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A HUNDRED YEARS
OF
MEDICINE

by

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"How many excellent physicians have written just volumes and elaborate tracts of this subject? No news here: that which I have is stoln from others; *dicitque mihi mea pagina, fur es.* If that severe doom of Synesius be true, *it is a greater offence to steal* dead mens labours, than their cloaths, what shall become of most writers? I hold up my hand at the bar amongst others, and am guilty of felony in this kind."

Burton's *Anatomy of Melancholy*
(Democritus to the reader).

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PREFACE

It is hoped that this historical essay may prove to be of value not only to the layman, for whom it is primarily intended, but also to those medical practitioners and students who have not found time for any specialized study of the history of medicine.

This book cannot claim to be comprehensive. In many respects it is necessarily incomplete. The available material is unmanageably abundant. To have included everything in detail would have made the book unwieldy, whereas to have condensed excessively would have made it unreadable. I have therefore presumed to select some of the important and more interesting aspects of the subject while omitting others which may be equally important but which are too technical to be readily described to the non-medical reader. It will be noticed, for example, that there is no description of the immense advances which have been made in the technique of surgery. It would be impossible to do justice to these without inferring a fairly detailed knowledge of anatomy which I cannot assume the reader to possess. It will also be observed that the chapter on State Medicine concerns itself almost exclusively with England. I make no apology for this except to say that the development of modern public health legislation can best be followed through the study of the country where it had its beginnings.

The arrangement of this book has been determined largely by the fact that important medical advances are not made in a single day but are generally the result of a laborious series of steps made by a number of different workers over long periods of years. Consequently the importance of each contribution to medicine can best be understood by tracing it separately from its origins rather than by attempting to survey the whole field of advance in strict chronological order. Furthermore, by treating each subject separately it is possible to appreciate the train of thought more clearly at a great saving of space and repetition.

I have refrained from using technical terms without explaining their meaning and hope that the ordinary English words which in some places have been substituted for the technical ones will not irritate those with medical knowledge.

Except for those great ones who make it, history is necessarily secondhand. The author is therefore gratefully indebted to many different writers for the material from which this book is made. Many such writers are mentioned in the footnotes but in a work of this kind it is impossible to give a reference for every statement made. Consequently apologies and thanks are respectfully tendered to those authors both dead and alive from whom facts have been gathered without acknowledgment.

PART I

INTRODUCTORY

I. The Origins of Medicine

The importance of studying the history of medicine or, indeed, the history of any subject lies in the fact that a mere summary of concepts and the results obtained therefrom without a knowledge of their evolution cannot give any true picture of the matter. Without being aware of the laborious foundations upon which an edifice is built we can gain but a superficial idea of the great superstructure.

The history of medicine in its entirety would carry us back to the remotest periods of antiquity; but we cannot travel so far in time within the compass of this small book. Nevertheless, in order to understand the developments of medical theory and practice during the last century, we must have at least some idea of the state of knowledge which existed a hundred years ago and of the general trend of events which led up to this.

At the dawn of history medicine was by no means a new thing: but the medicine of the ancients, the wisdom of the Egyptians and Babylonians, was in general based upon magic and upon astrology rather than science. However, in the fourth and fifth centuries before Christ, Hippocrates of Cos first began to insist upon the scientific and also the ethical aspects of medicine. He founded the profession and from his school came directly or indirectly all the famous physicians, practical observers, of the past. His teaching, essentially scientific, held unchallenged priority for many years, until the times of Galen of Pergamum, physician to the Emperor Marcus Aurelius.

The widest and most original discoveries and studies have been accredited to Galen—in anatomy, physiology, the study of disease and also of drugs. Most of the pathways that Galen had begun to cut through the jungle of ignorance remained as he left them for nearly fourteen centuries, while others were overgrown by the weeds of forgetfulness and dogma which flourished so vigorously in the Dark Ages. The knowledge of the Greeks virtually disappeared from Europe at the fall of the Western Empire. The ignorance of the barbarians wantonly destroyed that knowledge which the Christians, finding no place for it in their lives, lost through lack of interest rather than through active hostility. Indeed, had not the vigorous peoples of Arabia absorbed, largely from the Nestorian Christians, the great ideas of the Greeks, it is doubtful how much there would have been left of the early foundations of medicine on which the present-day science has been built.

The most famous of all text-books of medicine is of Persian origin. This is the "Canon" of the Persian philosopher who is generally known as Avicenna (A.D. 979-1037). This, his most influential work, follows the ideas of Hippocrates and Galen intermingled with those of Aristotle, worked up into a great System of Medicine. It deals, in five books, with physiology, the study of disease, hygiene, the treatment of sickness and the compounding of physic. This great work contains many fallacies but much good sense, and remained the standard work on medicine for many years.

In the Middle Ages medicine was purely dogmatic. What the ancients had said, what Hippocrates, Aristotle, Galen and Avicenna had written was right, and there was none to dispute the oracular pronouncements of the past. If we except Roger Bacon, an experimental genius whose discoveries were premature and consequently without any wide influence, until the reawakening of knowledge in the fifteenth, sixteenth and seventeenth centuries, no one dared to question the truth of the old authorities. Many fallacies which were then accepted could have been shattered so easily by Experimental Science. But Experimental Science was asleep.

The beginning of the modern experimental period may be said to date from Paracelsus, that strange sixteenth-century figure, sorcerer, philosopher, alchemist and physician, who overthrew the absolute sovereignty of Hippocrates, Galen and Avicenna. That men should research into the workings of nature for themselves, that was the keynote of his teaching at the university of Basle: and he startled the world by publicly committing the "Canon" to the flames of a students' bonfire.

At the same time Vesalius was laying the foundations of modern anatomy at the university of Padua. Galen's excellent anatomical knowledge had suffered sad mutilation at the hands of the Arabians and other mediæval scribes. Vesalius, as a result of many personally conducted dissections, put anatomical studies on a sure basis of fact with his famous *De Humani Corporis Fabrica*, published at Basle in 1543.[1] At the same university of Padua the great Englishman Harvey, at the beginning of the seventeenth century, was educated in that thorough knowledge of anatomy which enabled him to make his far-reaching discovery of the circulation of the blood. Modern physiology, that is to say the study of the functions of the normal healthy organism, had its beginning here. Harvey, like Paracelsus, insisted on the direct experimental appeal to nature.

[1] If we may believe Robert Burton, the zeal of Vesalius was such that "they say that Vesalius the anatomist was wont to cut up men alive" (*Anatomy of Melancholy*, Part I, Sec. I, Memb. II, Sub-sec. III).

The seventeenth century busied itself mainly with physics and chemistry and attempted to explain function and disease in terms of these and to apply these principles to the practice of medicine: for example, we find that the vegetable drugs, the "Galenicals", were beginning to be replaced by "chemicals". But this period also produced a revival of the Hippocratic methods of *observation*, apart from any consideration of theory, in the work of the great Englishman, Thomas Sydenham. He believed that all theories were valueless and set out to provide accurate descriptions of the signs and symptoms of diseases. He supposed, as we do now, that each disease was a definite individual species and could be classified like an animal or plant. Sydenham's influence continues to be felt even today.

For a fuller account of the early history of medicine see :—

Sir William Osler. *The Evolution of Modern Medicine*, New Haven, 1921.

Max Neuburger. *History of Medicine*, English translation, London, 1910-25.

II. Theories of Medicine in the Eighteenth Century

In the eighteenth century theories of medicine abounded.[1] Some of these were quite fantastic while others, even if fallacious and unworkable, were at least credible. Some of them, though false in themselves, led directly to good results which were particularly apparent in those systems which indicated the use of mild remedies in the place of the more vigorous measures then in vogue, measures which too often were the final blow to the weakened strength of the patients.

There had been many brilliant achievements in other sciences—in chemistry, in physics and in astronomy. Certain all-embracing theories had had widespread success. Kepler and Newton, for example, had brought the motions of the planets, the tides and the falling apple all under one universal law. Inspired by the results of such wonderful simplicity, it was natural that physicians should seek to discover some complete and universal system of medicine. The result of this was a large crop of " systems ", particularly in Germany and in Scotland, which for the most part had a very great effect in hampering positive progress.

Some hoped to follow the great mathematicians of the seventeenth and eighteenth centuries and to base their theories on mechanics or mathematics. A complete mathematical system, for example, was attempted by Dr. Richard Mead, the fashionable physician, who had inherited the

[1] Excellent accounts of many of these are to be found in the *History of Medicine* by J. H. Baas (translated into English by H. E. Handerson, New York, 1889), and that of F. H. Garrison (4th ed., London and Philadelphia, 1929).

practice of the successful and insolent[1] John Radcliffe. It was the latter who had left a huge sum of money, which was used for the foundation of a library, an astronomical observatory and an infirmary at Oxford. Mead's teacher, Archibald Pitcairne of Edinburgh, had endeavoured to apply mechanics to physic and to base medicine on geometry.

At Halle university Hoffmann was teaching that life is based on the presence of some kind of universal fluid or ether: while Stahl postulated a conscious soul whose efforts, often ill-directed, to throw off some adverse influence constituted disease. Stahl's theory was a kind of animism which, rejecting any sort of mechanical explanation, was contrary to all the scientific ideas which were then in vogue.

Most famous perhaps among the Scottish physicians was John Brown of Edinburgh, the disreputable boor whose theories, though they may appear to us unsound, had a tremendous influence throughout Europe up to the end of the century. The Brunonian theory, as it was called, held that the phenomena of life depend on stimulus and that diseases were of two kinds, those that were due to lack of stimulus (the asthenic) and those in which there was too much stimulus (the sthenic). Fortunately Brown decided that the great majority of diseases were asthenic and therefore required stimulants. Now in many diseases stimulating treatment is very desirable, so that in this respect he made a distinct advance on the drastic weakening measures employed by so many of the practitioners of that time. Brown had two sovereign remedies, the one stimulant and the other depressant. These were alcohol and opium and to these he himself is said to have fallen a victim. It has

[1] "Mead, I love you", Radcliffe is reported to have said, "and I'll tell you a sure secret to make you a fortune—use all mankind ill" (cited by Garrison, *History of Medicine*, 4th ed., London and Philadelphia, 1929, p. 390).

been stated that the Brunonian system "destroyed more people than the French Revolution and the Napoleonic Wars combined".[1]

Homœopathy, which was first put forward as a medical doctrine towards the end of the eighteenth century, was the invention of a German, Hahnemann of Meissen. Homœopathy took no account of the causes of diseases but studied only the symptoms. It affirmed that symptoms can be cured by those very drugs which would produce these symptoms in a healthy person. Hahnemann furthermore added to his theory the extraordinary notion that the physiological effect of drugs is made much stronger by diluting the drugs, by pounding them and shaking them. His practice then was to give incredibly minute doses such as could generally have had little or no effect either beneficial or the reverse. Here again the theory had considerable success simply because the very mild nature of the treatment gave the *Vis Medicatrix Naturæ* the needful opportunity to effect a cure.

It must be added, however, that of all the eighteenth-century systems of medicine homœopathy alone has survived in active practice today. Its supporters have pointed out that many of the procedures adopted by orthodox present-day physicians are, in essence, homœopathic. The use of small doses of vaccines has been held up as an example. Whether we believe in Hahnemann's principles or not it must be admitted that the very survival of his theory is evidence that homœopathic methods of treatment appeal to the patient and are not without considerable success.

In general the great theories, of which we have given examples, bade their exponents try one or sometimes two

[1] Garrison. *History of Medicine*, 4th ed., London and Philadelphia, 1929, p. 315.

kinds of treatments on every one of their patients. It was the age of panaceas; and we find different practitioners placing all their hopes on purges, on clysters, on bleeding, on mineral waters or on whatever remedy their systems demanded.

Among these fanatics we may perhaps mention Broussais. Certainly his theory was better than many others, for he tried to do away with vague notions of mysterious "Disease" and endeavoured to show that any given malady was due to something wrong with some definite organ. Irritation, he declared, was the basis of life—and of disease. Disease occurred when there was some increased irritation in some particular organ. He selected the stomach as the usual seat of such trouble. In practice his system resulted in an orgy of blood-letting rivalling the excesses of the great Dr. Sangrado himself.[1] It is related that in the year 1833 it was found necessary to import forty-one and a half millions of leeches into France.[2] Broussais' ideas were widely accepted and blood flowed in cataracts until Laennec and other more advanced clinicians and, above all, Louis, with his medical statistics, had made it very obvious that the effects of ill-judged bleeding were not only merely worthless but often fatal.

[1] See *Gil Blas.*

[2] Garrison. *History of Medicine*, 4th ed., London and Philadelphia, 1929 p. 409.

III. Practical Scientific Progress

There were, besides all these theory-mongers, many who devoted themselves wholeheartedly to more practical medicine. These were trained and highly practical *observers* and, if they had their theories, they did not allow their work to be hampered by any preconceived notions. It was during the eighteenth and early nineteenth centuries that the foundations of pathology, the principles of hygiene and of sound clinical diagnosis were firmly laid.

The progress that was made during this period in medicine and surgery was the work of several different schools in different countries. Owing to the unsettled state of Europe discoveries and methods did not always travel very readily from one country to another. Consequently we find the English and various Continental schools divided from one another by their opinions. It is thus that we must examine them.

On the Continent there was Boerhaave at Leyden, whose teaching spread to England through his many English pupils. His was the great medical training centre and he endeavoured to apply all the available discoveries in every scientific subject to the practical advancement of medicine.

At Padua Morgagni had laid the very important foundations of morbid anatomy. He examined great numbers of bodies after death and carefully and systematically recorded everything which he found abnormal. The great importance of his work lies in the fact that he also recorded the diseases and signs and symptoms of the diseases in the individuals before they died. In this way he began the scientific study of the changes brought about in the body by disease—a study without which medicine could hardly have made any but purely empirical advance.

Morgagni's great work was followed up by the Scotsman Matthew Baillie, who was a pupil at William Hunter's famous Windmill Street School, to which we shall have occasion to refer later. Baillie published the results of an enormous amount of diligent work in a systematic treatise *Morbid Anatomy*,[1] excellently illustrated with careful copper-plates.

In England Richard Mead, in spite of his mathematical theories and his examination of the power of the sun and moon over the human body,[2] had very definite ideas about epidemic diseases. In 1720 he published a *Short Discourse Concerning Pestilential Contagion and the Methods to be used to prevent it*. This remarkable work contains detailed instructions for quarantine, for segregation of the sick from the healthy, for the evacuation of towns, for the cleansing or demolition of infected houses, for cleaning the streets, for removing nuisances and for the prohibition of assemblies. He definitely states that lack of cleanliness and overcrowding is the reason " why the poor are most obnoxious to contagious diseases ". Almost the whole of his recommendations are such as would appeal to any sanitary authority today.

Notable studies of certain infectious fevers had been made in England by John Huxham and John Fothergill. The former made careful reports on such diseases as typhus and typhoid, scarlatina and diphtheria, though he did not, of course, use these names, nor did he always distinguish between the various fevers. He, too, was a pupil of

[1] London, 1793. Plates published separately, 1803.

[2] Of course there is nothing inherently foolish about this conception of disease. That seasonal and climatic variations affect some maladies is obvious enough and it is certain that such influences are primarily controlled by the sun and the moon.

Boerhaave of Leyden. Fothergill made important contributions towards the study of infectious sore-throats.

Another notable Englishman who studied at Leyden was Sir John Pringle. He gained considerable experience as physician to the British forces during the campaigns in Flanders and wrote a valuable work on the health of the Army. In this he studied carefully the types of the various diseases together with the climate and season of their incidence. He showed that many diseases had removable causes and pointed out the means of removing them. Later he became President of the Royal Society and presented the Copley Medal in 1756 to the representative of Captain Cook, who had achieved a remarkable performance in preserving the health of his crew during a three-year voyage, with only one man dead of sickness. It was Pringle who was responsible for the war against damp, filth and bad air in the Army and so inaugurated Military Hygiene.

The Navy had its sanitary champion in James Lind, who did for the seamen what Pringle had accomplished for the soldiers. His successful essay on the most effectual means of preserving the health of sailors had run into three editions by 1772. His directions against gaol-fever (typhus) and scurvy met with well-merited success. To Lind is due the almost complete disappearance of scurvy from the Navy.

In surgery the eighteenth-century Englishmen also made very great advances, and of these Englishmen the greatest was John Hunter. He was the pupil of the celebrated Percival Pott of St. Bartholomew's Hospital, whose name is recalled to medical men by Pott's fracture (of the fibula) which he himself sustained through falling from his horse, and Pott's disease (tuberculosis of the spine) which he described.

Hunter's activities were multifarious. Besides his medical discoveries on the repair of tendons, on digestion, on teeth, on transplantation, inflammation, wounds, shock and many other subjects, he also made large numbers of important excursions into human anatomy, physiology and the comparative anatomy of beasts, insects and plants. He collected a magnificent private museum of over thirteen thousand specimens which was eventually acquired for £15,000 by the Government and placed under the care of the Corporation of Surgeons.[1]

Hunter's importance, however, lies in his methods rather than in his individual discoveries. He began almost a new era in surgery by the application of the principle of experimental verification. Before his time surgery had been based solely on anatomy and little or no heed had been paid to pathology, that is to say the causes and sequence of changes—the natural history of disease. The work of the great morbid anatomist Morgagni had had no practical application. It was Hunter's great achievement that he showed the importance firstly of applying the available knowledge to surgery, and secondly of making experiments to try the accuracy of his conclusions.

A typical instance of the use to which he put his discoveries is that of his experience with a deer in Richmond Park. He had tied up the artery which supplied blood to one of the antlers of a buck. This antler, deprived of its blood-supply, became cold: but, so far from dying, in a few days the antler had regained its blood-supply, not because the tying had been badly done, but through the enlargement of subsidiary connecting arteries above and below the ligature. Shortly after this he was able to apply the same process for the cure of those pulsating swellings

[1] After Hunter's death in 1793 his executors offered to sell the collection to the Government. But Pitt, then Prime Minister, said, "What! Buy preparations! Why I have not money enough to purchase gunpowder" (1799).

of arteries which are known as aneurisms, and which generally proved fatal if they were not arrested. Previously surgeons had been forced to cut down on the tumour and remove its contents after tying the artery above and below. This was often disastrous. The alternative had been amputation. Hunter was able to show that successful results could be obtained by tying the artery higher up in a healthy part of the limb without danger of the limb suffering from want of blood. The aneurism then healed itself. The astonishing success of this one discovery must have saved thousands of limbs and hundreds of lives.

Outwardly, John Hunter seems to have been a rude and quarrelsome man: in fact, as he himself had prophesied, he met his death from an attack of angina pectoris—to which he was subject—brought on by a fit of rage.

Among Hunter's pupils was one who was destined to have a most profound effect upon medical thought and medical practice. This was Edward Jenner, who, starting from the popular belief in Gloucestershire that cow-pox and smallpox were antagonistic to one another, conceived the prodigious idea of vaccination against smallpox. His great discovery, which was published in 1798, was hailed with enthusiasm on the Continent and in America and many thousands of persons had been vaccinated before the close of the year 1800.

Methods of clinical diagnosis received a tremendous impetus from two discoveries of the first importance; namely, the methods of *percussion* and *auscultation.* Both of these methods came from the Continent, the one from Vienna, the other from France.

Percussion is a way of finding out the gross physical conditions inside the body, particularly in the chest, by studying the varying sounds which occur when the body is tapped with the fingers. Auenbrugger, of Vienna, made this important contribution to medicine. In 1761 he published his *Inventum Novum* which set forth the principles of the method. The ridicule and sarcasms which this brought upon his head delayed the general application of the invention for nearly fifty years. In 1808 his book was translated into French and rapidly attained fame throughout Europe. The method itself depends upon the principle that the chest (and abdominal) wall is a kind of drum which, when lightly struck in different places, gives out notes which differ according to whether there is gas, liquid or solid lying inside at the place where the wall is struck.

Auscultation means simply the study of the noises which go on inside the body and is chiefly applied to the heart and lungs. Laennec, a regimental surgeon and a native of Brittany, invented the stethoscope in 1819. This was simply a tube which he constructed at first from rolled paper. With this instrument he made so careful an examination of the sounds that he heard in the heart and lungs of patients both healthy and sick that he put the study of these sounds for the first time upon a really firm foundation. The methods of Auenbrugger and Laennec together are responsible directly for almost all of the knowledge which has since been gained about the diagnosis of disease in the chest.

It was not until after the close of the Napoleonic wars that these ideas were put into practice in the British Isles. The famous Dublin school of medicine began to adopt the methods of Laennec at this time. William Stokes brought the use of the stethoscope to the notice of the profession and published much valuable work on heart-disease.

From France, too, came the first medical statistics. Of course there had been statistics of births and of deaths and causes of deaths before this time, but it was Louis

(1787-1872) who showed the value of purely medical statistics. By collecting the records of numbers of cases of different diseases and the treatment of each case he was able to show convincing proof of the efficacy, worthlessness or disastrous result of such treatment. It was by this kind of work[1] that he helped to stem the torrent of blood-letting in which Broussais and others indulged: for he brought forward figures to show that in pneumonia, at least, bleeding was worse than useless. To Louis belongs the credit of showing that statistics are an important high-road to the advancement of medicine.

In German medicine at the beginning of the nineteenth century we find numbers of different schools of thought, some of which made great advances while others indulged too often in such overwhelming masses of verbiage that it is almost impossible to discover any meaning at all in many of their systems. Some, following the zoologists and botanists, tried to formulate a dogmatic classification which, in the state of medical knowledge which existed at that time, would not be likely to be very successful. This latter school was led by Schönlein, who did valuable work in introducing the use of the microscope and examinations of the blood. Schönlein made also one very significant discovery when he showed that the skin disease, known as *favus*, was due to a parasitic fungus. This was an isolated discovery—the first of the microscopical parasites of which many more were to be found in the course of the next hundred years.

At Vienna a new school of medicine was growing up. Josef Skoda made considerable advances in the use of auscultation for the diagnosis of chest diseases. Though he believed that diagnosis could be perfected, when it came to treatment he confessed himself impotent and took up a

[1] *Recherches sur les effets de la Saignée, etc.*, Paris, 1835.

completely defeatist attitude. "Nichts tun is das beste der inneren Medizin."[1] The most remarkable discovery which came from the New Vienna school was that of Semmelweiss who, about the middle of the nineteenth century, demonstrated the way in which puerperal fever is spread and showed the methods of preventing it.[2]

The treatment at the disposal of the physicians of these times was necessarily inadequate. Before the discovery of the parasitic nature of many diseases there could be no specific remedies except the few drugs that were known by experience to be effective. Quinine for malarial fevers and mercury for syphilis were used with good effect. Most drugs, however, could only be used to relieve symptoms and could not strike at the cause of the disease—for this was unknown.

[1] Garrison, *op. cit.*, p. 429. [2] See below, p. 111.

IV. Surgery and its Limitations

If we look at the surgical writings, the notes and reports of hospitals, the text-books and other publications, we must at once be struck by one fact. We must notice that the diseases commonly treated or most discussed have by no means always the same importance today as they seem to have had a hundred years ago. The reasons for this are many, but the two discoveries which have had the most profound effect are almost certainly anæsthetics and antisepsis.

As early as 1799 Humphry Davy had discovered the anæsthetic properties of nitrous oxide or, " laughing gas ". Although he had pointed out that this gas might prove of advantage in surgical operations, the matter was not taken up. Ether was the substance which first came into general use, but not before the forties. From this time onwards the use of anæsthetics became by degrees a matter of course. It seems remarkable that the discovery of Sir Humphry Davy should have been allowed to remain for so many years a philosophical curiosity.

It will be readily understood that in the days when operations were done without anæsthetics, it was highly desirable that they should take the smallest possible time. Agony called for speed which took precedence of everything except safety. The great surgeons of the past justly prided themselves on the dexterity and rapidity with which they could perform operations.

It must be realized that there were only a few surgeons who would undertake big operations and these were found only in the great towns. Operating must have been a ghastly business and he who could perform feats of skill amid the agonizing scenes in the operating theatre must have had nerves of steel. Some surgeons might alleviate the frightful distress by dosing the patients with opium or alcohol, but even this could not make the pain bearable.

Operation therefore was generally only undertaken with the object of saving life. The patient was not usually cured even if he survived the surgeon's care, because such procedures as amputation, for example, which formed a large part of all the operations performed, could hardly be said to be cures. They were often undertaken in emergencies where they were the only hope for the patient's life.

Many of the greatest surgeons were fully alive to the opinion that the knife should be the last resort and that wholesale removal of parts of the body was an admission of ignorance and failure. We read, for instance, about the indefatigable Sir Astley Cooper, the most successful and the most popular of all the practitioners in the London of the early nineteenth century: "In cases of operation he would show, that its performance, although too often considered by the public as the highest point in surgery, was regarded by the profession as an opprobrium to the science, being a want of skill in the knowledge and application of efficient remedies for the *cure* of the disease: a knowledge only to be obtained by constant opportunities for examining the diseases which have hitherto been considered incurable except by their extirpation by the knife".[1]

The absence of anæsthetics, apart from the patient's point of view, had the further disadvantage that the surgeons were prevented from embarking upon new operations of a

[1] B. B. Cooper. *Life of Sir Astley Cooper*, London, 1843, II, p. 104.

more severe or intricate kind, such as can now be attempted with success. It was not until the coming of anæsthetics that painstaking attention to detail could take the place of the lightning legerdemain of the older school of operators and that conservative measures could be practised at comparative leisure.

Antisepsis means the counteracting of processes of putrefaction, while asepsis means the use of cleanliness to prevent such processes from beginning. The latter is the more modern method which grew out of the first antiseptic teaching of Lister. These methods have contributed beyond everything else to the enlargement of the fields of surgery. Before this, the abdomen, the brain and the chest were outside any help from surgical interference. Any attempt at abdominal surgery invited disaster, and operations which have a mortality of one hundred per cent. cannot be recommended either from the point of view of the patient or that of a surgeon who values his reputation.

With all these changes, the proportions of the different kinds of treatment were bound to undergo considerable alteration. Let us take one example to illustrate this point. Under the old surgical regimen, as late as 1848, there were in St. Bartholomew's Hospital 397 surgical beds, and the average number of operations per year (taken over a period of five years) was 370, of which 78 were amputations.[1] Compare this with the same hospital in modern times when the surgical beds numbered 390. There were in 1912 3,561 operations, of which only 25 were amputations. The very great increase in the number of operations is largely due, as we have pointed out, to the enlarged scope for operation and not from any actual increase in the incidence of disease generally. Of course

[1] Godlee. *Lord Lister*, London, 1917.

the population has increased, but then so has the number of hospitals. The considerable decrease in the number and the enormous reduction in the proportion of amputations must mean that a vast number of limbs have been saved by conservative treatment.

V. THE HOSPITALS: HOSPITALISM AND ITS CAUSES

THE older hospitals in England had their origin in religious foundations and their functions differed essentially from those of today. They were not medical but ecclesiastical. They were for the care rather than the cure of their inmates. Excluding monasteries and friaries there were more than 750 charitable institutions in mediæval England.[1] It was from some of these that the oldest of our present-day hospitals grew, but there were others that retained their original characters as homes for the aged and infirm. Of the former type is the great hospital of St. Bartholomew in the City of London, while a good example of the latter kind is the hospital of St. Cross, near Winchester.

In the eighteenth century many of the more famous hospitals of England were built to fill the growing need for purely medical care of the sick. St. Thomas's Hospital had previously been founded in 1693, while St. Bartholomew's was rebuilt in 1739. The philanthropist Guy, who spent next to nothing on himself but gave away magnificently, began to build the hospital that bears his name and, when he died in 1724, left the bulk of his fortune, amounting to over £200,000, for its completion and endowment. It was to be further supported by donations which gave the benefactor in question "free letters" by which they could obtain entry for any sick person whom they might choose. The Westminster, St. George's and the London hospitals were all founded between 1719 and 1740, while

[1] R. H. Clay. *The Mediæval Hospitals of England*, London, 1909.

Edinburgh and Glasgow and other large towns also built for themselves similar institutions.

All these were general hospitals: they took in anyone whatever his complaint might be. There were a few, but very few, hospitals for special diseases. In London, for example, a special smallpox hospital was opened in 1746 and the Children's Hospital in 1769. The Royal Sea-Bathing Infirmary for scrofula (the King's evil) was started in 1791, largely through the action of the famous Dr. Lettsom. He had, however, been anticipated by Russell who, observing that scrofula seldom or never attacked fishermen, began an institute for sea-bathing at Brighton. The great "sea-water Russell" himself describes how "children sent to him for treatment delicate and pale, overclothed and glandular, had been returned to their parents after sea-bathing bare-necked, their hair shaved, the tumours of the neck cured, and the countenances healthy".[1]

The character of the buildings of general hospitals can be seen from certain examples, St. George's and the older blocks of buildings at St. Bartholomew's, for instance, which, with the addition of a little modern plumbing, are still in use today. But, though the buildings were the same, the hospitals were far from being the clean and sanitary institutions that they are now. The new buildings rapidly lapsed into unparalleled squalor, largely through overcrowding, lack of cleanliness and inadequate water supplies. A sidelight on the cleanliness of the rooms may be gained from the fact that Dr. Lettsom, when a student, seemed to think his teacher, the poet Mark Akenside, fussy in not allowing spitting in the wards.[2] Overcrowding was the rule and we read, for example, that in the Hôtel-Dieu

[1] J. J. Abraham. *Lettsom*, London, 1933, p. 281.

[2] J. J. Abraham. *Lettsom*, London, 1933, p. 113.

at Paris the sick lay four and even six in the same bed[1]—pregnant women along with the diseased.

The surgical wards were veritable forcing-houses for sepsis. They could hardly have been organized in a way that was better calculated to favour the spread of septic diseases. There were four horrible sicknesses which were so much more prevalent in hospitals than outside them that they were called " hospital diseases ". These were erysipelas, pyæmia, septicæmia and gangrene, mysterious pestilences that came upon the patients and killed them like flies. There seemed neither rhyme nor reason for these deaths. It appeared to be simply a matter of misfortune. The fatalities bore little or no proportion to the care or skill with which the operations had been performed. The scourges came in waves, and, once established in a ward, would travel from patient to patient with heart-rending swiftness. Sir James Simpson in his statistical investigations on " Hospitalism "[2] showed that in one hospital five out of every twelve patients who underwent amputation died, for the most part of sepsis: while outside, in private and country practice, only five out of forty-six succumbed. Women who were delivered out of hospital stood seven times the chance of coming safely through a confinement.

In those times wounds were seldom known to heal in the clean and straightforward way in which they mostly do today. Suppuration was the rule, healing " by first intention " a rarity. Some, indeed, taught that pus formation was one of the essential processes of healing, and they talked of " laudable pus ". A simple fracture mended wonderfully well, but when the fracture was compound, that is to say when the skin was broken, the outlook was

[1] Tenon. *Memoires sur les Hôpitaux de Paris*, Paris, 1788, preface.

[2] Erichsen. *On Hospitalism and the Causes of Death after Operation*, London, 1874, p. 49.

black with anxiety. The surgeon waited gloomily fearing the dreaded shivering attack which ushered in the fatal poisoning of the blood.

The methods of treatment varied with different surgeons. There was the "open" method in which the wound was left uncovered in order to promote the formation of a scab; for it was noted that when a healthy scab had once formed, then the wound would heal without accident. Other surgeons, believing the air to be the bearer of disease, closed up the wound with airtight dressings such as gold-beater's skin. Where the wound was already infected this treatment, which shut in the poisons, led to frequent disaster. Perhaps one of the most successful methods was that practised by Syme, the great Edinburgh surgeon and the teacher of Lister: the drainage of the wounds by leaving the long ends of the ligatures hanging out. In this way he sought to drain out the poisons into the dressings of the wound, but such drainage must have been at best imperfect.

The latest of the pre-antiseptic surgeons were agreed upon one point at least: namely, that sepsis was favoured by dirt and by having other "dirty" (suppurating) wounds in the same ward, and by overcrowding the patients. Little did they realize that, in general, it was they themselves who were unconsciously poisoning their patients every time they used the probe or the knife. The probe was a favourite instrument for the examination of wounds, it was never sterilized and, at the most, was washed between its use on each patient. Who could devise a better means of carrying infection? And these conditions continued until late in the nineteenth century.

The surgeons themselves wore their oldest frock-coats in the operating theatre. These were often heavily encrusted with dried blood and pus. In some instances the surgeons even attached a certain sense of superiority to these poisonous garments, much as schoolboys feel the prouder that their " colours " have not the newness of the tyro's clothes. These loathsome coats might be used for six months, a year or more without being changed. When we consider that frequently the pieces of whipcord used for the tying of arteries were kept hanging in the button-hole of such a coat, we can only be astonished that every operation did not end in disaster.

The hospital nurses demand some brief description. They were generally of the charwoman type, unreliable, tipsy and incompetent. " All drunkards without exception, sisters and all, and there but two nurses whom the surgeon can trust to give the patients their medicine ", said a London doctor.[1] A nurse went even further in stating that there was in addition " immoral conduct practised in the very wards ". Dickens assures us that he considered it " not the least among the instances of their [the hospital's] mis-management that Mrs. Betsey Prig is a fair specimen of a Hospital Nurse ".[2]

It is needless to say that there were many vigorous champions of the nurses, who absolutely denied the charges of tippling. Their denials may perhaps be accorded the weight they deserve when we read Lord Granville's ingenuous observation: " The nurses are very good now, perhaps they do drink a little, but so do the ladies' monthly nurses " [Sarah Gamp!]—" and nothing could be better than them: poor people, it must be so tiresome sitting up all night "[3]

With this brief description of the hospitals of a hundred

[1] Cook. *Life of Florence Nightingale*, revised by R. Nash, London, 1925, p. 20.

[2] Preface to *Martin Chuzzlewit*.

[3] Cited by Cook. *Life of Florence Nightingale*, revised by R. Nash, London, 1925, p. 21.

years ago, we can hardly be surprised that they were by no means popular institutions and were often regarded as death-traps. What is more surprising is the late period at which the reform of the hospitals began and, as we shall see later, the person who stands out pre-eminently is Florence Nightingale.

VI. The Sanitary Conditions of the People

In reading descriptions of the sanitary conditions of the people a hundred years ago it is important to bear in mind first of all that these conditions were in many ways better than they had ever been for hundreds of years. Secondly, it must be remembered that such accounts often described the worst slums that could be found and cannot therefore be accepted as representative of the state of the people as a whole. This is not to say that the hygiene of the people was good; indeed, much of what we read appears horrible beyond belief.

If we wish to find out some of the worse features in the lives of the people at that time we cannot do better than turn to the admirable report of the Poor Law Commissioners on the *Sanitary Condition of the Labouring Population of Great Britain.*[1] Here we find described conditions that must appear absolutely inconceivable to us today were we not convinced of the sincerity and veracity of Edwin Chadwick, the author of the report.

The book deals particularly with the towns. These, largely as a result of recruitments from the country for the new factories, had been growing fast—too fast indeed for any proper scheme of housing to be made. In the big towns it was the speculative builder who supplied the houses for the rapidly increasing additions to the population. In order to obtain the highest possible yield for their money the builders set about leasing and buying land and cramming as many people as was possible on to a given acreage at the least possible cost.

[1] London, 1842.

The streets were made as narrow as was feasible, the houses were built back to back without draining or foundations and constructed of the flimsiest and cheapest materials available. There was nothing to stop the builder doing exactly as he pleased, and what he pleased was generally as far removed from any kind of town planning as it is possible to imagine. There was, in fact, actual encouragement to build bad houses because, if the house was bad enough, it escaped payment of rates, "partly through the inefficiency of the law and partly through the difficulty of enforcing it".[1] There were, of course, notable exceptions. Certain enlightened landlords made conditions before granting leases[2] and insisted on substantial buildings, wide streets and sometimes even sewers. In general this was not so and the results of such thoughtless building were worse than the most pessimistic landlord could have supposed.

In the older towns like Edinburgh and Glasgow overcrowding was as bad as in the newer towns. Large families were living in rooms that had been originally intended for cellars, without light, air or drainage. Here might be found twelve or eighteen persons in as many square feet.[3] The absence of drainage or sewers produced the most lamentable state of affairs. There were low passages leading into square courts "occupied entirely as dung receptacles of the most disgusting kind". Indeed, part of the rent of the houses was paid by the sale of these heaps for manure.

We read of open drains in Stirling[4] which were flushed only when there was a hard shower. The filth from the

[1] Health of Towns Commission. Second Report, 1845, Appendix p. 15.

[2] Health of Towns Commission. Report, 1844, Appendix.

[3] *Glasgow Medical Journal*, III, 1830, p. 437. *Present Condition of the Poor in Glasgow.*

[4] *Sanitary Condition of the Labouring Population*, London, 1842, p. 34.

gaol was washed down the public streets at intervals. Blood flowed from the slaughter-house down the highways. Often the lower parts of the houses themselves were used as dung-heaps or pigsties. There were no "public necessaries" and the stairs and streets were often used as such.

In Manchester the streets were barely passable from mud or tolerable from stench. There were many "open cesspools, obstructed drains, ditches full of stagnant water, dunghills, pigsties, etc., from which the most abominable odours are emitted".[1] That the streets in these and many other towns were not drained would have been of little consequence had they been properly scavenged; but attempts at street-cleaning were of the most inadequate and perfunctory kind.

In many places the sewers that did exist were hopelessly unsuitable and never originally intended for house-drainage, or indeed for anything more than water from the streets. They were often badly constructed, with flat bottoms so that they were rapidly silted up, or through carelessness or ignorance they were built without regard to geographical levels so that frequently, especially during floods, the contents of the sewers were regurgitated into the houses. This was particularly likely to happen when the drains opened into a tidal river. Nauseous gases too often found their way from untrapped sewers into dwelling-houses. Where efficient main sewers existed there was more likely to be a considerable charge for connecting a house to the main rather than a penalty for omitting to do so.

In places where house-drainage was connected up with sewers, these generally ran directly into the local river, canal or stream with the natural result that such

[1] *Sanitary Condition of the Labouring Population*, London, 1842, p. 38

water became a stinking open drain. The Thames had become horribly polluted. "What was the use of praying to be delivered from plagues and pestilences so long as the common sewers ran into the Thames?"[1] "The Serpentine, itself, intended . . . as an ornamental water, became an open sewer which drained Kilburn, Paddington and Bayswater."[2]

The absence in many places of an adequate supply of water had a very pronounced effect in increasing or keeping up an intense squalor. Water is important not only because it induces cleanly domestic habits, but also because it is an absolute necessity for the flushing of sewers and the cleaning of streets.

In certain districts the shortage was pitiful. In Hampstead and Hendon water was bought by the pailful, while in Edinburgh many persons had to carry it for long distances and then perhaps to the top of a five- or six-story house.[3] In many places the supply was intermittent and turned on for grossly inadequate periods. Generally the only supply of running water that was available for private houses was to be had at considerable expense from private water companies. A notable exception to this was Bath, where there was a plentiful supply which, owing to the geography of the town, needed no mechanism to arrive at any part.

Often the little water that was available was of the most disgusting kind, filthy, unwholesome, malodorous and discoloured. A water-supply was not an unmixed blessing where it enabled people to have their own cesspools. London, for example, was riddled with these contrivances which were often liable to leak or overflow and as a result

[1] Cook. *Life of Florence Nightingale*, revised by R. Nash, London, 1925, p. 52.

[2] Hammond. *The Age of the Chartists*, London, 1930, p. 91.

[3] *Sanitary Condition of the Labouring Population*, London, 1842, pp. 65-66.

any neighbouring water-supply might be contaminated with sewage.

Lack of ventilation and light was by no means peculiar to the cellar dwellings which we have described. The notorious window tax, though reduced in amount, still set a price on these necessities. It is true that the duties were levied only on those houses which had more than eight windows: but in many places there were large houses inhabited by several families of poor people, and these were taxed on the total number of windows.

If such abominations were to be found in the larger towns, what sort of sanitation was there likely to be in the villages? Little or none. It must be remembered, though, that conditions that are likely to create squalor in towns can be comparatively harmless in the country. If one were to apply the standards of many small villages in England today to a town of considerable size, the results would be horrible. The country villagers had no piped water-supply and no need for drains and sewers: but if they had overcrowding in their cottages, they had also the fresh air of the countryside and lived their lives for the most part out of doors. The country folk were liable to the same diseases which attacked the townsmen; but it is significant that the death-rate of the country was lower. This circumstance may be partially accounted for by the fact that many who were born in the country went to die in the towns.

There has been an unfortunate tendency to idyllize the village life of "those days", but the legend of the healthy villages of the eighteenth century is probably no truer than that of the "healthy savage" of today. Goldsmith's "Sweet Auburn" must have been an insanitary place even before it became deserted. In George Crabbe's *The Village* we find a graphic account of the sorrow and squalor in the parish poor-house and "of the consequential apothecary who gives an impatient attendance in these abodes of misery. . . ."

> "A potent quack long versed in human ills
> Who first insults the victim whom he kills;
> Whose murd'rous hand a drowsy Bench protect,
> And whose most tender mercy is neglect."

It has been customary to blame the Industrial Revolution for the unhealthy state of the towns and to some extent this is justified. But the industrialists were not wholly to blame. That there was "sweated labour" under vile conditions there can be no doubt. The descriptions of the badly ventilated, overheated and candle-lit workrooms of the London journeymen tailors, for example, make sad reading. The depressing effect of long hours in foul air, laden with moisture and perspiration, drove them surely to the habit of breakfasting off gin. Small wonder that numbers of them were "taken with a decline". The master tailors attributed this ill-health to drink, whereas it seems fairly clear that heavy drinking was but one of the appalling results of the conditions under which the journeymen lived.

Industry drew countless numbers of men, women and children into towns too small to hold them. Overcrowding was an inevitable result. If the new houses of the speculative builder were "unfit for human habitation" (in the language of the modern sanitary inspector) they were probably no worse and sometimes better than the normal artisan's house of the day. Drainage and water-supply there had been none before and they were not missed.

It is necessary to view the advantages of industrialism as well as its drawbacks. Commerce, improved agriculture and new facilities for transport, had made the food of the people more plentiful, more varied and, above all, more certain. Manufacturers had given them cheap cotton—a circumstance which, next to water, was likely to do more towards keeping them clean than any other single factor. The truth of the matter is that the great evils which had been present for many hundreds of years were simply accentuated by the Industrial Revolution. There was nothing new about them. They were a legacy from the Middle Ages. It has been pointed out that the reason we hear so much of these distressing circumstances is that the masses were becoming articulate. Previously they had suffered in silence but with leadership they could make themselves heard. The Victorian novelists, too, were to do much to draw attention to the abuses that were current: but to convince ourselves that these things were not new we have only to read some of the novelists of the eighteenth century—for example, Tobias Smollett, himself a doctor of medicine, who gives us so graphic a description of the methods of sewage disposal at Edinburgh, of the food supply of London, and of the waters of Bath.

VII. THE HEALTH OF THE PEOPLE[1]

WHEN we come to study the health of the people at the beginning of the nineteenth century we find ourselves seriously handicapped by lack of material. We can find plenty of information about individual institutions, doctors, diseases or cases of sickness, but about the health of the public in general the data are meagre. There are no accurate statistics. In order to make any reliable estimate of the prevailing health conditions it is essential to know the population at any given time, the number of births in each succeeding period, the number and the causes of the deaths and the age of each person at death. None of these can we find accurately.

The London Bills of Mortality, from 1605, were compiled by the parish clerks, who also entered the cause of death which was discovered by official searchers, generally persons ignorant of the elements of medicine. There are also the parish registers, but in these we find many defects. Firstly, there are many omissions, for it is baptisms and burials, not births and deaths that are entered here. Dissenters might not be entered, while Jews and Roman Catholics often had separate cemeteries. In many places, too, the registers were kept with the utmost carelessness. In making up the Bills of Mortality the information was taken from the parish registers, so that the same mistakes occur in both.

The first census in this country was taken in 1801, but

[1] See Buer. *Health, Wealth and Population*, London, 1926, from which much information has been gathered.

through lack of efficient control it was unreliable. Consequently it is only from information obtained later in the century that we can obtain by retrospective computation the best, but by no means accurate, estimate of the population. Much calculation on these important matters had been done in the eighteenth century but, as we have seen, the information on which these calculations were based was inaccurate. This was known and attempts were made to allow for it, but without a true knowledge of the population no very useful results could be obtained.

Meagre and uncertain as is the information we have, we can see certain tendencies which stand out quite clearly: there are movements which occurred on so large a scale that they show obviously through all possible sources of error. First and foremost is the undoubted fact that, while previously the population had not increased very quickly, an enormous increase occurred in the last half of the eighteenth century throughout Europe. If we discount immigration and emigration (which were not on so large a scale as to affect the general conclusion), this can have arisen only from one of two sources (or, of course, from both); either an increased birth-rate or a decreased death-rate.

It has been often assumed that the birth-rate rose rapidly, but there is really very little good evidence for this. If we assume, however, that the population increased because of a diminished death-rate, we can point to many very good reasons for this. We can show the disappearance of a number of adverse factors which had combined to kill off the people in previous times and we can point to the active measures which had been carried out to achieve this disappearance.

In the Middle Ages famine had been a destructive agent. Agriculture was primitive and a failure of the crops in one area led to a scarcity of food through lack of efficient transport from other districts. The same factors led furthermore to a lack of variety of foods, especially of fresh food during the winter months. By 1830 improved methods of agriculture and better transport had to a large extent banished the fear of famine from the land.

The other great enemy was pestilence, and if we inquire into the diseases which took a heavy toll of life in previous times we shall find that many of these were decreasing, some of them to vanishing-point. Some diseases may have disappeared of themselves for no very obvious cause, but with others we can point to some excellent reasons.

Leprosy was virtually extinguished and this has been claimed as a triumph for the method of segregating the sick; but the disappearance of leprosy may well have been due to some quite different cause; for the exact method of infection is as yet unknown.

Plague, too, had disappeared from London and, except for occasional epidemics, from Western Europe. The reason for this is by no means clear. Strict quarantine against the dreaded pestilence may have had much to do with it, but other reasons have been advanced. For example, it has been suggested that it was due to the chief carrier of disease, the black rat, having been largely displaced in numbers by the brown rat of Norway whose habits are not so domestic as his black cousin's.

Smallpox was always present in the eighteenth century, attacking principally the very young, killing enormous numbers, particularly of infants, disfiguring and often blinding those it did not kill. No class was exempt: indeed in the previous century it had carried off the Queen of England herself. Smallpox hospitals were founded for the reception of the sick. Purposed inoculation of mild smallpox to guard against a more virulent attack was freely practised. This certainly achieved its effect in making many people immune, but it was a highly dangerous practice[1] and must have helped to keep the disease alive after the coming of vaccination. Jenner's discovery that inoculation with cow-pox (vaccination) instead of with mild smallpox was effective and safe, was announced in 1798 and gave new hope against the scourge. In the years that followed vaccination began to be practised on an increasing scale. The results must have helped materially to swell the population by saving the lives of thousands of infants every year, for the death-rate from smallpox declined throughout Europe.

The chief diseases of London had been malignant, "intermittent and remittent fevers and dysentery",[2] in fact such diseases as would be diminished by proper drainage, and a good water-supply: for hidden in this list, but unrecognized, were the diseases which are now known as malaria and typhus (gaol fever). The latter was not clearly differentiated by the physicians of the period from typhoid fever (enteric) and relapsing fever. Both typhus and relapsing fever are diseases of dirt and starvation and this was fully recognized by some of the observers of this time. As we have seen, Pringle and Lind had shown the way to rid the Army and Navy from typhus fever. John Howard, the great prison-reformer, at great personal risk and with immense energy made a tour of the gaols in England and Wales. The shocking squalor of these pestilential dens is recorded in his famous book.[3] Howard, however, was not merely an observer, for he added to his description many sound hygienic suggestions for remedying

[1] See below, pp. 149, 150, and 241.

[2] Bateman. *Diseases of London*, London, 1819.

[3] Howard. *The State of the Prisons of England and Wales*, Warrington, 1777 onwards.

this deplorable state of affairs. His recommendations have a modern flavour: baths, soap and water, smooth floors, ovens for baking the louse-ridden clothes of the prisoners, segregation of the sick and the provision of the services of doctors. Later these methods, with fumigation, ventilation and lime-washing, were taken up by others and applied, for example, in hospitals. Later still separate wards were reserved for those with infectious fevers. The energetic campaign included eventually the provision of separate fever hospitals in some of the larger towns, and typhus began slowly but surely to decline. Howard's lesson, though successful in the prisons and in other spheres, was rapidly unlearnt in the prisons themselves. In 1812 Neild visited the prisons as Howard had done and found them "relapsing into their former horrid state of privation, filthiness, severity and neglect", so that Neild had to fight Howard's battle anew.

Agues, many of which were undoubtedly malaria, were also rapidly diminishing in many parts of the country, though they were not finally extinguished until much later. The disappearance of these fevers almost always followed the efficient draining of marsh-lands. Such drainage was not, of course, made with this object primarily in view, but rather for the reclaiming of land or the prevention of floods. Whether the dying out of malaria in this country can be attributed entirely to this cause is more than doubtful, for mosquitos capable of conveying malaria are not uncommon in England today; but, historically speaking, we may say that the sequence of events looks temptingly like cause and effect.

In viewing such statistics as there are we find that a large decrease in death-rate seems to have occurred among infants and young children apart from all considerations of infectious fevers, and this has been attributed, with great probability, to better standards of living, healthier dwellings and better medical advice. When we say "healthier dwellings" it must be clearly understood that this is not intended to mean good housing as judged by present-day standards, but that there had been much improvement in the conditions of living. Many medical writers of the early nineteenth century, Bateman[1] and Farr,[2] for example, are almost lyrical about the improvements that had taken place in the health of the metropolis and in the whole of England and Wales. These advances were observed on all sides and were attributed to more hygienic habits, to cleaning and scavenging, to drainage, to greater temperance, to better agriculture and to better medicine.

[1] Bateman. *Diseases of London*, London, 1819.

[2] Section on vital statistics in J. R. McCullough's *A Statistical Account of the British Empire*, 1837.

VIII. Some Common Infectious Diseases

Now that we have outlined briefly just a few of the abject conditions under which the people struggled for life, it will not be surprising to find that the towns were very hotbeds of infectious disease. "Low" or "putrid" fevers were hardly ever absent from the worst of these Augean stables. We hear much more of epidemic infectious disease than of other kinds for an obvious reason. A sudden attack of a pestilence produces a profounder stir among the people than does the toll levied continuously by more insidious diseases. An unexpected outbreak obtrudes itself where the more ordinary of the killing maladies are taken as a matter of course. We tolerate the occurrence of a hundred or more deaths every week on the roads of this country, whereas a similar number on the railways would leave us profoundly shocked.

We hear much of typhus fever throughout England and Ireland, but rather less of the other diseases which carried off so many lives. The reason for this is not far to seek. Typhus was likely to attack the adolescent and adult breadwinner, while smallpox, for example, wrought havoc among infants and young children[1] and was taken more as a matter of course. These contagions must have been readily spread by all the circumstances of squalor and overcrowding which we have mentioned, as well as by the wholesale pawning of clothes and bedding and the migrations in search of work that took place in times of scarcity; but there were other diseases which were carried, above

[1] Creighton. *History of Epidemics in Britain*, Cambridge, 1894, Vol. II, p. 571.

everything, by the water-supplies which, as we have mentioned, were frequently contaminated with sewage.

