric acid be added to these cell crystalline bodies placed between the slides of the microscope, the crystalline matter is seen to be gradually dissolved out, with considerable effervescence, and we have, finally, the light, empty, thin walled cells left, with spinous projections and prominences in their walls, as seen at G and H, Plate VII.; at I the cells are exhibited with the crystalline matter but partially dissolved out; and at M″ the solution is still more complete. Sometimes the cells, filled with crystals, have no sharp projections; one of these is represented at C, and another is seen in the group K. When the crystalline matter is dissolved out of these, they present the appearance exhibited at F, Plate VII. The peculiar crystalline forms represented at O′, R′, O, and O″, Pl. VII., are equally interesting, and appear also to be deposited in cells.

At L, L′, L″, N′, N″, and N‴, are seen cells in which this form of crystal deposits has just begun. These cells do not differ from the cells L‴ and E′, which are from the epithelial tissue lining the urinary organs. As these deposits progress, they assume successively the appearance exhibited at O, O′, R′.

If now the crystals, O′, R′, be placed between the slides of the microscope, and nitric acid added, the crystalline matter is gradually dissolved, with effervescence; and there finally remains a simple thin, light membranous casing, represented at W′, Y′, Plate VII. The successive appearances of these cells, as the crystalline matter is gradually more and more dissolved, is represented at Q, R, S, and T of one kind, and at U, U′, and V for the other. When deprived of crystalline matter, nothing but a thin, highly transparent, cylindrical cell remains, with a faint hour-glass marking internally, as represented at X, W, and Y. We here have, then, a type of crystallization going on in living, metamorphosing cells, from the epithelial tissue of the urinary organs, and bearing a not distant resemblance to diatoms. They appear to be connecting links between the lowest vegetable forms, the animal epithelial cell, and the mineral kingdom. These forms can no longer be regarded as simply mineral crystallizations. They are crystallizations brought about and controlled by organic life, and are under the direct influence of developing and metamorphosing cells. Here we perhaps may learn something connected with the formation and development of bony tissue.

In examinations connected with the minute structure and functions of the kidneys, I have arrived at data which satisfy me that the kidneys perform important functions connected with the formation of bony and cartilaginous products.[1] Every one is familiar with the remarkable tendency existing in the urinary apparatus to the formation and deposition of bony concretions, in the shape of gravel, calculi, etc. This matter is more fully treated in the paper above referred to.

At Y′ are epithelial cells with crystalline plates forming within.

At T′ are a couple of algoid cells. This species is seldom found in the urine. At A′ and B′ are represented two peculiar forms of the so-called vibriones. The form exhibited at A, I have met with only in a couple of instances. One of them was in the urine of a married female patient laboring under obstinate phosphuria.

[1] For an extended view of this matter, see my paper on the minute structure and functions of the kidneys.

## TREATMENT OF PATIENTS SUFFERING WITH MALARIA.

Since nature in the last stage of the paroxysm excites all the excretory organs of the body, and especially the perspiratory, urinary, and mucous surfaces generally, and as these excretions contain spores and plants of the ague palmellæ, it is evident that the sweating stage is a curative process. If so, it points us to important medicinal means as aids in eradicating the poison. These are diuretics, diaphoretics, expectorants, and alteratives. While we should keep quinia constantly in the front rank to impart tonicity to the ganglionic and cerebro-spinal systems and to the epithelial tissue, and to control in the body cryptogamic development, we should use diaphoretics, diuretics, and expectorants freely as eliminators. The nightly sweating of the patient laboring under the disease might be supposed to result in enervating the system. The reverse, however, is the case. Under active nightly diuresis and diaphoresis, in ague, the sallow countenance rapidly clears up, the dull eye becomes bright, the depression of spirits and torpor of mind and body disappear and give place to the elastic step and tonicity of muscle. The result is that even when the system is exposed to constant accession the paroxysms are not only avoided, but organic lesions and the long train of unpleasant symptoms are not allowed to get their hold upon the system, the ague poison being eliminated as fast as it is taken into the organism.

In cases where the patient is removed from the exciting cause, the system is soon thoroughly cleansed, and no ague returns during the following spring unless there are new exposures.

The power of the system to resist paroxysms of ague varies greatly in different individuals, and even in the same individual at different periods. This power of resistance is directly proportioned to the tonicity of the system. Habits of bracing, active exercise, such as horseback riding, will often protect the system against attacks. This is noticed in a marked degree in the cavalry and infantry service of the army. In malarious localities, the former are seldom attacked, if on active duty, with intermittent fever, while the latter are extremely liable to suffer. This is the case when both branches of the service are occupying the same malarious district, and are equally exposed. Quinia as a prophylactic enables the system to resist the paroxysms. It braces up the system and controls cryptogamic growth till nature can effect a cure by eliminating the malarious cause through the skin, mucous surfaces, and kidneys. Quinia then is not, strictly speaking, a curative or specific agent, but simply acts beneficially by controlling cryptogamic development, and imparting such tonicity to the organism as enables it to resist the paroxysm till aided nature can cure the disease by eliminating the cause. Any cause that enervates the system in malarial regions tends to bring on the paroxysms earlier than they otherwise would appear. Very frequently it is noticed, especially when the system has been under the influence of the disease a long time, and most especially if the disease is contracted in a region where there is a tendency to congestive paroxysms (limestone regions especially), as in the southern part of Tennessee, in Mississippi, and Louisiana, quinia appears at first to have some influence in enabling the system to resist the paroxysms, but soon almost entirely loses its power. In fact, in many instances it really aggravates the paroxysms, as is evidenced by stopping the quinia entirely. In such cases the skin will be found dry, the mucous surfaces less active than normal and covered with a scant, clammy, mucous secretion, and the renal secretions small; in fact, all the eliminating organs have their functions deranged and their normal action partially suppressed. So long as these are in this condition, the malaria is hemmed up in the organism, poisoning the tissues so much that the tonic influence of the quinia frequently rather tends to aid the abnormal actions than to restore the normal tone of the system.

If, however, the normal functions of the eliminating organs are restored and the spleen and liver properly attended to, quinia will again act beneficially and soon eradicate the disease, especially if the patient be removed from constant accessions. It is highly important to keep the eliminating organs in a healthy and rather increased state of action when the system is under the influence of any malarious poison, as it is through these channels that the causes are eliminated. We have then in this disease no such thing as a specific in quinia. It simply imparts tonicity to the system and controls cryptogamic development till nature, aided by remedial means for exciting the excretions, is able to eliminate the poison. These principles should be strongly impressed upon the mind of the physician who has charge of malarious diseases. Many old and obstinate cases of ague, with the system filled with the malarious poison, and all the channels of egress closed, are being daily dosed largely with quinia, arsenic, and iron, to little or no effect, with the view of curing the disease in some empirical and mysterious way by these so-called specifics. The very name specific should be blotted from medical science, and left entirely to the quack, who knows nothing else. There is really no such thing in medicine. All we can do in any disease is to aid Nature, and to follow her as closely as possible in her curative processes; and this we can only do wisely and well by understanding fully the true cause and pathology of every disease we treat.

In treating intermittent fever, it is of the first importance to correct any abnormal condition of the portal system, and to accompany this by diuretic, diaphoretic, and expectorant remedies, to excite into activity all the eliminating organs of the body. It is impossible to mark out a fixed course for all cases. The following prescriptions will, however, illustrate the general plan of treatment: —

| | | |
|---|---|---|
| ℞. | Potass. acetat | ℥ii. ʒi. |
| | Spts. nitr. dulcis | ℥i. ʒiv. |
| | Syr. scill. comp. | ℥ss. ʒiss. |
| | Aquæ menth. pip. | ℥viii. |

M. S. Take from one to two tablespoonfuls in a glass of water, morning, noon, and night. Every evening, on retiring, take a warm diaphoretic draught. Also, —

| | | |
|---|---|---|
| ℞. | Quinia Sulph. | Gr. xxx. |
| | Strychnia sulph. | " ¼. |
| | Mass. hydr. | " iv. |
| | Pulvis capsici | " xx. |
| | Ferri lactat | " xx. |
| | Ext. Gentian, | |
| | Syrupi | āā q. s. |
| | Fit pill xxx. S. | |

Take two pills every two hours till thirty are taken. Every day or every other day after, according to the type of the disease, take four pills two hours before the time for the paroxysm. At the end of ten days, take two pills every two hours till thirty pills are taken, and continue as before for ten days more, then take thirty more pills. By this time, if the eliminating remedies are kept faithfully up, the patient will be thoroughly cured, if he is not exposed to constant accessions. If he is, the eliminating organs must be kept constantly excited, that the cause may be removed as fast as it enters. Under this treatment a paroxysm need never occur after the commencement of the remedies.

## TREATMENT OF SOIL.

The means are within our reach for removing the prolific cause of intermittents. Rich, humid, low grounds, which produce ague plants abundantly when they are new, undergo some changes by culture and drainage that unfit them for the growth of the palmellæ.

As the malarious portions of the country become older, and the low, humid, rich grounds become drained and cultivated, ague districts will become more and more circumscribed and intermittents proportionally decrease; as long, however, as there remain in such localities pools, ponds, ditches, streams, the beds of which are liable to become more or less dry during the warm summer months, intermittents may be expected to prevail to a certain extent. These sources of the disease, however, may be much lessened by turning the open ditches into blind ones, draining pools, swamps, and ponds, and subjecting the soil of their beds to repeated cultivation. By this process intermittents, which now extensively prevail over a large portion of our richest districts, may be so circumscribed in their limits as to be no longer a dreaded accompaniment to the most fertile agricultural sections of our country.

Where it is necessary to make excavations during the warm, dry months, in new, rich, humid soil, the bottom and sides of these excavations, with the earth removed, should at the close of each day's work be plentifully sprinkled over with caustic lime. If this precaution be well attended to, the ague plants will not develop. It is also highly desirable in making ditches through malarial soil to keep the bottom, sides, and thrown-up earth well sprinkled with lime. As fast as the beds of streams, ditches, pools, and ponds in ague districts become dry, they should also be well strewn with caustic lime. This is especially desirable in this climate during July, August, and September.

When new prairie lands, or new, humid, low grounds are being turned up for the first time, and lime can be readily obtained, sowing it over with a good top dressing of caustic lime will save much sickness. If one application is not sufficient, a second should be made. This application will by no means be lost on the soil, as it serves to neutralize acidity, convert resinous matters into soluble soaps, and the soil is thereby rendered more fertile, and its increased and better crops will more than pay for the lime application. If lime cannot be obtained wood ashes may be used, though their effect will not be as marked or enduring.

In selecting camping grounds for armies, or locations for hospitals, new soil and low prairie or other humid grounds should be avoided as much as possible.

Wherever open ditches are made, streets are excavated, wells and cellars dug, or new earth thrown up or exposed in any way to the drying influence of the sun and atmosphere of May, June, July, August, and September, and especially during the two latter months, if the region is at all malarious, caustic lime should be freely strewn over all such excavations, and over the heaps of soil removed.

To conclude: if the health of the residents is in splendid order, the eliminating glands of the body will throw off the poison as fast as introduced. But this should be reckoned among the labors of the constitution, and such exposed individuals should not task their powers in addition. I here also say that I only claim that the intermittent fever that I have studied has been caused by the plants in question. Ague in other localities may be caused by the same and other vegetations. A wide and open field is presented, which demands of the profession occupation. Studies should be made of the Panama fever, as they have been made of the Roman fever.

I have made careful microscopic examinations of the blood in several cases of Panama fever I have treated, and find in all severe cases many of the colorless corpuscles filled more or less with spores of ague vegetation and the serum quite full of the same spores.

*Case* 1. — *Mr. John Thomas. Panama fever. Vegetation in blood and colorless corpuscles.* (Fig. N, Plate VIII.) *Vegetation in the colorless corpuscles of the blood. Spores in serum of blood adhering to fibrin filaments.*

Mr. Thomas has charge of the bridge-building on the Tehuantepec Railroad. Went there about one year ago. Was taken down with the fever last October. Returned home in February last, all broken down. Put him under treatment March 15, 1882. Gained rapidly (after washing him out with hot water, and getting his urine clear and bowels open daily) on two grains of quinia every two hours, till sixteen doses were taken. After an interval of seven days, repeated the quinia, and so on.

This fever prevails on all the low lands, as soon as the fresh soil is exposed to the drying rays of the sun. The vegetation grows on the drying soil, and the spores rise in the night air, and fall after sunrise. All who are exposed to the night air, which is loaded with the spores, suffer with the disease. The natives of the country suffer about as badly as foreigners. Nearly half of the workmen die of the disease. The fever is a congestive intermittent of a severe type.

*Case* 2. — *Henry Thoman. Leucocythæmia. Spleen eleven inches in diameter, two white globules to one red. German. Thirty-six years of age. Weight, one hundred and eighty pounds. Colorless corpuscles very large and varying much in size, as seen at N. Corpuscles filled — many of them — with the spores of ague vegetation. Also spores swimming in serum.*

This man has been a gardener back of Hoboken on ague lands, and has had ague for two years preceding this disease.

I will now introduce a communication made to me by a medical gentleman who has followed somewhat my researches for many years, and has taken great pains to see if my researches are correct.

REPORT ON THE CAUSE OF AGUE. — BY DR. EPHRAIM CUTTER, TO THE WRITER.

At your request I give the evidence on which I base my opinion that your plan in relation to ague is true.

From my very start into the medical profession I had a natural intense interest in the causes of disease, which was also fostered by my father, the late Dr. Cutter, who honored his profession nearly forty years. Hence I read your paper on ague with enthusiasm, and wrote to you for some of the plants of which you spoke. You sent me six boxes containing soil, which you said was full of the gemiasmas. You gave some drawings, so that I should know the plants when I saw them, and directed me to moisten the soil with water and expose it to air and sunlight. In the course of a few days I was to proceed to collect. I faithfully followed the instructions, but without any success. I could detect no plants whatever.

This result would have settled the case ordinarily, and I would have said that you were mistaken, as the material submitted by yourself failed as evidence. But I thought that there was too much internal evidence of the truth of your story, and having been for many years an observer in natural history, I had learned that it is often very difficult for one to acquire the art of properly making examinations, even though the procedures are of the simplest description. So I distrusted, not you, but myself, and hence, you may remember, I forsook all and fled many hundred miles to you from my home with the boxes you had sent me. In three minutes after my arrival you showed me how to collect the plants in abundance from the very soil in the boxes that had traveled so far backward and forward, and from the very specimens on which I had failed.

The trouble with me was that I went too deep with my needle. You showed me that it was simply necessary to remove the slightest possible amount on the point of a cambric needle, deposit this in a drop of clean water on a slide cover with a covering glass and put it under your elegant one-fifth inch objective, and there were the gemiasmas just as you had described.

I have always felt humbled by this teaching, and I at the time rejoiced that instead of denouncing you as a cheat and fraud (as some did at that time), I did not do anything as to the formation of an opinion until I had known more and more accurately about the subject.

I found all the varieties of the palmellæ you described in the boxes, and I kept them for several years and demonstrated them to medical men as I had opportunity. You also showed me on this visit the following experiments that I regarded as crucial: —

1st. I saw you scrape from the skin of an ague patient sweat and epithelium with the spores and the full grown plants of the Gemiasma verdans.

2d. I saw you take the sputa of an ague patient and demonstrate the spores and sporangia of the Gemiasma verdans.

3d. I saw you take the urine of a female patient suffering from ague (though from motives of delicacy I did not see the urine voided — still I believe that she did pass the urine, as I did not think it necessary to insult the patient), and you demonstrated to me beautiful specimens of Gemiasma rubra. You said it was not common to find their full development in the urine of such cases, but only in the urine of the old, severe cases. This was a mild case.

4th. I saw you take the blood from the forearm of an ague patient, and under the microscope I saw you demonstrate the gemiasmas, white and bleached in the blood. You said that the coloring matter did not develop in the blood; that it was a difficult task to demonstrate the plants in the blood; that it required a long and careful search of hours sometimes, and at other times the plants would be obtained at once.

When I had fully comprehended the significance of the experiments I was filled with joy, and like the converts in apostolic times I desired to go about and promulgate the news to the profession. I did so in many places, notably in New York city, where I satisfactorily demonstrated the plants to many eminent physicians at my room at the Fifth Avenue Hotel; also before a medical society where more than one hundred persons were present. I did all that I could, but such was the preoccupation of the medical gentlemen that a respectful hearing was all I got. This is not to be wondered at, as it was a subject now, after the lapse of nearly a decade and a half, quite unstudied and unknown. After this I studied the plants as I had opportunity, and in 1877 made a special journey to Long Island, N. Y., for the purpose of studying the plants in their natural habitat, when they were in a state of maturity. I have also examined moist soils in localities where ague is occasionally known, with other localities where it prevails during the warm months.

