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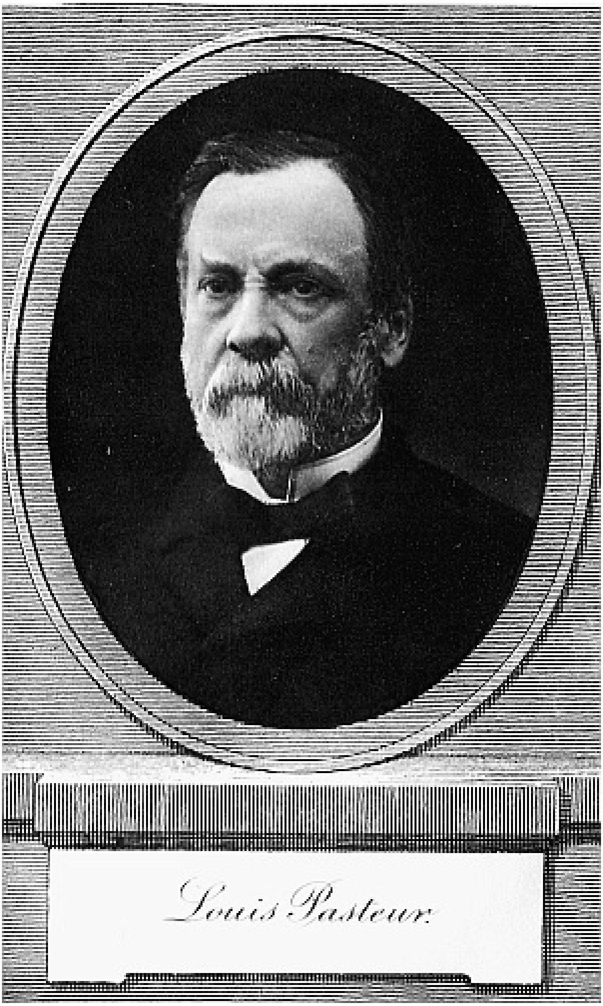
LITTLE MASTERPIECES OF SCIENCE



Louis Pasteur.

Little Masterpieces of Science

Edited by George Iles

HEALTH AND HEALING

By

Sir James Paget, M.D.
Patrick Geddes and J. Arthur Thomson
Sir J. R. Bennett, M.D.
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PREFACE

When we remember that sound health is the foundation of every other good, of all work fruitful and enjoyed, we see that in this field new knowledge and new skill have won their most telling victories. Pain, long deemed as inevitable as winter's cold, has vanished at the chemist's bidding: the study of minutest life is resulting in measures which promise to rid the world of consumption itself. Dr. Billings's masterly review of medical progress during the nineteenth century, following upon chapters from other medical writers of the first rank, strikes Prevention as its dominant note. To-day the aim of the great physicians is not simply to restore health when lost, but the maintenance of health while still unimpaired.

Worthy of remark is the co-operation in this good task which the physician receives at the hands of the inventor and the man of business. To-day the railroad, quick and cheap, disperses crowded cities into country fields: even the poorest of the poor may take a summer outing on mountain slopes, on the shores of lake or sea. As easily may the invalid escape the rigors of a Northern winter as he journeys to the Gulf of Mexico. For those who stay at home the railroad is just as faithfully at work. It exchanges the oranges of Florida for the ice of Maine, and brings figs and peaches from California to New England and New York. These, together with the cold storage warehouse and the cannery, have given the orchard and the kitchen garden all seasons for their own. Nor must we forget the mills that offer a dozen palatable cereals for the breakfast table, most of the drudgery of preparation shifted from the kitchen to the factory.

Because food is thus various and wholesome as never before, the health and strength of the people steadily gains, while medicine falls into less and less request; for what is medicine three times in ten but a corrective for a poor or ill-balanced diet?

But if the best health possible is to be enjoyed by everybody, the co-operation with the physician must include everybody. Already a considerable and increasing number of men and women understand this. If they have any reason to suspect organic weakness of any kind, they have recourse to the physician's advice, to the end that a suitable regimen, or a less exacting mode of livelihood, may forefend all threatened harm. A few pages of this volume set forth the due care of the eyes: the work from which those pages is taken gives hints of equal value regarding the care of the ears, the lungs and other bodily organs, so much more easily kept sound than restored to soundness after the assail of disease.

George Iles.

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Jenner's early observations in natural history. He hears a countrywoman say, “I can't take small-pox for I have had cow-pox.” This sets him thinking. He finds that of various forms of cow-pox but one gives protection against small-pox. In 1796 successfully vaccinates a patient. Holds that small-pox and cow-pox are modifications of the same disease and that if the system be impregnated 25
with the milder disease, immunity from the severer is conferred. Immense saving of life by vaccination.

Pasteur, a chemist, studies fermentation, which is due to the rapid multiplication of organisms. Similar organisms he detects as the cause of the silkworm disease and of anthrax in cattle. He adopts the method of Jenner, prepares an attenuated virus and protects cattle from anthrax.

GEDDES, PATRICK, AND J. ARTHUR THOMSON

Pasteur and His Work

Distinguishes minute facets, not before observed, in certain chemical compounds. Proves that the fermentation of tartrate of lime is due to a minute organism and that a similar agency underlies many other kinds of fermentation. Protects wine from fermentation by heating it for a minute to 50° C. Disproves the theory of spontaneous generation. Discovers an antitoxin for hydrophobia.

PRUDDEN, T. M., M.D.

In Nature an extremely important part is played by minute organisms. Some of them take up their abode in the human body and there set up diseases of which consumption is the chief. The tubercle bacillus is the sole cause of consumption: its entrance may be prevented, mainly by destroying the spittle of patients. Susceptibility to consumption may be inherited: the disease itself is not. Any cause which lowers vitality increases susceptibility. Dust is a source of danger both out-of-doors and in. Dust in houses should be removed, not simply stirred up. Encouragement for sufferers in early stages of disease.

be judicious. Diet should be digestible and moderate. Clothing should be sensible and cleanliness habitual.

RICHARDSON, B. W., M.D.

Natural Life and Death

Man should be as unconscious of death as of birth. To this end let him observe the rules of Health.

Rules of Health

The health of the unborn should be ensured. Many diseases usual in children may be avoided by isolation and disinfection. An equable temperature should be maintained. Regular and various mental labour is a benefit. Physical exercise should be moderate. The passions should obey 137
the reason. Alcohol and tobacco are harmful. Opium, and other narcotics should be shunned. Not too much meat. Water the natural beverage. Air should be pure and not damp. Rest and recreation gainful. Idleness injurious. Sleep should be adequate.

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Care of the Eyes

Improvements in hospital construction and management.

HEALTH AND HEALING

ESCAPE FROM PAIN: THE HISTORY OF A DISCOVERY

Sir James Paget, M.D.

[Sir James Paget was one of the most eminent English surgeons of the last century: his writings on surgical themes are of the first authority. The essay, the chief portions of which follow, appeared in the *Nineteenth Century Magazine*, December, 1879. The editor's permission to reprint is thankfully acknowledged. The essay is contained in "Selected Essays and Addresses," by Sir James Paget, published by Longmans, Green & Co., 1902. The same firm publishes "Memoirs and Letters of Sir James Paget," edited by Stephen Paget, one of his sons.]

The history of the discovery of methods for the prevention of pain in surgical operations deserves to be considered by all who study either the means by which knowledge is advanced or the lives of those by whom beneficial discoveries are made. And this history may best be traced in the events which led to and followed the use of nitrous oxide gas, of sulphuric ether, and of chloroform as anæsthetics—that is, as means by which complete insensibility may be safely produced and so long maintained that a surgical operation, of whatever severity and however prolonged, may be absolutely painless.

In 1798, Mr. Humphry Davy, an apprentice to Mr. Borlase, a surgeon at Bodmin, had so distinguished himself by zeal and power in the study of chemistry and natural philosophy, that he was invited by Dr. Beddoes, of Bristol, to become the “superintendent of the Pneumatic Institution which had been established at Clifton for the purpose of trying the medicinal effects of different gases.” He obtained release from his apprenticeship, accepted the appointment, and devoted himself to the study of gases, not only in their medicinal effects, but much more in all their chemical and physical relations. After two years' work he published his *Researches, Chemical and Philosophical, chiefly concerning Nitrous Oxide*, an essay proving a truly marvelous ingenuity, patience, and courage in experiments, and such a power of observing and of thinking as has rarely if ever been surpassed by any scientific man of Davy's age; for he was then only twenty-two.

In his inhalations of the nitrous oxide gas he observed all the phenomena of mental excitement, of exalted imagination, enthusiasm, merriment, restlessness, from which it gained its popular name of “laughing gas”; and he saw people made, at least for some short time and in some measure, insensible by it. So, among other suggestions or guesses about probable medicinal uses of inhalation of gases, he wrote, near the end of his essay: “As nitrous oxide in its extensive operation appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place.”

It seems strange that no one caught at a suggestion such as this. True, the evidence on which it was founded was very slight; it was with a rare scientific power that Davy had thought out so far beyond his facts; but he had thought clearly, and as clearly told his belief. Yet no one earnestly regarded it. The nitrous oxide might have been of as little general interest as the carbonic or any other, had it not been for the strange and various excitements produced by its inhalation. These made it a favourite subject with chemical lecturers, and year after year, in nearly every chemical theatre, it was fun to inhale it after the lecture on the gaseous compounds of nitrogen; and among those who inhaled it there must have been many who, in their intoxication, received sharp and heavy blows, but, at the time, felt no pain. And this went on for more than forty years, exciting nothing worthy to be called thought or observation, till, in December, 1844, Mr. Colton, a popular itinerant lecturer on chemistry, delivered a lecture on "laughing gas" in Hartford, Connecticut. Among his auditors was Mr. Horace Wells, an enterprising dentist in that town, a man of some power in mechanical invention. After the lecture came the usual amusement of inhaling the gas, and Wells, in whom long wishing had bred a kind of belief that something might be found to make tooth-drawing painless, observed that one of the men excited by the gas was not conscious of hurting himself when he fell on the benches and bruised and cut his knees. Even when he became calm and clear-headed the man was sure that he did not feel pain at the time of his fall. Wells was at once convinced—more easily convinced than a man of more scientific mind would have been—that, during similar insensibility, in a state of intense nervous excitement, teeth might be drawn without pain, and he determined that himself and one of his own largest teeth should be the first for trial. Next morning Colton gave him the gas, and his friend Dr. Riggs extracted his tooth. He remained unconscious for a few moments, and then exclaimed, “A new era in tooth-pulling! It did not hurt me more than the prick of a pin. It is the greatest discovery ever made.”

In the next three weeks Wells extracted teeth from some twelve or fifteen persons under the influence of the nitrous oxide, and gave pain to only two or three. Dr. Riggs, also, used it with the same success, and the practice was well known and talked of in Hartford.

Encouraged by his success Wells went to Boston, wishing to enlarge the reputation of his discovery and to have an opportunity of giving the gas to some one undergoing a surgical operation. Dr. J. C. Warren, the senior Surgeon of the Massachusetts General Hospital, to whom he applied for this purpose, asked him to show first its effects on some one from whom he would draw a tooth. He undertook to do this in the theatre of the medical college before a large class of students, to whom he had, on a previous day, explained his plan. Unluckily, the bag of gas from which the patient was inhaling was taken away too soon; he cried out when his tooth was drawn; the students hissed and hooted; and the discovery was denounced as an imposture.

Wells left Boston disappointed and disheartened; he fell ill, and was for many months unable to practice his profession. Soon afterwards he gave up dentistry, and neglected the use and study of the nitrous oxide, till he was recalled to it by a discovery even more important than his own.

The thread of the history of nitrous oxide may be broken here.

The inhalation of sulphuric ether was often, even in the eighteenth century, used for the relief of spasmodic asthma, phthisis, and some other diseases of the chest. Dr. Beddoes and others thus wrote of it: but its utility was not great, and there is no evidence that this use of it had any influence on the discovery of its higher value, unless it were, very indirectly, in its having led to its being found useful for soothing the irritation produced by inhaling chlorine. Much more was due to its being used, like nitrous oxide, for the fun of the excitement which its diluted vapor would produce in those who freely inhaled it.

The beginning of its use for this purpose is not clear. In the *Journal of Science and the Arts*, published in 1818 at the Royal Institution, there is a short anonymous statement among the "Miscellanea," in which it is said, "When the vapor of ether mixed with common air is inhaled, it produces effects very similar to those occasioned by nitrous oxide." The method of inhaling and its effects are described, and then "it is necessary to use caution in making experiments of this kind. By the imprudent inspiration of ether a gentleman was thrown into a very lethargic state, which continued with occasional periods of intermission for more than thirty hours, and a great depression of spirits; for many days the pulse was so much lowered that considerable fears were entertained for his life."

The statement of these facts has been ascribed to Faraday, under whose management the journal was at that time published. But, whoever wrote or whoever may have read the statement, it was, for all useful purposes, as much neglected as was Davy's suggestion of the utility of the nitrous oxide. The last sentence, quoted as it was by Pereira and others writing on the uses of ether, excited much more fear of death than hope of ease from ether-inhalation. Such effects as are described in it are of exceeding rarity; their danger was greatly over-estimated; but the account of them was enough to discourage all useful research.

But, as the sulphuric ether would "produce effects very similar to those occasioned by nitrous oxide," and was much the more easy to procure, it came to be often inhaled, for amusement, by chemists' lads and by pupils in the dispensaries of surgeons. It was often thus used by young people in many places of the United States. They had what they called "ether-frolics," in which they inhaled ether till they became merry, or in some other way absurdly excited or, sometimes, completely insensible.

Among those who had joined in these ether-frolics was Dr. Wilhite of Anderson, South Carolina. In one of them, in 1839, when nearly all of the party had been inhaling and some had been laughing, some crying, some fighting—just as they might have done if they had had the nitrous oxide gas—Wilhite, then a lad of seventeen, saw a negro boy at the door and tried to persuade him to inhale. He refused and resisted all attempts to make him do it, till they seized him, held him down, and kept a handkerchief wet with ether close over his mouth. Presently his struggles ceased; he lay insensible, snoring, past all arousing; he seemed to be dying. And thus he lay for an hour, till medical help came and, with shaking, slapping, and cold splashing, he was awakened and suffered no harm.

The fright at having, it was supposed, so nearly killed the boy, put an end to ether-frolics in that neighbourhood; but in 1842 Wilhite had become a pupil of Dr. Crauford Long, practising at that time at Jefferson (Jackson County, Georgia). Here he and Dr. Long and three fellow-pupils often amused themselves with the ether-inhalation, and Dr. Long observed that when he became furiously excited, as he often did, he was unconscious of the blows which he, by chance, received as he rushed or tumbled about. He observed the same in his pupils; and thinking over this, and emboldened by what Mr. Wilhite told him of the negro boy recovering after an hour's insensibility, he determined to try whether the ether-inhalation would make any one insensible of the pain of an operation. So, in March, 1842, nearly three years before Wells's observations with the nitrous oxide, he induced Mr. Venable, who had been very fond of inhaling ether, to inhale it till he was quite insensible. Then he dissected a tumour from his neck; no pain was felt, and no harm followed. Three months later, he similarly removed another tumour from him; and again, in 1842 and 1845, he operated on three other patients, and none felt pain. His operations were known and talked of in his neighbourhood; but the neighbourhood was only that of an obscure little town; and he did not publish any of his observations. The record of his first operation was only entered in his ledger:

“James Venable, 1842. Ether and excising tumour, $2.00.”

He waited to test the ether more thoroughly in some greater operation than those in which he had yet tried it; and then he would have published his account of it. While he was waiting, others began to stir more actively in busier places, where his work was quite unknown, not even heard of.

Among those with whom, in his unlucky visit to Boston, Wells talked of his use of the nitrous oxide, and of the great discovery which he believed that he had made, were Dr. Morton and Dr. Charles Jackson, men widely different in character and pursuit, but inseparable in the next chapter of the history of anæsthetics.

Morton was a restless, energetic dentist, a rough man, resolute to get practice and make his fortune. Jackson was a quiet, scientific gentleman, unpractical and unselfish, in good repute as a chemist, geologist, and mineralogist. At the time of Wells's visit, Morton, who had been his pupil in 1842, and for a short time in 1843 his partner, was studying medicine and anatomy at the Massachusetts Medical College, and was living in Jackson's house. Neither Morton nor Jackson put much if any faith in Wells's story, and Morton witnessed his failure in the medical theatre. Still, Morton had it in his head that tooth-drawing might somehow be made painless, and even after Wells had retired from practice, he talked with him about it, and made some experiments, but, having no scientific skill or knowledge, they led to nothing. Still, he would not rest, and he was guided to success by Jackson, whom Wells advised him to ask to make some nitrous oxide gas for him.

Jackson had long known, as many others had, of sulphuric ether being inhaled for amusement, and of its producing effects like those of nitrous oxide: he knew also of its employment as a remedy for the irritation caused by inhaling chlorine. He had himself used it for this purpose, and once, in 1842, while using it, he became completely insensible. He had thus been led to think that the pure ether might be used for the prevention of pain in surgical operations; he spoke of it with some scientific friends, and sometimes advised a trial of it; but he did not urge it or take any active steps to promote even the trial. One evening, Morton, who was now in practice as a dentist, called on him, full of some scheme which he did not divulge, and urgent for success in painless tooth-drawing. Jackson advised him to use the ether, and taught him how to use it.

On that same evening, the 30th of September, 1846, Morton inhaled the ether, put himself to sleep, and, when he awoke, found that he had been asleep for eight minutes. Instantly, as he tells, he looked for an opportunity of giving it to a patient; and one just then coming in, a stout, healthy man, he induced him to inhale, made him quite insensible, and drew his tooth without his having the least consciousness of what was done.

But the great step had yet to be made—the step which Wells would have tried to make if his test experiment had not failed. Clearly, operations as swift as that of tooth-drawing might be rendered painless, but could it be right to incur the risk of insensibility long enough and deep enough for a large surgical operation? It was generally believed that in such insensibility there was serious danger to life. Was it really so? Jackson advised Morton to ask Dr. J. C. Warren to let him try, and Warren dared to let him. It is hard now to think how bold the enterprise must have seemed to those who were capable of thinking accurately on the facts then known.

The first trial was made on the 16th of October, 1846. Morton gave the ether to a patient in the Massachusetts General Hospital, and Dr. Warren removed a tumour from his neck. The result was not complete success; the patient hardly felt the pain of cutting, but he was aware that the operation was being performed. On the next day, in a severer operation by Dr. Hayward, the success was perfect; the patient felt nothing, and in long insensibility there was no appearance of danger to life.

The discovery might already be deemed complete, for the trials of the next following days had the same success, and thence onwards the use of the ether extended over constantly widening fields. A coarse but feeble opposition was raised by some American dentists; a few surgeons were over-cautious in their warnings against suspected dangers; a few maintained that pain was very useful, necessary perhaps to sound healing; some were hindered by their dislike of the patent which Morton and Jackson took out; but as fast as the news could be carried from one continent to another, and from town to town, so fast did the use of ether spread. It might almost be said that in every place, at least in Europe, where the discovery was promoted more quickly than in America, the month might be named before which all operative surgery was agonizing, and after which it was painless.

But there were other great pains yet to be prevented, the pains of childbirth. For escape from these the honour and deep gratitude are due to Sir James Simpson. No energy, or knowledge, or power of language less than his could have overcome the fears that the insensibility, which was proved to be harmless in surgical operations and their consequences, should be often fatal or very mischievous in parturition. And to these fears were added a crowd of pious protests (raised, for the most part, by men) against so gross an interference as this seemed with the ordained course of human nature. Simpson, with equal force of words and work, beat all down; and by his adoption of chloroform as a substitute for ether promoted the whole use of anæsthetics.