It is often difficult to say exactly what disease was meant when a patient was said to have died of "fever". Relapsing fever and typhus fever undoubtedly accounted for a large proportion of such deaths. Enteric fever certainly existed, but these diseases were not satisfactorily separated until Sir William Jenner made "an elaborate analysis of the symptoms" of typhus and enteric fevers in 1849-51.[1]

There was, however, one terrible disease for which a magnificent welcome had been prepared and which, though it may never have been to this country before, was expected with alarm. In the year 1831 the Asiatic cholera, which had been laying waste the continent of Asia for the past dozen years, at length made its dreaded appearance in Europe, where the evils of war helped to propagate the contagion. In Hungary the havoc was fearful. More than a quarter of a million persons took the infection and of these some hundred thousand died. To add to the horror of the situation "a moral pestilence" supervened. It was the lower classes who were singled out to bear the full weight of the disaster. The cause was unknown and there readily entered into the minds of the peasants the delusion that there was a conspiracy of the upper classes to exterminate the hated lower orders. Incontinently the peasants rose in open revolt, "sacked the castles of the nobility and outraged their persons".[2]

In England a rigorous quarantine was instituted and the people waited with anxiety. The pestilence reached Hamburg in October and it was not long before some

[1] Creighton. *History of Epidemics in Britain*, Cambridge, 1894, p. 183 (Sir Wm. Jenner. *Lectures and Essays on Fevers and Diphtheria*, 1849-79, London, 1893).

[2] *Annual Register*, 1831, p. 438.

vessels from Europe evaded the quarantine and the cholera disembarked at Sunderland. The disease quickly slew some two hundred persons but had well-nigh exhausted itself in this district before it spread with undiminished violence to other towns.

Early in January of 1832 the cholera was at Newcastle and on its way to Edinburgh. Scotland began to suffer, and the disease, as is its wont, took its chief toll in regions where dirt and depression most prevailed. Glasgow acted promptly by providing a cholera hospital, by closing the theatres and places of public entertainment and by discouraging shipping.[1] Neglect of sanitation, however, brought its own reward. The disease appeared with explosive violence in the pauper infirmary and, before the epidemic waned, Glasgow had lost more than three thousand souls.[2]

London was attacked in February and Parliament hurriedly conferred large powers on the Privy Council to make arrangements against the danger. The *Annual Register* states that " the alarm was infinitely greater than the danger " and, indeed, it is true that this country suffered less, proportionately, than France or Hungary; but, nevertheless, the total deaths amounted to 21,882 in England and Wales; 20,070 in Ireland and 9,592 in Scotland.

The importance of this epidemic, which was the first of a series of visitations, lies not in the actual mortality which it caused but in the psychological effect which it produced on the rulers and the people, to say nothing of the medical profession. There does not seem to be very much doubt that it was the mortal fear of the cholera which was largely responsible for the acceleration of the movement towards the improvement of the towns. The actual mode of

[1] Creighton, *op. cit.*, Vol. II, p. 808. [2] ibid., p. 813.

propagation was not discovered until much later, but it was generally agreed that, whatever the primary cause of the disease, it had been abundantly shown that squalor was its meat and drink.

It is well to bear in mind this agreement among doctors. It has been said that "the cholera left medical men as it found them—confirmed in the most opposite opinions, or in total ignorance as to its nature, its cure, and the cause of its origin, if endemic—of the mode of its transmission if it were infectious."[1] This is not altogether a just observation. As Farr pointed out later,[2] the matter had been taken up energetically by the Board of Health, the disease had been excellently described, the pathology studied, a variety of remedies had been tested and hospitals had been provided. True the origin, the cure, or the mode of propagation were yet unknown, but the cholera did not leave medical men as it had found them. The attention of thinking people was concentrated on the state of the towns, for here was an obvious and *removable* cause of disease.

This was a time of intense political agitation, so that it was fortunate that the "moral pestilence" that had overtaken the people of Hungary, and also indeed of Paris, did not rouse the people of England to riot or murder. It may be mentioned that the so-called cholera riots, trivial affairs at Paisley and at Manchester, arose more from the idea which the populace entertained that the bodies of their relations dead of the cholera had been transferred to the dissecting-table.

Influenza is a disease which is regrettably prevalent today. It has visited this country in epidemic form for as long as we can trace it back. When we follow it into the eighteenth century it becomes inextricably mixed up with

[1] *Annual Register*, 1832.

[2] *Report on the Cholera Epidemic of* 1866 *in England*, London, 1868.

the various agues and other fevers which were not then sufficiently well distinguished from one another. In the nineteenth century we find influenza occurring in 1803, in 1831 and again in 1833 following the first outbreak of cholera. The influenza of 1833 seems to have claimed many deaths among the rich and, in this respect, it differed from the cholera of the preceding year.[1] One observer stated that he had heard of "no less than nine lords or ladies who had been carried off by it or through its indirect agency in the course of the last week".[2] The monthly bills of mortality rose suddenly to double their previous total, but they sank again fairly soon.

The epidemic of 1833 seems to have been very widespread indeed, and there was no place or class exempt. A doctor is reported to have given utterance to the following observations: "I have not a moment to spare. In the very thick of my best harvest. Best thing I ever had: quite a Godsend: everybody ill, nobody dies—so the recoveries are all cures you know".[3]

The doctors did not at first realize the seriousness of the disease. When they did so we find them eagerly discussing the pathology and treatment, without, however, coming to much agreement even about the advisability of blood-letting. The consensus of opinion was against the belief that influenza was contagious. They declared it to be no more so than the last year's cholera. The rapidity of the spread and the way in which it jumped from one part of the country to another were against the contagion theory. Evidently at this time contagion was very much out of vogue.

That this disease was not at first considered serious may have been due to an effect on statistics which is now known

[1] Creighton, *op. cit.*, Cambridge, 1894, II, p. 380.

[2] *Lancet*, 1832-3, II, p. 145. [3] *Lancet*, 1832-3, II, p. 125.

to be highly characteristic of influenza. This illness kills directly only a proportion of its true victims. For example, attacks occur frequently among persons of middle age who are suffering from consumption, asthma or some other respiratory disease, or among the aged who also have a lowered resistance to infection. The result is that many deaths are recorded as being due to some other cause than influenza, although they might not have occurred if this disease had not been contracted on the top of the other ailments. The consequence of this is that an epidemic of influenza sends up the figures of the "deaths from all causes" out of proportion to the deaths from the disease itself.

Measles has been present in this country ever since it was first properly distinguished from other eruptive diseases. Deaths from measles were comparatively rare in the eighteenth century, but for some reason the mortality had been steadily increasing at the close of the century and continued to do so throughout the nineteenth. Both measles and whooping-cough were gradually becoming more and more important causes of death. Smallpox was declining. This is to be accounted for, partially at least, by the increasing numbers of children who were being inoculated with cow-pox according to the teaching of Jenner. Measles generally attacks later in life than smallpox. Weakly children are likely to die. If they are prevented from dying from smallpox then they will die of measles or of something else later on. The mortality of diseases other than smallpox therefore rises.

Scarlet fever came also in epidemics during the eighteenth and nineteenth centuries, though it is difficult always to be sure whether an account of a "throat distemper" refers to this or to some other disease. Diphtheria became common quite suddenly, as late as 1858.

Diphtheria is another kind of "throat distemper", but there is no rash. It was suggested that this was quite a new disease: but it is pretty certain that it had existed before and was not generally distinguished from other serious kinds of sore throat.

These are the very brief histories of a number of common infectious diseases which attacked our forefathers. Of these, smallpox is not now very common in England, while typhus and relapsing fever are virtually extinguished, at least in their epidemic forms. Many of these diseases are still with us. Our list has been far from complete, but those who would study further the history of infectious diseases in this country are recommended to Charles Creighton's excellent *History of Epidemics in Britain*,[1] to which the writer is indebted for much of the information contained in the preceding paragraphs.

[1] Cambridge, 1891 and 1894.

IX. The Medical Profession, its Organization and Education

A hundred years ago the medical profession was not organized as it is today. A man could be a physician or a surgeon or he might be a mere quack, and for the general public there was no means of distinguishing one from another. Even today, of course, there is nothing to prevent anyone who likes from practising medicine, but there are disabilities attaching to unregistered practitioners and the public can easily find out who is a registered practitioner and who is not.

In Tudor times attempts had been made to prevent unauthorized persons from practising medicine. In 1511 it was enacted that no one should practise medicine or surgery in London unless he was first examined and approved by appropriate authorities. But this arrangement did not work and the poor became neglected by the surgeons, so that a further act was passed to allow persons with botanical knowledge to attend the sick poor.

From the time of the Renaissance and onwards we find a sharp distinction drawn between the physicians and the surgeons. The physicians were considered to constitute a superior profession. In 1518 they were formed into a college which was to become in 1851 The Royal College of Physicians. Surgery, on the other hand, was a less distinguished trade and was practised by the barber-surgeons, for in the time of Henry VIII the Barbers' Company was united with the Guild of Surgeons to become the United

Barber-Surgeons' Company. This union lasted until 1745 when the surgeons were separated and eventually, in 1800, obtained a charter which incorporated them as the Royal College of Surgeons; to them was entrusted the care of John Hunter's great medical collection.

The two colleges could issue degrees and diplomas, the fees for which paid for the upkeep of the colleges. These were not the only bodies which issued degrees in medicine. Each university as well as the Apothecaries Hall could issue similar qualifications without interference or supervision from any higher authority. In this way there came to be many ports of entry to the medical profession and this strange multiplicity still obtains in England today. It was not until the Medical Act of 1858 that the State began to exercise any real control over the profession.

Just over a hundred years ago the British Medical Association was founded by Sir Charles Hastings at Worcester. This was a private body to which qualified doctors could belong and its object was to be a united and organized body which should represent the profession in this country. Its aims included the advancement both of learning and of the social status, the respectability, of medical men. The Association has done much good work in pressing for reforms in matters of public health and can well claim to represent the opinion of the great majority of general practitioners in the country.

We have seen that there were medical schools in different parts of Europe and that these were generally formed round some eminent teacher. In the eighteenth century these centres of teaching began to expand and to become more numerous. Anatomy was taught at Paris, Berlin, Strasbourg and in Edinburgh, Cambridge and Glasgow. Clinical instruction was more of a novelty.

Professorships of clinical medicine were founded in Edinburgh in 1741.

It was largely at the voluntary hospitals that students in this country gained experience and knowledge while they worked under the great physicians and surgeons of the time. From these beginnings, at Guy's, St. Thomas's and St. Bartholomew's, for examples, have grown up the great medical schools of today. A number of private medical schools which were run for profit by individual teachers constituted another important source of medical education. Among the more famous of these in London were Smellie's school for obstetrics, Cullen's for internal medicine, Black's for chemistry and William Hunter's great school in Windmill Street, where some of the greatest surgeons of their day received instruction in anatomy, surgery and obstetrics. These extra-academic schools were of immense importance elsewhere besides London. It was largely due to these that the Edinburgh medical school attained its great reputation. It is interesting to recall that the most celebrated anatomy school in that town was kept by the notorious Dr. Knox.

There was little specialization in teaching. The leading surgeons of the past were also the teachers of anatomy, which they studied sedulously in such spare time as they could find. We read of Sir Astley Cooper rising at six o'clock to put in an hour or more in his private dissecting-room before starting the day's work. The private teachers who kept their own schools may have been more specialized.

The chief obstacle in the way of teaching anatomy lay in the great difficulty of obtaining corpses or " subjects ", as they are called, for dissection. The law on the matter of obtaining such corpses was not helpful. Under Henry VIII it was granted that the Company of Barbers and

Surgeons should have the bodies of malefactors, and in 1752 it was ordered that the bodies of murderers executed in London and Middlesex "should be conveyed to the hall of the Surgeons' Company to be dissected and anatomized". This was the only legal supply in the early nineteenth century and there was consequently a shortage of subjects, for it was natural that the general public was not prepared to hand over its own bodies to suffer a murderer's fate.

A knowledge of anatomy is obviously essential, and indeed was insisted on by the Corporation of Surgeons for practitioners, who otherwise must experiment blindly on their patients. The result of the inadequacy of the law was that there grew up an illicit traffic in dead bodies, conducted by the notorious body-snatchers or "resurrection-men". This gruesome occupation was in the hands of a few "regular men" although there were many outsiders who plied the same trade. There was plenty of rivalry between different factions of the resurrectionists. There was no kind of ingenuity or artifice to which they did not resort to obtain their prey or injure their rivals. Ordinarily they merely robbed newly filled graves, bribing the custodian if necessary. Sometimes, however, they would pose as relatives of the deceased and lay claim to the body from a hospital or workhouse or even one which was on the dissecting table and had been already paid for, and convey it elsewhere to be sold anew. Brawls in the very graveyards between rival gangs were far from rare.

The price paid for a subject rose at one time from two guineas up to fourteen or even sixteen: and besides this the teachers had to pay the men "opening money" at the beginning of each course to secure a monopoly of their services and a regular supply of bodies, as well as a retaining fee during the vacation and compensation for any man who was unfortunate enough to get a spell of imprisonment. Some of the buyers formed an "Anatomy Club" in an attempt to regulate the prices and limit the extortion: but this was never very successful. Some teachers refused to pay the extra fees and of these men the resurrectionists made an example. A Mr. Joshua Brookes of Great Marlborough Street, was rewarded by having decomposed bodies left on his doorstep and on one occasion was sold a live confederate of the resurrectionists done up in a sack.

As may be well imagined, popular feeling grew to a white-hot pitch of fury. Guards were instituted over recent graves and frequently came into conflict with the body-snatchers, whom they sometimes severely manhandled. The Government was reluctant to act. The need for subjects was imperative, but the popular outcry made it probable that any attempt at legislation might be fatal to the intended object.

Both the private teachers and the surgeons were hand in glove with the resurrection-men. Sometimes a surgeon would specially commission one of these miscreants to obtain for him the body of one of his patients who had been subjected to some interesting operation or who had suffered from some disease which made a post-mortem examination desirable. When giving evidence before the Select Committee on Anatomy (at which also some of the snatchers themselves were anonymous witnesses), Sir Astley Cooper said: "The law does not prevent our obtaining the body of an individual if we think proper: for there is no person, let his situation in life be what it may, whom, if I were disposed to dissect, I could not obtain. . . . The law only enhances the price and does not prevent the exhumation".

Some enlightened people saw the necessity for dissection and saw too how unwise it was to drive all the would-be doctors to Continental universities to learn anatomy. Jeremy Bentham went so far as to set the example of leaving his own body to be dissected. When he died in 1832 this was done by a friend in accordance with his instructions and his skeleton is still preserved in University College, London.

It was not until this same year, four years after the Select Committee had presented its report, that the Anatomy Act was passed. This was undoubtedly expedited by the still greater public feeling which was aroused when it came to light that certain malefactors, Bishop and Williams in London, and Burke and Hare in Edinburgh, had resorted to cold-blooded murder with the object of selling bodies for anatomy.

The Act abolished the dissection of the bodies of murderers, thereby removing the stigma attaching to being dissected. It provided that properly qualified practitioners, teachers and students should be given licences to practise dissection. It insisted upon proper death certificates and a decent burial afterwards. It allowed executors or any persons having lawful possession of a body to give it up provided no relative objected. The Act was successful, for it secured a reasonable number of bodies and it also put the resurrectionists out of business.

X. On the Sources of Modern Scientific Medicine

It is often assumed that scientific medicine is a quite recent development. In some respects this may be true. The remarkable discoveries of X-rays and radium, for example, are nowhere foreshadowed in the works of scientists of a hundred years before. On the other hand, if we review the situation critically, we find that many of the much vaunted triumphs of modern medicine are little more than the logical outcome of the work of the great men of the eighteenth century. There is not the least doubt that the foundations of almost the whole of the medical methods of today were well and truly laid more than a century ago. Let us take but a few instances.

Our present-day methods of immunization against disease follow directly on the " inoculation " against small-pox and Jenner's introduction of vaccination. Our vitamin therapy and other dietetic successes are developments from the ideas put forward by the eighteenth-century physicians on the great value of variety in food, on the evils of the abuse of alcohol and on the undoubted fact that scurvy can be abolished by the proper use of fresh vegetable food.

The " modern " methods of studying epidemics follow on the teaching of the great observers of the past. Sydenham, Huxham, Mead, Fothergill and a host of others have left us the most valuable descriptions of the signs and symptoms of individual diseases. They have shown the supreme importance of accurate *observation*. Apart from immunization our control of infectious disease is based mainly on the isolation of the sick, on disinfection and on notification of diseased persons. Every one of these ideas was applied as long ago as 1720 by Dr. Richard Mead in his proposals for controlling the plague. Long before the danger of mosquito bites or of the common louse was proved Howard had shown that cleanliness could bring health to the gaols, while drainage had banished agues from the land.

Our institutions for treatment all had their conception in the hospitals and dispensaries of the eighteenth century. There were medical schools and there were specialized institutions for different diseases. Industrial welfare, too, was being studied and attention was drawn to the great evils of unwholesome conditions of work, of child labour, and of the immensely long hours of employment.

These statements are not made with any intent to belittle the achievements of the past century, but rather to give honour to the more remote past, and to counteract the widely current conception that before the days of Virchow, Pasteur and Lister, medicine was necessarily less "scientific" than it is today. Any tendency to pat ourselves on the back should at least be corrected by pointing out how little there is that is new in modern thought. We have a million new *facts*, it is true: but how many men have contributed new *ideas?* In the following pages an attempt is made to survey the main lines of advance during the past hundred years and to describe the work of the leading medical thinkers of the time.

PART II

SCIENTIFIC DISCOVERY IN THE LAST HUNDRED YEARS

I. The New Pathology

During the last century there occurred a fundamental change of outlook, which has coloured the whole of medical thought ever since. The decisive factor was the discovery of the animal cell, which led to the conception of the living body as a vast organization consisting of millions of tiny individual cells. It is difficult to give any adequate idea of the tremendously far-reaching results of this or of the immensely fertile field which it was to lay open to medical science. Suffice it for the moment, before we go on to describe the development of the Cell Theory, that every doctor of today thinks of health and disease ultimately in terms of these cells.

In 1665 the initial discovery had been made by Robert Hooke, who found that if he cut a sufficiently thin slice of cork, then he could see under the microscope that the whole substance of the cork was made up of little bladders of air with little wooden walls separating them from one another. The same was found to be true of green plants except that, as the great botanist Robert Brown showed more than a hundred and fifty years later, each little cell contained an essential structure called the "nucleus". Incidentally Brown was also the discoverer of the important fact that the pollen of the plant played the part of the male element in the process of fertilization.

Germany, however, was to have the distinction of elaborating the new biological theory. Mattias Jacob Schleiden of Hamburg, turned his attention to the development of the cells in growing plants. He conclusively showed[1] that every part of a plant is made of groups of cells and that the nucleus was the controlling influence inside each cell. Furthermore he believed that every part was developed from one or another group of cells.

Stimulated by these discoveries in the vegetable kingdom, Theodor Schwann began to look for cells in animal tissues: and he found them everywhere. He had received a sound biological training in the laboratories of Johannes Müller at Bonn and Berlin and was already an experienced scientist when he began his study of the microscopical appearances of animal matter. Among other achievements he had disproved the theory of spontaneous generation which held that life might arise *de novo* from dead materials under suitable circumstances.

The stronghold of the supporters of that idea was the proved appearance of small organisms in material which was undergoing fermentation or putrefaction. Schwann was able to show that these processes were in fact the *effect* of the growth of the organisms and not by any means the *cause.* This will be seen to be of great significance when we come to discuss the work of Pasteur.

Schwann proved that both vegetable and animal tissues are all composed of and developed from cells. The cells of each individual tissue are all alike. Different tissues have different kinds of cell, but any cell of a given tissue is like all the rest in the same tissue. He showed, too, that the ovum, the "seed" from which all plant and animal life developed, was itself a cell. He noticed also that the cells had some kind of internal substance besides the nucleus and pointed out the movements occurring in this stuff which today we call protoplasm. It is noteworthy

[1] *Beiträge zur Phytogenese.* Müller's Archiv., Berlin, 1838, pp. 137-176.

that Schwann's religious convictions made him secure the approval of the Bishop of Malines[1] before he gave to the world his remarkable work.[2]

It was Rudolf Virchow, the most influential of all Germany's medical thinkers, who applied the discoveries of Hooke, Schleiden and Schwann to the intimate study of disease. Virchow was above all a man of science and he firmly believed that practical medicine must be based only upon the firm structure of applied theoretical medicine, which must in turn rest upon pure scientific physiology and pathology.

In 1839 Virchow arrived on the scene in Berlin just when the tremendous discovery of animal cells had been published from Müller's laboratory and to him it fell to announce the important truth that no cell ever arises except by direct formation from another cell. Life is continuous: *Omnis cellula e cellula.* Before this it had been assumed that in certain circumstances cells could develop from the "organization" of some more homogeneous animal substance, much as foam is formed from soap. This supposition had been found necessary to explain, for instance, how a homogeneous clot in a wound could be converted into a living scar composed of cells. Virchow showed quite definitely that these cells were not formed from the clot but grew out into the clot from the living cells of the surrounding tissues.

Virchow's academic career very nearly came to an untimely end owing to his left-wing political views. An outbreak of relapsing fever in Upper Silesia had called him as a member of a commission to investigate the cause. He quickly saw that famine and unwholesome conditions

[1] Garrison. *Introduction to the History of Medicine*, London and Philadelphia, 1929, p. 456.

[2] *Mikroskopische Untersuchungen über die Übereinstimmung in der Struktur und dem Wachsthum der Tiere und Pflanzen*, Berlin, 1839.

were the precipitating if not the ultimate cause of the pestilence. Accordingly his report, after detailing the villainous conditions which he found, became political rather than medical and, in the storm of indignation which he aroused, Virchow was suspended from his post at Berlin.

Happily he was invited to take up a position at Würzburg where, as professor of pathology, he turned his attention to more purely scientific matters. He worked assiduously for years at the study of the animal cells in disease. He returned later to Berlin and two years afterwards, in 1858, he gave to the world his greatest work.[1] In this he enunciated the doctrine that every diseased tissue consists of cells which arise only as the offspring of pre-existing cells. This may seem to us today suspiciously like a truism. But it was not always so. Indeed the very fact that this truth seems so obvious goes to show how deeply the fundamental idea enters into our mental make-up.

In the eighteenth century Marie François Xavier Bichat, the great French anatomist, began to observe animal tissues under the microscope in an attempt to make some sort of systematic classification. He found, as was to be expected, that certain tissues recurred in different parts of the body. He counted as many as twenty-one distinct types of tissues or " membranes ". He observed only the grosser features of each and that is why he supposed that there were so many.

Disease, he decided, must ultimately be some change in one or more kinds of tissue. Any tissue in any organ might be affected while the other kinds of tissue in the same organ might undergo no change. Indeed this is what so often happens. This conception would account for

[1] *Die Cellularpathologie in ihrer Begründung auf physiologische und pathologische Gewebelehre.*

multiple changes all over the body in some generalized disease. Rickets, for example, affects the same kind of tissue wherever this occurs. The fact that the disease attacks the tissue of the growing parts of bones accounts for the bony deformities which occur in every region of the body.

Bichat had carried pathology one step further than Morgagni. The latter considered *an organ* to be the seat of the disease while the former showed that it was a particular *tissue* that was at fault. Virchow thought, as we all do now, in terms of *cells*. Disease is simply the life of the cell under abnormal conditions which naturally cause abnormal life. In other words, sickness is the reaction of the cell to altered conditions. If the conditions become altogether too anomalous then the cell dies. Speaking prematurely in terms of the germ theory, we might add that the disease is not the germ but the behaviour of the body-cells towards the germ. It takes two to make a quarrel.

Virchow made many individual discoveries extending over a wide field not only in pathology but also in anthropology and archæology; but it is by his cellular pathology that his name will live. Upon this rests the whole edifice of the modern study of disease and its influence extends to every branch of medical thought. It may be a little difficult to point out immediate and direct results, but there is not the least doubt that Virchow's doctrine has been extraordinarily fertile. The microscope has become a necessary part of the equipment of every doctor. In the diagnosis of cancer, of blood disease and of kidney disease, to quote but three examples, the present-day pathologist is looking daily and hourly through the lenses of his microscope to observe the minutest variation from the normal appearances of the cells. Here lies the key not only to diagnosis but to the discovery of the fundamental nature of disease.

Virchow became the Grand Old Man of German medicine. He was to medicine what Liebig was to chemistry, an acute thinker, an oracular figure-head and an influence which is still felt in every corner of the civilized world.

In 1862 he returned to the political stage as a member of the Prussian lower house and later in 1880 of the Reichstag, where he was among the most formidable of the opponents of Bismarck. Municipal affairs also claimed some of the attention of the indefatigable professor and it is largely to him that Berlin owes its excellent water-supply and drainage system. He died in 1902 at the age of eighty-one, but his work is being carried on in every pathological laboratory in the world—a supreme tribute to this remarkable man—while his name survives in the periodical which he founded and which is known to every doctor as Virchow's Archives.[1]

[1] *Virchow's Archiv für pathologische Anatomie und Physiologie.*

II. New Aids to Diagnosis

One of the most striking changes in medical practice which we must now consider is the addition, during the last century, of various scientific weapons, physical and chemical, to the armament of the diagnostician. The important principle underlying all these new inventions is that of accurate measurement which began to replace the mere qualitative observations of the signs and symptoms of disease. Today these methods have increased in number and refinement of technique to such an extent that the average doctor cannot possibly perform all these measurements for himself. In consequence of this special laboratories have sprung up and to these the practitioner can send his patient, or any specimens that he wishes, and can obtain the information he needs from technical experts.

One of the earliest instances of the use of scientific instruments in medical practice was that of the pendulum which Galileo employed to count the frequency of the pulse. The chemist Lavoisier had employed a weighing machine in his experiments on respiration and nutrition.

Attempts had been made before the invention of the modern thermometer to make some sort of estimation of the temperature of the human body. In the seventeenth century Santorio had used a bulb filled with air and opening into a tube. The other end of the tube opened under the surface of some water in a vessel. He placed the bulb inside a person's mouth and the air inside expanded as it became warm and issued in bubbles through the water. By counting these bubbles he could gain some idea of the "hotness" of the person in question. This was an extremely rough-and-ready method but it was not until the researches of the physicists, notably Helmholtz and Sir William Thomson (Lord Kelvin), had improved the thermometer and placed thermometry on a sound basis that much more could be achieved.

Although Boerhaave and others had certainly made some use of the thermometer, it remained for Carl August Wunderlich to show its real value to medicine. He began to collect careful records of the varying temperature of the human body in health and disease. Working at Leipzig he showed that in "fevers" the variations of temperature were an essential feature and indeed the precise nature of the variations formed an important indication of the nature and course of the disease. He published numbers of papers on this subject and followed them up in 1868 with his *Das Verhalten der Eigenwärme in Krankheiten.*[1]

It is certainly due to Wunderlich that the thermometer has become an instrument for the everyday use of the bedside physician. The first instruments began to be used in the hospitals in England about 1866 and their use rapidly became universal. These early thermometers were quite unwieldy, being generally some ten inches long, and the quantity of mercury that they contained so large that five or more minutes were necessary if a reliable reading was to be obtained. Sir Clifford Albutt saw these grave disadvantages and it is to him that we owe the use of the smart and accurate little pocket thermometers which everyone knows so well today.

Physics again came to the help of medicine with a whole series of optical instruments for the examination of various

[1] Leipzig, 1868. English translation: *On the Temperature in Diseases: a Manual of Medical Thermometry.* Translated from the second edition by W. B. Woodman, London, 1871.

parts of the body. The first of these was the ophthalmoscope, the invention of the great German physicist and physiologist, Hermann Ludwig von Helmholtz. He argued that since the eyes of an animal shone by reflected light when the surroundings were dark, then, if a suitable optical system were devised, it would be possible to see into the interior of the living human eye. The problem was to obtain a source of light which would shine directly into the eye without being interrupted by the head of the observer—to find a source of light which was virtually proceeding from the observer's eye. This he solved in 1851 by placing the source of light at the side of the patient's head, and reflecting the light into the eye by means of a concave mirror. This mirror was pierced in the centre by a small hole through which Helmholtz looked, and he was then able to see for the first time the living human retina. There is a considerable knack in adjusting the instrument so that a clear view is obtained and consequently it is worth noting that if Helmholtz had not been quite sure, from purely physical reasoning, that the thing was possible, he might never have persevered with his invention.

With the ophthalmoscope the retina, that is the light sensitive part of the eye, can be studied in health and disease. Much useful information has thus been gained not only in diseases of the eye itself but also in more general ailments. For example, the changes in the retina in diabetes, kidney disease and arteriosclerosis are all quite characteristc and can be readily seen with the ophthalmoscope. Besides this invention Helmholtz made other valuable contributions to the study of eyesight. For example, he worked out in considerable detail the mechanism of binocular vision.

Following the ophthalmoscope came a larger number of scopes of all kinds and varieties. A singing teacher, Manuel Garcia, invented a laryngoscope which, in the capable hands of the physiologist Nepomuk Czermak, became an important instrument for the examination of the larnyx or speech-organ. Later still came instruments for looking into the urethra, the bladder, the gullet, the stomach and the rectum. These, however, had to await the development of the electric light before it became possible to see into these natural cavities which are, of course, dark inside. It was only when it was possible to obtain tiny electric lamps which were small enough and cool enough to be introduced harmlessly into the respective organs that these new instruments became workable. There is no doubt that all these inventions, particularly the cystoscope, with which the interior of the bladder can be examined, have proved of immense value in the diagnosis of disease.

Machines were also devised, from 1881 onwards, for measuring the blood-pressure in the arteries and veins of patients and for recording the pulse-waves in graphic form. These have been very useful for studying the action of the heart in health and sickness as well as for watching the effect of treatment in diseases of the heart or arteries. Sir James Mackenzie (1853-1925) was the greatest exponent of the value of these instruments in the study of heart-disease and for watching the course of the disease and the effect of drugs on the heart.

Another instrument which shows in even more intimate detail the working of the heart is the electro-cardiograph, the invention of Willem Einthoven of Leyden. It was known that the heart-beat was accompanied by electrical changes, but these, being of a very small order, were not easy to measure with the ordinary galvanometers or electrometers. Einthoven therefore set out to make a highly sensitive machine especially for the purpose. He stretched a very fine thread of platinum (or else one of quartz coated with silver) between the poles of a powerful electro-magnet, and at right-angles to the magnetic field. He connected up the two ends of the threads with two pads, soaked in salt solution, which were applied one to each arm or leg of the patient. The magnetic field was turned on and at each heart-beat the fine thread pulsated. Einthoven was able to photograph these pulsations by throwing the shadow of the thread on to a moving photographic dry-plate. In this way he obtained graphic representations of the electrical changes accompanying the heart-beat. These, which he called electro-cardiograms, have been carefully analysed and used to study the different kinds of heart disease. They are invaluable in the diagnosis of such conditions as heart-block, auricular fibrillation, valvular disease and other morbid affections. The electro-cardiogram, too, shows up the improvements in the heart-beat under the influence of such drugs as digitalis, which is used extensively in certain kinds of heart disease.

Laboratory science has brought other great changes in medical practice. During the nineteenth century the science of chemistry as well as that of physics began to be the servant of the diagnostician. The first important contribution to chemical diagnosis was the discovery of Bouchardat and Peligot[1] that the sweet substance in diabetic urine was identical with grape-sugar (glucose or dextrose). Suitable chemical tests for such sugar were then devised. In 1848 Hermann von Fehling devised his famous method of testing for and estimating the quantity of sugar in urine by means of the alkaline copper solution that bears his name today.

[1] F. H. Garrison, *op. cit.*, p. 474.

From that time onwards scores of chemical tests were invented to detect the presence of abnormal substances or of normal ones present in abnormal amounts. Later these methods were greatly refined and made exceedingly delicate. For example, Rothera's test for aceto-acetic acid is sensitive to one part of the acid in one hundred thousand parts of solution. A new technique was invented to apply these tests to the chemical analysis of blood. Since it was clearly important to use blood in very small quantities, the methods were made even more sensitive yet. The delicacy of some of these estimations will be better appreciated when it is stated, for example, that a quantitative test is able to measure the amount of uric acid in one-fifth of a cubic centimetre of blood, which means that the actual weight of the uric acid in the test-tube may be less than the one hundred thousandth part of a gramme.

These chemical reactions are of very great service in the diagnosis of disease. They are also valuable in that they enable the clinician to obtain an accurate impression of the course of the disease. For example, in diabetes the physician will regulate the diet and dosage of insulin for the patient very largely by means of laboratory tests on urine and blood. Similarly he can gain much information about the efficiency of the patient's kidneys or liver by appropriate chemical means.

It is impossible to describe all of the large number of these tests which have recently developed in response to the demands of the clinician. Valuable as such investigations undoubtedly are for the advancement of knowledge, it may well be that the complication of laboratory methods tends to obscure the outlook for the practitioner, who may come to rely too much on the technical abilities of the chemical expert. It is a mistake to think that a huge laboratory staff and equipment necessarily make medicine more "scientific".

The physician may only too easily fall into the error of making rule-of-thumb diagnosis from the reports he receives from the chemist. The logical absurdity has been reached in an American automatic machine which gives the patient a diagnosis in return for a coin. He passes urine into the machine, the chemical tests are visibly performed and if the liquid in one vessel turns red he has diabetes, whereas if the second liquid turns white his kidneys are diseased. . . . Invaluable information all for twenty-five cents![1]

Chemistry, then, has an important place in medicine today but we must be careful that it does not usurp the functions of the physician's brain. The laboratory should be the slave and not the master of the consulting-room.

[1] *Lancet*, 1935, I, p. 721.

III. THE COMING OF ANÆSTHETICS

WE have already given some short account of the horrors of surgery in the pre-anæsthetic days, when the operating-theatre must have resembled something between a torture-chamber and a slaughter-house, a sight which was calculated to bring a feeling of revulsion to any but the most callous. It is said that after his first view of an operation, Simpson seriously considered abandoning medicine for legal work.[1]

Before Davy's[2] discovery of the anæsthetic properties of laughing gas, attempts had been made to lighten the burden of pain by means of various drugs. Of these hashish was used, and opium and mandragora, "the drowsy syrups" of the East, had been employed with some success but with no little danger. Alcohol, too, was used freely by some of the Western surgeons, while in some instances they had even resorted to the highly dangerous practice of compressing the carotid arteries until unconsciousness supervened—of garotting the patients in fact.

The most successful method of conducting painless surgery was the use of hypnotism. This process was known hundreds of years ago by the Indian Yogis and others, and there is no doubt that many surgical procedures were undertaken after hypnotizing the patients. In Western schools of science the subject seems to have fallen into the hands of mountebanks, who invented a whole jargon of pseudo-science with which they surrounded the

[1] H. Laing Gordon. *Sir James Young Simpson*, London, 1897, p. 91.

[2] See above, p. 29.

mysteries of "mesmerism" so that even the very existence of such phenomena became discredited. John Elliotson,[1] who made a serious attempt to introduce hypnotism into surgery, was forced to resign his appointments. James Esdaile[2] succeeded in conducting many painless surgical operations on Hindus but, unfortunately, found that Europeans were not so susceptible to his hypnotic influence. His results were received by the medical journals with incredulity and a black stream of abuse which stigmatized mesmerism as an odious fraud. Here was a typical example in medical history of the way in which the strength of the reputations of the pundits was able to discredit not only opinions but very facts. It must be admitted, however, that Esdaile may have weakened his case by exaggerating his claims.

Thirty years after Davy's discovery, Michael Faraday showed that ether could produce much the same effect as Davy's gas. Again, however, the seed fell on barren soil and the idea failed to take root. The miraculous properties of ether were relegated to the use of pleasure parties who inhaled the vapour for its exhilarating effect.

It was in America that gas and ether were first used to achieve painless surgery. There has been considerable dispute as to who is to be credited with the actual priority in the use of anæsthetic for this purpose, but possibly the earliest instance was the removal of a tumour under ether by Dr. Long of Athens, Georgia, in 1842. It was a dentist, Horace Wells, who called public attention to the use of gas in 1844. While watching the effects of laughing gas demonstrated at a popular lecture, he noticed that one of the subjects of the experiment injured his leg while

[1] Garrison, *op. cit.*, p. 427.

[2] J. Esdaile. *Mesmerism in India*, 1846. Also *The Introduction of Mesmerism (with the Sanction of the Government) into the Public Hospitals of India*, second edition, London, 1856.

under the influence of the vapour and felt no pain. The following day Wells had a tooth drawn from his own head under the influence of the gas and thus inaugurated " a new era in tooth pulling ". Unfortunately, at a public demonstration which he staged the operation was bungled and brought the unfortunate Wells nothing but ridicule.

After this failure, W. T. G. Morton, who was a pupil of Wells, began to look for something stronger than gas and, with considerable courage, to experiment on himself. In this way on September 30th, 1846, after inhaling ether from a handkerchief, " he speedily lost consciousness, and in seven or eight minutes awoke in possession of the greatest discovery that had ever been revealed to suffering humanity ".[1]

He had barely time to recover from the ether when he was visited by a patient with a bad tooth who dreaded the extraction so much that he begged to be mesmerized. Morton administered his handkerchief soaked with ether and wrenched out the aching tooth while the patient remained unconscious. His alarm when the latter remained still as death was speedily dispersed by the restorative effects of a glass of cold water which Morton dashed in his face. The recent sufferer had felt no more pain and would not at first believe that his tooth was indeed drawn.

Shortly afterwards Morton, like Wells, arranged for a demonstration of his discovery, but luckily met with a better reception. At the Massachusetts General Hospital at Boston both the surgeon and his audience were more than sceptical but with Morton as the anæsthetist a tumour was removed with the knife without any vestige of pain. " Gentlemen, this is no humbug " was the verdict of the operating surgeon.

[1] H. Laing Gordon. *Sir James Young Simpson and Chloroform*, London, 1897, p. 99.

At last the new discovery was accepted and the good news spread gradually all over the civilized world. Pain was conquered. There were other advantages too: the new anæsthetic produced a complete relaxation of the muscles, which enabled the surgeon to perform his work with greater ease and certainty. Morton unfortunately became involved in arguments and recriminations about the originality of his discovery and cannot be said to have been responsible for the eventual widespread acceptance of ether as an agent of practical value. James Young Simpson was the man who fought the great battle for anæsthesia against the hostile critics who opposed him with every weapon which prejudice and jealousy could devise.

When Simpson first began to test for himself the value of ether anæsthesia he was still a young man but already famous. In January, 1847, though not yet thirty-six, he had been for nearly seven years the Professor of Midwifery at Edinburgh. He was quick to see that if only it were possible to put a woman under the influence of ether for a prolonged period, then all the pain of child-birth could be controlled. He started his investigations at once and by March, 1847, he was already able to publish a series of records of successful births conducted under ether.

Simpson, however, was by no means satisfied that ether was necessarily the best substance for his purpose, so he set about to look for something better. Night after night, when his busy professional day was finished, at great personal risk, he would inhale the vapours, one after another, of all the likely drugs which he could obtain. Having failed with the likely he had recourse to the rarer and less likely, but for some time without success, until, on November 4th, 1847, the great discovery was made. Chloroform had been invented by von Liebig in 1831, but had remained a chemical curiosity. Professor Miller, Simpson's colleague, tells us of the historic evening when Dr. Simpson "with Drs. Keith and Duncan sat down to their hazardous work in Dr. Simpson's dining-room. It occurred to Dr. Simpson to try a ponderous material which he had formerly set aside on a lumber table and which, on account of its great weight he had hitherto regarded as of no likelihood whatever: that happened to be a small bottle of chloroform. . . . And with each tumbler newly charged, the inhalers resumed their vocation. Immediately an unwonted hilarity seized the party—they became bright-eyed, very happy, and very loquacious—expatiating on the delicious aroma of the new fluid. . . . But suddenly there was talk of sounds being heard like those of cotton mills louder and louder; a moment more then all was quiet—and then crash! On awakening Dr. Simpson's first perception was mental—'This is far stronger and better than ether', he said to himself. His second was to note that he was prostrate on the floor and that among the friends about him there was both confusion and alarm".[1]

Six days later Simpson had already used the new substance in several cases of labour and had convinced himself of the superiority and harmlessness of chloroform. But, alas, chloroform is not entirely innocuous, and a little later, when it was found that deaths could occur from chloroform poisoning, Simpson's adversaries armed themselves with this additional weapon. It must be understood that, important as was the discovery of chloroform as an anæsthetic, Simpson's real claim to the gratitude of posterity lies in the brave fight which he made against the opposition which arose on all sides.

Almost every important medical discovery has been received with ridicule and prejudice, amounting some-

[1] Cited by H. Laing Gordon. *Sir James Young Simpson and Chloroform*, London, 1897, pp. 106, 107.

times to a denial of the basic facts. This is not entirely undesirable, for, were every alleged discovery to be received with open arms, the high road to success would be open to the charlatan who could invent the most sensational results. It is important that the inventor should be made to prove beyond all doubt that his discovery is genuine.

In Simpson's case, however, no one seems to have attempted to deny that the chloroform abolished pain. The opposition was on medical, moral and religious grounds. Firstly, his critics said that the use of chloroform in child-birth certainly resulted in an increased maternal and infantile death-rate, and they prophesied hæmorrhages, convulsions, pneumonia and palsies. Such positive criticism could be refuted by an appeal to the facts, and Simpson's statistics showed that, so far from an increase, the new anæsthetic produced a decrease in the mortality of the mothers and the children. The critics then put forward the astonishing argument that pain itself is beneficial. Here again Simpson was able to show statistically that pain is a potent contributing cause of shock and that shock often leads to death, and he mocked his opponents for the originality of their great discovery that the agony of the operating-theatre was so salutary for its victim.

Simpson went on to point out the perversity of those who had rejected other great inventions such as Jenner's vaccination. But this is a dangerous line of reasoning which makes use of a false syllogism. Every great discovery is repudiated. My discovery is repudiated. Therefore my discovery is a great one. Furthermore, it must be pointed out that it is unhappily the truth that twenty years later Sir James Simpson was himself to be in the forefront of the bitter and discreditable attack on Lister and his antiseptic system.

The religious objections to the new painless delivery were based on selected Biblical quotations and on the general belief that Divine Providence knew its own business and could be relied upon to have chosen the best possible way of managing it without any presumptuous interference from Simpson. The latter showed that he could secure better results than unaided "Nature", but, of course, statistics cannot be the answer to religious convictions. He found counter-quotations from the Bible. He pointed out that "In *sorrow* thou shalt bring forth children" does not mean "In *pain* thou shalt bring forth children", and reminded his opponents that, in the creation of Eve, before removing a rib, "the Lord God caused a deep sleep to fall upon Adam". We cannot here enter into further details about Simpson's great fight, but he won, and today, as all the world knows, the blessings of anæsthesia are being used night and day for the relief of suffering humanity, which owes an incalculable debt of gratitude to this great man.

The new invention was unfortunately found to be not without its own dangers. Deaths began to occur under chloroform, but gradually there developed a careful technique of administration which has very considerably lessened the risk. No general anæsthetic which is fool-proof and perfectly safe has yet been found, and we still hear of regrettable deaths under chloroform; but the proportion of fatal cases is very small indeed compared with the immense number of operations painlessly performed.

To be able to conduct a painless surgical operation upon a patient without previously rendering him unconscious has clear advantages. For one thing the willing co-operation of the patient can be secured and secondly, the small but ever-present risk of sudden death or secondary pneumonia attached to the use of chloroform or ether can be avoided as well as the disagreeable vomiting and nausea which often follow the administration of these two anæsthetics. The earliest method of obtaining so-called "local anæsthesia" was by freezing the part on which it was proposed to operate. For example, a small superficial abscess in a finger can be incised painlessly after freezing the skin over the abscess. Nowadays, this is generally done by spraying liquid ethyl chloride from a fine nozzle. Ethyl chloride is very volatile and consequently it evaporates rapidly and absorbs heat from the skin so quickly that freezing occurs. This method has one very grave drawback in that, when the skin thaws, the patient has to endure the very considerable pain which occurs in any condition of frost-bite.

It was V. K. Anrep who first introduced cocaine as an anæsthetic. This is the active principle obtained from the leaves of the plant *Erythroxylon Coca* which, mixed with clay or ashes, are chewed extensively by the natives of Peru and other South American countries. In moderate doses the leaves produce a sense of calm well-being and happiness and they abolish all sense of hunger by paralysing the sensory nerves in the stomach wall. By injecting a solution of cocaine with a hypodermic syringe (introduced in Europe by F. Rynd in 1845) it was found possible to produce complete absence of feeling in the skin round the injection, and in this way minor surgical operations could be conducted painlessly.

The use of local anæsthetics was extended very much by W. S. Halstead who conducted many brave experiments on himself. He established the method of injecting the anæsthetic into the main trunks of the nerves which supplied the part to be operated on. In this way very large regions of the body can be made quite insensitive. More daring still, J. K. Corning introduced the cocaine into the space surrounding the spinal cord itself.

The use of cocaine has certain drawbacks which have gradually been lessened. For one thing, it is a powerful poison and it is not always easy to prognosticate how dangerous it will be in any given case. An ingenious way of keeping the cocaine localized at the site of injection was devised. To the solution of the anæsthetic is added a minute trace of adrenalin. This substance causes all the little blood-vessels to contract and consequently the circulation through the tissues is impeded, and the cocaine is not so readily washed into the general blood-stream. Thus the anæsthetic effect is prolonged, the effective dose of cocaine can be diminished and the risk of general poisoning minimized.

From 1905 onwards novocaine and other substances have been introduced which are good anæsthetics but far less toxic than cocaine itself. In using spinal anæsthetics there is a very considerable risk that the anæsthetic may spread upwards to the higher parts of the spinal cord, and at a certain level the nerves which control respiration and other vital functions become paralysed and the patient dies. This can be avoided by making the solution of the anæsthetic heavy and taking care to keep the head and neck well above the level of the rest of the body.

Local anæsthetic has proved very useful in many fields of surgery and dentistry. It is very valuable in dealing with operations on the skin, the eye and nose, and it has been used also for major operations with great success. It is often better to employ combined local and general anæsthesia as this greatly diminishes the shock to the patient.

IV. Food: Its Chemistry and Digestion

(a) The Chemists

The scientific study of foodstuffs and of nutrition may be said to have begun in the eighteenth century when the chemist Lavoisier, who perished in the French revolution, first recognized the true nature of combustion. He had proved that " organic " foods contain carbon and hydrogen and that in the process of burning these elements became combined with oxygen from the air to form carbon dioxide and water. He also showed that respiration was a precisely similar phenomenon, and again carbon dioxide and water were the end products. It is true that he wrongly supposed that the process of burning went on in the lungs, but this was shown to be a mistake by Lagrange, who demonstrated that the lungs were simply a mechanism whereby oxygen was taken up by the blood from the air and the products of combustion given up to the air. The actual combustion process went on all over the body and the blood acted as a transport service in bringing up supplies of oxygen and removing the waste products.

It was not possible to make much further progress until the chemists had worked out in detail the essential nature of foodstuffs. The greatest of the nineteenth-century chemists was Justus von Liebig. His most important contributions were three in number.[1] Firstly, he devised and perfected a way of analysing organic matter. The essential groundwork of this method still forms the basis

[1] W. A. Tilden. *Famous Chemists*, London, 1921.

on which all our analyses are made today. Secondly, he invented a number of entirely new substances of which chloral and chloroform are not the least important. Thirdly, Liebig introduced the far-reaching idea of "compound radicals". These, he showed, were special groups of atoms which might undergo many different chemical combinations with other atoms or groups of atoms, but which all through these changes maintained their existence as identical groups. Except for the fact that a radical is never found except in combination with other atoms, we might compare it to a group consisting of several friends who remain fast together throughout the vicissitudes of life, although as a group they frequently join and leave other larger or smaller groups. This conception has had an immense influence on chemical thought ever since.

Liebig paid particular attention to organic compounds, that is to say those obtained from plant or animal products. All these contain carbon. These substances are of very great importance in that they alone can be utilized as food for animals. Having made his great discoveries in pure chemistry, Liebig spent the last thirty years of his life in investigating the processes of life. He recognized the new idea that the heat of the animal body comes from the carefully regulated burning up of food, and accordingly he divided foodstuffs into two classes, those that went to supply energy—the respiratory foods, as he called them, consisting of sugars and fats—and those that went towards building up new tissues and repair of wear and tear—the plastic foods, which are the nitrogen-containing foods or proteins. He saw that all food comes eventually from plants which obtain their carbon from the carbon dioxide in the air and not, as had been previously supposed, from the soil.

All these discoveries Liebig made by clinging to the idea that the processes of life are purely chemical and physical. He would not believe that the processes of fermentation or putrefaction were in any way due to special living organisms and he treated bacteria with derision. Yet, undoubtedly, he really believed in some sort of vital force. Lord Kelvin relates that once he "asked Liebig if he believed that a leaf or a flower could be formed or could grow by chemical forces. He answered, 'I would more readily believe that a book on chemistry or on botany could grow out of dead matter by chemical processes'".[1]

Liebig's tremendous importance lies not only in his own discoveries but in the fact that he pointed out the best methods of studying and of teaching chemistry. In this way his influence flourished long after his death and is still a fruitful inspiration to science. He virtually invented the chemical laboratory as we know it today. His pupils and their successors have made immense strides in every branch of chemistry and in his *Annalen* he founded one of the first and most important of chemical journals.

It had always been considered that there was some essential difference between mineral or non-living chemical compounds and those which were found in animal or vegetable products. These latter were held to be formed by "vital" forces. Hence the former were called inorganic and the latter organic compounds. In 1828 Friedrich Wöhler, a personal friend of Liebig, shattered for ever the distinction between the organic and the inorganic. He was able to prepare artificially the substance known as urea which had previously been found only in animal excreta. For the first time an organic material had been made out of inorganic materials without any "vital" interference. The

[1] Kelvin. *Popular Lectures and Addresses*, London, 1894, p. 464 (cited by Garrison).

two names still remain, but organic chemistry now means simply the chemistry of the carbon compounds, whatever their origin.

This discovery started a whole train of work on the artificial synthesis of substances, which has thrown a flood of light on the essential structure of foodstuffs. Wöhler made one other very significant discovery when he showed that benzoic acid is converted in the animal body into a more complex substance, hippuric acid. This does not sound a particularly startling announcement: but when we recall that before this it had been held that the animal body was incapable of manufacturing the complicated substances it needs and had to receive all such requirements in the shape of food, then we can more readily appreciate the striking nature of Wöhler's discovery. The animal body is able to build up at least some more complex compounds from relatively simple ingredients. The chemical processes of the body can be constructive as well as destructive.

