III. The investigation of the biological relations of these organisms may be approached from two different sides. In those forms which come under observation chiefly in the animal body itself, the diseased organs furnish the most suitable object of investigation; while in those processes which I have spoken of as soil diseases, the examination of soil, water, and air, has also furnished favourable results. The latter method was first successfully applied by Tommasi-Crudelli and myself to malaria, and lately by Pasteur also to splenic fever. If we succeed in breeding from one of these objects organisms which remain constant in form and development, and which when conveyed to animals give rise to the corresponding diseases, it is even by this alone rendered highly probable that the organisms contained in the cultivation-fluids are the actual causes of those diseases. But this demonstration may be exhibited in a stricter form, if we separate the fluid and solid constituents of these cultivation-fluids, and verify the activity of the solid residue, as well as the inactivity of the fluid constituents by experiments on animals. This "separation experiment" was first carried out by Chauveau with respect to vaccine, by allowing the fluids to deposit a sediment. This method is, however, not adequate, since all cultivation-fluids do not furnish sediments. For this reason I first made the attempt in 1871 to use filtration through porous masses of clay, by means of the water air-pump; and the result justified my expectations. Pasteur has of late years substituted for them gypsum filters, which have proved still better adapted to the purpose. The experiment was carried out with favourable results by myself and Fugel on the microsporina of sepsis and diphtheria, as well as on the bacilli of splenic fever; and has been lately repeated by Pasteur for the latter object. The application, in my laboratory, of this method to the monadina of pneumonia and syphilis gave like results.

Finally, we must mention the important results which have been obtained quite recently with respect to the cause of the protective power of certain inoculations with cultivated organisms; and which we owe more particularly to the French investigators, Pasteur, Chauveau, and Toussaint.

They have shown that by certain physical operations the virulence of certain specific organisms may be destroyed, though their protective power is preserved. Heat and the action of oxygen (Pasteur) appeared to be able to produce this effect. Still it remains open to question in what way the organisms thus enfeebled make the body capable of resisting infection with more active organisms of the same species. The French investigators just mentioned appear inclined to ascribe this action either to the introduction or the removal of a definite chemical substance; that is to say, to a chemical alteration of the inoculated animal. Still we should perhaps be hardly justified in assuming a permanent alteration of this kind in the body without a simultaneous development of the protective organism. This question also, highly important as it is, may perhaps receive further elucidation through anatomical investigation; the method which in this department, as in pathology as a whole, has shown itself to be the one, furnishes us with the most fundamental and trustworthy information.

The conclusion which appears to me to follow inevitably from this short survey of the results of modern investigation, is this:—that specific communicable diseases are produced by specific organisms.

HEXHAM.—Dr. Jackson reports an alarmingly high death-rate of 28.7 in an estimated population of 5,500 souls; and, in the population given by the 1871 census (5,331), a death-rate of 27.8 per 1,000. The mortality from diseases of the respiratory organs was excessive, no fewer than 35 deaths being returned as due to this cause—a rate equal to 20.35 per cent. of the total deaths. The zymotic death-rate was 20.93 per cent. of the total deaths, and 6.54 per 1,000 of population. In addition to an excessive zymotic death-rate, the infantile mortality was unduly high, the mortality amongst children under five years of age being equal to 36.04 per cent. of the total deaths. Referring to this subject, Dr. Jackson states that "a large proportion of these deaths occurred in the lower parts of the town, in badly ventilated properties"; and again, in alluding to excessive mortality, "Hexham is still, what it has been for the last thirty years, one of the most unhealthy towns in England—even the death-rate remains steadily fixed at 60 per cent. above its proper value". An outbreak of scarlet fever, which was fatal in 22 cases, was for some time kept in check by isolation in the fever wards of the workhouse; but, on an independent outbreak occurring there, the wards became no longer available for patients from the town. The water-supply is insufficient in quantity, and "the most considerable portion of it is composed of casual flood waters, contaminated by farm-sewage". The public sewers are not effectively cleansed or properly ventilated, whilst the sewer outlets are practically stagnant cesspools. The slaughter-houses are described as of the "worst possible type".