Ether and chloroform seemed to supply all that could be wished from anæsthetics. The range of their utility extended; the only question was as to their respective advantages, a question still unsettled. Their potency was found absolute, their safety very nearly complete, and, after the death of Wells in 1848, nitrous oxide was soon neglected and almost forgotten. Thus it remained till 1862, nearly seventeen years, when Mr. Colton, who still continued lecturing and giving the gas "for fun," was at New Haven, Connecticut. He had often told what Wells had done with nitrous oxide at Hartford, and he wanted other dentists to use it, but none seemed to care for it till, at New Britain, Dr. Dunham asked him to give it to a patient to whom it was thought the ether might be dangerous. The result was excellent, and in 1863 Dr. Smith of New Haven substituted the nitrous oxide for ether in his practice and used it very frequently. In the nine months following his first use of it, he extracted without pain nearly 4,000 teeth. Colton, in the following year, associated himself with a dentist in New York and established the Colton Dental Association, where the gas was given to many thousands more. Still, its use was very slowly admitted. Some called it dangerous, others were content with chloroform and ether, others said that the short pangs of tooth-drawing had better be endured. But in 1867 Mr. Colton came to Paris and Dr. Evans at once promoted his plan. In 1868 he came to London and, after careful study of it at the Dental Hospital, the nitrous oxide was speedily adopted, both by dentists and by the administrators of anæsthetics. By this time it has saved hundreds of thousands of people from the sharp pains of all kinds of operations on the teeth and of a great number of the surgical operations that can be quickly done.

Such is the history of the discovery of the use of anæsthetics. Probably, none has ever added so largely to that part of happiness which consists in the escape from pain. Past all counting is the sum of happiness enjoyed by the millions who, in the last three-and-thirty years, have escaped the pains that were inevitable in surgical operations; pains made more terrible by apprehension, more keen by close attention; sometimes awful in a swift agony, sometimes prolonged beyond even the most patient endurance, and then renewed in memory and terrible in dreams. These will never be felt again. But the value of the discovery is not limited by the abolition of these pains or the pains of childbirth. It would need a long essay to tell how it has enlarged the field of useful surgery, making many things easy that were difficult, many safe that were too perilous, many practicable that were nearly impossible. And, yet more variously, the discovery has brought happiness in the relief of some of the intensest pains of sickness, in quieting convulsion, in helping to the discrimination of obscure diseases. The tale of its utility would not end here; another essay might tell its multiform uses in the study of physiology, reaching even to that of the elemental processes in plants, for these, as Claude Bernard has shown, may be completely for a time suspended in the sleep produced by chloroform or ether.

And now, what of the discoverers?[1] What did time bring to those who brought so great happiness to mankind?

Probably most people would agree that Long, Wells, Morton and Jackson deserved rewards, which none of the four received. But that which the controversy and the patent and the employment of legal advisers made it necessary to determine was, whether more than one deserved reward, and, if more than one, the proportion to be assigned to each. Here was the difficulty. The French Academy of Sciences in 1850 granted equal shares in the Monthyon Prize to Jackson and to Morton; but Long was unknown to them, and, at the time of the award, the value of nitrous oxide was so hidden by the greater value of ether that Wells's claim was set aside. A memorial column was erected at Boston, soon after Morton's death in 1868, and here the difficulty was shirked by dedicating the column to the discovery of ether, and not naming the discoverers. The difficulty could not be thus settled; and, in all probability, our supposed council of four or five would not solve it. One would prefer the claims of absolute priority; another those of suggestive science; another the courage of bold adventure; sentiment and sympathy would variously affect their judgments. And if we suppose that they, like the American Congress, had to discuss their differences within sound of such controversies as followed Morton's first use of ether, or during a war of pamphlets, or under burdens of parliamentary papers, we should expect that their clearest decision would be that a just decision could not be given, and that gratitude must die if it had to wait till distributive justice could be satisfied. The gloomy fate of the American discoverers makes one wish that gratitude could have been let flow of its own impulse; it would have done less wrong than the desire for justice did. A lesson of the whole story is that gratitude and justice are often incompatible; and that when they conflict, then, usually, "the more right the more hurt."

Another lesson, which has been taught in the history of many other discoveries, is clear in this—the lesson that great truths may be very near us and yet be not discerned. Of course, the way to the discovery of anæsthetics was much more difficult than it now seems. It was very difficult to produce complete insensibility with nitrous oxide till it could be given undiluted and unmixed; this required much better apparatus than Davy or

Wells had; and it was hardly possible to make such apparatus till india-rubber manufactures were improved. It was very difficult to believe that profound and long insensibility could be safe, or that the appearances of impending death were altogether fallacious. Bold as Davy was, bold even to recklessness in his experiments on himself, he would not have ventured to produce deliberately in any one a state so like a final suffocation as we now look at unmoved. It was a boldness not of knowledge that first made light of such signs of dying, and found that what looked like a sleep of death was as safe as the beginning of a night's rest. Still, with all fair allowance for these and other difficulties, we cannot but see and wonder that for more than forty years of the nineteenth century a great truth lay unobserved, though it was covered with only so thin a veil that a careful physiological research must have discovered it. The discovery ought to have been made by following the suggestion of Davy. The book in which he wrote that "nitrous oxide—capable of destroying physical pain—may probably be used with advantage during surgical operations," was widely read, and it would be hard to name a man of science more widely known and talked of than he was. Within two years of the publication of his *Researches* he was appointed to a professorship in the Royal Institution; and in the next year he was a favourite in the fashionable as well as in the scientific world; and all his life through he was intimately associated with those among whom all the various motives for desiring to find some means "capable of destroying physical pain" would be most strongly felt. Curiosity, the love of truth, the love of marvels, the desire of ease, self-interest, benevolence,—all were alert in the minds of men and women who knew and trusted whatever Davy said or wrote, but not one mind was earnestly directed to the rare promise which his words contained. His own mind was turned with its full force to other studies; the interest in surgery which he may have felt during his apprenticeship at Bodmin was lost in his devotion to poetry, philosophy, and natural science, and there is no evidence that he urged others to undertake the study which he left. Even his biographers, his brother, Dr. John Davy, and his intimate friend, Dr. Paris, both of whom were very capable physicians and men of active intellect, say nothing of his suggestion of the use of nitrous oxide. It was overlooked and utterly forgotten till the prophecy was fulfilled by those who had never heard of it. The same may be said of what Faraday, if it were he, wrote of the influence of sulphuric ether. All was soon forgotten, and the clue to the discovery, which would have been far easier with ether than with nitrous oxide, for it needed no apparatus and even required mixture with air, was again lost. One could have wished that the honour of bringing so great a boon to men, and so great a help in the pursuit of knowledge, had been won by some of those who were giving themselves with careful cultivation to the search for truth as for its own sake. But it was not so: science was utterly at fault; and it was shown that in the search for truth there are contingencies in which men of ready belief and rough enterprise, seeking for mere utility even with selfish purposes, can achieve more than those who restrain themselves within the range of what seems reasonable.

Such instances of delay in the discovery of truth are always wondered at, but they are not uncommon. Long before Jenner demonstrated the utility of vaccination it was known in Gloucestershire that they who had had cow-pox could not catch the small-pox. For some years before the invention of electric telegraphy, Professor Cumming of Cambridge, when describing to his class the then recent discovery by Oersted of the power of an electric current to deflect a magnet, used to say, "Here, then, are the elements which would excellently serve for a system of telegraphy." Yet none of his hearers, active and cultivated as they were, were moved from the routine of study. Laennec quotes a sentence from Hippocrates which, if it had been worthily studied, might have led to the full discovery of auscultation [trained listening to sounds]. Thus it often has been; and few prophecies can be safer than that our successors will wonder at us as we do at those before us; will wonder that we did not discern the great truths which they will say were all around us, within reach of any clear, earnest mind.

They will wonder, too, as we may, when we study the history of the discovery of anæsthetics, at the quietude with which habitual miseries are borne; at the very faint impulse to action which is given by even great necessities when they are habitual. Thinking of the pain of surgical operations, one would think that men would have rushed after the barest chance of putting an end to it as they would have rushed to escape from starving. But it was not so; the misery was so frequent, so nearly customary, deemed so inevitable, that, though it excited horror when it was talked of, it did not excite to strenuous action. Remedies were wished for and sometimes tried, but all was done vaguely and faintly; there was neither hope enough to excite intense desire, nor desire enough to encourage hope; the misery was "put up with" just as we now put up with typhoid fever and sea-sickness, with local floods and droughts, with the waste of health and wealth in the pollution of rivers, with hideous noises and foul smells, and many other miseries. Our successors, when they have remedied or prevented them, will look back on them with horror, and on us with wonder and contempt for what they will call our idleness or blindness or indifference to suffering.

FOOTNOTE

[1] Those only are here reckoned as discoverers from whose work may be traced not merely what might have been the beginning of the discovery, but the continuous history of events, consequent upon the evidence of its truth. Long, it is true, might under this rule be excluded; yet his work cannot fairly be separated from the history. Of course, in this, as in every similar case, there were some who maintained that there was nothing new in it. Before 1842 there were many instances in which persons underwent operations during insensibility. There may be very reasonable doubts about what is told of the ancient uses of Indian hemp, and mandragora; but most of those who saw much surgery before 1846 must have seen operations done on patients during insensibility produced by narcotics, dead-drunkenness, mesmerism, large losses of blood or other uncertain and often impracticable methods. Besides, there were many guesses and suggestions for making operations painless. But they were all fruitless; and they fail at that which may be a fair test for most of the claims of discoverers—the test of consequent and continuous history. When honour is claimed for the authors of such fruitless works as these, it may fairly be said that blame rather than praise is due to them. Having seen, so far as they profess, they should not have rested till they could see much further.

JENNER AND PASTEUR

Sir J. Risdon Bennett, M.D.

[Sir J. Risdon Bennett was a leading physician of London for many years, holding the highest offices as an educator and administrator. The article from which the following extracts have been taken appeared in the *Leisure Hour*, 1882.]

No department of medical science has made greater advances in modern times than that which is termed "Preventive Medicine." Nor is there any in which the public at large is more deeply interested, and the knowledge of which it is of more importance should be diffused as widely as possible. The devoted and zealous service rendered by the medical profession in all questions relating to the maintenance of health and the prevention of disease is a sufficient answer, if any be needed, to the ignorant and prejudiced statements that are sometimes made, that in support of various scientific theories and proceedings medical men are actuated by interested and selfish motives. No name stands, or will ever stand, out more brilliant among the benefactors of mankind than that of Edward Jenner, by whose genius and labours untold multitudes of human lives have been saved, and an incalculable amount of human suffering and misery prevented. At the present time various circumstances, both social and scientific, have combined to recall attention to this illustrious man and his remarkable scientific and beneficial labours. It is not, however, our intention on the present occasion to give either a complete sketch of his life, or a detailed account of his work. But in order to show the connection between his discoveries and more recent advances in the same field of scientific investigation, it will be necessary to give a brief *resume* of Jenner's life-work, and the benefits which he conferred on the human race throughout the world.

He was born on the 17th May, 1749, at Berkeley, in Gloucestershire, of which place his father was the vicar. On leaving Dr. Washbourn's school, at Cirencester, he was apprenticed to Mr. Ludlow, a gentleman in practice as a surgeon at Sudbury, near Bristol. On the completion of his apprenticeship he came to London, and had the good fortune to be placed under the care of the celebrated John Hunter, with whom he resided for two years. The observing powers and taste for natural history which Jenner had early shown, as a boy, were quickened and fostered by the daily example and friendship of the illustrious man who, as surgeon and lecturer at St. George's Hospital, was carrying on those laborious scientific investigations, and building up that marvelous monument of his genius, which have rendered his name and fame immortal. So much skill and knowledge had been shown by Jenner in arranging the natural history collection of Sir J. Banks, to whom he had been recommended by Hunter, that he was offered the appointment of naturalist to Captain Cook's second expedition. He, however, declined this and other flattering proposals, in order to return to the rural scenes of his boyhood, and be near an elder brother who had been the guide of his orphanhood. He rapidly acquired an extensive business as a general practitioner, while his polished manners, wide culture, and kind and genial social qualifications, secured him welcome admission to the first society of his neighbourhood. His conscientious devotion to his professional duties did not, however, quell his enthusiastic love of natural history, or preclude him from gaining a distinguished reputation as a naturalist. A remarkable paper on the cuckoo, read before the Royal Society and printed in the *Transactions*, gained him the fellowship of that illustrious body. Jenner's paper established what has been properly termed the “parasitic” character of the cuckoo, *i. e.*, it deposits its eggs in the nests of other birds, by whose warmth they are hatched, and by whom the young are fed. His observations have received general confirmation by subsequent observers, more especially the remarkable facts that the parent cuckoo selects the nests of those birds whose eggs require the same period of time for their incubation as its own (which are much larger), and the food of whose young is the same, viz., insects, which the young cuckoo ultimately monopolizes by ousting the young of the rightful owner of the nest.

By this and similar studies was Jenner preparing his acute powers of investigation for the great purpose of his life. For this he secured more time and more extended opportunities for inquiry by abandoning general practice, and confining himself to medicine proper, having obtained, in 1792, the degree of M.D. from the University of St. Andrews. In conjunction with the “dear man,” as he used to call his great master, John Hunter, he carried on his experiments illustrative of the structure and functions of animals. With great industry and ingenuity he explained some of the unaccountable problems in ornithology; he ascertained the laws which regulate the migration of birds; made considerable advances in geology and in our knowledge of organic remains; he amended various pharmaceutical processes; he was an acute anatomist and pathologist, and investigated and explained one of the most painful affections of the heart, and many of the diseases to which animals are liable. By such labours he established a just claim to distinction as a medical philosopher, apart from his claims to the gratitude and admiration of mankind by his self-denying and devoted labours in connection with his great discovery; but like other great men absorbed in the establishing of important truths, he was regardless of personal objects, and never ostentatiously promulgated his claims to public distinction.

It was while still a youth, living with his master at Sudbury, that his mind first became deeply impressed on the subject of the cow-pox. A young country woman came to seek advice, when the subject of small-pox was incidentally mentioned in her presence, and she immediately observed, "I cannot take that disease, for I have had cow-pox." This was a popular notion prevalent in the district, and not unknown to Jenner, but from this time he never ceased to think on the subject. On coming to London he mentioned it to several persons, and among others to Hunter; but all thought his notion of getting rid of small-pox Utopian, and gave him little or no encouragement. Hunter, however, who never liked to daunt the enthusiasm of inquirers, said, in his characteristic way: "Don't *think*, but *try*; be patient, be accurate." About the year 1775, some time after his return to the country, he first had the opportunity of examining into the truth of the common traditions regarding cow-pox, but it was not until 1780, after much study and careful inquiry, that he was able to unravel the various obscurities and contradictions with which the subject was involved, and in that year he first disclosed his hopes and his fears to his friend, Edward Gardner. His mind seems to have caught a glimpse of the reputation awaiting him, and he felt that, in God's good providence, it "might be his lot to stand between the living and the dead, and that through him a great plague might be stayed."

It would be impossible in the brief space at our disposal to recount the various difficulties and sources of error that Jenner encountered. It may, however, be mentioned that he ascertained that there was more than one form of local disease with which cows are afflicted, and which may give rise to sores on the hands of milkmaids, but that one only of these was the true cow-pox, giving origin to constitutional as well as local disease, and which proves protective against small-pox. He also found reason to believe that it was only in a particular stage of its development that the true cow-pox vesicle was capable of being transmitted so as to prove a prophylactic [preventive]. He was aware that though, as a rule, persons did not have small-pox a second time, yet there are instances where, from peculiarity of constitution or other causes, small-pox occurs a second time in the same individual. Such considerations as these cheered him to continue his inquiries when apparent exceptions occurred to the protective influence of true cow-pox.

Having at length satisfied his own mind, and, indeed, succeeded in convincing others also, respecting the important protective influence exerted on the constitutions of those who had received the true cow-pox in the casual way, he sought to prove whether it was possible to propagate the disease by inoculation from one human being to another. On the 19th May, 1796, an opportunity occurred of making the experiment. Matter was taken from the hand of Sarah Nelmes, who had been infected by her master's cows, and inserted into the arm of James Phipps, a healthy boy eight years of age. He went through the disease in a regular and perfectly satisfactory way. But was he secure against the contagion of small-pox? It is needless to say how full of anxiety Jenner was, when in July following he put this to the test by inoculating the boy with matter taken from the pustule of a small-pox patient. No disease followed! This, his first crucial experiment, Jenner related to his friend Gardner, and said: "I shall now pursue my experiments with redoubled ardour." This ever-to-be-remembered day, 19th May, 1796, is commemorated by an annual festival in Berlin, where, in 1819, little more than twenty years after, it was officially reported that 307,596 persons had been vaccinated in the Prussian dominions alone. The account which Jenner has given of his own feelings at this time is deeply interesting. "While the vaccine discovery was progressing," he says, "the joy I felt at the prospect before me of being the instrument destined to take away from the world one of its greatest calamities, blended with the fond hope of enjoying independence and domestic peace and happiness, was often so excessive that in pursuing my favourite subject among the meadows I have sometimes found myself in a kind of reverie. It is pleasant to me to recollect that these reflections always ended in devout acknowledgments to that Being from whom this and all other mercies flow." Having obtained further corroboration of the truth of his conclusions by the vaccination of his own son and several others, he published in the form of a quarto pamphlet called "An Inquiry," a brief and modest but complete account of his investigations and discoveries. By this the attention of the whole medical world and general public was called to the subject. His doctrines were put to the test and abundantly confirmed, so that Mr. Clive, the celebrated surgeon of the day, urged him to come to London, and promised him an income of £10,000 a year. Jenner, however, declined the request, saying, "Admitting as a certainty that I obtain both fortune and fame, what stock should I add to my fund of little happiness? And as for fame, what is it? A gilded butt forever pierced by the arrows of malignancy."

Jenner always maintained that small-pox and cow-pox were modifications of the same disease, and that in employing vaccine lymph we only make use of means to impregnate the system with the disease in its mildest form, instead of propagating it in its virulent and contagious form, as is done when small-pox is inoculated. He felt, also, that there was this objection to the latter practice, which had obtained prevalence since its introduction to this country by Lady Mary Wortley Montagu, that the disease was thus spread among the community. He had, however, at that time to contend against the prevalent notions that epidemic diseases affecting the human race are peculiar to man and have no influence on the lower animals, and that the diseases of other animals are not communicable to man. But we have now abundant evidence that both these notions are erroneous. Jenner himself, indeed, had shown what was well known in various parts of the country, that the "grease" of the heel of the horse was frequently communicated to those who had the care of horses, whether or not it was the same disease as that which affected the cow. It is sufficient only further to adduce another disease of horses, called "farcy," which is not infrequently fatal to grooms and others, not to mention the still more dreaded hydrophobia communicated by dogs and animals of the feline species.

The rapid acceptance and spread of Jenner's doctrines speedily silenced all cavillers except that small minority of incredulous and fanatical opponents who are always to be found refusing to accept any truth that does not coincide with their own ignorant and prejudiced views. The frightful mortality and appalling effects of small-pox prior to the introduction of vaccination were indeed such as to impel men to grasp at any means that held out a probability of escape from the scourge. In the present day the public can form but a faint idea of the ravages of small-pox before Jenner's time. The records of historians, not only of our own country, but throughout the world, teem with the most appalling accounts. Dr. Lettsom calculated that 210,000 fell victims to it annually in Europe. Bernouilli, an Italian, believed that not less than 15,000,000 of human victims were deprived of life by it every twenty-five years, *i. e.*, 600,000 annually. In Russia 2,000,000 were cut off in one year. In Asia, Africa, and South America, whole cities and districts were depopulated. Nor was it only the actual mortality which rendered it so appalling. The records of the Institution for the Indigent Blind in our own country showed that three-fourths of the objects relieved had lost their sight by small-pox, while the number of persons with pitted and scarred faces and deformed features that were met with in the streets testified to the frightful ordeal that they had passed through. Multitudes died of diseases set up by this plague, or from ruined constitutions which it entailed. And what, of all this, it may be asked, do we now see? Is it not a rare thing to meet a person whose face is scarred and his features deformed by small-pox? How few persons can cite instances among their acquaintance of those who have died of small-pox after having been properly vaccinated? Is it necessary to go into statistics and elaborate investigations of the bills of mortality of the present day in order to be convinced that, as compared with the records of anti-vaccine times, we have indeed cause to bless the memory of Jenner?

