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Croonian Lectures

ON

THE NUMERICAL METHOD, AND ITS APPLICATION TO THE SCIENCE AND ART OF MEDICINE.*

DELIVERED AT THE ROYAL COLLEGE OF PHYSICIANS, 1860.

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PART I.

Introductory Remarks. Explanation of Terms. The "Numerical Method" and the "Statistical Method". Meaning of the Terms "Statist" and "Statistics". Plan of the Course. Review of Sciences and Scientific Arts. The Universal Sciences. The Art of Calculation and the Science of Arithmetic; the Pure and Mixed Mathematics; Geometry. "Instruments of Calculation", as applied to the "Relations" and to the "Properties" of Matter. Names of "Recognition" and Names of "Identification". Sources of Uncertainty and Embarrassment in the Sciences which deal with the Properties of Matter. The Sciences and Arts of Construction: the Science and Art of Chemistry: the Science of Botany and the Arts of Horticulture and Farming: the Science of States and the Art of Government: the Science of Medicine and the Art of Healing.

MR. PRESIDENT AND GENTLEMEN,—When the President of this College informed me that he had done me the honour to appoint me Croonian Lecturer for the year, I first made it my business to inquire whether any, and, if so, what restrictions or limitations had been put to the choice of a subject. Finding that there were no such limitations or restrictions, I proceeded to inquire whether there was any peculiarity in the tastes or pursuits of the founder which would serve to indicate the sort of subject which, were he living, he would approve. I found, as the result of this inquiry, that, in addition to this endowment, Dr. Croone had founded no fewer than seventeen algebraic lectureships in the colleges of Cambridge. To one so anxious to encourage the culture of this universal arithmetic, a course of lectures having for its object to promote the application of arithmetic, in a less abstract shape, to medicine, would certainly have commended itself; and if any fresh reason for being satisfied with the choice which I had made were needed, I had before me the precedent of Dr. Bisset Hawkins, who more than thirty years ago made Vital Statistics the subject of his Gulstonian lectures, and those lectures the foundation of his well-known work on that subject.

Having, as I trust, justified my choice of a subject, I will only add to this short preface the expression of a hope that those who may have come here in the expectation of adding something to their stores of practical knowledge will bear with me if I seem to them to give to my subject, and especially to some parts of it, too abstract a character. As, in treating such a subject, it is impossible to be too exact and methodical, I will begin by defining the terms used in framing the title of the lectures.

My subject is, "*The Numerical Method, and its Application to the Science and Art of Medicine*". It will be seen that I have made deliberate choice of the term *numerical method*

where some would have used the term *statistical method*. I have used the one form of words, and set aside the other, because I know nothing of a statistical method. I know of no use of numbers which claims to be peculiar to the Science of States; and I think that, whatever may have been the meaning of the barbarous word *statistics*, when first used in Germany, we ought now to limit it to what it always means in practice—a state-science built up by the aid of facts brought together in large numbers, and their results expressed in the terse, simple, and intelligible language of figures.

Several of our old writers of repute use the word *statist* in the sense of a scientific or speculative statesman; and statistical societies and congresses do practically make use of the term *statistics* to designate the science which our statist cultivate.

On the other hand, the term *Numerical Method* commends itself by obvious considerations, but especially by the fact that there is no science or scientific art in which a certain well defined use of figures, limited by rules, and governed by a logic of its own, does not find some place.

This, then, is the term which I shall use in these lectures, in preference to the more restricted and less correct phrase, *statistical method*.

I shall also use the terms *science of medicine* and *art of healing* in their largest and most comprehensive sense, so as to include the science and art of surgery and the science and art of hygiene, drawing my illustrations indifferently from the one or the other, as I shall find most convenient.

And now a few words on the object and plan of this short course of lectures. My object is to place the numerical method before you in the broadest and clearest light in which I am able to set it; and my plan, which is in accordance with this object, is to begin by passing in brief review some of the principal sciences and scientific arts, and endeavouring to find out, in respect of each in turn, what is the secret of the degree of excellence to which it has attained, and how far that excellence is to be traced to the facilities which it offers for the application of figures. This review, with that more special examination of our own science and art which may naturally be expected at my hands, will occupy the remainder of this lecture. The second lecture, with perhaps some part of the third, I propose to devote to the principles and rules of the numerical method, or, in other words, to the logic of large numbers. In what may remain of the course, I shall consider the extent to which this numerical method admits of application to the science of medicine, and in the art of healing; and, in doing so, I shall hope to remove some misapprehensions which seem to prevail in regard to this twofold application of the method, to the obvious discouragement of scientific inquiry, and the obvious injury both of the science and the art of medicine.