AN ADDRESS

ON

THE SCIENTIFIC STATUS OF MEDICINE.

Delivered before the Section of Diseases of the Teeth.

By RICHARD OWEN, M.D., C.B., F.R.S.

THE aim of every student of medicine—and such the true student never ceases to be—is to raise the healing art to the status of a science.

The most significant testimony that the application of human intellect to comprehend phenomena has attained its noble aim, is the "power of prediction".

When the astronomer foretold the date to hour and minute of the advent of an eclipse, or of a comet, or even of a cluster of seemingly migrant aërolites, his peaceful victory was manifest. So, when the palæontologist, on inspection of a new-found fragment, proclaimed the nature and affinities of the extinct animal which, long ages past, had left such fossil evidence of its existence, his methods of interrogating and interpreting Nature were acknowledged to be of the rank of a science.

Certificates to life-assurance offices,* and the bulletins issued by the medical attendants on personages in whose health and life the public have interest, are amongst the forms of prophecy in the precise fulfilment of which the claims of medicine to a like rank may be tested.

The definition of disease is the expression of a sum of knowledge and experience by which the constant and essential characters are distinguished from accessory and occasional symptoms; and the remedies applied are, in like manner, those which the best experience has proved to be most potent. The technical terms of maladies so discerned are, as a rule, "collective names for groups of morbid symptoms".

Permit me to trespass on your patience and crave your indulgence toward one who has long ceased to practise the profession, deemed divine by sages of ancient Greece, if I venture to submit a few examples illustrative of the dependence of medicine upon a once-deemed unpromising inlet of light; but of which, in researches connected with the branch of medicine of the present Section, I have availed myself with unexpected advantage.

The healer may be called in to one whom he finds suffering from "loss of appetite, discomfort and weight in the gastric region, distension of stomach, with eructations and nausea": to this group of symptoms he applies the name of "dyspepsia"; if it be aggravated by aching or burning pain referred to the pit of the stomach, he may term it "gastrodynia". According to symptoms, he may prescribe, for one class carminatives, for another alkaline carbonates in effervescence, or may be led by special indications to administer such drugs as nitrate of silver, hydrocyanic acid, bismuth, and opium, the latter especially, if pain be attended with spasmodic action.

If the physician be called to a case in which the alvine evacuations are excessive in quantity and unnatural in quality, and sums up such symptoms as diarrhoea, he may administer castor-oil or saline purgatives, followed by various astringents, vegetable or mineral. But should a patient, whom the healer may see for the first time, be suffering also from febrile or pyrexial symptoms, thirst and headache, tenesmus and tormina, with rigid abdominal walls, frequent uncontrollable calls to defecate, with little discharge save of watery mucus, of peculiar factor, perhaps stained with blood, he pronounces the case to be one of dysentery, and may prescribe leeches, fomentations, and, according to one authority, may administer purgatives, but, according to another, opiates. In one of our latest compendiums of practice, it is written of this disease—"Calomel is said to have fallen into disuse, and perhaps deservedly" (Bristowe's *Theory and Practice of Medicine*, 1878, p. 683). An eminent physician, Dr. Trousseau, has confidence in ipecacuanha.

Again, the aid of the medical man may be invoked to abate or banish a group of symptoms which he terms peritonitis; and, under this treatment, there may supervene, without the least evidence of causation, another series of sufferings—pain during respiration, dyspnoea—calling for leeches to the chest, counterirritants, as mustard-

* Mr. A. H. Smee, in his *Hunterian Oration*, of February 9th, 1881, at the Hunterian Society of London, affirms, from his experience as medical adviser to an insurance office receiving 1,000 certificates annually: "I have noticed from year to year, for the last fifteen years, the number of cases in which, if the diagnosis of the medical attendant was right, his prognosis was manifestly wrong." P. 6.

plasters, flannel rollers and compresses, opiates; in short, the recognised remedies for pleuritis. Again, these symptoms may be aggravated by those of pneumonia, requiring other or added modes of treatment; and the pulmonary symptoms may become further complicated by abnormal affections of a more vital thoracic organ—"the bosom's lord".