We do not ignore the fact that small-pox, like other similar diseases having an epidemic character, may be absent for a length of time from certain districts and then break out again; nor that each epidemic has its period of increment and decrement, and varies in its degree of malignancy. But a full and careful review of the whole history of small-pox since the introduction of vaccination, proves to every unprejudiced mind that every recurring epidemic finds its victims, with comparatively few exceptions, among the unvaccinated, that its spread is arrested by renewed attention to vaccination and its vigorous enforcement, and that, even taking into account the countries and localities where from various causes it has been neglected, the mortality from this foul and fatal disease, small-pox, has been enormously reduced. Human lives have been saved, and human life prolonged to such an extent that it is impossible to estimate the benefits that mankind has derived from the genius and devoted patriotic labours of one man.

That doubts and difficulties in connection with this subject, involving the well-being of the whole human race, have lately arisen, must be admitted. But there is good reason to believe that, by modern researches on the subject of epidemic diseases and the germ theory of disease, these doubts are already being dispelled, and that the difficulties will be speedily obviated.

The grounds for this belief will be understood by the consideration of those scientific investigations to a brief detail of which we now proceed. The reader will then also be better able to judge of the propriety, and necessity of certain measures which, to the uninformed, must appear objectionable or even repulsive and arbitrary.

We now, then, turn to the remarkable experiments and discoveries of M. Pasteur, which have gained for him a world-wide reputation, and the bearing of which on the science of preventive medicine is commanding the attention and admiration of the whole scientific world, and indeed we may say of mankind at large. M. Pasteur is not a medical man, nor, indeed, a physiologist. He is simply a French chemist, a modest, retiring labourer in the field of science whose sole object has been the discovery of truth, and whose chemico-physical researches gained for him the Rumford Medal of the Royal Society in 1856. Having devoted himself specially to the chemistry of organic substances, he was naturally attracted by the discovery of Cagniard de la Tour, that yeast is really a plant, a species of fungus, whose vegetative action in fermentable liquids is the true cause of their fermentation. This was so opposed to the theories of all the chemists of the day, among whom may particularly be mentioned the celebrated Liebig, that it met with their warm opposition. When, however, Helmholtz and others succeeded in showing that by preventing the passage of the minute organisms constituting the yeast plant into fermentable liquids, no fermentation took place, the doctrine soon became established that the first step in the process of alcoholic fermentation is due, not to ordinary chemical changes, but to the presence of living organisms. In like manner the putrefaction and decomposition of various liquids containing organic matter was found to be due, not to the simple action of the oxygen of the atmosphere, but to the introduction from without of microscopic germs which found material for their development in such liquids. So that if by mechanical filtration of the air the entrance of such germs can be prevented, or if by heat or other means they can be destroyed, any fluid, however readily it may undergo putrefaction in ordinary circumstances, will remain perfectly sweet, though freely exposed to the air. And the same fluid will undergo a different kind of fermentation according as it is subjected to the action of different species of germs. These and other facts of scarcely less importance, which cannot here be detailed, induced Pasteur to test the application of the doctrines deduced from them to the study of disease in living animals.

His attention was first directed to the disease affecting the silkworm, and known as the *Pebrine*, which at one time seemed likely to destroy the silk cultivation both in France and Italy. It had been ascertained that the bodies of the silkworm, in all its stages of chrysalis, moth, and worm, were in this disease infested by minute corpuscles which even obtained entrance into the undeveloped eggs. After a prolonged and difficult inquiry, Pasteur found that these minute corpuscles were really independent, self-propagating organisms, introduced from without, and were not merely a sign of the disease, but its real cause. As a result of the application of these discoveries, the silkworm disease has been extinguished, or so controlled as to have saved a most important and valuable culture.

Between the years 1867 and 1870 above 56,000 deaths from a disease variously designated as “anthrax,” or “carbuncular disease,” and “splenic fever,” and in France known by the terms “charbon,” or “pustule maligne,” are stated to have occurred among horses, cattle, and sheep in one district of Russia, Novgorod, occasioning also the deaths of 528 among the human population. It occurs in two forms, one more malignant and rapid in its action than the other. In France the disease appears to be scarcely ever absent, and is estimated to entail on the breeders of cattle an annual loss of many millions of francs. As a milder epidemic it has prevailed in this country, and the disease which has lately broken out in Bradford and some other towns in the north among wool-sorters, has now been shown to be a modification of the same disease communicated by the wool of sheep that have been infected.

On examining the blood of animals, the subjects of "splenic fever," some French pathologists had discovered the presence of certain minute transparent filaments which, by the investigations of a German physician named Koch, were proved to be a fungoid plant developed from germ particles of microscopic minuteness. By gradual extension these minute particles, termed "microbes," attain the form of small threads or rods, to which the name of "bacilli" has been given, from the Latin *bacillus*, a rod or staff. These rods were found to be in fact hollow tubes, divided at intervals by partitions, which, on attaining full growth, break up into fragments, the interiors of which are found to be full of minute germs similar to those from which the rods were at first developed. These germs were found by Koch and his collaborateurs to be capable of cultivation by being immersed in some suitable organic liquid kept at a proper temperature, and the supply could be kept up by introducing even a few drops of such impregnated fluids into other fluids, and repeating the process again and again. The next step to test the potency of these germs to generate the disease in animals whence they were originally obtained, was to vaccinate animals with a few drops of the fluid thus artificially infected. Accordingly it was found that the bodies of guinea-pigs, rabbits, and mice thus inoculated became infected, and developed all the characteristic symptoms of splenic fever or carbuncular disease.

Pasteur, whose enthusiasm in the pursuit of investigations which had already been crowned with such signal success kept him awake to all that was being done by other inquirers, and made him watchful of every event that transpired relative to the epidemic diseases of cattle, was struck with the fact that some of the most fatal outbreaks of "charbon" among flocks of sheep occurred in the midst of apparently the most healthy pastures.

His sagacity led him to inquire what had been done with the carcasses of animals that had died from previous outbreaks of the disease in these localities, when he found that they had been buried in the soil and often at great depths, of the same pastures. But how could the disease germs make their way to the surface from a depth of eight or ten feet? Earthworms, he guessed, might have conveyed them. And notwithstanding the incredulity with which his explanation was received, he forthwith proceeded to verify his supposition. Having collected a number of worms from the ground of the pastures in question, he made an extract of the contents of the alimentary canal of the worms, and with this he inoculated rabbits and guinea-pigs, gave them the "charbon" in its most fatal form, and proved the identity of the malady by demonstrating that the blood of the victims swarmed with the deadly "bacillus." And here we cannot but stop to notice the remarkable confirmation that is thus given to the wonderful and beautiful observations of Darwin as set forth in his last work on "The Formation of Vegetable Mould Through the Action of Worms." Darwin has shown beyond all dispute, as the result of his incomparable researches, that though "the plough is one of the most ancient and most valuable of man's inventions, long before he existed the land was in fact regularly ploughed, and still continues to be ploughed, by earthworms." He has shown us that the smoothness which we admire in a wide, turf-covered expanse "is mainly due to all the inequalities having been slowly leveled by worms," and that "the whole of the superficial mould over any such expanse has passed, and will pass again, every few years, through the bodies of worms!" It was left for Pasteur to show that these innumerable and indefatigable plowmen, whilst rendering to man such efficient service, may also be the carriers of the seeds of disease and death.

In proceeding with our brief historical account of Pasteur's and allied researches, we are arrived at the point where their analogy to Jenner's becomes manifest, and where their direct bearing on the welfare of mankind comes into view. So soon as it was known that these disease germs were low forms of vegetation, and that, like other vegetables, they could be cultivated, it was natural to ask whether, like other vegetables, their characters and properties could not be so modified as to render them at least less deleterious. Every one knows the difference between the crab-apple and its cultivated variety, the sloe and the plum, the wild and the cultivated celery. It is all the difference between unwholesome and wholesome food.

Two methods of cultivation, with a view to obtaining the desired modification of the power exercised by the bacilli and other similar germs, presented themselves, the one analogous to that really pursued by Jenner where small-pox, or the grease of the horse, was passed through the system of the cow, and then from one human being to another; and the second by carrying on the cultivation out of the living body. Both these plans have been adopted, with the result of proving that the potency of the germs can be so diminished as to render the disease produced by their introduction so mild as to be of no importance. Pasteur cultivated the bacillus in chicken broth or meat juice, and allowed a certain time to elapse before he made use of the mixture. After allowing only two months to elapse, the virulence of the germs seemed to be but little impaired, but after three or four months animals inoculated with the fluid, though they took the disease, had it in so mild a form that the greater number recovered. After a long period of six or eight months the engendered disease was so mild that all the animals speedily recovered and regained health and strength.

And now the question will naturally arise, Did animals which had passed through the mild disease thus induced acquire a protection against the original disease, if brought in contact with it in subsequent epidemics, in the same way that Jenner's vaccinated patients were protected against small-pox?

An answer in the affirmative may now be given with the utmost confidence. Experiments conducted, both in this country and abroad, by both methods of procedure, have abundantly proved that animals may be protected by inoculation so as to render them insusceptible of any form of the destructive anthrax disease.

From a remarkable paper read by Pasteur before the International Medical Congress we extract the concluding paragraph. After detailing the method pursued to obtain the requisite attenuation of the virus, and stating that by certain physiological artifices it may be made again to assume its original virulence, he proceeds: “The method I have just explained, of obtaining the vaccine of splenic fever, was no sooner made known then it was very extensively employed to prevent the splenic affection. In France we lose every year by splenic fever animals to the value of 20,000,000 francs, and even, according to one of the persons in the office of the Minister of Agriculture, more than 30,000,000 francs, but exact statistics are still wanting. I was asked to give a public demonstration at Pouilly-le-Fort, near Melun, of the results already mentioned. This experiment I may relate in a few words. Fifty sheep were placed at my disposition, of which twenty-five were vaccinated, and the remaining twenty-five underwent no treatment. A fortnight afterwards the fifty sheep were inoculated with the most virulent anthracoid microbe (or germ). The twenty-five vaccinated sheep resisted the infection, the twenty-five unvaccinated died of splenic fever within fifty hours.

"Since that time the capabilities of my laboratory have been inadequate to meet the demands of farmers for supplies of this vaccine. In the space of fifteen days we have vaccinated in the departments surrounding Paris, more than 20,000 sheep, and a large number of cattle and horses. This experiment was repeated last month at the Ferme de Lambert, near Chartres. It deserves special mention.

"The very virulent inoculation practiced at Pouilly-le-Fort, in order to prove the immunity produced by vaccination, had been effected by the aid of anthracoid germs deposited in a culture which had been preserved in my laboratory more than four years, that is to say, from the 21st March, 1877. There was assuredly no doubt about its virulence, since in fifty hours it killed twenty-five sheep out of twenty-five. Nevertheless, a commission of doctors, surgeons, and veterinary-surgeons, of Chartres, prejudiced with the idea that virus obtained from infectious blood must have a virulence capable of defying the action of what I call cultures of virus, instituted a comparison of the effects upon vaccinated sheep and upon unvaccinated sheep of inoculation with the blood of an animal which had died of splenic fever. The result was identical with that obtained at Pouilly-le-Fort—absolute resistance of the vaccinated and deaths of the unvaccinated. If I were not pressed for time I should bring to your notice other kinds of virus attenuated by similar means. These experiments will be communicated by-and-by to the public."

The bearing of these researches of Pasteur on vaccination with cow-pox, and the whole of the Jennerian doctrines, will be evident. They throw a flood of light both on the efficacy of vaccination and the many supposed failures which have given a handle to the unscrupulous fanatical detractors of Jenner and his doctrines. They go far toward establishing the correctness of the view entertained by Jenner as to the identity of small-pox and cow-pox, showing how great may be the modifications effected in the original virus by repeated transmission, either through the animal or the human system.

But apart from the question of identity or diversity of small-pox and vaccinia, Pasteur's researches prove beyond all question that a disease virus may be both diminished and augmented in power by physiological devices, and that therefore the efficacy of the vaccine lymph may, in various ways, be so diminished as to lose its protective power, without shaking our faith in the principle of vaccination or detracting in the least from the inestimable value of Jenner's discovery. The attention of the scientific world will now be, and is, directed to the important inquiry, How far has the original vaccinia of Jenner lost its protective power? If so, how has this been brought about, and by what means can it be restored? Must we again revert to the cow for a new supply? Need we only be more scrupulous in the selection of the vesicles, and the particular stage of their development, and in the mode in which the operation of vaccination is performed? These and numerous other similar questions are now being discussed and investigated, but none probably is more important than the question how far the protective influence in each individual is dissipated by time, and hence the principle of re-vaccination is now being enforced. There can be no doubt that different epidemics possess different degrees of virulence, and what proves a sufficient protection in a mild epidemic of small-pox may not be sufficient in a more virulent one. In certain seasons and in certain conditions of the atmosphere, the human system is more prone to certain disease than at other times. Pasteur's experiments on cultivated virus or germs show that in the course of time, and in certain conditions of exposure to the action of oxygen or other agents, the vitality, or constitution, so to speak, of the germs may be so changed as materially to alter their action on the animal system. We have, therefore, scientific grounds for reverting from time to time to the heifer for a new stock, rather than continuing to rely on the perpetual transmission from one human body to another.

This is not the place to enter on the whole question of the germ theory of disease, but who does not see how wide is the field for investigation opened up by Pasteur and others? Already the application of the principle of vaccination has been successfully applied by Pasteur to a very fatal epidemic disease attacking fowls, and known by the name of "chicken cholera." By inoculating chickens with the cultivated variety of the particular "bacillus" he has afforded to them complete protection. The economic value of this to France may in some measure be estimated by the many millions of eggs which are exported from France to this country alone. How many other diseases, such as scarlatina and diphtheria, which now carry off annually thousands of children, may not ere long be extinguished by like means who shall say? "I venture," states Mr. Simon, in his address to the Health Section of the International Congress, "to say that in the records of human industry it would be impossible to point to work of more promise to the world than these various contributions to the knowledge of disease and of its cure and prevention, and they are contributions which, from the nature of the case, have come, and could only have come, from the performance of experiments on living animals."

Compulsory vaccination is, no doubt, a strong measure, and one which might, in this land of individual liberty, be expected to give rise both to question and opposition. It can only be justified by proving that it is to the interest of the individual as well as of the whole community that it should be enforced. Of its propriety and necessity we believe it needs only a calm and unprejudiced inquiry to be convinced. Most of the objections raised against it are either baseless or admit of being obviated. That some of the objections are of a character that command our respect may be admitted, but mere sentiment or prejudiced and ill-founded objections, must give place to sound arguments and well-established evidence. In this, as in many similar cases, opposition and discussion open up entrances for light by which the clouds of ignorance and darkness are sure to be dispelled. But even as this whole question of vaccination now stands, the responsibility of those who are persistently misrepresenting facts and misleading the public is great, nay, criminal, when we reflect how many lives are sacrificed by the neglect of precautionary means within the reach of all.

LOUIS PASTEUR AND HIS WORK

PATRICK GEDDES AND J. ARTHUR THOMSON

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The course of Pasteur's scientific work is one of remarkably natural and logical sequence. As the veteran M. Chevreuil long ago said in the Academy of Sciences, “It is by first examining in their chronological order the researches of M. Pasteur, and then considering them as a whole, that we appreciate the rigor of his conclusions, and the perspicacity of a mind which, strong in the truths which it has already discovered, sweeps forward to the establishment of what is new.” We shall therefore summarize the record of his greatest achievements.

As was natural in a pupil of Dumas, Balard, and Delafosse, Pasteur's first important piece of work was chemical and crystallographic, and we may best understand its spirit by recalling the work of Delafosse's master in mineralogy, the Abbé Hauy, who is still remembered for that bold attempt to visualize the ultimate structure of the crystal, to penetrate the inmost secret of its architecture, which also reappears in another way in the work of Mendelejeff. Pasteur's puzzle concerned the tartrates and paratartrates of soda and ammonia. These two salts are alike in chemical composition, in crystalline form, in specific gravity, and so on, but they differ in behaviour. Thus, as Biot had shown, a solution of tartrate deflects the plane of polarized light passed through it, while a solution of the paratartrate does not. The salts are the same, yet they behave differently. A note to the Academy from the famous chemist Mitscherlich emphasized the entire similarity of the two salts, and this acted as an additional stimulus to Pasteur. He succeeded in distinguishing the minute facets which even Mitscherlich had missed; he proved that the paratartrate is a combination of a left-handed and a right-handed tartrate, and did much else which only the expert chemist could duly explain. Biot was first doubtful, then delighted; Arago, who had also busied himself with these matters, moved that Pasteur's paper be printed in the memoirs of the Academy, and Mitscherlich himself congratulated the young discoverer who had tripped him up.

Already, then, in this minute and laborious piece of work, we may detect ultra-microscopic mental vision, and that rigorous accuracy so characteristic of the man. Yet it is interesting to observe that at this early stage he was sowing his wild oats of speculation. Impressed by the strange rotation of the plane of polarization exhibited by these organic salts, he deduced therefrom an hypothesis of molecular dissymmetry, and hazarded the view that this was a fundamental distinction between the organic and the inorganic. For various reasons, neither chemist nor biologist would nowadays accept this distinction; but it is hard to tell what Pasteur might have made of this inquiry had not circumstances, regretted at the time, directed his attention to very different subjects.

Being thus known in connection with tartrates, Pasteur was one day consulted, so the story goes, by a German manufacturer of chemicals, who was puzzled by the fermentation of his commercial tartrate of lime, which contained some admixture of organic impurities. Pasteur undertook to look into the matter, and probably deriving some hint from the previous work of Cagniard Latour, and Schwann who had demonstrated the yeast-plant which causes alcoholic fermentation, he demonstrated the micro-organism which fermented the tartrate of lime. He extended this discovery to other tartrates, and made the neat experiment of showing how the common blue mould (*Penicillium glaucum*), sown in paratartrate of ammonia, uses up all the right-handed tartrate and leaves the left-handed salt alone, its identical chemical composition notwithstanding. These and similar inquiries led him to tackle the whole question of fermentation, but his transference to Lille had probably much to do with this. For, as one of the chief industries of the district is making alcohol from beet-root and grain, Pasteur's practical sense led him to devote some of his lectures to fermentation; here, as always, as his biographer reminds us, wishful to make himself directly useful to his hearers.

The prevalent theory of fermentation, before Pasteur took the subject in hand, was that of Willis and Stahl, revised and elaborated by Liebig. According to this theory, nitrogenous substances in a state of decomposition upset the molecular equilibrium of fermentable matter with which they are in contact. What Pasteur did was to show that lactic, butyric, acetic, and some other fermentations, were due to the vital activity of micro-organisms. In spite of Liebig's prolonged opposition, Pasteur carried his point; and although some of his detailed interpretations have since been revised, it is universally admitted that he changed the whole complexion of the fermentation problem. It must, of course, be borne in mind that his theory of the vital nature of many fermentations does not apply to soluble ferments or enzymes—such as diastase and pepsin—which are chemical substances, not living organisms. Part, indeed, of the opposition to Pasteur's views was due to the fact that this distinction between organized and unorganized ferments was not at the time clearly drawn. Perhaps, indeed, we are as yet by no means out of the woods.

In the course of his work on fermentation, Pasteur made an important theoretical step by distinguishing the micro-organisms which require the presence of free oxygen, from forms which are able to live apart from free oxygen, obtaining what they require by splitting up oxygen-containing compounds in the surrounding medium. These he termed ærobic and anærobic respectively. Practically, this piece of work immediately led to what is known as the Orleans process of making vinegar. Some years later, after he had returned to Paris, he followed this up by his studies on wine, in the course of which he tracked various wine-diseases to their sources, and showed how deterioration might be prevented by raising the wine for a minute to a temperature of 50°C. The wine-tasters of Paris gave their verdict in his favour.