(b) *The Physiologists*

The next phase in the elucidation of the problems of digestion came not from the chemists but from the physiologists, and of these the most important from this point of view was Claude Bernard.[1] He was the son of a Burgundian wine-grower and early in life he worked in a pharmacist's shop at Lyons. Here he was speedily disillusioned about the value of the mixtures prepared for the cure of the customers. There was a famous syrup which seemed to cure everything and for which he was always being asked. Bernard was astonished to discover that the syrup varied very much in composition, in fact it was com-

[1] Michael Foster. *Claude Bernard*, London, 1899.

pounded from all the odds and ends and spoiled drugs of the shop.

Claude Bernard turned his attention to writing plays and his vaudeville comedy "La Rose du Rhône" met with some fair provincial success: but a critic who read his next work, a tragedy, advised him to take up medicine. Thus instead of a great playwright he became one of the most famous physiologists of his day.

Before his time physiology in France was much handicapped by the teaching of the "Vitalists" who held that "the phenomena of living bodies could never be the subject of exact experimental enquiry". Whether this is true or not it is certain that anyone who adopts this attitude in a laboratory will not be likely to progress very far. It is a defeatist and stultifying doctrine to presuppose that the business of physiologist is merely to describe and to make no attempt to explain.

Bernard's teacher, Magendie, made many important discoveries through experimenting: but it has been said that he gave too little attention to the interpretation of his results—that he substituted experimentation for thinking. Bernard's method was far sounder. He would think out a matter thoroughly and then test the conclusions of his rational speculation by experimental appeal to nature.

Bernard's researches into nutrition began with his discovery that if he injected a solution of cane-sugar into the veins of a dog, the sugar reappeared in the urine: but if the sugar had previously been treated with gastric juice (the secretion of the stomach) of the dog, then this did not happen. The inference he drew was that unaltered cane-sugar is useless for nutrition and so was discarded in the urine: but that the stomach juices altered the sugar in some way so that it became suitable. This was the first clue to the now well-known fact that all the more complicated sugary and starchy substances must be broken up by "ferments" in the bowel until they are reduced to the simplest kinds of sugar, and that until this is done sugar cannot be used by the body-tissues.

Claude Bernard's next line of inquiry was to discover what happened to fats in the animal bowel. He noted that fat in the stomach was not changed by the action of the gastric juice, but that as soon as ever the fat reached the point where the pancreas (sweetbread) poured its juices into the intestine, then the fat began to be digested. This was a big step forward, for up till then it had been assumed that digestion took place almost entirely in the stomach itself.

As early as 1833 an American Army surgeon, called Beaumont, had made many valuable observations on the digestive processes of the stomach. This he was enabled to do by a curious accident whereby a gunshot wound had made a permanent hole leading from the abdominal wall into the interior of the stomach of a Canadian half-breed named Alexis St. Martin. Beaumont carefully described the movements of the stomach during digestion and showed that the gastric juice is not manufactured continuously but is poured out only when there is food present. He also showed that the juice contained hydrochloric acid and a highly active milk-clotting ferment. These discoveries are of fundamental importance, as every doctor who has a patient with indigestion well knows. For example it has been shown that gastric indigestion is often associated with an excess or a deficiency of this hydrochloric acid. The doctor is accordingly able to remedy this by giving alkalis or acids as the case may demand.

Bernard then followed up this work by showing that the digestion in the stomach is simply a preliminary phase and that both fat and protein are not fully digested until they encounter the pancreatic secretion. Next he turned his attention to sugars because he was aware that in the chemistry of the sugars lay the key to the cause of diabetes. What happened to the glucose that he injected into the veins of the dog? It must be stored or destroyed somewhere in the body: and surely if this "somewhere" were put out of action the glucose would accumulate in the blood—a condition of diabetes would be established. He discovered that the liver was able to produce glucose and, later, that it could do so because it had a store of some substance which it could turn into glucose. This substance, now called glycogen, is a kind of "animal starch" and is made in the liver from the glucose in the blood; it can be turned back again into glucose when occasion demands.

This discovery was a blow to the well-established theory that each organ had one function. The consequence of this belief had been that once the function of an organ had been discovered there was a tendency to assume that there was nothing more to be found out about it. It had long been known that the function of the liver was to secrete bile: and now Bernard had shown that it had also this "glycogenic" function.

These were by no means the only contributions that Claude Bernard made to physiological knowledge. For example, he discovered that the flow of blood in the arteries is controlled by an elaborately balanced system of nerves of two kinds, the one set constricting and the other dilating the blood-vessels. This has a very important bearing on our present-day physiological outlook. These systems are called into action every moment of our lives. They ensure supplies of blood to our digestive organs after meals, they control the temperature of our skin and through this they regulate that of our entire body and, furthermore, they make sure that our brain is properly supplied with blood at the right pressure whatever posture we assume.

The next steps in the elucidation of the mechanism of digestion were due to Karl von Voit, who developed a method of measuring the total amount of food eaten by an animal while at the same time he also measured the amounts of carbon dioxide and nitrogen given out in the breath and excreta. In this way he was able to calculate how much of each kind of foodstuff (sugar, fat and protein) was actually being burned up to supply the needs of the body.

Max Rubner, a pupil of von Voit, began to investigate these problems from the point of view of the heat-value of the foods (that is to say, how much heat they give out when completely burnt) and of the amount of heat given out by the animal body. A whole host of workers have given their attention to this, and many elaborate and ingenious machines have been invented for measuring the heat given off by an animal. Some of them have been large enough to contain a man. Rubner was able to show that the food burnt up by a resting animal was proportional to the area of the body-surface of the animal.

By these heat-measuring experiments the energy values of the various kinds of food were found. These values are measured in Calories, or units of heat. A Calorie is the amount of heat required to raise a kilogramme of water through one degree Centigrade. It was shown that starches, sugars and other members of the carbohydrate family each provided 4.1 Calories for each gramme of their weight. The nitrogen-containing substances, that is to say the proteins (lean meat and white-of-egg, for example), have about the same heat-value as the carbohydrates. Fats, on the other hand, give as much as 9.3 Calories per gramme.

From all these findings have gradually emerged the true principles of diet. It began to be realized that the total energy put out by the body must be exactly equal to the energy obtained by the combustion of the foodstuffs and tissues in the body *at the same time*. It immediately follows from this that, given the knowledge of how many Calories are necessary for people following various modes of life, we can calculate the exact food requirements for any individual following any definite occupation. It is now pretty generally agreed that the average requirement for an adult is about 3,000 Calories per day, but individuals require more if they are heavy manual workers. In calculating a suitable diet to contain a given number of Calories it is important to bear in mind that there is always a certain amount of wastage. Everything is not digested, especially in vegetables. A purchase of food furnishing 3,400 Calories makes allowance for this and for loss in the preparation of the meals.

It must be understood that quantity is not the only requirement: for, if this were so, two pounds of sugar a day would more than supply enough Calories for anyone but the hardest manual worker. It is obvious that no one could live on such a diet. There must be a balance of foodstuffs with a proper proportion of each of the three main kinds of food. An easily remembered formula for a daily diet, which gives 3,390 Calories, consists of 100 grammes of fat, 100 grammes of protein and 500 grammes of carbohydrate. Today it is generally held that not all the proteins have the same biological value and that most of the animal products are superior to the vegetable. Consequently an assured minimum of first-class animal protein is desirable.

The animal body always contains fat and it might be thought that it was necessary to provide all this in the food.

It appears, however, from the classical experiment of Lawes and Gilbert that fat can be manufactured inside the animal from other kinds of food. They took two pigs from the same litter, ten weeks old and of almost equal weights. The first they killed at once and measured the total fat and nitrogen in its body. The second pig they fed on barley (which contains very little fat). The amount eaten was very carefully measured and analysed, as were also the excreta of the pig. After four months the second pig was also killed and its fat and nitrogen estimated as before. The experimenters then drew up a balance-sheet showing the amount of fat eaten and that present in the pig at the end of the four months. They conclusively proved that at least five kilogrammes of fat must have been manufactured by the pig out of the carbohydrate in the food.

Fat forms a reserve supply of nourishment which can be drawn upon when necessary. It can be manufactured from carbohydrates or can, of course, be obtained directly as fat in the food. In this connection the experiment of Lebedev is very interesting. He took two dogs and, after keeping food from them until they were thin, he fed one on a diet containing much mutton fat, while the other was given food containing linseed oil. Later he killed the two dogs and found that while the fat of the first was solid even when heated to 50 degrees Centigrade, that of the other was still liquid at the freezing-point of water. It seems from this result that the fat is stored in the body without very much alteration. Cows fed on an excess of oilcake produce too soft a butter.

Sugar or carbohydrate is used primarily for the immediate energy requirements of the body. There is a nicely balanced adjustment whereby the blood is kept supplied with the right amount of sugar. If there is too much then the surplus is stored as glycogen or converted into fat. In diabetes the arrangements for dealing with excess of sugar are upset and consequently glucose accumulates in the blood and is eventually passed out in the urine. If there is too little sugar in the blood then the normal processes are reversed, glycogen or fat being re-converted into sugar ready for use as fuel. A feeling of faintness after exertion may often be due to there being too little sugar in the blood, and a timely administration of cane-sugar, or better still glucose, will speedily relieve the symptoms.

Sugar is eaten mainly in the form of starch (in potatoes, bread, peas, beans, etc.), cane-sugar and also in fruits, vegetables and milk. Sugar in one form or another comprises about three-quarters of the weight and half the energy value of all our food. It appears, however, that sugar is necessary to us for other reasons besides its energy value. No man can live long without some sugar. Deprived of it he develops a condition known as *acidosis* (too little alkali in the blood) which is a characteristic in diabetic people. It seems that the presence of sugar is in some way essential for the proper combustion of fats. In its absence the fats are only partially burnt and give rise to poisonous substances. The sugar has been compared to the draught without which the fats burn with a smoky flame. In this lies the crux of diabetes. We cannot say that there is not enough sugar in the diabetic's blood: indeed there is much too much. It may well be that the sugar is not quite the right kind: or perhaps the mechanism for dealing with it has gone wrong. We will refer to this matter again later.[1]

The proteins are required for two purposes: Firstly, the building up of the body tissues, that is to say for

[1] See below, pp. 105, 191 *et seq.*

growth; and secondly, to replace the natural loss of body-substance from wear and tear. The chief sources of proteins are meat, fish, eggs, milk, cereals, and some kinds of vegetables, but the amount which most of us eat greatly exceeds the minimum requirements for healthy life. About two and a half ounces of proteins should be ample for all purposes.

Recent work has shown that it is possible to maintain good health on very low-protein diets and some have maintained that such simple diets are the best. Hindhede[1] lived himself and brought up a family of children on a diet containing only 67 grammes of protein per day, and of these the majority was vegetable. The children became healthy and strong and, be it noted, the (pre-war) cost of the food was about fourpence a day!

Hindhede has worked out a simple standard diet consisting of wholemeal bread, butter, margarine, potatoes and barley, which he asserts can maintain an adult in good health at the cost of sixpence a day! Such a diet would prove exceedingly unpalatable to most people so that he suggests that fruit and vegetables should be added. This diet should be compared with the minimum diet shown in the report of the British Medical Association's Committee on Nutrition. Here the smallest diet for an adult man is stated to cost 5s. 11d. per week, but this includes meat and other expensive items to which the Englishman is accustomed.

During digestion the proteins are all broken up into a number of simpler substances of which there are many different kinds. These are called " amino-acids ". They are absorbed into the blood-stream and later on are built up into the complicated proteins of the living animal tissue.

[1] Mikkel Hindhede. *Gesundheit durch richtige und einfache Ernährung*, Leipzig, 1935.

These animal proteins consist of combinations of the individual amino-acids arranged together in a way which may be quite different from those which obtain in the food proteins. The whole process of digestion, absorption and reconstruction may be compared to the pulling down of a building into its original bricks and then using these to build another building which may be of quite another architectural style and may subserve an entirely different purpose. The amino-acids may also be compared with the letters of the alphabet which are used to form long words which can be rearranged into various anagrams. This is perhaps a better analogy because the number of different "species" of amino-acids is roughly the same as that of the letters of the alphabet.

It further appears that the body can synthesize some of tnese amino-acids but that certain individual amino-acids cannot be so made and consequently are absolutely essential to a proper diet. Hopkins and Wilcock,[1] for example, fed animals on a diet in which the only available protein was zein, which is derived from maize. This contains none of an amino-acid called tryptophane. The animals soon sickened. This showed that not only was tryptophane essential but also the body is incapable of manufacturing it. Osborn and Mendel in 1912 fed a rat for 178 days on a protein called gliadin together with milk from which all the proteins had been removed and to which some carbohydrate and fat was added. It appeared that all the necessary factors for growth were present. Four young rats were then born, and were fed for thirty days on their mother's milk. Then three of the young were put on a normal diet while the fourth was fed on the same food as the mother had received. The three grew up normally while the fourth ailed. From this it appears that a diet

[1] *Journal of Physiology*, 1906, 35, pp. 88-102.

which will keep an adult in good health may be quite inadequate to support a growing infant.

Besides the three main kinds of food there are other essential requirements. The need for water is obvious enough. Water is continuously being lost through the skin and from the lungs and, furthermore, a supply must at all times be available for washing out from the blood all the waste products of the chemical processes of life. Salts, too, are absolutely necessary to replace those lost in the urine and sweat. Certain particular salts must be present to fulfil particular functions. Iron, for example, is needed for the oxygen-carrying part of the blood, while lime-salts are required for the bones and the teeth as well as being necessary for the proper clotting of the blood in a wound. These salts should be obtained in any reasonably well-balanced diet if it is properly cooked.

For the efficient elimination of waste products from the bowel it is very desirable that these should have a large bulk so that the action of the bowel should be stimulated. The food should therefore contain a considerable amount of indigestible material to make up this bulk. Such "roughage" is generally composed of cellulose which is abundantly present in all fruit and vegetables. Without these the bowels will act badly. Pure concentrated food will not do. As one writer has put it, "Refined foods do not lead to refined habits".

Armed with all these and many other facts, the physician faced with a patient suffering from digestive or other troubles is in a strong position to give his advice on the subject of diet. In fever, for example, the patient burns up far more than the normal energy requirements. So far then from "starving a fever" it is important to supply as much food as can be used. We must, however, compromise about this because a sick man has a weakened digestion and an increased diet would not be absorbed. We start off first with a lowered diet and then feed up the patient as soon as ever we think his digestion will stand it.

Another way in which the physician takes advantage of the new knowledge follows directly from Claude Bernard's discovery that some substances were not digested until they reach the pancreatic juice. When it is desired to administer a drug which would unnecessarily irritate the stomach wall if it came into contact with it, or a drug which would be destroyed by the acid juices of the stomach, or again one which the physician does not wish to act on the stomach but on the intestine, then all that it is necessary to do is to enclose the drug in a little capsule made of some substance which is not dissolved until it reaches the juices of the pancreas.

In the case of a drug which is irritant to the stomach it is sometimes possible to combine it chemically with another substance and so form a non-irritant compound which is split up into its original parts only when it reaches the small intestine. Such a drug is salicylic acid which is irritant to the stomach but when combined to form acetyl-salicylic acid (more commonly known as aspirin) acts in the way described above.

Yet another important application of the basic principles of diet is found in diabetes. Here, as we have seen, the doctor is confronted with the problem that there is already too much sugar in the blood, but that also sugar is necessary for the proper utilization of fats. The noxious acids are being formed possibly because the sugar in the blood is of the wrong kind. What is the doctor to do? He must in fact give a diet so balanced that it will produce in the patient the very least possible quantity of those noxious acids. Such diets have been worked out very carefully, but the problem has been much simplified, as we shall see later, by the invention of insulin.

It is clear that there are endless applications of these dietary principles. Infant feeding, for example, has ceased to be a matter of folk-lore. But lack of space forbids us to enlarge upon such matters here. Suffice it to say that upon the experiments and facts which we have outlined is founded every dietary régime that is prescribed today.

V. The Germ Theory

I. INFECTIVE ORGANISMS

(a) Early Conceptions

From the remotest periods of history we find mention of plagues and pestilences and it is scarcely surprising that mankind should have invented many different hypotheses to account for the undoubted fact that many diseases are epidemic. From antiquity to the Middle Ages these hypotheses postulated as the cause of disease factors which varied from cosmic influences (hence " lunacy " and " influenza ") to witchcraft and from the will or vengeance of the gods to the poisoning of wells by the Jews.

The doctrine of contagion is not a new one. The writer of " Leviticus "[1] clearly recognizes this as the method of spread of leprosy and gonorrhœa when he lays down the principle that persons who are suffering from these diseases must be restricted from mixing with their fellows. Thucydides,[2] too, in his description of the plague at Athens, seems to recognize that the disease was conveyed directly from one person to another. More recently in the eighteenth century, the practice of inoculating smallpox from person to person was brought[3] into this country from the East and clearly shows that contagion was recognized as the means of spread of this disease at least.

[1] Leviticus XIII-XV.

[2] Thucydides, II, 47 *et seq.* Jowett's Trans., Oxford, 1900, Vol. I, p. 135.

[3] By Timoni and Pilarini's communications to the Royal Society, 1713-16, and later by Lady Mary Wortley Montagu.

Another theory of epidemics, however, that received wide recognition appears under a variety of forms and names. In general, it assumes that there is an "atmospheric influence" or "epidemic miasma" which may pass over a country and that its progress may be shown by outbreaks in different localities where there is some determining factor or localizing condition, such a condition existing where there are present all the well-known circumstances which make a place unwholesome. In other words, the air is to blame: there is a bad air, a *mal aria*, and from this, of course, comes the name of a disease which, while once common in this country under the heading of ague, is now found chiefly in tropical and sub-tropical lands. This hypothesis of epidemic miasmata is by no means worthless; for, while it shows us no means (other than flight) of avoiding the miasm, it at least teaches that filth is a predisposing cause of disease. It was believed pretty generally until the actual living germs of certain diseases were discovered, although it was fighting a losing battle against the theory of contagion. The latter was forced on medical opinion by certain diseases which were quite obviously contagious, epidemics which swept over Europe —notably the Black Death (probably the bubonic plague) which killed more than sixty million human beings and entered Europe about 1348, after having ravaged Asia and Africa, the wave of syphilis in the fifteenth, smallpox in the eighteenth and cholera in the nineteenth century.

Before the discovery of the living organisms which produced many diseases, attempts at the prevention of such diseases were for the most part unsuccessful. Isolation of the diseased and quarantine for those who had been in contact with such people were the only available methods. There were successes, but more often there were failures. The greatest triumph claimed for the isolation method is the disappearance of leprosy from Western Europe. This disease which was possibly introduced and probably spread by the Crusaders[1] had been so far eradicated in France, Italy, Spain, England, Denmark and Switzerland[2] by the middle of the sixteenth century that we hear little, after this, of the lazar houses of which there had existed in this country more than two hundred[3] in the previous century. It must be added that modern experience in the East has shown that compulsory isolation of lepers leads to endless concealment and consequently is not very effective in preventing the spread of the disease. It must have been even less useful in the past when no hope of cure could be held out for the sufferers. Since the exact mode of transmission is yet uncertain, we cannot fairly assume that the isolation of the infected was the only cause of the disappearance of leprosy from England.

More recently, by the method of muzzling all dogs, the scourge of rabies was abolished in the country: the effect being due not only to the virtual isolation of the dogs by the muzzles but to their further isolation from Continental infection by the fact that we live on an island and have a very strict quarantine for dogs. On the other hand, the quarantine method had conspicuously failed to keep the plague from Venice in the fourteenth century and, in the light of our present knowledge of the means of communication of this disease, this cannot be considered altogether astonishing.

There is no doubt that in the instance of more than one disease, the method of propagation of the contagion and the means of prevention had been well understood many years before the actual microbes were known.

[1] Garrison, *op. cit.* p. 187. [2] ibid., p. 240.

[3] ibid., p. 179. Also P. H. Denifle. *La désolation des églises, monastères et hôpitaux pendant la guerre de cent ans*, Paris, 1897.

A conspicuous example of this type is found in the death-dealing spectre of the lying-in chamber, puerperal fever. As early as 1795, Dr. Gordon of Aberdeen had shown that this latter disease " seized such women only as were visited or delivered by a practitioner, or taken care of by nurses who had previously attended patients affected with the disease ".[1] He gave tables to show that this was not an assertion but a fact admitting of demonstration and added that it was a disagreeable declaration for him to make that he himself was the means of carrying the infection to a great number of women.

The same subject was taken up in 1843 by Oliver Wendell Holmes of Boston: but the opposition he aroused from his pig-headed American colleagues was incredible. They argued that the transmission of the disease by themselves was very improbable, that a doctor who had a series of cases consecutively of puerperal fever was merely " unlucky ". Holmes, however, taking into account the total incidence of the disease compared with the total number of births " had the chances calculated that a given practitioner A shall have sixteen fatal cases in a month " and declared that " there was not one chance in a million million millions that such a series should be noted . . . chance, therefore, is out of the question as an explanation of the admitted coincidence ".[2] The fact was that medical men naturally found it extremely inconvenient to admit that so many women had died from the poison conveyed to them by the doctors themselves. Holmes added that " the facts shall reach the public ear: the pestilence carrier of the lying-in chamber must look to God for pardon, for man will never forgive him ",[3] and went on to

[1] O. W. Holmes. *Medical Essays, 1842-82*, London, 1891, p. 134.

[2] ibid., p. 114.

[3] ibid., p. 128.

point the way to remedy this deplorable state of affairs. He advocated that no doctor should attend a woman in child-birth if he had recently had a patient with puerperal fever, or if he had attended post-mortem examinations. He extended these recommendations to include the nurses and advised ablutions and change of clothes both for them and for the physicians.

Elsewhere the discovery was made again, but Ignaz Semmelweiss saw more deeply than the others. Working in the Allgemeines Krankenhaus in Vienna he noticed that the mortality from puerperal fever in the first ward greatly exceeded that in the second. The first ward was used for the instruction of students, unwashed from the dissecting-room, the second for the cleaner midwives. It was not, however, until in 1847, as he watched the post-mortem on the body of one of his colleagues who had died from a blood-poisoning contracted from a dissecting-wound, that the light suddenly dawned. The appearances in the body were the same, the very same as those in the dead mothers from the first ward. Puerperal fever was a form of blood-poisoning and the cause came from the dead-infective material brought in by the students. Here was the greatest piece of good fortune; for, where all had been doubt ("only the great number of the dead was an undoubted reality")[1] he had shown the clear truth and, by insisting on cleanliness and rinsing the hands in a solution of chloride of lime, he quickly reduced the mortality by more than six per cent. Again the truth was unwelcome: but he put up a vigorous fight for his remarkable discovery. He was ridiculed and his opinions conspued; but his memorable book[2] remains to show the lasting debt of gratitude which every mother owes to Semmelweiss, who

[1] Quoted by Sir Rickman John Godlee. *Lord Lister*, London, 1917, p. 138.

[2] Semmelweiss. *Die Ætiologie, der Begriff und die Prophylaxis des Kindbettfiebers*, Budapest, Vienna and Leipzig, 1861.

died in 1865 embittered and insane. The case was proved, but it was not until the teaching of Lister had spread that the principles of cleanliness and antisepsis were widely applied to save the lives of women in child-birth.

(b) The Discovery of Bacteria

The discoveries of Gordon, Holmes and Semmelweiss had been made years before the actual streptococcus which causes the disease had been demonstrated. Many micro-organisms had long been known, but it was left to a chemist, Louis Pasteur, to point to some of these as the true and only causes of certain diseases. Pasteur did not "discover" germs in the sense that he first saw any microbes through his microscope. In the latter half of the seventeenth century the great Dutch microscope-maker, van Leeuwenhoek, had described a variety of such minute organisms. Bacteria, in fact, are found almost everywhere on the earth in enormous numbers and countless species. Fortunately, only a very few species are capable of producing diseases in human beings. Pasteur's researches led him to the discovery that putrefaction is a kind of fermentation, that both these processes are due to micro-organisms and that putrescible material (such as blood, for example) can be kept indefinitely if care is taken to ensure the absence of all living micro-organisms. These are, in fact, absolutely necessary to, and the cause of, putrefaction.

First of all, he began by trying to find what turns milk sour. He pointed to the little globules seen down the microscope, living globules that budded and multiplied, so that just a trace of these globules could sour the milk. Alcoholic fermentation he showed to be due also to self-reproducing globules, but these were different globules from the others: they could produce alcohol from sugar, but they could not turn the milk sour. Each fermentation had its own kind of organism and each organism its own kind of fermentation. This is the important principle of *specificity*.

Pasteur showed that these ferments came from the atmosphere and multiplied in the putrefying or fermenting liquids; they were present in very different numbers in different places; they swarmed in towns and rooms but were scarce in the high mountain air. He showed also that by heat, by passing the air along narrow curly tubes, or by filtering the air through plugs of cotton wool, the germs could be prevented from reaching any vessel although the air itself passed freely in and out.

In the agent which produces butyric acid, that causes the smell of rancid butter, he found an astonishing state of affairs. Here was an organism which will only grow in the absence of air, or rather, of oxygen. This was the first germ of this kind discovered, the first of the *anaërobic* bacteria, as he called them.

All these fermentative changes he showed were due to these *living* microscopic beings and to them alone. The opposition which this idea roused was so enormous as to seem almost incredible to us now, but Pasteur had against him the full crushing weight of the terrific Baron von Liebig, the leading chemist of his day. Liebig's dicta were looked up to by an enormous following but since, while denying Pasteur's ideas, he absolutely refused to look through a microscope,[1] the matter could not very well be argued to a conclusion. This kind of attempt to stultify his activities seems to have occurred more than once to Pasteur. He spent much time in proving his point about the ferments against Liebig's belief that fermentation and

[1] Garrison, *op. cit.*, p. 473.

putrefaction were processes akin to slow chemical combustion and that the dead portion of the yeast alone was responsible for the production of alcohol; but he spent even more over his celebrated controversy with Pouchet over the "spontaneous generation" of life. Were the germs the cause or the effect of fermentation? After a bitter fight in which his experimental proofs were answered with flowers of oratory and his arguments with rhetoric, he eventually, in 1862, succeeded in convincing the Academy of Sciences at Paris that "spontaneous generation is a chimæra" and that all life comes from life and from life alone. Pasteur had a negative point to prove and that is not easy; but he convinced them all.

The wine industry in France was losing huge quantities of wine every year from a wine disease of unknown origin when Pasteur, whose every investigation seems to have been crowned with success, turned his discerning mind to the matter. As he had surmised, the disease of wine was due to an organized ferment, and he showed that by heating the wine for a short time to a temperature of between fifty and sixty degrees Centigrade, the ferment could be destroyed while the wine remained unaltered and would keep indefinitely. The wine, as we say, had been "pasteurized".

The wine industry was not alone in receiving the attentions of Pasteur. He saved this industry untold loss; but by showing how to breed silkworms which should be free of the two scourges *pébrine* and *flacherie* which had brought the silk industry almost to a standstill, he earned also the undying gratitude of all those engaged in the production of silk. Beer, too, claimed a portion of his studies and he was able to demonstrate that the quality of every brew was determined by the nature of the micro-organisms present.

As early as 1863 we find him saying to the Emperor, to whom he had been presented by the great French chemist, Dumas, that his "ambition was to arrive at the knowledge of putrid and contagious disease". He turned from diseases of wines, through diseases of silkworms, to diseases of mankind.

Before Pasteur there were isolated discoveries of microscopic beings which caused disease. The little rod-like organisms in the blood of animals dead of anthrax had been seen as early as 1838, but it was not until Davaine was acquainted with the work of Pasteur on fermentation that he began to inoculate rabbits with these organisms and to reproduce the disease. In 1839 Schönlein had discovered the fungus which produces the skin disease known as *favus*: but it was Pasteur and his pupils who put the germ theory of disease upon a sound footing and the whole structure of the science of bacteriology is built directly upon his work.

To a German, Robert Koch, we owe the beginnings of modern bacteriological technique. He it was who first laid bare the natural history, the life story, of the anthrax bacillus and showed the method of growing the bacillus, of obtaining it unmixed with other organisms, that is, of obtaining organisms in "pure culture". Also he cunningly grew organisms on gelatinous surfaces so that each kind of germ grew in a separate colony on a *solid* surface and he could choose whichever he liked. From these first discoveries an enormously complicated technique has grown up, which enables the bacteriologist to separate and identify the different disease-producing agents. But even today the subject is far from being a complete and orderly one and this is largely due, as has been pointed out, to the fact that bacteriology has been an *applied* science and that "investigators have been more interested in what bacteria do than what they are, and much more interested in the ways in which they interfere with man's health or pursuits than in the ways in which they function as autonomous living beings ".[1] The general natural history of germs has been neglected for the study of the specialized behaviour of a few species.

Pasteur, then, had shown how to cultivate germs in his liquid media which he prepared synthetically in the laboratory; he had realized that different bacteria needed media which differed not only in the varying quality of the nutrient material, but also in the amount of oxygen or the degree of acidity. He had grown an organism in a tube and then sown one drop of the liquid into another tube, waited, then sown one drop from this into a third tube and so on for many generations of tubes, so that any extraneous, non-living substances which might have been present in the first tube were inconceivably dilute in the last tube, but the organisms were alive, reproduced themselves and were as numerous and had the same disease-producing properties in the last as in the first tube. It was the organisms and they alone which produced the disease.

Koch had shown how to grow the organisms on solid media. He showed also that different organisms took up different dyes from a solution, so that they could be distinguished one from another by observing what colour they took on when dyed with different chemicals.

Following the work of these two leaders came the discovery of a large number of the bacteria responsible for many different diseases. Some were discovered by the masters, and more by the pupils. Before the close of the nineteenth century there had been discovered the causative organisms of leprosy, gonorrhœa, suppuration, typhoid,

[1] Topley and Wilson. *The Principles of Bacteriology and Immunity*, London, 1929, p. 1.

malaria, tuberculosis, cholera, diphtheria, pneumonia, cerebro-spinal meningitis, Malta fever, tetanus (lock-jaw), plague, botulism and dysentery; while more recently, in the present century, observers have found the organisms of sleeping-sickness, syphilis, whooping-cough, infective jaundice and scarlet fever. This list is far from complete and there are numbers of organisms which are almost certainly the cause of different diseases, but the absolute proof is sometimes lacking. Until it can be shown that the organism is always present in every case of the disease, that it can be cultivated through several generations and that the last generations can reproduce the disease with certainty, it cannot be asserted that this organism is the cause of the disease beyond any shadow of doubt.

The bacteriologists have invented a large number of clever expedients for studying germs and for distinguishing one kind from others. The first method is an obvious one: to see what the organism looks like, or, as they prefer to say, to study its morphology. The germs are of different sizes and shapes, they may have granules in them, they may be surrounded with a kind of capsule, they may have one or more little thread-like appendages called flagellæ, or they may be grouped together in certain definite formations such as clumps or long chains. Furthermore, a large group or "colony" of bacteria which is large enough to be seen with the naked eye, has characteristics which often vary according to the species of the bacteria. The colonies are of different colours, different sizes, different shapes and have different surface texture. Certain bacteria, when stained with certain aniline dyes and then washed in a solution of iodine, are easily decolorized by washing again in alcohol; other kinds of bacteria retain their colour under this process. There are some kinds which remain coloured when acted upon by strong mineral acids. By these and other microchemical means many bacteria can be distinguished from one another, although at first sight they may seem very much alike.

Other methods depend upon the behaviour of growing cultures of the bacteria. Some will liquefy gelatin, others not; some can set free the red blood-pigment of mammals from the containing corpuscles, while others are unable to do this; some can ferment different kinds of sugar with the production of carbonic-acid gas, some can ferment them without the production of gas, whilst others cannot alter the sugars at all. There are some bacteria that need oxygen for their growth, some can do without it, while others still cannot grow at all except in the complete absence of free oxygen. These are but a few of the main contrivances of which there are a great number. There are many more delicate biological tests, too, but these we must leave until we have described the chief phenomena of immunity from disease.

It began to be assumed, then, that every infectious disease had its own particular organism which caused this disease alone; but it may be that the matter is not quite as simple as this. For example, the pneumococcus, though quite the commonest and most important, is by no means the only cause of pneumonia. As an antithesis to this we may consider whether one species of bacteria can cause more than one disease. There seems little doubt that the diseases scarlet fever, puerperal fever, infectious sore throat and erysipelas, besides some forms of wound infection, are all due to *streptococci*. These are organisms which can be seen under the microscope as minute rounded bodies arranged in chains. Controversy has raged between those who believe that these streptococci are all of one kind and those who think there is a separate kind for each of the diseases which we have mentioned. An immense amount of work has been done during the last few years and the view seems to be gaining ground that the organisms are all of one kind and that varying factors, such as the different susceptibilities of the individuals, may cause the disease to take on one form or another. Certainly there is a relationship between these diseases and the bacteriologists have not succeeded in distinguishing clearly different forms of streptococci.[1] One fact remains undisputed, that there has been a very great decline in the epidemics of these streptococcal diseases and, since puerperal fever, when it does occur, still has an undiminished virulence, this seems to be more the result of hygiene than any decline in the virulence of the germs or increase in the cunning of the physicians.

(c) The Filterable Viruses

The bacteriologists have met with one particularly great difficulty in their search after the microbes of disease. There is a large number of diseases which are undoubtedly infectious since they can be produced by inoculation, but no one, search how he may, has been able to see the organisms, or at least anything resembling the known germs of other diseases. The melancholy fact is that there is a limit to the power of the ordinary microscope. When an object is much smaller than the wavelength of the light used to view it, the light, because of its wave nature, bends round the object so that the effect is as though the light came uninterrupedly through the object: in other words, the object is invisible, and this is true however "powerful" the microscope may be.

If we throw a very bright beam of light on to a small

[1] *Lancet*, 1932, I, pp. 867 *et seq.*

body and view the body sideways, that is, at right-angles to the beam, we may be able to see the body by virtue of the light which is scattered. In theory the smallest bodies might be seen by this method which is, indeed, an extension of the principle that the little motes, otherwise invisible, can be seen dancing in a sunbeam. In practice there are a number of difficulties which greatly limit the distinguishing power of such a microscope, although very small particles which cannot be properly distinguished can at least be made visible. We can, of course, use a light of shorter wavelength and in fact this has been done. The ingenious Mr. Barnard[1] has succeeded by means of ultra-violet light in photographing (for we cannot *see* such "light") objects as small as 75 millionths of a millimetre in diameter. The difficulties are enormous: for example, the microscope lenses must be made of quartz, since glass is opaque to this kind of light. The smallest-sized object that can be seen under an ordinary microscope is about 250 millionths of a millimetre.

Are there, then, living germs which are absolutely too small to be seen? Has the search for the cause of certain diseases been profitless because the germs are not only unseen but even unseeable? Different observers have shown that some diseases can be transmitted from man to man, from animal to animal, or between man and animal, by means of extracts prepared from the raw tissues of an infected victim, even when these extracts are filtered or shown to contain no visible organized cells whatsoever. The active principles in these extracts are known technically as the *filterable viruses*. Some of these viruses can be cultivated in the presence of living animal tissue: but in many cases the results obtained by different observers vary very considerably. This is not surprising when it is

[1] *Lancet*, II, 117, 1925.

not possible to obtain the virus pure and unadulterated by extraneous organic matter. However, some viruses have definitely been shown to reproduce themselves through several generations of culture. This, of course, raises the question whether these viruses are themselves organized living beings or whether they are a kind of non-living ferment which becomes increased in quantity during their own action on the living cells. The answer to such a question is uncertain. What we can definitely state is that they are self-reproducing and parasitic.

Filterable viruses have been found to be responsible for a number of diseases, to some of which human beings are susceptible, while others are diseases both of animals and men, others are confined to animals alone and others yet are found among plants. Among the most important of these diseases are smallpox, cow-pox, infantile paralysis, rabies, foot-and-mouth disease, yellow-fever, encephalitis lethargica—the so-called sleepy sickness, a comparatively new disease which was first reported in Vienna in 1917 and of which an outbreak caused 4,000 deaths in Japan in 1924[1]—and distemper, which attacks dogs and other carnivorous animals. There is an important group of diseases which attack mainly the breathing mechanism of the body. This includes measles, influenza, the common cold and psittacosis (the parrot disease which came recently into prominence in this country). It seems likely that most of these are due to definite viruses, although many of the ordinary bacteria which are frequently found in the respiratory organs of man have been accused in turn of causing colds and influenzas.

What is also of extreme interest is the evidence which Gye[2] has brought forward in favour of his hypothesis that

[1] Topley and Wilson, *op. cit.*, p. 1299.

[2] Gye, 1925. *Lancet*, II, 109.

certain malignant tumours of fowls are produced by a living filterable virus. This, of course, may have an important bearing on the problem of the causation of cancer, although it must be pointed out that the microscopic structure of these fowl-tumours differs considerably from the cancers which gradually attack human beings at a comparatively late stage in life. They are, however, more akin to certain very malignant growths which generally occur earlier in life.

Certain observers had described very minute bodies in material taken from certain virus diseases. Von Prowazek found " elementary bodies " in the lesions of cow-pox, while Paschen discovered little granules in smallpox and cow-pox material. Within the last few years " the specific nature of some of these ' elementary bodies ' has been placed beyond all reasonable doubt ".[1] Some of these bodies have been isolated in a fairly pure state by the process of centrifugation; that is to say, by putting the solution containing the bodies into tubes which are whirled by machinery rapidly round by one end so that the bodies are driven to the other end by " centrifugal force ".

Psittacosis (the parrot disease) seems to have been definitely transmitted from animal to animal by means of purified collections of these bodies.[2] Eagles and Ledingham,[3] too, have shown that the virulence lies entirely in these " Paschen bodies "—so that it seems that we must accept some, at least, of them as the actual virus.

Viruses, then, are on the borderline of visibility. Some have been observed, but it may be that there are others which must always be too small to be seen.

Hope ran high when the agents of contagious disease

[1] *Lancet*, 1932, I, p. 843.

[2] Bedson. *British Journal Experimental Pathology*, 1932, XIII, 65.

[3] *Lancet*, 1932, I, p. 823.

began to be discovered; when the opposition was dying and the truth was acknowledged. Here was something new and tangible. The mystery was laid bare. If these minute beings are the true cause of disease we have only to wage war on them, to exterminate them after they infect the body or prevent them from reaching the body and there need be no more infectious disease.

Much has been done and much remains to be done. In many instances, once the channel of infection, that is, the means of access of the germs to the body, had been found it was possible to prevent dsiease; but disappointments were many. In reviewing briefly the expedients to which experimenters have resorted in the war against disease-producing bacteria and the difficulties they have encountered, it will be convenient to abandon direct chronology and trace separately the two phases of the battle: firstly, we will describe the attack on the germ outside the body and then pass on to all the various means, both natural and artificial, by which the germ can be checked or slain inside the body.

2. THE ATTACK ON THE GERM OUTSIDE THE BODY

(a) Listerism

The distressing condition of the surgical wards in hospitals before the days of antiseptics has already been described. The frightful mortality not only among those who came into hospital with open wounds, but worse still, those who became victims of sepsis through the direct intervention of the operator, was a mysterious Nemesis which came swiftly and suddenly to wreck the handiwork of even the most skilful surgeon. Of course, no one could have failed to notice that these hospital diseases attacked only those patients who had broken skins. A simple fracture with the skin intact mended quite readily, while a compound fracture with its open wound often ended in tragedy.

Joseph Lister, born in 1827 of Quaker parents, was teaching surgery at the Royal Infirmary in Glasgow in 1865 when he began his researches on wound infection, but before this he was pointing out "to his class that anyone who should explain this difference and enable an open wound to behave like a closed one would be among the greatest benefactors of his age".[1]

Now that Pasteur had shown that decomposition was due not to the air but to the living organisms carried by particles of dust, Lister could see that here in the work of the French chemist lay the simple key to the situation. His patients were suffering "from the evils alluded to in a way that was sickening and often heart-rending, so as to make me feel it a questionable privilege to be connected with the institution"[2] and all because, as he rightly surmised, there were organisms which found their way on to the open surfaces of the wounds. His object, then, must be to destroy the germs in the wound and, by insisting on the absolute cleanliness of the instruments, the dressings and anything that might come in contact with the wound, to prevent the infection of the wound. Pasteur had shown how to destroy the organisms by heat or by filtration and there was the third method of antiseptic chemicals, which seemed to Lister to be the most feasible to use. As all the world knows, carbolic acid was the substance which he chose and this was, perhaps, unfortunate because it was falsely asserted that Lister had claimed to be the first to use this compound. This led to endless bitterness although he repeatedly stated in public that he set no store

[1] Godlee. *Lord Lister*, London, 1917, p. 179.

[2] ibid., p. 130. Lister. *Collected Papers*, Oxford 1909, Vol. II, p. 123.

by any specific virtue in that substance, but that the principles of the Antiseptic Method were strict attention to technique in preventing the access of organisms to a wound, and that without this there was no magic in carbolic acid or indeed in any other chemical whatsoever.

His carbolic spray he abandoned later when he found that it could never do what he had supposed it to be doing —namely, to destroy the life of the germs floating in the air—and that attention to the hands of the surgeon, the skin of the patient and the dressings and instruments were what really mattered. This also was unfortunate since his abandonment of the spray was misinterpreted into his having given up his faith in antisepsis.

Of enormous importance was his discovery of the sterile catgut ligature which was gradually absorbed by the tissues of the patient and so did not act as a source of irritation and sepsis like the usual unabsorbable silk ligature. From his Christmas holiday in 1868 throughout the whole of his active life, he was constantly experimenting and improving his ligatures at a cost in sheer labour that cannot be adequately appreciated. His first discovery of the absorbable ligature was done by means of tying the carotid artery of a living calf which was killed a month later. The results exceeded all expectations. He found the catgut gone and the site of the ligature occupied by a living ring of tough fibrous material. I mention these circumstances because it would be as difficult to exaggerate the importance of his invention as it has been easy for the misguided efforts of some of those, " whose hearts are where their heads should be ", to belittle the remarkable humane results that have proceeded directly from experiments on animals, without which, as Lister himself (in spite of a personal appeal from the Queen that he should condemn such practices),[1]

[1] Godlee. *Lord Lister*, London, 1917, p. 377.

asserted before the Royal Commission on Vivisection,[1] these results could not have been obtained.

It is not possible here to trace in detail the early experiments of Lister with various mixtures containing carbolic acid or metallic antiseptics—his carbolized oil, his carbolic putty, his cyanide gauze—which have led gradually, but directly, to the elaborate aseptic ritual which can be seen daily in the operating-theatre of any hospital. The importance of Lister's work lay not in the discovery of chemical agents for the destruction of germs (indeed, as Sir R. J. Godlee has pointed out in his Life of *Lord Lister*,[2] antiseptics have been employed empirically from time immemorial—for example, the Good Samaritan favoured oil and wine), but in his practical application of Pasteur's discoveries, his untiring and zealous work in perfecting details of technique, and not least in the vigorous fight in which he was forced to engage before his work could be received without strong condemnation " couched in the flowery language which too frequently took the place of argument in the speeches and writings of the older surgeons of that time ".[3]

(b) Infection from Water and Food

The channels of infection, the portals of entry of the germs to the body, are by no means confined to cases of surgical wound infection. In order to deal effectively with the prevention of infectious diseases, the first important step is to determine the natural history of the organism, and this, of course, includes the means of access to the body.

[1] London, 1876. Royal Commission. Minutes of Evidence.

[2] London, 1917, p. 157. [3] ibid., p. 311.

Some diseases have been shown to arise by direct contact of the skin with infective material, but generally the skin must be broken. For example, hide-porters are frequently attacked with the malignant pustule of anthrax—primarily a disease of animals—which develops on the back of the neck where the infected hides are most liable to rub. The same disease sometimes attacks the faces of people who are unfortunate enough to have bought and used an unsterilized and infected shaving-brush. Wool-sorters, on the other hand, are more likely to develop the disease in their lungs, since they are constantly inhaling quantities of dust which sometimes contains spores of the anthrax bacillus.

To develop certain other diseases, however, it is generally necessary to swallow the germs. Two striking instances of this mode of infection are seen in typhoid fever and cholera. From the fact that infection is through the alimentary tract, we can at once see that an epidemic of one of these diseases will be likely to follow the distribution of food or water supplies; and such indeed were the facts, which we may take as an illustration, in the great cholera epidemics which recurred in this country between 1831 and 1866.

It was John Snow[1] who put forward a mass of evidence to show that cholera was in general a water-borne disease. It had long been observed that the pestilence came out of the East along the great trade routes and from seaport to seaport, " never going faster than people travel ".

Snow definitely stated that some material passes from the sick to healthy " which has the property of increasing and multiplying in the systems of the persons it attacks. . . . As cholera commences with an affection of the alimentary canal . . . it follows that the morbid material

[1] John Snow. *On the Mode of Communication of Cholera*, second edition, much enlarged, London, 1855.

producing cholera must be introduced into the alimentary canal . . . must, in fact, be swallowed accidentally. . . ."[1] He goes on to point out how by uncleanliness the swallowing of "minute quantities of ejections and dejections" is favoured; how cholera spreads most easily and rapidly among the dirt of the masses; and how the mining population suffered so much because they worked eight hours at a stretch and consequently took down their food and drink, which they ate with unwashed hands, in the pits which were little better than "one huge privy".

In London the water-supplies were, in some districts, nothing more nor less than diluted sewage: the water was polluted by leaking sewers and overflowing cesspools. A fearful outbreak of cholera occurred in Broad Street, Golden Square, Soho, and caused 500 fatal attacks in ten days—and the mortality would have been worse had not the populace taken refuge in flight. Snow traced all these deaths, or nearly all, to the pump which stood in Broad Street, and endeavoured to stay the pestilence by removing the pump-handle.

More convincing than this was the information which he collected in the parts of London south of the river. This area was supplied with water by different companies which overlapped in certain areas. "It is extremely worthy of remark", wrote Snow, "that whilst only 563 deaths occurred in the whole metropolis, in the four weeks ending August 5th (1853), more than one-half of them took place amongst the customers of the Southwark and Vauxhall company and a great portion of the remaining deaths were those of mariners and persons employed in the shipping in the Thames, who almost invariably drew their drinking water directly from the river".[2]

[1] John Snow. *On the Mode of Communication of Cholera*, second edition, much enlarged, London, 1855, p. 15.

[2] *op. cit.*, p. 80.

Of course, the matter was hotly contested. Many adhered to the old theory of miasmata and epidemic influences. It was only reasonable to blame the air and besides there was no vested interest in the atmosphere and consequently, unlike the water, which had sturdy champions in the directors of the various companies, the air went undefended.

Snow gave excellent recommendations, including cleanliness about the sick and the sterilization of infected bed-linen, the importance of obtaining clean or, failing this, boiled water for drinking, and added that it was unwise to hide from the people the fact that cholera was communicable with the idea of preventing a panic. A true knowledge of the cause was likely to be far more helpful.

Cholera in epidemic form has not visited this island since 1866 and there is no doubt that this is due not only to quarantine measures but also to improved hygiene, particularly the excellent systems of sewage and water-supply which now exist; in fact, to the knowledge that cholera is a water-borne disease. It was not, however, until 1884 that Koch was enabled to announce at the Berlin Conference that he had isolated the causative organism, the comma bacillus, which he had found in Egypt and in India.

Water, however, is not the only article of diet that can spread disease. Tuberculosis may, and often does, lurk in cow's milk. The diphtheria bacillus, too, can grow in milk without giving rise to any appreciable change in the appearance or taste, while Malta fever is purveyed in the milk of goats. But there is another important group of diseases which are spread by food and which are generally known as "food-poisoning".

Everyone has heard of "ptomaine" poisoning but when it is realized that the "ptomaines" are chemical products of putrefaction and that any food containing enough ptomaine to do anyone a serious mischief would be likely to be extremely offensive both to the nose and the palate of the eater, no one can suppose that anything more than a small fraction of all the cases of "ptomaine" poisoning can be due simply to the presence of these substances. The truth is that in many instances living germs are swallowed.

We all eat shell-fish and sausage-meat, sometimes with the uneasy feeling that the result may be uncomfortable if not unexpected, but it may come as a surprise to learn that outbreaks of food poisoning have occurred also through eating tinned fruits and cheese. In some instances it is possible to acquire the disease even though the food has been cooked or re-cooked before eating it, for it has been shown that the powerful poisons manufactured by some of these germs are not destroyed by boiling.[1] These poisons can produce very severe internal derangements although, of course, the outlook is much more favourable than when the living germs are eaten and continue to brew their poisons in the belly of their unwilling host.

Botulism is a word that was very familiar to the "man in the street" a few years ago. In August, 1922, eight people died within a few days after eating sandwiches made from the contents of a glass jar of wild-duck paste at Loch Maree (Ross-shire) and later the dreaded bacillus botulinus was found in the paste. It was never discovered how the bacillus got there nor why in this one instance alone was there death in the pot. Apart from three deaths in London in 1935 from botulism acquired from eating nut-meat brawn[2] this is the only outbreak in this country which was definitely proved to be due to this disease. Such poisoning, however, occurs occasionally in Germany and in America, and consequently, we may expect that sooner

[1] Medical Research Council. Special Report Series No. 92.

[2] *British Medical Journal*, 1935, II, p. 500.

or later another consignment of germs of this lethal malady will be shipped to England. Indeed, it is possible that some has arrived already, but fortunately meat containing this toxin almost always smells and looks peculiar, so that it is only rarely that it is eaten at all. At Loch Maree no doubt the strong flavour of the wild-duck paste masked the peculiarity. The poison is one of the most powerful known and it is by no means necessary to swallow the living germs to develop a fatal attack.

(c) Carriers of Infection

It has been shown that an unsuspected source of infection lies in certain individuals who, though in perfect health themselves, carry about and distribute bacteria which spread disease among those who come in contact with them. These "carriers", as they are called, have sometimes suffered shortly before from the disease in question; indeed, this is usually so in the instances of those who carry typhoid fever. In diphtheria, however, the carriers have often not had the disease themselves, while in the example of the meningococcus, the organism of cerebro-spinal meningitis, we find the remarkable fact that the number of carriers enormously exceeds the number of persons who actually take or have taken the disease.

The importance of carriers in keeping diseases endemic among populations is very readily understood. Diphtheria is kept with us in this manner although, as we shall see later, we now know quite enough about the habits of *Corynebacterium diphtheriæ* to abolish the disease if only the community would make up its mind to stomach the interference and inconvenience which it would incur if preventive medicine were given a free hand.

The danger that comes from carriers is well illustrated in the example of a patient who developed cholera in Manila (in 1915) after having been distributing cholera germs for at least eighteen days previously. As has been pointed out, it was fortunate that the man was in prison, otherwise he might have "travelled half-way round the world scattering his infection broadcast . . . and died of true cholera in a place many thousands of miles from any other source of infection ".[1]

Man himself is by no means the sole offender who carries about with him diseases which may prove the undoing of his fellows. Everyone knows that the hopeless disease of hydrophobia may follow the bite of a mad dog, and, as we have seen, it has been possible to eradicate this disease in Great Britain by means of muzzling orders when necessary and the strictest possible quarantine for immigrant dogs. In Continental countries the matter is one of much greater difficulty since the methods which have been used here cannot be applied successfully on so enormous a scale. Another difficulty arises because dogs are not alone in spreading the disease: a number of other animals are susceptible to rabies (as the disease is called when it affects animals) and, when infected, can inoculate humans by biting. Cats, jackals, wolves, ruminants and even human beings[2] have been the rabid biters. Recently, too, it has been suggested that the Sangre Grande daylight bat of Trinidad may also be to blame.[3] Another example of an illness produced by animal bites is the so-called rat-bite fever of Japan, where the rats may inoculate man with a little spiral organism which has been known by the name of *Spirochæta morsus muris*.