I now proceed, without further preface, to that brief review of sciences and scientific arts which, according to my plan, as just explained, is to form the staple of the remainder of this lecture.

Now, the first consideration which offers itself, as it were at the threshold of this inquiry, is, that there are certain universal arts, and sciences to correspond, which find an application, more or less extensive, in all the special and more limited arts and sciences. There is the *art of language*, spoken and written, and the *science of grammar*: the *art of observing*, and the *science of observation and experiment*: the *art of reasoning*, and the *science of logic*: and the *art of calculation*, with the *science of arithmetic*. It is with this art of calculation and science of arithmetic that we have now to do. This universal science attains to its highest development in algebra, and finds its most successful application in geometry and in the sciences known as the *pure mathematics*; but it also plays an important part in the *theory of probabilities*, and in that numerical method which may be said to be one of its principal branches, and certainly its most important one.

In reviewing the principal sciences and scientific arts, with the practical object of understanding the true position of the science of medicine and the art of healing, we perceive at once

* The three lectures, of which the course of Croonian Lectures consists, have been divided into portions of convenient length, and are here published very nearly as they were delivered. Some slight alterations are rendered necessary by the absence of the tables and curves referred to in the lectures.

that, if we place the arts and sciences in the order of the perfection to which they have attained, the first place must needs be assigned to the art of calculation and the science of arithmetic; for, in the first place, the words which we use to designate numbers, abstracted from all consideration of the properties of the things counted, cannot be used in two senses, nor can their meaning be misunderstood. The words *one, two, three, one hundred, one thousand, one million*, can have but one meaning: two and two must make four, simply because we have chosen to call two and two added together by that name. It matters not whether the things which are added to, or taken from, each other, are small or great—sands on the seashore, or worlds in the milky way—we use but one set of words, and we cannot use them amiss. In the second place, as arithmetic deals with numbers in the abstract—that is to say, without regard to the material properties of the things counted—all the fallacies arising from the imperfections of our senses, and of those faculties of the mind which take cognisance of the things of sense, are effectually excluded. In the third place, for words to which but one meaning can be attached, and for ideas so free from all the obscurities that belong to things of sense, it is possible to substitute symbols—figures for words, letters for known and unknown quantities, signs for simple phrases—so as to bring about a compactness of expression in the highest degree favourable to the carrying out of long and complicated processes of reasoning.

These, then, are the causes which combine to place calculation and arithmetic at the head of all the arts and sciences. But they merit that distinguished place for another reason already alluded to. They are of universal application in the service of all other arts and sciences; and the services rendered are of the most important kind—so important, that it is not affirming too much to say, that the extent and degree to which other arts and sciences admit of the application of figures, is the best test and measure of the position which they have attained.

The possession of a numerical theory—like the theory of gravitation in astronomy, or the theory of definite proportions in chemistry—confers, so to speak, a patent of nobility, and a title to precedence. The sciences which possess such theories are endowed not only with the gift of interpretation, but also with the gift of prophecy. They not only explain isolated facts and phenomena by a reference to general principles, but they make effectual guesses at the unknown, and foretell the very time and place of future events. It is as discoverers of numerical theories that the names of Newton and Dalton rank so high; it is the numerical exactness and precision of their prophecies which gives such a lustre to the names of Adams and Leverrier.

The art and science of reasoning might perhaps, with propriety, be classed with the art and science of arithmetic, as being equally certain, and equally extensive in its applications to other art and sciences. Logic, in the limited sense of the science and art of reasoning from premisses assumed to be sound, owes its position among the arts and sciences to the successful analysis made by Aristotle of the mental process employed in every act of reasoning which the common sense of mankind recognises as valid. This analysis once made, it was easy to lay down abstract forms, expressed in that same terse symbolic language which I have just pointed out as so important an element in the science of calculation; and then to use these forms as tests by which every process of reasoning might be tried—as standards to which every sound process of reasoning might be made to conform.

Of the art of observing and the science of observation, which comprise the art and science of experiment (for experiments are but observations of phenomena prudently and skilfully prepared), I will only observe that this art and this science are also of universal application in the service of other arts and sciences; and that they have a logic of their own most happily set forth and explained in the lucid language of John Stuart Mill.

The art of verbal expression and the science of grammar have also their universal application in the service of science; but they do not suggest any considerations which need detain us.