If pain and oppression in the region of the heart predominate, with accelerated pulse, and if acoustic scrutiny be superadded to vocal and visual interrogation, the accomplished physician may be able to pronounce the malady to be either pericarditis or endocarditis. In either case he will prescribe the appropriate remedies, and form, according to their effects, his prognosis, or prophecy of results.

Should diffused muscular pains supervene, or be associated with the peri- or endo-cardial symptoms, and these pains be attended with stiffness, loss of muscular power, or repugnance to exert such power, and a healer be invoked at this stage, he may pronounce it to be a case of "rheumatismus", or even of "acute rheumatism"; and his treatment will be guided by the urgency or predominance of one or other of the symptoms. But the intractability of the so-called malady is significantly indicated by the expressions of one of our most accomplished physicians, under whom I was myself a student, and whose loss was deeply regretted and is still lamented by his survivors. Dr. Peter Mere Latham, in his *Lectures on Subjects connected with Clinical Medicine*, in which relation to practice and instruction he was a master, writes of acute rheumatism as follows: "No disease has been treated by such various and opposite methods. Venesection has wrought its cure, and so has opium, and so has calomel, and so have drastic purgatives." (*Op. cit.*, Lecture X, "Diseases of the Heart".) Had Latham, at the date of that lecture, been aware of a subsequently discovered cause of acute rheumatism, he would have known that, at such stage of the cause's baneful operations, the malady was beyond the influence of any of the proposed and supposed remedies. But, without knowledge or suspicion of such cause, noting abatement of symptoms as time went on, bringing a transition from the acute to the chronic stage of rheumatism, the experienced physician might well attribute the cure of the tetrasyllabic symbol of symptoms to one or other of the remedies which the then stage of his art had suggested.

In a modified form of muscular malady, to which the phrase "rheumatic arthritis" has been applied, and which, at a dropsical stage, proved fatal, a justly celebrated professor of physiology in the University of Heidelberg observed, in his *post mortem* examination, that the muscular tissues of the defunct were studded with minute white specks, which quickly blunted the scalpel. Chemical analysis showed the grittiness to be due to deposits of phosphate and carbonate of lime; and Tiedemann confirmed his observation in Forriep's *Notizen* for 1823. The case was concluded to be a previously unnoted instance of "diffused gout". The pathologist was little aware how near he was to a discovery to which he might have been led by application of the microscope.

The finding of the wormlet within the cysticule in 1835 (*Proceedings of the Zoological Society of London*, 8vo, February 24th, 1835; also *Transactions*, *ibid.*, 4to, vol. i), and the more important discovery by Dr. Zenker of Dresden, in 1860, of its causative relations to a direful disease, have demonstrated that the several groups of symptoms to which I have briefly referred under the respective technical denominations applied to their groups, may, one and all, be due to the deglutition of *Trichina spiralis*. The larva of this wormlet in the flesh of the animal it infested, being introduced as food into the human stomach, finds in that warm cavity an environment of muco-chymous nutriment, in which it rapidly matures, acquires activities, and develops its generative organs and products. If permitted to pass into the intestinal canal, it there excludes its progeny, which also rapidly acquire their full size and procreative faculty. But the grave symptoms of their presence are due to the curious migratory instinct of the young trichine, which impels them to make their escape by perforating the tunics of the intestine, in the course of which operation the majority find their way into the venous capillaries. Such as wriggle through the meshes of the vascular network bore their way through the serous tunic of the gut, and pass into the abdominal cavity, whereupon the peritonitis are complicated with the enteritic symptoms. But the majority are carried to the right side of the heart, and thence by the pulmonary artery to the lungs. Threading, then, the capillaries continuous with the commencement of the pulmonary veins, the trichine are brought back to the heart. As many as may have burrowed into the vascular walls of the right or of the left ventricle, or may have got into the cavity of the pericardium, give rise to the symptoms summed up in the terms of art already cited.