[1] Topley and Wilson, *op. cit.*, London, 1929, p. 903.

[2] *League of Nations. Quarterly Bulletin of the Health Organization*, Vol. I, No. 1, Geneva, 1932, p. 122.

[3] *Nature*. 1932, cxxix, p. 198.

Insects, however, are responsible in a far greater degree for some disastrous afflictions from which enormous numbers of persons have perished in the past and are likely to do in the future. The first discovery of the remarkable fact that insects can cause disease was made in 1879 by Patrick Manson, who demonstrated how the embryos of the worm which causes a common tropical disease are taken from the blood of an infected human being by a female mosquito; how these embryos undergo development inside the mosquito and are finally injected into another human being who is bitten by the same insect.[1] This discovery was of tremendous importance although it was not so regarded at the time. It was, however, directly due to this theory of insect-borne disease that Ronald Ross was able, in 1898, to show that the parasite of malaria, which had been discovered eighteen years previously by Alphonse Laveran in Algeria,[2] is conveyed from man to man in a similar manner. He demonstrated that the parasite has a double life-cycle; one set of changes occurs in the body of man at regular intervals, which accounts for the remarkable regularity of the recurring fevers of malaria; while the other cycle of change takes place within a special kind of mosquito, until the insect's spit-glands are heavily charged with the spores of malaria, ready to infect the next victim of the mosquito's hunger.

The cause found, the remedy becomes evident. Malaria is no longer a bad air, an exhalation from the marshes, but a phase in the life-cycle of a known organism. To abolish the spread of malaria it is necessary to break the life-cycle at some point. The first and most obvious way is to avoid being bitten by the mosquito, and since the habits of the insect are nocturnal, the provision of fine-mesh

[1] Manson. *Journal of the Linnæan Society*, London, 1879, XIV, pp. 304-311

[2] Laveran. *Comptes rendus de l'Academie des Sciences*, Paris, 1880, XCIII, p. 627.

nets in the windows of houses and nets under which to sleep has procured safety for those who stay indoors after dark.

This, of course, is not an ideal method. The next most feasible way to break the life-cycle of the malarial organism is to destroy the mosquitoes themselves. The anti-mosquito campaign began in 1901 and has met with considerable success. Mosquitoes breed in stagnant water on the surface of which the eggs are laid. The eggs hatch into little wriggling larvæ which swim about in the water, coming to the surface occasionally for breath. The full-grown mosquito emerges from the water after an interval of seven to ten days.

We have then four methods at our disposal for ridding ourselves of the insects. We can dry up the breeding-places or convert the stagnant pools into running streams; we can poison the larvæ, we can asphyxiate them, or we can find some animal which will eat them. All these methods are employed. The poisoning is done with "paris green", a powder containing arsenic and copper, while asphyxiation is accomplished by pouring on the surface of the water some kind of oil—Diesel oil, kerosene, or waste oil is commonly used—so that the larvæ cannot breathe. Small predatory fish will feed with avidity on "the wrigglers" and have proved invaluable. In spite of all these possible ways of killing off mosquitoes there are often considerable difficulties in practice. For example, it is almost impossible to deal with every collection of stagnant water, and any small quantity such as might occur in the fork of a tree or a puddle is quite sufficient for the breeding of mosquitoes provided it remains in existence for the few days required for the eggs to develop completely.

Furthermore, there is more than one species of "anopheles" mosquito which carry malaria and the species often have different habits. One kind may breed in small pools, puddles, quarries, or wheel-ruts, another may prefer large freshwater swamps, another brackish swamps. "Only about one species of anopheles in ten carries malaria and care must be taken to do nothing that would increase the number of the dangerous species. Indeed, the unwary medical officer may easily stir up a virulent outburst of malaria by the adoption of a method that would be 100 per cent. successful in another type of land perhaps only a few miles away."[1]

The methods outlined above have been employed with great success in Sierra Leone and elsewhere, although in some instances success has been marred by the inhabitants' dislike of interference. To take a recent example, in the Shanghai area the oil was voted too smelly, the "paris green" was mortal to the local ducks and the fish were too well appreciated as a delicacy by the Chinese and the ducks. Furthermore, the fear of political difficulties slowed down the zeal of the municipal authorities; consequently, the incidence of malaria on the British troops rose from 26.9 per thousand in 1929 to 77.2 per thousand in 1930.[2]

On the whole, however, energetic and skilled organizers have succeeded in making admirable reductions in the incidence of malaria in certain districts. It must also be realized that malaria not only kills directly, but also, by weakening the resistance of those who are attacked, it allows other diseases to gain entry to the damaged body. It is very noticeable that where the incidence of malaria has been greatly reduced by general sanitation and special anti-malarial measures, there also the number of deaths

[1] Sir Malcolm Watson. *The Times*, July 1st, 1932, p. 15.

[2] *The Health of the Army*, 1930, London, 1931, p. 11.

from other diseases is also lessened. This has been particularly noticeable in Malaya and in Northern Rhodesia.[1]

Malaria still flourishes over vast tracts of the earth's surface and will continue to do so in spite of an almost complete knowledge of the means of preventing it. The lack of money to carry out the extensive and expensive campaign is only too obvious today. The only hope seems in the discovery of cheaper and more ingenious methods of attack.

It follows from what we have seen that human beings are also real carriers of the disease. The mosquitoes do not infect each other but require to bite an infected person in order to become bearers of malaria. It will therefore be realized that an important factor in the control of the disease is to keep those who are suffering from it out of reach of the voracious anopheles mosquito. This could be done either by screening with nets or, perhaps better, by sending the malarial patient to some district where the pestiferous insects do not dwell, but the numbers of the infected make this project unfeasible.

Yellow fever—or the yellow jack—the appalling pestilence which has played such havoc in the tropics, had its chief seats in Central America and the West Coast of Africa. At the beginning of the present century it had already been suggested that a mosquito was the vector of the infection when the American Army Board, under the leadership of Walter Reed, was sent to Cuba to investigate the matter. The story of yellow fever and the fight against it is one of heroism and tragedy, but it resulted in a magnificent triumph.

The difficulty lay in the fact that it had not been found possible to transmit the disease to any animal and consequently if experiments were to be done there must be found human volunteers who would be willing to run the

[1] Sir Malcolm Watson. *The Times*, July 1st, 1932, p. 15.

enormous risk of taking this loathsome disease. One of the Board, James Caroll, was the first of the volunteers to be inoculated by an infected mosquito and he was fortunate enough to survive the attack of yellow fever which resulted. It was found that the disease could be produced by the injection of blood or blood-serum even if it were filtered or by the mosquito-bite, but the seven men who volunteered to sleep in the bedding of those who had suffered from the fever failed to have the disease, thus showing that the disease was not communicable except by inoculation.

Other investigators were not so fortunate as Caroll. J. W. Lazear, who was also a member of the Board, died of the yellow fever through being accidentally bitten. More recently, the brilliant Japanese bacteriologist, Hideyo Noguchi, met with a similar fate in Africa where he had gone to make sure of the true cause, for his own germ, a spirochæte, which he had claimed as the culprit was beginning to be thought "not guilty". Thus also died Adrian Stokes, whose great contribution to the pathology of this fever was that he found that certain Asiatic monkeys could be made to take the disease[1] and thus did away with the necessity for human volunteers.

The results of this brilliant piece of research have shown that these men did not die in any useless cause. War was declared on the swarms of death-dealing insects. Gorgas, the Chief Sanitary Officer of Havana, began in 1901 isolating from the mosquitoes all the yellow-fever patients and by an unbelievably energetic campaign against the offending "villain-of-the-piece", *Stegomyia fasciata* alias *Aëdes ægypti,* he succeeded in three short months in clearing Havana of a plague which had hardly been absent in recent history. Through the efforts of this same

[1] Stokes, Bauer and Hudson. *Amer. Jour. Trop. Med.*, 1928, 8, p. 103.

man, Panama, which had formerly been a veritable pest-hole, is now one of the healthiest of places. Without him the canal could scarcely have been built.

The actual cause of the disease is generally believed to be a filterable virus. Noguchi[1] had found a spiral organism in Central and South America, but outside these places no one has confirmed his work. It now seems probable that there was a mistake in the diagnosis of his patients and that they must have been suffering from infective jaundice (either alone or with yellow fever in addition), because this disease is certainly caused by a spiral organism which is probably identical with the one he claimed as the germ of yellow fever.

In spite of the successful campaigns against yellow fever, the danger of its further spread is very real. The distribution of *Aëdes ægypti* has been widely studied and it has been found to extend over immense tracts of the earth in every continent, not excluding Europe, so that presumably it is only necessary for a few cases of yellow fever to travel to such areas to provoke explosive outbreaks. In addition to this there is reason to suppose that *Aëdes ægypti* is not the only carrier of the disease, for, in South America—in the emerald-mining village of Muzo, for example—epidemics have occurred "*in spite of the absence of Aëdes ægypti*".[2]

In the West of Africa there is a disease with which the natives are only too familiar which kills slowly with long fever and protracted wasting and increasing lethargy. This is the African sleeping sickness, which must not be confounded with the European disease encephalitis lethargica. The latter has been rather unfortunately called sleepy

[1] Noguchi. *Jour. Exp. Med.*, 1919, 29, p. 547 *et seq.*

[2] League of Nations, Epidemiological Report on Yellow Fever, Geneva, 1935, p. 120.

sickness, and has been referred to above in connection with the filterable viruses.

An organism of the kind known as trypanosomes had been found in Zululand by Bruce in the blood of cattle suffering from a sickness called " tsetse fly disease ". Bruce put forward the suggestion that this disease was similar to sleeping sickness in man, and showed that the trypanosome was conveyed from big game to domestic animals by the tsetse fly, *Glossina morsitans.*

That the subject of sleeping sickness was considered of urgent importance is shown by the fact that it was vigorously taken up by an international arrangement.

Castellani discovered the parasite, a trypanosome, but a different one, lurking in the fluid which bathes the brain and spinal cord in patients suffering from the disease, and it was shown that the organism is inoculated by the bite of another kind of tsetse fly called *Glossina palpalis.* It has also been shown that the tsetse fly is infected from biting a sufferer from the disease and that the fly does not merely bear the germ from one person to another but that the germs breed rapidly in the stomach of the fly and gain access to the spit-glands which may be infectious for a very long period.[1]

Trypanosomes have been found by Bruce, as we have seen, in big game, and it has been suggested that Bruce's trypanosome may be identical with the Rhodesian trypanosome which was found more recently to cause human infections in Nyasaland, Tanganyika Territory and Northern Rhodesia. This would mean that big game were acting as a reservoir of the disease, which was conveyed from the game to man by the fly. Much work has been done

[1] Report of the Inter-Departmental Committee on Sleeping Sickness, London, 1914. See also Interim Report of League of Nations International Commission on Human Trypanosomiasis, C.H. 536, Geneva, 1927.

and the controversy has been prolonged. In this connection it may be worth while to note that with heroism supported by true scientific ardour, Dr. Taute made repeated attempts to infect himself with trypanosomes which he took from big game and which were to all appearances indistinguishable from the Rhodesian organism. Fortunately, he experienced no ill effects and although the evidence is conflicting it is held by many that man is the principal if not the only reservoir of the disease. If such is the fact, then, if we cannot destroy the flies, we must keep those who are infected away from the flies unless we are to abandon whole tracts of land to the dominion of this pest. It has been claimed, however, that some of the drugs which are used in the cure of African Sleeping Sickness keep the blood of the patient free of the germs. If this is so, and if man is the sole reservoir, then efficient treatment of all patients should lead to eradication of the malady.

It is, of course, of very great importance to find out whether animals do act as a reservoir of trypanosomes, because, if this is the truth, then it may be necessary to destroy the big game if we cannot destroy the flies. It is fortunate that nothing hasty has been done before the facts are truly known, especially since there is reason to believe that if the game were destroyed the hungry flies would turn their attention with renewed vigour to human beings.

It has been possible to limit the numbers of the flies by altering the character of their favourite breeding-places; for example, by clearing up swamps and thickets. A capital example of a really successful campaign is that which was carried out during the three years from 1911 to 1913 in the Portuguese island of Principe[1] off the west

[1] League of Nations Health Organization. Further Report on Tuberculosis and Sleeping Sickness. Geneva, 1925, p. 62.

coast of Africa. Here, in addition to the methods of clearing thickets, draining the land and segregating those affected with the sleeping sickness from the biting flies, an ingenious method was used for trapping the insects. Ten men in white clothes with suitable protective headgear carried on their backs a square of dark-coloured cloth spread with bird-lime. They were set to walk in pairs through the infested clearings. In this way in the three years 470,000 flies were caught. The results were remarkable. Principe was cleared completely of a disease which had previously accounted for one-third of the total deaths on the island. *Glossina palpalis* became extinct!

Many negro slaves imported into the New World died of African Sleeping Sickness, but the tsetse fly remained in Africa and the disease did not spread. There is, however, an infection with a trypanosome which occurs in South America and it has been shown that this is transmitted by the bite of bugs—not flies.

The bubonic plague in this country is, at least in its epidemic form, almost a matter of history,[1] but history which is gruesome enough when we recollect that the Black Death accounted for one-half of the inhabitants of this island and probably one-quarter of the population of the known earth.[2] But the plague is not dead and may yet come again out of the East where it dwells widely but patchily endemic. Indeed, in the last years of the nineteenth century, the old scourge threatened the whole world. From Hong Kong in 1894 it spread to India, Japan, Turkey and Russia. In 1897 it was at Madagascar and the Mauritius; by 1899 it was in Europe again and had even reached Hawaii. In India alone, between 1898 and

[1] There was a small outbreak in Glasgow in 1900.

[2] Garrison, *op. cit.*, p. 187.

1918, there have been recorded more than ten million deaths.[1] As may be imagined from this figure, the mortality of the plague is enormous. When it assumes the bubonic form not less than sixty per cent. of those attacked perish, but when the plague is pneumonic not one escapes.[2]

It was at the beginning of this last pandemic that the bacillus of the plague was found independently by Kitasato and Yersin at Hong Kong. The means of spread of the disease was unlike any other yet discovered. Early in the twentieth century it was found that plague is, in the first place, a disease of rodents and in particular of rats, and is conveyed from rat to rat by the bites of fleas. These particular fleas generally live upon rats, but when pressed by hunger will bite human beings. The rat dies of the plague, the fleas leave the dead body for new pastures and so the pestilence is spread.

This discovery throws some light on various pestilences recorded in history. When the Philistines had carried the ark of God to Gath, the Lord " smote the men of the city, both small and great, and they had emerods in their secret parts ".[3] In order to appease the Lord the priests and diviners advised offerings of golden " images of your emerod and images of your *mice* that mar the land ".[4] Surely it is significant that the rodent and the bubo (or emerod) are connected in this way!

The prevention of plague, then, consists in keeping down the numbers of rats and avoiding human contact with them: in other words, hygiene. There are certain foci where there is always some plague among the rodents—for example, a district in the South-West Himalayas. Other rodents which convey the infection besides rats are

[1] Topley and Wilson, *op. cit.*, p. 1057. [2] ibid., p. 1058.

[3] I Samuel, v, 9. [4] ibid., vi, 4.

the ground squirrels of California and the gerbilles in South Africa. It is, of course, highly important to prevent the rats from migrating from one country to another. This they often do in ships and the attempt to prevent them from landing is the reason why we see the circular metal discs on the mooring-ropes of ships in port. If a ship arrives with the plague on board the authorities at once set about the extermination of all the rats by chemical fumigation.

Recently yet another disease-bearing parasite has been shown to have been responsible for endless mischief. The three fevers, relapsing fever, trench fever and typhus fever, are all conveyed by lice. In these instances it seems that it is not the bite that causes the infection but that the lousy person scratches himself and thus inoculates himself with the infective body fluids of the louse.

Relapsing fever, or famine fever, is a malady of which we hear little in this country at the present time, although it still flourishes in Eastern Europe, Asia, and Central and South America; but during the last century this disease, together with typhus (gaol fever) and dysentery, caused frightful distress, especially in Ireland. These three furies came savagely on the unfortunate people in the midst of the appalling potato famine of 1847. A correspondent, writing from Dingle, says: "The state of the people of this locality is horrifying. Fever, famine and dysentery are daily increasing, deaths from hunger daily occurring, average weekly twenty—men, women and children thrown into the graves without a coffin—dead bodies in all parts of the country, being several days dead before discovered—no inquests to inquire how they came by their death, as hunger has hardened the hearts of the people ".[1]

[1] Cited by Rev. John O'Rourke. *History of the Great Irish Famine of* 1847, second edition, Dublin, 1879 (?), p. 409.

The causative organism of relapsing fever is a spirochæte which was discovered by Obermeier during the Berlin epidemic of 1867-68, and it has been shown that it is transferred by blood-sucking insects. In the Congo and in Central and South America it is transferred by a tick and thus earns its alternative name of " tick fever ", while in Europe, Asia and North Africa it is lice which are responsible.

Gaol fever, or typhus, is uncommon where sanitation and hygiene have left their mark, but this sickness also was with us during the nineteenth century. It is yet endemic in the Slav countries and indeed it follows closely the geography and the history of dilapidation and dirt, wretchedness and war. Typhus used always to occur not only in gaols but also in the Army and the Navy. It has been suggested that the fever of the Navy was constantly recruited directly from the prisons by the press-gangs who impressed the newly discharged convicts. The organism which is generally believed to be responsible was first discovered by da Rocha Lima in 1916 and he suggested the name of *Rickettsia prowazekii*, to commemorate Ricketts and Prowazek, who had both fallen martyrs to the study of this kind of disease. These Rickettsia bodies are not looked on by everyone in the same light: by some they are regarded as inanimate products of degeneration, by some as peculiar forms of bacteria, but the latter, who are in the majority, think them to be definite living organisms which reproduce their kind. The evidence is circumstantial and sometimes contradictory. The Rickettsia are classified under the filterable viruses. They are microscopically visible.

The prevention of these louse-borne diseases is simple in principle and consists essentially in preventing the louse from changing its host. This is most easily done by preventing overcrowding and " delousing " the inhabitants as far as possible.

(d) Air-borne Diseases

There is another important channel by which disease-germs may enter the human body and which we must now consider. This is the respiratory tract. We must ask whether germs do actually get in through the nose, larynx, windpipe and lungs.

Pasteur himself had shown that the air in inhabited places was swarming with micro-organisms; but most of these are harmless. However, harmful germs certainly do get loose about the air. A person coughs or sneezes and into the air is thrown a fine spray consisting of innumerable droplets of moisture. The patient may be suffering from some disease in his respiratory system or he may be a " carrier " of some respiratory disease. He may be coughing diphtheria germs or scarlet fever germs into the air. Furthermore, a person who has consumption spits into the street and later the fine powder into which the sputum has dried may be carried to another on the wind. There is very little doubt that many common infectious diseases, ranging from the common cold to the pneumonic plague, are spread in this kind of " droplet " way.

There has been much dispute about whether pulmonary tuberculosis (consumption) gains entry by the air or by the food. Now there are two kinds of tubercle bacillus which may infect human beings. The one is called *human* and the other *bovine* tubercle. It is not necessary to describe fully how they can be distinguished from one another, but let us note that we can tell the difference because the bovine bacillus is much more virulent towards certain lower animals such as the rabbit than is the human bacillus. It has been found that 99 per cent. of infections of the lungs and 95 per cent. of infections of the glands in the neighbourhood of the air passages are caused by the human type of tubercle bacillus.[1] It therefore seems not unlikely that most of this kind of tuberculosis is inhaled, for bovine tuberculosis is only likely to come from drinking milk and it is significant to note that abdominal tuberculosis is often of this type, while bovine pulmonary tuberculosis is proportionally rarer.

The air, as we have seen from the miasm theory, from time immemorial has been suspect. The great prison reformer, Howard, believed that the poisonous effluvia of the nauseous dungeons which he inspected were the cause of gaol fever. Florence Nightingale, too, declared her belief that fevers arose *de novo* from bad air and filth. The diseases were seen to spread rapidly and mysteriously and it is, therefore, scarcely surprising that the air was blamed. In 1750 the prisoners at the Old Bailey conveyed their typhus fever (surely through the air, it was thought) even to the Bar and the Bench so that many died, including the Lord Mayor and other notables.[2]

A hundred years ago Maidstone gaol was rid of gaol fever by the energetic use of soap, water, quicklime, clean clothes, sulphur and nourishing food,[3] and the same methods are used today to prevent such diseases, although they are now done with fuller knowledge of the rationale. Thus we see that gradually the number of diseases for which the air can be blamed is declining, but it seems very probable that certain respiratory diseases, at least, will remain in this category. Certainly no one will deny the

[1] Topley and Wilson, *op. cit.*, p. 819.

[2] Creighton. *op. cit.*, II, p. 93.

[3] Sweating. *The Sanitation of Public Institutions.* Howard Prize Essay, London, 1884.

beneficial effect of fresh air, yet we send our children and go ourselves into the foul air of cinematograph theatres and schoolrooms where, as Leonard Hill has pointed out,[1] the air is usually much more laden with germs than the comparatively healthy atmosphere in a well-conducted sewer!

In some instances the remarkable rapidity with which a disease will spread, especially in a population unused to the disease, almost forces us to conclude that the spread is by means of the air. For example, it is stated that in the island of Wharekauri, 480 miles east of New Zealand, the visit of a ship to the island is followed by a four-day illness (called murri-murri) of both whites and coloured. "The mere appearance of murri-murri is proof to the inhabitants *even at distant parts* of the island, which is thirty miles long, that a ship is in port."[2]

In many of these influenza-like diseases the air, it is fairly certain, is the channel of infection, but it is very difficult to prove the matter if we cannot see the microbes. In consumption and diphtheria, it can be readily demonstrated that morbid germs are coughed into the air. Can germs travel long distances in the air and appear spontaneously at some distant site? Considering the fact that disease almost always can be kept out by strict quarantine, we must admit that this appears unlikely. However, it has recently been shown by the United States Bureau of Plant Industry that the spores of the black stem rust, the dreaded pestilence of American wheat, can be collected on glass microscope slides, by means of an aeroplane, at the astonishing height of ten thousand feet above the earth.

[1] Privy Council. Med. Research Council. Special Report Series, No. 52.

[2] Creighton, *op. cit.*, II, p. 432. See also Boswell's *Journal of a Tour to the Hebrides with Samuel Johnson, LL.D.*, where on October 2nd, 1773, the latter "disputed the truth of what is said, as to the people of St. Kilda catching cold whenever strangers come".

These spores fall so slowly that it has been calculated that it would be possible that regions a thousand miles and more to the leeward of the original source *might* become infected.[1] We must, therefore, not be too sure about how far germs may travel in the air. It should, however, be stated that the viruses which are known are essentially parasitic and are found in association with living matter: so that it does not seem probable that they will be found borne passively by themselves on the wind.

Bacteria are not possessed of any organs that can help them to fly and in general any movement they make is a passive one: we may note, however, that certain germs—such, for instance, as those which cause enteric fever—are able to move about in liquids. Other organisms such as the amœbæ of dysentery and the various disease-producing spirochætes are very active while swimming, but they definitely cannot fly. We must not, then, conclude that, because a disease seems to appear independently at a fresh geographical focus isolated from the source, therefore it has propagated itself through the air. We must, for example, consider that common pests like the domestic house-fly can, and often do, act in the odious rôle of disease carriers and may infect our food with their germ-laden feet as they fly " from the dunghill to the dinner-table ".

3. THE ATTACK ON THE GERM INSIDE THE BODY

(a) The Conception of Immunity

It must surely have been noticed at a very early stage in the history of man that certain infectious diseases rarely, if ever, attacked the same person twice. Thucydides categorically states that no one was ever attacked a second

[1] *Nature*. 1932, cxxix, p. 754.

time, or not with a fatal result, by the plague at Athens, and this belief was so strong in those who had taken the malady and recovered that they even entertained the innocent fancy that they could not die of any other sickness.[1]

The practice of inoculation of smallpox with the idea of " getting it over " and in the hope of inducing a mild attack came to us first from the east of Europe. It is supposed that this practice originally contained no idea of engendering in the body antidotes to the contagion, but was intended either by magical symbolism or scientifically to rid the patient of the disease by passing it on either to another person or to an animal. It is said that there is the " germ of this idea in the scapegoat of the Israelites and the miracle of the swine of Gadara ".[2] This kind of belief exists today. For example, the writer has heard the opinion expressed among the Riffs in North Africa that a certain distressing and very prevalent contagious disease can be cured most easily by passing it on in the same manner in which it was acquired to a negress, or, failing this, a donkey.

This kind of belief regards a disease as an entity, a sort of possessive devil, for instance, which goes from one person to another. The present-day belief, however, is that a disease is a process and that any kind of immunity to disease is due to the building up by the body, generally as a result of infection, of specific substances which either oppose the life of the germs in the body or neutralize the poisons given out by them.

Inoculation of smallpox matter from a mild case was certainly almost always successful, if it produced an artificial attack, in preventing a subsequent natural attack. The

[1] Thucydides, II, 51. Jowett's Trans., Oxford, 1900, Vol. I, p. 138.

[2] Creighton, *op. cit.*, Vol. II, p. 475.

method was widely used in the latter part of the eighteenth century; but unfortunately it was not always possible to gauge the virulence of the inoculated matter, so that the results were sometimes fatal and often disfiguring. Moreover there was considerable risk of infecting the patient with other diseases. Nevertheless numbers of people were successfully protected from smallpox by this means, and without disfigurement, if we may judge from the remark of Mrs. Hardcastle in Goldsmith's *She Stoops to Conquer*: "I vow, since inoculation began, there is no such thing to be seen as a plain woman". The story of Jenner's substitution of vaccination (the inoculation of cow-pox) for the more dangerous procedure is too well known to require restatement here. It is necessary to mention it, however, because this was the beginning of the science of "immunology", this isolated discovery which confined itself to one disease. No further progress at all was made until Pasteur published his brilliant discoveries of the microbic nature of infectious disease.

Pasteur's discovery of preventive inoculation was a kind of accident, but an accident of which a less acute mind might so easily have overlooked the importance. He had been studying the disease of fowls which is vulgarly called "chicken cholera" and of which the microbe had already been found. One evening he attempted to inoculate a bird with a stale culture of chicken cholera germs some weeks old. The bird sickened slightly and then recovered.[1] Using the same bird and a fresh tube of virulent germs he was delighted to find that the bird was resistant to the infection although the germs were quite virulent to any normal chicken. He was quick to notice the prime importance of this discovery. The oxygen of the air was responsible for the attentuation. He could now cultivate

[1] Vallery-Radot. *La Vie de Pasteur*, Paris, 1900, p. 427.

germs to any lessened virulence that he desired and with these produce an immunity to future infection.

These studies led him to an attempt to provide a preventive inoculation for sheep and cattle against anthrax (splenic fever). By discovering the principle that the virulence of germs can be "attenuated" or reinforced by passing the germs through suitable animals—that is, by inoculating the animals and recovering the germs later in a fresh culture from the animal—he brought his research in 1881 to a triumphant success. In 1882 he completely annihilated the opposition of those who constantly denigrated his opinions and impugned his scientific honesty, by the world-famous and classical experiment on the farm of Pouilly-le-Fort near Melun.[1] Here he had three groups of sheep: twenty-five sheep had been previously injected with an attenuated culture of living anthrax germs and twenty-five were untouched. All these animals were then publicly injected with a culture of virulent anthrax germs and, as he predicted, all the unprepared animals died and the inoculated ones remained alive and just as well as ten "control" animals which were kept apart, to the confusion of his enemies and triumphant jubilation of his supporters.

Hydrophobia[2] was the first human disease which he tried to prevent by inoculation. He started with the assumption that the rabid virus was in the spittle of the mad dog. He was unable at first to transmit the disease to animals by inoculating them with human saliva from a patient with hydrophobia. It then occurred to him that, from the nature of the symptoms of the disease, the virus surely attacked the central nervous system. He found that he could convey the disease to animals by trephining them. Thus he came to use the central nervous system of rabbits

[1] Vallery-Radot. *La Vie de Pasteur*, Paris, 1900, p. 446 *et seq.*

[2] ibid., Chapter XII.

as a culture medium for growing the virus, which of course he was unable to see in a microscope since it belongs to the class of "filterable viruses". By drying the infected spinal cord from rabbits for varying lengths of time, he could produce samples which might have their virulence attenuated to any degree he required.

Pasteur saw clearly that it would be impossible to inoculate all the French dogs against rabies since there were some hundred thousand in Paris and two and a half million in the Provinces,[1] and each dog would have to have several inoculations. We find him deciding, therefore, that the method must be one which could be applied to human beings *after* they had been bitten by mad dogs. Courageously, but with some mistrust of a treatment which up to then he had used only on dogs, he began by inoculating with gradually increasing strengths of virus a little Alsatian boy of nine years old who had been bitten in fourteen places by a rabid dog. There was no doubt that the dog was mad and Pasteur adopted the method in the one hope of saving the boy's life. The result was successful and, as all the world soon knew, the boy remained well.

This, in 1885, was the beginning of the justly celebrated Pasteur treatment for the prevention of hydrophobia. It was followed shortly afterwards by the inauguration in Paris of the Pasteur Institute in 1888. At the present time there are Pasteur institutes scattered throughout the world and in these persons bitten by rabid animals are given one or another modification of the original methods of Pasteur.

The discovery that the virulence of bacteria can vary under different conditions is one which is extremely significant in the study of epidemics. It may, in fact, account

[1] Vallery-Radot. *La Vie de Pasteur*, Paris, 1900, p. 578.

for the disappearance or sudden virulent outbreak of an epidemic in the history of nations.

Pasteur looked upon these inoculations as preventive and not curative. His high hope was that every infectious disease could be combated in a similar way, but unfortunately success has been limited. In order to trace a further development of methods of fighting infective processes in the body it will be convenient to study the history of diphtheria.

(b) Immune Sera

Diphtheria was a mysterious sickness. Before the middle of the last century it was little known, and the older epidemics of " throat-distemper " cannot be definitely assigned between this disease and scarlet fever. Quite suddenly between the years 1856 and 1859 diphtheria, as we know it, became common.[1] The reason for this can only be surmised, but it seems not to be due entirely to improved diagnosis. Löffler's masterly researches on the diphtheria bacillus, which had actually been observed before by Klebs, marked the beginning of the bacteriology of the disease in 1884. The important point about this bacillus is that it is only found in the body at the site where it first took root. It does not spread throughout the body like anthrax and other disease-germs which had been studied before. Four years after Löffler's discoveries it was shown that there is a potent poison which is given out by the bacillus. This " toxin " circulates in the system and is responsible for the mortality from diphtheria. The bacillus itself multiplies only in the throat or wherever it was first implanted.

By inoculating a horse with gradually increasing doses of

[1] Creighton, *op. cit.*, Vol. II, p. 679.

this powerful toxin it is possible to make the horse immune to further large doses. This is a modification of the method used upon himself by the great Mithridates IV, King of Pontus, to protect himself from death by poison. The blood of the horse then possesses antitoxic properties. The horse is bled from the jugular vein, the blood is allowed to clot and the serum is filtered off. The strength of this is carefully standardized by measuring its protective action on guinea-pigs against a standard dose of toxin. This serum is used in the *treatment* of diphtheria. It is sold under the name of diphtheria antitoxin, although of course it is really a very diluted solution of the antitoxin in the blood-serum of the horse.

The importance of this method is so great that it is rarely necessary to provide any other specific treatment for diphtheria. The serum must be inoculated without delay and in large amounts. The statistics are all in agreement with the view that the case mortality is considerably reduced by this procedure, but they are unfortunately by no means decisive. Since the antitoxin is believed on good experimental evidence to be very valuable, it is obviously unjustifiable to withhold it from a group of patients for the purpose of comparing their mortality. This is the reason why no good statistics are available.

It must be noticed that the principles involved in vaccines and sera are quite different. A vaccine is a poisonous product consisting either of living, or, as we shall see later, dead germs which provokes the formation of some resistance in the body. An antitoxic serum, on the other hand, is an animal's blood-serum containing substances which can neutralize bacterial poisons.

Statistics have shown that diphtheria is more prevalent in certain classes of society and in certain age-groups. This has been explained by the demonstration that some people are immune in a greater or less degree because they have some antitoxin in their blood. This is called Natural Immunity. In 1913 Schick elaborated the technique of the famous " Schick test " which enables us to determine whether individuals are possessed of any natural immunity to diphtheria. A minute and measured quantity of a standardized solution of toxin is injected into (not under) the thickness of the skin of the forearm. Into the other arm a similar injection is made with some of the same solution which has been heated to destroy the toxin. This serves as a control in the event of the patient reacting to substances other than the toxin. A positive reaction is said to occur when a red flush appears at the side of the injection in twenty-four or thirty-six hours and reaches its maximum on the fourth day. The control arm should show no redness. This means that the patient has little or no antitoxin in his blood and is therefore susceptible to diphtheria. Those who show a negative reaction are immune.

We have seen how the antitoxin can be used for the treatment of diphtheria, but it has also been used in epidemics in order to immunize those who have been in contact with persons suffering from the disease. Such an injection of antitoxin brings about a rapid immunity, but unhappily it is not a lasting one. Within a few days or weeks the antitoxin disappears again and the immunity goes too. A fresh infection may then bring on an attack of the disease. Such " passive " immunity is therefore of limited use, since it is clearly of value only when there is a risk for a limited time.

In the disease known as tetanus (lock-jaw) the organisms gain entry by means of a wound and they grow in the wound and give out poisons without themselves being disseminated all over the body. In this respect the disease resembles diphtheria. It has been found that an injection of antitetanic serum, prepared in a similar manner to the antidiphtheritic serum, has had a remarkable effect in lowering the incidence of tetanus. Here is an ideal circumstance for the use of the passive immunity. The risk is only for a short time, while the wound is infected. This technique is now used as a routine measure in all cases where there are dirty wounds, especially those contaminated with mud or manure.

During the Great War the use of antitetanic serum was introduced in the middle of October, 1914. The figures of the incidence of tetanus among the wounded are remarkable. In September, 1914, 15.9 out of every thousand developed tetanus; in October the figure had risen to the horrible rate of 31.8; but the following month saw an immediate drop to 1.7.[1] It is impossible not to ascribe this magnificent result to the general preventive use of the serum.

Can we not produce some lasting immunity to disease? If the horse can produce antitoxin when injected with toxin, cannot the same process be applied to man? It is obviously unwise to inject unaltered toxin into human beings, but it has been found that the human body will produce antitoxin when we inject a suitable mixture of toxin and antitoxin. This produces a lasting immunity from diphtheria. The Schick test is very useful in this connection, since we can determine those who are susceptible and then proceed to immunize these alone without the necessity of having to do it to everyone. Further, we can see if the immunization has been successful, for if it has, the Schick reaction should then become negative.

The wholesale immunization of people has been tried in America, and certainly in New York the mortality from

[1] Topley and Wilson, *op. cit.*, p. 1156.

diphtheria has fallen considerably. At the same time it must be observed that the mortality in this disease is subject to unexplained fluctuations when no preventive measures are tried. The fall in mortality *might* have occurred without any precautions at all!

In certain fever hospitals an enormous reduction in the incidence of diphtheria among the nurses has occurred when they have been immunized. These results are much more significant because the reduction is four times the probable errors of estimation.[1]

Diphtheria is spread by contact with those suffering from the disease, by human carriers and by cows. The latter develop diphtheria lesions on their teats which may discharge supplies of highly virulent bacteria into the milk. All of these sources of diphtheria, once known, can be stopped and if this were done and all Schick-positive persons could be immunized, there seems every possibility that we could extinguish the malady entirely.

In scarlet fever a test similar to the Schick test has been devised to discover those who are susceptible. This is the Dick test and and it consists, like the other, of the intradermal injection of a toxin prepared by filtration from a bacterial culture. The culture used is of streptococci which are almost certainly the cause of scarlet fever. The test is positive at the beginning of the illness but 80 per cent. negative after the attack. A serum has also been prepared from the blood of animals who have been inoculated with increasing doses of the same streptococcal toxin. This antistreptococcal serum is now used in the treatment and sometimes in the prevention of scarlet fever, though it produces only a temporary (passive) immunity.

There is also a method of producing artificially a permanent immunity to scarlet fever. As with diphtheria,

[1] Topley and Wilson, *op. cit.*, p. 874.

this is done by injecting gradually increasing doses of toxin and it is claimed that this procedure will effectively protect the majority of susceptible persons.[1] Furthermore, " scarlet fever and diphtheria prophylactics may be safely administered as a combined injection ". This method has been used with success on the nursing staffs of fever hospitals and is without doubt an effective method of prevention.

Recently it has been found possible to prevent the onset of measles by the use of a serum. This again is prepared from the blood of a patient who has just had the disease and is convalescent. The serum is injected into those who have been in contact with the disease and produces a passive immunity which probably lasts about four weeks.

To prevent the disease from developing at all it is essential that the serum should be injected before the fifth day after the contact. If it is given after more than nine days it has no preventive effect and the disease runs its usual course. If, however, the injection is made between the fifth and the ninth days, then the patient develops a mild attack of measles and this leaves him with a lasting immunity. This last method will probably be the one which will be used very widely in the future. Its general application is at present limited by the difficulty of obtaining adequate supplies of this human serum.

There is good ground for hoping that in the not far distant future there may be some kind of serum treatment available for influenza. Before 1933 experiments with the alleged filterable virus of this highly infectious disease had been difficult because no animal had been found to be susceptible to the infection. Now it was shown that ferrets could be infected with filtered throat washings from a patient with influenza.[2] Furthermore, the infection could

[1] Benson and Rankin. *Lancet*, 1934, II, p. 1357.

[2] Wilson Smith, Andrewes and Laidlaw. *Lancet*, 1933, II, p. 66.

be readily transferred from ferret to ferret. If virus was mixed with serum from a ferret which had been infected and had recovered, then it became harmless. Recovered ferrets were not susceptible to a further infection for at least some weeks. Most important, too, is the fact that neutralizing antibodies were found in serum from recovered human beings. In 1934 it was further discovered that mice also can be infected. This is likely to expedite the research. It is unlikely that any really good method of inducing an active immunity will be found because one attack of influenza does not protect against another.

Recently a serum has been used in the treatment of certain types of pneumonia. There are several kinds of pneumococcus and with certain of these the results of serum treatment have been disappointing. It is difficult to obtain reliable statistics since the mortality of pneumonia varies so much with each outbreak. Nevertheless there is good reason for supposing that in some instances, at least, a very appreciable reduction in the mortality has been achieved.

(c) Vaccines

We have seen how immunity can be artificially produced firstly, by inoculation with an attenuated *living virus*, and secondly, by the use of toxin-antitoxin mixtures. There is a third available method which, in certain instances, has proved invaluable. This is the injection of emulsions of *dead* germs. These emulsions also have regrettably been christened " vaccines " although they have nothing whatever to do with cows. The original antismallpox vaccine of Jenner was prepared directly from infected cows and in this instance only does the name seem justified.

Pasteur believed that immunity could be acquired only by infection with living bacteria. In certain diseases where it has been impossible to grow the organisms in pure culture, unmixed with other substances, we continue to use the living virus. This is still done in rabies and in smallpox.

More recently efforts have been made to deal with tuberculosis by wholesale immunization with living germs of lowered virulence. Dr. Calmette has produced a strain of weakened tubercle bacilli which is generally known as B.C.G. (Bacillus Calmette-Guérin) which is lineally descended, through successive sub-cultures made at fourteen to twenty-five-day intervals over a period of many years, from bacilli originally isolated in 1901.

The results of prolonged investigation go to confirm Dr. Calmette's view that B.C.G. can be used as a vaccine without any danger of causing progressive tuberculosis.[1] Obviously, however, we should feel happier if some method could be found by which dead germs could secure effective immunity. This is clearly the safer course. In this connection it may be wise to bear in mind the ghastly affair at Lübeck in Germany.[2] In the winter of 1930-31 some two hundred and fifty infants were given by the mouth (*not* by injection) this vaccine which was prepared by sub-culturing the organisms received from Paris. Within three months sixty-eight of them were dead of acute tuberculosis. The question at issue was whether the B.C.G. for some unexplained reason, had become suddenly virulent or whether there had been some blunder whereby another virulent strain of organism had been given in error. The court of inquiry took the latter view and punished those whom it held responsible,

[1] Stanley Griffith. *Lancet*, I, 1932, p. 303 *et seq.*

[2] *Lancet*, I, 1932, p. 353.

so that Calmette's vaccine was vindicated; but it may be observed that legal and scientific proof are not always the same.

It is certainly true that many thousands of infants have been treated with B.C.G. without untoward results except at Lübeck. How far this treatment attains its object cannot be calculated with any scientific accuracy. It is too early to judge the results.

Robert Koch, the brilliant discoverer of the tubercle bacillus, had hoped that his work would be the key to a certain cure for tuberculosis. Enthusiasm ran high, but Koch was modest in his claims and cannot be held responsible for "the mad rush of sick and dying to Berlin".[1] Koch prepared a non-living toxic substance from cultures of tubercle bacilli which he named tuberculin. If a very small quantity of this is injected into a new-born infant who has not been infected, there is very little reaction. With a healthy adult who is not clinically found to be tuberculous but who has at one time been infected, there is more reaction. Any animal that has once been infected is, in fact, very sensitive to the toxin. It is found that ninety per cent. of persons in big towns react positively to tuberculin.[2] It seems then that most people are, at one time or another, the victims of a slight infection with tuberculosis, that they recover and have some kind of resistance to the disease. This accounts for the fact that, in spite of the widespread possibility of infection, only a relatively small number of people seem to develop obvious signs of the disease. This is corroborated by the fact that in post-mortem examinations old and healed tuberculous foci are often found in people who have no history of having suffered from tuberculosis.

[1] Sir Robert Philip. *British Medical Journal*, 1932, II, p. 1.

[2] Topley and Wilson, *op. cit.*, p. 835.

Tuberculin is of great value in diagnosis both in man and in animals. Thus it has been possible to test cattle and in this way to collect herds of tested cows that are guaranteed to give milk which is free from all tubercle bacilli. This seems to be a highly desirable measure in spite of the argument advanced by some that, by drinking small quantities of tubercle bacilli, a child gradually acquires immunity to the disease. This argument will hardly appeal to those who know that more than two thousand children die every year in England and Wales from bovine tuberculosis, which probably comes from drinking tuberculous milk.[1]

It will not have escaped the reader that the tuberculin reaction presents a marked contrast to the Schick reaction. If a patient reacts positively to tuberculin we say that he must have been previously infected with the tubercle bacillus. On the other hand if he reacts positively to an injection of diphtheria-toxin we say that he is likely to take the disease if he encounters the diphtheria bacillus. Those who have had tuberculosis are tuberculin-positive. Those who have had diphtheria are Schick-negative. This is an unfortunate discrepancy. Attempts have been made to explain away this by showing that in the case of diphtheria the patient develops antitoxins which neutralize the toxin used in the test, while in tuberculosis no such antitoxins are formed, but that, on the contrary, the body becomes "sensitized" by the action of the toxin derived from a previous infection. Such "explanations" are not very satisfactory, but the valuable facts remain and can be used purely empirically. The whole theory of immunity is by no means an orderly one, and if new facts emerge that are inconsistent with it, then so much the worse for the theory.

[1] Topley and Wilson, *op. cit.*, p. 839.

But let us return to the subject of vaccines made from dead organisms. The classic instance of this kind is the antityphoid inoculation, for the successful exploitation of which we are indebted to Sir Almroth Wright and his co-workers. Enteric fever (which includes typhoid, paratyphoid A and paratyphoid B) is in general conveyed by sewage—polluted water—either directly or through some such agency as oysters which have been grown in contaminated areas. Consequently any community which can build for itself an efficient system of sanitation can reduce the incidence of enteric fever almost to vanishing point. There is likely to be always some difficulty in dealing adequately with chronic typhoid carriers.

The three diseases—typhoid fever, paratyphoid A and paratyphoid B—are only distinguishable from each other by bacteriological means. It happens that, while a person who has recovered from an attack of one of these diseases has a good immunity against future infection, he may not be immune from the other two. Consequently the vaccine used must contain all the three germs. These vaccines will only be necessary for preventive purposes in districts where the disease is prevalent or where there is inadequate sanitation. British troops proceeding abroad are all urged to undergo inoculation. Nearly 98 per cent. of such soldiers are thus treated.[1] In 1930 there were twenty-four cases of enteric fever among the inoculated soldiers and four cases among those not inoculated.[2] At first sight this must seem unfortunate for the prestige of the method, but we must consider that nearly all the soldiers were inoculated. We then find that 0.09 per cent. of those inoculated took the fever, while 0.73 per cent. of those not inoculated did so. There seems little doubt that to anti-typhoid inoculation we owe the remarkably small

[1] *The Health of the Army*, 1930. [2] ibid., p. 9.

incidence of enteric fever among the British troops during the Great War.

It is impossible here to analyse the enormous mass of miscellaneous information which has been discovered about the way in which immunity is produced or the mechanism of the action of the blood on invading organisms. Briefly, it may be stated that a number of substances having a hostile action on infective agents have been demonstrated. They have not been isolated but their presence is presumed from the properties of immune sera. These agents have been stigmatized by the unhappy appellation of "antibodies".[1] We have already discussed the antitoxins; but besides these there are substances which cause the germs to break up into fragments, to heap themselves into clumps or to be precipitated.

The blood contains numbers of white corpuscles which have the power of taking organisms into their interiors and digesting them. These are the "phagocytes" about which we read in Bernard Shaw's brilliantly satirical play.[2] Sir Almroth Wright has shown that there are substances, called opsonins, in the blood which act upon the organisms so that they are more readily devoured by the phagocytes. Further, he has pointed out how the quantity of opsonins at any given moment can be estimated. From this he has found that there is a right time and a wrong time to administer vaccines. When germs are injected into the body there is first of all a decreased resistance, and then later the resistance to infection becomes greater than ever it was before. It follows, then, that it is necessary to avoid injecting a second dose during the phase of decreased resistance, otherwise the resistance will be still further

[1] See Sir Arthur Quiller-Couch on this. *The Art of Writing*, Cambridge 1920, p. 34.

[2] G. Bernard Shaw. *The Doctor's Dilemma*, London, 1911.

decreased and the patient in a correspondingly worse condition.

In general these antibodies are "specific": that is to say, they react only towards the kind of germ which induced their formation in the first place. We can therefore use them for diagnostic purposes. Thus, if we find in a patient's blood substances which will agglutinate, say, typhoid organisms, we can conclude that either he is suffering or has suffered from typhoid fever, unless, of course, he has had antityphoid inoculation, which also produces agglutinating substances.

Conversely the same method can be used to identify the species or strain to which an organism belongs. If we suspect that a bacterial culture is, say, paratyphoid A, then if we mix it with a serum which is known to agglutinate paratyphoid A, our bacillus should become agglutinated. If it does not, it cannot be paratyphoid A. It is by means of biological tests such as this that we can differentiate between organisms which appear identical under the microscope. It was in this kind of way that the paratyphoids were distinguished from the typhoid bacillus and the four types of pneumonia organism were discovered.

When the *bacteriolysins*, which disintegrate bacteria, act upon the corresponding bacteria, there is also removed from the blood a third substance called "the complement" which is normally present in everyone's blood. It has been found possible to test for the presence or absence of this substance in normal blood in which we have mixed the disease-producing agent with the serum of the person we suspect of containing antibodies. One of the most famous of these tests for the disappearance of the complement is the Wassermann test for syphilis. If the complement is reduced in amount after mixing the appropriate substances we say that there is a positive Wassermann. This is often a help in the diagnosis of this disease. Unfortunately for the theory of the matter it has been shown that it is quite unnecessary to use syphilitic material to mix with the serum and blood in carrying out the test. In fact extracts of normal liver act just as well so that the test has not the specificity which was originally attributed to it. However, the fact remains that the results of the test have coincided in a remarkable way with the clinical findings. We therefore use the test empirically while admitting that we have no explanation that will cover all the facts.

(d) The Attack by Means of Drugs

One of the most ancient methods of combating sickness has been by the use of drugs. Many people seem to think that there must be a drug appropriate to every disease and that once this is diagnosed it is only necessary to "look in the book" to find the right physic. Unhappily there are very few drugs which have a direct action in curing the diseases for which they are administered. Most of the drugs in the pharmocopœia are useful only in removing some unpleasant symptom, or in treating some aspect of the disease. For example, we give aspirin for a headache. This often removes the headache but not the cause of it. If the cause is a trifling one, it may have vanished before the aspirin loses its effect, but this is not always so, for headache has a multitude of causes. Similarly, morphia removes pain but not its cause. Purgatives remove constipation without always removing its cause.

Among the drugs which do have a definite specific effect on the causal organism of a sickness is quinine. This drug was imported into Europe from South America in the seventeenth century, or rather, the crude Cinchona bark,[1] Peruvian or Jesuit's bark, from which quinine itself was not isolated until the early nineteenth century. Cinchona is grown now also in the old world, in Java. The bark was used for the ague without any knowledge of its action except the most important fact that it was successful.

It has been discovered that quinine exerts a definitely hostile action on certain phases of the life-cycle of the malarial parasite in the blood of the invalid. Unfortunately, it has little or no action on other phases of the parasite. More recently other synthetic products have been tried and some of these have been found which will attack the parasite in its other phases. Some of these products are too poisonous to be used regularly in preventing infection with malaria. The results of trial with various drugs have not always been consistent, and it is possible that this is due to the fact that there are different breeds, so to speak, of malarial parasite which are more or less resistant.[2]

Since quinine acts only at one period in the life-cycle of the parasite, it has certain grave disadvantages. Firstly, it does not prevent infection even when taken in huge doses, secondly it does not always prevent relapses, and thirdly it does not prevent the mosquitoes from becoming infected from the blood of human beings. Plasmoquin and atebrin, two synthetic drugs, will attack the parasite at other stages and in certain cases will prevent the infection of human beings from a mosquito bite. Plasmoquin will also keep the parasite under control during the phase when the mosquito is liable to become infected. Thus these two

[1] First used by the Countess of Chinchon, the vice-reine of Peru, in 1638 (Dr. Murray's Dictionary). The name was given to the plant by Linnæus in 1742: but the facts about the Countess are said to be inaccurate. (*British Medical Journal*, 1932, II, p. 212.)

[2] *British Medical Journal*, 1932, II, p. 57.

drugs are valuable not as substitutes for but as auxiliaries to quinine.