I have spoken of an art of calculation and a science of arithmetic as being distinct from the mathematics of which they are generally held to form a part. Those who are familiar with mathematical studies will, I think, agree with me that such a distinction admits of being made, and that there is some advantage in insisting upon it.

The pure mathematics may be said to consist of algebra, or

universal or abstract arithmetic, in which we reason, not by the aid of figures representing definite values, but by the aid of letters representing indefinite values; and of geometry, in which we trace the relations of straight and curved lines, on plain and curved surfaces, and of solid figures bounded by straight or curved lines, to each other; also, of the various so-called mathematical forms and figures, such as the angle, triangle, circle, square, and parallelogram.

All the truths of algebra and geometry may be, and have been, worked out by reasoning, without the aid of figures; and as these truths are pure deductions from *definitions* which could not be misunderstood, and from *axioms* which cannot be disputed or denied, they themselves cannot be gainsaid, and they accordingly constitute the only absolutely and necessarily certain portions of our knowledge. To these certainties—to these sure relations of lines and figures drawn on paper, or conceived in the mind itself—we may, if we please, apply the figures of arithmetic, and obtain results as certain as those relations themselves.

Then, again, there are other portions of the mathematics, technically known as the *mixed mathematics*, which apply the truths of geometry and the sure method of algebra to some well ascertained and well defined properties of matter. Hence the mixed mathematical sciences of *statics* (or the science of solids at rest), *dynamics* (or the science of bodies in motion), *hydrostatics* (or the science of fluids at rest), *hydrodynamics* (or the science of fluids in motion), *astronomy*, and *optics*. The leading truths of these sciences, too, may be worked out without the aid of arithmetic; though it is quite possible at every step to substitute the figures of arithmetic for the abstract expressions of algebra. As a general rule, however, we do not employ figures or numbers in the mixed mathematical sciences (or we use them only to a very limited extent) till we come to apply the truths of those sciences in actual practice.

I have spoken of geometry as a science based upon certain simple definitions and axioms, and having for its principal object the discovery of the properties of angles, triangles, and other simple figures. Now, these properties of angles, triangles, and other simple geometric figures, become, in the hands of scientific and practical men, so many *instruments of calculation*—instruments which admit of application as readily to lines measured out upon the earth's surface, as they did to lines drawn on paper. Hence the scientific art of land-measuring and surveying. But the use of these instruments of calculation is not confined to accessible objects, which we can measure by the foot-rule or the chain; they are equally applicable to those straight lines which represent the distances between the eye of an observer and the most remote and inaccessible objects. They may be applied to determine the height of a mountain which we cannot scale, or the width of a river which we cannot cross. And they are not even restricted to this service. They equally admit of application to visible objects altogether beyond our reach. They enable us to determine the relative positions and distances of the most remote of the heavenly bodies from each other, and from our own planet. Hence the *science of astronomy* and the *art of navigation*.

Of the perfection of this science, and the exactness of the corresponding art, Sir John Herschel shall give us an example. After remarking, with great truth, that to persons ignorant of physical astronomy, it must appear little short of a miracle "that a man, by merely measuring the moon's apparent distance from a star with a little portable instrument held in his hand and applied to his eye, even with so unstable a footing as the deck of a ship, shall say positively, within five miles, where he is on a boundless ocean," he gives a striking instance in point, on the authority of a distinguished naval officer, Captain Basil Hall. This officer "sailed from San Blas, on the west coast of Mexico; and, after a voyage of eight thousand miles, occupying eighty-nine days, arrived off Rio de Janeiro, having in this interval passed through the Pacific Ocean, rounded Cape Horn, and crossed the South Atlantic, without making any land, or even seeing a single sail, with the exception of an American whaler off Cape Horn. Arrived within a week's sail of Rio, he set seriously about determining, by lunar observations, the precise line of the ship's course, and its situation in it at a determinate moment; and, having ascertained this within from five to ten miles, ran the rest of the way by those more ready and compendious methods known to navigators, which can be safely employed for short trips between one known point and another, but which cannot be trusted in long voyages, where the moon is the only sure guide." The rest of the tale Sir John Herschel gives in the captain's own words.

"We steered towards Rio de Janeiro for some days after taking the lunars above described; and, having arrived within fifteen or twenty miles of the coast, I hove to at four in the morning till the day should break, and then bore up; for, though it was very hazy, we could see before us a couple of miles or so. About eight o'clock, it became so foggy that I did not like to stand in farther, and was just bringing the ship to the wind again, before sending the people to breakfast, when it suddenly cleared off, and I had the satisfaction of seeing the great sugar-loaf rock, which stands on one side of the harbour's mouth, so nearly right ahead that we had not to alter our course above a point in order to hit the entrance of Rio. This was the first land we had seen for three months, after crossing so many seas, and being set backwards and forwards by innumerable currents and foul winds."