Trichine which may have strayed into the tissue of the lungs, or which may have wriggled through the pulmonic serous covering, and

from the pleural cavity may have invaded the serous membrane in their way to the intercostal muscles, add the pleuritic and pulmonitic to the pericarditic symptoms.

The natural affinity or attraction of the trichine is to myonine, or the muscular tissue. There their wanderings come to an end. They are conveyed so soon and so rapidly by branches of the carotids to the muscles of the larynx, that the trichine are there found most constantly and abundantly; but usually so vast is their number, that they are carried to the voluntary muscles of the entire body.

In the exceedingly delicate connective tissue of the ultimate bundles of the ultimate fibrils, the young trichine coil themselves up to their larval repose, exciting no other organic change than an outflow of plasma, which condenses with the contiguous cellulosity, and becomes moulded into the shape of an elliptic case, in which may be seen, under the microscopic compressorium, one or more of the tiny worms disposed in two or more circular coils.*

The natural history of *Trichina spiralis* leads the physician, cognisant thereof, to put a question to his patient, the reply to which would reveal the veritable cause of the malady at whichever of the stages—dyspeptic, dysenteric, pleuritic, pneumonic, carditic, or rheumatic—he might happen to have been called in. That question would be: "What did you eat last before you became unwell?" If the answer denoted pork in any of its culinary forms, the physician would require a portion of the meat, or of the ham or sausage; and, being practised, as every competent medical man now is, in the use of the microscope—an instrument as indispensable to the consulting-room as the stethoscope—he would detect the minute parasite, and recognise the *fons et origo* of all and every the groups of symptoms personified under one or other of the several before-cited tetra- or pente-syllabic terms of medical art.

If, fortunately for the patient, he were called in at the first stage, ere the wormlet had passed on out of the stomach, he might ask for the mustard-pot, and therewith, or with any other quickly attainable strong and promptly acting emetic, clear the stomach of its lethal invaders; after which he might administer a strong dose of calomel, knowing its destructive operation on any lingering trichine which might not have been dislodged. If the aid of the scientific healer had not been invoked until the dysenteric symptoms had set in, still he might see a chance of directly combating the *vera causa* by combining calomel with the remedies for which accessory symptoms would call. On the supervision of the pulmonary or cardiac troubles, the physician would know, with a scientific knowledge enabling him to prophesy, that he could do no more in way of cure of the malady, *i. e.*, in eradication of its cause; but that his treatment henceforth must be merely palliative. He now could predict confidently to his patient and the friends that symptoms of pleurisy and pericarditis would set in, that the chest-symptoms would be followed by rheumatic—probably severely rheumatic—ones: furthermore, that, if life were preserved until these symptoms should subside, a certain deterioration of muscular power, with general stiffness, would long remain, if ever lost. The prophet would know that, when such stage of recovery was gained, although the wormlets would die and dissolve, their cysts would remain, and arrest and precipitate salts of lime, such as attracted, but misled, the conclusions of the justly celebrated anatomist and physiologist already cited.

My aim, as may perhaps have been surmised by the distinguished members of the medical profession whom I have the honour to address, has been to exemplify under what condition and in what proportion medicine may be termed an art, and under what circumstances it rises to the dignity of a science.

In the degree in which the veritable cause of groups of symptoms summed up as dysentery, pneumonia, rheumatisms, and other species of disease is recognised, and the remedy specially applicable to the removal of such cause has been experimentally determined, the applier of such knowledge to the relief of suffering mankind exerts a power which science imparts.

The technical terms in which the symptoms of one or other of the four or five stages of trichinosis would have been defined prior to the discovery of their veritable cause; when, also, under the same pre-trichinal condition of knowledge, various causes might have been assigned, and the then approved legitimate remedies applied to the respective groups of symptoms—exemplify a stage of medical research which had not risen to the level of science. A significant evidence of such status will be manifested when specific names of disease indicate their cause, and are founded on demonstrative knowledge of such. The recognition of the efficient cause of the several symptoms, and of

* These cysts, which in their partially calcified state Tiedemann conceived to be arthritic deposits, Hilton subsequently described as a species of cysticercus (*Medical Gazette* for February, 1833).

the relations of these to the anatomical structures affected by such cause, exemplifies the rise to the dignity of a science.