Below I give the results, which from convenience I divide into two parts : —

1st. Studies of the ague plants in their natural habitat.

2d. Studies of the ague plants in their unnatural habitat (parasitic). I think one should know the first before attempting the second.

*First.* — Studies to find in their natural habitat the palmellæ described as the Gemiasma rubra, Gemiasma verdans, Gemiasma plumba, Gemiasma alba, Protuberans lamella.

*Second.* — Outfit: Glass slides, covers, needles, toothpicks, bottle of water, white paper and handkerchief, portable microscope with a good Tolles one inch eyepiece, and one quarter inch objective.

Wherever there was found on low, marshy soil a white incrustation like dried salt, a very minute portion was removed by needle or toothpick, deposited on a slide, moistened with a drop of water, rubbed up with a needle or toothpick into a uniformly diffused cloud in and through the water. The cover was put on, and the excess of water removed by touching with a handkerchief the edge of the cover. Then the capillary attraction held the cover in place. The handkerchief or white paper was spread on the ground at my feet to reflect white light, and the observation conducted at once after the collection and on the very habitat. It is possible thus to conduct observations with the microscope in boats on ponds or sea, and, adding a good kerosene light, in bed or bunk or on lounge.

August 11, 1877. — Excursion to College Point, Flushing, Long Island : —

Observation 1. 1.50 P. M. Sun excessively hot. Gathered some of the white incrustation on sand in a marsh west of Long Island Railroad depot. Found some Gemiasma verdans, Gemiasma rubra; the latter were dry and not good specimens, but the field swarmed with the automobile spores. The full developed plant is termed sporangia, and seeds are called spores.

Observation 2. Another specimen from same locality, not good; that is, forms were seen, but they were not decisive and characteristic.

Observation 3. Earth from Wallabout, near Naval Hospital, Brooklyn. Rich in spores (A) with automobile protoplasmic motions, (B) Gemiasma rubra, (C) Gemiasma verdans, very beautiful indeed. Plants very abundant.

Observation 4. Walking up the track east of Long Island Railroad depot I took an incrustation near creek; not much found but dirt and moving spores.

Observation 5. Seated on long marsh grass I scraped carefully from the stalks near the roots of the grass where the plants were protected from the action of the sunlight and wind. Found a great abundance of mature Gemiasma verdans, very beautiful in appearance.

*Notes.* — The time of my visit was most unfavorable. The best time is when the morning has just dawned and the dew is on the grass. One then can find an abundance, while after the sun is up and the air is hot the plants disappear; probably burst and scatter the spores in billions, which, as night comes on and passes, develop into the mature plants, when they may be found in vast numbers. It would seem from this that the life epoch of a gemiasma is one day under such circumstances, but I have known them to be present for weeks under a cover on a slide, when the slide was surrounded with a bandage wet with water, or kept in a culture box. The plants may be cultivated any time in a glass with a water joint.

Observation 6. Some Gemiasma verdans; good specimens, but scanty. Innumerable mobile spores. Dried.

Observation 7. Red dust on gray soil. Countless mobile spores. Dried red sporangia of Gemiasma rubra.

Observation 8. White incrustation. Innumerable mobile spores. No plants, fully developed.

Observation 9. White incrustation. Many minute algæ, but two sporangia of a pale pink color; another variety of color of gemiasma. Innumerable mobile spores.

Observation 10. Gemiasma verdans and Gemiasma rubra in small quantities. Innumerable mobile spores.

Observation 11. Specimen taken from under the shade of short marsh grass. Gemiasma exceedingly rich and beautiful. Innumerable mobile spores.

Observation 12. Good specimens of Gemiasma rubra. Innumerable spores present in all specimens.

Observation 13. Very good specimens of Protuberans lamella.

Observation 14. The same.

Observation 15. Dead Gemiasma verdans and G. rubra.

Observation 16. Collection very unpromising by macroscopy, but by microscopy showed many spores, mature specimens of Gemiasma rubra and G. verdans. One empty specimen with double walls.

Observation 17. Dry land by the side of railroad. Protuberans not abundant.

Observation 18. From side of ditch. Filled with mature Gemiasma verdans.

Observation 19. Moist earth near a rejected timber of the railroad bridge. Abundance of Gemiasma verdans, sphærotheca, diatoms.

Observation 20. Scrapings on earth under high grass. Large mature specimens of Gemiasma rubra and G. verdans. Many small ones.

Observation 21. Same locality. Gemiasma rubra and G. verdans; good specimens.

Observation 22. A dry stem of a last year's annual plant lay in the ditch not submerged, that appeared as if painted red with iron rust. This redness evidently made up of Gemiasma rubra dried.

Observation 23. A twig submerged in a ditch was scraped. Gemiasma verdans found abundantly with many other things, which if rehearsed would cloud this story.

Observation 24. Scrapings from the dirty end of the stick (23) gave specimens of the beautiful double wall palmellæ and some empty Gemiasma verdans.

Observation 25. Stirred up the littoral margins of the ditch with stick found in the path, and the drip showed Gemiasma rubra and verdans mixed in with dirt, débris, other algæ, fungi, infusoria, especially diatoms.

Observation 26. I was myself seized with sneezing and discharge running from the nostrils during these examinations. Some of the contents of the right nostril were blown on a slide, covered, and examined morphologically. Several oval bodies and round algæ were found with the characteristics of Gemiasma verdans and rubra. Also some colorless sporangia, and spores abundantly present. These were in addition to the normal morphological elements found in the excretions.

Observation 27. Dried clay on margin of the river showed dry Gemiasma verdans.

Observation 28. Saline dust on earth that had been thrown out during the setting of a new post in the railroad bridge showed some Gemiasma alba.

Observation 29. The dry white incrustation found on fresh earth near railroad track entirely away from water, where it appeared as if white sugar or sand had been sprinkled over in a fine dust, showed an abundance of automobile spores and dry sporangia of Gemiasma rubra and G. verdans. It was not made up of salts from evaporations.

Observation 30. Some very thick, matted, long, green marsh grass was carefully separated apart like the parting of thick hair on the head. A little earth was taken from the crack, and the Protuberans lamella, the Gemiasma rubra and G. verdans found were beautiful and well developed.

Observation 31. Brooklyn Naval Hospital, August 11, 1877, 4 A. M. Called up by the Quartermaster. With Surgeon C. W. White, U. S. N., took (A) one five inch glass beaker, bottomless, (B) three clean glass slides, (C) chloride of calcium solution, ʒi. to ℥i. water. We went, as near as I could judge in the darkness, to about that portion of the wall that lies west of the hospital, southeast corner (now all filled up), where on the 10th of August previously I had found some actively growing specimens of the Gemiasma verdans, G. rubra, and protuberans. The chloride of calcium solution was poured into a glass tumbler, then rubbed over the inside and outside of the beaker. It was then placed on the ground, the rim of the mouth coming on the soil and the bottom elevated on an old tin pan, so that the beaker stood inclined at an angle of about forty-five degrees with the horizon. The slides were moistened. One was laid on a stone, one on a clod, and a third on the grass. Returned to bed, not having been gone over ten minutes.

At 6 A. M. collected and examined for specimens the drops of dew deposited. Results: In every one of the five instances collected the automobile spores, and the sporangia of the gemiasmas and the protuberans on both sides of slides and beaker. There were also spores and mycelial filaments of fungi, dirt, and zoöspores. The drops of dew were collected with capillary tubes such as were used in Edinburgh for vaccine virus. The fluid was then preserved and examined in the naval laboratory. In a few hours the spores disappeared.

Observation 32. Some of the earth near the site of the exposure referred to in Observation 31 was examined and found to contain abundantly the Gemiasma verdans, G. rubra, Protuberans lamella, confirmed by three more observations.

Observation 33. In company with Surgeon F. M. Dearborne, U. S. N., in charge of Naval Hospital, the same day later explored the wall about marsh west of hospital. Found the area abundantly supplied with palmellæ, Gemiasma rubra, G. verdans, and Protuberans lamella, even where there was no incrustation or green mould. Made very many examinations, always finding the plants and spores, giving up only when both of us were overcome with the heat.

Observation 34. August, 1881. Visited the Wallabout; found it filled up with earth. August 17. —

Visited the Flushing district; examined for the gemiasma the same localities above named, but found only a few dried up plants and plenty of spores. With sticks dug up the earth in various places near by. Early in September revisited the same, but found nothing more; the incrustation not even so much as before. The weather was continuously very dry for a long time, so much so that vegetables and milk were scarce.

The grass and grounds were all dried up and cracked with fissures.

There must be some moisture for the development of the plants. Perhaps if I had been able to visit the spots in the early morning, it would have been much better, as about the same time I was studying the same vegetation on 165th Street and 10th Avenue, New York, and found an abundance of the plants in the morning, but almost none in the afternoon.

Should any care to repeat these observations, these limits should be observed, besides the old adage about "the early bird catching the worm," etc.

Some may object to this directness of report, and say that we should mention all the forms of life seen. To this I would reply that the position I occupy is much different from yours, which is that of discoverer. When a detective is sent out to catch a rogue, he troubles himself but little with people or things that have no resemblance to the rogue. Suppose he should return with a report as to the houses, plants, animals, etc., he encountered in his search; the report might be very interesting as a matter of general information, but rather out of place for the parties who desire the rogue caught. So in my search I made a special work of catching the gemiasmas and not caring for anything else. Still, to remove from your mind any anxiety that

I may possibly not have understood how to conduct my work, I will introduce here a report of search to find out how many forms of life and substances I could recognize in the water of a hydrant fed by Croton water (two specimens only), during the present winter (1881 and 1882). I beg leave to subjoin the following list of species, not individuals.

In this list you will see the Gemiasma verdans distinguished from its associate objects. I think I can in no other way more clearly show my right to have my honest opinion respected in relation to the subject in question.

List of objects found in the Croton water, winter of 1881 and 1882. The specimens obtained by filtering about one barrel of water: —

1. Acineta tuberosa.
2. Actinophrys sol.
3. Amœba proteus.
4. Amœba radiosa.
5. Amœba verrucosa.
6. Anabaina subtularia.
7. Anguillula fluviatilis.
8. Ankistrodesmus falcatus.
9. Anurea longispinis.
10. Anurea monostylus.
11. Arcella mitrata.
12. Arcella vulgaris.
13. Argulus.
14. Arthrodesmus convergens.
15. Arthrodesmus divergens.
16. Astrionella formosa.
17. Bacteria.
18. Bosmina.
19. Botryiococcus.
20. Branchippus stagnalis.
21. Castor.
22. Centropyxis.
23. Chetochilis.
24. Chilomonads.
25. Chlorococcus.
26. Chydorus.
27. Chytridium.
28. Clathrocystis æruginosa.
29. Closterium didymotocum.
30. Closterium lunula.
31. Closterium moniliferum.
32. Cœlastrum sphericum.
33. Cosmarium binoculatum.
34. Cyclops quadricornis.
35. Cyphroderia ampulla.
36. Cypris tristriata.
37. Daphnia pulex.
38. Diaptomas castor.
39. Diaptomas, new species.
40. Diatoma vulgaris.
41. Difflugia cratera.
42. Difflugia globosa.
43. Dinobryina sertularia.
44. Dinocharis pocillum.
45. Dirt.
46. Eggs of bryozoa.

47. Eggs of entomostraca.
48. Eggs of plumatella.
49. Eggs of polyp.
50. Enchylis pupa.
51. Eosphora aurita.
52. Epithelia, animal.
53. Epithelia, vegetable.
54. Euastrum.
55. Euglenia viridis.
56. Euglypha.
57. Eurycercus lamellatus.
58. Exuvia of some insect.
59. Feather barbs.
60. Feathers of butterfly.
61. Floscularia.
62. Fragillaria.
63. Fungus, red water.
64. Gemiasma verdans.
65. Gomphospheria.
66. Gonium.
67. Gromia.
68. Humus.
69. Hyalosphenia tincta.
70. Hydra viridis.
71. Leptothrix.
72. Melosira.
73. Meresmopedia.
74. Monactina.
75. Monads.
76. Naviculæ.
77. Nitzschia.
78. Nostoc communis.
79. Œdogonium.
80. Oscillatoriaceæ.
81. Ovaries of entomostraca.
82. Pandorina morum.
83. Paramecium aurelium.
84. Pediastrum boryanum.
85. Pediastrum incisum.
86. Pediastrum perforatum.
87. Pediastrum pertusum.
88. Pediastrum quadratum.
89. Pelomyxa.
90. Penium.
91. Peredinium candelabrum.
92. Peredinium cinctum.
93. Plagiophrys.
94. Platiptera polyarthra.
95. Pleurosigma angulatum.
96. Plumatella.
97. Pollen of pine.
98. Polycoccus.
99. Polyhedra tetraëtica.
100. Polyhedra triangularis.
101. Polyphema.
102. Protococcus.
103. Radiophrys alba.
104. Raphidium duplex.
105. Rotifer ascus.
106. Rotifer vulgaris.
107. Saprolegnia.
108. Scenedesmus acutus.
109. Scenedesmus obliquus.
110. Scenedesmus obtusum.
111. Scenedesmus quadricauda.
112. Sheath of tubelaria.
113. Silica.
114. Sphærotheca spores.
115. Spicules of sponge.
116. Spirogyra.
117. Starch.
118. Staurastrum furcigerum.
119. Staurastrum gracile.
120. Staurogenum quadratum.
121. Surirella.
122. Synchœta.
123. Synhedra.
124. Tabellaria.
125. Tetraspore.
126. Trachelomonas.
127. Trichodiscus.
128. Uvella.

129. Volvox globator.
130. Volvox, new species.
131. Vorticel.
132. Worm fluke.
133. Worm, two tailed.
134. Yeast.

More forms were found, but could not be determined by me. This list will give an idea of the variety of forms to be met with in the hunt for ague plants; still, they are as well marked in their physical characters as a potato is among the objects of nature. Although I know you are perfectly familiar with algæ, still, to make my report more complete, in case you should see fit to have it pass out of your hands to others, allow me to give a short account of the Order Three of algæ, namely, the chlorosporeæ or confervoid algæ, derived from the Micrographic Dictionary, this being an accessible authority.

### CHLOROSPOREÆ.

Algæ form a class of the thallophytes or cellular plants in which the physiological functions of the plant are delegated most completely to the individual cell. That is to say, the marked difference of purpose seen in the leaves, stamens, seeds, etc., of the phanerogams or flowering plants is absent here, and the structures carrying on the operations of nutrition and those of reproduction are so commingled, conjoined, and in some cases identified, that a knowledge of the microscopic anatomy is indispensable even to the roughest conception of the natural history of these plants; besides, we find these plants so simple that we can see through and through them while living in a natural condition, and by means of the microscope penetrate to mysteries of organism, either altogether inaccessible or only to be attained by disturbing and destructive dissection, in the so-called higher forms of vegetation. We say "so-called" advisedly, for among the algæ are included the largest forms of plant life.

The Macrocystis pyrifera, an alga, is the largest of all known plants. It is a sea-weed that floats free and unattached in the ocean. It covers the area of two square miles, and extends three hundred feet in depth (Reinsch). At the same time its structure on examination shows it to belong to the same class of plants as the minute palmellæ which we have been studying. Algæ are found everywhere in streams, ditches, ponds, even the smallest accumulations of water standing for any time in the open air, and commonly on walls or the ground, in all permanently damp situations. They are peculiarly interesting in regard to morphological conditions alone, as their great variety of conditions of organization are all variations, as it were, on the theme of the simple vegetable cell, produced by change of form, number, and arrangement.

The algæ comprehend a vast variety of plants, exhibiting a wonderful multiplicity of forms, colors, sizes, and degrees of complexity of structure, but algologists consider them to belong to three orders: —

1. Red spored algæ, called rhodosporeæ or florideæ.

2. The dark or black spored algæ, or melanosporeæ or fucoideæ.

3. The green spored algæ, or chlorosporeæ or confervoideæ. The first two classes embrace the sea-weeds. The third class, marine and aquatic plants, most of which when viewed singly are microscopic. Of course some naturalists do not agree to these views. It is with order three, confervoideæ, that we are interested. These are plants growing in sea or fresh water, or on damp surfaces, with a filamentous, or more rarely a leaf-like pulverulent or gelatinous thallus; the last two forms essentially microscopic. They consist frequently

of definitely arranged groups of distinct cells, either of ordinary structure or with their membrane silicified — diatomaceæ.