In this anecdote, we have a remarkable example of a practical result brought about by the application of a few simple scientific principles, aided by calculations previously performed and ready for use. We have a ship conducted eight thousand miles over a pathless ocean by the aid of arithmetic and geometry, cooperating with the use of an instrument—"a little portable instrument"—measuring the moon's apparent distance from a star! Now, what is the secret of this surprising accuracy? Is it not this—that we are here dealing, not with the *properties of matter*, but simply with relative position; that we are applying the instruments of calculation of which I have been speaking, and the figures of arithmetic, not to the *properties*, but to the simplest *relations of matter*—to those "primary existences and relations" which are themselves abstract, and which, if there were but one form of matter in the universe, "we could not even conceive not to be"?

The science of astronomy and the art of navigation may, therefore, be safely placed at the head of the applied arts and sciences. They occupy the first place in point of accuracy, certainty, and precision; and this position of honour is obviously due to the causes to which I have referred. Astronomy has another claim to this foremost position, inasmuch as the universally received numerical theory of gravitation may be said to constitute one of its possessions.

If what I have just said of the cause of the high position occupied by the science of astronomy and the art of navigation be true, those sciences and arts ought also to occupy a high position which, like astronomy and navigation, have to do not so much with the *properties* as with the *relations of matter*; or if with *properties of matter*, then with such simple *properties* as can be submitted readily to experiment, and resolved, like distance and relative position, into an affair of lines and angles. *Optics and dynamics* evidently belong to this category; for the rays of light and the direction of forces may obviously be represented by lines and angles.

Without pretending to enumerate all the sciences and arts, or parts of sciences and arts, on which a character of accuracy and precision is conferred by the circumstance that they deal with the *relations of material objects*, and not with their *properties*, I shall content myself with observing, once for all, that wherever we can apply the figures of arithmetic and the instruments of calculation to the simple *relations of matter*, we can attain to a certainty little less complete than that with which we reason on the abstract truths of mathematics and geometry.

Leaving these highly favoured departments of human knowledge, I pass on, in the next place, to consider those arts and sciences which deal not with the *relations* but with the *properties of matter*. These properties are of two kinds—*mechanical and chemical*. The study of the mechanical properties of matter subserves all the varied purposes of manufacture, and gives rise, among other arts and sciences, to those of *construction*, which occupy the attention of the engineer and architect. The study of the more intimate composition of the particles or molecules of matter constitutes the science and art of *chemistry*, which finds its practical applications in almost every human pursuit.

The arts and sciences which have to do with the *properties of matter* are at once distinguished from those which treat solely of the *relations of matter*, inasmuch as they require, either as a constituent part of those arts and sciences themselves, or as a preliminary acquisition, minute descriptions of the several forms of matter, marks or tests by which they may be recognised, and names which may help us to remember them, and to classify and arrange them. The man who would be master of the art and science of construction (as architect or engineer) must have a preliminary knowledge of the descriptive sciences of geology and mineralogy. He must be

able to recognise and appreciate the soil *in* which he builds, as well as the materials *with* which he builds; and in either case, the name by which he designates any soil or material is not, like the name of a star or a planet, used merely for purposes of recognition, as a man's name is, but as the representative of certain properties which it is not easy to identify. The difference between the two cases is, that when we deal with the *relations of matter*, we use names merely for the sake of *recognition*; but when we deal with the *properties of matter*, we use names for the purpose of *identification*. It is obvious that this circumstance introduces a new element of difficulty and uncertainty into all the arts and sciences which have to do with the *properties* and not with the simple *relations of matter*.

Another peculiarity in this class of arts and sciences is well worth noticing. I mean the wide variations in quality and consistence to which portions of matter bearing the same name, and even found in the same place, are liable. In speaking, for instance, of the strength of a given material used in building, as wood or iron, we are speaking of that which experience has shown to be subject to great variation of strength and tenacity; and experiments have accordingly to be made with a view to ascertain the mean or average strength of the material in question, as well as its extreme strength; and conscious of the great differences which may exist in this respect, the engineer, architect, or mechanic, is obliged to use an average value, or to resort to actual experiment on the material he is about to employ, when the scientific or practical man (the astronomer or the navigator) dealing solely with the *relations of matter* would be able to make use of an absolute numerical value. Here then is a second source of uncertainty and embarrassment, from which the more perfect sciences and arts are free.