The old notion of spontaneous generation still lingered in some quarters, and in 1858 Pouchet had given new life to the question by claiming before the Academy of Sciences that he had succeeded in proving the origin of microscopic organisms apart from pre-existing germs. But Pasteur knew more than Pouchet as to the insidious ways of germs: he showed the weak point of his antagonist's experiments, and gained the prize, offered in 1860 by the Academy, for "well-contrived experiments to throw new light upon the question of spontaneous generation." As every one knows, the victory was with Pasteur, but the idea is an old and recurrent one, and dies hard. Thus, not many years afterward, Pasteur and Tyndall had to fight the battle over again with Bastian. The important result of what seems at first sight an abstract discussion has been not only an increased knowledge of the distribution and dissemination of bacteria, but the establishment of the fundamental conditions and methods of experimental bacteriology....

[Here follows substantially the same narrative as that given by Sir J. Risdon Bennett on pages 36 to 49 of this volume. It recites how Pasteur devised preventives for the disease which was destroying the silkworms; preventives for splenic fever or anthrax.]

Opposition was an ever-recurrent factor in Pasteur's life. He had to fight for his crystallographic and chemical theories, and for his fermentation theory; he had to fight against the theory of spontaneous generation, and for his practice of inoculating as a preventive against splenic fever; he had to fight for each step. But no part of his work has met with so much opposition and adverse criticism as that concerning hydrophobia, though it is easy to exaggerate the importance of the discussion, in which Pasteur himself took little part. Feeling ran high in this country; hence, when it was announced that Pasteur—surely best qualified to speak—was to write the article Hydrophobia in

“Chamber's Encyclopædia,” a shower of letters inundated the office; hence the article in question includes an editorially demanded summary of the grounds of the opposition by one of ourselves, and to which therefore we may refer the reader.

While avoiding controversy and partisanship as far as may be, the question remains, What did Pasteur do in regard to hydrophobia? His claims are to have proved, first of all, that the disease was particularly associated with the nervous system. The virus is usually spread through the saliva, but it is not found in the blood or lymph, and it has its special seat in the nerves, brain, and spinal cord. Secondly, he showed that the virus might be attenuated in its virulence. The spinal cord of a rabbit which has died of rabies, is, when fresh, powerfully virulent, but when exposed for a couple of weeks to dry air at a constant temperature of 23°-24°C. it loses its virulence. Thirdly, he showed that inoculation with the attenuated virus rendered an animal immune from infection with rabies. To make the animal immune it has first to be inoculated with infected spinal cord fourteen days old, then with that of thirteen days, and so on till inoculation with almost freshly infected spinal cord is possible. In this way the animal becomes refractory to the infection, and if it be bitten it will not die. Fourthly, he showed that even if the organism had been bitten, it was still possible to save it, unless the wounds were near the head—that is, within close reach of the central nervous system. For in the case of a superficial wound, say on hand or leg, the virus takes some considerable time to spread, and during this period of spreading and incubation it is possible to forestall the virus by inoculation with that which has been attenuated. In this case there is obvious truth in the proverb, “He gives twice who gives quickly.” And the outcome was, that while out of a hundred persons bitten, nineteen or twenty will in ordinary circumstances die, “the mortality among cases treated at the Pasteur Institute has fallen to less than 1-2 per cent.” According to another set of statistics, a mortality of 40 per cent. has been reduced to 1.3 per cent.; and of 1673 patients treated by Pasteur's method only thirteen died.

As to the adverse criticism of Pasteur's inoculation against rabies, it consists, first and second, of the general argument of the anti-vaccinationists, and thirdly, of specific objections. To the two former the school of Pasteur, of course, replies that the value of human life answers the one, and the results of experience the other; but on these controversies we cannot enter here. The main specific objections we take to be three—that as the micro-organism of rabies has not really been seen, the theory and practice of Pasteur's anti-rabic method lack that stability which is desirable; that the statistics in favor of the Pasteur procedure have been insufficiently criticised; that there have been failures and casualties, sometimes of a tragic nature. In regard to this last point—that deaths have occurred as the result of the supposed cure, instead of from the original infection—we may note that the *possibility* of such casualties was admitted by the English Investigation Committee (1887), while, on the other hand, Dr. Armand Ruffer, who speaks with much authority, denies with all deliberateness that there is any known case in which death followed as the result of Pasteur's treatment.

Microscopic verification is, of course, most desirable, and statistics are proverbially difficult of criticism. But, on the whole, we think it likely that those who, like ourselves are not medical experts will incline to believe that Sir James Paget, Dr. Lauder Brunton, Professor George Fleming, Sir Joseph Lister, Dr. Richard Quain, Sir Henry Roscoe, and Professor Burdon

Sanderson must have had grounds for saying, in the report which they presented to Parliament in 1887, “It may, hence, be deemed certain that M. Pasteur has discovered a method of protection from rabies comparable with that which vaccination affords against infection from small-pox.”

So far a summary of Pasteur's personal life and scientific work, but is it not possible to make a more general and rational estimate of these? So much was his life centred in Paris that most people are probably accustomed to think of him as a townsman; but it is more biologically accurate to recognize him as a rustic, sprung from a strong, thrifty stock of mountain peasants. Nor can his rustic early environment of tanyard and farm, of village and country-side, be overlooked as a factor in developing that practical sense and economic insight which were so conspicuous in his life work. The tanner's son becomes the specialist in fermentation; the country boy is never throughout his life beyond hail of the poultry-yard and the farm-steading, the wine press and the silk nursery; brought up in the rural French atmosphere of careful thrift and minute economies, all centred not round the mechanism or exchange of town industries, but round the actual maintenance of human and organic life, he becomes a great life-saver in his generation.

In short, as we might almost diagrammatically sum it up, the shrewd, minutely careful, yet inquiring rustic, eager to understand and then to improve what he sees, passes in an ever-widening spiral from his rural centre upward, from tan-pit to vat and vintage, from manure-heaps, earthworms, and water-supply to the problems of civic sanitation. The rustic tragedies of the dead cow and the mad dog excite the explanation and suggest the prevention, of these disasters; from the poisoning of rats and mice he passes to suggestive experiments as to the rabbit-pest of Australia, and so in other cases from beast to man, from village to state. And on each radius on which he paused he left either a method or a clew, and set some other inquirer at work. On each radius of work he has left his disciples; for he founded not only an Institute, but a living school, or indeed whole schools of workers. We think of him, then, not only as thinking rustic, but as one of the greatest examples in science of the Rustic Thinker—a type of thinker too rare in our mechanical and urban generation, yet for whom the next generation waits.

As to his actual legacy to the world, let us sum it up briefly. There is the impulse which he gave, after the successful organization of his own Institute, to the establishment in other countries of similar laboratories of preventive medicine, and, one may also say, of experimental evolution. There is his educative work at Strasburg and Lille, at the Ecole Normale and the Sorbonne, and, above all, in the smaller yet world-wide circle of his immediate disciples. To general biology his chief contribution has been the demonstration of the part which bacteria play, not only in pathological and physiological processes, but in the wider drama of evolution. To the chemist he has given a new theory of fermentation; to the physician many a suggestive lesson in the etiology [inquiry into the causes] of diseases, and a series of bold experiments in preventive and curative inoculation, of which Roux's treatment of diphtheria and Professor Fraser's new remedy for snake-bite are examples at present before the public; to the surgeon a stable foundation, as Lister acknowledged, for antiseptic treatment; to the hygienist a multitude of practical suggestions concerning water-supply and drainage, disinfection and burial. On brewer, distiller, and wine-maker he has forced the microscope and its results; and he has shown both agriculturist and stock-breeder how some, at least, of their many more than ten plagues may be either averted or alleviated.

TUBERCULOSIS AND ITS PREVENTION

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It is commonly neither wise nor necessary for people not professionally concerned to think much about disease, or weigh anxiously the chance or mode of its acquirement. But now and then conditions arise which demand general attention and instruction regarding certain diseases in order that a great, threatening calamity may be averted. Such a condition faces the people in all lands to-day in the appalling prevalence of tuberculosis. A disease which in mild or severe form affects at least one-half of the whole human race, and which causes the death of full one-seventh of all who pass away, killing about one-third of those who perish between the ages of fifteen and forty-five—a disease which is most insidious in its onset, and often relentless in its course, and which may be largely prevented—is one about which we cannot be indifferent, and should not be longer inactive.

There has long been reason for believing that tuberculosis is a communicable disease. Its prevalence in certain families and communities, its frequent occurrence in those who have personally attended upon its victims, its onset in those who have occupied apartments vacated by consumptives—such facts observed over and over again abundantly justify the belief in its communicability. Up to the commencement of the last decade the cause of the disease was altogether unknown, and no definite data were at hand which could enable us to fix upon a feasible plan for limiting its ravages. But in these later years a great light has been thrown upon this and other kindred diseases.

Most intelligent people are aware that within the past decade a new field in the domain of life has been revealed and widely explored. It has been learned that in earth and air and water there exist countless myriads of living things so minute as to lie far beyond the limits of the unaided vision, and yet in the aggregate so potent in the maintenance of the cycle of life upon earth that without their activity all life would soon cease to be, and the elements which for a short span fall under the sway of the life forces in all higher animals and plants would lapse finally and irrevocably into their primal state. These tiny organisms are called germs, microbes, or micro-organisms. One great and important group of them belongs among the microscopic plants called bacteria. These bacteria as a class are important in their economy of nature, because they live for the most part on dead organic material—that is, such material as has once formed a portion of some living thing.

The world's store of available oxygen, hydrogen, carbon and nitrogen, out of which all living beings are largely formed, is limited, and if after these have served their temporary uses, as the medium through which that mysterious potency called life alone can find expression, they were not speedily released, new generations of living beings could neither assume nor maintain their place in the great cycle of life. And so these tiny plants, year in, year out, by day and by night, unseen and mostly unheeded, are busy always in making possible the return of each year's visible vegetation and the maintenance of an unbroken succession of generations in man and beast.

Different groups and races among the bacteria have different habitations, and vary widely in their special powers. Complex and powerful as is the aggregate result which they accomplish in the world, the performances of the individual are comparatively simple. They are most liberally endowed with the capacity for multiplication, and each germ acts as a tiny chemical laboratory, taking into itself the organic matter on which it feeds, and resolving it into new compounds. Some of the latter are used in building up and maintaining its own body, while others are given off into the surrounding media.

We are but just beginning to peer at the mysterious processes which go on under the influence of the bacteria in this underworld of life, and to realize that all the lore which unwearied toilers in the past have gathered in their studies of the visible forms of animals and plants, makes but one of the many chapters in nature's story-book of life.

But this new and stimulating point of view, toward which the studies of the past decade have led us, does not look so largely into the domain of the practical that it would greatly attract the majority of business and pleasure and *ennui* ridden mankind were it not for one very practical fact which these recent studies have revealed. This is, that among the myriads of altogether beneficent bacteria which people the earth, and air, and water, there are a few forms which have chosen out of all the world as their most congenial residence the bodies of men. But even this would be of only passing interest to most people were it not still further unfortunately true that in the performance of their simple life-processes these man-loving bacteria, feeding on the tissues of their host, and setting free certain subtle poisons in his blood, each after its kind, can induce those disturbances of the body's functions and those changes in its structure which we call disease.

The diseases caused by the growth of germs in the body are called infectious. The germs causing some of the infectious diseases are given off from the bodies of their victims in such form as to be readily transmitted through the air to others, in whom they may incite similar disease. Such diseases are spoken of as readily communicable, though it is not actually the disease itself, but only the germ causing it, which is transmitted. In other infectious diseases transmission but rarely occurs. Many infectious diseases are very easily communicated from the sick to the well under unsanitary and uncleanly conditions, which with proper care are very little liable to spread.

I need not here put on parade the whole uncanny list of germ diseases, in which tuberculosis stands foremost, followed by pneumonia, diphtheria, typhoid fever, scarlatina, cholera, small-pox, and the rest. Nor need I call to mind the means by which our growing knowledge in this domain has been day by day laid under tribute for suggestions of hope and safety for the stricken. It is a record of brilliant conquest in nature, and already of far-reaching beneficence to man.

But the great fundamental advance which signalizes the past decade is the lifting of this whole class of fateful germ diseases out of the region of the intangible and mysterious, and their establishment, on the basis of positive experimental research, in the domain of the comprehensible and definite. The things which cause them are no longer for us mysterious emanations from the sick, or incorporate expressions of malign forces against which conjurations or prayers could alone promise protection, but they are particulate beings, never self-engendered, never evolved in the body, always entering from without—things which we can see and handle and kill.

Let us now glance at the germ called the tubercle bacillus, the germ which induces and which alone can induce tuberculosis. It does not exist and thrive in the body of men or animals in health. Without the entrance of this particular germ into the human body from without, tuberculosis cannot develop in it. Without the transmission of this germ in some way or other in a living condition from the sick to the well, tuberculosis cannot spread. In the life-story of this tiny germ lie both the potency for mischief which we deplore and the secret of our release from its bondage.

The tubercle bacillus is a little colourless, rod-like plant, so small that even many thousands of them piled together would make a heap far too small to be visible to the naked eye. It cannot move about, nor can it grow without moisture, nor at a temperature much above or much below that of the human body. The material on which it feeds must be very nicely adapted to its requirements, and it has no lurking and growing places in nature outside of the bodies of men and a few warm-blooded animals. It can be cultivated artificially in the laboratory, and we know more about its life and peculiarities than about almost any other germ. While it can remain alive in a dried state for many weeks, it is readily killed by heat, by sunlight, and by many of those chemical substances which we call disinfectants. It does not flourish equally well in the bodies of all human beings.

When once it gains lodgment in a body suited to its growth it multiplies slowly, each germ dividing and subdividing, taking from the tissues material for its growth, and returning to them certain subtle poisons which it sets free. The action of the tubercle bacillus is peculiar in that it stimulates the cells of the body, wherever it may lodge and grow, to the formation of little masses of new tissue, which we call tubercles. These tubercles are as a rule short-lived, and, if the disease progresses, tend to disintegrate. If the tubercles have grown in such situations as to make this possible, as in the intestinal canal or the lungs, the disintegrated and broken-down material, often containing myriads of the living germs, may be cast off from the body. In tuberculosis of the lungs, or consumption, this waste material is thrown off with the sputum [spittle]. While almost any part of the body may be affected, tuberculosis of the lungs is by far the most common form of the disease.

It follows from what has been said that the only way in which we can acquire tuberculosis is by getting into our bodies tubercle bacilli from tuberculous men or animals. The only animals liable to convey the disease to man are tuberculous cattle, and these through the use of either meat or milk. The danger from the use of uncooked meat or the unboiled milk from tuberculous cattle is real and serious, but it will not be considered here at length, because the great and prevailing danger of infection comes from another source.

Almost as soon as the significance of the tubercle bacillus was established, a series of studies was undertaken on the possibility of the spread of the disease by the breath or exhalations of the persons of consumptives. These studies at once showed that the tubercle bacillus cannot be given off into the air of the breath from the moist surfaces of the mouth and air passages, nor from any material which may come from them while this material remains moist, nor from healthy unsoiled surfaces of the body. The establishment of this fact is of far-reaching consequence, because it shows that neither the person nor the breath of the consumptive is a direct source of danger, even to the most constant and intimate attendants.

While the discharges from the bowels in persons suffering from tuberculosis of the intestinal tract may contain many living bacilli, the usual mode of disposal of these discharges protects us from any considerable danger from this source.

It is the sputum after its discharge from the body on which our attention must be fixed. While the sputum is moist it can, as a rule, do no harm, unless it should be directly transmitted to those who are well by violent coughing, sneezing, etc., by the use of uncleansed cooking or eating utensils, by soiled hands, or by such intimate personal contact as kissing or fondling. But if in any way the sputum becomes dried, on floors or walls or bedding, on handkerchiefs or towels, or on the person of the patient, it may soon become disseminated in the air as dust, and can thus be breathed into the lungs of exposed persons.

The wide distribution of tubercle bacilli in the air of living-rooms, and in other dusty places where people go, is due partly to the frequency of the disease and the large numbers of living bacilli which are cast off in the sputum (sometimes millions in a day), and partly to the fact that many of the victims of consumption go about among their fellows for purposes of business or pleasure for months or years. So each consumptive, if not intelligently careful, may year after year be to his fellow-men a source of active and serious and continual infection.

This, then, the dried, uncared-for sputum of those suffering from pulmonary tuberculosis, is the great source of danger; this the means so long concealed by which a large part of the human race prematurely perishes. Let but this discharged material be rendered harmless or destroyed before it dries in all cases, and the ravages of this scourge would largely cease. This is not a theoretic matter only, for again and again have the living and virulent germs been found clinging to the walls and furniture and bedding and handkerchiefs of consumptive persons, and in the dust of the rooms in which they dwell. A malady whose victims far outnumber those of all other infectious diseases put together, sparing neither rich nor poor, seizing upon life while it is as yet only a promise, but most inexorable in the fulness of its tide—this malady can be largely prevented by the universal and persistent practice of intelligent cleanliness.

We have learned in the past few years one fact about tuberculosis which is of incalculable comfort to many, and that is that the disease is not hereditary. It is very important that we should understand this, because it seems to contradict a long-prevalent tradition, and a belief still widely and sorrowfully entertained. Bacteria, and especially most disease-producing bacteria, are very sensitive in the matter of growth and reproduction to the conditions under which they are placed, and especially to the material on which they feed. So that a germ which can induce serious disease in one species of animal is harmless in the body of a different though closely allied form. More than this, different individuals of the same species, or the same individual at different times, may have the most marked differences in susceptibility in the presence of disease-producing germs. What this subtle difference is we do not know. Whether the body at one time affords a congenial soil to the invading germs and at another does not, whether its marvelous and complex powers of resisting the virulent tendencies of disease-producing bacteria at one period or in one individual are more vigorous than in another, and vary at different times, we do not certainly know. This, however, we do know, that certain individuals are more likely than others to yield to the incursions of the tubercle bacillus. This vulnerability in the presence of invading germs we call susceptibility, and susceptibility to the action of the tubercle bacillus is hereditary. It is not the disease, tuberculosis, which comes into the world with certain individuals or with successive children of the same family, but the aptitude to contract it should external conditions favour. What subtle impress on the cells which are to develop into the new individual renders him more than another an easy prey to the tubercle bacillus should it later find lodgment in his body we do not know, and we may not hope soon to be enlightened, since all the intricate mysteries of heredity seem involved in the problem. But this we do know, that how ever much the child of tuberculous parents or a member of a tuberculous family may be predisposed to the disease, he cannot acquire tuberculosis unless by some mischance the fateful germ enters his body from without. What has been all through these years regarded as the strongest proof of the hereditary transmission of tuberculosis—namely, the occurrence of the disease in several members of the same household—is, in the new light, simply the result of household infection—the breathing of air especially liable to contain the noxious germs, or their entrance in some other way into the bodies of persons especially sensitive to their presence. I do not mean to imply that under no conditions can the tubercle bacillus be transmitted from the mother to the child before its birth. In a few instances this is believed to have happened. But its occurrence is so extremely infrequent that it may be regarded as accidental, and of no serious importance from our present point of view.

But it will perhaps be said, “If the tubercle bacilli are so widely diffused, why do we not all acquire tuberculosis, and why was the world not long since depopulated?” In order to explain this matter I must ask the reader to look with me for a moment at some of the body's natural safeguards against bacterial and other invaders from the air. It has been found that a person breathing in germ and dust-laden air through the nose breathes out again air which is both dust and germ free. The air passages of the nose are tortuous, and lined with a moist membrane, against which the air impinges in its passage. On these moist surfaces most of the solid suspended particles, the germs among them, are caught and held fast, and may be thrown off again by secretion. In breathing through the mouth this safeguard is not utilized. Again, the upper passages leading to the lungs are lined with a delicate membrane of cells, whose free surfaces are thickly beset with tiny hairlike projections. These projections are constantly moving back and forth with a quick sweep, in such a way that they carry small particles which may have escaped the barriers above up into the mouth, from which they may be readily discharged. In this way much of the evil of breathing dust and germ-laden air is averted. But in spite of these natural safeguards a great deal of foreign material does, under the ordinary conditions of life indoors or in dusty places, find lodgment in the delicate recesses of the lungs. The body tolerates a good deal of the deleterious material, but its overtasked toleration fails at last, when serious disease may ensue.