We note three forms of fructification: 1. Resting spores produced after fertilization either by conjugation or impregnation. 2. Spermatozoids. 3. Zoöspores; bi-, quadri-, or multi-ciliated active automobile cells — gonidia — discharged from the mother cells or plants without impregnation, and germinating directly.

There is also another increase by cell division.

## SYNOPSIS OF THE FAMILIES.

1. *Lemaneæ.* — Frond filamentous, inarticulate, cartilaginous, leathery, hollow, furnished at irregular distances with whorls or warts, or necklace-shaped. Fructification: tufted, simple or branched, necklace-shaped filaments attached to the inner surface of the tubular frond, and finally breaking up into elliptical spores. Aquatic.

2. *Batrachospermeæ.* — Plants filamentous, articulated, invested with gelatine. Frond composed of aggregated, articulated, longitudinal cells, whorled at intervals with short, horizontal, cylindrical or beaded, jointed ramuli. Fructification: ovate spores and tufts of antheridial cells attached to the lateral ramuli, which consist of minute, radiating dichotomous beaded filaments. Aquatic.

3. *Chætophoraceæ.* — Plants growing in the sea or fresh water, coated by gelatinous substance; either filiform or a number of filaments being connected together constituting gelatinous, definitely formed, or shapeless fronds or masses. Filaments jointed, bearing bristle-like processes. Fructification: zoöspores produced from the cell contents of the filaments; resting spores formed from the contents of particular cells

after impregnation by ciliated spermatozoids produced in distinct antheridial cells. Coleochætæ.

4. *Confervaceæ.* — Plants growing in the sea or in fresh water, filamentous, jointed, without evident gelatine (forming merely a delicate coat around the separate filaments). Filaments very variable in appearance, simple or branched; the cells constituting the articulations of the filaments more or less filled with green, or very rarely brown or purple granular matter; sometimes arranged in peculiar patterns on the walls, and convertible into spores or zoöspores. Not conjugating.

5. *Zygnemaceæ.* — Aquatic filamentous plants, without evident gelatine, composed of series of cylindrical cells, straight or curved. Cell contents often arranged in elegant patterns on the walls. Reproduction resulting from conjugation, followed by the development of a true spore, in some genera dividing into four sporules before germinating.

6. *Œdogoniaceæ.* — Simple or branched aquatic filamentous plants attached without gelatine. Cell contents uniform, dense, cell division accompanied by circumscissile dehiscence of the parent cell, producing rings on the filaments. Reproduction: by zoöspores formed of the whole contents of a cell, with a crown of numerous cilia; resting spores formed in sporangial cells after fecundation by ciliated spermatozoids formed in antheridial cells.

7. *Siphonaceæ.* — Plants found in the sea, fresh water, or on damp ground, of a membranous or horny hyaline substance, filled with green or colorless granular matter. Fronds consisting of continuous tubular filaments, either free or collected into spongy masses of various shapes. Crustaceous, globular, cylindrical, or flat. Fructification: by zoöspores, either single or very

numerous, and by resting spores formed in sporangial cells after the contents have been impregnated by the contents of antheridial cells of different forms.

8. *Oscillatoriaceæ.* — Plants growing either in the sea, fresh water, or on damp ground, of a gelatinous substance and filamentous structure. Filaments very slender, tubular, continuous, filled with colored, granular, transversely striated substance; seldom branched, though often cohering together so as to appear branched; usually massed together in broad floating or sessile strata, of a very gelatinous nature; occasionally erect and tufted, and still more rarely collected into radiating series bound together by firm gelatine and then forming globose lobed or flat crustaceous fronds. Fructification: the internal mass or contents separating into roundish or lenticular gonidia.

9. *Nostochaceæ.* — Gelatinous plants growing in fresh water, or in damp situations among mosses, etc., of soft or almost leathery substance, consisting of variously curled or twisted necklace-shaped filaments, colorless or green, composed of simple, or in some stages double rows of cells, contained in a gelatinous matrix of definite form, or heaped together without order in a gelatinous mass. Some of the cells enlarged, and then forming either vesicular empty cells or densely filled sporangial cells. Reproduction: by the breaking up of the filaments, and by resting spores formed singly in the sporanges.

10. *Ulvaceæ.* — Marine or aquatic algæ consisting of membranous, flat, and expanded tubular or saccate fronds composed of polygonal cells firmly joined together by their sides. Reproduced by zoöspores formed from the cell contents and breaking out from the surface, or by motionless spores formed from the whole contents.

11. *Palmellaceæ.* — Plants forming gelatinous or pulverulent crusts on damp surfaces of stone, wood, earth, mud, swampy districts, or more or less regular masses of gelatinous substance or delicate pseudo-membranous expansion or fronds, of flat, globular, or tubular form, in fresh water or on damp ground; composed of one or many, sometimes innumerable, cells, with green, red, or yellowish contents, spherical or elliptical form, the simplest being isolated cells, found in groups of two, four, eight, etc., in course of multiplication. Others permanently formed of some multiple of four; the highest forms made up of compact, numerous, more or less closely joined cells. Reproduction: by cell division, by the conversion of the cell contents into zoöspores, and by resting spores, formed sometimes after conjugation; in other cases, probably, by fecundation by spermatozoids. All the unicellular algæ are included under this head.

12. *Desmidiaceæ.* — Microscopic gelatinous plants, of a green color, growing in fresh water, composed of cells devoid of a silicious coat, of peculiar forms, such as oval, crescentic, shortly cylindrical, cylindrical, oblong, etc., with variously formed rays or lobes, giving a more or less stellate form, presenting a bilateral symmetry, the junction of the halves being marked by a division of the green contents; the individual cells being free, or arranged in linear series, collected into fagot-like bundles or in elegant star-like groups which are embedded in a common gelatinous coat. Reproduced by division and by resting spores produced in sporangia formed after the conjugation of two cells and union of their contents, and by zoöspores formed in the vegetative cells or in the germinating resting spores.

13. *Diatomaceæ.* — Microscopic cellular bodies, growing in fresh, brackish, and sea water: free or attached,

single, or embedded in gelatinous tubes, the individual cells (frustules) with yellowish or brown contents, and provided with a silicious coat composed of two usually symmetrical valves variously marked, with a connecting band or hoop at the suture. Multiplied by division and by the formation of new larger individuals out of the contents of individual conjugated cells, perhaps also by spores and zoöspores.

14. *Volvocineæ.* — Microscopic cellular fresh water plants, composed of groups of bodies resembling zoöspores connected into a definite form by their enveloping membranes. The families are formed either of assemblages of coated zoöspores united in a definite form by the cohesion of their membranes, or assemblages of naked zoöspores inclosed in a common investing membrane. The individual zoöspore-like bodies, with two cilia throughout life, perforating the membranous coats, and by their conjoined action causing a free coöperative movement of the whole group. Reproduction by division, or by single cells being converted into new families, and by resting spores formed from some of the cells after impregnation by spermatozoids formed from the contents of other cells of the same family.

From the description I think you have placed your plants in the right family. And evidently they come in the genera named, but at present there is in the authorities at my command so much confusion as to the genera, as given by the most eminent authorities, like Nageli, Kutzing, Braun, Rabenht, Cohn, etc., that I think it would be quite unwise for me to settle here, or try to settle here, questions that baffle the naturalists who are entirely devoted to this specialty. We can safely leave this to them. Meantime let us look at the matter as physicians who desire the practical advantages of the discovery you have made. To illustrate this position let us take a familiar case. A boy going through the fields picks and eats an inedible mushroom. He is poisoned and dies. Now, what is the important part of history here from a physician's point of view? Is it not that the mushroom poisoned the child? Next comes the nomenclature. What kind of agaricus was it? Or was it one of the gasteromycetes, the coniomycetes, the hyphomycetes, the ascomycetes, or one of the physomycetes? Suppose that the fungologists are at swords' points with each other about the name of the particular fungus that killed the boy? Would the physicians feel justified to sit down and wait till the naturalists were satisfied, and the true name had been settled satisfactorily to all? I trow not; they would warn the family about eating any more, and if the case had not yet perished, they would let the nomenclature go and try all the means that history, research, and instructed common-sense would suggest for the recovery.

This leads me here to say that physicians trust too much to the simple dicta of men who may be very eminent in some department of natural history, and yet ignorant in the very department about which, being called upon, they have given an opinion. All everywhere have so much to learn that we should be very careful how we reject new truths, especially when they come from one of our number educated in our own medical schools.

If the subject is one about which we know nothing, we had better say so when asked our opinion, and we should receive with respect what is respectfully offered by a man whom we know to be honest, a hard worker, eminent in his department by long and tedious labors. If he asks us to look over his evidence, do so in a kindly spirit, and not open the denunciations of bar-room vocabularies upon the presenter, simply because we don't see his point. In other words, we should all be receptive, but careful in our assimilation, remembering that some of the great operations in surgery, for example, came from laymen in low life, as the operation for stone, and even the operation of spaying came from a swineherd.

It is my desire, however, to have this settled as far as can be among scientists, but for the practical uses of practicing physicians I say that far more evidence has been adduced by you in support of the cause of intermittent fever than we have in the etiology of many other diseases. I take the position that so long as no one presents a better history of the etiology of intermittent fever by facts and observations, your theory must stand. This, too, notwithstanding what may be said to the contrary.

Certainly you are to be commended for having done as you have in this matter. It is one of the great rights of the profession, and duties also, that if a physician has or thinks he has anything that is new and valuable, to communicate it, and so long as he observes the rules of good society the profession should give him a respectful hearing, even though he may have made a mistake. I do not think you had a fair hearing, and hence so far as I myself am concerned I indorse your position, and shall do so till some one comes along and gives a better demonstration. Allow me also to proceed with more evidence.

### HUNT FOR GEMIASMAS.

Observation at West Falmouth, Mass., September 1, 1877. I made five observations in like manner about the marshes and bogs of this town, which is, as it were, situated on the tendo achillis of Cape Cod, Mass. In only one of these observations did I find any palmellæ like the ague plants, and they were not characteristic.

Observation at Chelsea, Mass., near the Naval Hospital, September 5, 1877. Three sets of observations. In all spores were found and some sporangia, but they were not the genuine plants as far as I could judge. They were protococcaceæ. It is not necessary to add that there are no cases of intermittent fever regarded as originating on the localities named. Still, the ancient history of New England contains some accounts of ague occurring there, but they are not regarded as entirely authentic.

Observation at Lexington, Mass., September 6, 1877. Observation made in a meadow. Found no saline incrustation, and no palmellæ. No local malaria.

Observation at Cambridge, Mass. Water works on the shore of Fresh Pond. Found a few palmellæ analogous to, but not the ague palmellæ.

Observation at Woburn, Mass., September 27, 1877, with Dr. J. W. Moore. Found some palmellæ, but scanty. Abundance of spores of cryptogams.

Observation at Stonington, Conn., August 15, 1877. Examined a pond hole nearly opposite the railroad station on the New York Shore Line. Found abundantly the white incrustation on the surface of the soil. Here I found the spores and the sporangias of the Gemiasma verdans and G. rubra.

Observation 2. Repetition of the last.

Observation 3. I examined some of an incrustation that was copiously deposited in the same locality, which was not white or frosty, but dark brown and a dirty green. Here the spores were very abundant, and a few sporangias of the Gemiasma rubra. Ague has of late years been noted in Connecticut and Rhode Island.

Observations at Middlefield, near Middletown, Conn., summer of 1878. Being in this locality, I heard that intermittent fever was advancing eastward at the rate of ten miles a year. It had been observed in Middlefield. I was much interested to see if I could find the gemiasmas there. On examining the dripping of some bog moss I found a plenty of them.

Observations at New Haven. Early in the summer of 1881 I visited this city. One object of my visit was to ascertain the truth of the presence of intermittent fever there, which I had understood prevailed to such an extent that my patient, a consumptive, was afraid to return to his home in New Haven. At this time I examined the hydrant water of the city water works, and also the east shore of the West River, which seemed to be too full of sewage. I found a plenty of the oscillatoreaceæ, but no palmellæ.

In September I revisited the city, taking with me a medical gentleman who, residing in the South, had had a larger experience with the disease than I. From the macroscopical examination he pronounced a case we examined to be ague, but I was not able to detect the plants either in the urine or blood. This might have been that I did not examine long enough. But a little later I revisited the city and explored the soil about the Whitney Water Works, whence the city gets its supply of water, and I had no difficulty in finding a good many of the plants you describe as found by you in ague cases. At a still later period my patient, whom I had set to use the microscope and instructed how to collect the ague plants, went to work himself. One day his mother brought in a film from off an ash pile that lay in the shade, and this was found to be made up of an abundance of the ague plants. By simply winding a wet bandage around the slide, Mr. A. was enabled to keep the plants in good condition until the time of my next visit, when I examined and pronounced them to be genuine plants.

I should here remark that I had, in examining the sputa of this patient sent to me, found some of the ague plants. He said that he had been riding near the Whitney Pond, and perceived a different odor, and thought he must have inhaled the miasm. I told him he was correct in his supposition, as no one could mistake the plant; indeed, Professor Nunn, of Savannah, Ga., my pupil, recognized it at once.

This relation, though short, is to me of great importance. So long as I could not detect the gemiasmas in New Haven, I was very skeptical as to the presence of malaria in New Haven, as I thought there must be some mistake, malaria being a very good cloak to hide diseases under. There is no doubt but that the name has covered lesions not belonging to it. But now the positive demonstrations above so briefly related show to my mind that the local profession have not been mistaken, and have sustained their high reputation.

I should say that I have examined a great deal of sputa, but, with the exception of cases that were malarious, I have not encountered the mature plants before. Of course I have found them, as you did, in my own excretions as I was traveling over ague bogs.

OBSERVATIONS IN WASHINGTON, D. C., NEAR CONGRESSIONAL CEMETERY, SEPTEMBER 5, 1879, 8.35 A. M., BOSTON TIME.

1. Seized with sneezing on my way to cemetery. Examined nasal excretions and found no palmellæ.

2. Pool near cemetery. Examined a spot one inch in diameter, raised in centre, green, found œdegonium abundant. Some desmids, Cosmarium binoculatum plenty. One or two red gemiasmas, starch, Protuberans lamella, pollen.

3. Specimen soft magna of the pool margin. Œdogonium abundant, spores, yeast plants, dirt.

4. Sand scraped. No organized forms but pollen, and mobile spores of some cryptogams.

5. Dew on grass. One stellate compound plant hair, one Gemiasma verdans, two pollen.

6. Grass flower dew. Some large white sporangia filled with spores.

7. Grass blade dew. Not anything of account.

One pale gemiasma, three blue gemiasmas, cosmarium, closterium, diatoms, pollen, found in greenish earth at foot of grass blade and wet with the dew.

Remarks: Observations made at the pool with clinical microscope, one quarter inch objective. Day cloudy, foggy, hot.

8. Green earth in water-way from pump near cemetery. Anabaina plentiful. Diatoms, oscillatoriaceæ. Polycoccus. Pollen, cosmarium, leptothrix, gemiasma, old sporangia, spores many. Fungi belonging to fruit. Puccinia. Anguillula fluviatilis.

9. Mr. Smith's blood. Spores, enlarged white corpuscles. Two sporangia (?). Gemiasma dark brown, black. Mr. Smith is superintendent Congressional Cemetery. Lived here for seven years. Been a great sufferer with ague. Says the doctors told him they could do no more for him than he could for himself. So he used Ayer's ague cure with good effect for six months. Then he found the best effect from the use of the Holman liver ague pad in his own case and that of his children. Notwithstanding the excellence of the ague pad, when he is attacked, he uses blue mass, followed with purgatives, then 20 grains of quinine. Also has used arsenic, but it did not agree with him. Also used capsicum with good results. Had enlarged spleen; not so now.

2d specimen of Mr. Smith's blood. Stelline, no gemiasma. 3d specimen of do. One gemiasma. 4th specimen. None. Skin scraped showed no plants. Urine: amyloid bodies; spores; no sporangia.

### NAVAL MAGAZINE GROUNDS.

Observation 1. Margin of Eastern Branch River. Substance from decaying part of a water plant. Oscillatoriaceæ. Diatoms. Anguillula. Chytridium. Dirt. No gemiasma.

Observation 2. Moist soil. Near by amid much rubbish, one or two doubtful gemiasmas; white, clear, peripheral margin.