I ought, however, to remark in this place, that even the astronomer is not wholly exempt from the necessity of resorting to a method of averages. He, too, must make some use of a numerical method. He has found out by experience that, though his instruments of calculation are perfect, the instruments by which he assists the sense of sight are imperfect, and his observations, partly for that reason, and partly from the variable condition of his own senses, are liable to certain slight errors both in excess and defect. To correct these errors, and to arrive as near as possible to the truth, he also resorts to that same method of averages which the engineer, the architect, the mechanic, the artilleryman, so constantly employ. The only difference is, that in the one case the method of averages is applied to observations; in the other, to experiments. Still, that part of the science of astronomy which consists in a record of such observations and their average results, is very small compared with the part which experiments and their mean results bear in rearing the science of the architect or engineer.

The elements of difficulty and uncertainty introduced into the science and art of construction by the necessary use of names which are subservient rather to identification than to simple recognition, and by the necessity of numerous experiments which can only issue in the establishment of average and extreme results—these elements of difficulty and uncertainty cling also to the science and art of *chemistry*. The names employed by the chemist are not simply names of recognition, but they are names of identification. Much of his time is taken up in ascertaining, by delicate manipulations and experiments, whether a substance submitted to him for examination possesses that aggregate of characters which a given name implies. And he, too, as we are all aware, constantly resorts to the average results of several experiments, because his experiments, like the observations of the astronomer, are apt to yield only approximations to the truth; and errors, both in excess and in defect, errors due partly to the imperfection of instruments, partly to the very place and time of the experiment, and partly to his own variable aptitude of hand and eye.

Hitherto, I have been speaking exclusively of the arts and sciences which deal with unorganised matter, or matter not endowed with life. I must now say something of those arts and sciences which have to do with living objects, whether belonging to the vegetable or to the animal kingdom. And first, of the science of botany, and the arts of *horticulture and farming*.

The science of botany may be said to consist of two parts—a part given up to the work of identification, and busied with names, descriptions, and classifications; and a part generally known as physiological botany, which is engaged in inquiries

into the minute structure, functions, and vital properties of plants.

Of the descriptions of the botanist, by means of which we are able to ascertain the true name of a plant, it will suffice to observe that they are of necessity extremely complicated as compared with the descriptions of inorganic bodies; inasmuch as plants consist of many different parts, such as the root, the stem, the leaf, the flower, the seed—each of which parts has to be so described as to be easily recognised; whereas inorganic substances have the same, or nearly the same, composition throughout, each fragment similar to every other.

Of the department of physiological botany, it may be observed, that it presents at least this peculiar difficulty when compared with sciences which deal with inorganic matter, that some experiments which are needful for the clearing up of disputed questions relating to the functions of plants are rendered unsatisfactory by the very circumstance that the subjects of the experiment are constantly undergoing vital changes which are interfered with by the experiments themselves.

The science of botany, in conjunction with the sciences of entomology, chemistry, geology, and meteorology, may be said to have its practical application in the art of gardening, and in that part of the art of farming which has for its object the culture of vegetable substances; and in these arts we see imperfectly set forth the peculiar difficulties which attach to the study and practice of the art of healing. We have to deal with living objects, over the growth of which we can exercise but limited control; while that process of growth is influenced by a vast number of different agencies as difficult to appreciate for purposes of science, as to bring under subjection for purposes of art. Over matter not endowed with life, we can exercise almost unlimited control. We can submit it to the operation of all kinds of force. We can crush it, melt or dissipate it by heat, dissolve or alter it by chemical agents, and transform it by the electric fluid. In short periods of time it undergoes no changes which we do not ourselves bring about. But these living things are in a state of perpetual change. There is a principle at work within them which we do not understand, and can only influence indirectly. From the sowing of the seed in the ground to the production of a plant in its turn bearing seed, external agencies liable to great and constant fluctuations are brought to bear, of which some are quite beyond our control, and others admit of only partial modification at our hands. Plants grown in the same soil, in the same climate, and with the self-same culture, are exposed to a new combination of the elements every year. No single constituent of that proverbially fickle and variable thing, the weather—neither the temperature, nor the fall of rain, nor the force and direction of the wind, nor the pressure of the atmosphere, nor the electric state of the air, presenting the same aggregate results in any two years, or even in any two seasons. Then there are the attacks of insects, and blights, and obscure diseases (such as those which have lately attacked the potatoe and the grape), occurring with strange irregularity; and still further interfering with the natural growth and perfection of the plant, baffling all the calculations of the scientific observer, and disappointing the most reasonable hopes of the gardener and farmer. All these things combine to render experiment difficult, and observation fallacious; and remind us forcibly of those analogous, but still more formidable and perplexing, difficulties which attach to the study of medicine as a science, and to the practice of the art of healing.