When ordinary forms of living bacteria get into the tissues of the body, a very complex cellular mechanism, not fully understood, usually results in their destruction and ultimate removal. In the presence of the tubercle bacillus the body cells are often able to build a dense enclosing wall around the affected region, shutting it off from the rest of the body. This is one of the modes of natural cure. The body cells are sometimes able, if sustained by nourishing food and an abundance of fresh air, to carry on, year after year, a successful struggle with the invading germs, so that the usefulness and enjoyment of life are but little interfered with. Finally, a certain proportion of human beings seem to be endowed at birth with some as yet unknown quality in the cells or fluids of the body which naturally unfits them for the life uses of the tubercle bacillus, and so renders the individual for longer or shorter periods practically immune.

Others, on the contrary, are, as we have seen, from birth unusually susceptible. This inherited susceptibility to the incursions of the tubercle bacillus, should this find lodgment in the body from without, by no means always reveals itself in any apparent lack of vigour or robustness of the body. Still, any habit or mode of life which diminishes the bodily vigour, whether in those predisposed to this malady or in the apparently immune, and gives it a leaning toward disease, diminishes, as a rule, the chances of a successful contest with the bacillus. And so it is that in spite of the wide distribution of these fateful germs in frequented places, and the tendency of certain vulnerable persons to succumb to their ravages, so many people are not affected by them, and so many, although not altogether escaping their malign influence, are yet able to wrest at least a moiety of life from the hand of the great destroyer.

The degree of success which may attend our crusade against tuberculosis will largely depend upon the wide diffusion of the knowledge of its communicability by means of the sputum dried and powdered and floating in the air as dust, and the intelligent persistence with which the morbid material may be safely cared for at its sources. The resolute avoidance by consumptives of the not only filthy but dangerous practice of spitting upon floors or streets, or anywhere else except into proper receptacles; the use of receptacles which may be and are frequently and thoroughly cleansed, and, best of all, of water-proof paper cups, which with their contents may be burned; or, when circumstances require, the receiving of the dangerous material on cloths or Japanese paper napkins, which may be destroyed by fire, and not on more valuable handkerchiefs on which the sputum is allowed to dry while in use or before disinfection and washing; scrupulous care by others of the sputum of those too ill to care for it themselves—these are the comparatively simple means from which we may most confidently expect relief. The details of these precautions and their adaptation to the special circumstances of those suffering from the disease can be most wisely left to the physician, and though of paramount importance, need not further engage our attention here.

To the consumptive himself these measures are not without a vital significance. For his chances of recovery may be in no small degree diminished if he be more or less constantly liable to a fresh infection from material which he has once got rid of, and which should have been destroyed.

The great volumes of fresh, moving air which we encounter out-of-doors in properly cleansed streets usually so greatly dilutes the dust, of whatever kind, that little apprehension need be felt from its presence. When, however, in crowded cities, the streets are, as is nearly always the case, save for a few favored localities, filthy, and but fitfully cared for; when choking dust clouds must be encountered by the citizen during the haphazard and slatternly essays at cleaning made by untrained and irresponsible sweepers; we cannot ignore a danger from street dust which may well incite grave apprehension. The citizen can, if he must, run from the presence of cloud-enwrapped machines furiously whirled along half-sprinkled pavements; he may avoid a block on which the hand-sweepers, in the absence or in disregard of rules, ply their nefarious brooms over unwet surfaces, because too indolent or indifferent to sprinkle them—these things he can do if he be not willing or ready to apply the citizen's remedy for municipal misrule.

But it is in rooms either of dwelling or assembling places that the ill effects of infectious dust are most potent, because the air is here not so constantly renewed as it is out-of-doors, and is liable to be breathed over and over again. Dust which gets into houses does not readily leave them, unless special and intelligent means be directed to its removal. We do not usually realize that, though the air itself in inhabited rooms is constantly changing more or less rapidly by diffusion, by draughts, or by purposed ventilation, fine dust particles are not removed under the same influences in proportionate degree. They cling more or less tenaciously to all surfaces on which they have settled, and especially to fabrics, so that currents of abundant force and sufficient distribution to change the air may and usually do leave the lodged dust particles almost entirely undisturbed.

One of the most threatening tendencies of modern times in matters of health is that of overcrowding in cities, and the great element of danger from this overcrowding is not only and not chiefly the insufficiency of air in living-rooms and the lack of ready means for its renewal, but the accumulation in this air of infectious germs floating with the dust. Abundant water supply and good sewerage have rendered possible and measurably safe, so far as the ordinary waste of life is concerned, the building of vast tenements which swarm with people. But the means of getting pure air, and especially of disposing of infectious material often floating in it when it is confined, have not at all kept pace with the demands of health and cleanliness.

But when we return to larger and more liberally furnished dwellings of the well-to-do classes, we are not reassured, for in some respects the rich are sadly handicapped by the “tyranny of things.” Of course, long and thick piled carpets afford persistent lurking-places for infectious as well as other dust. Certainly heavy hangings in a measure hinder the detergent action of the sunlight, shut the used air in and the fresh air out, and shelter floating matter which might otherwise escape. Without doubt, complex upholstery with roughened fabrics increases the difficulties in the maintenance of cleanliness. But the usage of the householder in these matters will, after all, depend upon whether his practical devotion be most at Fashion's or Hygeia's shrine. We may hope for the coming of a time when clean, clear, airy, simply furnished living-rooms shall replace the stuffy, fabric strewn apartments in which the fashionable citizen so much delights to-day.

In one particular, however, the devotion to cleanliness may be unreservedly insistent, and that is that in the cleaning of living-rooms, whether occupied by the sick or the well, the distinct and recognized purpose of the operation shall be to remove, and not simply to stir up, the ever-gathering dust. The past few years, so beneficently signalized by the exploitation of the new germ lore, have seen marked departures from the traditional sweepings and dustings of a past era; and the emancipation of the housekeeper, and incidentally of the household, from the thrall of the pestiferous feather duster seems fairly under way. Still, some of the old barbarous travesties upon cleaning widely persist. The dry broom still seeks out in the deep recesses of the carpets not the coarser particles of dirt alone, but the hordes of living germs which were for the time safely ensconced, and among these such malignant forms as the chances of the day have gathered. These all are set awhirl in the air; some collect upon salient points of the fittings and furnishings; many stay with the operator, to vex for hours the delicate breathing passages or the deeper recesses of the lungs. Then in the lull which follows, gravity reasserts its sway, and the myriad particles, both the living and the dead, slowly settle to the horizontal surfaces, especially to the carpets. Then the feather duster comes upon the scene, and another cyclone befalls. The result of it all is that the dust has finally been forced to more or less completely abandon the smooth and shining surfaces where it would be visible, and is largely caught in the surface roughness of the carpets or upholstery or hangings, ready at the lightest footfall or the chariest touch to dance into the air again, and be taken into the lungs of the victims of the prevailing delusion—the delusion that the way to care for always obnoxious and offensive and often dangerous dust is not to get it out of the house, but to keep it stirring in the air until at last it has settled where it does not vex the eye.

By the use of moist tea leaves in the sweeping of carpets, by the use of soft-textured fabrics, frequently shaken out-of-doors, or by moist cloths or chamois in dusting, much useless dust-scattering may be avoided. But no matter what the means employed, the final purpose of every household cleaning should be to get the dust, not afloat, but away.

Probably the most serious source of infection which one is liable to encounter in the usual ways of life is the occupancy at hotels of bed-rooms vacated by consumptives without subsequent efficient cleansing, and travel in sleeping cars. I need not enter here into the harrowing details of desperate uncleanness which the ordinary railway travel brings to light. It is to be hoped that popular demand for reform in the routine of hotel-keepers and railroad managers in the matter of ordinary sweeping and dusting, and in the precautions against the spread of tuberculosis, may soon usher in among them a day of reasonable sanitary intelligence.

A belief in the communicability of tuberculosis is becoming widely diffused, and it would seem to be desirable, on the ground of policy alone, for the managers of summer, and especially of winter resorts frequented by consumptives, to let it be known in no uncertain way that their precautions against the spread of infectious diseases are effectually in line with the demands of modern sanitary science.

The members of families bearing a hereditary susceptibility to the acquirement of this disease should strive to foster those conditions which favour a healthy, vigorous life in occupation, food, exercise and amusement and remember that for them more than for others it is important to avoid such occupations and places as favour the distribution, in the air or otherwise, of the tubercle bacillus.

But when the individual has done what he can in making his surroundings clean, and in thus limiting the spread of the tubercle bacillus, there still remains work for municipal and State and national authorities in diffusing the necessary knowledge of the disease and its modes of prevention; in directly caring for those unable to care for themselves; in securing for all such freedom from contact with sources of the disease as the dictates of science and humanity may require.

To health boards, either national or local, must be largely entrusted the primary protection of the people against the danger from tuberculous cattle.

A national bureau of health might be of incalculable service in stimulating and harmonizing measures for the suppression of tuberculosis in various parts of the land, and in fostering research in lines which promise large practical return in the saving of life.

Tuberculosis has in this country been officially almost entirely ignored in those practical measures which health boards universally recognize as efficient in the suppression of this class of maladies. Physicians are not now generally required to report it to the local health boards. Systematic official measures of disinfection are not widely practised. But such official measures have been found extremely useful in the limitation of other communicable diseases. While consumption must logically be classed with diphtheria and scarlatina and small-pox as a communicable germ disease, it is, in fact, in the light of our present knowledge, when intelligently cared for, so little liable to spread that it is properly exempt from some of those summary measures which health authorities are justified in adopting with the more readily and less avoidably communicable maladies. Moreover, consumption is apt to involve such prolonged illness, and so often permits affected persons for months and years to go about their usual avocations, that general isolation would be both impracticable and inhumane. Moreover, for reasons which it is hoped are evident to the reader, isolation among those capable of caring for themselves is at present entirely unnecessary.

But while extreme measures are not called for, local health boards must soon act in the prevention of tuberculosis. For the present the wisest and most humane course would seem to be to attempt to secure the desired ends rather by instruction and counsel and help than by direct and summary procedures. There is no more pitiable spectacle in this land to-day than that of hundreds of victims of advanced tuberculosis in every large town who cannot be comfortably or safely cared for in the dwellings of the poor, and yet who are always unwelcome applicants at most of our hospitals and at many are denied admission altogether. They are victims of ignorance and of vicious social and hygienic conditions for which they are not largely responsible, and States and municipalities, which are most to blame, owe them at least a shelter and a place to die. Unquestionably one of the urgent duties immediately before us in all parts of the land where tuberculosis prevails is the establishment of special hospitals in which this disease can be treated and its victims safely cared for.

And now at last remains to be spoken what word of cheer and hope our new outlooks may have given us for those who are already under the shadow of this sorrowful affliction. The dreams and aspirations and strenuous labours of the students of this disease have looked steadily toward the discovery of some definite and positive means of cure, but as yet full success lingers beyond their grasp. The methods for the early detection of tuberculosis which science has pointed out make it possible for affected persons to plan such modes of life and early seek such salubrious climates as promise a hope of recovery. We have studied closely the ways in which the cells of the body often successfully resist the incursions of the already seated germs, and learned how in many ways the natural forces of cure may be sustained and strengthened. We have learned much about certain complicating occurrences which often form the most serious features in the progress of tuberculosis of the lungs, and how they may be best avoided. And so to-day the outlook for those in the earlier stages of this disease is in a considerable proportion of cases extremely encouraging. It is no longer for us the hopeless malady which it was earlier believed to be. It is not necessarily a bitter losing fight upon which one enters who becomes aware that the finger of this disease is upon him. A long and happy and useful life may still be his if the conditions which favour his cure be early and intelligently fixed upon, and patiently and faithfully persisted in. The wise physician is here the best adviser in climate and regimen, as well as in the proper selection of remedial measures, and the earlier his counsel is sought and acted on, the brighter will usually be the outlook for recovery.

Research in tuberculosis and the ministration of the physician should, and generally do, go hand in hand, and no time should be lost in bringing to the aid of the stricken what light and promise the studies of the laboratory day by day may yield. The great and beneficent work which has been accomplished by Trudeau in the Adirondack woods, in at once widening the bounds of knowledge of tuberculosis and in carrying to a successful issue in so many the varied and delicate processes of cure, is a cheering example of what may be accomplished with persistent devotion, by the light of our new knowledge, in mastering a malady so long considered hopeless.

MALARIA AND MOSQUITOES

George M. Sternberg, M.D., LL.D.

[Dr. Sternberg, Surgeon-General of the United States Army, is an investigator and author of distinction. His works include a “Manual of Bacteriology,” a “Text-Book of Bacteriology,” and “Immunity, Protective Inoculations and Serum-Therapy,” all published by William Wood & Co., New York. The address which follows was delivered by Dr. Sternberg as president of the Philosophical Society of Washington, December 8, 1900. It appeared in the *Popular Science Monthly*, February, 1901, copyright, and is here reprinted by the kind permission of the editor of the *Monthly* and the author.

A book well worth reading in this connection is “Mosquitoes,” by Leland O. Howard, Chief of the Division of Entomology, United States Department of Agriculture, Washington, D. C., and published by McClure, Phillips & Co., New York.]

In my address as President of the Biological Society, in 1896, the subject chosen was “The Malarial Parasite and Other Pathogenic Protozoa.” This address was published in March, 1897, in the *Popular Science Monthly*, and I must refer you to this illustrated paper for a detailed account of the morphological character of the malarial parasite. It is my intention at the present time to speak of “Malaria” in a more general way, and of the recent experimental evidence in support of Manson's suggestion, first made in 1894, that the mosquito serves as an intermediate host for the parasite. The discovery of this parasite may justly be considered one of the greatest achievements of scientific research during the nineteenth century. Twenty-five years ago the best informed physicians entertained erroneous ideas with reference to the nature of malaria and the etiology [inquiry into the causes] of the malarial fevers. Observation has taught them that there was something in the air in the vicinity of marshes in tropical regions, and during the summer and autumn in semi-tropical and temperate regions, which gave rise to periodic fevers in those exposed in such localities, and the usual inference was that this something was of gaseous form—that it was a special kind of bad air generated in swampy localities under favourable meteorological conditions. It was recognized at the same time that there are other kinds of bad air, such as the offensive emanations from sewers and the products of respiration of man and animals, but the term malaria was reserved especially for the kind of bad air which was supposed to give rise to the so-called malarial fevers. In the light of our present knowledge it is evident that this term is a misnomer. There is no good reason for believing that the air of swamps is any more deleterious to those who breathe it than the air of the sea coast or that in the vicinity of inland lakes and ponds. Moreover, the stagnant pools, which are covered with a "green scum" and from which bubbles of gas are given off, have lost all terrors for the well-informed man, except in so far as they serve as breeding places for mosquitoes of the genus *Anopheles*. The green scum is made up of harmless algæ such as Spirogyra, Zygnema Protococcus, Euglena, etc.; and the gas which is given off from the mud at the bottom of such stagnant pools is for the most part a well-known and comparatively harmless compound of hydrogen and carbon—methane or "marsh gas." In short, we now know that the air in the vicinity of marshes is not deleterious because of any special kind of bad air present in such localities, but because it contains mosquitoes infected with a parasite known to be the specific cause of the so-called malarial fevers. This parasite was discovered in the blood of patients suffering from intermittent fevers by Laveran, a surgeon in the French army, whose investigations were conducted in Algiers. This famous discovery was made toward the end of the year 1880, but it was several years later before the profession generally began to attach much importance to the alleged discovery. It was first confirmed by Richard in 1882; then by the Italian investigators, Marchiafava, Celli, Golgi and Bignami; by Councilman, Osier and Thayer in this country, and by many other competent observers in various parts of the world. The Italian investigators named not only confirmed the presence of the parasite discovered by Laveran in the blood of those suffering from malarial fevers, but they demonstrated its etiological rôle by inoculation experiments and added greatly to our knowledge of its life history (1883-1898). The fact that the life history of the parasite includes a period of existence in the body of the mosquito, as an intermediate host, has recently been demonstrated by the English army surgeons Manson and Ross, and confirmed by numerous observers, including the famous German bacteriologist, Koch.

The discoveries referred to, as is usual, have had to withstand the criticism of conservative physicians, who, having adopted the prevailing theories with reference to the etiology of periodic fevers, were naturally skeptical as to the reliability of the observations made by Laveran and those who claimed to have confirmed his discovery. The first contention was that the bodies described as present in the blood were not parasites, but deformed blood corpuscles. This objection was soon set at rest by the demonstration, repeatedly made, that the intra-corpuscular forms underwent distinct amœboid movements [resembling those of the amœba, a jelly-like organism of simple type]. No one witnessing these movements could doubt that he was observing a living micro-organism. The same was true of the extra-corpuscular flagellate bodies [resembling a whip-lash], which may be seen to undergo very active movements, as a result of which the red blood corpuscles are violently displaced and the flagellate body itself dashes about in the field of view.

The first confirmation in this country of Laveran's discovery of amœboid parasites in the blood of malarial fever patients was made by myself in the pathological laboratory of the Johns Hopkins University in March, 1886. In May, 1885, I had visited Rome as a delegate to the International Sanitary Conference, convened in that city under the auspices of the Italian Government, and while there I visited the Santo Spirito Hospital for the purpose of witnessing a demonstration, by Drs. Marchiafava and Celli, of that city, of the presence of the *plasmodium malariæ* in the blood of persons suffering from intermittent fever. Blood was drawn from the finger during the febrile [feverish] attack and from individuals to whom quinine had not been administered. The demonstration was entirely satisfactory, and no doubt was left in my mind that I saw living parasitic micro-organisms in the interior of red blood corpuscles obtained from the circulation of malarial fever patients. The motions were quite slow, and were manifested by a gradual change of outline rather than by visible movement. After a period of amœboid activity of greater or less duration, the body again assumed an oval or spherical form and remained quiescent for a time. While in this form it was easily recognized, as the spherical shape caused the light passing through it to be refracted and gave the impression of a body having a dark contour and a central vacuole [minute cavity]; but when it was flattened out and undergoing amœboid changes in form, it was necessary to focus very carefully and to have a good illumination in order to see it. The objective used was a Zeiss's one-twelfth inch homogeneous oil immersion.

But, very properly, skepticism with reference to the causal relation of these bodies to the disease with which they are associated was not removed by the demonstration that they are in fact blood parasites, that they are present in considerable numbers during the febrile paroxysms. These facts, however, give strong support to the inference that they are indeed the cause of the disease. This inference is further supported by the evident destruction of red blood corpuscles by the parasite, as shown by the presence of grains of black pigment in the amœba-like micro-organisms observed in these corpuscles and the accumulation of this insoluble blood pigment in the liver and spleen of those who have suffered repeated attacks of intermittent fever. The enormous loss of red blood corpuscles as a result of such attacks is shown by the anæmic condition of the patient and also by actual enumeration. According to Kelsch, a patient of vigorous constitution in the first four days of a quotidian [daily recurrent] intermittent fever, or a remittent of first invasion, may suffer a loss of 2,000,000 red blood corpuscles per cubic millimeter of blood, and in certain cases a loss of 1,000,000 has been verified at the end of twenty-four hours. In cases of intermittent fever having a duration of twenty to thirty days the number of red blood cells may be reduced from the normal, which is about 5,000,000 per cubic millimeter, to 1,000,000 or even less. In view of this destruction of the red blood cells and the demonstrated fact that a certain number, at least, are destroyed during the febrile paroxysms by a blood parasite, which invades the cells and grows at the expense of the continued hæmoglobin [the red substance in the blood], it may be thought that the etiological rôle of the parasite should be conceded. But scientific conservatism demands more than this, and the final proof has been afforded by the experiments of Gerhardt and of Marchiafava and Celli—since confirmed by many others. This proof consists in the experimental inoculation of healthy individuals with blood containing the parasite and the development of a typical attack of periodic fever as a result of such inoculation. Marchiafava and Bignami, in their elaborate article upon "Malaria," published in the *Twentieth Century Practice of Medicine*, say:

"The transmission of the disease occurs equally whether the blood is taken during the apyretic [aguish] period or during a febrile [feverish] paroxysm, whether it contains young parasites or those in process of development, or whether it contains sporulation [minute spore-like] forms. Only the crescent forms, when injected alone, do not transmit the infection, as has been demonstrated by Bastianelli, Bignami and Thayer, and as can be readily understood when we remember the biological significance of these forms.