Observation 3. Green deposit on decaying wood. Oscillatoriaceæ. Protuberans lamella. Gemiasma alba. Much foreign matter.

Mr. Russell, Mrs. R., Miss R., residents of Magazine Grounds, presented no ague plants in their blood. Sergeant McGrath, Mrs. M., Miss M., presented three or four sporangias in their blood. Dr. Hodgkins, some in urine. Dr. H.'s friend with chills, not positive as to ague. No plants found.

### OBSERVATIONS IN EAST GREENWICH, R. I., AUGUST 16, 1877.

1. At early morn I examined greenish earth, northwest of the town along the margin of a beautiful brook. Found the Protuberans lamella, the Gemiasma alba and G. rubra. Observation 2. Found the same. Observation 3. Found the same.

Observation 4. Salt marsh below the railroad bridge over the river.

The scrapings of the soil showed beautiful yellow and transparent protuberans, beautiful green sporangias of the Gemiasma verdans.

Observation 5. Near the brook named was a good specimen of the Gemiasma plumba. While I could not find out from the lay people that any ague was there, I now understand that it is all through that locality.

OBSERVATION AT WELLESLEY, MASS., AUGUST 20, 1877.

No incrustation found. Examined the vegetation found on the margin of the Ridge Hills Farm pond. Among other things I found an Anguillula fluviatilis. Abundance of microspores, bacteria. Some of the protococci. Gelatinous masses, allied to the protuberans, of a light yellow color scattered all over with well-developed spores, larger than those found in the protuberans. One or two oval sporanges with double outlines. This observation was repeated, but the specimens were not so rich. Another specimen from the same locality was shown to be made up of mosses by the venation of leaves.

Mine host with whom I lodged had a microscopical mount of the Protococcus nivalis in excellent state of preservation. The sporangia were very red and beautiful, but they showed no double cell wall.

In this locality ague is unknown; indeed, the place is one of unusual salubrity. It is interesting to note here how some of the algæ are diffused. I found an artificial pond fed by a spring, and subject to overflow from another pond in spring and winter. A stream of living water as large as one's arm (adult) feeds this artificial pond, still it was crowded with the Clathrocyotis æruginosa of some writers and the polycoccus of Reinsch. How it got there has not yet been explained.

The migration of the ague eastward is a matter of great interest; it is to be hoped that the localities may be searched carefully for the plants.

In this connection I desire to say something about the presence of the gemiasmas in the Croton water. The record I have given of finding the Gemiasma verdans is not a solitary instance. I did not find the gemiasmas in the Cochituate, nor generally in the drinking waters of over thirty different municipalities or towns I have examined during several years past. I have no difficulty in accounting for the presence of the gemiasmas in the Croton, as during the last summer I made studies of the gemiasma at Washington Heights, near 165th St. and 10th Ave., New York.

Plate VIII. is a photograph of a drawing of some of the gemiasmas projected by the sun on the wall and sketched by the artist on the wall, putting the details in from microscopical specimens, viewed in the ordinary way.

I visited this locality several times during August and October, 1881. I found an abundance of the saline incrustation of which you have spoken, and at the time of my first visit there was a little pond hole just east of the point named that was in the act of drying up. Finally it dried completely up, and then the saline and green incrustations both were abundant enough. The only species, however, I found of the ague plants was the Gemiasma verdans. On two occasions of a visit with my pupils I demonstrated the presence of the plants in the nasal excretions from my nostrils. I had been sneezing somewhat.

There is one circumstance I would like to mention here: when, for convenience' sake, my visits were made late in the day, I did not find the plants abundant, still could always get enough to demonstrate their presence; but when my visits were timed so as to come in the early morning, when the dew was on, there was no difficulty whatever in finding multitudes of beautiful and well-developed plants.

To me this is a conclusive corroboration of your own statements in which you speak of the plants bursting and being dissipated by the heat of the summer sun, and the disseminated spores accumulating in aggregations so as to form the white incrustation in connection with saline bodies which you have so often pointed out.

I also have repeated your experiments in relation to the collection of the mud, turf, sods, etc., and have known them to be carried many hundreds of miles off and identified. I have also found the little depressions caused by the tread of cattle affording a fine nidus for the plants. In September, 1883, I found in Glastonbury, Conn., the Gemiasma rubra and G. verdans abundantly. Protuberans ovalis. On the green corn in the silo of J. B. Williams, Esq., I found an abundance of Gemiasma rubra. Took specimen of soil and corn home to New York, and had an attack of malaria.

I visited the Palisades last summer and examined the localities about Tarrytown. This is an elevated location, but I found no gemiasmas. This is not equivalent to saying there were none there. Indeed, I have only given you a mere outline of my work in this direction, as I have made it a practice to examine the soil wherever I went, but as most of my observations have been conducted on non-malarious soils, and I did not find the plants, I have not thought it worth while to record all my observations of a negative character.

I now come to an important part of the corroborative observations, to wit, the blood.

I have found it, as you predicted, a matter of much difficulty to discover the mature forms of the gemiasmas in the blood, but the spore forms of the vegetation I have no difficulty in finding. The spores have appeared to me to be larger than the spores of other vegetations that grow in the blood. They are not capable of complete identification unless they are cultivated to the full form. They are the so-called bacteria of the writers of the day. They can be compared with the spores of the vegetation found outside of the body in the swamps and bogs.

You said that the plants are only found as a general rule in the blood of old cases, or in the acute, well marked cases. The plants are so few that it is at times difficult to encounter them. So also of the blood of those who have had the ague badly and recovered.

### OBSERVATION AT NAVAL HOSPITAL, N. Y., AUGUST, 1877.

Examined with great care the blood of Donovan, who had had intermittent fever badly. Negative result.

The same was the result of examining another case of typho-malarial (convalescent); though in this man's blood there were found some oval and round bodies like empty gemiasmas, $\frac{1}{1000}$ inch in diameter. But they had no well marked double outline. There were no forms found in the urine of this patient.

In another case, who six months previous had had Panama fever, and had well-nigh recovered, I found no spores nor sporangia.

### OBSERVATIONS MADE AT WASHINGTON, D. C., SEPTEMBER, 1879.

I examined with clinical microscope the blood of eight to ten persons living near the Congressional Cemetery and in the Arsenal grounds. I was successful in finding the plants in the blood of five or more persons who were or had been suffering from the intermittent fever.

In 1877, at the Naval Hospital, Chelsea, I accidentally came across three well marked and well defined gemiasmas in the blood of a marine whom I was studying for another disease. I learned that he had had intermittent fever not long before.

Another positive case came to my notice in connection with micrographic work the past summer. The artist was a physician residing in one of the suburban cities of New York. I had demonstrated to him Gemiasma verdans. I showed him how to collect them from the soil in my boxes. For the purpose of more perfectly completing his drawings I gave him some of the gemiasmas between a slide and cover, and also some of the earth containing the soil. He carried them home. It so happened that a brother physician came to his house while he was at work upon the drawings. The artist showed his friend the plants I had collected, the plants he collected from the earth, and then he called his daughter, a young lady who had malaria, and took a drop of blood from her finger. The first specimen contained several of the gemiasmas. The demonstration, coming after the previous ones, carried a conviction that it otherwise would not have had.

### AGUE PLANTS IN THE URINE.

I have found them in the urine of persons suffering or having suffered from intermittent fever.

When I was at the Naval Hospital in Brooklyn, one of the accomplished assistant surgeons, after I had showed him some plants in the urine, said he had often encountered them in the urine of ague cases, but did not know their significance.

I might multiply evidence, but think it unnecessary. I am not certain that my testimony will convince any one save myself, but I know that I had rather have my present definite, positive belief, based on this evidence, than to be floundering on uncertainties. There is no doubt that the profession believe that intermittents have a cause; but this belief has a vagueness which cannot be represented by drawings or photograph. Since I have photographed the gemiasmas, and studied their biology, I shall hold on to your dicta, until upset by something more than words.

In relation to the belief that no algæ are parasitic, I would state that on February 9, 1878, I examined the spleen of a decapitated speckled turtle with Professor Reinsch. We found various sized red corpuscles in the blood in various stages of formation; also filaments of a green alga traversing the spleen, which my associate, a specialist in algology, pronounced one of the oscillatoriaceæ. These were demonstrated in your own observations made years ago. They show that algæ are parasitic in the living spleen of healthy turtles.

This leads to the remark that some parasitic growths are not nocent. I understand you take the same position. Prof. Reinsch has published a work in Latin, "Contributiones ad Algologiam," Leipsic, 1874, in which he gives a large number of drawings and descriptions of algæ, many of them entophytic parasites on other animals or algæ. Some of these, he said, were innocent guests, but many were death to their host.

This is for the benefit of those who say that the gemiasmas are innocent plants and do no harm. All plants, phanerogams or cryptogams, can be divided into nocent or innocent. I am willing to change my position on better evidence than yours being submitted, but till then call me an indorser of your work as to the cause and treatment of ague.

Respectfully, yours,

EPHRAIM CUTTER.

There are others who have been over this ground, but the above must suffice here.

I wish to conclude this paper by alluding to some published investigations into the cause of ague, which are interesting, and which I welcome and am thankful for, because all I ask is investigation — not words without investigation.

The first, —

DOCTOR BARTLETT'S NOTES.

Dr. John Bartlett is a gentleman of Chicago, of good standing in the profession. In January, 1874, he published in the Chicago "Medical Journal" a paper on a marsh plant from the Mississippi ague bottoms, supposed to be kindred to the gemiasmas. In a consideration of its genetic relations to malarious disease, he states that at Keokuk, Iowa, in 1871, near the great ague bottoms of the Mississippi, with Dr. J. P. Safford, he procured a sod containing plants that were as large as rape seeds. He sent specimens of the plants to distinguished botanists, among them M. C. Cook, of London, England. Nothing came of these efforts.

2. In August, 1873, Dr. B. visited Riverside, near Chicago, to hunt up the ague plants. Found none, and also that the ague had existed there from 1871.

3. Lemont, a town on the Illinois and Michigan Canal, was next visited. A noted ague district. No plants were found, and only two cases of ague, one of foreign origin. Dr. B. here speaks of these plants of Dr. Safford's as causing ague and being different from the gemiasmas. But he gives no evidence that Safford's plants have been detected in a human habitat. In justice to myself I would like to see this evidence before giving him the place of precedence.

5. Dr. B., September 1, 1873, requested Dr. Safford

to search for his plants at East Keokuk. Very few plants and no ague were found, where they both were rife in 1871.

5. Later, September 15, 1873, ague was extremely prevalent at East Keokuk, Iowa, where two weeks before no plants were found; they existed more numerously than in 1871.

6. Dr. B. traced five cases of ague, in connection with Dr. Safford's plants found in a cesspool of water in a cellar 100 feet distant. It is described as a plant to be studied with a power of 200 diameters, and consisting of a body and root. The root is a globe with a central cavity lined with a white layer, and outside of these a layer of green cells. Diameter of largest plant, one quarter inch. Cavity of plant filled with molecular liquid. Root is above six inches in length.

Dr. B. found the white incrustation; he secured the spores by exposing slides at night over the malarious soil.

He speaks of finding ague plants in the blood of ague patients, one fifteen-hundredth of an inch in diameter. He found them also in his own blood associated with the symptoms of remittent fever, quinine always diminishing or removing the threatening symptoms.

Professors Babcock and Munroe, of Chicago, call the plants either the hydrogastrum of Rabenhorst, or the botrydium of the Micrographic Dictionary, the crystalline acicular bodies being deemed parasitic. Dr. B. deserves credit for his honest and careful work and for his valuable paper. Such efforts are ever worthy of respect.

There is no report of the full development of the plant found in the urine, sputa, and sweat.

Again, Dr. B. or Dr. Safford did not communicate the disease to unprotected persons by exposure.

While then I feel satisfied that the gemiasmas produce ague, it is by no means proved that other cryptogams may not produce malaria. I observed the plants Dr. B. described, but eliminated them from my account as not causative. I hope Dr. B. will pursue this subject farther, as the field is very large and the observers are few.

When my facts are upset, I then surrender.

NOTES ON MARSH MIASM (LIMNOPHYSALIS HYALINA). BY ABR. FREDRIK EKLUND, M. D., STOCKHOLM, SWEDEN, PHYSICIAN OF THE FIRST CLASS IN THE SWEDISH ROYAL NAVY.[1]

Before giving a succinct account of the discovery of paludal miasma and of its natural history, I ought in the first place to state that I have not had the opportunity of reading or studying the great original treatise of Professor Salisbury. I am acquainted with it only through a *résumé* published in the "American Journal of the Medical Sciences" for the year 1866, new series, vol. li., p. 51. At the beginning of my investigations I was engaged in a microscopic examination of the water and mud of swampy shores and of the marshes, also with a comparison of their microphytes with those which might exist in the urine of patients affected with intermittent fevers. Nearly three months passed without my being able to find the least agreement, the least connection. Having lost nearly all hope of being able to attain the end which I had proposed, I took some of the slime from the marshes and from the masses of kelp and confervæ on the sea-shores, where intermittent fevers are endemic, and placed them in saucers under the ordinary glass desiccators exposed on a balcony,

[1] Translated from the *Archives de la Médecine Navale*, vol. xxx., No. 7, July, 1878, by A. Sibley Campbell, M. D., Augusta, Ga.

open for twenty-four hours, the most of the time under the action of the burning rays of the sun. With the evaporated water deposited within the desiccators, I proceeded to an examination, drop by drop. I at length found that which I had sought so long, but always in vain.

The parasite of intermittent fever, which I have termed Limnophysalis hyalina, and which has been observed before me by Drs. J. Lemaire and Gratiolet,[1] and B. Cauvet,[2] is a fungus which is developed directly from the mycelium, each individual of which possesses one or several filaments, which are simple or dichotomous, with double outlines, extremely fine, plainly marked, hyaline and pointed. Under favorable conditions, that is, with moisture, heat, and vegetable matter in decomposition, the filaments of mycelium increase in length. From these long filaments springs the fungus. The sporangia, or more exactly the conidia, are composed of unilocular vesicles, perfectly colorless and transparent, which generally rise from one or both sides of the filaments of the mycelium, beginning as from little buds or eyes; very often several (two to three) sporangia occur, placed one upon the other, at least on one side of the mycelium.

With a linear magnitude of 480, the sporangia have a transverse diameter of one to five millimeters, or a little more in the larger specimens. The filaments of mycelium, under the same magnitude, appear exceedingly thin, and finer than a hair. The shape of the conidia, though presenting some varieties, is, notwithstanding, always perfectly characteristic. Sometimes they resemble in appearance the segments of a semicir-

[1] *Comptes Rendus Hebdomadaires de l'Académie des Sciences*, Paris, 1867, pp. 317 and 318.

[2] *Archives de Médecine Navale*, November, 1876.

cle more or less great, sometimes the wings of butterflies, double or single. It is only exceptionally that their form is so irregular.

Again, when young, they are perfectly colorless and transparent; sometimes they are of a beautiful violet or blue color (mykianthinin, mykocyanin). Upon this variety of the Limnophysalis hyalina depends the vomiting of blue matters observed by Dr. John Sullivan, at Havana, in patients affected with pernicious intermittent fever (algid and comatose form). In the perfectly mature sporangia, the sporidia have a dark brown color (mykophæin). From the sporidia, the Italian physicians, Lanzi and Perrigi, in the course of their attempts at its cultivation, have seen produced the Monilia penicinata friesii, which is, consequently, the second generation of the Limnophysalis hyalina, in which alternate generation takes place, admitting that their observations may be verified. The sporangia are never spherical, but always flat. When they are perfectly developed, they are distinctly separated from their filament of mycelium by a septum — that is to say, by limiting lines plainly marked. It is not rare, however, to see the individual sporangia, perfectly isolated and disembarrassed of their filament of mycelium, floating in the water. It seems to me very probable that these isolated sporangia are identical with the hyaline coagula so accurately described by Frerichs, who has observed them in the blood of patients dying of intermittent fevers. But if two sporangia are observed with their bases coherent without intermediary filaments of mycelium, it seems to me probable that the reproduction has taken place through the union, which happens in the following manner: Two filaments of mycelium become juxtaposed; after which the filaments of mycelium disappear in the sporangia newly formed, which by this same metamorphosis are deprived of the faculty of reproducing themselves through the filaments of mycelium of which they are deprived. The smallest portion of a filament of mycelium evidently possesses the faculty of producing the new individuals.