From the group of scientific studies which find their practical application in the arts of the gardener and farmer, the transition is easy and natural to the science of states and the art of government—to the abstract studies of the statist and the practical duties of the statesman. Between the work of the agriculturist and the work of the statesman there is an obvious and strict analogy. Each deals with events or results brought about by the operation of a multitude of causes acting with ever varying intensity and to a great extent beyond his control. Take, again, the case of the farmer. The seed he sows is of variable quality; the land he sows it in consists of a variable combination of soils; the mechanical preparation of the soil is more or less complete; no two specimens of the manure which he applies have exactly the same strength; and the crop grows up, arrives at maturity, is cut and harvested, each year under a new combination of atmospheric influences. From the same land, with the same preparation, the same quantity of the same manure, and, as nearly as he can judge, the same seed, he one year obtains an abundant, another year a scanty, crop.

So also with the scientific statesman. Relying upon the

best information which he can procure, and basing himself upon the most accurate returns he can obtain, he makes some great financial change. But he is disappointed in the results, because he falls upon evil times—upon one of those cycles of years in which nothing prospers—or, he obtains an unwonted and unmerited success, because he happens to operate in a fortunate cycle of years. The unlucky statesman may encounter a bad harvest, or a series of bad harvests, a glut of foreign markets, a monetary crisis, an epidemic, rumours of wars, and popular outbreaks; and these things make themselves felt in the national balance-sheet, and insure the failure of all his calculations. His successor, on the contrary, when he attains to office may find everything taking a favourable turn. Abundant harvests at home and abroad, an active and remunerative commerce, an easy state of the money market, a sound condition of the public health, the best possible relations with foreign states, contentment among the people—all this, aided, perhaps, by the discovery of some new and unexpected source of wealth at home or abroad; and these things working together make all his plans to prosper, and all his reforms to seem the inspirations of genius. Like the physician, therefore, who gains credit where he does not deserve it, and loses it where he is not to blame, the statesman is often successful or unsuccessful through the concurrence of causes over which he can exercise no control.

In the sciences and arts which have to do with beings of a lower organisation endowed with life, such as the entire vegetable kingdom, and with the complex interests of human societies: in the science and art of agriculture and in the science and art of government, we see reflected, as in a mirror, but faintly and dimly, the difficulties and perplexities which surround the science of medicine and the art of healing. This important subject must be reserved for separate consideration.

[To be continued.]

Clinical Lecture ON OPIUM: ITS USE AND ABUSE.

BY
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[Concluded from page 315.]

THE cases I have now brought before you, amply illustrate the wonderful efficacy of the narcotic power of opium. Opium soothes the nervous system, and renders it comparatively insensible to the operation of disturbing agencies, whilst by inducing tranquil sleep, it procures for the central organs that season of rest and repair, for which nature has provided in the state of health, by the periodical recurrence of night after the day, and without which those organs must undergo progressive wasting and degeneration. By restoring health to the nervous system, opium also indirectly invigorates the nutrition of the entire body; it restores energy to the functions of digestion and assimilation, renovates the muscles, and in so doing, strengthens the organs of circulation and respiration. It thus produces the effect of a tonic and a stimulant, and I have always thought that opium was indebted to this, its indirect action, for much of its stimulant property. It removes the depressing irritability and restlessness of exhaustion, whether induced by hæmorrhage, or by physical injury, and robs depressing influences, such as severe pain or intense cold, of half their power, by rendering the nervous system insensible to their operation.

I must now reverse the picture, and speak of the failure of opium. Like many other medicines, opium acts only in certain conditions of the system favourable to its operation, but such conditions appear to be of a very special nature. I put out of the question those constitutions which are entirely intolerant of its influence, though this circumstance constitutes a great obstacle to its general employment. But beyond such cases, there are many individuals in whom the medicine entirely fails either to soothe or to cause sleep. The stomach and digestive organs must be free from any great disorder, for opium to act favourably; this is a very important rule, and applies to opium as forcibly as to tonics; but there may be, and often is, something in the constitution of the nervous system itself, either natural or induced, which occasions resistance to the beneficial operation of the