"In order that the disease be reproduced in the inoculated subject it is not necessary to inject the malarial blood into a vein of the recipient, as has been done in most of the experiments; a subcutaneous injection is all-sufficient. Nor is it necessary to inject several cubic centimeters, as was done especially in the earlier experiments; a fraction of a cubic centimeter will suffice, and even less than one drop, as Bignami has shown."

After the inoculation of a healthy individual with blood containing the parasite a period varying from four to twenty-one days elapses before the occurrence of a febrile paroxysm. This is the so-called period of incubation, during which, no doubt, the parasite is undergoing multiplication in the blood of the inoculated individual. The duration of this period depends to some extent upon the quantity of blood used for the inoculation and its richness in parasites. It also depends upon the particular variety of the parasite present, for it has been ascertained that there are at least three distinct varieties of the malarial parasite —one which produces the quartan type of fever, in which there is a paroxysm every third day and in which, in experimental inoculations made, the period of incubation has varied from eleven to eighteen days; in the tertian type, or second day fever, the period of incubation noted has been from nine to twelve days; and in the æstivo-autumnal type the duration has usually not exceeded five days. The parasite associated with each of these types of fever may be recognized by an expert, and there is no longer any doubt that the difference in type is due to the fact that different varieties or "species" of the malarial parasite exist, each having a different period of development. Blood drawn during a febrile paroxysm shows the parasite in its different stages of intra-corpuscular development. The final result of this development is a segmenting body, having pigment granules at its center, which occupies the greater part of the interior of the red corpuscle. The number of segments into which this body divides differs in the different types of fever, and there are other points of difference by which the several varieties may be distinguished one from the other, but which it is not necessary to mention at the present time. The important point is that the result of the segmentation of the adult parasites contained in the red corpuscles is the formation of a large number of spore-like bodies, which are set free by the disintegration of the remains of the blood corpuscles and which constitute a new brood of reproductive elements, which in their turn invade healthy blood corpuscles and effect their destruction. This cycle of development without doubt accounts for the periodicity of the characteristic febrile paroxysms; and, as stated, the different varieties complete their cycle of development in different period of time, thus accounting for the recurrence of the paroxysms at intervals of forty-eight hours, in one type of fever, and of three days in another type. When a daily paroxysm occurs, this is believed to be due to the alternate development of two groups of parasites of the tertian variety, as it has not been possible to distinguish the parasite found in the blood of persons suffering from a quotidian form of intermittent fever from that of the tertian form. Very often, also, the daily paroxysm occurs on succeeding days at a different hour, while the paroxysm every alternate day at the same hour is a fact which sustains the view that we have to deal, in such cases, with two broods of the tertian parasite which mature on alternate days. In other cases there may be two distinct paroxysms on the same day, and none on the following day, indicating the presence of two broods of tertian parasites maturing at different hours every second day.

The hypothesis that malarial infection results from the bites of mosquitoes was advanced and ably supported by Dr. A. F. A. King, of Washington, D. C., in a paper read before the Philosophical Society on February 10, 1883, and published in the *Popular Science Monthly* in September of the same year. In 1894, Manson supported the same hypothesis in a paper published in the *British Medical Journal* (December 8), and the following year (1895) Ross made the important discovery that when blood containing the crescentic bodies was ingested by the mosquito, these crescents rapidly underwent changes similar to those heretofore described, resulting in the formation of motile [spontaneously moving] filaments, which become detached from the parent body and continue to exhibit active movements. In 1897, Ross ascertained, further, that when blood containing crescents was fed to a particular species of mosquito, living pigmented parasites could be found in the stomach walls of the insect. Continuing his researches with a parasite of the same class which is found in birds, and in which the mosquito also serves as an intermediate host, Ross found that this parasite enters the stomach wall of the insect, and, as a result of its development in that locality, forms reproductive bodies (sporozoites), which subsequently find their way to the venenosalivary [poisonous salivary] glands of the insect which is now capable of infecting other birds of the same species as that from which the blood was obtained in the first instance. Ross further showed that the mosquito which served as an intermediate host for this parasite could not transmit the malarial parasite of man or another similar parasite of birds (halteridium). These discoveries of Ross have been confirmed by Grassi, Koch and others, and it has been shown that the mosquitoes which serve as intermediate host for the malarial parasites of man belong to the genus *Anopheles*, and especially to the species known as *Anopheles claviger*.

The question whether mosquitoes infected with the malarial parasite invariably become infected as a result of the ingestion [taking in] of human blood containing this parasite has not been settled in a definite manner, but certain facts indicate that this is not the case. Thus there are localities noted for being extremely dangerous on account of the malarial fevers contracted by those who visit them, which on this very account are rarely visited by man. Yet there must be a great abundance of infected mosquitoes in these localities, and especially in low swampy regions in the tropics. If man and the mosquitoes are alone concerned in the propagation of this parasite, how shall we account for the abundance of infected mosquitoes in uninhabited marshes? It appears probable that some other vertebrate animal serves in place of man to maintain the life cycle of the parasite, or that it may be propagated through successive generations of mosquitoes.

It is well known that persons engaged in digging canals, railroad cuts, etc., in malarious regions are especially liable to be attacked with one or the other of the forms of malarial fever. This may be due to the fact that the digging operations result in the formation of little pools suitable for the development of the eggs of *Anopheles*, but another explanation has been offered. Ross and others have found in infected mosquitoes certain bodies, described by Ross as “black spores,” which resist decomposition and which may be resting spores capable of retaining their vitality for a long time. The suggestion is that these “black spores” or other incysted [enclosed in a small vessel] reproductive bodies may have been deposited in the soil by mosquitoes long since defunct, “and that in moving the soil these dormant parasites are set at liberty, and so, in air, in water or otherwise, gain access to the workmen engaged” (Manson). This hypothesis is not supported by recent observations, which indicate that infection in man occurs only as a result of inoculation through the bite of an infected mosquito. The question is whether malarial fevers can be contracted in marshy localities independently of the mosquito, which has been demonstrated to be an intermediate host of the malarial parasite? Is this parasite present in the air or water in such localities as well as in the bodies of infected mosquitoes? Its presence has never been demonstrated by the microscope; but this fact has little value in view of the great variety of micro-organisms present in marsh water or suspended in the air everywhere near the surface of the ground, and the difficulty of recognizing the elementary reproductive bodies by which the various species are maintained through successive generations. It would appear that a crucial experiment for the determination of this question would be to expose healthy individuals in a malarious region and to exclude the mosquito by some appropriate means. This experiment has been made during the past summer, and the result up to the present time has been reported by Manson in the London *Lancet* of September 29, 1900. Five healthy individuals have lived in a hut on the Roman Campagna since early in the month of July. They have been protected against mosquito bites by mosquito-netting screens in the doors and windows and by mosquito bars over the beds. They go about freely during the daytime, but remain in their protected hut from sunset to sunrise. At the time Manson made his report all these individuals remained in perfect health. It has long been known that labourers could come from the villages in the mountainous region near the Roman Campagna and work during the day, returning to their homes at night, without great danger of contracting the fever, while those who remained on the Campagna at night ran great risk of falling sick with fever, as a result of "exposure to the night air." What has already been said makes it appear extremely probable that the "night air," by itself, is no more dangerous than the day air, but that the real danger consists in the presence of infected mosquitoes of a species which seeks its food at night. As pointed out by King, in his paper already referred to, it has repeatedly been claimed by travelers in malarious regions that sleeping under a mosquito bar is an effectual method of prophylaxis [prevention] against intermittent fevers.

That malarial fevers may be transmitted by mosquitoes of the genus *Anopheles* was first demonstrated by the Italian physician Bignami, whose experiments were made in the Santo Spirito Hospital in Rome. The subjects of the experiment, with their full consent, were placed in a suitable room and exposed to the bites of mosquitoes brought from Maccarese, "a marshy place with an evil but deserved reputation for the intensity of its fevers." It has been objected to these experiments that they were made in Rome, at a season of the year when malarial fevers prevail to a greater or less extent in that city, but Marchiafava and Bignami say:

"It is well known to all physicians here that, although there are some centers of malaria in certain portions of the suburbs, the city proper is entirely free from malaria, as long experience has demonstrated, and at no season of the year does one acquire the disease in Rome."

In view of the objection made, a crucial experiment has recently been made in the city of London. The result is reported by Manson, as follows:

"Mosquitoes infected with the parasite of benign tertian malarial fever were sent from Rome to England, and were allowed to feed upon the blood of a perfectly healthy individual (Dr. Manson's son, who had never had malarial disease). Forty mosquitoes, in all, were allowed to bite him between August 29 and September 12. On September 14 he had a rise of temperature, with headache and slight chilliness, but no organisms were found in his blood. A febrile paroxysm occurred daily thereafter, but the parasites did not appear in the blood until September 17, when large numbers of typical tertian parasites were found. They soon disappeared under the influence of quinine."

We have still to consider the question of the transmission of malarial fevers by the ingestion of water from malarious localities. Numerous medical authors have recorded facts which they deemed convincing as showing that malarial fevers may be contracted in this way. I have long been of the opinion that while the observed facts may, for the most part, be authentic, the inference is based upon a mistake in diagnosis [determination]. That, in truth, the fevers which can justly be ascribed to the ingestion [taking into the body] of a contaminated water supply are not true malarial fevers—*i. e.*, they are not due to the presence of the malarial parasite in the blood. This view was sustained by me, in my work on "Malaria and Malarial Diseases," published in 1883. The fevers supposed to have been contracted in this way are, as a rule, continued or remittent in character, and they are known under a variety of names. Thus we have "Roman fever," "Naples fever," "remittent fever," "mountain fever," "typhomalarial fever," etc. The leading physicians and pathologists, in regions where these fevers prevail, are now convinced that they are not malarial fevers, but are simply more or less typical varieties of typhoid fever, a disease due to a specific bacillus [minute comma-shaped plant], and which is commonly contracted as a result of the ingestion of contaminated water or food. The error in diagnosis, upon which the inference has been based that malarial fevers may be contracted through drinking water, has been widespread in this country, in Europe and in the British possessions in India. It vitiated our medical statistics of the Civil War and of the recent war with Spain. In my work already referred to, I say:

"Probably one of the most common mistakes in diagnosis, made in all parts of the world where malarial and enteric [intestinal] fevers are endemic [characteristic of the locality], is that of calling an attack of fever, belonging to the last mentioned category, malarial remittent. This arises from the difficulties attending a differential diagnosis at the outset, and from the fact that having once made a diagnosis of malarial fever, the physician, even if convinced later that a mistake has been made, does not always feel willing to confess it. The case therefore appears in the mortality returns, if it prove fatal, or in the statistical reports of disease, if made by an army or navy surgeon, as at first diagnosed."

THE ART OF PROLONGING LIFE

Robson Roose, M.D.

[Dr. Robson Roose, an eminent physician of London, is the author of standard works on Gout on Nerve Prostration, on Waste and Repair in Modern Life. The *Fortnightly Review*, 1889, contained the admirable article which follows: it is reprinted with the kind permission of the author and the editor.]

The doctrine that a short life is a sign of divine favour has never been accepted by the majority of mankind. Philosophers have vied with each other in depicting the evils and miseries incidental to existence, and the truth of their descriptions has often been sorrowfully admitted, but they have failed to dislodge, or even seriously diminish, that desire for long life which has been deeply implanted within the hearts of men. The question whether life be worth living has been decided by a majority far too great to admit of any doubt upon the subject, and the voices of those who would fain reply in the negative are drowned amid the chorus of assent. Longevity, indeed, has come to be regarded as one of the grand prizes of human existence, and reason has again and again suggested the inquiry whether care or skill can increase the chances of acquiring it, and can make old age, when granted, as comfortable and happy as any other stage of our existence.

From very early times the art of prolonging life, and the subject of longevity, have engaged the attention of thinkers and essayists; and some may perhaps contend that these topics, admittedly full of interest, have been thoroughly exhausted. It is true that the art in question has long been recognized and practiced, but the science upon which it really depends is of quite modern origin. New facts connected with longevity have, moreover, been collected within the last few years, and some of these I propose to examine, and further to inquire whether they teach us any fresh means whereby life may be maintained and prolonged.

But, before entering upon the immediate subject, there are several preliminary questions which demand a brief examination, and the first that suggests itself is, What is the natural duration of human life? This oft-repeated question has received many different answers; and inquiry has been stimulated by skepticism as to their truth. The late Sir George Cornewall Lewis expressed the opinion that one hundred years must be regarded as a limit which very few, if indeed any, human beings succeed in reaching, and he supported this view by several cogent reasons. He pointed out that almost all the alleged instances of abnormal longevity occurred among the humbler classes, and that it was difficult, if not impossible, to obtain any exact information as to the date of birth, and to identify the individuals with any written statements that might be forthcoming. He laid particular stress upon the fact that similar instances were altogether absent among the higher classes, with regard to whom trustworthy documentary evidence was almost always obtainable. He thought that the higher the rank the more favourable would the conditions be for the attainment of a long life. In this latter supposition, however, Sir George Lewis was probably mistaken: the comforts and luxuries appertaining to wealth and high social rank are too often counterbalanced by cares and anxieties, and by modes of living inconsistent with the maintenance of health, and therefore with the prolongation of life. In the introduction to his work on “Human Longevity,” Easton says, “It is not the rich or great ... that become old, but such as use much exercise, are exposed to the fresh air, and whose food is plain and moderate—as farmers, gardeners, fishermen, labourers, soldiers, and such men as perhaps never employed their thoughts on the means used to promote longevity.”

The French naturalist, Buffon, believed that if accidental causes could be excluded, the normal duration of human life would be between ninety and one hundred years, and he suggested that it might be measured (in animal as well as in man) by the period of growth, to which it stood in a certain proportion. He imagined that every animal might live for six or seven times as many years as were requisite for the completion of its growth. But this calculation is not in harmony with facts, so far, at least, as man is concerned. His period of growth cannot be estimated at less than twenty years; and if we take the lower of the two multipliers, we get a number which, in the light of modern evidence, can not be accepted as attainable. If the period of growth be multiplied by five, the result will in all probability not be far from the truth.

If we seek historical evidence, and from it attempt to discover the extreme limit of human life, we are puzzled at the differences in the ages said to have been attained. The longevity of the antediluvian patriarchs when contrasted with our modern experience seems incredible. When we look at an individual, say ninety years of age, taking even the most favourable specimen, a prolongation of life to ten times that number of years would appear too absurd even to dream about. There is certainly no physiological reason why the ages assigned to the patriarchs should not have been attained, and it is useless to discuss the subject, for we know very little of the conditions under which they lived. It is interesting to notice that after the Flood there was a gradual decrease in the duration of life. Abraham is recorded to have died at one hundred and seventy-five; Joshua, some five hundred years later, "waxed old and stricken in age" shortly before his death at one hundred and ten years; and his predecessor, Moses, to whom one hundred and twenty years are assigned, is believed to have estimated the life of man at threescore years and ten—a measure nowadays pretty generally accepted.

There is no reason for believing that the extreme limit of human life in the time of the Greeks and Romans differed materially from that which agrees with modern experience. Stories of the attainment of such ages as one hundred and twenty years and upward may be placed in the same category as the reputed longevity of Henry Jenkins, Thomas Parr, Lady Desmond, and a host of others. With regard to later times, such as the middle ages, there are no precise data upon which any statements can be based, but there is every reason to believe that the *average* duration of life was decidedly less than it is at present. The extreme limit, indeed, three or four centuries ago, would appear to have been much lower than in the nineteenth century. At the request of Mr. Thoms, Sir J. Duffus Hardy investigated the subject of the longevity of man in the thirteenth, fourteenth, fifteenth, and sixteenth centuries, and his researches led him to believe that persons seldom reached the age of eighty. He never met with a trustworthy record of a person who exceeded that age.

To bring the investigation down to quite recent times, I can not do better than utilize the researches of Dr. Humphry, Professor of Surgery at Cambridge. In 1886 he obtained particulars relating to fifty-two individuals then living and said to be one hundred years old and upward. The oldest among them claimed to be one hundred and eight, the next one hundred and six, while the average amounted to a little more than one hundred and two years. Many interesting facts connected with the habits and mode of life of these individuals were obtained by Dr. Humphry, and will be referred to in subsequent paragraphs.

A short account of the experience of a few life-assurance companies will conclude this part of my subject. Mr. Thoms tells us that down to 1872 the records of the companies showed that one death among the assured had occurred at one hundred and three, one in the one hundredth, and three in the ninety-ninth year. The experience of the National Debt Office, according to the same authority, gave two cases in which the evidence could be regarded as perfect; one of these died in the one hundred and second year, and the other had just completed that number. In the tables published by the Institute of Actuaries, and giving the mortality experience down to 1863 of twenty life-assurance companies, the highest age at death is recorded as ninety-nine; and I am informed by the secretary of the Edinburgh Life Office that from 1863 onward that age had not been exceeded in his experience. In the valuation schedules, which show the highest ages of existing lives in various offices, the ages range from ninety-two to ninety-five. It is true that one office which has a large business among the industrial classes reports lives at one hundred and three, and in one instance at one hundred and seven; but it must be remembered that among those classes the ages are not nearly so well authenticated as among those who assure for substantial sums. There is, moreover, another source of error connected with the valuation schedules. When a given life is not considered to be equal to the average, a certain number of years is added to the age, and the premium is charged at the age which results from this addition. It follows, therefore, that in some cases the age given in the schedules are greater by some years than they really are.

Taking into consideration the facts thus rapidly passed under review, it must, I think, be admitted that the natural limit of human existence is that assigned to it in the book of Ecclesiasticus, “The number of a man's days at the most are an hundred years” (chapter xviii. 9). In a very small number of cases this limit is exceeded, but only by a very few years. Mr. Thoms's investigations conclusively show that trustworthy evidence of one hundred and ten years having been reached is altogether absent. Future generations will be able to verify or reject statements in all alleged cases of longevity. It must be remembered that previous to the year 1836 there was no registration of births, but only of baptisms, and that the registers were kept in the churches, and contained only the names of those therein baptized.

Whatever number of years may be taken as representing the natural term of human life, whether threescore and ten or a century be regarded as such, we are confronted by the fact that only one-fourth of our population attains the former age, and that only about fifteen in one hundred thousand become centenarians. It is beyond the scope of this article to discuss the causes of premature mortality, but the conditions favourable to longevity, and the causes to which length of days has been assigned, are closely connected with its subject.

A capability of attaining old age is very often handed down from one generation to another, and heredity is probably the most powerful factor in connection with longevity. A necessary condition of reaching advanced age is the possession of sound bodily organs, and such an endowment is eminently capable of transmission. Instances of longevity characterizing several generations are frequently brought to notice. A recent and most interesting example of transmitted longevity is that of the veteran guardian of the public health, Sir Edwin Chadwick, who was entertained at a public dinner a few weeks ago on the occasion of his reaching his ninetieth year. He informed his entertainers that his father died at the age of eighty-four, one of his grandfathers at ninety-five, and that two more remote ancestors were centenarians.

It is difficult to estimate the influence of other contingencies which affect longevity. With regard to sex, Hufeland's opinion was that women were more likely than men to become old, but that instances of extreme longevity were more frequent among men. This opinion is to some extent borne out by Dr. Humphry's statistics: of fifty-two centenarians, thirty-six were women. Marriage would appear to be conducive to longevity. A well-known French *savant*, Dr. Bertillon, states that a bachelor of twenty-five is not a better life than a married man of forty-five, and he attributes the difference in favour of married people to the fact that they take more care of themselves, and lead more regular lives than those who have no such tie. It must, however, be remembered that the mere fact of marrying indicates superior vitality and vigour, and the ranks of the unmarried are largely filled by the physically unfit.