The search still goes on for some product which may be at the same time lethal to the parasite, least harmful to the patient and, what is of very great importance, cheap enough and abundant enough to be used on a large scale. It will be recognized how necessary is this last condition when it is known that the British Empire, inside which the bulk of the three and a half million deaths from malaria recorded annually occurs, spends each year about £450,000 on quinine alone.[1]

Malaria is still very far from being under control. The recent epidemic in Ceylon serves only too clearly to illustrate the fact. Here, in an area smaller than Yorkshire, fourteen and a half tons of quinine, costing £50,700, were used but even so the mortality was enormous. Immense sums have been spent throughout the world with varying success in different parts. We are assured by Col. S. P. James that in Lagos, the capital of Nigeria, in spite of great expenditure the present position is that every native above the age of one year has malaria.[1] The methods of exterminating the mosquitoes can hardly be carried out on a sufficiently wide scale, so that at present we must pin our hopes on the chemists who are looking for the much needed drug.

The substance that had been mostly in vogue against syphilis had for many years been mercury. When the pale spirochæte had been discovered in 1905 by Schaudinn, it was hoped that some successful method of killing it would soon be found. The invention of staining methods in the examination of organisms under the microscope had given rise to the idea that it might be possible to find a dye that would at the same time be poisonous and also stain

[1] S. P. James. *Nature*, 1935, cxxxvi, p. 743.

the organisms of disease more readily than the tissues of the host. The hunt for such a substance to stain the spirochæte of syphilis led to the magnificent discovery of salvarsan by Ehrlich in 1909.

There must be few who have not heard of " 606 ", Salvarsan, the drug which has saved so many from the horrors which are the late manifestations of syphilis. There will be fewer still who can appreciate the immense labour expended in the inconceivably industrious search for such a poison—for poison it is, both to the spirochæte and to human beings. The precautions to be taken, therefore, in its administration are many. Salvarsan must be given in dilute solutions, in small doses at a time, into the veins of the patient so that it is rapidly diluted again by the patient's blood and as rapidly disseminated throughout his system. Each dose, too, must be given at lengthy intervals of time. Woe betide him who receives it into the tissues around the site of the injection and not quite into the vein. The local poisoning which follows is an unhappy experience. It is necessary, too, to give the patient rests between each bout of treatment to let his body recover from the poison. During this interval it is usual to resort to the older drugs, mercury and bismuth.

The success of salvarsan, or rather its more modern modifications such as neo-salvarsan and other compounds, has been remarkable. There seems little doubt that the disease can be cured, at least in its earliest stages, by the persevering and regular administration of this drug. Unfortunately it has not been possible to produce immunity with any vaccine made of dead spirochætes.[1]

Arsenic is one of the elements which go to the compounding of " 606 ", and arsenic is contained in the drug " tryparsamide ", which has been invented in the

[1] Topley and Wilson, *op. cit.*, p. 1191.

endeavour to kill off the trypanosomes in the blood of the unfortunates who suffer from sleeping sickness. Tryparsamide and other drugs too, including metallic antimony, have been found very useful in the treatment of individual cases, but it must be realized that, unlike some of the remedies for malaria, these drugs are of no avail at all in the control of epidemics of the disease.

The drug known as Emetine has proved of very great value in treating certain forms of dysentery. There are two main kinds of this disease—namely, that caused by certain bacilli and that which is due to an attack on the bowel by a species of amœba called *entamœba histolytica.* Emetine, which has a lethal action on the entamœba, is of value only in amœbic dysentery. The entamœba has the power of burrowing, or rather, digesting, its way into the tissues of the patient's bowel and may form abcesses in more distant sites. These will call for surgery. Bacillary dysentery can be treated with a specific serum.

(e) One Disease used to Attack Another

An interesting experiment conducted by Pasteur is very significant in connection with recent attempts at the cure of General Paralysis of the Insane. Pasteur had been unable to infect birds with anthrax.[1] Colin had claimed that nothing was easier, but he never produced the chicken, dead of anthrax, which he had promised to Pasteur. However, Pasteur turned the tables on Colin by producing the infected bird himself. Now chickens, and other birds too, have a much higher temperature than mammals. The normal temperature of a chicken is about 107 degrees Fahrenheit, as opposed to 98.4 degrees Fahrenheit in

[1] Vallery-Radot. *La Vie de Pasteur*, Paris, 1900, p. 384.

human beings. Pasteur wondered if the immunity of chickens to anthrax lay in this difference of temperature. He took a chicken and gave it a prolonged cold bath. Its temperature was lowered and, sure enough, the bird took the disease and died.

This is remarkably interesting. Perhaps the fever which accompanies many infections is a reaction which tends to be hostile to the invading parasite. It is therefore unwise to try to reduce the temperature of a feverish person by means of antipyretic drugs. We may be robbing him of his one chance of defeating the infection. Lowering the temperature artificially should be done by means of carefully regulated cold baths and only when the temperature is increasing so rapidly that the patient is threatened with death from the very height of the temperature itself.

General Paralysis of the Insane is an occasional late manifestation of syphilis. Its truly syphilitic nature, long suspected, was proved by Noguchi, the Japanese bacteriologist, who, after a long and unwearied search, found the spirochætes in the brain of a man dead of general paralysis. This slowly progressive disease involves, as its name implies, both paralysis and insanity. The march of the disease is slow but unrelenting. Now it was noticed that there was sometimes a remission of this disease in patients who caught malaria in addition to the syphilitic disease. Following up this clue attempts have been made to cure general paralysis by purposely infecting the patient with benign malaria from the bite of an infected mosquito. The success of these measures has been limited.

Good results, however, have been reported in Germany[1] and America.[2] At one American hospital 192 patients

[1] Bonhoeffer und Jossmann. *Ergebnisse der Reiztherapie bei progressiver Paralyse*, Berlin, 1932.

[2] W. A. White. *The Malarial Treatment of Paresis*. International Clinics. Vol. III, Forty-first Series, Sept., 1931.

were successfully inoculated with malaria. Of these 140 were definitely improved, fourteen remained unchanged, while in twenty the disease continued its progress. Eighteen died. At first sight this may not seem a very encouraging result. but let us compare with this another series of cases of General Paralysis treated in the same hospital, but without using malaria. Of 214 patients, 137 were dead in less than one year, while only five were alive after five years. Thus we can see that the method offers a very considerable chance of improvement for the patients; but it would be idle to deny that some of them die of malaria. Nevertheless it is surely preferable to run some risk of death: —

> " To jump a body with a dangerous physic
> That's sure of death without it." [1]

To the untreated comes an almost certain death when the brain is gradually rotted away and one by one the faculties leave the body speechless, paralysed and insane. The method must, of course, be followed up, after several recurrent fevers, by doses of quinine to cure the malaria. It has been suggested that the curative effect of the malaria is due entirely to the recurring fevers which this disease produces. Therefore other and safer methods of raising the temperature of the patient have been tried. Among these the injection of sulphosin, which is a suspension of sulphur in olive oil, has certainly been followed by some cures; but the proportion of successful results is very much less than when malaria is used.

The principle that one disease may cure another had previously been used in several methods of treatment. Among these we may mention blistering, blood-letting or the administration of emetics. Metchnikoff, the discoverer

[1] *Coriolanus*, III, i, 154.

of phagocytes, had said that lactic acid was a life-giving principle which counteracted bacteria and poisons in the bowel. He therefore proposed that one should eat quantities of the lactic acid bacillus which would be detrimental to the harmful bacteria in the intestine. This is another example of setting a thief to catch a thief, although the lactic acid bacillus (which we can buy in certain kinds of cheese) is in itself quite harmless.

(f) Storehouses of Infection

There is yet a further method which we have to destroy the ill-effects of microbes in the human body. This is by removing them *en masse* where this is possible: that is to say, when they are all collected in some localized situation which is accessible to the surgeon's knife.

The opening of abcesses, with subsequent drainage by means of tubes or dressing, is ancient history. More recently it has come to be realized that there are certain organs in the body which frequently become infected and act as a kind of reservoir, from which germs and poisons are consistently sent out to the rest of the body. The tonsils, the chronically inflamed appendix or gall-bladder, or the various air spaces which lie within the thickness of some of the bones of the skull; all these can, and do frequently, act in this way. Pyorrhœa or abcesses round the roots of the teeth often form such a focus of infection.

Sometimes a patient may be ill in some rather indefinite way, while at other times there may be symptoms which definitely point to one or another of these organs as the source of the trouble. Chronic rheumatism, for example, may be exacerbated if not actually caused by some localized infection. In all diseases where the general health is at fault it is important to examine a patient with the thought of these "septic foci" in mind and often the removal of such a source of poisoning has made a striking improvement in the health of an invalid.

In this connection constipation, that nightmare of some and hobby-horse of others, must certainly receive mention. It is another infective focus. The relief of constipation is almost always desirable, but it is very doubtful whether a costive patient does himself all the irreparable damage which some ardent preachers would have us believe.

VI. Some Larger Parasites

We must not leave the subject of the living causes of disease without making mention of some of the larger animal parasites. The bacteria belong to the vegetable kingdom, while the parasites of malaria, sleeping sickness and amœbic dysentery are members of the single-celled and primitive animal group known as protozoa. There are, however, certain very much larger internal parasites which are extremely worthy of note not only because they cause considerable damage to human life in many parts of the world but also because of the great interest attaching to their very remarkable life-histories. We have already discussed the importance of certain carriers of diseases such as lice, but we must now turn to some of the animals which cause disease from their very presence, independently of any smaller parasite, virus or bacterium that they may carry. The existence of many of these creatures must in the nature of things have been noted long ago, but it is only quite recently that their strange habits have been fully disclosed.

The first large group of these are the flukes. In many tropical and sub-tropical parts of the world, notably Africa, India, parts of Asia (including Japan), West Indies and Brazil, there occur varying forms of disease due to infection by these animals. The symptoms are generally those of irritation of the bladder or rectum with considerable hæmorrhage, fever and other disturbances. The first of the flukes which cause these disorders was discovered by the German Theodor Bilharz in Cairo in 1851, while

Manson found a different species in 1903, and a third variety has also been found in their own country by Japanese biologists.

These schistosomes, as they are called, are minute flat worms, about half an inch in length. They are chiefly remarkable for their extraordinary life-cycle. They effect an entrance into man while he is washing in or drinking infected water. Tiny swimming larval forms pierce the skin or the lining of the mouth or throat and so enter the blood-stream. In this they are carried to the lung, through the small blood-vessels of the lungs and so to the heart. From there they are pumped with the blood into the main circulation and travel to the stomach and intestine, and thence into the great vein which brings the blood from these regions to the liver. Once in the liver they mature rapidly and conjugate. They then travel down another vein until they reach the neighbourhood of the bladder (or intestines). From this coign of vantage the female worm discharges her eggs which find their way into the urine. It is in passing through the wall of the bladder that the eggs cause the main symptoms of irritation.

The eggs are voided in the urine and so escape into water. In order to develop into the larvæ which can infect other human beings, the embryos must enter certain freshwater snails, for these intermediate hosts are quite essential for the full life-cycle of the parasite. This remarkable requirement is very fortunate because it at once provides us with a method of preventing the disease, namely, by exterminating the snails. This can be done by periodically drying up the pools where they live, by poisoning them with compounds of copper or by employing ducks to eat them up. Apart from these means human beings must drink filtered water and avoid washing in water where the snails are found. It is also important to see that the excreta of infected persons (or indeed any other) are not allowed to pollute the water-supplies. Once infected, patients are healed effectively with injections of compounds of antimony which in time will kill off the worms.

There is in this country also a very common fluke, *Fasciola hepatica*, which sometimes attacks man, although it more generally works considerable havoc among sheep. The disease known as "sheep-rot" which may be so disastrous to the farmer is caused by the invasion of the liver of the sheep by this parasite. In the liver the flukes lay their eggs which are discharged into the intestine along with the bile and so reach the outside in the fæces. When the eggs reach water they open to allow the little embryos to escape. Here again, for further development, the necessary intermediate host is found in a freshwater mollusc which is common enough in swamps and ditches. Inside the mollusc the embryos find their way to the liver and after developing they leave their host and attach themselves in little cysts on blades of grass. In this way fresh sheep or men can become infected from chewing the grass: and so the cycle recurs. Sheep-rot, like schistosome infection, can also be prevented by extermination of the responsible molluscs.

In parts of Asia there is another species of liver-fluke which is frequently found in the bile-passages of Chinese and Japanese. This fluke is remarkable in that after passing through the appropriate mollusc it seeks a second intermediate host in gold-fish or carp, where it remains dormant. Human beings may become infected by eating such fish without thoroughly cooking it. The way to prevent this is obvious enough and be it added that prevention here is very much the better road; for there is no satisfactory cure.

Let us now turn to much larger parasites, the tape-worms. There are some five varieties, of which four are found in the intestine of man. Apart from the dwarf tape-worm, they vary in length from ten up to as much as thirty feet. They consist of a head which fixes the worm to the wall of the intestine and a great number of segments, those furthest from the head being the most mature. Each segment is almost a complete individual, being able to produce fertilized eggs. The ripe segments drop from the worm and are discharged in the excreta, and the eggs become freed. These are then eaten by an intermediate host, which varies with the species of worm, and burrow into its muscles. Here they remain until they are eaten in uncooked flesh by another individual, when they develop into adult worms.

The three main intermediate hosts for the three larger species are respectively the pig, the ox and in the case of the Russian tape-worm, the largest of them all, certain fish such as trout, grayling or pike. Here, man infects himself by eating insufficiently cooked pork, beef or fish as the case may be. It should be added that it is very doubtful if smoking fish kills the worms, so that certain smoked fish—for example, those which are not otherwise cooked—may convey the infection to man. Prolonged freezing is said to be effective in killing the parasites.

The tape-worms are very unpleasant but by no means very dangerous infections. They may not give rise to any symptoms at all and be noticed only accidentally by the discovery of whole segments or eggs in the excreta. There may, however, be a noticeable increase in the appetite of the infected person and sometimes pains and indigestion or psychological disturbances. Fortunately in the extract of the male fern we have a potent remedy for the destruction of the invader. This drug is given on an empty stomach and followed up by a brisk purge (*not* castor oil, because this dissolves a poisonous ingredient from the drug and so allows it to be absorbed with serious consequences). It is important to be sure that the head of the parasite has been discharged because if not the worm can quickly grow as big as ever it was.

There is another very small tape-worm which lives in the intestine of the dog. The intermediate host in this case may sometimes be man. If a living egg is swallowed the embryo burrows into the inside of its host and may finish up in almost any situation but it generally lodges in the liver. Here it may form a cyst which may grow as big as a coco-nut or even larger. These cysts are known as " hydatid cysts " and are very common in Australia and Iceland but may occur in any community which keeps dogs. The symptoms may not be at all serious, but the growing cyst may press upon important structures and give rise to symptoms which will vary according to the position of the cyst.

The methods of prevention of this disease must be, firstly, to prevent the dogs becoming infected, which they frequently do from eating infected meat in slaughter-houses, and secondly, by preventing them from fouling food or water intended for human use. If hydatid cysts cause trouble from pressure, then they can often be removed by the surgeon.

There is yet another large group of worms which infect human beings, namely, the *round-worms*; and these, too, have the most curious life-histories. The commonest of them all is *ascaris lumbricoides* which looks not unlike a very long and pale earthworm. These worms live in the human intestine where they lay their eggs which pass out with the excreta. They have no intermediate host and to become infected requires the direct swallowing of the eggs.

When such an egg is eaten it quickly hatches and the young worm pierces the wall of the gut and is carried in the blood-stream to the liver, to the heart and then to the lungs. Here the worm finds its way into the internal air space of the lungs and travels up the air tubes into the wind-pipe, past the vocal chords and, when it reaches the throat it is swallowed down the gullet and so arrives in the intestine where it grows to its full size of some inches. Here is a most extraordinarily roundabout route for a worm to travel and, at the end, it finds itself at the place where it started.

A person infected with ascaris may be quite unaware of his condition or may be troubled with vague "stomach-ache"—but on the other hand the worm (or worms, for many may be present) may cause obstructive symptoms or wander into the appendix and set up inflammation there. If many eggs are swallowed at once then symptoms of pneumonia may be caused by the worms as they travel through the lung. This worm, like the tape-worm, can be killed with drugs; but in this case santonin is used instead of the male fern.

The thread-worm is smaller but, like *ascaris*, is very common in this country. It is said to develop directly in the intestine. The same is true of the whip-worm. A more interesting creature is the Guinea-worm which is not found in England but occurs commonly in India, Arabia, Turkestan, Iran, Africa and the tropical parts of South America. This worm lays no eggs, for the embryos are born alive and swim about in water until they meet a minute freshwater crustacean called *cyclops;* they then find their way into the body cavity of this intermediate host and await the moment when the *cyclops* is accidentally swallowed in drinking water by a human being. The young worm burrows through the stomach wall, develops in about twelve months in the body tissues, mates and while the male dies, the female starts to wander until she comes to lie under the skin. Here the Guinea-worm may be seen and sooner or later she puts her head through the skin, making a little ulcer, through which the new-born embryos are discharged. The natives extract the worm by means of a stick, round which they wind the protruding end of the creature, and each day the stick is turned a little more, so that gradually the whole worm is secured. It is most important not to hurry the process as the worm will break and it will be impossible to extract the rest of it.

The hook-worm is of considerable interest in that it is a potent cause of anæmia in tropical and sub-tropical countries. It occurs also in colder regions but is then confined to such sheltered localities as tunnels and mines. This worm caused severe damage to the men engaged in the construction of the St. Gothard Tunnel. In 1902 it was discovered to be the cause of the severe "miner's anæmia" which attacked the underground workers in the Cornish mines.

The worm, which is from one-third to one-half an inch long, lives in the upper part of the small intestine of man and discharges its eggs which leave the host in the excreta. If the outside climate is suitably warm and moist, the larvæ develop into a very sharp needle-like body about one-fifth of a millimetre long. This can pierce the bare skin of man and so find its way via the heart, lungs, air-pipe, gullet and stomach to the small intestines where it can develop into a full-sized hook-worm. When the larvæ pierce the skin they often give rise to a rash which is known as "ground itch", but the chief trouble is due to the worm itself which causes grave anæmia, resembling pernicious anæmia, emaciation, fever and dropsy.

The methods of preventing this disease are by segregating those who are infected, by promoting cleanly habits among the miners and providing sanitary accommodation for them and stout boots impregnated with oil. A very effective method of preventing the spread of the disease is by making the climate of the mines or tunnels unsuitable for the development of the eggs of the hook-worm. This can often be achieved by ventilation, drainage or washing with lime. Those who have contracted the disease can best be rid of their unwelcome guests by a suitable dose of carbon tetrachloride followed by a purge.

The last worm which we have space to mention here is the thin thread-like filaria which is the cause of elephantiasis—a hideously deforming disease which is prevalent in Africa, Asia, the West Indies, South America, the South Seas, and some parts of Australia. The worm lives in the lymphatic system of human beings and it is by blocking up the lymph channels that it brings about the enormous dropsical swellings which are the characteristic features of the disease.

Little filariæ are born and live in the daytime in the lungs, but at night they earn their name *filaria nocturna* by their habit of migrating to the skin where they can be found in the blood. In this superficial blood they are found by the nocturnal mosquito *culex fatigans* which is mainly responsible for the spread of the disease. In this respect the *culex* plays a very similar rôle to that of other mosquitoes in malaria and yellow fever. Extermination of the mosquito is the best method of prevention. It is interesting to note that it was the discovery of a filaria which was transmitted by mosquito bites that led to the conception of insect carriers of disease and so to the magnificent discoveries to which we have referred above.

VII. Hormones

The conception of the control of the body by chemical means has, in recent years, provided medicine with a whole series of new therapeutic weapons. The history of chemical messengers or hormones, as they are called, may be said to have begun in 1855, when Dr. Thomas Addison of Guy's published his work *On the Constitutional and Local Effects of Disease of the Suprarenal Capsules.*[1] He described a disease which is characterized by progressive loss of strength, anæmia, low blood-pressure and an enfeebled heart, together with curious patchy discoloration of the skin. The oddest part of his discovery lay in the fact that in every case of this disease he found that the little gland perched on the top of each kidney (the suprarenal "capsule") was degenerated. If the failure of these little glands was the cause of the other changes, then here was something quite new: that a minute disturbance in a special organ could cause so profound and generalized a change. At the time of the discovery, however, its full significance was missed and for a long time the matter remained a pathological curiosity.

A further step in the elucidation of the mystery was taken by Charles Edouard Brown-Séquard, the Americo-Frenchman, who succeeded Claude Bernard at the Collège de France. Brown-Séquard cut out the suprarenal capsules from animals and they rapidly developed symptoms which could be described as an exaggerated caricature of Addison's disease. Here was proof that failure of the

[1] London, 1855.

suprarenal glands was the cause and not one of the many effects of the condition. It should be noted that this experiment was conducted by operative surgery; for, as we shall see, much of our knowledge of hormones has been gained by procedures such as this.

We must now turn to the thyroid gland, a structure with two lobes situated, in man, on either side of the Adam's apple. A condition of enlargement of this gland, associated with other serious disorders, had been described previously, but in 1835, Robert Graves, a Dublin physician, put forward his classic account of the disease which now bears his name.[1] The patient—generally a woman—is "highly strung" and suffers from an enlarged thyroid gland, fine tremors of the hands, a rapid heartbeat and protruding eyes. This latter symptom explains the alternative name of the disease—"exophthalmic goitre". Here again was a mysterious alteration in one small gland producing serious constitutional disturbances, although in this case, unlike Addison's disease, there was not too little but too much of the gland substance.

There are, however, other diseases where the patient is suffering from deficiency of thyroid. As early as 1850 Curling described a condition of absence of thyroid which was accompanied by defective brain development and swellings at the sides of the neck. This disease is called *myxœdema*, the cause of which has now been definitely shown to be a degeneration of the thyroid gland in adults. A fully developed case of myxœdema presents an unpleasing picture. There is a great increase in bulk, the skin becomes puffy, while the features become coarsened with thick lips and enlarged nostrils, and the hair falls out. There is also marked mental sluggishness and the memory begins to fail.

[1] Graves. *London Medical and Surgical Journal*, 1835, vii Part 2, pp. 516, 517.

Closely allied to this condition is that of *cretinism* which occurs among children, particularly in definite localities—certain valleys in Switzerland, the Tyrol and the Pyrenees and, in this country, in Derbyshire. The child may appear normal when it is newly born, but generally when it is about eighteen months old it becomes apparent that the child's intelligence is sadly lacking, its growth below normal and its general form remarkably ugly. The bones fail to grow properly, the skin becomes doughy and hangs in folds around the joints and on the abdomen, and the hair is coarse and thin. The child fails to walk at the correct time and, in general, will never be able to perform anything better than a clumsy waddle. Its speech, if it comes at all, arrives late and it is often almost unintelligible. The child seldom grows to more than four feet high and when fully grown its mentality may remain that normally found at three or four years. All these symptoms are due to lack of thyroid gland. Cretinism and myxœdema are the same disease except that in the former the deficiency occurs early in life.

The actual proof of the cause of myxœdema came from two sources, both observers using the method of operative surgery. Moritz Schiff of Frankfort-on-Main first of all showed that complete removal of the thyroid gland was fatal to a dog. Later Reverdin at Geneva proved that a partial removal of this gland led to an experimental disease closely resembling myxœdema. Schiff went a step further when he demonstrated that the fatal results of his former experiments did not occur if he previously grafted a piece of thyroid gland elsewhere in the dog, before removing the gland from the neck. Evidently the thyroid acted by giving out some substance into the blood since the actual position of the graft made no difference. The fatal result could also be postponed by injecting the juices of thyroids into the dogs.

Dr. George Murray saw the importance of these discoveries and in 1891 he was able to announce that the the hypodermic injection of extracts of animal thyroid was very beneficial in cases of myxœdema. Directly following this, Howitz of Copenhagen and other independent observers began to try the effect of giving the patients thyroid to eat. Unexpectedly it proved equally as effective as the injections. The patients recovered steadily and almost completely. No one who has not seen such a remarkable occurrence, or at least periodical photographs of patients under this treatment, can truly appreciate the wonderful transmogrification, which can be likened to the changing of the Beast of the fairy tale into the Prince.

The same remedy was then tried on cretins and wonderful success resulted. The dose of thyroid must be very carefully controlled, for as we can see from cases of Graves' disease, an excess of thyroid can have highly deleterious consequences. But with proper treatment (which must be continued throughout the patient's life) it is possible to watch with wonder the slow process which transforms the misshapen moron into a normal healthy child.

It should be added that more recently chemists have been able to extract from thyroid glands a pure substance which performs most of the functions of the active gland. This is a compound containing iodine, which seems to be essential to the normal function of the human body. It is significant that in certain localities where simple goitre (which, unlike Graves' disease, is only harmful from its disfiguring appearance—unless indeed it attains sufficient size to interfere with breathing) is endemic it has sometimes been shown that there is a deficiency of iodine in the water or soil. Giving small doses of iodides has been found very useful in the prevention of this type of disease.

In 1902, while inquiring into the way in which the various digestive juices were poured into the stomach and intestine, W. M. Bayliss and E. H. Starling made a very surprising discovery. It was thought that the pancreas (sweetbread) gave out juice when the food reached the neighbourhood of the pancreatic duct, and that the mechanism was a local one. However, Bayliss and Starling were able to show that if they ground up a piece of stomach wall with some acid and then injected it into the circulation of an animal, a powerful flow of pancreatic juice resulted. Evidently, then, a substance contained in the acid stomach juices is normally absorbed into the blood-stream and conveyed by the blood to the pancreas, which is stimulated thereby to pour out its juice into the intestine. The discoverers called this hypothetical substance *secretin*.

Here was a new mechanism whereby messages or signals could be sent from one part of the body to another—by these chemical messengers or hormones as they were christened. It has been supposed that these mechanisms are survivals of the most primitive method of intercommunication and coordination of the body as a whole. The nervous system, previously the only known system of communication, is held to be a more recent evolutionary development.

The hormone mechanism has been compared with the penny post, while the nervous system is the electric telegraph. The analogy, however, is not a very good one since an individual hormone is carried everywhere in the body but acts only on particular tissues. It is probable, too, that the nervous mechanism is in the end a chemical process and that when the nerve impulse reaches its destination a small quantity of some specific chemical is formed, and it is this which produces the required response. The nerve generates the particular chemical locally where it is to act, while the hormone mechanism provides the chemical stimulus in bulk.

The discovery of secretin started the theory of the control of the organism as a whole, apart, of course, from interference from the nervous system, by chemical means; by hormones, in fact. It is probable that there are a very great number of these and that the behaviour of the body depends largely on some delicate balance between many hormones each tending to produce some different effect.

A typical hormone is found in adrenalin, a substance prepared from the central part of the suprarenal glands. This substance has nothing to do with Addison's disease, for the hormone of the latter seems to be manufactured by the cells of the outer crust of the suprarenal glands. In 1894 Oliver and Schäfer found that if they injected a watery extract of these glands into an animal there was a great rise of blood-pressure. Seven years later Jokichi Takamine succeeded in isolating in pure crystalline form the substance adrenalin which is responsible for this effect. This drug is extremely potent; a clinical dose is rarely more than a few drops of a solution of 1 part in 1,000 of water.

Adrenalin causes a rise of blood-pressure because it causes all the little arteries in the body to contract and thus the resistance to the blood-flow is increased. Because of this constricting effect adrenalin applied locally (say in nose-bleeding) is a very valuable drug for the control of hæmorrhage. Of course if it is injected into the general circulation the resulting rise of blood-pressure will have a bad influence on bleeding. The constrictor action of this drug is also put to good use in local anæsthesia. By mixing the anæsthetic with adrenalin the former is prevented from diffusing too rapidly away from the site of injection. Adrenalin is used in the treatment of shock and is also a very valuable stimulant to a failing heart. It also has the property of relieving spasm in the muscles of the air-tubes of the lung and is employed with great effect in asthma.

Quite recently adrenalin has been prepared synthetically in the laboratory from non-living materials. It was then found, rather oddly, that although perfectly pure, the synthetic variety was not nearly so potent as the natural animal stuff. It then turned out that there were two kinds of adrenalin, chemically identical except for the fact that the various atoms in each molecule were arranged "the other way round": one was the mirror-image of the other —left-handed and right-handed adrenalin as it were. The animal body prepares only left-handed adrenalin, to which it is singularly sensitive. The synthetic product is a mixture of equal parts of the left-handed and right-handed varieties. The animal body is about three times as sensitive to the former as to the latter. Hence the natural stuff is much more active than the artificial. This is a remarkable instance of how particularly and specifically the animal reacts to chemical substances. Alice made a very profound remark when she said to the black kitten: "Perhaps looking-glass milk isn't good to drink".

Adrenalin is quite without effect when swallowed because it is destroyed in the stomach. There is, however, a recently fashionable substance called *ephedrine* which was prepared from the ancient Chinese herbal drug Ma Huang in 1885. This has almost exactly the same pharmacological properties as adrenalin except for the fact that it is not so potent and is also not so readily destroyed in the animal body. Consequently its action is less marked but more prolonged, and it is active even when swallowed. It is used in asthma, hay fever, whooping-cough and bronchitis.

Another highly important hormone-producing gland is the pituitary, which is hidden away inside the skull, attached to the base of the brain by a short stalk. This gland, like the suprarenal capsules, is actually formed from two different kinds of tissue which have different functions and are derived embryonically from different organs. Nearly forty years ago it was found that an extract of the hinder (posterior) part of the gland when injected into animals caused a large and prolonged rise of blood-pressure. Later it was shown that the extract caused strong contractions of the muscles of the womb. The posterior part of the gland contains two highly active hormones, the one acting on the blood-pressure, the other on the womb. Extracts of posterior pituitary glands are now used extensively in medical practice under a variety of different trade names. They are used, for example, by obstetricians to ensure firm contraction of the womb after the child is born, and by surgeons to raise the blood-pressure in cases of surgical shock.

The front (anterior) part of this remarkable gland has very different functions, one of the most important being control of growth. It was found that certain giants and dwarfs had obviously deranged pituitary glands. In some cases it is possible to show by X-rays that the bony cavity in which the gland is lodged has become much larger than normal. Such an enlargement may be caused by a tumour of the anterior or of the posterior parts. In the former case there will be too much of the anterior part and this, if it occurs in young people, causes tremendous overgrowth of the bones and a giant results. If it occurs in adults then the disease known as acromegaly develops. This comes on insidiously. The bones of limbs and head begin to enlarge, the first symptom often being that the patient finds that he has to buy larger and larger boots or hats. The features become broader and coarsen and the lower jaw more and more prominent, until the sufferer assumes so characteristic an appearance that he may well be mistaken for a blood-relation of any one of his co-sufferers.

If a tumour of the posterior pituitary occurs, as it enlarges the anterior part becomes atrophied from pressure. The patient then suffers from lack of the anterior hormones and, if a child, will fail to grow properly and consequently will become a dwarf. There may equally well be a congenital lack of sufficient anterior pituitary and a similar state of affairs will occur.

It appears that the anterior pituitary is concerned with sex development, so that too little of the gland will cause sexual infantilism. Often such people become in addition exceedingly fat—the juvenile obesity of which we have all seen specimens of more or less degrees of severity. It is not possible at present to treat such patients by making up the deficiency with the proper hormones, but there is some probability that preparations of these may soon be available.

The experimental investigations into diabetes hardly progressed at all from the time of Claude Bernard[1] until in 1889 von Mehring and Minkowski proved that complete removal of the pancreas from a dog resulted in an artificial diabetes characterized by intense thirst and increased sugar in the blood. The pancreas evidently had another function besides that of digestive juices.

[1] *vide supra.*, p. 97.

Attention was called to certain peculiar "islets" of tissue in the pancreas, which differed considerably in microscopic appearance from the ordinary pancreatic glandular tissue. These were the famous "islets of Langerhans" called after the man who discovered them in 1869.[1] The cells of the islets had no duct to drain off any juices they might manufacture. Evidently such juices must find their way into the general circulation. The islets then were "ductless glands" like the thyroid, suprarenal and pituitary glands. Then it was found that in fatal cases of diabetes these islets were degenerated. Here was the clue that led to Banting's famous discovery.

Injections of ordinary pancreatic extracts were of no avail to save a dog whose pancreas had been removed. Possibly it was because the juices from the ordinary cells digested and so destroyed the special stuff from the islets. How could this be prevented? It occurred to the Canadian doctor, Banting, that if he tied the pancreatic duct of a living dog and waited, then the ordinary digestive part of the pancreas would atrophy. Then if he extracted what was left of the gland perhaps he might isolate the active factor from the islets. Banting communicated his ideas to Professor Macleod of Toronto, who wisely gave him laboratory accommodation, dogs and an assistant, Charles Best.

Soon they were able to show that the juice of the artificially degenerated pancreas could temporarily save the life of a dog after his pancreas had been removed. They had found a way of preparing the active principle. They next tried the injection on a doctor who was in the last stages of diabetes—and it worked, for his blood-sugar came down to the normal figure. This was the birth of insulin called after the islets of Langerhans.

[1] Langerhans. Berlin Dissertation, 1869.

Much work has been done towards simplifying the commercial production of pure insulin. By suitable chemical procedure it was found possible to prepare the pure crystalline product from raw pancreas without the preliminary surgical operation by which Banting made his discovery. Insulin can now be bought quite cheaply and in standardized doses. When first on the market it cost as much as twenty-five shillings for a hundred "units", a prohibitive price for any but the very wealthy; but in the last twelve years commercial competition has brought the price as low as one shilling.

It must be noted that insulin is not a cure for diabetes; it is a form of treatment which greatly prolongs life by making up the deficiency of natural insulin, which is the cause. The reason why the diabetic's pancreas fails is yet unknown; nor is there any known method of completely restoring this function. Consequently a diabetic must receive his insulin injections during the rest of his life.

The actual mode of action of insulin has not been clearly proved. One can say for certain that its presence is absolutely necessary for the proper storage and combustion of glucose. If insulin is present in excess then storage mechanism works too well and the sugar content of the blood may fall so low that the patient falls into a coma which at first sight resembles the coma of diabetes. Hence it is extremely important for a diabetic to avoid an overdose of insulin—and, if he feels the symptoms of low blood-sugar approaching, he must rapidly eat some glucose, in the form of barley-sugar for example.

There are many other hormones in the human body and we must content ourselves here with a brief mention of just a few. There is one which is made by the parathyroid glands which controls the amount of lime in the blood. It is an important function because too little lime gives rise to a disease called tetany which is found in children but also occurs in adults in certain conditions: for example, if the parathyroid glands have been accidentally removed during an operation on the thyroid gland—a circumstance which does not occur nowadays since the significance of these small glands has been appreciated.

There are also certain hormones connected with the reproductory system. There is one which controls menstruation and another which is formed during pregnancy and controls the remarkable physiological changes which take place in the mother. One such substance also makes its appearance in the urine of pregnant women and its presence, determined by suitable animal tests, may form valuable evidence for the early diagnosis of pregnancy.

There is yet another sex hormone which is manufactured in the testis of the male and is responsible for all the secondary sexual changes which occur in a boy at puberty. After castration, the absence of this hormone accounts for the characteristic hairlessness and the shrill voice of the eunuch. There is also reason for believing that a decrease of this internal secretion accompanies the onset of "old age". On this idea hangs the rationale of Voronoff's treatment of senility by testicular grafts from apes. It is probable, however, that degeneration of the sex glands is a symptom and not a cause of old age. If this is so Voronoff's treatment is based on a misconception.

There are, then, very many of these curiously active chemical substances in the body and the concept has arisen of the chemical control of the body by a delicate balance between all these various hormones. There is much evidence to show that the pituitary gland is the main seat of this chemical government.

There is no doubt that many fresh hormones await discovery. An interesting suggestion has been put forward by Professor Zondek, which, though the chemical methods he used have been much criticised, may yet help to explain the mystery of sleep. He claimed to have found a substance containing bromine, which he isolated from the pituitary gland and which when injected produced a decrease of muscular power and induces fatigue and apathy.[1] He stated that there is a deficiency of bromine in the blood of some people who are suffering from a certain kind of insanity which is characterized by sleeplessness. This is interesting in view of the fact that bromides have long been used as sedatives. If these results are confirmed it may be possible to treat insomnia with this new hormone. Incidentally perhaps the fat boy of *Pickwick Papers* was both fat and sleepy for the same reason—there was something wrong with his pituitary gland!

It is probable indeed that almost every organ gives out some form of chemical substance which has some effect in more distant parts of the body. This idea is by no means a new one. In the eighteenth century Théophile de Bordeu had stated his opinion that " every organ—not merely the glands—serves as a factory of specific substance, which enters the blood-stream and that these substances are of the greatest importance for the integrity of the organism ".[2]

Some writers have gone even further and have suggested that not only do the hormones control the growth of the body and other changes both physical and chemical, but that the actual mental make-up may also be coloured if not controlled by similar agencies. They point, for

[1] *Lancet*, 1932, I, p. 1009.

[2] *Œuvres Completes*, II, p. 942. Cited by Max Neuburger. *Essays in the History of Medicine*, (Translated), New York, 1932, p. 109

example, to the symptoms of fear or excitement—sweating, pallor, the quickened heart-beat, the hair which stands on end—and they show that every one of these symptoms can be " explained " by assuming that there is a sudden release of adrenalin in the blood-stream. This may be true enough, but it does not explain how the adrenalin becomes released. There is little doubt that the character of a person may be considerably influenced by his internal chemistry since it is a fact that a person is chemically changed during different times in his life-history and his behaviour certainly differs at each of these periods; but many will be rightly perturbed at any attempt to explain the whole of human mental activity in such terms, and there will always be many who will vigorously fight the suggestion that: —

> " Courage now is mere hormonogen
> And loyalty entails some ductless gland."[1]

In brief, the study of hormones and of the ductless glands has provided us with a number of exceedingly useful drugs. Among the most important of these are insulin, thyroid extract, adrenalin and pituitrin. It is an unfortunate fact, however, that glandular therapy has fallen into the hands of commercial firms who have shamelessly exploited the credulity not only of the public but, if one may judge from the countless circulars which every doctor finds in his letter-box, the medical profession as well. Hundreds of preparations are being advertised, and presumably sold, backed by experiments which are uncontrolled and therefore pseudo-scientific. Countless glandular tonics are on the market, yet there is very little evidence that any hormones, with the important exception of thyroid extract, have any effect whatever when taken by

[1] H. S. Mackintosh in *One Hundred and One Ballades*. London, 1931, p. 69.

the mouth; while the number of complex substances which the manufacturers urge the doctors to inject into their patients is positively frightening. It is fortunate indeed that the internal chemistry of the body is so well balanced that the injection of such highly complex animal substances rarely has any deleterious effect.

VII. The Röntgen Rays

Of all the new physical aids to diagnosis there was none that was so unexpected, unhoped-for and consequently unlooked-for as the Röntgen Rays. This discovery, like so many others, had its beginning in an accident. In saying this we have no wish to detract from the genius of the inventor; for, had not Wilhelm Conrad Röntgen been a physicist of exceptional ability, the new rays might so easily have been overlooked. Indeed it is certain that the rays had been produced previously in many physical laboratories all over the world; but their existence remained unrecognized.

Towards the close of the last century almost every well-equipped physical laboratory possessed, in what is known as a Crookes tube, a potential means of producing the rays. These tubes were of glass and contained various gases at very low pressures. By means of wires sealed into the glass high-voltage electrical discharges could be passed from an induction-coil through the gas in the tube and the extraordinary phenomena which occurred could be studied. Hertz and Lenard had made brilliant experiments with a new kind of ray which, under certain conditions, they found emanating from the negative wire inside the tube. It was while experimenting with these so-called cathode rays that Röntgen, professor of physics at Würzburg, made his startling observations on November 8th, 1895.

Working in the dark, with the Crookes tube completely enclosed, he noticed that a small piece of paper covered with a coating of barium platinocyanide shone brightly while the electrical discharge was taking place. This may not seem a very striking observation, but it was to have far-reaching effects. Röntgen told no one of his discovery, but with incredible energy set out along truly scientific lines to investigate the phenomenon.

Some weeks passed before he convinced himself that the unlikely results which he had obtained were indeed facts. He had worked out pretty completely the fundamental character of the new rays and on December 28th, with some hesitation, he presented his astonishing communication *On a New Kind of Rays*[1] to the Physical Medical Society of Würzburg. "Now the devil will be to pay", he observed.

The paper showed at once how thorough Röntgen had been. He proved that the rays emanated from the point where the cathode rays struck the glass wall of the tube. The most surprising objects, a book for example, seemed transparent to the rays, and objects varied in their degree of transparency according to their thickness and their density. Other substances besides barium platinocyanide fluoresced in the path of the rays. A photographic plate was sensitive to the rays, but the human eye was not. The behaviour of the rays differed in many ways from that of light-rays, in that the former could not be reflected by any substance nor deviated by a prism, nor could he produce "interference" effects nor polarize the rays by any of the ordinary methods. Yet the rays seemed to travel in straight lines, for the shadows cast by a dense object were sharp. They differed, too, from the cathode-rays in that the new rays travelled much farther through the air and other substances, and, unlike the cathode-rays, could not be deflected by a magnet. Röntgen illustrated his communication with some photographic shadow-pictures

[1] *Eine Neue Art von Strahlen.*

including one of a human hand showing the shadow of the bones. Since the inventor admitted that he was unaware of the true nature of the rays, he proposed to call them the X-rays and he put forward the suggestion, which was subsequently disproved, that they differed from light in being longitudinal (as opposed to transverse) vibrations in the ether. After a demonstration before the Physical Medical Society it was decided that the rays should be called "Röntgen's rays". However, in this country they are more usually known as X-rays, possibly owing to the difficulty of pronouncing the professor's name.

Unlike so many great men who have had to fight desperately for the recognition of their discoveries, Röntgen became famous at once (although it should be added that, scientifically, he would have been considered a great man even if he had not invented his rays). When the news became known there was great excitement all over the world and, since almost every laboratory possessed or could obtain a Crookes tube, the existence of the X-rays was soon confirmed.

Here, too, was something to interest the public. The popular press took up the subject but, as so often happens, it failed to appreciate the true nature of the new scientific discovery. It misunderstood the "invisible light" which could penetrate where the eye could not. In general people did not properly grasp the fact that the new photographs were merely shadows and not focused pictures. One periodical spoke of the "revolting indecency" of an invention that would make privacy impossible. In London advertisements appeared offering X-ray-proof underclothes, while in America an attempt was made to legislate against "the use of X-rays in opera-glasses in theaters".[1]

[1] Otto Glasser. *Wilhelm Conrad Röntgen and the Early History of the Roentgen Rays*, London, 1933, pp. 44 and 45.

The immense value of the new discovery to medical diagnosis was quickly seen and it was not long before surgeons began to take shadow-pictures of fractures and dislocations. Shot or other foreign bodies showed up well on the plates and photographs were also taken of teeth, tumours and stones in the kidney. The bony changes which occur in gout, rickets and other diseases began to be examined by the same method while the heart and lungs, though not so dense as the bones, could also be photographed with a suitable length of exposure.

The new discovery was fortunately given active encouragement by educated opinion and was patronized by many distinguished personages. The German Emperor, for instance, before whom Röntgen demonstrated his rays as early as January, 1896, was sufficiently impressed to have a picture taken of his crippled left arm with the object of determining the nature of the deformity.[1] Queen Amelia of Portugal is said to have " had X-ray pictures made of several of her court ladies in order to demonstrate to them the evils of tight-lacing ".[1] So Röntgen's fame spread and messages of congratulation began to reach him from all over the world. In 1901 he was awarded a Nobel prize.

Attempts were made to discredit Röntgen, including the allegation that his discovery was really that of a junior assistant. Even if this were true it is certainly due to Röntgen himself that the accidental shining of a piece of paper led to so valuable a gift to mankind. There were also many claims to priority in the discovery, but all these have been carefully scrutinized and not one can be substantiated. Such recriminations seem to have embittered the discoverer, who was a modest and retiring man. He

[1] Otto Glasser. *Wilhelm Conrad Röntgen and the Early History of the Roentgen Rays*, London, 1933, p. 271.

was wounded by the vituperation of a few and, retiring into private life, he died in 1922, lonely and neglected.

The uses of Röntgen rays in medicine and surgery have multiplied a hundred times during the forty years that have elapsed since their beginnings. It was realized that if certain hollow organs in the body, which were not ordinarily seen in an X-ray picture, were to be filled up with some substance which was opaque to the rays, then a picture could be taken showing the shape of the inside of the organ in question.

A beginning was made in 1896 when W. Becher of Berlin photographed the stomach of a guinea-pig after filling it up with a solution containing lead. Such a substance is very poisonous, so that in order to apply the same process to human beings it was necessary to find something that should be at the same time both opaque and non-toxic. Compounds of bismuth were found to fulfil both these requirements.

The patient eats a large quantity of very unappetizing bismuth porridge and this meal can be watched and photographed during the whole of its passage through the gut. In this way it is possible to gain very useful information. For example, a tumour or an ulcer may sometimes be seen and a diagnosis made with certainty, and, in the case of a tumour, measures can be taken for its early removal. The actual movements occurring in the stomach and intestines have also been very carefully studied and any departure from the normal is often of great diagnostic value.

Other opaque substances have been used in photographing different organs. X-ray pictures can be made of the kidney and ureters by injecting suitable materials. An ingenious method of obtaining a picture of the gall-bladder was devised by Graham and Cole in 1924. They found an opaque compound containing iodine, which, if eaten, is found later in the bile that is stored in the gall-bladder. An X-ray picture of this may show little holes, as it were, in the shadow of the gall-bladder if there are gall-stones present: for these stones are often more transparent to the rays than is the iodine compound. Thus one can clearly see such stones while an ordinary X-ray picture might show no evidence of their presence at all. A non-irritating oily substance called lipiodol has been employed to fill up the tubes of the living lung and valuable evidence in cases of lung-diseases can be found from an X-ray picture of this.

Much work has been done with the object of improving the quality of X-ray photography. In the early days very long exposures were necessary to secure a good picture. Soon better and better tubes were devised. A target of platinum was found to be a better source of the rays than the glass wall of the tube. Research was made into the optimum currents and gas-pressures and into the best kind of glass for the tubes. Photographic plates, too, were improved very much in quality and sensitivity. Nowadays films have pretty well superseded glass plates in X-ray work, although the former are much more inflammable and much more expensive. The superiority of the films lies not only in the convenience of storage but also in the fact that they are sufficiently thin to allow a sensitive coating to be applied on both sides without too much blurring of the picture. In this way the time of exposure can be halved, and, by placing on each side of the film sheets of paper coated with material that shines in the path of the X-rays, the speed is still further increased. With this arrangement the actual picture is taken largely by the fluorescence of the coated paper as well as by the direct effect of the rays on the plate.

Apart from considerations of convenience it was found highly important to reduce the exposure-time to the minimum necessary for a satisfactory examination and for a good picture to be made. Unfortunately the Röntgen rays were not an unmixed blessing, for gradually among the pioneers of Röntgenology appeared the distressing and disastrous effects of X-ray burns. Inflammation, brown pigmentation, dropping out of the hair, superficial ulceration or deeper burns—all these followed insidiously and relentlessly in the wake of prolonged exposure to rays. There were many workers who lost limbs and lives in this horrible way. Now happily the danger is recognized and every worker with X-rays protects himself, his neighbours and his photographic plates with walls, screens, aprons and gloves heavily impregnated with lead. Professor Röntgen himself escaped without harm because, although he never anticipated the evil effects which the rays have on the skin, for the sake of convenience he worked almost entirely inside an enclosed and metal-lined cabinet with only one window through which the rays were admitted from the Crookes tube outside.

Once it was known that X-rays had a direct effect on the skin it was natural that empirical attempts should be made to cure skin-diseases by the same means. The rays were turned from diagnostic to therapeutic use. They are used now, for example, with frequent success in the cure of rodent ulcers which, if untreated, slowly advance, malignantly eating up every structure in their path and producing the most ghastly deformity. X-rays are also used with the object of preventing a recurrence of a cancer after it has been removed surgically. Deep internal tumours have also been attacked by the rays, but since the radiation cannot be focused, there is the grave danger that the skin over the tumour is likely to be burned before the tumour has received a lethal dose. This has largely been avoided by giving multiple short doses directed at the tumour from various angles outside, so that no single part of the skin receives more than one small dose, while the tumour receives them all. Again X-rays have been employed for removing " superfluous hair ". This, except in the hands of an expert, is a highly dangerous procedure, since there is a very small margin between the minimum lethal dose for the hair and that for the skin. A lesser dose which removes the hair temporarily has been found an effective treatment for ringworm. Methods have been invented for accurate scientific measurement of the dose, and this is of the utmost importance; for even today, the danger of burns is a very real one.

IX. Radium

The revolutionary effect of the discovery of radium on the basic science of physics completely outweighs the medical value of the new substance. The study of radioactive elements has changed our fundamental ideas about the constitution of matter. It has given rise to the new conception of intra-atomic energy and not only has it made a reality of the ancient belief in the transmutation of the elements but it has provided proof that matter itself is spontaneously changing into energy. We must confine ourselves here to the medical aspect of radium.

The first clue to the discovery was found when Henri Becquérel began to study the relationship of X-rays to fluorescent substances. In 1896 he accidentally found that the metal uranium and any compound of the metal had the remarkable property of emitting penetrating rays which could affect a photographic plate. The rays arose quite spontaneously and the magnitude of the effect depended solely on the quantity of uranium used.

Two years later Marie Sklodowska, the Polish wife of physicist Pierre Curie, while investigating the Becquérel rays found that thorium was also "radioactive". She then began to examine systematically every different kind of metallic substance to see which gave out the rays. She made the valuable observation that certain ores which contained uranium were several times more radioactive than uranium itself. From this she inferred that such ores must contain a small amount of some substance many hundred times as potent as uranium. Mme. Curie and her husband then set out to isolate this hypothetical substance by purely chemical means. More than a ton of pitchblende (the active ore) was presented by the Austrian Government and after immense labour the two savants succeeded in extracting from this some few thousandth parts of an ounce of pure chloride of radium (the name they gave to the element).

They found that this new stuff possessed truly remarkable properties. It gave off light, heat and electricity continuously without suffering any apparent change. Furthermore, it emitted highly penetrating rays even more powerful than X-rays. We know now that the element is spontaneously turning part of its own substance into energy and is, in fact, slowly losing weight. A definite small fraction of all the atoms of radium undergoes disintegration in any given interval of time. Since less than one two-thousandth part of the atoms are changed in one year it will be clear why the loss of weight is not very obvious. Indeed it would take more than a thousand years for a mass of radium to lose one half of its weight. No known chemical or physical process has been found to influence the rate of radiation and disintegration which proceeds continuously and inevitably.

From the unlucky circumstance of receiving a burn at the site of the rays from some radioactive material that he was carrying in his pocket, Becquérel was able to draw attention to the strange physiological properties of radium. Pierre Curie confirmed this observation by producing on himself in a few hours a burn which took months to heal.

Curie was awarded a Nobel prize and a special professorial chair was created that he might continue his important work; but in 1906 the scientific world was shocked to learn that his valuable brain had been instantly crushed by the wheel of a two-horse dray in the streets of

Paris. Curie was dead, but his wife lived for many years more to carry on the scientific investigations on radium, the child of their great labour. She died in 1934 from anæmia which was almost certainly due to the destruction of her blood-forming bone-marrow by the constant and relentless action of the rays with which she worked.