It is unquestionable that the Limnophysalis hyalina enters into the blood either by the bronchial mucous membrane, by the surface of the pulmonary vesicles, or by the mucous membrane of the intestinal canal, — most often, no doubt, by the last, with the ingested water; this introduction is aided by the force of suction and pressure, which facilitates its absorption. It develops in the glands of Lieberkuhn, and multiplies itself; after which the individuals, as soon as they are formed, are drawn out and carried away in the blood of the circulation.

The Limnophysalis hyalina is, in short, a solid body, of an extreme levity, and endowed with a most delicate organization. It is not a miasm, in the common signification of the term; it does not carry with it any poison; it is not vegetable matter in decomposition, but it flourishes by preference amid the last.

In regard to other circumstances relative to the presence of this fungus, there are, above all, two remarkable facts, namely, its property of adhering to surfaces as perfectly polished as that of a mirror, and its power of resistance against the reagents, if we except the caustic alkalies and the concentrated mineral acids. This power of resisting the ordinary reagents is that of the schistomycetes in general, and explains in a plausible manner why the fungus is not destroyed by the digestive process in the stomach, where, however, the acid reaction of the gastric juice probably arrests its development and keeps it in a state of temporary inactivity. [See Appendix A.] This property of adhering to smooth surfaces explains, perhaps, the power of the Eucalyptus globulus in arresting the progress of paludal miasm (?). But it is evident that other trees and plants of resinous or balsamic foliage, as, for example, the Populus balsamifera, Cannabis sativa, Pinus silvestris, Pinus abies, Juniperus communis, have with us [in Sweden] the same faculty; they are favorable also for the drying of the soil, and the more completely, as their roots are more extended and more ramified.

In order to demonstrate the presence of the limnophysalis in the blood of patients affected with intermittent fever during the febrile stage, properly speaking, it appeared necessary for me to dilute the blood of patients with a solution of nitrate of potassa, having at 37.5° C. the same specific gravity as the serum of the blood. With capillary tubes of glass, a little dilated toward the middle, of the same shape and size as those which are used in collecting vaccine lymph, I took up a little of the solution of nitrate of potassa above indicated. After this I introduced the point of an ordinary inoculating needle under the skin, especially in the splenic region, where I ruptured some of the smallest blood-vessels of the subcutaneous cellular tissue. I collected some of the blood which flowed out or was forced out by pressure, in the capillary tubes just described, containing a solution of potassa; after which I melted the ends with the flame of a candle. With all the intermittent fever patients whose blood I have collected and diluted during the febrile stage, properly speaking, I have constantly succeeded in finding the Limnophysalis hyalina in the blood by microscopic examination.

It is only necessary for me to mention here that it is of the highest importance to be able to demonstrate the presence of fungus in the blood of the circulation and in the urine of patients in whom the diagnosis is doubtful. The presence of the Limnophysalis hyalina in the urine indicates that the patient is liable to a relapse, and that his intermittent fever is not cured, which is important in a prognostic and therapeutic point of view.

When the question is to prevent the propagation of intermittent fevers, it is evident that it should be remembered that the Limnophysalis hyalina enters into the blood by the mucous membrane of the organs of respiration, of digestion, and the surface of the pulmonary vesicles.

We have also to consider the soil, and the water that is used for drinking.

In regard to the soil, several circumstances are very worthy of attention. It is desirable, not only to lower as much as possible the level of the subterranean water (*Grundwasser*) by pipes of deep drainage, the cleansing, and if there is reason, the enlargement (J. Ory) of the capacity of the water collectors, besides covering and keeping in perfect repair the principal ditches in all the secondary valleys to render the lands wholesome, but also to completely drain the ground, diverting the rain water and cultivating the land, in the cultivation of which those trees, shrubs, and plants should be selected which thrive the most on marshy grounds and on the shores and paludal coasts of the sea, and which have their roots most spreading and most ramified. Some of the ordinary grasses are also quite appropriate, but crops of the cereals, which are obtained after a suitable reformation of marshy lands, yield a much better return. After the soil in the neighborhood of the dwellings has been drained and cultivated with care, and in a more systematic manner than at present, the bottoms of the cellars should be purified, as well as the foundations of the walls and of the houses.

The water intended for drinking, which contains the Limnophysalis hyalina, should be freed from the fungus by a vigorous filtration. But, as it is known, the filtering beds of the basins in the water conduits are soon covered with a thick coating of confervæ, and the Limnophysalis hyalina then extends from the deepest portions of the filtering beds into the filtered water subjacent. It is for this reason that it is absolutely necessary to renew so often the filtering beds of the water conduits, and, at all events, before they have become coated with a thick layer of confervæ. The disappearance of intermittent fevers will testify to the utility of these measures. It is for a similar reason that wooden barrels are so injurious for storage. When the wood has begun to decay by the contact of the impure water, the filaments of mycelium of the Limnophysalis hyalina penetrate into the decayed wood, which becomes a fertile soil for the intermittent fever fungi.

The employment for the preparation of mortar of water not filtered, or of foul, muddy sand which contains the Limnophysalis hyalina, explains how intermittent fevers may proceed from the walls of houses. This arises also from the pasting of wall-paper with flour paste prepared with water which contains an abundance of the fungi of intermittent fever.

The miasm in the latter case is therefore endoecic, or more exactly entoichic. With us the propagation of intermittent fever has been observed in persons occupying rooms scoured with unfiltered water containing the Limnophysalis hyalina in great quantity.

The following imperial ordinance was published on the 25th of March, 1877, by the chief of admiralty of the German marine. It has for its object the prevention and eradication of infectious diseases: —

"In those places where infectious diseases, according to experience, are prevalent and unusually severe and frequent, it is necessary to abstain as much as possible from the employment of water taken from without the ship for cleansing said vessel, and also for washing out the hold when the water of the sea or of a river, in the judgment of the commander of a vessel, confirmed by the statement of the physician, is shown to be surcharged with organic matter liable to putrefaction. With this end in view, if you are unable to send elsewhere for suitable water, you must make use of good and fresh water, but with the greatest economy. In that event the purification of the hold must be accomplished by mechanical means or by disinfectants."

"As I have demonstrated by my investigations that in the distillation of paludal water and that from the marshy shores of the sea the Limnophysalis hyalina, which is impalpable, is carried away and may be detected again after the distillation, it must be insisted that the water intended to be used for drinking on shipboard shall be carefully filtered before and after its distillation."

## KLEBS-TOMMASI AND STERNBERG.

The Klebs-Tommasi's and Dr. Sternberg's report, as summarized in the Supplement No. 14, National Board of Health Bulletin, Washington, D. C., July 18, 1881, I would cordially recommend to all students of this subject.

I welcome these observers into the field. Nothing but good can come from such careful and accurate observations into the cause of disease. For myself I am ready to say that it may be that the Roman gentlemen have hit on the cause of the Roman fever, which is of such a pernicious type. I do not see how I can judge, as I never investigated the Roman fever; still, while giving them all due credit, and treating them with respect, in order to put myself right I may say that I have long ago ceased to regard all the bacilli, micrococci, and bacteria, etc., as ultimate forms of animal or vegetable life. I look upon them as simply the embryos of mature forms, which are capable of propagating themselves in this embryonal state. I have observed these forms in many diseased conditions; many of them in one disease are nothing but the vinegar yeast developing, away from the air, in the blood, where the full development of the plant is not apt to be found. In diphtheria I developed the bacteria to the full form — the Mucor malignans. So, in the study of ague, for the vegetation which seems to me to be connected with ague I look to the fully developed sporangia as the true plant.

Again, I think that crucial experiments should be made on man for his diseases as far as it is possible. Rabbits, on which the experiments were made, for example, are of a different organization and food than man, and bear tests differently. While there are so many human beings subject to ague, it seems to me they should be the subjects on whom the crucial tests are to be made, as I did in my labors.

As far as I can see, Dr. Sternberg's inquiries tend to disprove the Roman experiments, and as he does not offer anything positive as a cause of ague, I can only express the hope that he will continue his investigations with zeal and earnestness, and that he will produce something positive and tangible in his labors in so interesting and important a field.

I would then that all would join hands in settling the cause of this disease; and while I do not expect that all will agree with me, still I shall respect others' opinions, and so long as I keep close to my facts I shall hope my views, based on my facts, will not be treated with disrespect.

## APPENDIX A.

Plate VIII. Gemiasma verdans and Gemiasma rubra collected September 10, 1882, on Washington Heights, near High Bridge. The illustrations show the manner in which the mature plants discharge their contents.

A, B, and C represent very large plants of the Gemiasma verdans. A represents a mature plant. B represents the same plant, discharging its spores and spermatia through a small opening in the cell walls. The discharge is quite rapid but not continuous, being spasmodic, as if caused by intermittent contractions in the cell walls. The discharge begins suddenly and with considerable force — a sort of explosion which projects a portion of the contents rapidly and to quite a little distance. This goes on for a few seconds, and then the cell is at rest for a few seconds, when the contractions and explosions begin again and go on as before. Under ordinary conditions it takes a plant from half an hour to an hour to deliver itself. It is about two thirds emptied.

C represents the mature plant entirely emptied of its spore contents, there remaining inside only a few actively moving spermatia, which are slowly escaping. The spermatia differ from the spores of young plants in being smaller, and in possessing the power of moving and tumbling about rapidly, while the spores of young plants are larger and quiescent.

D, E, F, and G represent mature plants belonging to the Gemiasma rubra. D represents a ripe plant, filled with spores, embryonic plants, and spermatia. E represents a ripe plant in the act of discharging its contents, it being about half emptied. F represents a ripe plant after its spore and embryonic plant contents are all discharged, leaving behind only a few actively moving spermatia, which are slowly escaping. G represents the emptied plant in a quiescent state.

A, B, C represent an unusually large variety of the Gemiasma verdans. This species is usually about the size of the G. rubra. This large variety was found on the upper part of New York Island, near High Bridge, in a natural depression where the water is standing all the year, except in July, August, and September, when it becomes an area of drying, cracked mud two hundred feet across. As the mud dries these plants develop in great profusion, giving an appearance to the surface as if covered thickly with brick dust.

These depressions and swaly places, holding water part of the year and becoming dry during the malarial season, can be easily dried by means of covered drains and grassed or sodded over, when this vegetation will cease to grow, and ague in such localities will disappear.

The malarial vegetations begin to develop moderately in July, but do not spring forth abundantly enough to do much damage till about the middle of August, when in ague localities they spring into existence in vast multitudes, and continue to develop in great profusion till frost comes.

# ANALYSIS OF THE MALARIA PLANT (GEMIASMA RUBRA).

BY PROF. PAULUS F. REINSCH.[1]

Dr. Cutter writes me, September 28, 1882: "My dear Professor: By this mail I send you a specimen of the Gemiasma rubra of Salisbury, described in 1862 as found in bogs, mud-holes, and marshes of ague districts, in the air suspended at night, in the sputa, blood, and urine, and on the skin of persons suffering with ague. It is regarded as one of the palmellaceæ. This G. rubra is found in the more malignant and fatal types of the disease. I have found it in all the habitats described by Dr. Salisbury. Both he and myself would like you to examine and hear what you have to say about it."

The substance of clayish soil contains, besides fragments of shells of larger diatoms (Surirella synhedra), shells of Navicula minutissima, Pinnularia viridis, spores belonging to various cryptogams.

1. Spherical transparent spores with laminated covering and dark nucleus — 0.022 millimeter in diameter.

2. Spherical spores with thick covering of granulated surface.

3. Spherical spores with punctulated surface — 0.007 millimeter in diameter.

[1] Author *Algæ of France*, 1866; *Latest Observations on Algology*, 1867; *Chemical Investigation of the Connections of the Lias and Jura Formations*, 1859; *Chemical Investigation of the Viscum Album*, 1860; *Contributions to Algology and Fungology*, 1874–75, vol. i.; *New Investigation of the Microscopic Structure of Pit Coal*, 1881; *Micrographic Photographs of the Structure and Composition of Pit Coal*, 1883.

4. Very minute, transparent, bluish-green colored spores, with thin covering and finely granulated contents — 0.006 millimeter in diameter.

5. Chroöcoccoid cells with two larger nuclei — 0.0031 millimeter in diameter. Sometimes biciliated minute cells are found; without any doubt they are zoöspores derived from any algoid or fungoid species.

I cannot say whether there exists any genetic connection between these various sorts of spores. It seems to me that probably numbers 1–4 represent resting states of the hyphomycetes.

No. 5 represents one and two celled states of chroococcus species belong to Chroöcoccus minutus.

The crust of the clayish earth is covered with a reddish brown covering of about half a millimeter in thickness. This covering proves to be composed, under the microscope, of cellular filaments and various shaped bodies of various composition. They are made up of cells with densely and coarsely granulated reddish colored contents — shape, size, and composition are very variable, as shown in the figures. *The cellular bodies make up the essential organic part of the clayish substance, and, without any doubt, if any organic compounds of the substance are in genetical connection with the disease, these bodies would have this role.* The structure and coloration of cell contents exhibit the closest alliance to the characteristics of the division of chroölepideæ and of this small division of chlorophyllaceous algæ, nearest to gongrosira — a genus whose five to six species are inhabitants of fresh water, mostly attached to various minute aquatic algæ and mosses. Each cell of all the plants of this genus produces a large number of mobile cells — zoöspores.

Plate X. Fig. 9 represents very probably one zoospore developed from these plants as figured from 10 to 16.

# ILLUSTRATIVE PLATES,

WITH

## EXPLANATIONS OF THE FIGURES.

## MORPHOLOGY OF NIGHT AIR IN MALARIOUS DISTRICTS.

(Page 63.)

### Plate I.

*Fig.* 1. — Bodies elevated in the night air vapors in malarious districts, and found in the water condensed under glass plates 16×22 inches square, one foot above the surface of soil.

A, B, D, F, G, H, J, Zoöspores.

C, Vibriones.

E, Transparent cell (cilia left out).

I, Parent cell.

K′, Inactive cells with nuclei.

M, Algæ with two diatoms attached.

N, Algoid filament.

O, Diatom.

P, Minute oblong cells, *also constant in the expectoration of ague cases.*

*Fig.* 2. — Bodies in the night vapors of recently exposed drying soils of rich, humid, low grounds and drying peat bogs.

O, N near O, K, K′ always present in the night air *and morning expectoration of persons exposed.*

The rest come from bogs partially covered with water during a portion of the year.

C, C′, Beautiful brownish yellow spores of palmellæ.

M, M′, D, D′, B, Spores of Sphærotheca pyrus.

N, N′, F, I, Young palmellæ.

G, L, Greenish cells with granular contents.

V, W, O, Cell contents discharged.

*Fig.* 3. — Plants composing the incrustations of ague districts, and producing the cells, spores, and young plants of Fig. 2.

A, Protuberans gelatiformis.

B, Protuberans lamella.

T, Protuberans ovalis.

R, S, T, U, V most constant bodies found.

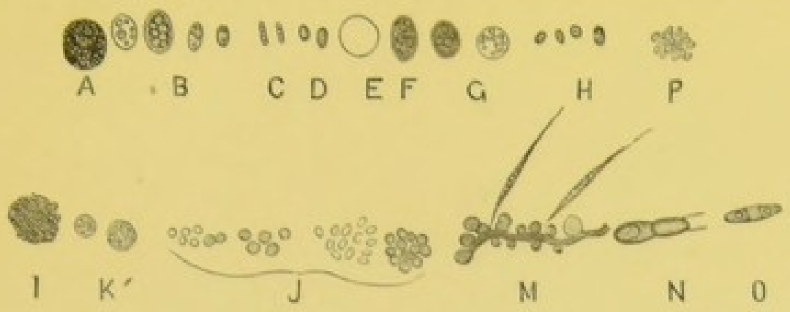



Fig 1.

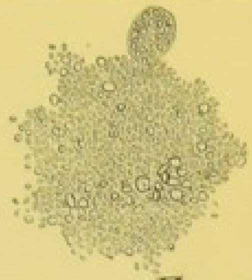


Fig. 4.