"Knowledge is Power": but what of half-knowledge?

Microscopic discovery of an otherwise invisible parasite has enabled the practitioner to administer the remedies applicable to arrest or annihilate the cause of a direful malady; such knowledge gives also that of the stage beyond which there is no direct or specific remedy. In such phase of medicine, he can act with confidence and prophesy with certainty. Finally, I would refer to another test which, by the analogy of established sciences, bears upon my present subject.

When chemistry was struggling to its goal, a mockery disguised in its rags obtained the confidence of a majority, under the name of alchemy. It was long ere the professors of this pseudo-science lost the patronage of the rich and great, on whose credulity they batted. The extinction of the transmuters is an evidence, small, indeed, but significant, of the true and trustworthy status of the branch of experimental research to which the gifted, single-minded men devoted themselves, to raise chemistry to the status of a science.

Prior to, and for some time after, the promulgation of the Copernican theory, astrology continued to hold its ground against astronomy. The "caster of nativities" was patronised by monarchs, ministers, men of wealth, and lords of fair estates long after the periods disgraced by the persecution of Galileo, and by the cold neglect of Kepler. Finally, arose a Newton; and to the higher evidences of a "science of the stars," I may here add the lower one of the extinction of astrology or its relegation to some obscure almanac.

Are there, then, we may ask, at the present date, practitioners, professors of curative methods, analogous, in medicine, to the astrologers and alchemists at former periods of astronomy and chemistry? Do they, in like manner, obtain countenance and support, as did those empirics, from Prime Ministers and non-scientific people of rank and fortune.

In the degree in which the unlicensed dentist, the bone-setter, the mesmeriser, and homœopathist may flourish or get means of subsistence, may be estimated, in some degree, the stage at which inductive medicine has reached, on its rapidly advancing career, to the status of a science.

AN ADDRESS

ON

VACCINATION IN RELATION TO CHICKEN CHOLERA AND SPLENIC FEVER.*

BY M. PASTEUR, PARIS.

GENTLEMEN,—I had no intention of addressing this admirable Congress, which brings together the most eminent medical men in the world, and the great success of which does so much credit to its principal organiser, Mr. Mac Cormac. The goodwill of your esteemed president has decided otherwise. How could one, in fact, resist the sympathetic words of that eminent man whose goodness of heart is associated in no small degree with great oratorical ability? Two motives have brought me to London. The first was to gain instruction, to profit by your learned discussions; and the second was to ascertain the place now occupied in medicine and surgery by the germ theory. Certainly I shall return to Paris well satisfied. During the past week I have learned much. I carry away with me the conviction that the English people is a great people; and as for the influence of the new doctrine, I have been not only struck by the progress it has made, but by its triumph. I should be guilty of ingratitude and of false modesty, if I did not accept the welcome I have received among you and in English society as a mark of homage paid to my labours during the past five and twenty years upon the nature of ferments—their life and their nutrition, their preparation in a pure state by the introduction of organisms (*ensemencement*) under natural and artificial conditions—labours which have established the principles and the methods of *microbie* (microbiotism), if the expression is allowable. Your cordial welcome has revived within me the lively feeling of satisfaction I experienced, when your great surgeon Lister declared that my publication in 1857 on milk-fermentation had inspired him with his first ideas on his valuable surgical method. You have reawakened the pleasure I felt when our eminent physician Dr. Davaine declared that his labours

* We have availed ourselves of the excellent translation published in the *Times*, which, on comparing it with the MS. of M. Pasteur, we have found very accurate.

upon *charbon* (splenic fever or malignant pustules) had been suggested by my studies on butyric fermentation and the vibrio which is characteristic of it.