As soon as it had been shown that skin burns could be caused by radium, medical men began to experiment in order to find out if malignant growths of the skin could be destroyed by the same agency. The first results of treating cancer with radium were published by Danlos in 1904. Fortunately it was discovered that not only could some cancers be burned away by radium but also that the growths were several times more susceptible to the destructive rays than were the normal tissues. Later it was found that accurate dosage was of paramount importance. The dose of rays varies, of course, with the amount of radium used, its distance from the tumour and the time during which it is allowed to act. The unit of radiation is called the " curie " but for healing purposes much smaller doses are required, so that the unit chosen is a millicurie which is just one-thousandth part of the curie.

Immense strides have been made in the technique of applying the radium to kill cancers. Experience showed, for example, that of the three different parts of the complex beam from radium, only one, the highly penetrating " gamma-rays ", was desirable. To achieve the required result the radium is put into little hollow needles made of platinum the thickness of which is such that it allows the gamma-rays to pass out, while it filters out the other less penetrating parts of the radiation. These needles are then inserted at strategic positions into and around the cancer, so that a complete barrage of gamma-rays reaches every part of the tumour and the neighbouring lymphatic drainage system along which the malignant cells are so prone to spread. Homogeneous radiation is the ideal. The needles are left in place until the surgeon estimates that the required number of millecuries has done its work. They are then removed and if all has gone well the cancer gradually disintegrates.

The technique of placing the needles properly calls for a high degree of skill. It requires, too, great experience to decide which cases are properly suited for treatment by radium, because certain growths by reason of their inaccessability, nearness to dangerous areas or other cause, cannot be cured in this way. Cancers of the skin and lip are, in general, best treated by radium, with every prospect of a permanent cure. Growths of the mouth, the uterus and the breast can also be treated with results, in competent hands, that compare favourably with surgical treatment by the knife. In cases where there is no prospect of a cure by any known means, treatment with radium will often bring very great relief and add months of relatively healthy life to the patient.

Radium in the process of disintegration goes through several stages, and among other products gives out a gaseous substance called radium emanation (or radon). It is this latter substance that in breaking down yet further is largely responsible for the healing fraction of the radiation from radium. Radon disintegrates comparatively quickly, half its mass disappearing in less than four days. Furthermore, radon, being gaseous, can readily be pumped off from the parent radium and sent away to various surgeons for the cure of cancer. In this way the original mass of radium can be preserved from loss at some centre, while the radon which is sent out loses its activity very rapidly and so when its work is done it ceases to be a cause for anxiety.

The importance of securing radium at some centre is made clear when we consider its enormous cost and the fact that more than once needles containing the valuable element have been lost through inadvertence in the dust-bins or sewers of hospitals. The great cost of radium is due primarily to the labour involved in separating it from its natural ore. The main sources are pitchblende (oxide of uranium), which is found in Czechoslovakia and in the Belgian Congo, and other ores of uranium from Australia and the United States of America. To extract one gramme of radium from the richest minerals obtainable it is necessary to use nearly six tons of ore: while ores containing as little as a gramme per two hundred tons are still worth extracting. It is not surprising then that radium fetches many thousand pounds for a single gramme.

In conclusion it may be stated that at the present time radium and X-rays form two of our best weapons against the ghastly scourge of cancer. Technique is rapidly improving and there is not the least doubt that to these agencies many people owe the fact that they are alive today. It cannot be too widely known that *early* cancer can very often be cured by these means alone without resort to the knife.

X. The Vitamins

After the discoveries of the great nineteenth-century chemists and physiologists, it appeared that the knowledge of the necessary constituents of food was pretty complete, if not detailed. Yet all efforts to build up a satisfactory diet artificially from pure substances met with failure. It was N. Lunin who first showed, in 1880, that young animals would not grow on a diet which should have been adequate in the light of all the accumulated chemical knowledge: but not until 1912 was fresh light thrown on the matter by Frederick Gowland Hopkins, who later became the distinguished President of the Royal Society (1930-1935).

Hopkins fed groups of rats upon artificial mixtures of pure isolated casein (milk protein), and carbohydrates and salts. At the same time other groups of rats were fed with exactly similar food with the addition of a minute ration of fresh milk. If the constituents were pure the rats who had no fresh milk failed to grow although they ate just as much as the others. Later their appetites failed, but the important point was that they ceased to grow before they ceased to eat. The synthetic milk diet was wanting in some factor which is found in fresh milk and which is essential for growth.[1]

Comparable discoveries were made in connection with a disease known as beriberi which had been extremely prevalent in the East. The Japanese navy had suffered very severely from this and it had been found by Takaki in

[1] F. G. Hopkins. *Journal of Physiology*, 1912, 44, p. 425.

1882-86 that an improved diet was all that was necessary to combat the sickness. Acting upon this information Eijkman and Grijns were able to produce a very similar sickness in birds which they fed on a diet of polished rice. The birds soon developed the inflammation of the nerves, leading to paralyses which are characteristic signs of beriberi. Next these observers showed that by adding to the food some of the "polishings" of the rice the disease could be cured or prevented. There was an anti-beriberi substance in the husks. The disease was due to a deficiency of this substance in the diet. Human beings took the disease if they ate only rice or beans which had been polished, a process which removed the valuable husks. Unpolished rice was the remedy.

Thus began the hunt for those essential life-giving products which we know today as vitamins. The name "Vitamin" was originally proposed by Casimir Funk,[1] who applied it to the anti-beriberi substance found in the rice husks. He believed that this belonged chemically to that class of nitrogen-containing compounds which are known as "amines". Vitamins were the amines of life. This conception proved erroneous but the name survived and is now applied to any substance whose absence has been shown to give rise to one of the so-called "deficiency diseases". The vitamins are more accurately if more cumbrously described as "Accessory Food Factors".

Later it was suggested that not only beriberi but also scurvy, pellagra and rickets were deficiency diseases and the existence of the corresponding vitamins was postulated. There has been some confusion about the names of the different vitamins, but the following is the most widely accepted classification. A substance contained in butter and eggs was found to be necessary for the growth of young

[1] C. Funk. *Die Vitamine*, Wiesbaden, 1914.

animals and this was called " fat-soluble A ". Butter and eggs are of course animal products. How comes it then that animals *must* have vitamin A and therefore are presumably unable to manufacture it for themselves, and yet the vitamin is found in animal products? The answer is that the substance is contained in plant life. Thus the grass contains it, whence it passes viâ the cow to the milk and butter. Cod-liver oil is a potent source of this vitamin and it seems that the fish obtains its supplies from the plankton upon which it feeds.

The anti-beriberi substance was called " water-soluble B ": but later it appeared that vitamin B is not a single substance but contains at least two factors. These have been called B_1 and B_2, the former preventing beriberi while the latter is the anti-pellagra factor. Yeast contains both substances, wheat-germ is rich in B_1, and milk, meat and greens possess B_2.

The anti-scurvy substance, vitamin C, was sought for and found in fresh fruit and vegetables—a discovery which was by no means surprising in view of the fact that the eighteenth-century navigators had conclusively shown that fresh vegetable products were a specific remedy and a certain preventive in this disease. It is astonishing to think how small a quantity of orange juice can stand between us and this horrible scourge. The ill-fated crews of George (afterwards Lord) Anson's famous voyage round the world[1] might have been saved by this simple means from the fearful doom which came upon so many of their number. It seems certain that long before that time the knowledge was available had men chosen or been able to use it. Francis Bacon in his *New Atlantis*, which was published in 1627, the year after his death, wrote these uncompromising words: " Besides, there were brought in

[1] 1740-1744.

to us a great store of those scarlet oranges for our sick; which (they said) were an assured remedy for sickness taken at sea".

A man deprived of the life-giving vitamin C presents a terrible picture. His gums become swollen and putrid and his teeth fall out. Discoloured spots come out on his body and his legs swell up. He is overcome with extreme lassitude which passes later into utter misery and dejection. He is seized with terrors and, for the lack of this small thing, he dies.

Rickets is a disease of infancy and is all too common today. It produces the well-known bony deformities which are particularly noticeable in the legs, arms, chest and head, and are due to faulty deposition of lime-salts in the growing parts of the bones. Consequently the bones become softened and grossly altered in shape. In 1908 L. Finlay succeeded in producing the disease artificially in puppies by feeding them on a diet deficient in raw milk. Then it was shown that this experimental disease could be remedied or prevented from developing by the addition of small quantities of cod-liver oil to the food. There was another vitamin in the oil. At first this was thought to be identical with vitamin A, but Hopkins invented a way of destroying the vitamin A (or growth-promoting substance), yet the cod-liver oil retained its power against rickets. There must be a fourth or anti-rachitic factor, which was accordingly named vitamin D.

It was then discovered that ultra-violet light or sunlight (which contains ultra-violet rays) was also effective in the prevention of rickets and that this effect occurred whether the animal itself or its food was treated with the light. Later still the satisfactory discovery was made that a substance called ergosterol, which occurs in all animals, was partially "activated" into vitamin D by the action of ultra-violet rays. Rickets, then, can be prevented by giving cod-liver oil (and halibut-liver oil is more potent still). The application of this knowledge to the care of babies has produced remarkable results, and rickets, a disease of malnutrition and darkness, is becoming increasingly rarer wherever the facts are known and used. But, alas! knowledge spreads all too slowly.

The necessary vitamins are all contained in mother's milk and this is the only perfect food for a normal infant. This cannot be too emphatically stated. Most of the rickets of today occurs in infants who are artificially fed. They are often given tinned milks or boiled milks which may contain little or none of the essential vitamins. When it is impossible for the mother to feed her own child and a reliable wet-nurse cannot be provided, then it is of the utmost importance that adequate vitamins be provided for the child. This is a simple enough matter. There are many reliable preparations on the market including, for example, cow's milk which has been treated with ultra-violet light.

The importance of completely eradicating rickets can hardly be overestimated. Physical deformity in young children and grown men is distressing enough, but what effect may it not have on the future generation? A young mother who has suffered from rickets in infancy may have the bones of her hip-girdle so grossly deformed that she may be quite incapable of giving birth to a live child in the normal way. In such a case the results of a pregnancy may be disastrous to the mother or to the child or to both. Every case of severe rickets in a girl-child helps to swell the maternal mortality rate and it is worth noting that all the efforts of medical science to reduce this have so far been singularly ineffective. Let us make at least this simple effort to see that no child grows up with rickety deformity.

Besides the influence on the bony structure of the body, it appears that vitamin D has a marked action in protecting the teeth against decay. It has often been said by scientists (as well as by the purveyors of dentifrices) that " a clean tooth never decays ". Now caries (decay) is due to the acid which is produced by the fermentation of the sugary or starchy particles remaining on and between the teeth after meals and which attacks the protective layer of enamel on the teeth. Consequently, if the teeth could be kept absolutely clean, it is probable that they would never decay.

That the matter is not quite so simple as this is shown by the perfect teeth of some people for whom oral hygiene hardly exists. Although a clean tooth may never decay, it is by no means certain that a dirty one will. The islanders of Tristan da Cunha have extraordinarily good teeth.[1] Recently, out of 156 examined during the visit of H.M.S. *Carlisle* to the island,[2] 131 were found to be completely free from dental caries, and the oldest man, aged seventy-five, had a complete set of teeth. These islanders live mainly on potatoes, fish, milk and eggs and *they never clean their teeth!*[3] A sure way of inducing decay, one might think, seeing that they have plenty of soft starchy food and no toothbrush. It must be noted that they are all breast-fed and circumstances compel them to live on a diet without cereals, for in 1885 rats were introduced on the island and have prevented the growth of grain ever since.[4]

In marked contrast to the diet of these islanders is that of the Eskimos, who live almost entirely on meat, oil and blood which they get from fish, seal and walrus. Their

[1] *Nature*, cxxiii, 1929, p. 210. [2] *The Times*, February 22nd, 1932, p. 13.

[3] A more recent visitor, however, assures us that their " teeth are cleaned daily with a piece of wet rag dipped in salt ". *British Medical Journal*, 1936, I, p. 174.

[4] *British Medical Journal*, 1932, I, p. 538.

teeth are also very good indeed, although it is said that caries attacks those who adopt a more " civilized " diet.[1]

Light was thrown on all this by May Mellanby's discovery that vitamin D has considerable influence on the proper growth of the teeth.[2] Normal teeth are much more resistant to decay than those that are imperfectly formed. A sound method of preventing caries should be to ensure that the teeth are perfectly shaped. Evidently diet is of the utmost importance, but it appears that the food acts internally by shaping the teeth quite as much, if not more, than it does by local fermentation on the surface of the teeth.

Mellanby[2] went on to show that a diet containing much cereal, and oatmeal in particular, was associated with rapid decay of the teeth of children. Apparently there is present in cereals something which counteracts the beneficient action of the vitamin. With the help of Lee Pattison,[3] Mellanby tried to find out whether caries could be arrested when once started. At Sheffield a group of children was given a diet without cereals and rich in vitamin D and lime-salts for six months. Before the experiment was started their teeth were defective and badly decayed; but soon the caries ceased to spread and no fresh teeth were attacked. To control these observations another group of children was given similar food, but in addition they had bread and cereals. The second group did not benefit nearly so much as the first.

Dental caries is enormously prevalent in this country. Indeed a perfect set of teeth is a comparative rarity. Mellanby has pointed out that the natural foods which are rich in vitamin D—eggs, milk, suet, butter and cheese—

[1] Goldstein and Collins. *Science Service*, March 17th, 1932.

[2] Medical Research Council. Special Report Series, No. 140, 1929.

[3] *British Medical Journal*, 1932, I, p. 507.

are expensive compared with cereals and carbohydrates. The vegetable oils, as bought in shops, are generally no good as a source of the vitamin. The cheap cereals hinder the action of the vitamin, so that anyone who eats much of the former must have additional supplies of the latter. Cod-liver oil is one remedy for those who have preferred quantity to quality in balancing their housekeeping accounts.

Other vitamins have been discovered—one that controls fertility in animals, for example—and doubtless more will be found in the future. It must be pointed out that it is not very satisfactory to classify all these substances under one heading. They have only these factors in common. Firstly, their absence causes and their presence prevents or cures diseases, which, however, differ profoundly according to the substance which is absent. Secondly, they require to be present only in the most minute quantities to prevent the disease. Chemically they may, and some do, belong to widely different groups: so that the classification of vitamins is a very wide physiological one and perhaps an unfortunate one. As we have shown, certain mineral substances such as iron or iodine in minute amounts are also vitally necessary for the proper working of the animal body: yet no one calls these vitamins. Until the chemical nature of each of the accessory food factors is known it is not possible to devise any more satisfactory classification.

Advances in chemical technique have enabled preparations of pure specimens of some of the vitamins to be isolated in the laboratory. The first of these was vitamin D, which is believed to be identical with the substance called calciferol. The potency of this product is incredible. An infinitesimal addition to the food is so powerful that its deep-seated activity makes all the difference between a cripple and a normal healthy child. A concentrated, but not pure, preparation of vitamin D is now on sale to the public: but such a benefit is not without its disadvantage, for a massive dose of a concentrated product may be worse than no vitamin at all. It is a wise precaution to keep to the dosage on the label for fear of having too much of a good thing.

The original difficulty of isolating the vitamins lay in the fact that their presence could only be detected by long and laborious feeding experiments. Now that the chemistry of some of them has been worked out, other means have been and will be discovered for detecting their presence. Vitamin A, for example, has been found to give a blue colour when added to a solution of antimony trichloride. This at once gives us a method of measuring the vitamin A content of any given food by noting the intensity of the blue colour produced. This vitamin has been found to be nearly related to a plant substance called carotene and it appears that although animals cannot make it they can partially turn the carotene into the vitamin. The power of the substance can be visualized when we learn that from one to five ten-thousandth parts of a milligramme is the daily requirement for a healthy rat.

The problem of the chemical identity of the antiscorbutic factor, vitamin C, was solved by Professor Szent-Györgyi of Hungary, who showed that it was exactly the same stuff as a known organic compound which is now called ascorbic acid—a name which is intended to denote its remarkable physiological properties.

Very recently, even while this chapter was in course of composition, Professor Szent-Györgyi has developed a way of manufacturing vitamin C on a large scale.[1] He started with a large amount of the ripe fruit of the " noble

[1] Banga and Szent-Györgyi. *Biochemical Journal*, xxviii, 1934, p. 1625.

pepper "[1] which is used more ordinarily to make Hungarian paprika and, after an elaborate series of chemical operations, he was able to produce the vitamin in a pure crystalline form. Before this it had been possible to prepare ascorbic acid with some difficulty and in very small quantity; but now that the professor has shown the way to make it by the pound, surely the way lies open for the universal abolition of scurvy throughout the world. With proper scientific disinterest and humanity the inventor ends his paper with the words, " No patents were taken out for the process ".

Yet another dietetic success may be mentioned here, although it probably should not come under the heading of vitamins. This concerns the disease known as pernicious anæmia. The symptoms and signs of this sickness had been well described as long ago as 1849 by Thomas Addison of Guy's Hospital and consequently it is sometimes referred to as Addisonian anæmia.[2] It is (or was) a fatal disease in which the patient becomes progressively more and more bloodless. Frequently there are remissions and the sufferer may even appear to have recovered, but sooner or later the symptoms recur and death ensues from lack of good red blood. It is these remissions that make it so difficult to gauge the effectiveness of any treatment, since we cannot distinguish between the effects of a drug and a natural remission. It was customary to give large doses of arsenic. This certainly had some effect in increasing the number of red blood-cells in the circulation, but after a time the drug always failed to act any more.

It was an American, William Pepper, who found out that in pernicious anæmia the red marrow of the bones is

[1] *Capsicum Annuum.*

[2] Not to be confused with *Addison's disease* described above.

much altered in appearance. It is this bone-marrow that normally manufactures the red corpuscles of which a constant supply is required by the blood. In Addisonian anæmia the marrow seems unable to make or supply the perfect red-cells and immature cells are found in the blood and also heaped up in the marrow, which acquires the curious red colour so characteristic of this disease. Pernicious anæmia is a disease of the blood-forming organs.

In 1925 Whipple and Robscheit-Robbins found from feeding experiments on dogs that fresh uncooked liver had a powerful effect in bringing about increased formation of blood in cases of anæmia. Inspired by these observations and by the fact that pernicious anæmia has some points in common with some deficiency diseases, G. R. Minot and W. P. Murphy resolved to try the effect of raw liver. They fed their anæmic patients on a well-balanced diet to which they added plenty of raw liver and in 1926 they began to publish excellent results.[1] Within a week of beginning the treatment their patients began to mend and the improvement not only continued but was maintained for a year.

The daily dose of liver was generally as much as half a pound and this constituted one big difficulty about the treatment. Raw liver is not particularly palatable at any time but after a long course of it a patient faced with unending large amounts will be sickened to the point of revolt. Recently, however, it has been found possible to prepare an extract of liver which contains the active ingredients in a fairly potent form. It may be said that Minot and Murphy have added years to the lives of those to whom a short while ago the diagnosis of pernicious anæmia had meant a sentence of lingering death.

[1] *Journal of the American Medical Association*, 1926, lxxxvii, p. 470. Also ibid., 1927, lxxxix, p. 759.

The next step in the elucidation of the mystery occurred when it was found that liver extracts were much more active if they were first treated with normal gastric juice. Then it turned out that dried fresh hog's stomach worked just as well as liver-extract. Furthermore it was shown that certain commercial vegetable products, notably marmite (a substance prepared from yeast), were equally effective. The concensus of opinion seems to tend toward the view that the essential substance is manufactured in the animal stomach from materials taken from the food and that this substance can be stored in the liver. The disease, then, would seem to be due to a failure on the part of the stomach to make the substance or possibly of the liver to store it. This theory certainly seems to fit such facts as we have and is in accordance with the almost constant abnormalities which are found in the stomachs of those who are suffering from this complaint. In the yeast-product and the dried hog's stomach it appears that the anti-anæmic factor is produced during the commercial processes of preparation. One is curiously reminded of mediæval medical practice when one finds the modern physician using fishes' livers and the stomachs of hogs in the cure of mysterious internal complaints.

The blood-forming principle contained in liver-extract might be called a vitamin. The name is unimportant but the substance does not appear to be of quite the same nature as the other vitamins, for it is as certain that a normal person does not eat the quantities demanded by the anæmic patient as it is clear that all vegetarians do not develop Addisonian anæmia.

Finally, in connection with this disease we must mention the progressively paralysing complaint known by the cumbrous name of "subacute combined degeneration of the spinal cord". This affection occurs in people from middle age onwards and, because of the severe anæmia of the Addisonian type which always accompanies it, was always thought to be a late sequel of pernicious anæmia. It is now almost certain that this is so from the recent statistics. Since 1927, after which the liver treatment was widely used, the number of deaths from subacute combined degeneration have nearly doubled. Presumably this means that the patients who would formerly have died very rapidly have now been kept alive long enough for them to develop the late nervous sequel. It is said, however, that with adequate amounts of liver and prolonged treatment most of these deaths from subacute combined degeneration can be prevented.[1] The liver treatment is the most remarkable of the dietetic successes of recent years.

[1] W. Russell Brain. *British Medical Journal*, 1935, II, p. 1056.

PART III

HEALTH ORGANIZATION

Having reviewed some of the most important scientific discoveries which have contributed to the prevention and cure of disease we must turn our attention to the administrative and legislative aspects of medicine. Before considering the rise of the Public Health services and the State Medicine we shall find it convenient to give some brief account of the reform of the hospitals which play so large a part in the cure of sickness today. The latter began almost entirely through voluntary effort and is consequently better described separately from the sanitary services which had their origin largely through the law of the land.

I. The Reform of the Hospitals

We have seen what dirty and disorderly places the hospitals were in the past. To write of the early stages of their reform must be to give a very brief outline of the work of Florence Nightingale. The story is only too well known, but it is of fundamental importance. From her came the main inspiration and it is the direct result of her influence that the hospitals are managed in the efficient way in which they mostly are today. It needed, of course, the combination of good nursing and organization with the new Antiseptic Method of Lister: but the campaign for reform began before either the germ-theory or the antiseptic principle had been announced.

Florence Nightingale began her career in 1832, when she went for three months to Kaiserswerth in Germany to the Institution for Deaconesses, where there was a school for infants and a hospital where some sort of training in nursing was given. How little this was may be judged from her own words: " The nursing there was *nil*. The hygiene horrible. The hospital was certainly the worst part of Kaiserswerth. I took all the training there was to be had—there was none to be had in England—but Kaiserswerth was far from having trained me ".[1]

Shortly after her return home she became Superintendent of the *Establishment for Gentlewomen during Illness* in Harley Street, which, however, she left for a

[1] Sir E. Cook. *Life of Florence Nightingale*, revised by R. Nash, London, 1925, p. 45.

while to help to nurse the patients at the Middlesex Hospital during the cholera outbreak of 1854. Her great opportunity came with the Crimean War and it was her experience at Scutari and the magnificent results which she obtained that were to be the guiding principles in hospital reform.

The situation in the war area was horrible indeed. The old army pensioners who had been sent out to nurse the sick and wounded proved quite useless and in fact spent much of their time nursing one another. The shortage of medical supplies was scandalous. "Not only are there not sufficient surgeons—that, it might be urged, was unavoidable: not only are there no dressers and nurses—that might be a defect of system for which no one is to blame: but what will be said when it is known that there is not even linen to make bandages for the wounded?"[1]

It was through Sidney Herbert, who was Secretary at War, that Miss Nightingale both volunteered and was asked (the letters crossed) to undertake the formidable task of organizing the nursing at Scutari. She rapidly collected a body of thirty-eight women who were to be her staff. She had to choose these with care from the hundreds of volunteers who applied for service; for she saw at once that the women she wanted must not only be able-bodied and tender-hearted but must also be persons of prudence and capacity and have as much previous experience and training as was possible. Thus the great experiment (for such it was) began.

It must not be supposed, however, that this was absolutely the first experiment in female attendance on sick soldiers. The French had their Sisters of Charity, while, through the influence of the Grand Duchess Helena

[1] *The Times*, October 12th, 1854 (cited by Sir E. Cook).

Pavlovna, the great Russian surgeon Pirogov introduced female nurses to tend the wounded in the Crimea.[1]

The state of affairs at Scutari could hardly have been worse when Florence Nightingale arrived. There were more than seventeen hundred patients in the military hospital and among them raged cholera, dysentery, erysipelas, fever and gangrene. Amputations were carried out in the very wards so that the soldiers watched their companions dying under the surgeon's knife. To add to this, hundreds were dying of inanition simply because they were unable to digest the only available diet of boiled beef.

There was a complete breakdown of all medical organization. There was dirt, confusion and neglect. The floors were rotten and the walls encrusted with filth. The beds were both insufficient in their number and overcrowded in their arrangement. Vermin and lack of ventilation helped to make the place a stinking inferno. There were not only no medical supplies but there was no ordinary bedroom furniture. Basins, soap, towels, mops, knives, forks and plates—all were wanting. There was no laundry and often not even enough fuel.

That the new matron was undaunted by the task set before her was surprising enough: but she had also to fight against fierce opposition not only from the military authorities but even from the medical men themselves who resented her interference. We find her complaining to Sidney Herbert that Dr. Hall was trying to root her out. An accusation that she was "spoiling the brutes" was all the encouragement she got for providing reading-rooms "to avoid the convalescents coming in *dead* drunk (they *die* of it)".

The success of Florence Nightingale's great campaign is

[1] Garrison, *op. cit.* p. 498.

well enough known. It is necessary to give but a few examples of her figures. "In the first seven months of the war the mortality among the troops had been at the rate of sixty per cent. per annum—from *disease alone*—a rate of mortality which exceeds that of the great plague of London."[1] After she had been at Scutari for six months she was able to report that of the 1,100 patients left in the Barrack Hospital only 100 were in bed and the death-rate had fallen from 42 per cent. to 22 per mille.

By what means did she accomplish this extraordinary result? By methodical and unremitting hard work and by discipline. To aid her in her work she had with great foresight armed herself with medical and household supplies in huge amounts—in spite of the assurance she had received before she set out from Dr. Andrew Smith, the head of the Army Medical Department, that nothing was wanting at Scutari. Furthermore she had money, both her own Fund and that collected by *The Times*. She had also the loyal support not only of the Government through the influence of Sidney Herbert but also of public opinion at home.

Besides her battle with officialdom and etiquette she had to fight mainly against dirt and chaos. She procured and made use of soap and water. She provided a new laundry where the washing was done by the soldiers' wives. She produced socks, boots, shirts, trousers and dressing-gowns. She reorganized the kitchen and the cooking. She provided stores of all sorts and routed out much of the Government supplies which were hidden away under the munitions in the transport ships and in the labyrinths of the Turkish Customs House. She even engaged workmen to make fresh quarters fit for the reception of new consignments of sick and wounded. In fact, far from

[1] Sir E. Cook. *Life of Florence Nightingale*, London, 1925, p. 173.

being simply the matron of a hospital, she became practically "mistress of a barrack and indeed assistant purveyor to the British Army".[1]

It was while all this organizing was in progress that Miss Nightingale developed her idea of what a nursing service should be. Nurses were not to be an entirely separate service of domestics; much less were they to interfere with the work of the doctors. They were to be "a subordinate branch of the medical service under the doctor's orders as to the matter of treatment while under their own superintendent as to matters of discipline".

It should also be noted that Florence Nightingale introduced uniforms to promote cleanliness and to give the nurses a smart and sober appearance and to "disarm criticism and belie the untoward reputation of nurses": for the nursing profession was one of the most disreputable and, incidentally, it says much for her courage that she ever embarked on a career which carried with it so grave a stigma.

Her work, then, was successful and her contention was proved that soap and fresh air meant health and that good hospital hygiene could make all the difference between a death-trap and a house of recovery. Furthermore she had overcome the prejudices against female nurses. She was about to create an entirely new profession for her sex. But the strain, physical and mental, had been tremendous. The news came that Miss Nightingale was down with Crimean fever: but she refused to leave her mission, and remained at Scutari until the soldiers were gone. It was extremely fortunate that she did not die at this time, for her magnificent achievements were only a preliminary to a lifelong fight for reform in nursing and hospital organization. But her health was broken and only her

[1] Sir E. Cook. *Life of Florence Nightingale.* London, 1925, p. 77.

indomitable will enabled this perpetual invalid to carry on her great work.

Florence Nightingale returned home a heroine. She was ill, but she could not and would not rest so long as the old methods of organization existed in the Army Medical Service. Another war might easily see a repetition of the Crimean disaster. She set about to collect statistics. She found that the state of affairs in the Army at home was deplorable. "We had during the last six months of the war, a mortality among our *sick* not much more than among our *healthy* Guards at home, and a mortality among our troops, in the last five months, two-thirds only of what it is among our troops at home."[1] Here were some figures for contemplation. Further she showed that "even among the Guards, men of picked physique, the death-rate was nearly double what it was in civil life".

Armed with such figures as these with which she could, and would if necessary, have caused the gravest public scandal, she was able to browbeat the Government into appointing a Royal Commission. The mortality could only come from the grossest mismanagement and it was high time that something should be done: but what? In her *Notes on the British Army* Florence Nightingale gave the answer which contained "not only the scheme of all Sidney Herbert's subsequent reforms but the germ and often the details of further reforms in the same kind".[2] She was the adviser to the Commissioners and the power and the knowledge behind the scenes.

Many of these recommendations were carried out in Army barracks and hospitals. Buildings were ventilated and warmed; water-supplies were improved, while drainage was introduced or reconstructed; kitchens were

[1] Sir E. Cook. *Life of Florence Nightingale.* London, 1925, p. 174.

[2] ibid., p. 183.

remodelled and reorganized; gas-lighting was provided and many buildings were entirely reconstructed and others condemned. More than this, in 1860 was founded the Army Medical School to furnish proper training. This developed later into the present Royal Army Medical Corps.

The results of all this began to be evident almost at once. The death-rate during the years 1859 to 1861 was just halved; in fact it was brought down to that of the civil population. Immense improvements were also seen when the Army was on field service in the China expedition, where the mortality, including that of the wounded, was little more than three per cent. per annum.

During the same time Miss Nightingale also applied her ideas to the reform of hospitals and nursing in civil life. This she was enabled to do by making use of the Fund that had been raised for her to establish a Nightingale School of Nursing. This was to be an experiment in the proper training of nurses. In June 1860 the first probationers were admitted for a year's training at St. Thomas's Hospital. The previous year she published her *Notes on Nursing* in which she had defined nursing as signifying "the proper use of fresh air, light, warmth, cleanliness, quiet and the proper choosing and giving of the diet—all at the least expense of vital power to the patient". She added that it ought to include "nursing the well" or domestic hygiene. This outlook might almost pass for commonplace today, but at the time of publication the *Notes* contained much that was new. The book was a startling success, for 15,000 copies at five shillings each were sold within the first month.

We cannot follow Florence Nightingale's career at further length, but her work was far from completed. She took an active part in the reform of the workhouses, which may be said to have begun in 1867 under the Metropolitan Poor Act. From her bedroom in South Street she also reformed the Army in India. She even conducted a vigorous but unsuccessful fight to reform the War Office itself. It was in this battle that she literally worked poor Sidney Herbert to death.

There was plenty of room for improvement in English hospitals, for the so-called hospital diseases were still very prevalent. Lister's antiseptic campaign began in 1865 but at first it made but slow progress in this country. Until the surgeons adopted this system there was very little chance that these septic diseases could ever be banished from the surgical wards. Miss Nightingale herself smiled at the germ-theory, but much of her soap, water and fresh air was certainly instrumental in removing the bacteria of sepsis. The striking results of the application of the work of Pasteur and Lister to hospital practice may be seen by taking just one example, this time from Germany, which was one of the earliest countries to adopt the new methods. In 1875 in the hospital at Munich no less than 80 per cent. of the wounds whether surgical or accidental became gangrenous. Everything had been tried, wrote Professor von Nussbaum, when "in a single week, with great energy and industry we applied to all our patients the newest antiseptic method now in many respects improved by Lister, and did all operations according to his directions, we experienced one surprise after another . . . not a single case of gangrene occurred".[1] Today these methods are universal and gangrene in an operation wound is a rarity and is rightly considered a disgrace.

Towards the middle of the nineteenth century special hospitals began to appear. Before that there were no hospitals for special diseases, with the few exceptions men-

[1] Sir R. J. Godlee. *Lord Lister* London, 1917, p. 340.

tioned in our introductory chapter. Knowledge was rapidly growing and it became apparent to the younger men that specialization was imminent. The whole field of medicine was becoming too wide for any single individual to cover. First of all special departments were set up in the general hospitals: but it was so easy for the older practitioners who disapproved of specialization to refrain from sending their patients to these departments. In this way grew the conception of having special hospitals for particular diseases.

Like all forms of specialization this new step had its disadvantages. It was only too probable that, from being a man of wide culture, the consultant physician might degenerate into a mere technician. There were drawbacks, too, from the patient's point of view. If he was to go straight to a special hospital, then who was to decide which institution? Undoubtedly the patient himself would be the usual but not the best judge of this. If he went to a general hospital, then, if required, he could be sent by a doctor to a special department. Such departments are a necessary adjunct to any large general hospital, but it must be considered very doubtful whether special institutions for particular complaints are a desirable feature of the hospital services today.

At the present time there are specialized hospitals for cancer, consumption, eyes, ears-nose-and-throat, skin, venereal disease, women's diseases and for sick children and many other purposes. All of these do excellent work but probably no better than could be done in a general hospital. In certain circumstances the existence of special hospitals can be completely justified. This is particularly so in the case of fever hospitals (which are, as we shall see, mostly under Local Government) where isolation is of the first importance. We may also justify particular hospitals for consumption, for this, too, is a contagious disease. Institutions for children flourish especially by reason of the sentimental appeal they make to their supporting public. In general, however, it may be said that the multitude of special hospitals are uneconomic and increase the difficulties of co-operation between specialists in different subjects.

One of the most striking changes in hospital practice was the rapid rise of the municipal and county rate-paid institutions. These were built by Boroughs or Urban and Rural Districts under powers given them by the Public Health Act of 1875.[1] County Councils, too, acquired similar powers under the Local Government Act of 1929[2] although they could build hospitals for infectious disease under the earlier Isolation Hospitals Acts.[3]

The available accommodation both in voluntary and rate-paid hospitals has increased very rapidly in the past fifty years; but the former have now been outstripped by the latter. Formerly voluntary institutions were supported entirely by endowments, subscriptions and contributions from the public, and no charges at all were exacted from the patients. At the present time, however, payment is asked according to the means of the patients and the money thus obtained makes an appreciable help towards the immense expenditure which every hospital must of necessity incur today.

There has been much discussion about the relative merits and demerits of the two kinds of institution. In general the advantages of the voluntary system may be summed up as follows. They live by competition and efficiency so that only the best can survive. Dissatisfied patients are free to go elsewhere. There is no charge on the rates and the voluntary hospitals offer better facilities for teaching

[1] Sect. 131. [2] Sect. 14.

[3] 1893 and 1901.

and research than do their rate-aided rivals. Their senior staffs are unpaid and work under the constant criticism of their juniors and of the students, circumstances which must necessarily tend to keep them up to a high pitch of efficiency. Against the voluntary system it may be urged that the various institutions are often too jealous or self-centred to co-operate effectively with one another or with outsiders. Furthermore they are often situated far nearer the homes of the honorary staff than those of the patients they are designed to serve. In the rate-aided hospitals on the other hand there is the ever-present danger that lack of publicity, criticism and competition may allow them to fall into an uninspired level of mediocrity.

As we have seen, the reform of the hospitals was a very gradual process. In 1871 a Commission was appointed under Sir William Fergusson to inquire into hospital abuse. Soon after this the worst features began to disappear rapidly. Too many patients and too few hospitals was, and to some extent still is, the root cause of much trouble.

Sir D'Arcy Power tells us of the far from satisfactory conditions in the out-patient department of St. Bartholomew's Hospital as recently as 1898. The huge crowd of patients assembled in Smithfield in all weathers to await the opening of the doors at nine o'clock in the morning, including " the man who sold bottles and ointment pots to those who had forgotten to bring them and the woman who was reputed to buy confection of senna and linctus for her open jam tarts, and the cod-liver oil for use in her neighbours' lamps ".[1] The hall was small and overcrowded and the atmosphere poisonous. There were so many patients that it was almost impossible for the best-intentioned doctor to give a proper examination to each one. The late Poet Laureate, Dr. Robert Bridges, stated

[1] *Lancet*, 1932, I, p. 1000.

that "he saw and prescribed for 7,735 persons during his year of office in 1897 and that 5,330 of these were new patients. The average time spent on each case was 1.28 of a minute and he congratulated himself on having given a separate audience to the troubles of 150 talkative women in 3¼ hours".[1] An amusing tale is told of the wholesale methods of one apothecary at the same hospital.[2] When the crowd was assembled in the hall, he would say "All those with a cough stand up!" and he gave them each a ticket for a bottle of physic to be obtained at the dispensary. Then he would continue, "All those with the belly-ache, stand up" . . . and so forth. It may be said that this was a pretty perfunctory way of getting through the morning's work, but with long experience it would seldom happen that a skilled physician would overlook a really severe illness.

Such methods are not found today. One by one the abuses have been banished, but undoubtedly there is yet room for improvement. The out-patient departments of the large voluntary hospitals are still grossly overcrowded and it is no uncommon thing for a patient to wait three hours or more before being seen by the doctor. No doubt the huge figures of attendance duly impress the subscribers to the hospital funds; nevertheless it is nothing short of scandalous that such methods should be allowed to continue. It is true that when the patients are eventually seen and treated they get high-class medical treatment for next to nothing; but could not some system of appointments be made for all but the new cases (who, of course, are always seen as soon as practicable after their arrival)? The junior staffs of most of the big London hospitals could be considerably enlarged without much extra cost, for the competition to secure these posts is so keen that mere

[1] *Lancet*, 1932, I, p. 1000. [2] ibid.

pittances are paid to the house-surgeons and house-physicians.

The waiting-lists for the in-patients too is generally of such a length that all but the acute emergency cases (and, it might be added, the "interesting" cases) have often to experience more delay than can possibly be good for them.

Criticism has often been levelled at the inevitable bottle of medicine with which each patient is furnished, regardless of necessity. This adds considerably to the expenses of the hospital. It must be added in fairness that the patient demands his bottle and such a provision has the great advantage of stopping him from going round the corner to waste his money on some expensive and deleterious nostrum. It is scarcely an exaggeration to say that no patient expects to get well without being physicked—and this is a belief which will not lightly fade.

II. Medicine and the State

1. THE BEGINNINGS OF SANITARY LEGISLATION[1]

A HUNDRED years ago the knowledge of the principles of health was surely and steadily growing. But the ignorance of the masses was abysmal and there was hardly a vestige of interest taken by the public in the health of the community as a whole. It was being shown more and more clearly that many of the diseases which inflicted so much hardship and so many fatalities on the people were the result of demonstrable causes and, what was of the greatest importance, that these causes were largely removable.

Thinking men began to see that action by the State was imperative if anything was to be done to mitigate preventable disease. The knowledge was there, but legislation was needed to apply it and to give shape to an organization which might be capable of enforcing the fundamental principles of health.

Such laws as there were for safeguarding the public health were for the most part valueless, incomplete or fallen into desuetude. In early times common law right was the only means of redress from sanitary nuisance. As early as 1388, however, we find the first Sanitary Law which prohibited, under penalty of £20, the casting of animal filth and refuse into rivers and ditches in urban areas.[2] Certain restrictions were undoubtedly in force in

[1] A fuller account is given in Sir John Simon's *English Sanitary Institutions*, London, 1890.

[2] *Second Report of the Royal Sanitary Commission*, London, 1871, Vol. I, p. 4.

many parts of the country in the sixteenth century. It is interesting to note, for example, that Shakespeare's father was fined on two occasions at Stratford-on-Avon for insanitary behaviour.[1] From time to time legislation was enacted against extraordinary pestilences—against the plague, for instance, in the reign of James I. It will be remembered, too, that early in the eighteenth century Mead had published his very sound recommendations for preventing the spread of contagious disease.[2] These excellent suggestions were put on the Statute Book,[3] but unfortunately the most important clauses were repealed in the following year—as Mead alleged, through political acrimony.

As early at least as the reign of George II, individual towns began to ask for special legislation to enable them to improve their sanitary condition, but there was no compulsory Act for the redress of the state of the country as a whole.

There were, however, very encouraging aspects of the views of those in authority. Jenner's discovery of vaccination had been taken up by the Government, which had made an annual monetary grant to the National Vaccine Board for the upkeep of the supply of lymph for vaccination. The grant itself was beggarly; but it was a beginning. The first Vaccination Acts were passed in 1840 and 1841. The first of these prohibited the exceedingly dangerous practice of attempting to immunize people by purposely inoculating them with true smallpox. The 1841 Act provided that the expenses of public vaccination should come out of the Poor Rate. By these acts the Poor Law guardians and overseers were empowered to contract for

[1] *Second Report of the Royal Sanitary Commission*, London, 1871, Vol. I, p. 4.

[2] See above, p. 22.

[3] 7th Geo. I; Cap. 3.

the vaccination of all persons resident in their unions and parishes respectively.[1]

The various sicknesses, acute and chronic, which were constantly taking their toll among the people were not likely to arouse men to the consciousness of the necessity for action. These diseases were always with them and, being "natural" they were taken as a matter of course. A sudden violent visitation of an unknown or unusual pestilence was far more likely to arouse alarm and a clamour for protection. The Asiatic cholera, therefore, played a large part in moulding public opinion in matters of public health.

The great Reform Bill of 1832 may fairly be called the beginning of Public Health legislation, despite the fact that it contained no provisions which were directly concerned with preventive medicine. Nevertheless, as a direct result of this Bill becoming law, there followed in 1833, 1834 and 1835 respectively the Factory Act, the Poor Law Amendment and the Municipal Corporations Acts. The first of these aimed at limiting the working hours of children; the second had its importance in the formation of the Poor Law Commission which, we shall find later, was to be the beginning of a *central* Public Health Authority; while the third began the system of elected local authorities which are still today in control of the local administration of preventive medicine, besides wielding many of the powers which were formerly in the hands of the magistrates.

It was in 1834 that Edwin Chadwick was appointed secretary to the Poor Law Commissioners, and Chadwick was to be the leading spirit in the demand for Sanitary Reform. He saw clearly that those diseases which abounded wherever there was filth could and should be

[1] *Second Report of the Royal Sanitary Commission*, London, 1871, Vol. I, p. 5.

prevented by the removal of that filth. It was the needy and squalid that took the diseases. Disease itself produced poverty and squalor. It was a vicious circle that must be broken.

That such disease could be checked was the accepted medical opinion. Had not John Howard, the Bedfordshire squire, shown what could be done in the prisons of England? Through his work, conducted in a spirit that was both philanthropic and scientifically methodical, the gaols offered to the prisoners such hygienic conditions as few of them could have experienced outside. The prisons need no longer have been incubators of typhus fever.

It was shown that disease-prevention was not only a possibility but that it was sound economy. Good health would diminish pauperism and small expenditure for prevention would avoid greater outlay for the care of the sick and the burial of the dead. Prevention was not only better, it was cheaper than cure.

The Poor Law Commissioners made a very extensive inquiry into the state of towns and the health of the labouring classes. The results of this were made public in Chadwick's historic report.[1] As we have seen in our introductory chapter, the discoveries were appalling and revealed the vilest conditions of physical and moral decay. But, also, it seems certain that in some ways, or in some areas, conditions were improving, because during the eighteenth century the death-rate had been falling. Chadwick made urgent recommendations for the removal of all filth and the provision of adequate drainage. He stressed the importance of liberal supplies of water without which it would be impossible to maintain any thorough system of sewage-removal. He also insisted on the important principle that

[1] *General Report on the Sanitary Condition of the Labouring Population of Great Britain*, 1842.

waterworks and sewage and drainage should always be controlled by one authority.

It was to be expected that there would be opposition to any attempted legislation, especially any endeavour to coerce reluctant local authorities. There were also the vested interests of the landlords and of the speculative builders and the water companies. But in addition to these there was the public itself. People fear sickness and want to be protected, but they also hate interference. It was essential, if real sanitary improvements were to be made, that there should be active interference with insanitary persons as well as with property. Other objections were raised on the score of wasteful public expenditure by those who were short-sighted enough not to realize that ultimate advantages would well outweigh the unpleasantness of increased rates.

Bills were introduced in Parliament by Lord Normanby and later by Lord Lincoln, but both these reformers met with very great opposition and both had their projects wrecked by the fall of the respective ministries. But while the legislators were wrangling much good work in educating public opinion had been done by certain societies. The Health of Towns Association was active in its agitation. The Association for Promoting Cleanliness Among the Poor took more concrete steps by founding bathing establishments and wash-houses in the East End of London. There were other societies which set to work to provide decent lodging-houses and improvements in the houses of the labourers. Much, too, was done from this time onwards by the generosity of philanthropists. The American, George Peabody, for example, gave half a million pounds sterling towards the building of dwelling houses for artisans. Indignation had been aroused and an example set.

The first of a series of Acts for the removal of nuisances (defined as "the filthy or unwholesome condition of any dwelling-house or other building, or of any accumulation of any offensive matter, dung, etc., or the existence of any foul drain, privy or cesspool") was eventually passed in 1846. Two years later, after a great fight and with many alterations, a Bill, introduced by Lord Morpeth, was made law as the Public Health Act of 1848. This is the groundwork of all sanitary legislation. Its provisions were, for the most part, adoptive, and not compulsory except when enforced by the Board of Health on evidence of exceptional mortality.

The main effects of this legislation were to enable local authorities to obtain by a simple means powers which previously had demanded a special Local Act. They could have powers to construct or manage sewers and drains, wells, pumps, waterworks and gasworks; to control deposits of refuse, water-closets, slaughter-houses and offensive trades; to remove nuisances; to pave streets and regulate dwellings, common lodging-houses, cellars, etc.; to provide burial and recreation grounds and to supply public baths with water. For the first time local authorities could easily obtain these very comprehensive powers for the public good.

The 1848 Act furthermore set up the famous General Board of Health as a central Health Authority. The Board rapidly incurred unparalleled odium, one of the chief causes for its unpopularity being that one member was none other than Chadwick, the indefatigable busybody who had brought to light so many abuses and who, as Poor Law Secretary, led away by the zeal for reform, had made himself execrated by both rich and poor through his complete tactlessness in failing to make allowances for the personal feelings of others. Chadwick, too, had been the great exponent of the Poor Law principle which has been well summed up as giving " the paupers exactly what they don't want and then they get tired of coming ". The Board, then, started at a disadvantage. Its chief function was to act as a Central Authority from which local Boards of Health could acquire powers voluntarily and cheaply for sanitary improvements. There was also, as we have seen, a provision that in districts where there was an abnormally high death-rate the General Board could thrust powers on to any authority which might prove recalcitrant. Unfortunately the Board had no power to see that its instructions were carried out and consequently could be, and was, defied with impunity. Nevertheless, many towns made use of the Act to secure improvements.

The principle of the setting up of the General Board should be noted, for it is on this model that the Public Health system of this country has been based. This principle is that the actual sanitary work should be done by each district for itself, but that there should be a Central Authority, with limited powers, which can advise, direct, inspect and, if need be, compel.

The General Board made many useful investigations; for example, that on the water-supply of London. But, as has been pointed out,[1] the main success which it attained was that it awoke in the whole country " a conscience against filth ". The Board, however, was openly accused of ignorance, incompetence, intolerance and aggression and was dubbed a hopeless failure in matters of both theory and practice. Although most of the accusations levelled at the " bashaws of Somerset House ", as the Board was nicknamed, were conspicuously unjust, its unpopularity led, in 1854, to the overthrow of the Government which

[1] John Simon. *English Sanitary Institutions*, London, 1890, p. 224.

attempted to continue its existence. The Board was reformed on a changed plan and continued in office for another four years, when its functions were taken over by the Lords of the Privy Council.

The year of the Public Health Act was marked by another important event, the appointment of John Simon as Medical Officer of Health to the City of London. It was largely to this man's immense energy and extreme ability in directing the methods by which the structure of sanitary practice was built up that is due the excellent system of hygiene which we enjoy today. This was an entirely new experiment in State service which was originated in England and which Simon directed towards the success which it eventually achieved.

Simon was not the first medical officer of health in the country. Before this towns had been able to obtain private acts to obtain powers for improvement. Two years before Simon's appointment the town of Liverpool had availed itself of this and had its own Act for street improvement and to provide proper sewers and drains. The following year the same town appointed W. H. Duncan as its Officer of Health. Duncan's was the first of these appointments in the country and with commendable zeal he managed to rid the town of many of the most noxious infamies.

Simon quickly perceived that if good was to be done, it was essential to collect far more knowledge than was then available. It was statistics that he needed. There were no good statistics which went far back into the past. There were the old Bills of Mortality, weekly returns of the deaths in the various parishes in his London district, which had been published with varying accuracy for more than two hundred years. These were of little use for medical purposes, until 1728, when the *ages* of the dead were first given. Really reliable figures began under the Births and Deaths Registration Act in 1836. Returns of illness, as opposed to death, were not to be had.

What Simon required was not grand totals of the deaths in the City from various causes, but detailed figures for each district so that he could see at once where the dangerous areas lay and could exercise prompt inquiry and act. He was fortunate in securing the willing co-operation of the Registrar-General and of eleven Poor Law medical officers of the City, and thus was able to obtain weekly information of all new cases of fever arising in each separate area.

The information obtained he was quick to use. He instituted weekly inspections, secured orders for removing every nuisance and, what was of the utmost importance, he planned subsequent visits to see that those orders were carried out. The results demonstrated to all who cared to see what could be done by a really able and energetic man. Within the seven years in which Simon held this office, he had carried out almost all the necessary improvements which had been recommended by Chadwick. There was a new drainage system, good water-supply, strict street and house cleaning, the mitigation of all nuisances and " at a time when cesspools were still almost universal in the metropolis and while, in the mansions of the West End, they were regarded as equally sacred with the wine-cellars, they had been abolished, for rich and poor, throughout all the square mile of the City ".[1]

This sterling example seems to have been well appreciated, for when in 1855 the Government proposed to appoint a Central Medical Officer to the reconstituted Board of Health, this position was given to John Simon. His duties, as far as any details were concerned, were of the most nebulous kind, but again he set himself to the

[1] Simon. *English Sanitary Institutions*, London, 1890, p. 251.

diligent collection of facts and figures. During his term of office he initiated systematic scientific inquiries throughout the whole country and on a wide range of subjects. In addition to reports on the direct sanitary condition of the country, he published a number of very valuable studies of different individual diseases among which we may mention tuberculosis, bronchitis, ague, diarrhœa, industrial poisoning, and the diseases which different industries seemed to produce.