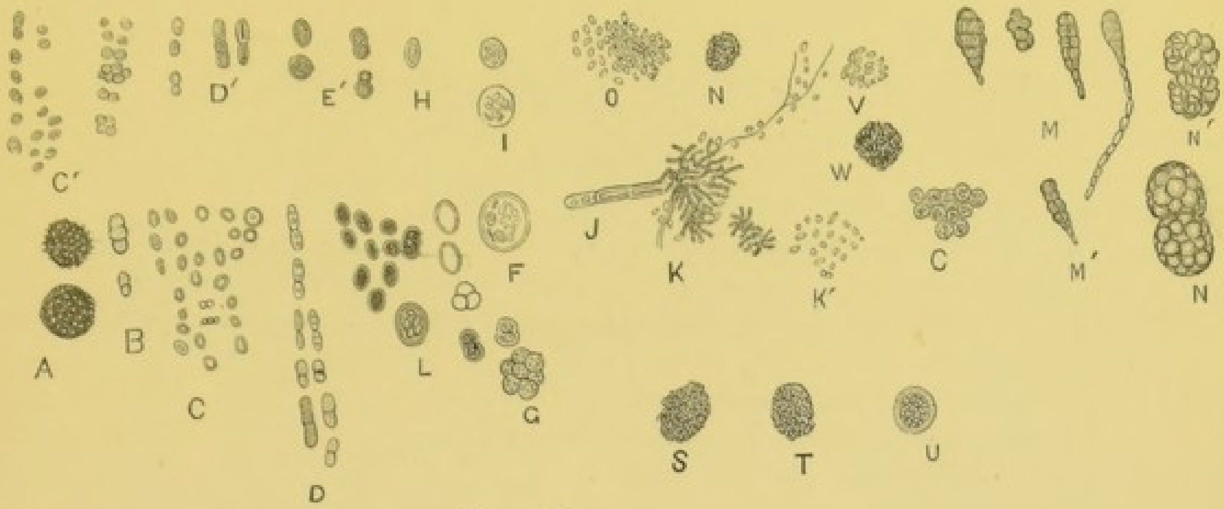



Fig. 2

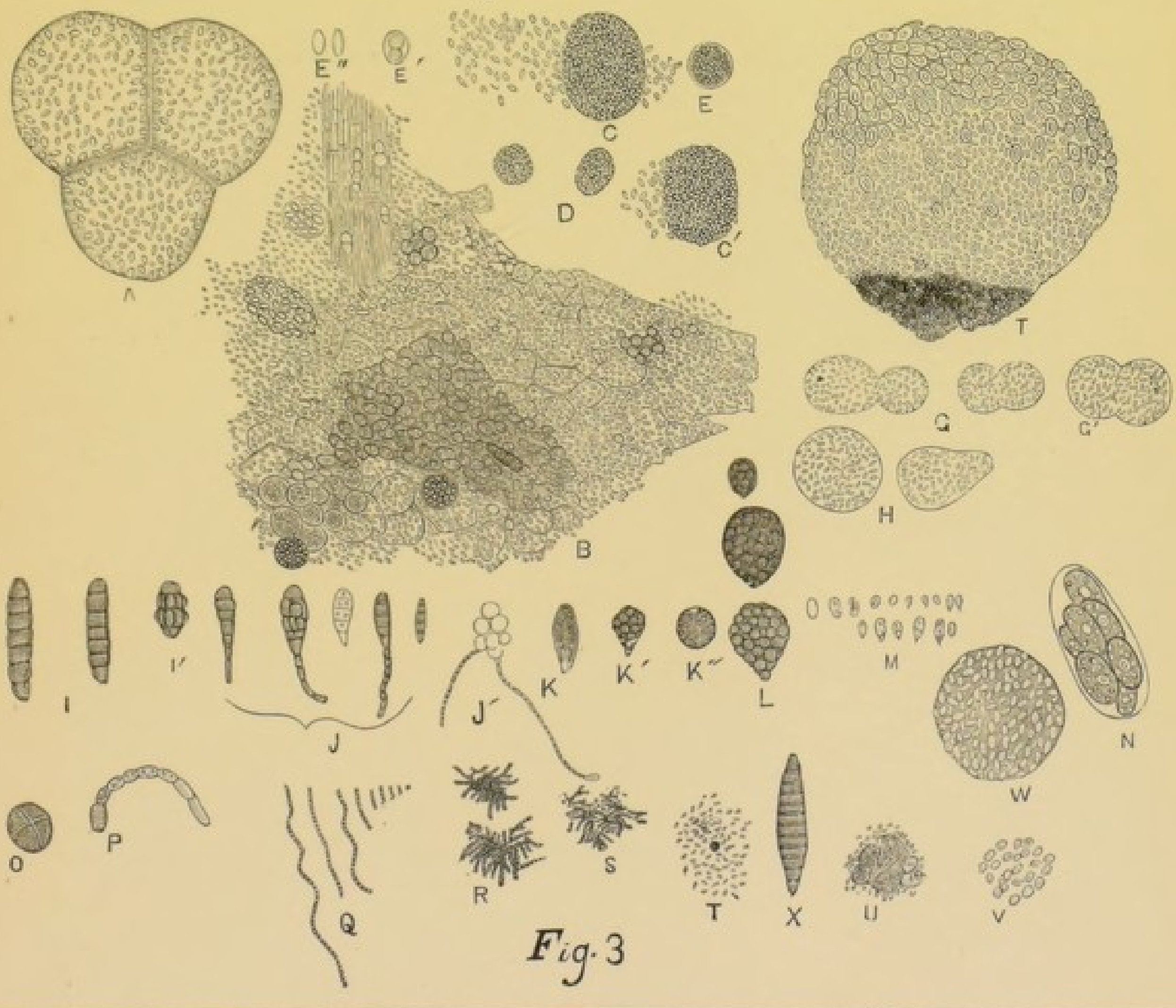



Fig. 3

## PLANTS IN SOILS OF MALARIOUS DISTRICTS.

### Plate II.

A, B, C, D, Section of Protuberans gelatiformis.

Near B are three sporangia *en route* for exit *via* opening at B. Toward the right smaller sporangia are seen. Ramifying through the substance of A, B, C, D, are interstitial mycelial filaments of a parasitic fungus, a species of sphærotheca.

E, Small Protuberans gelatiformis.

F, One mode by which E multiplies its cells.

G, Parasitic fungus spore vegetating.

H, Protuberans ovalis.

I, Protuberans lamella.

J, Protuberans ovalis throwing off spores.

K, K′, K′, K′, Filaments and spores of parasitic sphærotheca.

L, Sporangia developing from filament.

M, Microspores of K, highly magnified.

N, O, Mature spores of Protuberans gelatiformis.

P, Peculiar brownish spore case.

Q, Double sporangia.

R, Perithecium of I, Protuberans lamella.

S, T, Sporangia of Gemiasma rubra.

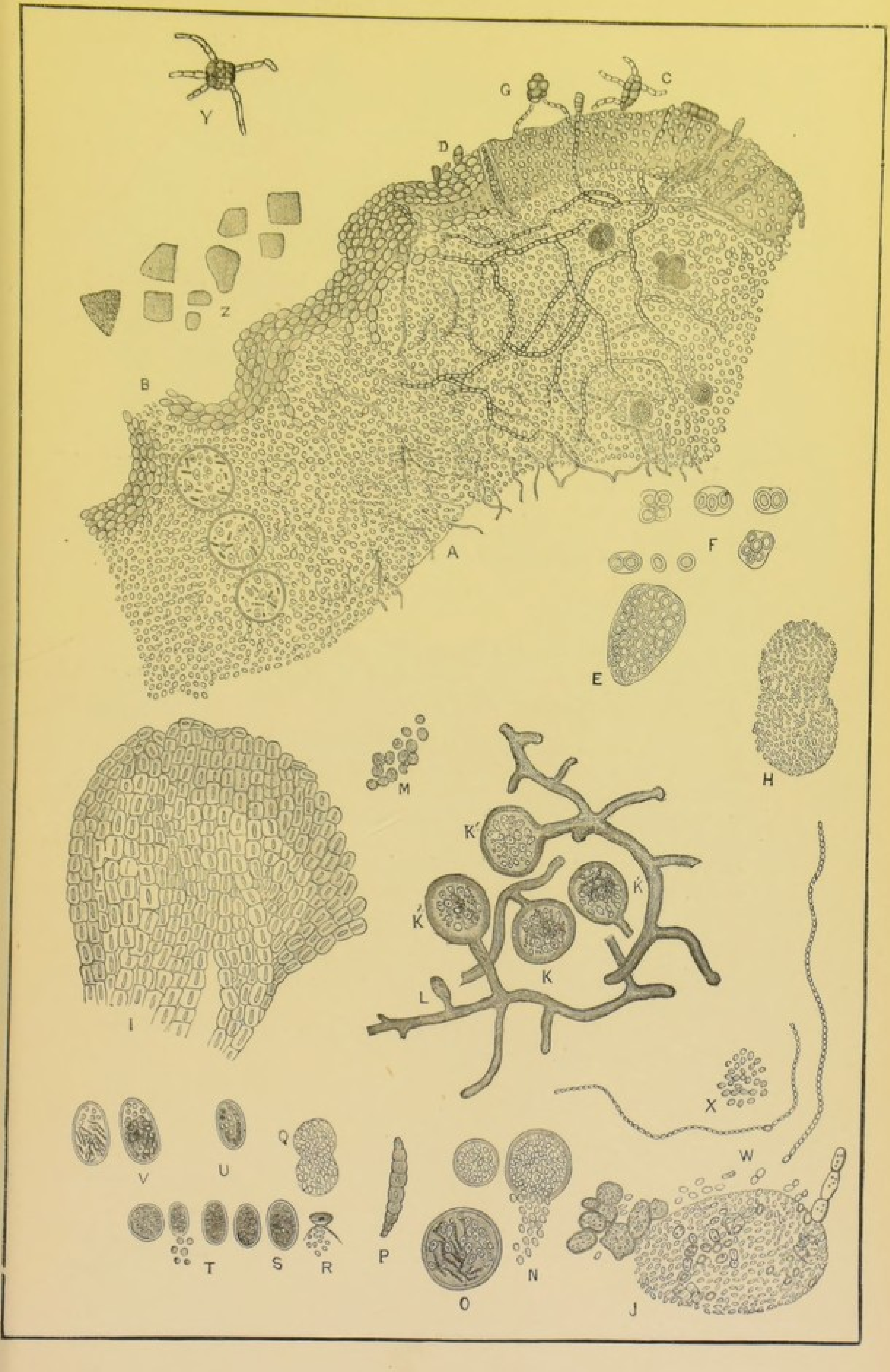
U, V, Sporangia with red and green mixed and contents partly discharged.

W, Fungus vegetating into filaments.

X, Spores more highly magnified.

Y, Fungus with five filaments.

Z, Crystalline bodies.


Y
G
C
D
Z
B
A
F
E
H
M
K'
Ḱ
Ḱ
K
L
I
X
W
V
U
Q
P
T
S
R
O
N
J

## PLANTS THAT PRODUCE CONGESTIVE INTERMITTENTS; AND OTHER BODIES; FROM THE DRAINED AND DRIED BED OF AN OLD FISH-POND SOON AFTER THE SOIL WAS SPADED UP FOR A CELERY BED. ALSO, PLANTS IN SWEAT OF AGUE CASE.

### Plate III.

A, A′, The simplest form of Gemiasma rubra.

B, B′, C, C′, D, Mode in which the plants grow.

D′, Body of acicular crystals radiating from one point; also sometimes found in ague urine (see W, Q, R, Plate V.).

E, Mature and dry plants in the soil.

E′, Diatoms.

F, G, Crystalline bodies.

H, Same as E.

I, Broken filaments of sphærotheca.

I′, Peculiar growth occurring among ague plants, and frequently found in the urine of malarial and typhoid cases.

J, J, J, J′, Like D′.

K, Like D′, but looking like fragments of membrane.

L, L′, M, M′, N, O, P, *Plants in the sweat of malaria cases.*

M, M′, Perfect gemiasmas.

N, Torula cerevisiæ found in the sweat, blood, and urine of ague, showing presence of sugar.

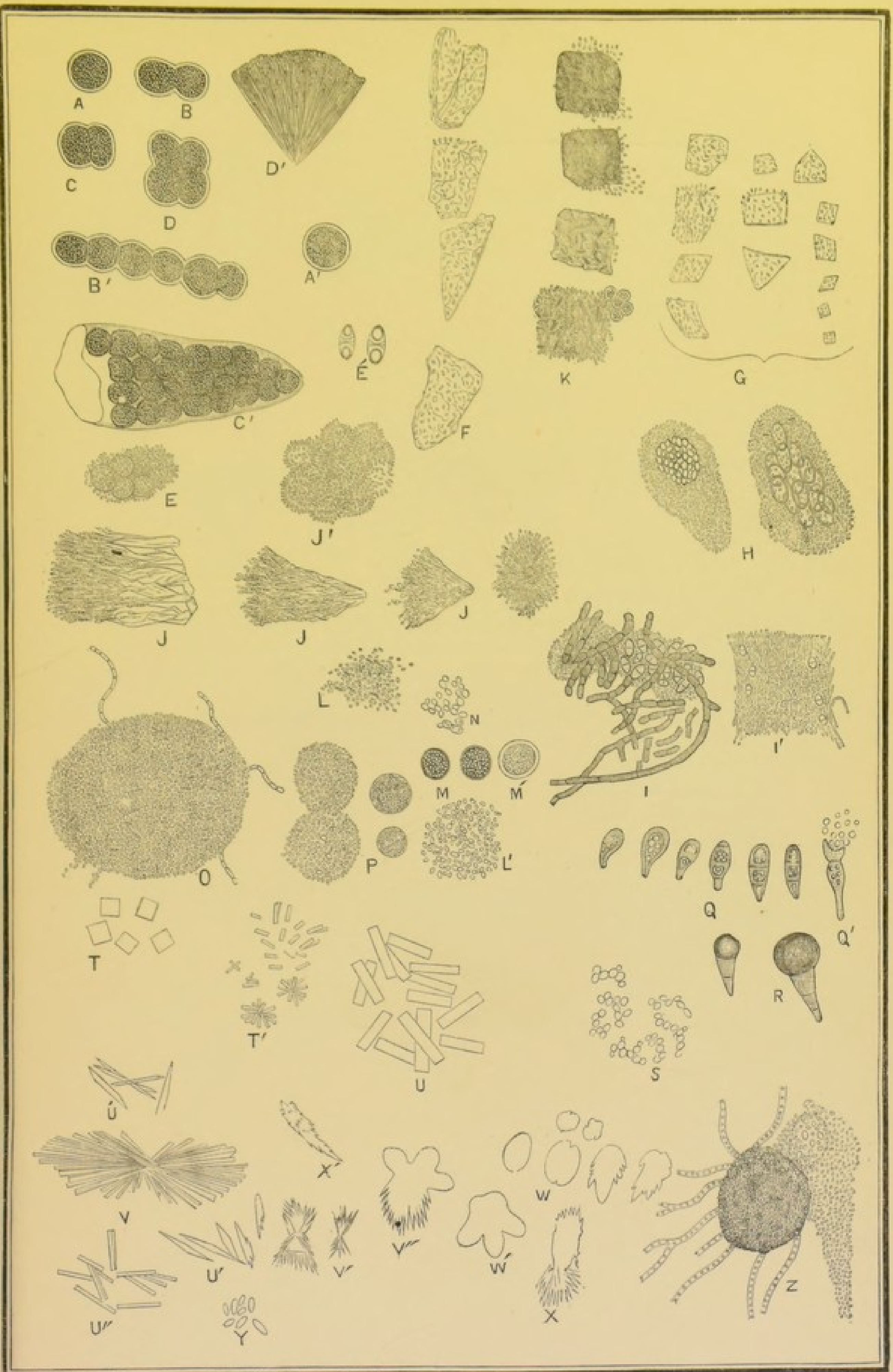
O, P, Larger specimens of plants found on skin of ague cases.

Q, Q′, R, Asci of a species of puccinia found abundantly in the sweat of a baker who labored under ague.

S, Same as N.

T, T′, U, U′, U″, V, V′, V″, W, W′, X, X′, and Y, Crystals and crystalline bodies separated from ague plants by ether; occurring in the plants in considerable quantity.

Z, Ague plant in urine of patients suffering from malaria, with sphærotheca filaments developing from it.


A
B
D′
C
D
B′
A′
É
C′
F
K
G
E
J′
H
J
J
J
L
N
I
I′
O
P
M
M′
L′
Q
Q′
T
T′
U
R
S
Ú
V
X
W
V‴
W′
U′
V″
X
Z
U″
Y

## PLANTS FOUND IN MALARIAL SOILS, AND ALSO IN THE EXPECTORATION AND URINE OF AGUE CASES.

(Page 68.)