Gentlemen, I am happy to be able to thank you by bringing to your notice a new advance in the study of micro-organisms as applied to the prevention of transmissible diseases—diseases which for the most part are fraught with terrible consequences, both for man and domestic animals. The subject of my communication is inoculation in relation to chicken cholera and splenic fever, and a statement of the method by which we have arrived at these results—a method the fruitfulness of which inspires me with boundless anticipations.

Before discussing the question of splenic fever vaccine, which is the most important, permit me to recall the results of my investigations of chicken cholera. It is through this inquiry that new and highly important principles have been introduced into science concerning the virus or contagious quality of transmissible diseases. More than once in what I am about to say I shall employ the expression virus-culture, as formerly, in my investigations on fermentation, I used the expressions, the culture of milk-ferment, the culture of the butyric vibrio, etc. Let us take, then, a fowl which is about to die of chicken-cholera, and let us dip the end of a delicate glass rod in the blood of the fowl with the usual precautions, upon which I need not here dwell. Let us then touch with this charged point some *bouillon de poule*, very clear, but first of all rendered sterile under a temperature of about 115° cent. (239° Fahr.), and under conditions in which neither the outer air nor the vases employed can introduce exterior germs—those germs which are in the air or on the surface of all objects. In a short time, if the little culture vase be placed in a temperature of 25° to 35° cent. (77° to 95° Fahr.), you will see the liquid become turbid and full of tiny micro-organisms, shaped like the figure 8, but often so small that under a high magnifying power they appear like points. Take from this vase a drop as small as you please, no more than can be carried on the point of a glass rod as sharp as a needle, and touch with this point a fresh quantity of sterilised *bouillon de poule* placed in a second vase, and the same phenomenon is produced. You deal in the same way with a third culture vase, with a fourth, and so on to a hundred or even a thousand, and invariably within a few hours the culture liquid becomes turbid and filled with the same minute organisms. At the end of two or three days' exposure to a temperature of about 30° cent. (86° Fahr.), the thickness of the liquid disappears, and a sediment is formed at the bottom of the vase. This signifies that the development of the minute organism has ceased—in other words, all the little points which caused the turbid appearance of the liquid have fallen to the bottom of the vase; and things will remain in this condition for a longer or shorter time, for months even, without either the liquid or the deposit undergoing any visible modification, inasmuch as we have taken care to exclude the germs of the atmosphere. A little stopper of cotton sifts the air which enters or issues from the vase through changes of temperature.

Let us take one of our series of culture preparations—the hundredth or the thousandth, for instance—and compare it in respect to its virulence with the blood of a fowl which has died of cholera; in other words, let us inoculate under the skin ten fowls, for instance, each separately with a tiny drop of infectious blood and ten others with a similar quantity of the liquid in which the deposit has first been shaken up. Strange to say, the latter ten fowls will die as quickly and with the same symptoms as the former ten: the blood of all will be found to contain after death the same minute infectious organisms. This equality, so to speak, in the virulence both of the culture preparation and of the blood is due to an apparently trivial circumstance. I have made a hundred culture preparations—at least, I have understood that this was done—without leaving any considerable interval between the impregnations. Well, here we have the cause of the equality in the virulence.

Let us now repeat exactly our successive cultures with this single difference, that we pass from one culture to that which follows it, from the hundredth to, say, the hundred and first, at intervals of a fortnight, a month, two months, three months, or ten months. If, now, we compare the virulence of the successive cultures, a great change will be observed. It will be readily seen from an inoculation of a series of ten fowls, that the virulence of one culture differs from that of the blood and from that of a preceding culture, when a sufficiently long interval elapses between the impregnation of one culture with the micro-organism of the preceding. More than that, we may recognise by this mode of observation that it is possible to prepare cultures of varying degrees of virulence. One preparation will kill eight fowls out of ten, another five out of ten, another one out of ten, another none at all, although the micro-organism may still be cultivated. In fact, what is no less strange, if you take each of these cultures of attenuated virulence at a point of departure in the preparation of successive cultures and