In considering occupations as they are likely to effect longevity, those which obviously tend to shorten life need not be considered. With respect to the learned professions, it would appear that among the clergy the average of life is beyond that of any similar class. It is improbable that this average will be maintained for the future; the duties and anxieties imposed upon the clergy of the present generation place them in a very different position from that of their predecessors. Among lawyers there have been several eminent judges who attained a great age, and the rank and file of the profession are also characterized by a decided tendency to longevity. The medical profession supplies but few instances of extreme old age, and the average duration of life among its members is decidedly low, a fact which can be easily accounted for. Broken rest, hard work, anxieties, exposure to weather and to the risks of infection can not fail to exert an injurious influence upon health. No definite conclusions can be arrived at with regard to the average longevity of literary and scientific men, but it might be supposed that those among them who are not harassed by anxieties and enjoy fair health would probably reach old age. As a general rule, the duration of life is not shortened by literary pursuits. A man may worry himself to death over his books, or, when tired of them, may seek recreation in pursuits destructive to health; but application to literary work tends to produce cheerfulness, and to prolong rather than shorten the life even of an infirm man. In Prof. Humphry's “Report on Aged Persons,” containing an account of eight hundred and twenty-four individuals of both sexes, and between the ages of eighty and one hundred, it is stated that forty-eight per cent. were poor, forty-two per cent. were in comfortable circumstances, and only ten per cent. were described as being in affluent circumstances. Dr. Humphry points out that these ratios “must not be regarded as representing the relations of poverty and affluence to longevity, because, in the first place, the poor at all ages and in all districts bear a large proportion to the affluent; and, secondly, the returns are largely made from the lower and middle classes, and in many instances from the inmates of union work-houses, where a good number of aged people are found." It must also be noticed that the "past life-history" of these individuals showed that the greater proportion (fifty-five per cent.) "had lived in comfortable circumstances," and that only thirty-five per cent. had been poor.

Merely to enumerate the causes to which longevity has been attributed in attempting to account for individual cases would be a task of some magnitude; it will be sufficient to mention a few somewhat probable theories. Moderation in eating and drinking is often declared to be a cause of longevity, and the assertion is fully corroborated by Dr. Humphry's inquiries. Of his fifty-two centenarians, twelve were recorded as total abstainers from alcoholic drinks throughout life, or for long periods; twenty had taken very little alcohol; eight were reported as moderate in their use of it; and only three habitually indulged in it. It is quite true that a few persons who must be classified as drunkards live to be very old; but these are exceptions to the general rule, and such cases appear to be more frequent than they really are, because they are often brought to notice by those who find encouragement from such examples. The habit of temperance in food, good powers of digestion, and soundness of sleep are other main characteristics of most of those who attain advanced years, and may be regarded as causes of longevity. Not a few old persons are found on inquiry to take credit to themselves for their own condition, and to attribute it to some remarkable peculiarity in their habits or mode of life. It is said that Lord

Mansfield, who reached the age of eighty-nine, was wont to inquire into the habits of life of all aged witnesses who appeared before him, and that only in one habit, namely, that of early rising, was there any general concurrence. Health is doubtless often promoted by early rising, but the habit is not necessarily conducive to longevity. It is, as Sir H. Holland points out, more probable that the vigour of the individuals maintains the habit than that the latter alone maintains the vitality.

If we pass from probable to improbable causes of longevity we are confronted by many extravagant assumptions. Thus, to take only a few examples, the immoderate use of sugar has been regarded not only as a panacea, but as decidedly conducive to length of days. Dr. Slare, a physician of the last century, has recorded the case of a centenarian who used to mix sugar with all his food, and the doctor himself was so convinced of the "balsamic virtue" of this substance that he adopted the practice, and boasted of his health and strength in his old age. Another member of the same profession used to take daily doses of tannin (the substance employed to harden and preserve leather), under the impression that the tissues of the body would be thereby protected from decay. His life was protracted beyond the ordinary span, but it is questionable whether the tannin acted in the desired direction. Lord Combermere thought that his good health and advanced years were due, in part at least, to the fact that he always wore a tight belt round his waist. His lordship's appetite was doubtless thereby kept within bounds; we are further told that he was very moderate in the use of all fluids as drink. Cleanliness might be supposed to aid in prolonging life, yet a Mrs. Lewson, who died in the early part of this century, aged one hundred and six, must have been a singularly dirty person. We are told that instead of washing she smeared her face with lard, and asserted that "people who washed always caught cold." This lady, no doubt, was fully persuaded that she had discovered the universal medicine.

Many of the alchemists attributed the power of prolonging life to certain preparations of gold, probably under the idea that the permanence of the metal might be imparted to the human system. Descartes is said to have favoured such opinions; he told Sir Kenelm Digby that, although he would not venture to promise immortality, he was certain that his life might be lengthened to the period of that enjoyed by the patriarchs. His plan, however, seems to have been the very rational and simple one of checking all excesses and enjoining punctual and frugal meals.

Having thus endeavoured to show the extent to which human life may be prolonged, and having examined some of the causes or antecedents of longevity, the last subject for inquiry is the means by which it may be attained. Certain preliminary conditions are obviously requisite; in the first place there must be a sound constitution derived from healthy ancestors, and in the second there must be a freedom from organic disease of important organs. Given an individual who has reached the grand climacteric, or threescore and ten, and in whom these two conditions are fulfilled, the means best adapted to maintain and prolong his life constitute the question to be solved. It has been said that "he who would long to be an old man must begin early to be one," but very few persons designedly take measures in early life in order that they may live longer than their fellows.

The whole term of life may be divided into the three main periods of growth and development, of maturity, and of decline.

No hard and fast line can be drawn between these two latter phases of existence: the one should pass gradually into the other until the entire picture is changed. Diminished conservative power and the consequent triumph of disintegrating forces are the prominent features of the third period, which begins at different times in different individuals, its advent being mainly controlled by the general course of the preceding years. The "turning period," also known as the "climacteric" or "middle age," lies between forty-five and sixty; the period beyond may be considered as belonging to advanced life or old age. The majority of the changes characteristic of these last stages are easily recognizable. It is hardly necessary to mention the wrinkled skin, the furrowed face, the "crow's feet" beneath the eyes, the stooping gait, and the wasting of the frame. The senses, notably vision and hearing, become less acute; the power of digestion is lessened; the force of the heart is diminished; the lungs are less permeable; many of the air-cells lose their elasticity and merge into each other, so that there is less breathing surface as well as less power. Simultaneously with these changes the mind may present signs of enfeeblement; but in many instances its powers long remain in marked contrast with those of the body. One fact connected with advanced life is too often neglected. It should never be forgotten that while the "forces in use" at that period are easily exhausted, the "forces in reserve" are often so slight as to be unable to meet the smallest demand. In youth, the reserve powers are superabundant; in advanced life, they are reduced to a minimum, and in some instances are practically non-existent. The recognition of this difference is an all-important guide in laying down rules for conduct in old age.

In order to prolong life and at the same time to enjoy it, occupation of some kind is absolutely necessary; it is a great mistake to suppose that idleness is conducive to longevity. It is at all times better to wear out than to rust out, and the latter process is apt to be speedily accomplished. Every one must have met with individuals who, while fully occupied till sixty or even seventy years of age, remained hale and strong, but aged with marvelous rapidity after relinquishing work, a change in their mental condition becoming especially prominent. There is an obvious lesson to be learned from such instances, but certain qualifications are necessary in order to apply it properly. With regard to mental activity, there is abundant evidence that the more the intellectual faculties are exercised the greater the probability of their lasting. They often become stronger after the vital force has passed its culminating point; and this retention of mental power is the true compensation for the decline in bodily strength. Did space permit, many illustrations could be adduced to show that the power of the mind can be preserved almost unimpaired to the most advanced age. Even memory, the failure of which is sometimes regarded as a necessary concomitant of old age, is not infrequently preserved almost up to the end of life. All persons of middle age should take special pains to keep the faculties and energies of the mind in a vigorous condition; they should not simply drift on in a haphazard fashion, but should seek and find pleasure in the attainment of definite objects. Even if the mind has not been especially cultivated, or received any decided bent, there is at the present day no lack of subjects on which it can be agreeably and profitably exercised. Many sciences which, twenty or thirty years ago, were accessible only to the few, and wore at best a somewhat uninviting garb, have been rendered not merely intelligible but even attractive to the many; and in the domain of general literature the difficulty of making a choice among the host of allurements is the only ground for complaint. To increase the taste for these and kindred subjects is worth a considerable effort, if such be necessary; but the appetite will generally come with the eating. The possession of some reasonable hobby which can be cultivated indoors is a great advantage in old age, and there are many pursuits of this character besides those connected with literature and science. Talleyrand laid great stress on a knowledge of whist as indispensable to a happy old age, and doubtless to many old people that particular game affords not only recreation but a pleasant exercise to the mind. It is, however, an unworthy substitute for higher objects, and should be regarded only as an amusement and not as an occupation.

Whatever be the sphere of mental activity, no kind of strain must be put upon the mind by a person who has reached sixty-five or seventy years. The feeling that mental power is less than it once was not infrequently stimulates a man to increased exertions which may provoke structural changes in the brain, and will certainly accelerate the progress of any that may exist in that organ. When a man finds that a great effort is required to accomplish any mental task that was once easy, he should desist from the attempt, and regulate his work according to his power. With this limitation, it may be taken for granted that the mental faculties will be far better preserved by their exercise than by their disuse.

Somewhat different advice must be given with regard to bodily exercises in their reference to longevity. Exercise is essential to the preservation of health; inactivity is a potent cause of wasting and degeneration. The vigour and equality of the circulation, the functions of the skin, and the aeration of the blood, are all promoted by muscular activity, which thus keeps up a proper balance and relation between the important organs of the body. In youth, the vigour of the system is often so great that if one organ be sluggish another part will make amends for the deficiency by acting vicariously, and without any consequent damage to itself. In old age, the tasks can not be thus shifted from one organ to another; the work allotted to each sufficiently taxes its strength, and vicarious action can not be performed without mischief. Hence the importance of maintaining, as far as possible, the equable action of all the bodily organs, so that the share of the vital processes assigned to each shall be properly accomplished. For this reason exercise is an important part of the conduct of life in old age; but discretion is absolutely necessary. An old man should discover by experience how much exercise he can take without exhausting his powers, and should be careful never to exceed the limit. Old persons are apt to forget that their staying powers are much less than they once were, and that, while a walk of two or three miles may prove easy and pleasurable, the addition of a return journey of similar length will seriously overtax the strength. Above all things, sudden and rapid exertion should be scrupulously avoided by persons of advanced age. The machine which might go on working for years at a gentle pace often breaks down altogether when its movements are suddenly accelerated. These cautions may appear superfluous, but instances in which their disregard is followed by very serious consequences are by no means infrequent.

No fixed rule can be laid down as to the kind of exercise most suitable for advanced age. Much must depend upon individual circumstances and peculiarities; but walking in the open air should always be kept up and practiced daily, except in unfavourable weather. Walking is a natural form of exercise and subserves many important purposes: not a few old people owe the maintenance of their health and vigour to their daily "constitutional." Riding is an excellent form of exercise, but available only by a few; the habit, if acquired in early life, should be kept up as long as possible, subject to the caution already given as to violent exercise. Old persons of both sexes fond of gardening, and so situated that they may gratify their tastes, are much to be envied. Body and mind are alike exercised by what Lord Bacon justly termed "the purest of human pleasures." Dr. Parkes goes so far as to say that light garden or agricultural work is a very good exercise for men past seventy: "It calls into play the muscles of the abdomen and back, which in old men are often but little used, and the work is so varied that no muscle is kept long in action." A few remarks must be made, in conclusion, with regard to a new form of exercise sometimes indulged in even by elderly men. I allude to so-called "tricycling." Exhilarating and pleasant as it may be to glide over the ground with comparatively little effort, the exercise is fraught with danger for men who have passed the grand climacteric. The temptation to make a spurt must be often irresistible; hills must be encountered, some perhaps so smooth and gradual as to require no special exertion, none, at least, that is noticed in the triumph of surmounting them. Now, if the heart and lungs be perfectly sound, such exercises may be practiced for some time with *apparent* impunity; but if (as is very likely to be the case) these organs be not quite structurally perfect, even the slightest changes will, under such excitement, rapidly progress and lead to very serious results. Exercise unsuited to the state of the system will assuredly not tend to the prolongation of life.

With regard to food, we find from Dr. Humphry's report that ninety per cent. of the aged persons were either “moderate” or “small” eaters, and such moderation is quite in accord with the teachings of physiology. In old age the changes in the bodily tissues gradually become less and less active, and less food is required to make up for the daily waste. The appetite and the power of digestion are correspondingly diminished, and although for the attainment of a great age a considerable amount of digestive power is absolutely necessary, its perfection, when exercised upon proper articles of diet, is the most important characteristic. Indulgence in the pleasures of the table is one of the common errors of advanced life, and is not infrequent in persons who, up to that period, were moderate or even small eaters. Luxuries in the way of food are apt to be regarded as rewards that have been fully earned by a life of labour, and may, therefore, be lawfully enjoyed. Hence arise many of the evils and troubles of old age, and notably indigestion and gouty symptoms in various forms, besides mental discomfort. No hard and fast rules can be laid down, but strict moderation should be the guiding maxim. The diet suitable for most aged persons is that which contains much nutritive material in a small bulk, and its quantity should be in proportion to the appetite and power of digestion. Animal food, well cooked, should be taken sparingly and not more often than twice a day, except under special circumstances. Dr. Parkes advocates rice as a partial substitute for meat when the latter is found to disagree with old persons. “Its starch-grains are very digestible, and it supplies nitrogen in moderate amount, well fitted to the worn and slowly repaired tissues of the aged.” Its bulk, however, is sometimes a disadvantage; in small quantities it is a valuable addition to milk and to stewed fruits.

The amount of food taken should be divided between three or four meals at fairly regular intervals. A sense of fullness or oppression after eating ought not to be disregarded. It indicates that the food taken has been either too abundant or of improper quality. For many elderly people the most suitable time for the principal meal is between 1 and 2 P. M. As the day advances the digestive powers become less, and even a moderately substantial meal taken in the evening may seriously overtask them. Undigested food is a potent cause of disturbed sleep, an evil often very troublesome to old people, and one which ought to be carefully guarded against.

It is an easier task to lay down rules with regard to the use of alcoholic liquors by elderly people. The Collective Investigation Committee of the British Medical Association has lately issued a "Report on the Connection of Disease with Habits of Intemperance," and two at least of the conclusions arrived at are worth quoting: "Habitual indulgence in alcoholic liquors, beyond the most moderate amount, has a distinct tendency to shorten life, the average shortening being roughly proportional to the degree of indulgence. Total abstinence and habitual temperance augment considerably the chance of death from old age or natural decay, without special pathological lesion." Subject, however, to a few exceptions, it is not advisable that a man sixty-five or seventy years of age, who has taken alcohol in moderation all his life, should suddenly become an abstainer. Old age can not readily accommodate itself to changes of any kind, and to many old people a little good wine with their meals is a source of great comfort. To quote again from Ecclesiasticus, "Wine is as good as life to a man, if it be drunk moderately, for it was made to make men glad." Elderly persons, particularly at the close of the day, often find that their nervous energy is exhausted, and require a little stimulant to induce them to take a necessary supply of proper nourishment, and perhaps to aid the digestive powers to convert their food to a useful purpose. In the debility of old age, and especially when sleeplessness is accompanied by slow and imperfect digestion, a small quantity of a generous and potent wine, containing much ether, often does good service. Even a little beer improves digestion in some old people; others find that spirits, largely diluted, fulfill the same purpose. Individual peculiarities must be allowed for; the only general rule is that which prescribes strict moderation.

It is not to be inferred from the hints given in the preceding paragraphs that the preservation of health should be the predominant thought in the minds of elderly persons who desire that their lives should be prolonged. To be always guarding against disease, and to live in a state of constant fear and watchfulness, would make existence miserable and hasten the progress of decay. Selfish and undue solicitude with regard to health not only fails to attain its object, but is apt to induce that diseased condition of mind known as hypochondriasis, ["the blues,"] the victims of which are always a burden and a nuisance, if not to themselves, at least to all connected with them. Addison, in the *Spectator*, after describing the valetudinarian who constantly weighed himself and his food, and yet became sick and languishing, aptly remarks, "A continual anxiety for life vitiates all the relishes of it, and casts a gloom over the whole face of nature, as it is impossible that we should take delight in anything that we are every moment afraid of losing."

Sleep is closely connected with the question of diet; "good sleeping" was a noticeable feature in the large majority of Dr. Humphry's cases. Sound, refreshing sleep is of the utmost consequence to the health of the body, and no substitute can be found for it as a restorer of vital energy. Sleeplessness is, however, often a source of great trouble to elderly people, and one which is not easily relieved. Narcotic remedies are generally mischievous; their first effects may be pleasant, but the habit of depending upon them rapidly grows until they become indispensable. When this stage has been reached, the sufferer is in a far worse plight than before. In all cases the endeavour should be made to discover whether the sleeplessness be due to any removable cause—such as indigestion, cold, want of exercise, and the like. In regard to sleeping in the daytime, there is something to be said both for and against that practice. A nap of "forty winks" in the afternoon enables many aged people to get through the rest of the day in comfort, whereas they feel tired and weak when deprived of this refreshment. If they rest well at night there can be no objection to the afternoon nap; but if sleeplessness be complained of, the latter should be discontinued for a time. Most old people find that a reclining posture, with the feet and legs raised, is better than the horizontal position for the afternoon nap. Digestion proceeds with more ease than when the body is recumbent.

Warmth is very important for the aged; exposure to chills should be scrupulously avoided. Bronchitis is the malady most to be feared, and its attacks are very easily provoked. Many old people suffer from more or less cough during the winter months, and this symptom may recur year after year, and be almost unheeded. At last, perhaps a few minutes' exposure to a cold wind increases the irritation in the lungs, the cough becomes worse, and the difficulty of breathing increases until suffocation terminates in death. To obviate such risk the skin should be carefully protected by warm flannel clothes, the outdoor thermometer should be noticed and winter garments should always be at hand. In cold weather the lungs should be protected by breathing through the nose as much as possible, and by wearing a light woolen or silken muffler over the mouth. The temperature of the sitting and bed-rooms is another point which requires attention. Some old people pride themselves on never requiring a fire in their bed-rooms. It is, however, a risky practice to exchange a temperature of 65° or 70° for one fifteen or twenty degrees lower. As a general rule, for persons sixty-five years of age and upward, the temperature of the bed-room should not be below 60°, and when there are any symptoms of bronchitis it should be raised from five to ten degrees higher.

Careful cleansing of the skin is the last point which needs to be mentioned in an article like the present. Attention to cleanliness is decidedly conducive to longevity, and we may congratulate ourselves on the general improvement in our habits in this respect. Frequent washing with warm water is very advantageous for old people, in whom the skin is only too apt to become hard and dry; and the benefit will be increased if the ablutions be succeeded by friction with coarse flannel or linen gloves, or with a flesh-brush. Every part of the skin should be thus washed and rubbed daily. The friction removes worn-out particles of the skin, and the exercise promotes warmth and excites perspiration. Too much attention can hardly be paid to the state of the skin; the comfort of the aged is greatly dependent upon the proper discharge of its functions.

Such, then, are the principal measures by which life may be prolonged and health maintained down to the closing scene. It remains to be seen whether, as a result of progress of knowledge and civilization, life will ever be protracted beyond the limit assigned to it in a preceding paragraph. There is no doubt that the *average duration* of human life is capable of very great extension, and that the same causes which serve to prolong life materially contribute toward the happiness of mankind. The experience of the last few decades abundantly testifies to the marked improvement which has taken place in the public health. Statistics show that at the end of the septennial period, 1881-'87, 400,000 persons were alive in England and Wales whose death would have taken place had the mortality been in the same proportion as during the previous decade. It may be reasonably expected that as time goes on there will be an increase in the proportion of centenarians to the population as a whole.