### Plate IV.

A, B, C, D, E, G, H, I, K, M, N, and T, Plants producing malarias of a congestive type, such as are developed on the rich calcareous soils back of Vicksburg, Yazoo, Nashville, Louisville, Cincinnati ; also found in the expectoration of persons exposed to the night exhalations from the soil of ague localities.

At C the minute contents of a plant are being discharged, which at E and G are more highly magnified.

H and I, Gemiasma verdans.

K, Gemiasma rubra.

L, Confervoid alga.

M, Fungus spore.

N, Gemiasma plumba.

O, P, Q, Gemiasma rubra found in the urine of patients suffering from chronic congestive intermittents. At Q is also a parasitic penicillium.


A
B
D
G
E
C
T
H
K
I
N
O
P
Q
L
M

## ABNORMAL BODIES FOUND IN THE URINARY BLADDERS OF AGUE CASES.

(Page 58.)

### Plate V.

A, B, C, D, and E, Ague plants that have developed in the urinary bladders of severe malarial cases.

F, Palmellæ met with in ague urine and in wet, low bogs.

G, H, I, Embryonal plants constantly found in ague urine.

K, Mass of plants growing in ague urine, with mycelia of sphærotheca vegetating from their peripheries, same as Z, Plate III.

L, L, L, O, Sphærotheca filaments developing from spores.

P, Mass of gemiasmas.

Q, R, S, T, U, V, and Y, Bodies found in the urine of a patient, aged 13, suffering with tertian ague.

Q, R, Bodies of acicular crystals found in ague urine identical with those found in ague bogs among the gemiasmas and represented at D, J, J, J, Plate III.

R, Body left to evaporate over night between cover and slide.

S, S, Pedunculated sacs resulting from evaporation.

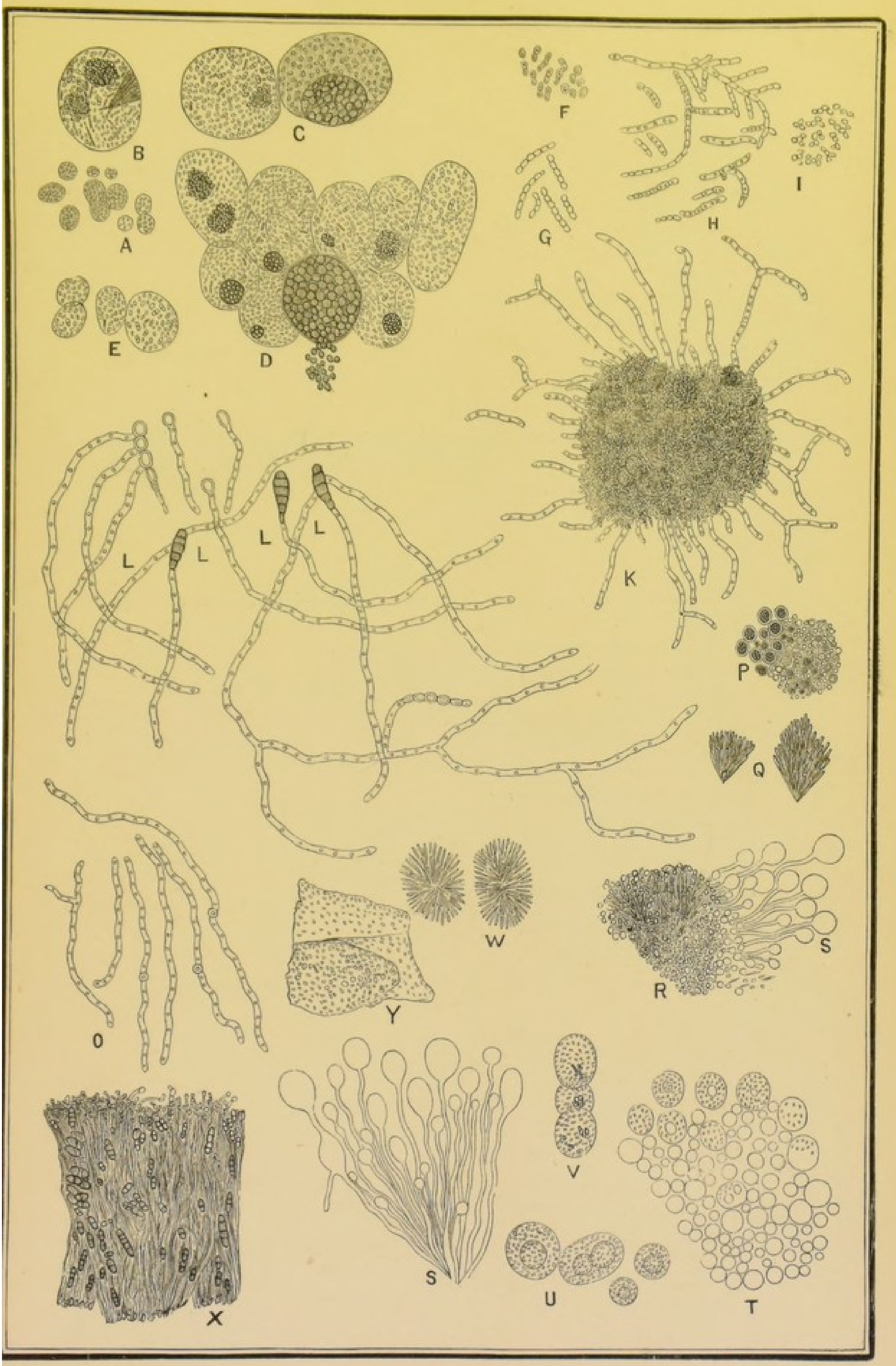
T, Cells formed from S, on applying moisture.

U and V, New plants formed from T after a time.

Q and W, Radiating bodies identical with D′, J, J, J, Plate III., found in bogs.

X, Body like I′, Plate III.

W and X met with in old debilitated cases of ague.


B
C
F
H
I
A
D
G
E
K
L
L
L
L
P
Q
W
S
R
Y
O
V
X
S
U
T

FERMENTATION VEGETATIONS IN THE URINE OF MALARIAL CASES, INDICATING THE PRESENCE OF SUGAR AND RAPID CHANGES.

(Page 80.)

PLATE VI.

A, Filamentous development of acetous fermentation vegetations, a species of penicillium.

B, Vegetating spores of mature plants of same.

C, Mature plants of same, bearing fruit.

D, Torula cells.

E, Same as A, but another species.

F, Same as B.

G, H, Torula cells.

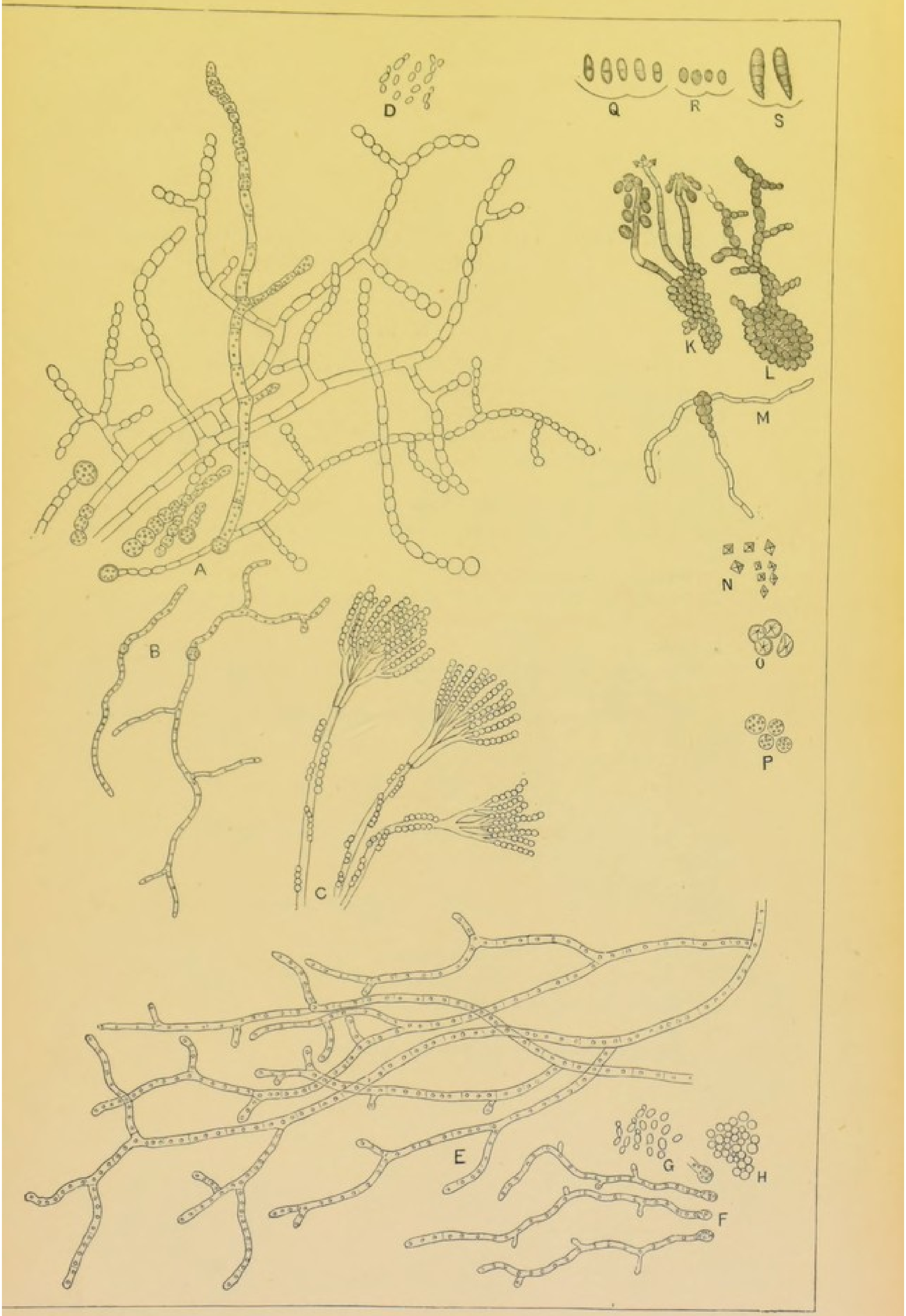
K, L, M, Sphærotheca spores.

N, Oxalate of lime.

O, Empty amyloid cells.

P, Epithelia.

Q, R, S, Sphærotheca spores.



A
B
C
D
E
F
G
H
K
L
M
N
O
P
Q
R
S

## URINARY DEPOSITS IN MALARIA. ACTION OF NITRIC ACID ON URINARY CRYSTALS.

(Pp. 82–85.)

### Plate VII.

A, B, Cells filled with crystals, some of them with radiations.

A′, B′, Peculiar forms of vibriones.

C, Crystalline cell with no projections.

C′, D″, E″, F′, G′, H″, Rhomboid forms of uric acid ; rarely met with.

D, E, Crystalline cells.

D′, E′, Epithelia.

F, Epithelia ; contents dissolved out by nitric acid.

G and H, Thin-walled cells left after A, E, K, M were treated with nitric acid.

H′, Rhomboid forms of uric acid.

H‴, I″, Crystalline bodies with organic framework in concentric layers.

I, Cells partially dissolved out by nitric acid.

I′, Oxalate of lime.

K, Crystalline cells with projections, save one to the right.

K′, Triple phosphate crystals.

L, L′, L″, L‴, N″, and W‴, Cells in which this form of deposit has just begun.

M, M′, Crystalline cells of uric acid.

M″, Cells in more complete solution by nitric acid.

N, Embryonal fungoid vegetation.

N′, Oxalate of lime, according to Hassall and Golding Bird.

O, O′, O″, Crystals deposited in cells.

P, Crystalline cells.

Q, R, S, T, U, U′, V, W, X, Y, Crystals in process of solution by nitric acid.

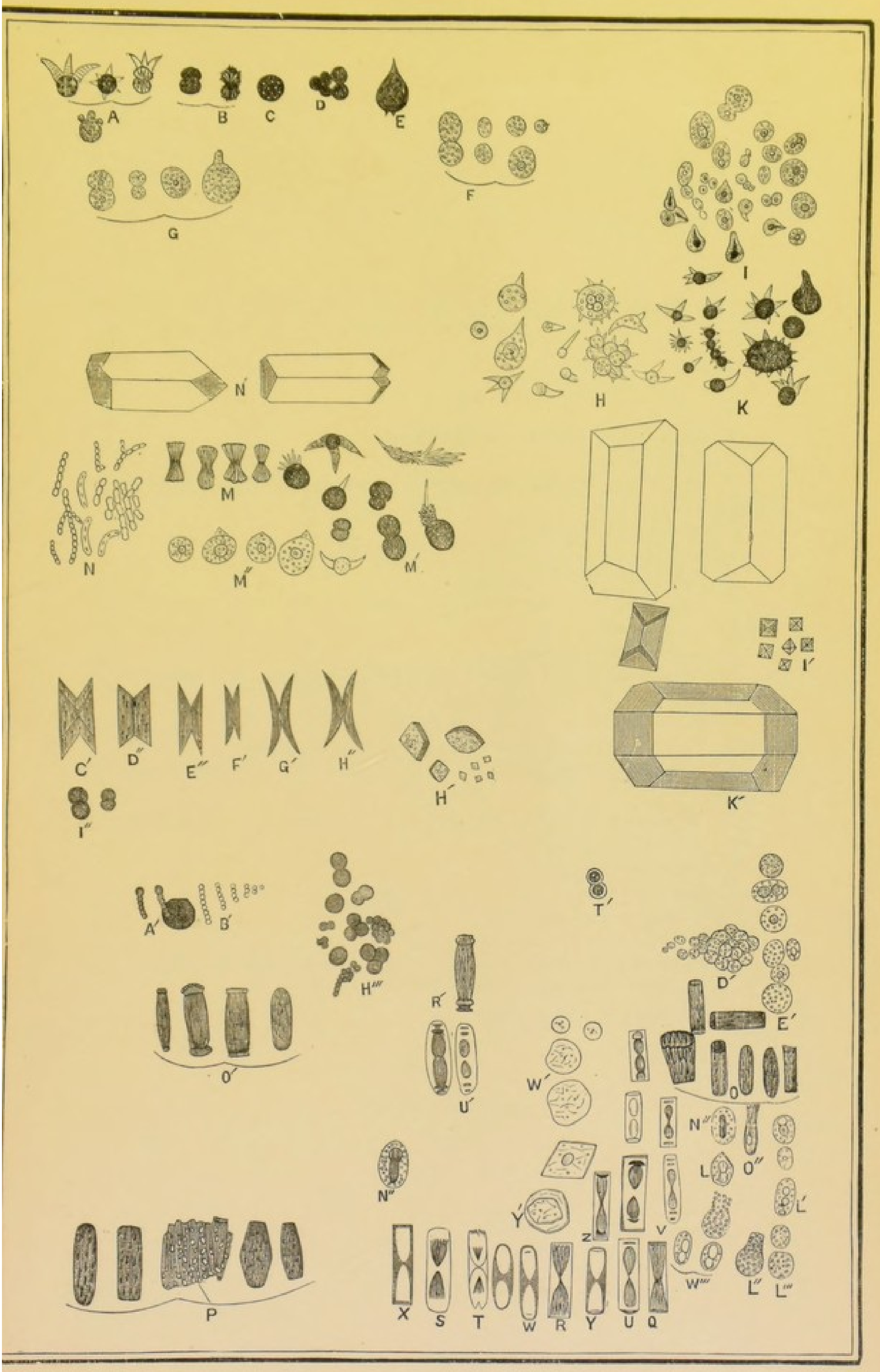
O, Q, R, R′, Y, S, Uric acid crystals.

W′, Light membranous cases left from the solution in nitric acid.

Y′, Epithelium with crystalline plate inside.

T′, Algæ.

Z, Peculiar form of uric acid found in urine.


A
B
C
D
E
F
G
I
N′
H
K
M
N
M″
M′
I′
C′
D″
E″
F′
G′
H″
H′
K′
I″
T′
A′
B′
H‴
D′
E′
R′
O′
U′
W′
O
N″
L
O″
L′
N‴
Y′
Z
V
W‴
L″
L‴
P
X
S
T
W
R
Y
U
Q

AGUE PLANTS FROM NATURAL HABITATS: FROM BLOOD: FROM SWEAT.

(Page 138.)

PLATE VIII.

A, B, C, Large plants of Gemiasma verdans.

A, Mature plant.

B, Mature plant discharging spores and spermatia through a small opening in the cell wall.

C, Plant nearly emptied.

D, Gemiasma rubra ; mature plant filled with microspores.