In one of his reports we again find him lamenting the lack of facts. How could one organize an efficient Public Health system without knowing exactly where there was lack of health and in what this lack consisted? This time Dr. Edward Greenhow came to his assistance. The Registrar-General's office contained much of the needed information but the published returns gave only general death-rates. Greenhow, using the accumulated mass of papers in the Registrar's office, with great labour produced some very informative and particular statistics for the seven years 1848-54. Now, for the first time, could be discovered the numbers, the sexes, the diseases and the districts of the dead. The importance of this was immediately clear to Simon. The figures demonstrated that the incidence of disease varied tremendously in different parts of the country. This was to be expected. In a district where a particular disease was unduly prevalent Simon searched for the cause. If there were several districts in which the same disease carried off above the average number of victims there must surely be a common cause in these districts. In this kind of way Simon was able to show that there were removable causes of disease, different in different areas. The value of such arithmetical methods in Public Health work began to be understood, and shortly after this the task of producing the required figures was undertaken by the Registrar-General. Today the returns of the Registrar are one of the most important, if not the most important, of all medical periodicals.

It was not long before the results of the campaign began to be convincing. The Ninth Report of the Central Medical Officer (1866) showed encouraging figures of the decline of certain diseases in definite districts where considerable improvements had been carried out. In Cardiff, to name the town where the greatest effect was observed, the general death-rate had fallen by almost one-third, from 332 per ten thousand population in the years 1847-54 down to 226 in the years 1859-66. In the particular instance of typhoid fever the death-rate had been reduced from 17½ to 10½, and of diarrhœa (other than cholera) from 17¼ to 4½.[1] Such figures as these could not fail to impress even the most sceptical. Unfortunately the figures, by some chance, showed exceptions. Chelmsford, for example, showed a rise in death-rate from each disease classified in the tables. But in general the improvement was very striking.

It was a relief to the sanitarians as it was a lesson to the country that the efforts to improve the public health had not been in vain. In these results lay justification for attempting further advance. There were many abuses yet to be abolished. Power was often lacking to bring the offenders to heel. A water company which might be poisoning thousands could be fined no more than £200. This was hopelessly inadequate, especially if we are to believe the allegation that the spread of the cholera outbreak of 1866 could be justly ascribed to the guilty mismanagement of the East London Water Company.

Up to this time nearly all the sanitary legislation had been adoptive: that is to say, there were at hand means

[1] Public Health Reports. Table in Ninth Annual Report.

for hygienic action which any district could adopt at its pleasure. But now under pressure from the growing volume of intelligent opinion the great Sanitary Act of 1866 made sanitation the duty and no longer the whim of local authorities. Compulsion was found necessary and penalties were enacted against sins of omission. Overcrowded houses and workshops were brought into the category of nuisances, which before had been confined to filth alone.

Following this important step came a number of other Acts dealing with merchant shipping, drugs, vaccination and a variety of other subjects. Before following the history of sanitary legislation any further, it will be convenient to mention here one other Government measure that has had an important influence for the good of the medical profession and of the public. This was the Act of 1858 which set up the General Medical Council. This consisted of twenty-three members of which seventeen were appointed by the various bodies (universities, the Royal Colleges of Physicians and Surgeons) which at this time granted their own degrees or licences to practice, while six were appointed by the Crown. Later the total number was increased to twenty-nine, including three who were elected by the profession as direct representatives. The General Medical Council was charged with important duties which it still fulfils today. Firstly, it compiles and keeps up the Medical Register, which is the official list of all medical practitioners who have followed certain approved courses in medicine, surgery and midwifery[1] and have passed certain examinations. This list at once provides a means for the general public to distinguish between a properly trained doctor and a "quack". No one whose

[1] This last was added by the Medical Act of 1886.

name is not on tne register may pretend that he[1] is a qualified doctor, but there is nothing whatever to prevent his practising "medicine" on any members of the public who may care to submit to his treatment. An unregistered practitioner, however, works under certain disabilities in that he cannot sign a death certificate, procure dangerous drugs or sue for his fees. The importance of the Register in protecting the public will be at once obvious.

There is no one statutory course of training (as there is in some countries) which must be followed to obtain admission to the Register. Today, in fact, there are some nineteen different bodies, including colleges, societies and universities, which are empowered to issue licences to practise medicine, and each of these can be registered with the Council. Thus there is no uniformity in the standard of training required, but the licensing body must satisfy the Council that its standards do not fall below some reasonable level of excellence.

The Council is, furthermore, concerned with keeping up the respectability of the profession by removing from the Register anyone who has been found guilty of felony or "infamous conduct" in a professional respect. Here again it will be noticed that the Council exists mainly to protect the public, not the profession.

The second duty of the General Medical Council is that of compiling an official list of drugs and medicaments, the *British Pharmacopœia.* This book gives also standards of purity below which the *materia medica* must not be sold and names the official strengths and doses of the various drugs.

Soon after these events it became very clear that the hygienic machinery constructed by legislation in instal-

[1] The registration of women is permitted by the Medical Act of 1876.

ments and amendments could not run smoothly. Progress could have been made only step by step as the enemies gave way, the result of which was a body of enactments and amendments which often resulted in anomalies and sometimes in confusion. Two separate authorities might find themselves severally responsible for the same duties, while each authority might be under more than one central control. The Boards of Guardians were responsible for the removal of nuisances, but the sewers were under the vestries of the parishes. Where there was a Medical Officer of Health he did not co-operate with the Registrar of Births and Deaths.[1] Unless some attempt was made to weld the whole sanitary system into one unified institution, there was danger that the people would never receive those benefits which it was the object of the law to confer.

A Sanitary Commission was appointed and its reports[2] advised that " the administration of the law should be made uniform, universal and imperative throughout the Kingdom ". A direct result of this was the Act of 1871 which set up the Local Government Board which acted as the central health authority up to the time when its functions were taken over by the Ministry of Health in 1919. The Board was to have powers advisory, permissive and mandatory to achieve the acceleration of sanitary progress. It was also to be a stimulus towards new legislation and the prevention of such diseases as were on all hands admitted to be preventable. It was to exercise medical and legal supervision over local authorities. It was to concern itself with the administration of the existing law and to promote fresh legislation to achieve the recommendations of the Sanitary Commission. But all was not plain sailing, and the Board was much troubled by refractory local authorities. For example, an attempt to force

[1] Simon. *op. cit.*, p. 323. [2] 1869-71.

the universal appointment of medical officers of health led to the appointment of nominal officials with beggarly stipends, while two authorities often appointed the same man, who consequently exercised his duties over an unmanageably large district. Furthermore, there was nothing to assure that the officers appointed had any skill or experience in sanitary matters or even had leisure enough from their practices to undertake any of the work at all.

The Board took steps to concentrate the whole administration of Public Health and Poor Relief into one bureau.

The Commission had advised that a complete system of medical officers and nuisance inspectors should be created, and half of the cost of this was to be borne by the Government where the appointments were considered satisfactory. The aim of the legislation was to ensure for every district a medical officer with special knowledge, with special powers and duties to supervise and advise in matters of the health of his particular district. The Act of 1872 allowed the compelling of authorities to appoint medical officers, but the enforcement of satisfactory obedience was another matter.

A later Act, the Public Health Act of 1875, is now the groundwork of the Public Health services in England and Wales. It is a vast code of sanitary law containing more than 300 sections. It deals with sewers, water-supplies, nuisances, the prevention and treatment of infectious diseases, the building of hospitals and with the finances of the Public Health services. It is from this Act that the modern Public Health machinery has come, and this is perhaps an unhappy circumstance, because it at once follows that preventive medicine has become permanently an entirely separate service from ordinary everyday medical practice.

From this time onward a whole network of Acts of

Parliament was passed, dealing with a number of different aspects of public health: but space forbids us to follow up the subject in chronological detail. In 1919 legislation was enacted with the object of bringing under one authority all the various matters affecting public health, which up to this time had been the duty of a number of separate departments. The new Act set up the Ministry of Health under a Minister of Health who, as a member of the House of Commons, should be responsible to Parliament.

The Minister was put in charge of duties previously performed by a number of bodies, of which the most important were the Local Government Board and the Insurance Commissioners. He was furthermore charged with taking measures for the prevention and cure of disease, initiating research, collecting statistics, publishing information and training persons for the health services. He also took over the duties of the Board of Education concerning the health of mothers and children of pre-school age and to some extent those connected with the school medical services, with which we shall deal subsequently. Other powers—those dealing with disabled soldiers and sailors, and with lunatics—were to be taken over at some time to be determined later. The Minister was to appoint Consultative Councils of persons with good practical experience of various subjects such as National Health Insurance and Local Health Administration. In this way the new Ministry became the central supervising authority over most of the schemes for the betterment of the public health.

The last stage in the unification of the health services came with the Local Government Act of 1929, an extensive measure of which only a part is concerned with matters of health. The most important provision in this respect was the transference of the functions of the Poor Law

Authorities to the County and County Borough Councils, each of which was forced to appoint a Public Assistance Committee to carry out the newly acquired duties. In this way these councils provide all assistance, including medical help, that is legally possible to any individual without his being classed as a pauper. The Act also gave powers to the County Councils to provide hospitals for the reception of the sick and it is under this provision that the County Councils may, with the approval of the Minister, provide hospital treatment for infectious diseases.

Having now reached the point where the Public Health services and the relief of the poor have been welded into a single system under one central control, we must turn back to survey some of the more specific services which have been set up to watch over certain particular aspects of the health of the people.

2. FOOD ADULTERATION

About the middle of the nineteenth century the increasing scandal of food adulteration began to receive a long-deserved publicity. It must have been clear to almost every consumer that certain foodstuffs were of very unpredictable quality and that unscrupulous purveyors were obviously swindling their customers by mixing cheaper ingredients with the more expensive foods. If such food had been merely diluted with inert substances, no more harm would have befallen the consumer than a slight financial loss or perhaps some degree of malnutrition. It began to appear, however, that many common articles of food contained substances that were definitely injurious to health.

In 1851 the *Lancet* began to publish the results of food analyses made by an Analytical Sanitary Commission. Various common articles were dealt with in turn. The microscope and the test-tube revealed a disgraceful state of affairs. Out of thirty-four samples of coffee, thirty-one were adulterated with chicory, and corn was found in twelve. Every single sample of bread out of two dozen contained alum, a chemical which was used not only to "improve" the colour and taste but also to give added weight. Milk was frequently found to be "sophisticated", generally with the comparatively harmless liquid tap-water, but it often contained as well thickening agents like flour and chalk in order to mask the thinness caused by the addition of as much as 45 per cent. of water. Sugar, cocoa, arrowroot, pepper, mustard and vinegar were all subjected to analysis. Chicory used to dilute coffee was in itself diluted with other cheaper substances, while vinegar was often strengthened with powerful mineral acids.

The *Lancet* gave public notice that three months after it began to publish these results it would mention in full the names and addresses of all tradesmen found to be selling adulterated food—and the names were duly printed as well as those of the comparatively few firms who, by selling pure stuffs, thus reaped a well-earned and gratuitous advertisement.

This public exposure of such fraudulent practices led to agitation which grew greater when it was discovered that poisonous preservatives were frequently added to perishable food, deodorants were being used to mask the smell and taste of articles of questionable freshness, while boiled sweetmeats were often coloured with red lead, vermilion (mercuric sulphide), arsenic, copper and chromium compounds—all poisonous in varying degrees.

Revelations such as these produced legislation in 1860 to guard against the adulteration of food and drink. This was the beginning of an outcrop of preventive laws which has continued up to the present time and includes Acts passed between 1875 and 1927 which were consolidated by the Food and Drugs (Adulteration) Act of 1928. Under an Act of 1907 the Ministry of Health (the formation of which we have discussed) now makes regulations to prevent danger to the public health from the importation, preparation, storage and distribution of food and drink. It is by means of such regulations that imported meats, shell-fish and the use of preservatives are controlled today.

At the present time every local authority, through its Medical Officer of Health and his Sanitary Inspectors, exercises a careful watch over the purity of the various articles of food sold or exposed for sale in its district. The inspector purchases samples of foodstuffs and has them analysed. Should they be found not to be genuine, prosecutions occur and heavy fines, and even imprisonment for subsequent offences, may be meted out to offenders. It is to this constant supervision that we owe the fact that most of our foodstuffs are not even now polluted with chemicals, and that it is no longer true that: "Chalk and alum and plaster are sold to the poor for bread".[1]

In general the position with regard to preservatives is this. Many, including boric acid, formalin and salicylic acid, are altogether forbidden. The permissible substances, benzoic acid and sulphur dioxide, may only be used in specified foods and in strictly limited quantities. Certain articles of food, if they contain preservatives, must be clearly labelled to that effect.

It should be stated that certain of the forbidden substances are not particularly harmful if present only in the minimal amounts necessary to achieve their object; but

[1] Tennyson. *Maud*, I, i, 39.

there is grave danger that anyone consuming a number of different foods, all of which contain the same preservative, may easily receive an injurious dose. The term " preservative " is not held to include such agents in common use as such as salt, saltpetre, sugar, vinegar, alcohol and spices.

Certain harmful colouring matters are strictly forbidden. These include firstly compounds of the poisonous metals, antimony, arsenic, cadmium, chromium, copper, mercury, lead and zinc; secondly, the vegetable gamboge, and lastly certain specified coal-tar products.

Owing to the importance of milk as a food, particularly for infants and young children, a whole body of legislation has been introduced to deal with this one article. The law concerning milk deals with almost every aspect of the attempt to secure a clean and wholesome supply, but owing to the large number of Acts and Orders lack of space forbids us to enter into further details.

A strict watch has also to be kept in order to ensure that certain poisons do not find their way into food and drink apart from any deliberate action of the manufacturers or purveyors. Poisoning from the metals used in tinning processes or from certain metal cooking utensils has been recorded. In 1900 several thousand beer drinkers in the North-West of England were taken severely ill, and some seventy died, from arsenic poisoning. The cause was eventually traced to the impure sulphuric acid which was used in the preparation of the " invert sugar " added to the wort during the process of manufacture. Outbreaks of antimony poisoning have occurred from the use of cheap enamel utensils, glazed with antimony, for the preparation of acid fruit drinks. These few examples will show how important is the watchful eye of the Medical Officer of Health.

3. MOTHERS AND CHILDREN

During the nineteenth century one of the gravest features of the mortality statistics was the immense numbers of children who died in the first few years of life. A huge total of infants in arms was carried off by epidemic summer diarrhœa which is undoubtedly a disease of dirt abetted by malnutrition. Measles and whooping-cough accounted for many under five years of age, while rickets handicapped so many others that they died of some intercurrent disease. These are some of the direct causes of infant mortality. Indirectly the two chief factors are undoubtedly poverty and ignorance.

The spectacular decline in the mortality rate of children under five years dates from the beginning of the present century and, be it noted, began before any specific action was taken by the state to reduce the appalling number of deaths. However, long before this medical men like Simon and Farr had written extensively on this very subject. They had seen that improved hygiene was bound to produce remarkable results. Most of the deaths were certainly due to faulty environment, in which must be included not only bad housing but also absence of sunlight and fresh air, dirt, poisonous food, lack of breast feeding and a hundred other details in the lives of the children. The causes of decline in the death-rate must therefore be sought in those factors which improved the general status of the masses. It was these general improvements rather than any measures directed particularly against child deaths that began to take effect.

Housing began to be improved both by the private enterprise of enlightened landlords as well as by voluntary charities and philanthropists. In this connection we must mention the great work of Octavia Hill and of Ruskin not only in bringing the facts to the attention of the public but also in their highly practical schemes for improving the housing conditions of the poor.

The sanitary conditions inside the homes of the poor have improved immensely in the last forty years and this can probably be attributed to the effects of elementary education, which became compulsory in the last quarter of the nineteenth century. Everyone was taught to read and by this means information could reach the homes in a way that was not possible before. The teaching of elementary cleanliness and hygiene in the schools must have had considerable influence for good. These benefits did not have any immediate effect upon the infant mortality rate. Time was necessary for the new generation to grow up. It is significant to note that thirty years from the introduction of compulsory education, when the girls born in the years subsequent to 1870 were in the prime of life and were becoming mothers, the decline in the death-rate among the children began.

In the past thirty-five years, however, more specific measures have been inaugurated with the direct object of protecting the lives and health of the children. The most effective of these protective schemes are the Midwifery, the Maternity and Child Welfare and the School Medical Services, which we must now examine briefly.

(a) Midwifery

We have already seen that it was even as late as 1886[1] that a knowledge of midwifery became compulsory for any student wishing to take a medical degree. The midwives themselves were completely uncontrolled and, since they conducted very large numbers of labours, often in a most

[1] See above, p. 251.

slatternly way, the damage to life and health must have been considerable. The discoveries of Semmelweiss and Lister could hardly have been put to any effective use by the ignorant "bodies" who by attending labour after labour might spread puerperal infection far and wide.

In 1902 legislation was enacted with the object of ensuring that practising midwives should have some kind of scientific training. The Act set up the Central Midwives Board which was to exercise jurisdiction over the midwives in some respects similar to the control of the General Medical Council over the medical profession. The Board was to frame rules for the training of midwives, to appoint examiners and arrange for the examination of candidates, and to publish annually an official roll of certified midwives. The Board was also to remove from the roll anyone found guilty of disobeying its rules or of misconduct. Lastly, the Board was to make regulations concerning the proper conduct of midwives when exercising their profession.

The rules of the Central Midwives Board are exceedingly strict. A midwife is directed to visit her patient before the birth of the child and to make all necessary inquiries and arrangements, personal and general, for the impending confinement. Scrupulous personal cleanliness is enjoined and the necessary medical equipment to be provided is described in detail. The exact duties both to the mother and to the child are defined and a list is given of conditions in which medical help must be sought without delay. No operative procedure is permitted except in grave emergency. The rules decide not only the conditions under which a midwife may be removed from the roll, but also those under which she may be temporarily suspended from practice to prevent the spread of infection. Any woman thinking herself aggrieved by having her name removed from the roll of midwives may appeal to the High Court of Justice. In this respect she has an advantage over the medical practitioner, for whom a decision of the General Medical Council is final.

The Midwives Act took the further and important step of prohibiting uncertified women from practising, although it made some provision for the certification of those who were actually in practice at the time. No woman may pretend to be a midwife unless certified. No one uncertified may attend " a woman in child-birth otherwise than under the direction and personal supervision of a duly qualified medical practitioner ", except in a case of sudden or urgent necessity. The Act, as it was subsequently amended in certain details, also makes it the duty of every County Council and County Borough Council to exercise a strict supervision over all midwives practising in their districts, to investigate charges of malpractice, negligence, or misconduct and " if a *prima facie* case be established to report the same to the Central Midwives Board ".

Under a different Act Maternity Homes are now strictly supervised and penalties are enacted for conducting such institutions if they are not registered. Local Authorities may refuse to register an improperly conducted home or if it is considered that the situation, construction, accommodation, staffing or equipment is unfit. The homes are liable to inspection at all reasonable times.

It should be noted that the Midwives' Acts, like the Medical Acts, are designed to protect the public, not the profession.

(b) Maternity and Child Welfare

This service, the name of which is self-explanatory, is a development of the present century when publicity was given to the wretched condition of the health of the poorer children. An alarm was raised about the ever-decreasing birth-rate and people began to see the national importance of preserving in good health the diminishing numbers of the newly born.

The beginnings were due entirely to voluntary effort. First of all, free additional food was provided for the mothers and then free instruction in the proper methods of nursing young children. Later Parliament was to show its appreciation of this type of work by monetary grants towards the expense of providing doctors, midwives, health-visitors and welfare centres. In the meantime, however, it became increasingly clear from the Report of a Committee on Physical Deterioration that some more effective scheme must be devised. The State control of the care of the mothers and children was mainly founded on the Notification of Births Act of 1907. This was quite separate from the Registration of Births with the proper authority: for this latter was merely to be used for statistical purposes. The new Act, which was adoptive, required the father of the child *and* any person attendant upon the mother at the time of or within six hours of the birth, under penalty, to notify the fact in writing within thirty-six hours to the Medical Officer of Health for the district concerned. The importance of this will be seen at once, for it enabled the Medical Officer to take immediate steps to ensure that everything possible was done for the mother and the new-born child.

Eight years later another Act made notification compulsory in all districts and also empowered local authorities to exercise their powers as Sanitary Authorities in order to look after the health of expectant and nursing mothers and young children. This was to be done through specially-appointed committees which were to include women. A parliamentary grant was made towards the expense. In this way the elected councils became the special guardians of the health of the women and infants, just as before they had been the protectors of the whole public against nuisance and disease.

At this time the Local Authorities had no special powers over the young children between the time when they ceased to be infants (in the medical, not of course the legal, sense) and the time when they reach the usual school age of five years, when they came under the control of the Educational Authority. In order to avoid this unprotected gap in the lives of the children, a further Act was passed in 1918 to allow Local Authorities to make arrangements for attending to the health of expectant mothers, nursing mothers and children below five years of age who were not attending school. The Authorities were directed to set up Maternity and Child Welfare Committees. It must be noted that a general domiciliary service by medical practitioners was not authorized.

From these beginnings a complete system of health supervision has arisen and includes the Maternity or Ante-natal Centres and the Infant Welfare Centres. The first of these institutions is designed to advise expectant mothers about their own health and is both educational and preventive. The staff of such a centre includes a doctor (who is generally a woman) and a certified midwife who may be one of the Health Visitors of the district. The main functions of the centre are these. The doctor gives consultations which are followed by a domiciliary visit by the midwife. Educational classes are given in the special hygiene of pregnancy, in " mothercraft " and in sewing. Special dinners or milk are often provided when necessary. Dental treatment should also be included since septic teeth constitute a grave menace to the health of a mother.

Especial attention is given in separate institutions to any woman suffering from venereal disease: for this is one of the most potent causes of congenital illness and deformity of children.

The Infant Welfare Centre is mainly intended for teaching mothers the best methods of caring for the health of her offspring and is consequently a preventive institution rather than one for treating the ailing child. Soon after the midwife has paid her final visit to the mother's home, the health visitor makes her appearance on the scene and besides giving good advice encourages the mother to bring her children regularly to the centre and not to wait until the babies fall sick. Classes are held both in hygiene and in such highly important subjects as cookery and sewing. Information is further disseminated by home-visiting. Treatment of minor ailments may also be given at such a centre, but it is most undesirable that the centre should become a clinic for sick children or an out-patient hospital. Any sickness but the most trivial should be treated at some special children's institution. The Welfare Centre should be for the maintenance of health not for the treatment of disease.

(c) The School Medical Service

We have seen how the watchful State protects the child from the time when it has not yet entered the world as a separate individual up to the time when it first goes to school to receive the elementary education which is enforced by the law. While at school the child comes under the control of the Education Authority, which is a County Council or a County Borough Council, and the care of its health is the duty of a new department, the School Medical Service, which in fact has been in existence some years longer than the Maternity and Child Welfare Service.

At the beginning of the present century much concern was felt about the deplorable physical conditions of the young men of England. This state of affairs was largely brought to light by the statistics of recruiting for the Boer War, which showed how many men of military age were physically unfit. Even before this it had been found necessary to provide special educational facilities for the very large numbers of children who were blind, deaf, mentally defective or epileptic. It was time to investigate the whole question of the health of the children in the elementary schools.

In 1903 a Royal Commission on Physical Training in Scotland pointed out the unventilated condition of many of the school buildings and the dirty and under-nourished appearance of the children. In England a Committee was inquiring into the physical deterioration of the children of the poorer classes. The facts, where they were available, were more than disconcerting and the Board of Education was urged to take action.

The first legislation was concerned with providing meals for necessitous children, but shortly afterwards much wider powers were obtained. The Education (Administrative Provisions) Act of 1907 gave power to Education Authorities to open vacation schools and classes, to make arrangements for the health of the children, and, what was most important, to provide for medical inspection of the children both on their first admission to school and as often afterwards as the Board might see fit. It was doubtful whether it was legal to compel the children to undergo the inspection and indeed a subsequent Act expressly states that there is nothing that can force the parents to submit their children to examination or treatment. Tact and persuasion was, and is still, a better weapon than force, and at the present time the parents who refuse the inspection are in a huge minority. If absolutely necessary, in the case of sick children, the parents can be prosecuted for cruelty.

The first examinations showed only too well how much needed they were. Between twenty and forty per cent. of the children had bad teeth while one-tenth of them had serious defects of vision. One in every hundred had tuberculosis!

There was no power, before this time, to provide the treatment which was clearly necessary. Suggestions could be made to the parents and inquiries were made to discover whether they had acted on the proffered advice. The new Act, however, provided for medical treatment of the children. Later, grants were made towards the expense and later still the Education Authorities were made responsible for seeing that the treatment was provided if the parents failed in their duties.

At the present time almost every child in every elementary school throughout the country is regularly inspected by the school doctor. The first inspection takes place shortly after the admission of the child to school, the last before it leaves and at least two others during its stay at the school, generally at the ages of eight and twelve years. If the child is found to be ailing, it receives special inspections in addition to the routine examination. The doctor inspects the child's clothing and footgear, the general state of nutrition and the cleanliness of its head and body, besides examining the various organs for any signs of disease or defect. Complete card-indexed records are kept for every child and these are of very great value in assessing the general state of health of the children in any one school or district.

The mothers are encouraged to attend at the examinations so that they may be advised about the treatment of any defect that may be discovered. Any child found ailing has a special card filled up stating the nature of the ailment and the treatment required. This card ensures that the child will be brought up for a special re-examination at the next visit of the doctor to the school. There are special hospitals and open-air schools to which children can be sent if it is considered by the doctor to be advisable. In this way children with tuberculosis, heart disease or mental defects can be sent away to institutions where they not only receive benefits for themselves but also cease to have a harmful and retarding effect upon the other pupils in the elementary school. Upon the school medical officer falls the task of deciding whether a child is mentally defective and, if so, whether it is sufficiently intelligent to benefit from the modified education in the special schools for the defective or whether it is so completely imbecile or idiotic that he must have it removed to the appropriate institution or home.

The school doctor has another important function, for he may have to be called upon to take drastic action in the event of epidemic disease breaking out among the pupils. If necessary he may have the school closed completely until the danger is past.

(d) Results

The consequences of these schemes for watching over the children are quite remarkable and the number of lives that has been saved is very large indeed. During the five years from 1896 to 1900 it is recorded that out of every thousand children born alive, one hundred and fifty-six on the average were dead before the first anniversaries of their births. In each succeeding quinquennium the average annual number of infant deaths per thousand live births became lower and lower until in 1931 it was reduced to sixty-six per thousand. This means that in the first thirty years of this century the infant mortality has decreased by more than half.

The figures for the children of pre-school age are also very encouraging. In the five years from 1911 to 1914 the standardized death-rate per thousand children living below the age of five years was as high as 37.5 per annum. In 1931 the rate had dropped to 20.6. This great saving of life may be largely attributed, without much fear of error, to the midwifery and the maternity and child welfare services. It has been estimated that the latter of these saves some thirty thousand lives in a single year.

The school-children have also benefited very considerably from the attentions of the medical services of the Education Authorities. The Registrar-General's Statistical Review for the year 1931 tells us that, when compared with 1930, the year of lowest mortality, a further decrease in the mortality rates occurred at the period of school life (from five to fifteen years), the rate at five to ten being the lowest ever recorded for both sexes.

The money of the taxpayer has not been spent in vain. The figures for the deaths among the children have sunk in a remarkable way. This, however, should give no cause for complacency. They are still too high, but there is little doubt that the best way of reducing them has been found and further sustained effort will produce even better results in the future.

When a child leaves school he ceases to be under the medical care of any authority until he reaches the age of sixteen when, if employed, he is cared for under the compulsory health insurance scheme which we will discuss later. It is extremely unfortunate that there should be this unprotected gap of two years at this important period in the life of the adolescent. It is to be hoped that some means will be available for mending this crack in the protective wall which the State has built round each individual member. There is considerable probability that the age of leaving school will shortly be raised.

In tragic contrast to the lowered mortality among the children is the complete failure of all the efforts which have been made to reduce the numbers of the mothers who die each year as a result of pregnancy and child-birth. At the beginning of the present century the mortality of women in or associated with child-birth was 5.56 for every thousand children born alive. From that time onwards, in spite of the new Midwifery and Maternity and Child Welfare Services, the figure has hardly altered. The lowest mortality, 4.82, was recorded for 1923, while in 1918 it was as high as 7.60. The figure for 1931 was still as large as 5.55: and this does not include the deaths resulting from illegal interference with pregnancy such as criminal abortion, suicide or murder.

The direct causes of these deaths are, in order of numerical importance, puerperal sepsis, the so-called toxæmias of pregnancy, hæmorrhage, accidents of pregnancy and labour together with certain causes of sudden death. Surely the discoveries of Semmelweiss and Lister should long ago have exterminated sepsis. Many reasons have been given to explain away these deaths. It seems clear that either the whole conduct of modern midwifery is wrong or else that it is inefficiently performed. Bad treatment, lack of facilities for obtaining advice or treatment, bad conditions of confinement and neglect of proffered medical advice all play their part in keeping up the numbers of the deaths. The mortality rate from sepsis in Holland is just about one-half of that in this country.[1] Certain institutions have records which are conspicuously favourable compared with those of the country as a whole. There is therefore little doubt that sepsis is largely preventable. Such measures as the compulsory notification of puerperal fever and the compensation for midwives who have been suspended from practice owing to contact with septic cases were designed to prevent the spread of sepsis, but so far the reduction that was expected has not occurred.

There has been much concern among responsible bodies over this urgent question. The final Report of the Committee of the British Medical Association on the Causation of Maternal Mortality stated its findings in 1928. The Committee affirmed that, though it did not doubt the existence of a minority of inefficient practitioners and midwives, yet on the whole conscientious use was being made of all the available knowledge and facilities. The Committee advised increased co-operation between the doctors, midwives and maternity homes, the absolute minimum of interference with labour, intelligent anticipation and treatment of any complications, more facilities for antenatal supervision, more midwifery beds, and an intensive educational campaign among the members of the general public. Attention was also drawn to the great shortage of material for the instruction of students and midwives, and the wasteful use of such as there was through the teaching of nurses who often took the certificate of the Central Midwives Board without any intention of practising midwifery at all.

Dame Janet Campbell, the Senior Medical Officer of Maternity and Child Welfare of the Ministry of Health, reported[2] that the training of students and midwives was

[1] H. Jellet. *The Cause and Prevention of Maternal Mortality*. London, 1929.

[2] *Protection of Motherhood*. Ministry of Health, No. 48, London, 1927.

by no means satisfactory. There is very little doubt that this is a fact and that although a thorough theoretical knowledge is demanded of an examination-candidate, his practical knowledge of obstetrics may be very small indeed and in the nature of things it is not possible to conduct an examination in the actual manipulation of a confinement. The maternity services clearly need to be improved and increased so that no woman should lack the fullest possible assistance. Education for the public, although very desirable, should be done with discretion, so that a scare may not be raised by insisting too much upon the dangers of child-birth; for fear is undoubtedly prejudicial to the health of the mother. Child-bearing should be regarded as a normal physiological process which should none the less be conducted with that great care which is due to so important an event in the lives of two individuals.

Tremendous efforts are being made to save the lives of the mothers and it is to be hoped that the mortality may soon show a decrease. Careful supervision from the moment when pregnancy is noticed until the child is born and the mother has recovered must give good results if intelligently, conscientiously and universally applied.

4. NATIONAL HEALTH INSURANCE

The great principle of National Health Insurance for manual workers did not reach the Statute Book in England until 1911, nor indeed did it begin in this country. Germany had instituted such a scheme more than a quarter of a century before, and it was mainly upon this that the new Bill was modelled. Health Insurance was one part of the measure brought in by Mr. Lloyd George as Chancellor of the Exchequer in the Liberal Government.

It was not, it should be noted, mainly a preventive measure but was designed to provide for medical treatment of disease.

The main idea was that all persons between sixteen and seventy years of age who were under contract of service (with certain exceptions) should be compulsorily insured, the premiums being paid partly by the workers and partly by their employers, totalling ninepence per week per person. For this payment the workers were to secure free medical treatment at home, payment during sickness of ten shillings for men and seven shillings and sixpence a week for women up to twenty-six weeks, disability payments and a maternity bonus for women. Furthermore, sanatorium treatment for tuberculosis was to be provided. These benefits were to be obtained through " approved societies ", that is to say, the trade unions, Friendly societies, etc., or, for those who did not belong or would not or could not join such societies, through the post office.

This was clearly an extremely important social measure; but there was much opposition on a variety of grounds from the working classes, including domestic servants, and from employers. Here we must confine our attention to the objections raised by the medical profession. It was the duty of the local authorities to arrange with the local practitioners for the medical treatment of the insured at a rate of payment of six shillings per head per annum. The British Medical Association, which could justly claim to represent the view of the general practitioner, was fully decided that the payment must be larger than this. The Government increased its offer to nine shillings, but this, too, was thought too small, and more than twenty-seven thousand doctors signed an undertaking to support the British Medical Association in its determination to fight the Government by withholding their services.

An offer was made to treat the insured for a minimum of eight shillings and sixpence a head, or a fee of two shillings and sixpence per visit, under some arrangements to be made between representatives of the doctors and of the patients, with the express proviso that a free choice of doctor should lie with the individual insured person. The Government, however, meant that there should be control of the public moneys by the insurance committees of the local authorities and the Central Insurance Authority and could not allow the matter to pass purely into the hands of the doctors and the approved societies. The Government therefore decided to rely on those doctors who would repudiate their pledges and flout the opinions of the British Medical Association. Mr. Lloyd George carried the day and gradually the " strike " was broken so that by 1913 the Association was compelled, by large-scale secessions from its ranks, to release its members from their promises.

The doctors, however, had protested to some purpose, for their more reasonable demands, such as the free choice of doctor and increase in the capitation fee, had been granted. The Act came into force and gradually its unpopularity faded, until today National Insurance is accepted as a necessary part of our social system.

Today more than fifteen thousand general practitioners are working under the scheme which provides for about one-third of the population. Any doctor may become a " panel " doctor, and the Minister of Health alone can remove him from the panel and only for some very good reason. The patient has a complete freedom of choice of doctor, being limited only by geographical distances; but no one doctor may take more than 2,500 panel patients on his practice. On the whole the system works very smoothly in spite of occasional outcries that the panel patient gets perfunctory treatment, that the doctors give disability certificates too readily, or that over-prescribing constitutes an unnecessary expenditure to the State.

There is little doubt that the good work done by this scheme far more than compensates for any minor flaws or irregularities which critics are only too anxious to expose. Any tendency towards neglect or slackness on the part of the doctors is obviated by the right which every patient has to change his doctor at will. This competition between doctors helps to maintain a standard of efficiency which it would be difficult to ensure under any system of whole-time medical officers paid fixed salaries by the State.

5. OCCUPATIONAL DISEASES

Under this head we must concern ourselves with diseases which occur almost exclusively among industrial workers and which are caused by the particular conditions under which they work. Certain ailments have long been known by names which indicate their occupational origin. Housemaid's knee and tennis elbow are two with which everyone is familiar. In the industrial world we find such names as grinders' rot, potters' asthma, chimney-sweeps' cancer and woolsorters' disease.

The earliest comprehensive study of such maladies seems to be that of Bernadino Ramazzini, Professor of Physic at Padua, who published his *De Morbis Artificum Diatriba* at the beginning of the eighteenth century. This work[1] contains forty-three chapters dealing with as many different vocations from the lowest to the highest, from the *Diseases of the Cleansers of the Jakes (de morbis Foricariorum)* to those arising from the sedentary pursuits of *Learned Men.* It includes detailed descriptions of the effects of many industrial poisons. For example, Ramazzini tells of the

[1] Editio Secunda, Utrecht, 1703.

dismal plagues inflicted by quicksilver upon goldsmiths. At that time gilding and the silvering of mirrors were done by dissolving gold or silver in mercury, applying the solution to the appropriate article and finally driving off the mercury by heat. With the greatest precautions it was impossible to avoid inhaling considerable quantities of the poisonous mercurial vapours so that workmen " do quickly become Asthmatick, Paralytick and liable to Vertigos; and their Complexion assumes a dangerous Ghostly Aspect. . . . Their Neck and Hands tremble, their Teeth fall out, their Legs are weak and maul'd with the Scurvy ".[1] The modern processes of electrical plating and silvering of mirrors by the use of ammoniacal solutions of silver nitrate have relieved these particular craftsmen from the dangers of mercurial poisoning: but casualties may occur today among the manufacturers of thermometers, barometers, mercury vapour lamps, mercurial explosives and various other products.

A valuable study of occupational diseases was made in Leeds by C. T. Thackrah just over a hundred years ago. His book on *The Effects of the Principal Arts, Trades and Professions*[2] describes many of the diseases which trouble industry today. He writes of the dangers of dusty employments and of the injury to the lungs from vapours. He calls attention also to skin diseases among grocers and bakers, to chimney-sweep's cancer, to lead poisoning among potters, housepainters, plumbers and braziers, and insists that wet and cold do not produce all the disorders so commonly attributed to them.

At the time of publication of Thackrah's book public attention was being drawn to the deplorable effects of industrial fatigue in the mills, especially among the young

[1] Ramazzini, *op. cit.*, translation, *Diseases of Tradesmen*, London, 1705, p. 15.
[2] London, 1831.

children who were employed there for twelve hours or so during six days a week. Factory legislation began in 1833 with an Act which prohibited the employment of children under nine years in the spinning and weaving trades. This was the beginning of the limitation of ages and hours which has continued up to the present day. Four Factory Inspectors were appointed to see that the provisions of the Act were carried out. Eleven years later the Inspectors were given powers to appoint Certifying Factory Surgeons who were to give certificates of age for the children and also to inquire into the nature of accidents in the factories. Such legislation was considerably extended to include many different aspects of the problem of securing health for the workers. Today most of the provisions governing this are to be found in the Factory and Workshops Act, 1901. This contains ten parts and more than a gross of sections dealing with health, safety, conditions of employment, education of children, homework and various specified trades which are known to be particularly unhealthy. We cannot detail the numerous sections which deal with the problem of the general health of the workers, although it must be noticed that these are the provisions which are the most effective in preventing disease. Here we must turn to some of the so-called dangerous trades which have a more particular medical interest.

In the latter half of the nineteenth century attention was especially directed towards certain trades which were injurious to health apart from any general consideration of fatigue, age or bad hygiene. As a preliminary the Act of 1895 specified certain maladies which were made compulsorily notifiable to the Chief Inspector of Factories. These were poisoning due to lead, phosphorus or arsenic, and the disease anthrax. By later legislation poisonings from mercury, carbon disulphide, aniline and benzene were included among the notifiable ailments, as well as ulceration due to chromium compounds, cancers of the skin and toxic jaundice.

We have already referred to anthrax, the deadly disease of animals against which Pasteur had discovered a means of preventive inoculation with attenuated cultures of the anthrax bacillus. Certain classes of workers were, and still are to a lesser extent, very liable to infection with the germs of this disease. In man the malady may begin either in the skin as an inflammatory swelling or in the lungs, when it is known as woolsorter's disease from the circumstance of its having been comparatively common in the woollen industry at Bradford. Cutaneous anthrax is extremely dangerous to life while the pulmonary variety is almost invariably fatal.

The skin of workers may become infected through contact with the hides, fleeces or skins of animals which have died of anthrax. Dust from such material may contain myriads of the highly resistant spores of the bacillus and may remain infective for years. When dust finds its way into cracks or cuts on the human skin, the spores quickly germinate into anthrax bacilli, a swelling appears at the site of infection and after a short interval the whole system becomes invaded by the bacteria. In a similar way those who come into contact with infected wool or horsehair may inhale the spore-laden dust and so develop pulmonary anthrax.

The ideal method of prevention would be to protect animals from becoming infected. In this country Acts have been passed to make certain diseases of animals notifiable. Under the Anthrax Order, 1928, this disease was made notifiable and stringent regulations were laid down for the disposal of any infected carcases and for the disinfection of premises. However, since most of the bacilli which are responsible for industrial anthrax are imported from abroad, these measures are not very effective in abolishing the disease. A second line of defence lies in the disinfecting of suspected hides or wool. Unfortunately wool becomes useless for many industrial purposes if it is heated for too long. A reliable method of sterilization has been found and is used in the Government Station at Liverpool to disinfect the more dangerous kinds of material. The best preventive measure is probably that adopted in this and certain other countries, namely, the attempt to prevent any infected hides or wool from appearing on the market, but since large countries such as China, India, Japan, Russia, Egypt and South Africa are all liable to furnish diseased animal products, the problem is exceedingly difficult. Further preventive measures have been introduced to stop the workers becoming infected from any spores which may be present in the materials they handle. Of these, exhaust ventilation in the places where the dust is likely to arise is probably the most efficacious, but so long as infected stuffs are used, then there is always considerable danger.

Once the disease has been contracted prompt treatment is of the utmost importance. The best remedy is the injection of an anti-anthrax serum which was first prepared by Professor Sclavo of Siena in 1895. It is said that the mortality of cutaneous anthrax has been reduced by this means from 48.3 per cent. to 4 per cent.[1] To ensure prompt treatment it is important to warn employees of the danger so that they may seek advice about any suspicious swelling. Excellent coloured plates representing typical anthrax pustules have been prepared for warning notices.

Lead poisoning is liable to occur in a number of different trades—for example, in metal-smelting, the preparation

[1] T. Legge. *Industrial Maladies*, Oxford, 1934.

of red lead, white lead and paints, coach-painting, house-painting, enamelling, pottery, plumbing, the making of electric accumulators and, to quote an even newer industry, in the manufacture of tetra-ethyl lead. Stringent precautions are enforced on every industry in which lead poisoning occurs. Exhaust ventilation in the workrooms has done much to avoid the inhalation of the vapour and dusty compounds of lead. Factory hygiene, including the provision of special clothing and washing facilities, and the prohibition of eating in the workrooms have greatly reduced the quantities of lead which the employees consume. The use of wet rubbing for removing old paint has lessened the risk for painters. Water is also invaluable for laying the lead-containing clouds of dust which would otherwise fill the rooms where accumulators are made. During certain operations in this process it has even been found necessary to wear gas-masks. In some industries it has been found possible to substitute harmless materials for the more dangerous. For example, it was discovered that in the preparation of glazes for pottery, the solubility of the glaze, and consequently its toxicity, could be much reduced by using lead mixed with silica instead of the highly poisonous red or white leads. In painting it is often possible to use zinc oxide in place of white lead. Machinery designed to avoid the handling of lead preparations is very valuable. An important factor in controlling this form of poisoning is the weekly medical examination by the Certifying Surgeon, which every employee is required to undergo. Lead is a slow and cumulative poison so that the inspection is especially valuable for the detection of early signs, of which an alteration in the microscopical appearance of the blood is one of the most characteristic.

The incidence of lead poisoning in industry has undoubtedly been very much reduced by precautions such as these. Between 1900 and 1904 on an average 753 cases were notified in each year, but between 1925 and 1929 the figure averaged only 245 and in 1934 the number was less than 200. However, it must be pointed out that a reduction in any given trade may be due partly to a depression in the industry in question.

In the manufacture of lucifer matches it was customary to use white phosphorus, an insidious poison which attacked the workers and gave rise to inflammation of the teeth and gums with eventual necrosis (death) of parts of the jawbone—a condition known as phossy jaw. Poisoning from this cause was very prevalent wherever matches were made and a considerable public agitation followed. The discovery that phosphorus sesquisulphide is equally effective for matches and also quite innocuous provided an easy way of prevention. Under the International Convention at Berne in 1906 all civilized countries undertook to prohibit the use of white phosphorus in matches. This undertaking was carried out in England by the White Phosphorus Prohibition Act of 1908. The remedy was immediately effective and fresh cases of phossy jaw are now unknown.

Arsenical poisoning in industry occurs either from the salts of arsenic or from breathing in the highly poisonous gas "arsenuretted hydrogen". The salts cause local irritant action on the skin while arsenuretted hydrogen is a powerful blood poison. Poisoning from the salts occurs in the making of certain chemicals—sheep-dips, paints, preservatives for the use of taxidermists and others. The symptoms include intense local irritation leading to eruptions and ulceration with general ill-health and cramps. Poisoning from the gas is rare but sometimes occurs in chemical works.

The methods of prevention are similar to those used against lead. The actual incidence of poisoning from arsenic is very small and this is undoubtedly due to the stringent precautions that are enforced.

Besides all these powerful chemical poisons there are certain substances which though not particularly poisonous in themselves have a highly deleterious effect when inhaled in finely powdered form into the lungs. The "dusty trades" are responsible for a very large amount of occupational illness among many different kinds of workmen. The substance silica which occurs abundantly in every part of the world is the chief cause of the damage. The diamond miners of South Africa, the tin miners of Cornwall, the worker in the rock upon which the city of New York is built, stonemasons, potters, the manufacturers of scouring powders and coal miners in certain districts are all liable to suffer from the effects of constantly inhaling air containing silica over long periods of time.

At one time it was thought that the silica caused damage to the lungs because of the mechanical irritation due to the fineness, sharpness and hardness of the particles inhaled. More recently it has been supposed that the effect is mainly a chemical one due to the gradual solution of the particles in the secretions of the lung. Whatever the mechanism of the process, the damage is undoubted. Firstly a chronic inflammation is set up and this leads to the formation of increasing masses of fibrous tissue throughout the affected areas. The gravest danger is that the bacillus tuberculosis so often obtains a sure foothold in a lung which has been injured in this way.

The prevention of silicosis, as the disease is called, presents a difficult problem. Water to allay the dust, exhaust ventilation at the points where the dust is first raised, masks and dust traps have all been used with varying success. In some trades harmless substances have been substituted for silica. For example, in the processes of sand-blasting the use of steel grit has given very good results. If the workers are examined regularly those that show signs of silicosis can be removed to other employments and may recover, although in some trades the proportion of those that do so is very small.

Even more dangerous than silica itself is the dust of asbestos, which is a compound of silica and magnesium. It has been said that " asbestosis is twice as swift in killing as silicosis ".[1] The recognition of asbestosis as a specific disease, although it was suspected early in the present century, was delayed by the current view that silica was only dangerous in the free (chemically uncombined) state. Some ten years ago Cooke and others were able to demonstrate peculiar nodules in the lungs of dead asbestos workers and in the centre of each nodule were found spicules of asbestos. Since that time the insidious course of the disease has been intensively studied from the gradual onset of shortness of breath until, after a few years, the fatal bronchitis, pneumonia or tuberculosis terminates the scene.

These discoveries led to the strict rules which have controlled the industry for the last four years. Besides the segregation of the dangerous processes in special rooms, exhaust ventilation and humidity, special gas-masks, overalls and head-protectors are required. It is to be hoped that with perseverance the occurrence of asbestosis will become almost negligible.

There is one other industrial disease which we must mention here because it is of peculiar medical interest in

[1] *Annual Report of Chief Inspector of Factories and Workshops for* 1931, London, 1932.

that it gives us hope that cancer may not be unpreventable. In the process of cotton spinning certain workers after years of employment are liable to develop cancerous ulceration of the skin, which is known as mule-spinner's cancer. Other trades also have their individual varieties of industrial cancer, but since the occurrence of all occupational cancer became notifiable it was found that the cotton workers were the heaviest sufferers.

It was known that workers in soot and tar sometimes developed cancer of the skin, and that such growths could be artificially induced in animals by repeatedly painting patches of skin with such tarry irritants. These growths were malignant and continued to increase after the causal irritant had been removed. It appeared that mule-spinner's cancer was caused by the mineral oil with which the hands of the spinners were habitually in contact.

Experimental evidence was brought to show that some specimens of oil were much more dangerous than others and that the danger varied even in oils from apparently similar sources. A search was instigated to discover the active ingredient in the oils. After a brilliant piece of research work Dr. Twort, the director of the Research Laboratory of the Manchester Cancer Committee, succeeded in devising purely physical tests which can be relied upon to determine the safety of a given specimen of oil.[1] A table was prepared to show the world's supply of oils in order of their danger. On the whole those from Russia appeared to be the most innocuous, whereas some samples prepared from Scottish shale were more than forty-five times as active in producing cancer. Here, then, was something new, a way of preventing at least some forms of cancer. A safe oil was all that was required.

[1] *Addendum to Annual Report for* 1933 *of the Medical Officer of Health for Manchester.*

Unfortunately there are other forms of industrial cancer. Chimney-sweep's cancer, for example, was recognized as an occupational disease more than a hundred years ago, but increasing cleanliness may do much to prevent this form of growth. Distillers of shale-oil and workers in pitch (used in the manufacture of patent fuels) are also liable to develop cancers of the skin, but apart from precautions of cleanliness and the substitution of machinery for human labour these forms of the disease are not at present very amenable to control. Periodical medical examination has been tried but it is exceedingly difficult to ensure the regular attendance of the workers who are naturally afraid, firstly of a diagnosis of cancer, secondly of an operation, and thirdly of being removed from their employment. It should be more widely known that these cancers are among the least malignant forms and can generally be cured by operation, radium or the Röntgen rays if early treatment is applied.

In connection with industrial cancers we may mention that there is reason for believing that certain workers in aniline dyes are more prone than the rest of the population to suffer from cancer of the bladder. Fortunately it is a comparatively rare condition. Five cases from the dye-industry were notified in 1933. It is readily understandable that, since aniline dyes are prepared from coal-tar there may be an irritant action on the bladder due to some substance similar to that which affects the skin of the worker in pitch, but in the dye-workers it finds its way into the urine.

6. TUBERCULOSIS

For thousands of years tuberculosis has taken its toll of humanity and its ravages can still be seen in the bones of the ancient Egyptians. Although until quite recently it was regarded by the majority as a non-infectious disease, there had always been current in certain parts of the world an unproven belief that consumption could be communicated from person to person. Certainly it was for the most part considered to be a lethal complaint and the Victorian ladies who were taken with a "decline" could not ward off the inevitable end by shutting out the fresh air nor by coddling one another ever so carefully.

The new conception that fresh air and sunlight might be beneficial to the consumptive was put forward by an Englishman, George Boddington, in 1840. Before this the examples of Russell's establishment at Brighton and the Royal Seabathing Hospital at Margate had shown that certain complaints were very much benefited by a more Spartan régime than was commonly practised. Boddington showed that there was great advantage to be had by treating consumption in the open-air with a nutritious in place of a lowering diet and by carefully graduated exercise. Here was the beginning of the idea of modern sanatorium treatment. In England Boddington was voted a dangerous crank, but his methods were taken up assiduously in Germany where the striking success of the sanatorium treatment of tuberculosis was first accepted by all. It was shown quite clearly that with proper management tuberculosis was a curable disease.

In 1865, the French Army surgeon, Jean Villemin, startled the medical world by his clear proof that tuberculosis was indeed a communicable disease. He was able to demonstrate that it could readily be passed from a human being to a rabbit by inoculation with tuberculous material. His results were soon confirmed in England and when in 1882 Koch announced his discovery of the tubercle bacillus it was hoped that victory was in sight.

Now that the infectious nature of the disease was proved, public opinion was aroused to the necessity of urgent action. Voluntary efforts began the campaign for new facilities for the treatment of consumptives. Sanatoriums were opened at Frimley and Midhurst. In 1887 the first voluntary tuberculosis dispensary was opened at Edinburgh. It was dispensaries such as this that were to form the central clearing-houses in the huge anti-tuberculosis schemes that developed in the first two decades of the present century. In England the first dispensaries were opened at Paddington and St. Marylebone in 1909 and 1910 respectively.