E, Ripe plants discharging contents.

F, Ripe plant, contents nearly discharged ; a few active spermatia left behind and escaping.

G, Nearly empty plant.

H, Vegetation in the SWEAT of ague cases during the paroxysm of sweating.

I, Vegetation in the BLOOD of ague.

J, Vegetation in the urine of ague during paroxysm.

K, L, M, Vegetation in the urine of chronic cases of severe congestive type.

N, Vegetation in BLOOD of Panama fever ; white corpuscles distended with spores of gemiasma.

O, Gemiasma alba.

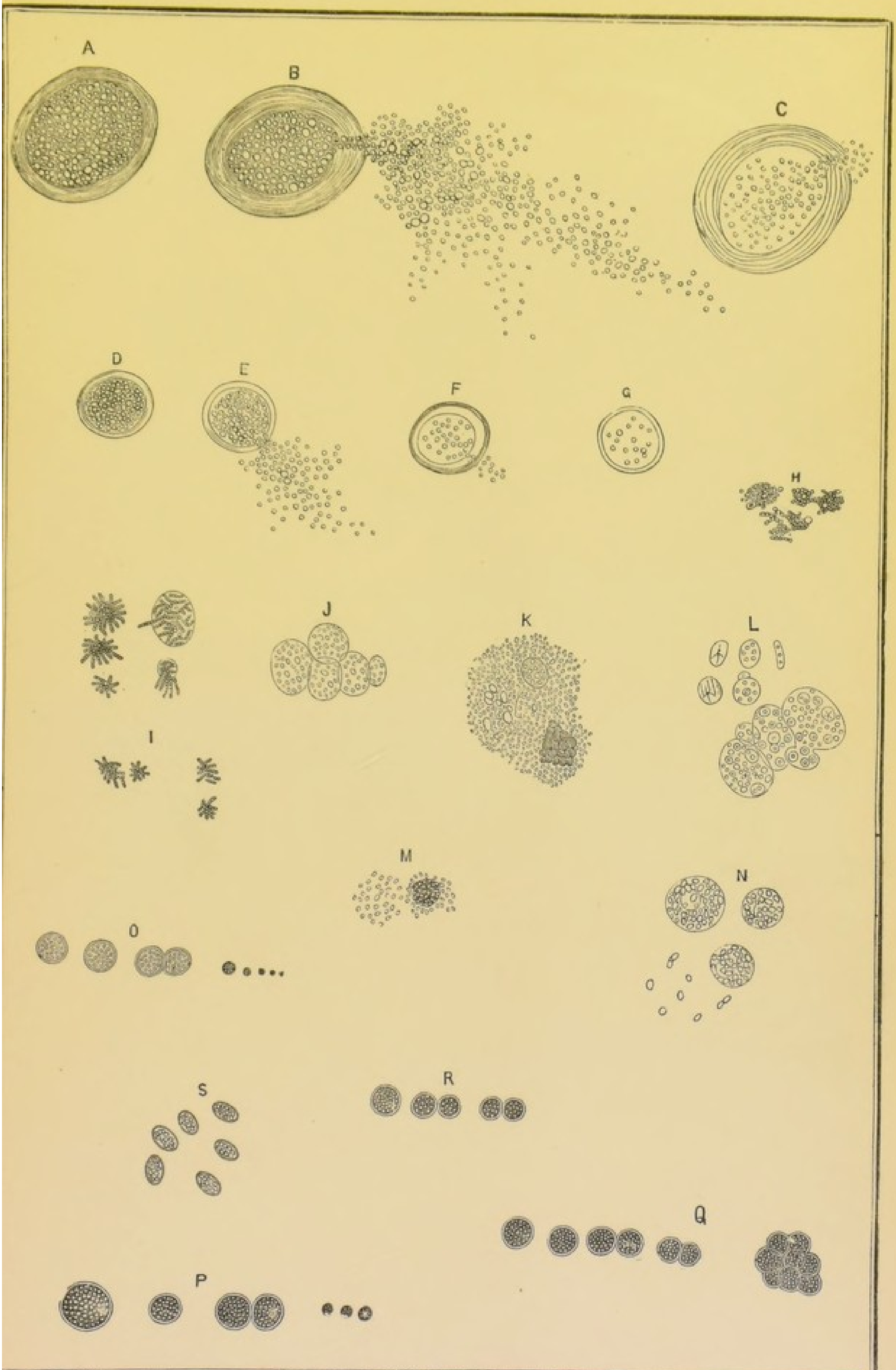
P, Gemiasma rubra.

Q, Gemiasma verdans.

R, Gemiasma alba.

O, P, Q, R found June 28, 1867, in profusion between Euclid and Superior Streets, near Hudson, Cleveland, O.

S, Sporangia of protuberans.



A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S

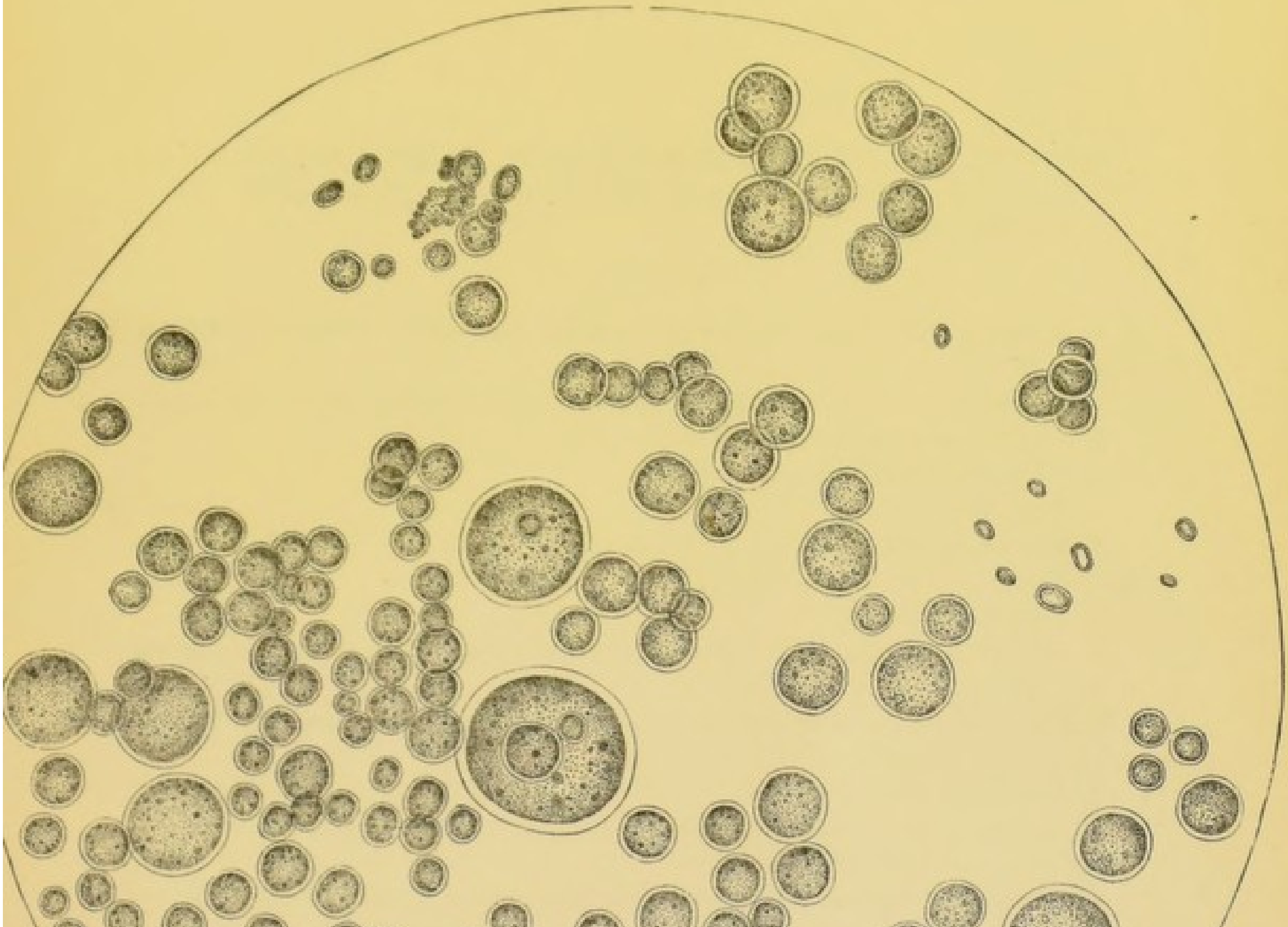
## GEMIASMA VERDANS.

### Plate IX.

Large group of malaria plants, Gemiasma verdans, collected at 165th Street, east of 10th Avenue, New York, in October, 1881, by Dr. Ephraim Cutter, and projected by him with a solar microscope.

Dr. Cuzner — the artist — outlined the group on the screen and made the finished drawing from the sketch. He well preserved the grouping and relative sizes.

The pond-hole whence they came was drained in the spring of 1882, and in August was covered with coarse grass and weeds. No plants were found there in satisfactory quantity, but those figured on Plate VIII. were found half a mile beyond. This shows how draining removes the malaria plants.



## ILLUSTRATIONS OF PROFESSOR P. F. REINSCH'S REPORT ON THE MORPHOLOGY OF A SPECIMEN OF AGUE SOIL.

### PLATE X.

1, *a*, Spore with thick laminated covering, constantly colorless contents, and dark nucleus.

*b*, Part of the wall of cell highly magnified, 0.022 millimeter in thickness.

2, Smaller spore with verruculous covering.

3, Spore with punctulated covering.

4, The same.

5, Minute spores with blue-greenish colored contents, 0.0021 millimeter in diameter.

6, Larger form of 5.

7, Transparent spherical spore, contents distinctly refracting the light, 0.022 millimeter in diameter.

8, Chroöcoccoid minute cells, with transparent, colorless covering, 0.0041 millimeter in diameter.

9, Biciliated zoöspore.

10, Plant of the Gemiasma rubra, thallus on both ends attenuated, composed of seven cells of unequal size.

11, Another complete plant of rectangular shape composed of regularly attached cells.

12, Another complete, irregularly shaped and arranged plant.

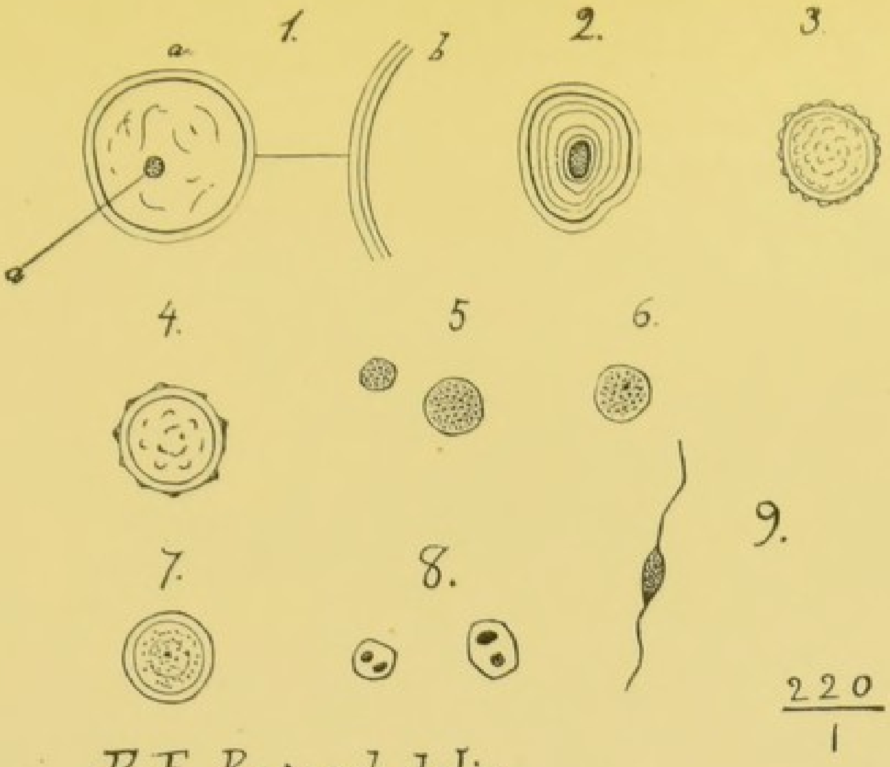
13, Another plant, one end with incrassated and regularly arranged cells.

14, Another elliptically shaped plant, the covering on one end attenuated into a long appendix.

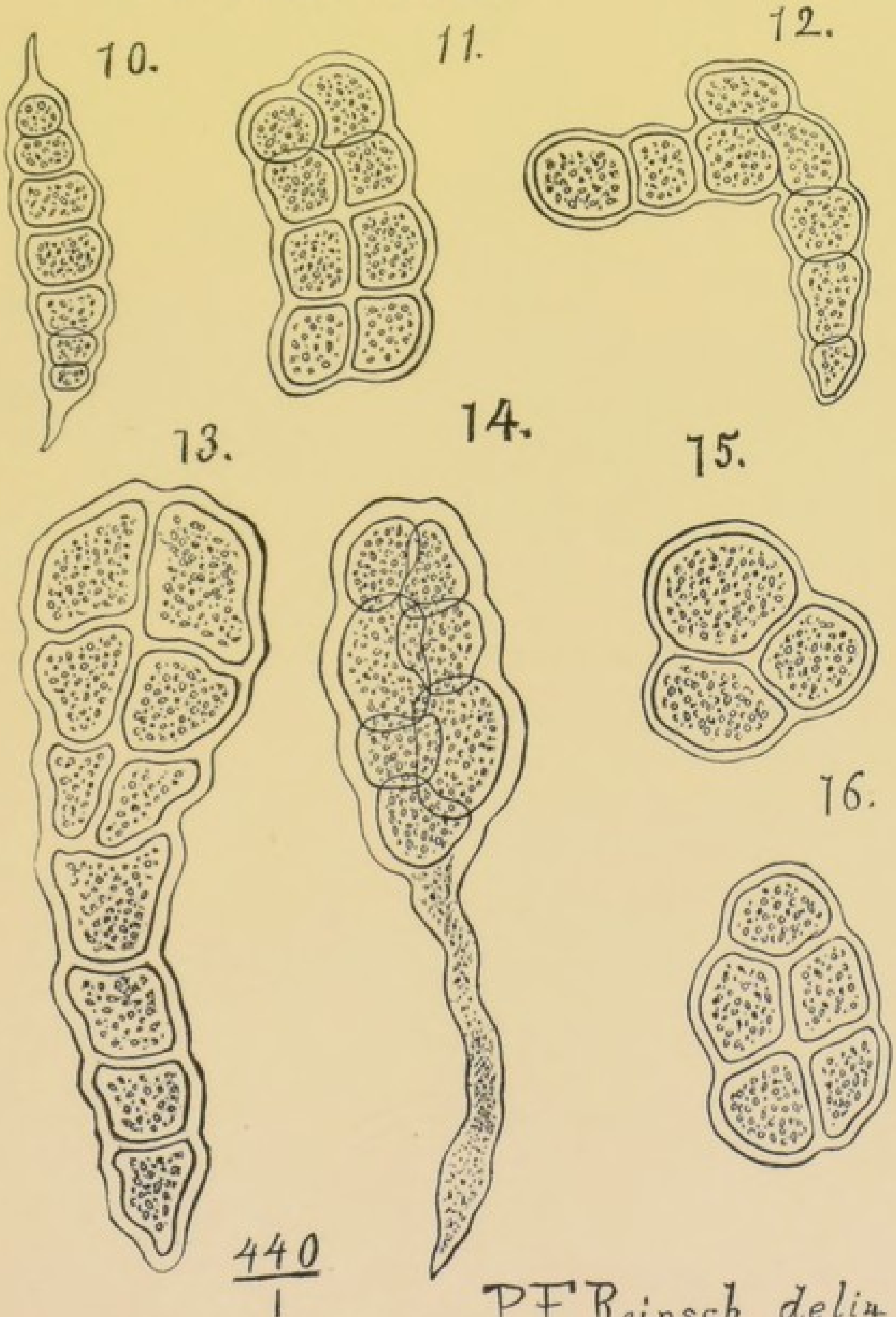
15, Three-celled plant.

16, Five-celled plant.

Plants 10 to 16 magnified $\frac{440}{1}$.




P.F. Reinsch delin




P.F. Reinsch delin

# INDEX OF NAMES.

# INDEX OF SUBJECTS.

1882