Since tuberculosis was infectious the desirability of making it a notifiable disease at once followed. Certain towns in England had a scheme of voluntary notification as early as 1899, but it was not until four years later that the notification was first made compulsory in Sheffield by means of a private Bill. In 1908 the Local Government Board used its powers under the Public Health Acts to make regulations providing for the compulsory notification of all cases of consumption which came under the Poor Law Medical Officers and three years later further regulations required the universal notification of all cases. Armed with this information the appropriate local authority could at once take steps not only to provide advice and treatment to the sufferer but also to protect his family and neighbours from the worst risks of becoming infected.

The National Insurance Act of 1911 provided, among other benefits, for the domiciliary treatment of consumptives by their panel doctors, for the building of sanatoria and hospitals, and for research into tuberculosis. Such advantages, however, were available only to persons who were insured under the Act. It therefore became increasingly clear that if any scheme for the eradication of tuberculosis was to be effective it must be all-embracing and available to the whole community. The Astor Committee on tuberculosis recommended that the organization of a complete anti-tuberculosis scheme should be put into the hands of each local authority. Accordingly in 1912 the Local Government Board invited each County Council and County Borough Council to prepare its own scheme. Such schemes as were approved were to be financed by the State to the extent of four-fifths of the cost of dispensaries and three-fifths of the cost of sanatoria and hospitals. The annual costs of the schemes were to be paid by the local authorities, but they were to be reimbursed partly by payments from Insurance Committees and half the remaining deficit was to be provided by the Local Government Board.

The anti-tuberculosis campaign was thus launched on a most ambitious scale. Its declared object was that " no single case of tuberculosis should be uncared for " and that all services should be available to everyone. A scheme is now fully developed in each area, and consists of various co-operating units, the dispensary forming the main link between the individual units and between the public, the outside doctors and these units.

Outside doctors send their consumptives or suspected consumptives to the dispensary where they are seen by the tuberculosis officer, who is a physician with special experience of the diagnosis and treatment of tuberculosis, and a diagnosis is made. But besides being merely a centre for diagnosis the dispensary is also a centre for the observation of progress that the patients make, for the treatment of those who are not sent to institutions, for the examination of people who have been living in close contact with the consumptives, and for the " after care " of those who have been discharged as cured. The ideal is that no patient who is definitely tuberculous should cease to be under supervision until he is cured or dead. Finally, the dispensary is an office for the dissemination of educational anti-tuberculosis propaganda.

The dispensary sends the consumptives on to the sanatoria or hospitals, if such treatment is considered advisable. Through its care committee it keeps in touch with employers and social welfare centres, and it co-operates with the maternity and child welfare centres and the school medical services in caring for the needs of the children. Special "tuberculosis visitors" attend at the dispensaries, and it is their duty to visit the home of patients who have been notified as suffering from tuberculosis. Here they obtain information about the home life of the patient and of those who are living in close contact with him, and give advice as to the best methods of improving the hygiene of the home. The visitors may also engage in the actual nursing of sick patients in their homes under medical attention.

The above paragraphs give the roughest outline of the particular measures which are now taken to prevent known consumptives from infecting others and to provide treatment for the sick. In addition to such a scheme it is important that attention should be paid to all the more general circumstances which tend to weaken the resistance of human beings to tuberculosis. Firstly, measures must be directed towards the improvement of the general health of the community as a whole. This can and should be interpreted on the widest scale. For example, the teaching of hygiene in schools, the provision of fresh air, open spaces and recreation grounds in towns, the provision of an ample and varied diet for every child and adult and, exceedingly important, a supply of clean and uninfected milk.

In considering the importance of pure milk, it must be said that there is considerable controversy, not only over the best means of assuring such a supply but even over the desirability of such a thing. As soon as it became known that tuberculosis was definitely communicable, it at once became obvious that there was need to inquire into the possibility of men becoming infected by their meat or drink. It was suggested that all meat found to be tuberculous should be seized and destroyed; and in some places it was carried out. Unfortunately Koch confused the issue by asserting in 1901 that the tuberculosis of cattle is not transmissible to human beings and stated that the risk of contracting the disease from milk or meat was so small that he considered precautions unnecessary. Since then, however, it has been shown definitely that a very appreciable proportion of tuberculous infection in humans is due to the bacillus of bovine origin.

Accordingly, action was taken to improve the standard of the milk supply. Numbers of Acts, Orders and Regulations have been made with this end in view. At the present time the position is as follows. All milk producers and dairies must be registered, cows may be inspected and milk samples may be taken, and dairymen may be prohibited from selling milk which is proved to be tuberculous, and no milk from a cow with tuberculosis of the udders may be sold. Cowsheds and milking-places must be adequately lighted, ventilated and equipped with a supply of water. Orders have been made to ensure that the milk is not contaminated either accidentally or wilfully after it has left the cow. Consumptives may not be employed for milking or the handling of milk.

In addition to these precautions a number of special designations have been laid down for milks. Any milk under a special designation must conform to certain standards. There are Certified Milk, Grade A Tuberculin Tested, Grade A Pasteurized and Pasteurized Milks. The first of these is undoubtedly the best, but since it costs just double the price of ordinary milk its use is very restricted. Certified milk is the product of special herds of cows, every animal of which has been examined and submitted to a tuberculin test every six months. Any animals reacting positively to the test must be removed at once. Every cow must be marked and registered and the milk must be bottled on the farm and firmly sealed and must not be heated at any stage. Furthermore, certain stringent standards of bacteriological purity are laid down.

Grade A Tuberculin Tested Milk must conform to much the same standards except that it need not be bottled by the producer and the bacteriological standards are not so strict. The name Grade A, without the addition of the words "Tuberculin Tested", is extremely misleading, since anyone uninformed of the facts might suppose that it was the best milk available. There are certain regulations to which a producer of such milk must conform, yet there is nothing to prevent such a product from being obtained from tuberculous cows.

Pasteurized milk has been heated to 145 degrees Fahrenheit for half an hour and then cooled at once and bottled in clean containers. Such a procedure kills almost all the germs and, in particular, the bacillus tuberculosis. This milk can be sold at the same price as ordinary milk, probably because it keeps longer. Unkind critics have alleged that the big distributing firms are more interested in prolonging the life of the milk than that of the customer. Most of the bottled milk sold in London today is pasteurized and it is probably the best milk to buy for those who will not or cannot pay more than the ordinary price. It has been suggested that pasteurization should be made compulsory, but against this it has been argued—not very convincingly—that the food value is adversely affected. A more serious argument is that such a compulsion would inevitably set back the movement for the production of clean raw milk and the formation of tuberculosis-free herds which produce the best (Certified) milk.

Some have urged that repeated small doses of tubercle bacilli taken in milk have a beneficial effect in that an immunity to tuberculosis may be gradually acquired on the vaccine principle. There is very little doubt, however, that much tuberculosis in children may come from drinking tuberculous milk. The position is made more serious by the practice of conveying milk bulked in enormous containers, so that a single tuberculous cow may indirectly infect many hundreds of gallons.

The Anti-Tuberculosis Scheme has met with a very large measure of success and, when we come to discuss in our concluding chapter the main causes of death, we shall see how many lives have been saved from this one disease which is rapidly being degraded from its position of "Captain of the Men of Death".

Note.—The special designations of milk are now changed (see p. 300).

7. VENEREAL DISEASE

The problem of State interference in the matter of venereal disease must necessarily be difficult. The whole subject has been almost inevitably mixed up with sex and tabu, and these, added to the general hatred of any kind of interference with personal liberty, have made the task of improving the health of the people in this respect an exceedingly thankless one. Nevertheless, the ravages of syphilis and gonorrhœa in the middle of the nineteenth century were of such dimensions that it was thought imperative that some sort of experimental legislation should be tried.

For this purpose the Contagious Diseases Prevention Act was passed in 1864. This was an endeavour to check the spread of syphilis and gonorrhœa by examining known prostitutes, detaining them if they were infected, and inflicting heavy punishments on the keepers of any house of ill-fame who knowingly harboured diseased women. The Act applied only to naval and military stations where it would be a comparatively easy task to enforce the provision and to discover whether any benefit resulted. Another Act gave even wider compulsory powers. The unpopularity of these measures gave rise to such an outburst of feeling that the Government felt obliged to appoint a Royal Commission to inquire into the whole question. Previously it had even been suggested that the compulsory powers should be universally applied throughout the country. This proposition, however, was attacked on all sides, but chiefly on the grounds of morality. It was suggested that the sole effect of the Acts would be to encourage promiscuity by lessening the risks attached thereto and that it ill became any country to afford legal recognition to prostitution. As a result of such agitation the Contagious Diseases Acts were repealed in their entirety in 1886.

Subsequently more and more knowledge of these diseases became available. The germs were discovered and the researches of Wassermann and Ehrlich had provided a new means of diagnosis and a valuable cure. The whole matter was coming more and more into the limelight and the far-reaching and revolting effects of venereal disease were becoming more fully recognized.

A Royal Commission published its final report in 1916. Here we find a grave insistence not only on the evil effects of the disease on the patient who acquires it but, more important still, on the disastrous results of congenital or hereditary syphilis on the next generation. Congenital syphilis is a very frequent cause of antenatal death or of death very soon after birth. The congenital syphilitic is of stunted growth and of subnormal intelligence. Eyes, ears, skin, bones, joints, muscles, nervous system and brain, all may be irretrievably damaged by this disease. It was stated that of 1,100 children in the London blind schools 31.2 per cent. were certainly and, in addition, 2.8 per cent. probably due to syphilis " . . . while as much as 25 per cent. of all blindness has been attributed to gonorrheal ophthalmia ".

The social and economic effects were prodigious, loss of child life, sterility in men and women, and blindness and idiocy which contributed enormously to the expenses of education and welfare. It was calculated, too, that in the Navy and Army together, in 1912, nearly half a million working days were lost from venereal disease alone. The actual incidence of such diseases among the population in general was difficult to assess, because since these complaints were not notifiable there were no general statistics. However, information could be obtained from several sources. The Registrar-General could furnish the numbers of deaths certified as due to syphilis, but such figures must certainly have been artificially diminished by the unwillingness of practitioners to wound the susceptibilities of the relatives of the dead. Other more reliable information was obtained from the Navy, the Army, the Police and the Local Government Board's institutions and the Prison Commissioners, while the figures for general paralysis of the insane (a late manifestation of syphilis) could be obtained from the Lunacy Commissioners. The estimates calculated by the Royal Commissioners were frightening.

They affirmed their belief that not less than ten per cent. of the whole population was infected with syphilis, while gonorrhœa was spread more widely still. It did not follow that these diseases were necessarily becoming more prevalent than before—indeed, increase in education may have contributed to their decline—yet clearly it was time for action.

There were considerable difficulties to be faced. The facilities for diagnosis were very insufficient. Some voluntary hospitals, through the pious outlook of their benefactors who did not believe that free treatment should be given to those who had acquired a disease through loose living, had regulations prohibiting their treating venereal disease. The Commissioners expressed the hope that " when the facts elicited from our inquiry are made public the view that morality can be encouraged by denying medical treatment to those who by violating its laws have become a public danger will disappear ".

The advisability of making venereal disease notifiable was also considered. This has been done in some countries but it has the very material disadvantage that it deters patients from seeking medical advice and leads to endless concealment and subterfuge. Furthermore, if the onus of notifying the cases of these diseases is put upon the medical profession the result is to drive the sufferers into the hands of the unqualified practitioners. The Royal Commission called special attention to the calamitous effect of the treatment of venereal disease by such persons. This announcement will hardly surprise anyone who has obtained an insight into the ignorance of the " quacks " by a perusal of the evidence given before the Commission. The Government, however, did not consider it wise to prohibit such quack treatment until some reliable alternative had been provided.

An important recommendation made by the Commission was that the Public Health Acts should be used to call into being a national scheme of treatment. This suggestion was adopted by the issue of the Public Health (Venereal Diseases) Regulations of 1916, which directed and empowered County and County Borough Councils to provide laboratory facilities for diagnosis and to prepare schemes for treatment and for the provision of salvarsan or other remedies. Treatment was to be free, the cost being borne by the councils, with a grant of three-quarters to be paid by the Central Authority. It was added that all information about patients was to be strictly confidential and to aid in ensuring secrecy it was recommended that treatment should not be provided at special centres but rather in departments of the general hospitals. Local councils were also urged to provide educational facilities to provide information about venereal disease, its dangers and its curability.

These schemes duly matured and have done an immense amount of good. When a committee on the same subject reported in 1923 it was stated that no less than 179 approved centres were engaged in the diagnosis and treatment of venereal disease and that there was good reason to suppose that there was a considerable decrease in the numbers infected.

In 1917, shortly after the new schemes for treatment began to work, it was decided to put a stop once and for all to the activities of quacks and mountebanks who were offering alleged cures for these diseases. The Venereal Disease Act prohibits the treatment of these complaints otherwise than by qualified practitioners, but only in areas where there is an approved scheme of treatment in operation. In such areas no one who is not a qualified physician may for direct or indirect reward treat or prescribe a remedy for, or give any advice directly or indirectly in connection with the treatment of, a case of venereal disease. Advertisements are strictly forbidden, either of treatment or of any preparation intended for the prevention, cure or relief of such diseases. The point of prohibiting the advertisement of preventives lies in the fact that there are none that are absolutely safe or fool-proof and that many might be useless, and consequently it is intended to prevent the spread of the disease which might well result from the increased promiscuity which a false sense of security might engender. There is no doubt, however, that careful instruction in self-disinfection and the issue of " prophylactic packets " has been very successful in minimizing the incidence of disease in some branches of the Services.

Apart from the question of treatment, the belief of the Commissioners was that prevention could best be achieved by educating young adults to lead clean and healthy lives, insisting on the importance of early and thorough treatment for all who become infected, and by warning them against the enormous risks that sexual promiscuity entails. In 1917 the National Council for Combating Venereal Diseases, which later changed its name to the British Social Hygiene Council, was set up. This is a voluntary body which is, however, partially subsidized by the Government and Local Public Health Authorities.

Its main activities are concerned with biological teaching in schools to break the conspiracy of silence on sexual matters by means of lectures, pamphlets and other forms of propaganda, and to instruct parents how they may best give to their children the right information in the right way and at the right time.

Gratifying results have followed all these preventive and curative measures. For example, the British Social

Hygiene Council states that the annual number of new cases of syphilis has been reduced by one-half, while the number of infants born syphilitic has sunk by 57 per cent. The prevalence of gonorrhœa is still enormous, and is likely to be so as long as its great seriousness remains unrecognized by the majority of laymen and it continues a subject for flippancy and smoking-room jest. However, it is stated that infantile blindness due to ophthalmia neonatorum (largely gonorrheal) has been reduced by 35 per cent. Much remains to be done, but it is clear from the good results that have been achieved that further intensive work on the present lines is certain to produce a large decline in venereal disease during the next generation.

ADDENDUM

Public Health Legislation in 1936

The present year has seen the beginning of an attempt to codify and simplify the whole of the existing law on the subject of Public Health. A Departmental Committee had come to the conclusion that a single Bill embracing all the legislation on health would be altogether unmanagable, so that the best course would be to prepare a series of Bills of more reasonable length.

The Public Health Bill, 1936, the first of such a series, was brought in by Lord Gage in the House of Lords and is to be considered by a Joint Select Committee of both Houses of Parliament. It concerns chiefly matters of sanitation and the prevention and treatment of disease. It codifies the great Public Health Act of 1875 and the subsequent amending Acts, and it includes the Maternity and

Child Welfare and numerous other Acts concerned with health. Twenty-seven Acts are to be repealed in their entirety and many others in part. The Bill contains 340 clauses which take the place of about 600 sections in the existing law.

Further attempts are to be made to reduce the maternal mortality rate. The Midwives Bill, 1936, proposes to improve the standard of domiciliary midwifery in England and Wales by putting an obligation on every local supervising authority to establish an adequate service of salaried midwives.

The special designations of milk[1] are also to be changed in 1936. The new Order[2] describes two grades of pasteurised and two of raw milk. In 1937 a chemical test with the dye known as methylene blue is to replace one of the bacteriological tests for raw milk.

The year 1936 also marks the unfortunate failure of a mild Bill[3] to limit the more disreputable of the practices connected with the advertising of quack medicines. This carefully prepared measure was "counted out" in the House of Commons because, it seems, our paid legislators could not find time or interest enough to attend to so important a matter.

[1] See pp. 291-293. [2] The Milk (Special Designations) Order, 1936.

[3] Medicines and Surgical Appliances (Advertisement) Bill.

EPILOGUE

THE OUTSTANDING PROBLEMS OF TODAY AND THE OUTLOOK FOR THE FUTURE

The Chief Causes of Death and the Possibilities of Prevention

We have now followed the course of many of the more important medical discoveries from a hundred years ago up to the present time. Any attempt to predict the purely medical developments of the future would be extremely rash. However, it is safe to say that many of the methods which we have discussed will be pushed to their extremes to provide fresh relief from ill-health. We may perhaps permit ourselves a brief review of some of the main problems which have yet to be solved, together with some indication of the lines on which work is being and will be done.

The future of medicine must clearly lie in prevention. That at least is the ideal. New cures will come, but apart from the extension of existing methods such as serum and vaccine therapy, drugging and radiation, it is not easy to guess from where. Here, then, we must concern ourselves for the most part with preventive medicine.

Before examining some of the unsolved problems let us note that it may be truthfully said that we are not using to the full even the knowledge that we have. It has been shown, for example, how so many of the common epidemic infections—with certain notable exceptions such as influenza and the common cold—can be prevented by one means or another. If they are not so prevented, then the blame must lie with lack of organization or of funds rather than with lack of knowledge. It must lie above all with the loathing of interference which is inherent in so many of us. Let us take just one example.

Vaccination banished the disfiguring and killing smallpox, yet how many persons shirk their responsibilities today, now that the danger is more remote? The Act which made vaccination compulsory for new-born infants allowed exemption to those whose parents or guardians satisfied a magistrate that they conscientiously believed such a procedure to be detrimental to the child. Here is a bad gap in our defensive armour for in 1932 no less than 291,015 such exemptions were obtained. Nearly one-half of the new-born went unvaccinated.[1] When virulent smallpox breaks out anew it will find many of us unarmed, and these will pay the penalty.

Smallpox frequently appears in this country in a very mild form which is called alastrim or variola minor. This form is neither disfiguring nor lethal but protects from smallpox. It has therefore been urged that, alastrim being just as effective and less dangerous than vaccination, we should do well to scrap the compulsory legislation as a piece of out-of-date machinery. This is a dangerous attitude, for if we let each individual take a small chance of contracting alastrim and so becoming protected, then the bulk of the population will remain susceptible to smallpox which may come in a virulent form to wipe out the unprepared.

Let us now inquire into the main difficulties which have yet to be faced. Some are purely medical, others should be the subject of legislation, while others still need the close co-operation of medicine and the law.

In spite of the great successes over which there is much cause for rejoicing, unhappily people continue to die. For example, in England and Wales in 1930 out of a population of nearly forty millions, 455,427 died, giving a crude

[1] The Ministry of Health's figure is 47.4 per cent. *British Medical Journal*, 1934, II, p. 1135.

death-rate of 11.4 per thousand of those alive. This figure, however, when standardized to allow for differences in age and sex, gives a death-rate of 9.6 which is the lowest ever recorded and indeed is less than one-half of the mortality of eighty years ago.

The future of medicine must clearly be directed towards the prevention and cure of the diseases which are the chief causes of the recorded deaths. Of what, then, do we die in large numbers today? To find out this we must turn to the valuable tables issued annually by the Registrar-General. Here we see that the main causes of death are, in order of importance, heart disease, cancer, diseases of the respiratory organs, tuberculosis and cerebral hæmorrhage (including apoplexy). Let us inquire why the figures for these diseases are so high.

Heart disease is due to a variety of causes and takes many forms. There are, however, certain diseases which are known to damage the heart very seriously. Of these the most important are acute rheumatism (rheumatic fever and chorea, popularly called St. Vitus's dance, diseases quite distinct from the affections described as chronic rheumatism) and syphilis. We have already discussed the methods used to combat the last of these, but our knowledge of acute rheumatism is much less complete.

It is thought that the actual cause of rheumatic fever is probably a filterable virus. The disease for the most part attacks children of the relatively poorer classes; those of the well-to-do suffer proportionately much less. The worst feature about this very prevalent ailment is that it causes grave and often irreparable damage to the muscle and valves of the heart. The earlier in life the disease occurs, the worse is the heart crippled. It has been estimated that about 40 per cent. of all heart disease is primarily rheumatic.[1] Sir George Newman has computed that eight out of every thousand elementary school-children have cardiac disease of rheumatic origin.[1] A vigorous campaign against acute rheumatism appears to be one of the most promising lines along which to attack the high mortality figures of heart disease.

The actual mode of infection is not clearly known, but the general environment which favours the disease is plain enough. The means of prevention lie in altering this. Well-built and dry houses in clean and smokeless towns and sunny playing-fields are the enemies of rheumatism. Parents should be educated in the proper hygiene of children, for general good health is the best defence against almost every kind of illness. Good food and clothes and drying facilities for wet garments are exceedingly important, while septic teeth and tonsils are two powerful influences for ill. If those who are attacked by the disease receive prompt and prolonged treatment much of the cardiac damage can be avoided.

Degeneration of the heart muscle in old age also contributes to the high mortality rate. The heart never gets a complete rest, and if its owner does not die of anything else, it is possible that the heart will eventually wear out. The increased strain of modern living is a possible cause of early failure. It has been pointed out that the increase in the mortality rate from this cause is partly due to the growing tendency to record heart degeneration on the death-certificate.

The second commonest cause of death is cancer. Over sixty thousand persons in England and Wales died in 1933 from this cause. The death-rate is increasing and the figure is the highest yet recorded. Here again the numbers are much swollen by the alteration in the age distri-

[1] *British Medical Journal*, 1935, II, p. 101.

bution of the population. Improved diagnosis undoubtedly helps to swell them yet further. The mortality from cancer is highest in London and the county boroughs and lowest in the rural districts. This may well be due to the hospitals and other facilities for diagnosis which are most plentiful in the towns. That the mortality is highest in the big towns is a fact which is frequently used by the exponents of the "healthy-savage" school of thought. They announce that cancer is a disease of civilization. Many are of the opinion that this is purely fanciful and argue that if fewer savages get cancer it is because few of them survive long enough to get it, for cancer is mainly a disease of middle and old age. It is quite possible, however, that the ordinary dietary of civilized peoples may have a bearing on at least some forms of cancer. It has been stated that the simple diet suggested by Hindhede is very much like those eaten by certain native races in China and in the Himalayas and that these people enjoy excellent health and physique and do not suffer from the intestinal diseases of the European or from cancer.[1]

It is impossible to estimate any decline in the case mortality (i.e., the ratio of those who die to those who are affected), because cancer is not a notifiable disease. If many are cured by radium, X-rays or the surgeon's knife—and undoubtedly many are so cured—then the increasing figures of cancer mortality must mean that the incidence of the disease has increased even more than the figures seem to show.

An immense amount of research work has been done and our knowledge of cancer is becoming daily more extensive. The facts accumulate at a bewildering rate, and it has even been said that the available knowledge might even be sufficient to discover the cause of the disease if only we

[1] R. H. A. Plimmer. *Nature*, cxxxv, p. 1016, 1935.

knew how to apply it. In the meantime the war against cancer goes on unremittingly in every civilized country.

One of the greatest of the pioneers in cancer research was the Danish pathologist Carl Olaf Jensen. It was he who first showed how cancer could be transplanted from one rat to another, and the "Jensen rat sarcoma" has become the object of countless experiments which have given us much insight into the natural history of the disease. Attempts have been made to prepare a serum to make animals immune to cancer either when transplanted or when started experimentally by irritating substances. As yet, however, there is no known way of preventing the scourge (except some skin cancers such as cotton spinner's cancer) but there is every prospect that, the cause once nailed to the laboratory bench, a preventive may soon be available, although, as pessimists have pointed out, there is no known reason why there *must* be a cure.

An ingenious attempt to provide a chemical cure for cancer was made by the Liverpool Cancer Committee and the Liverpool Medical Research Organization under the directorship of the late Professor W. Blair Bell. It was known that the outer covering (the chorion) of the developing human embryo has the property of burrowing into the membrane which lines the uterus. It is in this way that the embryo ordinarily becomes attached to the maternal tissues. Normally the process is arrested when the embryo is sufficiently attached to obtain adequate nourishment from the blood of the mother. In certain cases, however, if the embryo dies the burrowing chorion continues to invade the maternal tissues. The invader has become malignant or else the maternal tissue has lost its normal power of checking the invasion before it is too late. The result is a very malignant cancerous affection known as chorion-epithelioma, which may spread into almost any part of the body. Attempts were made to discover why the invading tissue became malignant or alternatively why the maternal tissues ceased to resist.

It was known that substances containing lead would readily cause abortion if given in poisonous doses, and it was supposed that the lead acted by poisoning the chorion which attaches the embryo to the wall of the uterus, the same tissue, in fact, that sometimes give rise to chorion-epithelioma. If lead had any specific action on such cancer-like tissues it might be appropriate to try the effect of the same substance on the more ordinary types of cancer. Accordingly the Liverpool workers set out to find some lead compound which would attack the cancer without being so toxic as to poison the patient. A great number of substances have been tried, but at present there is no proved cure generally available.

Space forbids us to discuss the numerous angles of attack which have been and are being tried. The newspapers cause untold mischief by announcing definite cures long before they have been properly verified. We may mention that Dr. Bendien and his followers have elaborated a serological test which may be of use in the diagnosis of early cancer, though no such test has yet proved its worth.

Early cancer can often be cured completely by radium or X-rays, and this fact cannot be too widely known. One of the greatest obstacles to the successful treatment of cancer is the delay in seeking advice. Fear of the diagnosis is too often the restraining factor. Delay may be fatal, for the cancer rapidly becomes so extensive that the outlook is almost hopeless. At the present time the best means of reducing the huge mortality seems to be to educate the public to recognize the early signs of the disease and to warn them that cancer is curable but that delay means death.

Diseases of respiration include a number of totally different conditions, varying from pneumonia to chronic bronchitis, asthma or the inhalation of foreign bodies. These cannot be discussed fully here, but it is worth mentioning that the peculiarities of our climate are undoubtedly responsible for much respiratory trouble.

The fifth cause of death on our list, cerebral hæmorrhage, at the present time can only be viewed despondently. High blood-pressure and brittle arteries are the main causes and no sure method of preventing these is yet known. A quiet life is the best prescription, for here we have a disease which is undoubtedly increased by the intense and restless life of our modern urban " civilization ".

It is to the fourth great cause of death, tuberculosis, that we can turn with some satisfaction and a more hopeful outlook. In 1930 there died of tuberculosis in England and Wales the huge total of 35,745 persons—giving a crude death-rate of 898 per million of the population. This, however, was the lowest figure then recorded. In the period 1912-14, it was as high as 1,349 per million. The mortality from tuberculosis has declined in sixteen years by thirty-five per cent. The rate for 1933 stands even lower, at 824. This is indeed a wonderful result when the difficulties encountered in the battle are so enormous, but it appears that the costly and complicated organization of the Anti-Tuberculosis Campaign has not been working in vain.

We must not confine our attention to the main causes of death. There are many ailments which produce much suffering and economic loss, but which are considered of secondary importance because they do not kill. Let us take just one example, the most widespread and intractable of them all. This is undoubtedly to be found in all those various inflictions which are indicated by the collective term

" chronic rheumatism ". The very mention of this should be sufficient to moderate any pæan of jubilation over the triumphs of modern medicine. Here is a condition for which there is yet no sure preventive or certain cure. Elaborate attempts have been made to identify the cause, to discover the climatic or other conditions which aid or hinder the development of rheumatism, and to find the best methods of curing the disease when it has developed or at least of delaying its progress. Much can be done to allay the worst pains of rheumatism and to cure it in the early stages before the joints have been permanently damaged, but how much remains to be done can be judged from the fact that a recent estimate puts the annual economic loss in this country due to rheumatism at some seventeen millions sterling.[1] It must be mentioned, however, that in these days of unemployment and alleged over-production, it is extremely doubtful if this figure has any real value except to bring home the fact that the amount of crippling from this one cause is enormous. Rheumatism is certainly one of the diseases which the medical profession must make an early and organized attempt to destroy.

When we say that the future must lie mainly with preventive medicine it must be understood that we mean prevention on a scale far wider than the direct application of medical discoveries to individual diseases. In certain cases, as we have seen, the causes once known, the ailments can be eliminated. But general good health is a highly influential factor in enabling the body to resist the attacks of many diseases besides those that are purely infectious. The road to better health is well enough known, but ignorance and economic factors prevent the mass of the

[1] *Lancet*, 1932, I, p. 941.

people from following it. There are certain outstanding evils which must be attacked.

First of all, no one will dispute the fact that many people are living under housing conditions which are totally incompatible with the principles of health. There are too few houses and many that are overcrowded or unfit, or often both. An energetic campaign has been launched to provide new houses and to demolish slums and to provide the additional water-supplies and drainage that will be necessary. The rate of progress in this direction could be increased with advantage. It must be observed, however, that any Government or other authority that launches large-scale plans for housing and water-supplies should keep constantly in mind what are to be the requirements of the future. For example, all the available evidence and calculation goes to show that "we are now on the eve of the greatest event in the population history of this country, for we reach our maximum population in two or three years, and thereafter a gradual decline is anticipated, with some most far-reaching changes in the age distribution".[1] Houses, then, must be built in the right numbers and of the right kind, bearing in mind, for instance, that in about twenty years' time the numbers under fifteen years will be halved, and the numbers from thirteen to forty-five will be down by twenty-five per cent.[1]

There is no doubt that there is a section of the population in almost every country, England included, where the value of wages in proportion to the cost of food is so low that it is virtually impossible for them to obtain a diet which is sufficient in quantity and variety to meet the true needs of health. This evil is increased by the availability of huge quantities of cheap foods which have comparatively little real value. This, added to the ignorance of the

[1] *The Times*, October 27th, 1934. Letter from Sir Josiah Stamp.

housewife, will often mean that even if her income is actually large enough she will starve herself of some essential ingredients. In this country there is very little starvation from want of calorie value, but there is still much ill-health due to lack of variety in the food consumed. The abolition of the evils is a matter for instruction in food-values, shopping, cookery and economics rather than medicine.

There is a curiously illogical outlook which almost everyone adopts in fact, if not in theory, with respect to medical practices. The doctor lives by sickness, not by health. The more people who are ill, the more the doctor earns, and most people take this state of affairs for granted. This is not to suggest that the private practitioners are not for the most part wholly upright, ethical and competent: but there ought to be more doctors who are paid to keep us healthy, and then we should need fewer to try to put us right when we have fallen ill. It is true that we have, in each district in this country, a Medical Officer of Health, but his business lies with the prevention of nuisances, infectious disease, with Mother and Child Welfare and other public activities. He does not interfere with the individual except when the general public health is at stake. The individual is left to his own devices until he falls ill, when he applies to his own practitioner for aid.

Here again ignorance is largely to blame. The average patient expects too much. Too often he wants to be cured in ten minutes, with a bottle of physic, of all the accumulated ills of forty years of offence against the principles of healthy living. It is not the fault of the doctor that he lives on other people's troubles. Ignorance of elementary biology is largely to blame. Everyone should be taught to go to the doctor to find out how to keep well and not to wait until sickness has struck him down. Unfortunately, it is improbable that many people will be persuaded that it is to their advantage to pay a fee to a doctor when they are feeling perfectly well. This is a kind of thrift which will hardly appeal to the masses.

Secret Remedies

Another outstanding evil which should long ago have been abolished by legislation is that of the innumerable secret remedies and nostrums which are consumed in ever-increasing quantities by an ignorant and eager public. As long ago as 1914 a Select Committee reported the abuses connected with patent medicines. Some are definitely injurious, more are purely fraudulent, while the healing powers of every one are misrepresented and exaggerated in the most shameless way. "For all practical purposes British law is powerless to prevent any person from procuring any drug, or making any mixture, whether potent or without any therapeutic activity whatever (so long as it does not contain a scheduled poison), advertising it in any decent terms as a cure for any disease or ailment,[1] recommending it by bogus testimonials and the invented opinions and facsimile signatures of fictitious physicians, and selling it under any name he chooses, with payment of a small stamp duty, for any prices he can persuade a credulous public to pay."[2] Furthermore, many patent medicine firms are very glad to pay the stamp duty, for they know that many of their clients believe the Government stamp on the package to be an official guarantee of the efficacy of the simples therein.

[1] Except Venereal Diseases under the *Venereal Disease Act*, 1917.

[2] *Report of Select Committee on Patent Medicines*, 1914.

The British Medical Association had previously exposed many individual secret remedies in two excellent volumes[1] which gave the results of a series of chemical analyses proving beyond doubt the fraudulence of the majority. The Association also estimated the approximate value of each package of medicine and the figures were ludicrously small compared with the retail price to the customer. In spite of these exposures a number of these very remedies still persist and are widely sold today. However, it is significant that many exploiters of the gullible have so far kept pace with the advancement of superficial medicine that in the newer panaceas the old-fashioned homely names have given place to others with a scientific guise. In place of " Aunt Agatha's Asthma Cure " or " Magic Balsam ", we find hosts of names cunningly designed to sound like scientific words, together with long-winded " explanations " of the most spurious and pseudo-scientific kinds.

Recently the Royal College of Surgeons stated its views on the matter.[2] It recommended legislation to prevent the sale of injurious medicines, fraudulent claims and harmful advertising, and to forbid anyone to advertise anything whatsoever as a cure for blindness, Bright's disease, cancer, consumption, diabetes, epilepsy, fits, locomotor ataxy, lupus or paralysis. It might also be well to allow nothing to be sold without the formula appearing on the package, as has been done, for example, in Austria, France and the United States of America. It appears that no political party has the courage to tackle this immediately pressing question. The vested interests are enormous, and as long as the less scrupulous newspaper-owners derive substantial revenue from the advertisements

[1] *Secret Remedies, what they cost and what they contain*, London, 1909; *More Secret Remedies*, London, 1912.

[2] *Annual Report*, 1934.

of quack cures there seems little hope that the matter will ever get a fair share of publicity.

Compulsory education may be held to blame. The object of teaching the children to read was to ensure the spread of knowledge, but judging from the quality of the reading matter purveyed by the average bookstall keeper, we may question whether the printed word has anything but a deteriorating influence. There is no doubt at all that the huge profits made by the vendors of secret remedies depend largely on the educational facilities provided by the prudence of the State!

Pure Air

How long are we to tolerate the constant pollution of the atmosphere of our great towns by the tons of soot and tar belched forth by millions of chimneys? Not for a moment would we drink dirty water, but we breathe air of the foulest description: and, be it noted, we use air in far larger quantities than we do water.

The actual damage to health caused by smoke nuisance, though it can be only very roughly estimated, must be very large. First of all, the smoky atmosphere causes an immense loss of sunlight, particularly of the health-giving ultra-violet rays. To make matters worse, this loss is far greater in the winter when the need for sunlight is the more acute. In the second place, there is actual damage to the lungs from the inhalation of particles of soot, tar and sulphuric acid, all derived from the improper use of coal. Much of the respiratory disease which takes so prominent a place in the list of causes of death must be aggravated if not caused by breathing polluted air. In view of the increasing incidence of cancer of the lungs and the known cancer-producing properties of tar, it may be legitimate at least to consider, without raising a scare, whether the tarry products which are constantly breathed in large towns may not be in part to blame.

That fog can cause rapid death was demonstrated only too clearly by the so-called "Belgian Death Fog" of December, 1930. In the valley of the Meuse one single fog killed at least sixty-seven persons, while 150 became ill.[1] Inquiry revealed that fog and fog alone was the cause and that no special chemical fumes were connected with the deaths. It must be admitted that all those who died were previously in a low state of health, through old age or sickness; but the fog itself was the precipitating cause of the disaster.

The worst polluters of the atmosphere are the countless users of coal in the ordinary domestic fire. It has been computed that household fires are "responsible for about 2.5 million tons of a total output of solids into the air of about 3 million tons".[2] Factories are also responsible for considerable pollution, but the Public Health (Smoke Abatement) Act of 1926 gives local authorities at least some measure of control over the worst of the industrial offenders. It is unfortunate that the domestic hearth is considered so sacred that the Act expressly excludes private chimneys from any interference.

Some improvement has occurred in the last twenty years, partly no doubt, from the working of the Act. More probably, however, it is the increasing use of smokeless fuels like anthracite, coke, oil, gas and electricity that has contributed to this end. The average annual deposit per square mile in London has been reduced from 392 tons in 1915-19 to 289 tons in 1930-31.[3]

[1] *The Times*, 1930, Dec. 8th, p. 12, and Dec. 22nd, p. 11.

[2] *Economist*, Nov. 17th, 1934, p. 913.

[3] *Economist*, Nov. 17th, 1934, p. 913.

There are other reasons than those of health which ought to have considerable effect in urging us to mitigate the smoke evil. Our buildings are corroded at an appalling rate by the chemical products of incomplete combustion of coal. We spend huge sums in extra illumination and laundry which could be avoided if the air were cleaned. Furthermore, since smoke is nothing more than part of the fuel which is not burnt, we could save millions of tons of coal every year if we were to employ only such fires or furnaces as would ensure a complete oxidization of the coal. About three-quarters of the coal used in domestic fires is frankly wasted, whereas a properly conducted gas-works can use for heating purposes as much as 86 per cent. of the energy value of the coal. Even if our Public Health authorities are powerless, surely the economic factors should prevail.

Congenital Disease

There are many thousands of persons alive in this country today who have suffered all their lives from ailments varying from slight physical or mental disability down to complete crippling, blindness or idiocy. These are largely cases of congenital disease, although many are the victims of malformations which are truly hereditary in the Mendelian sense. Can either of these classes be prevented?

Let us consider just one example of physical deformity, blindness. The number of registered blind persons has been rising by leaps and bounds from 25,840 in 1919 to 62,488 in 1932. A very great deal of such blindness dates either from birth or from the first year of life. The main causes are ophthalmia (i.e. inflammation, often gonorrheal), congenital defects of structure, syphilis and accidents. Of these the first could be readily prevented by due medical care, involving prenatal treatment of the mother if she is infected with gonorrhœa, carefully disinfecting the eyes of the infant at birth and guarding against subsequent infection. This is being widely done but dirt, ignorance and prejudice are still fighting on the other side.

To prevent blindness resulting from congenital syphilis is a more complicated business, but it can and must be done. The first line of defence must be to prevent syphilitic women from giving birth. She should avoid pregnancy either by voluntary abstinence or birth control, but should such an accident occur, it is claimed that vigorous anti-syphilitic treatment, if instituted early enough, will ensure that the mother shall bring forth a healthy child. No woman about whom there is the faintest suspicion of contagion should be allowed to go through her pregnancy without having the Wassermann test made, so that treatment could always be started in time. Other measures, such as sterilization, might with advantage be made legal in certain instances in this country, as they are in some others. Abortion is used in Russia as a second line of defence, but it is unlikely that this will be legalized in England so long as religion, medicine, morals, sentimentality, sex and tabu, are all as inextricably and illogically mixed up as they generally seem to be today.

When these forms of blindness have been prevented we shall still be left with the cases of congenital defects due to heredity. People who are blind from this cause should on no account be allowed to procreate children, for there is no doubt whatever that certain conditions such as albinism, gross short-sightedness (amounting practically to blindness), squints, optic atrophy, detached retina and aniridia (absence of the iris, or coloured part of the eye) are purely hereditary. The mischief done by the marriage of one blind person may be immense. One pedigree[1] of a man with aniridia shows that in three generations he was directly responsible for no less than 113 blind persons out of a total of 118 descendants. This is, of course, an exceptional instance, but the danger of hereditary blindness is a very real one.

Even more important than the hereditary malformations of the body are those of the mind. In January, 1934, the Board of Control recorded that the number of mental defectives under care in England and Wales was 70,764 while those actually reported to Local Authorities as defective reached the total of 106,439, an increase of 4,094 over the figures for the preceding year. Only a proportion of these are hereditary types, but certainly many of them are. What means are being taken to prevent their increase?

At present the only sound method which is employed is by segregating the individuals. The numbers are huge and the cost of following this policy in its entirety would be prohibitive. Consequently many of the higher grades of mental defectives are perfectly free and at liberty to procreate indefinitely. This is a state of affairs which should not be allowed to continue. Legislation is needed to put in hand some of the available preventives. Birth control, compulsory sterilization of defectives and *proved* carriers of mental defect (either absolutely or as an alternative to segregation), legalized abortion for certain cases, prohibition of marriage for defectives, and so forth—all these measures would tend to lessen the numbers of these useless and generally harmful members of society. It should be added, however, that many mentally defective

[1] Risley pedigree (1915), but the authenticity of this particular pedigree has been disputed. (*Nature*, 1934, cxxxiii, p. 574.)

children are born of apparently normal parents, and it has been contended that the measures considered above would have very little effect in reducing the numbers.

A further question arises. Would it be beneficial to the community to consign some of the worst types of imbeciles and idiots to the lethal chamber? Such a method would appear drastic and there is a very strong feeling about the "sanctity of human life". Whole colonies of defectives exist where one may see some of the helpless, twisted, moaning and slavering idiots who are kept alive only by constant nursing and feeding by hand. Anyone who has seen some of these may well be divided in his opinion as to whether there is any sanctity about such lives or whether indeed they can be rightly described as human. There is a strong case for euthanasia, if not for these people, at least for infants who will in future be born with gross and incurable defects.

Conclusion

These are but a few of the more pressing problems which medicine has yet to solve. Whatever the future may hold in store, it seems certain that some at least of these gaps in our knowledge and practice will be filled.

The last hundred years have seen many successes. First and foremost they have brought us a workable system of preventive medicine. Secondly, they have given us new methods of diagnosis and cures for many individual diseases and have shown the paths along which we may hope to come to further victories. Thirdly, they have brought a vast increase in knowledge based upon sound experimental work. Progress in the future must make use of all these accumulated facts.

With all this to our credit we would still be rash to be over-jubilant. A note of warning must be struck. At the present time there is a remarkable disproportion between the amount of available knowledge and the relatively few methods of applying it. Medicine is in grave danger of being overwhelmed by unco-ordinated facts. There are many thousands of scientific periodicals of varying worth, many of them directly or indirectly medical, which are piling up an unwieldy mass of data. Daily medicine is becoming more complicated. It has been said that a science which is truly progressing tends to become more simple, not in the sense that it may be more easily understood by the non-technical inquirer, but in that it brings more and more facts under one comprehensive scheme. The latter kind of simplicity we cannot claim for medicine today.

The science of physics may be contrasted: for although it has become extremely difficult for the layman because of its strange mathematical concepts and computations, none the less it has become more simple in that a very large number of different branches have been shown to bear a close relation to one another. It seems, however, that even the physicists are in danger of having their very groundwork swept from under them.

Wherein lies the remedy that shall save us from a traffic chaos when all the streets of thought are choked with facts? This is the chief question for the future to solve. Are we to fall back on some general system of medicine such as proved so unsatisfactory in the eighteenth century, or are we to continue the present analytic methods and accumulate still more facts with the possibility of bringing chaos even nearer?

As the horizon of knowledge spreads slowly in every direction from the centre, one individual can hope to master only an increasingly narrow sector of the whole. Specialism is inevitable and once it has gained the upper hand there can be no more unity in medicine. Can we hope for some intellect which may integrate the scores of separate branches into a whole living tree? Hopefully let us make medicine speak the words which Robert Browning put into the mouth of the dying Paracelsus: —

> ". . . If I stoop
> Into a dark tremendous sea of cloud,
> It is but for a time; I press God's lamp
> Close to my breast; its splendour, soon or late
> Will pierce the gloom: I shall emerge one day.
> You understand me? I have said enough?"

CHRONOLOGICAL TABLE

OF

EVENTS OF MEDICAL IMPORTANCE

1832. Reform Act.
Anatomy Act.
British Medical Association founded.
1833. Factory Act.
Beaumont published experiments on digestion.
Influenza epidemic.
1834. Poor Law Amendment Act.
1835. Municipal Corporations Act.
Louis's medical statistics.
Graves' disease described.
1836. Registration of Births and Deaths Act.
Middlesex Hospital founded.
1838. Schleiden on plant cells.
1839. Schwann on the cell theory.
Skoda on percussion and auscultation.
Schönlein discovered parasite of *favus*.
1840. First Vaccination Act.
Boddington on the value of fresh air for tuberculosis.
1842. Poor Law Commissioners on the *Sanitary Condition of the Labouring Population*.
Long operated under ether anæsthesia.
Liebig's book on Organic Chemistry.
1843. O. W. Holmes on puerperal sepsis.
Hookworm discovered.
Farr's statistical table.
1844. Metropolitan Health of Towns Association founded.
Society for Improvement of Conditions of Labouring classes founded.
Wells on gas anæsthesia.
1846. Morton introduced ether as anæsthetic.
Claude Bernard discovered pancreatic digestion.

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1847. Semmelweiss and puerperal sepsis.
Simpson discovered chloroform anæsthesia.
Irish Potato Famine.
Virchow's Archives began.
1848. Public Health Act.
General Board of Health formed.
Claude Bernard on sugar storage by liver.
Fehling's test for sugar in urine.
Cholera in Great Britain.
1849. Snow on the mode of communication of cholera.
Addison on pernicious anæmia.
Thomson (Kelvin) invented absolute temperature scale.
1851. Claude Bernard on vasomotor nerves.
Bilharz discovered flukes.
Helmholtz invented ophthalmoscope.
1852. Hospital for Sick Children, Great Ormond Street, founded.
St. Mary's Hospital (London) founded.
1853. Crimean War began.
1854. Dysentery in Europe.
1855. Simon became Central Medical Officer for London.
Garcia invented laryngoscope.
Addison on Addison's disease.
1855. Army Reforms began.
1856. Virchow became Professor at Berlin.
1858. Medical Act set up General Medical Council.
Public Health Act.
Cocaine isolated.
Virchow published *Cellularpathologie.*
1859. Florence Nightingale *Notes on Nursing.*
1860. Adulteration of Food Act.
Pasteur showed bacteria present in air.
Nightingale Training School at St. Thomas's Hospital founded.
1861. Pasteur discovered anaërobic bacteria.
1863. Pasteur on silkworm diseases.
Davaine produced anthrax experimentally.
1864. Contagious Diseases Prevention Act.
1865. Lister began researches on infection of wounds.
Villemin inoculated rabbits with tuberculosis.
1866. Sanitary Act.
1867. Lister's Antiseptic Method.

1868. Wunderlich's book on thermometry.
Obermeier discovered spirochaete of relapsing fever.
1869. Brown-Séquard on internal secretion.
Langerhans described pancreatic "islets."
1869–71. Reports of Royal Sanitary Commission.
1871. Local Government Board.
1875. Public Health Act.
Amœba of dysentery discovered.
1876. Registration of women practitioners permitted in England.
Cystoscope introduced.
Koch grew anthrax bacillus in pure culture.
1878. Koch showed cause of infection of wounds.
1879. Manson proved that mosquitoes carry filaria.
Neisser discovered gonococcus.
Leprosy bacillus discovered.
1880. Pasteur discovered streptococcus, staphylococcus and pneumococcus.
Pasteur immunised chickens against chicken-cholera.
Eberth discovered typhoid bacillus.
Lunin's dietetic experiments.
1880. Laveran discovered malarial parasite.
1881. Pasteur invented anti-anthrax vaccine.
Koch's gelatine cultures of germs.
1882. Koch discovered tubercle bacillus.
1883. Koch discovered cholera germs.
Klebs discovered diphtheria bacillus.
Metchnikoff's phagocytes.
1884. Tetanus bacillus discovered.
Löffler grew diphtheria bacillus in pure culture.
1885. Pasteur inoculated against rabies.
Ephedrine isolated.
1886. Midwifery added compulsorily to qualifying examinations.
1887. Meningococcus discovered.
Malta fever parasite discovered.
1888. Pasteur Institute founded.
Diphtheria toxin discovered.
1889. von Mehring and Minkowski produced artificial diabetes.
1890. Diphtheria antitoxin invented.
Koch prepared tuberculin.
1891. Thyroid extract injected for myxœdema.

1894. Plague pandemic began.
Plague bacillus discovered by Kitasato and Yersin.
Rat and human plague found to be the same.
Bruce discovered trypanosome.
1895. Röntgen discovered X-rays.
Ross showed malarial parasite in mosquitoes.
Sclavo prepared anti-anthrax serum.
1896. Becquérel discovered his rays.
1897. Droplet infection theory.
Dysentery bacillus discovered by Shiga.
1898. Curies discovered radium.
Ross showed mosquitoes carry malaria.
1899. Mosquitoes shown to carry yellow fever.
Aspirin introduced.
1901. Factory and Workshops Act.
Adrenalin isolated by Takamine.
Complement fixation tests discovered.
Trypanosome of sleeping-sickness discovered.
1902. Central Midwives Board set up by Midwives Act.
Jensen transmitted cancer in mice.
Bayliss and Starling discovered secretin.
1903. Almroth Wright discovered opsonins.
Einthoven introduced his galvanometer.
Bruce proved tsetse fly carried sleeping-sickness.
Ultra-microscope invented.
1905. Schaudinn discovered spirochaete of syphilis.
Novocaine introduced.
1906. Wassermann test for syphilis.
1907. Education (Administrative Provisions) Act.
Notification of Births Act.
1908. White Phosphorus Prohibition Act.
Rickets produced experimentally.
1909. Ehrlich discovered salvarsan for syphilis.
1911. National Insurance Act.
1912. Hopkins' early vitamin experiments.
Toxin-antitoxin immunisation against diphtheria.
1913. Schick test for susceptibility to diphtheria.
1914. Antitetanic serum used in Great War.
1916. Rickettsia discovered by da Rocha Lima.
1917. Venereal Disease Act.
Encephalitis lethargica appeared in Vienna.
General paralysis treated with malaria.

1918. Maternity and Child Welfare Act.
Influenza pandemic.
Existence of antirachitic vitamin shown.
1919. Ministry of Health formed.
Sunlight proved to be antirachitic.
1921. Insulin isolated.
1922. Blair Bell attempted lead-treatment of cancer.
Botulism in Scotland.
1924. Graham and Cole took X-ray pictures of gall-bladder.
B.C.G. used to immunise children against tuberculosis.
Dick test for susceptibility to scarlet fever.
Immunisation against scarlet fever.
1925. Whipple and Robbins treated anæmia with liver.
Gye reported filterable virus causing malignant tumours.
1926. Public Health (Smoke Abatement) Act.
Minot and Murphy's liver diet for pernicious anæmia.
1927. Serum treatment for measles introduced.
Vitamin D prepared from ergosterol.
1928. Food and Drugs (Adulteration) Act.
Stokes infected monkeys with yellow fever.
1929. Local Government Act.
1931. Isolation of Vitamin D.
1933. Andrewes and Laidlaw infected ferrets with influenza.
Vitamin C identified with ascorbic acid.
1934. Szent-Györgyi prepared Vitamin C in bulk.

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