The question whether long life is, after all, desirable does not admit of any general answer. Much depends upon the previous history of the individual, and his bodily and mental condition. The last stages of a well spent life may be the happiest, the shuffling-off of the mortal coil, though calmly expected, need not be wished for. The picture afforded by cheerful and mellow old age is a lesson to younger generations. Elderly people may, if they choose, become centers of improving and refining influence. On the other hand, old age can not be regarded as a blessing when it is accompanied by profound decrepitude and disorder of mind and body. Senile dementia, or second childishness, is, of all conditions, perhaps the most miserable, though not so painful to the sufferer as to those who surround him. Its advent may be accelerated by ignorance and neglect, and almost assuredly retarded or prevented by such simple measures as have been suggested. No one who has had opportunities of studying old people can shut his eyes to the fact that many of the incapabilities of age may be prevented by attention to a few simple rules, the observance of which will not only prolong life and make it happier and more comfortable, but will reduce to a minimum the period of decrepitude. Old age may be an incurable disease, admitting of but one termination, but the manner of that end, and the condition which precedes it, are, though not altogether, certainly to a very great extent, within our own power.

NATURAL LIFE AND DEATH: AND RULES FOR HEALTH

Benjamin Ward Richardson, M.D.

[Dr. Richardson was an English physician of uncommon originality and ability. He founded and for some years edited the *Journal of Public Health*, chiefly directed toward the prevention of disease. In 1875 he created widespread interest by sketching an imaginary "Model City of Health" to be called Hygeia. He wrote several important books; from "The Diseases of Modern Life," published by D. Appleton & Co., New York, are taken the extracts which follow.]

By the strict law of Nature a man should die as unconscious of his death as of his birth.

Subjected at birth to what would be, in the after-conscious state, an ordeal to which the most cruel of deaths were not possibly more severe, he sleeps through the process, and only upon the subsequent awakening feels the impressions, painful or pleasant, of the world into which he is delivered. In this instance the perfect law is fulfilled because the carrying of it out is retained by Nature herself: human free-will and the caprice that springs from it have no influence.

By the hand of Nature death were equally a painless portion. The cycle of life completed, the living being sleeps into death when Nature has her way.

This purely painless process, this descent by oblivious trance into oblivion, this natural physical death, is the true Euthanasia; and it is the duty of those we call physicians to secure for man such good health as shall bear him in activity and happiness onward in his course to this goal. For Euthanasia, though it be open to every one born of every race, is not to be had by any save through obedience to those laws which it is the mission of the physician to learn, to teach, and to enforce. Euthanasia is the sequel of health, the happy death engrafted on the perfect life.

When the physician has taught the world how this benign process of Nature may be secured, and the world has accepted the lesson, death itself will be practically banished; it will be divested equally of fear, of sorrow, of suffering. It will come as a sleep.

If you ask me what proof there is of the possibility of such a consummation, I point to our knowledge of the natural phenomena of one form of dissolution revealed to us even now in perfect, though exceptional, illustration. We have all seen Nature, in rare instances, vindicating herself despite the social opposition to her, and showing how tenderly, how soothingly, how like a mother with her foot on the cradle, she would, if she were permitted, rock us all gently out of the world. How, if the free-will with which she has armed us were brought into accord with her designs, she would give us the riches, the beauties, the wonders of the Universe for our portion so long as we could receive and enjoy them; and at last would gently withdraw us from them, sense by sense, with such imperception that the pain of the withdrawal would be unfelt and indeed unknown. Ten times in my own observation I remember witnessing, with attentive mind, these phenomena of natural Euthanasia. Without pain, anger, or sorrow, the intellectual faculties of the fated man lose their brightness. Ambition ceases, or sinks into desire for repose. Idea of time, of space, of duty, lingeringly pass away. To sleep and not to dream is the pressing and, step by step, still pressing need; until at length it whiles away nearly all the hours. The awakenings are shorter and shorter; painless, careless, happy awakenings to the hum of a busy world, to the merry sounds of children at play, to the sound of voices offering aid; to the effort of talking on simple topics and recalling events that have dwelt longest on the memory; and then again the overpowering sleep. Thus on and on, until at length, the intellectual nature lost, the instinctive and merely animal functions, now no longer required to sustain the higher faculties, in their turn succumb and fall into inertia.

This is death by Nature, and when mankind has learned the truth, when the time shall come—as come it will—that "there shall be no more an infant of days, nor an old man who hath not filled his days," this act of death, now, as a rule, so dreaded because so premature, shall, arriving only at its appointed hour, suggest no terror, inflict no agony.

The sharpness of death removed from those who die, the poignancy of grief would be almost equally removed from those who survive, were natural Euthanasia the prevailing fact. Our sensibilities are governed by the observance of natural law and the breach of it. It is only when nature is vehemently interrupted that we either wonder or weep. Thus the old Greeks, fathers of true mirth, who looked upon prolonged grief as an offence, and attached the word madness to melancholy,—even they were so far imbued with sorrow when the child or the youth died, that they bore the lifeless body to the pyre in the break of the morning, lest the sun should behold so sad a sight as the young dead; while we, who court rather than seek to dismiss melancholy, who find poetry and piety in melancholic reverie, and who indulge too often in what, after a time, becomes the luxury of woe, experience a gradation of suffering as we witness the work of death. For the loss of the child and the youth we mourn in the perfect purity of sorrow; for the loss of the man in his activity we feel grief mingled with selfish regret that so much that was useful has ceased to be. In the loss of the aged, in their days of second childishness and mere oblivion, we sympathize for something that has passed away, and for a moment recall events saddening to the memory; but how soon this consoling thought succeeds and conquers—that the race of the life that has gone was run, and that for its own sake the dispensation of its removal was most merciful and most wise.

To the rule of natural death there are a few exceptions. Unswerving in her great purpose for the universal good, Nature has imposed on the world of life her storms, earthquakes, lightnings, and all those sublime manifestations of her supreme power which, in the infant days of the universe, cowed the boldest and implanted in the human heart fears and superstitions which in hereditary progression have passed down even to the present generations. Thus she has exposed us all to accidents of premature death, but, with infinite wisdom, and as if to tell us that her design is to provide for these inevitable calamities, she has given a preponderance of number at birth to those of her children who by reason of masculine strength and courage shall have most frequently to face her elements of destruction. Further, she has provided that death by her, by accidental collision with herself shall, from its very quickness, be freed of pain. For pain is a product of time. To experience pain the impression producing it must be transmitted from the injured part of the living body to the conscious centre, must be received at the conscious centre, and must be recognized by the mind as a reception; the last act in truth being the conscious act. In the great majority of deaths from natural accidents there is not sufficient time for the accomplishment of these progressive steps by which the consciousness is reached. The unconsciousness of existence is the first and last fact inflicted upon the stricken organism: the destruction is so mighty, that the sense of it is not revealed.

The duration of time intended by Nature to extend between the birth of the individual and his natural Euthanasia is undetermined, except in an approximate degree. From the first, the steady, stealthy attraction of the earth is ever telling upon the living body. Some force liberated from the body during life enables it, by self-controlled resistance, to overcome its own weight. For a given part of its cycle the force produced is so efficient, that the body grows as well as moves by its agency against weight; but this special stage is limited to an extreme, say, of thirty years. There is then another period, limited probably also to thirty years, during which the living structure in its full development maintains its resistance to its weight. Finally, there comes a time when this resistance begins to fail, so that the earth, which never for a moment loses her grasp, commences and continues to prevail, and after a struggle, extended from twenty to thirty years, conquers, bringing the exhausted organism which has daily approached nearer and nearer to her dead self, into her dead bosom.

Why the excess of power developed during growth or ascent of life should be limited as to time; why the power that maintains the developed body on the level plain should be limited as to time; why the power should decline so that the earth should be allowed to prevail and bring descent of life, are problems as yet unsolved. We call the force that resists the earth Vital. We say it resists death; we speak of it as stronger in the young than in the old; but we know nothing more of it really, from a physical point of view, than that while it exists it opposes terrestrial weight sufficiently to enable the body to move with freedom on the surface of the earth.

These facts we accept as ultimate facts. To say that the animal is at birth endowed with some reserve force, something over and above what it obtains from food and air, would seem a reasonable conclusion; but we have no proofs that it is true, save that the young resist better than the old. We must therefore rest content with our knowledge in its simple form, gathering from it the lesson that death, a part of the scheme of life, is ordained upon a natural term of life, is beneficially planned, "is rounded with a sleep."

[Then follow chapters on disease, leading up to rules for health.]

RULES FOR HEALTH

I

The first step towards the reduction of disease is, beginning at the beginning, to provide for the health of the unborn. The error, commonly entertained, that marriageable men and women have nothing to consider except wealth, station, or social relationships, demands correction. The offspring of marriage, the most precious of all fortunes, deserves surely as much forethought as is bestowed on the offspring of the lower animals. If the intermarriage of disease were considered in the same light as the intermarriage of poverty, the hereditary transmission of disease, the basis of so much misery in the world, would be at an end in three or at most four generations.

II

Greater care than is at present manifested ought to be taken with women who are about to become mothers. Wealthy women in this condition are often too much indulged in rest and are too richly fed. Poor women in this condition are commonly underfed and made to toil too severely. The poor, as we have seen, fare the best, but both, practically, are badly cared for. Nothing that is extraordinary is required for the woman during this condition named. She needs only to live by natural rule. She should retire to rest early; take nine hours' sleep; perform walking or similar exercise, to an extent short of actual fatigue, during the day; partake moderately of food, and of animal food not oftener than twice in the day; avoid all alcoholic drinks; take tea in limited quantities; forego all scenes that excite the passions; hear no violence of languages, be clothed in warm, light, loose garments; and shun, with scrupulous care, every exposure to infectious disease.

III

In meeting the uncontrollable causes of disease the special influence of season deserves particular regard. It should always be remembered that, other things being equal, during winter the body loses, during summer gains in weight. Further, it should be remembered that these changes are abrupt: that usually the loss commences, sharply, in September and lasts until April, and that the gain commences in April and lasts until September. In September, though the weather even be warm, it is right, therefore, to add to the clothing and to commence a little excess of food. In summer it is right not only to reduce the clothing, but to eat less food than in winter.

IV

The best means of preventing the spread of the communicable diseases is perfect and instant isolation of the affected, and removal and thorough purifying of all clothing and bedding with which the affected have come in contact. It is a vulgar error to suppose that every child must necessarily suffer from the contagious maladies, and that the risk of exposure to infection is, therefore, of little moment. The chance of infection lessens with advance of life, and that person is strongest who has never passed through a contagious malady. Against small-pox vaccination is the grand safeguard, but even vaccination ought never to prevent the isolation of those who suffer from small-pox.

V

The mortality from the uncontrollable causes of disease amongst persons of advanced life is best prevented by providing against sudden vicissitudes of heat and cold. The primary care is to guard against sudden change of vascular tension from exposure to heat when the blood-vessels are weakened by cold. Such exposure is the cause of nearly all the congestions which occur during winter, and which carry off the enfeebled. The sound practice is to maintain the body, at all hours and seasons, but especially during the hours of sleep, at an equable temperature. The temperature of 60° Fah. may be considered a safe standard.

VI

The true danger of every form of mental exercise is the addition of worry. Laborious mental exercise is healthy unless it be made anxious by necessary or unnecessary difficulties. Regular mental labour is best carried on by introducing into it some variety. New work gives time for repair better than attempt at complete rest, since the active mind finds it impossible to evade its particular work unless its activity be diverted into some new channel. During the new work a fresh portion of the brain comes into play and the overwrought seat of mental faculty is secured repose and recovery. Excessive competition in mental labour is ruinous at all ages of life.

VII

The idea that excessive physical exercise is a sound means of promoting health is erroneous. Man is not constructed to be a running or a leaping animal like a deer or a cat, and to raise the physical above the mental culture were to return to the shortness and misery of savage life. Physical training, while it should be moderately encouraged, should be refined and made secondary to mental training. Every rash and violent feat of competitive prowess should be discountenanced.

VIII

The combination of mental and physical fatigue, as it is practised in many pursuits at this time, are exceedingly dangerous. Long journeys each day, to and from the sphere of profession or business, are hurtful. The idea that mental labour may be advantageously supplemented by violent muscular exercise, such as is implied in long and fatiguing walks or laborious exercise on horseback, is an error. Moderate and regular exercise, at the same time, favours mental work. The practical point is to regulate the physical labour that it shall not induce fatigue.

IX

One of the surest means for keeping the body and mind in perfect health consists in learning to hold the passions in subservience to the reasoning faculties. This rule applies to every passion. Man, distinguished from all other animals by the peculiarity of his reason, is placed above his passions to be the director of his will, can protect himself from every mere animal degradation resulting from passionate excitement. The education of the man should be directed, not to suppress such passions as are ennobling, but to bring under governance, and especially to subdue, those most destructive passions, anger, hate, and fear.

X

To escape the evils arising from the use of alcohol there is only one perfect course, namely, to abstain from alcohol altogether. No fear need be entertained of any physical or mental harm from such abstinence. Every good may be expected from it. True, a certain very qualified temperance, a temperance that keeps the adult to a strict allowance of one ounce and a half of alcohol in each twenty-four hours, may possibly be compatible with a healthy life; but such indulgence is unnecessary and encourages the dangerous desire to further indulgence. A man or woman who abstains is healthy and safe. A man or woman who indulges at all is unsafe. A man or woman who relies on alcohol for support is lost.

XI

Smoking tobacco, and the use of tobacco in every form, is a habit better not acquired, and when acquired is better abandoned. The young should especially avoid the habit. It gives a doubtful pleasure for a certain penalty. Less destructive than alcohol, it induces various nervous changes, some of which pass into organic modifications of function. So long as the practice of smoking is continued the smoker is temporarily out of health. When the odour of tobacco hangs long on the breath and other secretions of the smoker, that smoker is in danger. Excessive smoking has proved directly fatal.

XII

Indulgence in narcotics, opium, chloral, chlorodyne, ether, absinthe, and all others of the class, is an entire departure from natural law. Except under the direction of skilled opinion and for the cure of disease, the use of these agents is subversive of the animal functions, and is a certain means of embittering and shortening life. It is doubtful whether the freedom of the subject ought to be permitted to extend to the uncontrolled self-indulgence in these poisons. The indulgence indicates an unsound reason which requires to be governed by sound reason, temperately enforced.

XIII

The food on which the man who would be healthy should live should be selected so as to ensure variety without excess. Animal food should not be taken oftener than twice daily. The amount of animal and vegetable food combined should not exceed thirty ounces in the twenty-four hours, and for the majority of persons an average of twenty-four ounces of mixed solid food, a third only of which should be animal, is sufficient. All animal foods should be eaten while they are fresh and after they are well cooked. The habit of eating underdone flesh is an almost certain cause of parasitic disease. The amount of fluid taken, in any form, should not exceed an average of twenty-four ounces daily. Water is the only natural beverage.

XIV

To escape the injuries arising from impure air it is necessary to attend to the following rules: To avoid the admission into closed apartments of air charged with any substance that offends the sense of smell. To avoid surcharging the air with vapour of water. To keep the temperature in every room as nearly as possible at the safe standard of 60° Fah. To take ample means of allowing air to escape from the room by every available outward draught, by the chimney flue especially. To admit air freely at all times, and, when a room is not in use and the external air is not charged with moisture, to allow the entrance of air from without through every window and door.

XV

Occupations of every kind, however varied they may be, require to be alternated, fairly, with rest and recreation. It is the worst mistake to suppose that most and best work can be done when these aids are omitted. Strictly, no occupation that calls forth special mental and physical work should fill more than one-third of the daily life. The minds of men of all classes ought now to be devoted to the promotion of a systematic method by which the productive labour of every life should be carried on within the limited term of eight hours in the twenty-four. The body of man is not constructed to run its completed circle under a heavier burden of labour.

XVI

Enforced idleness, by those who have acquired wealth, is always an error so long as the health is good. Men of business should never actually retire while they retain fair bodily and physical faculty. It is one of the gravest of errors to attempt to enforce idleness on others from the mistaken sentiment of wishing to place them beyond the necessity for work. This is against nature. The earth, which is itself ever in motion, demands ever the motion of cultivation from its inhabitants that it may be a garden properly arranged from age to age. Those, therefore, who have idleness thrust upon them, by their progenitors, should throw it off as if some necessity for work were equally theirs. By this plan they will live longest to enjoy the greatest happiness.

XVII

The natural duration of sleep is eight hours out of the twenty-four, and those who can secure this lead the soundest lives. It is best taken from ten o'clock till six, and it is most readily obtained by cultivating it as an automatic procedure. All stimulants, all excitements, all excessive fatigues, all exhaustions pervert sleep even if they do not prevent it. The room in which sleep is taken should be the best ventilated and the most equably warmed room in the house. The air of the room should be maintained at the natural standard of 60° Fah., and the body of the sleeper should always be kept completely warm. The bed should be soft and yielding. A regular tendency to sleep at other hours than the natural is a sure sign of error of habit or of nervous derangement.

XVIII

Dress, to be perfectly compatible with healthy life, should fit loosely, should be light, warm, and porous, should be adapted to the season as to colour, should be throughout every part of the clothing, upper as well as under, frequently changed, and should be, at all times, scrupulously clean. The wearing of clothes until they are threadbare, is an invariable error in all that respects the health, to say nothing of the comfort of the wearer. All bands or corsets which in any way restrict the course of the blood in any part of the body are directly injurious. Dresses dyed with irritating dyestuffs ought to be carefully avoided.

XIX

Connected with cleanliness of clothing, as a means of health, is personal cleanliness. Perfected action of the skin, so essential to the perfect life, can only be obtained by thorough ablution of the whole body. The ablution ought, strictly, to be performed once in every twenty-four hours. It is best to train the body to the use of cold water through all seasons, so that the requirement for water of raised temperature may not become a necessity. The simplest and best bath is the ordinary sponge-bath. Plungings, splashings, showers, and the like are mere pastimes. The occasional use of the hot air or Turkish bath is an important adjunct to the means of maintaining health.

CARE OF THE EYES

Buel P. Colton

[“Physiology, Experimental and Descriptive,” by Buel P. Colton, Professor of Natural Science in the Illinois State Normal University, is a capital text-book which may be read as gainfully at home as in school or at college. Throughout its chapters are excellent directions for the care of health and strength. It is published by D. C. Heath & Co. Boston. 1898. The following extract was revised by Dr. Casey A. Wood, an eminent oculist of Chicago]

In reading we wish light from the printed page. Hence we should avoid light entering the eye from any other source at this time. While reading, then, do not face a window, another light, a mirror, or white wall, if it can be avoided. In a room, white walls are likely to injure the eyes. Choose a dark colour for a covering for a reading table. Sewing against the background of a white apron has worked serious mischief. Direct sunshine near the book or on the table is likely to do harm.

Preferably have the light from behind and above. Many authors say “from the left” or “over the left shoulder.” In writing with the usual slant of the letters this may be desirable. But vertical writing is now strongly advocated, as it enables one to sit erect, and have the light from above and equally to the two eyes. Having stronger light for one eye than for the other is bad. Sitting under and a little forward of a hanging lamp will give the light equally to the two eyes and send no light direct into the face. In reading by daylight avoid cross-lights as much as possible. The incandescent electric light has an advantage in being readily lighted without matches, and in giving out little heat, thus making it valuable for house-lighting; but owing to its irregular illumination (due to the shadow cast by the wire or filament), it is not well suited for study or other near work. For this purpose an Argand gas or kerosene burner is much to be preferred, since it throws a soft, uniform, and agreeable light upon the work.

Reading out-of-doors is likely to injure the eyes, especially when lying down. To try to read while lying in a hammock is bad in many ways. Too much light directly enters the eye, and often too little falls upon the printed page.

Do not hold the book or work nearer the eyes than is necessary. So far as possible avoid continuous reading in large or heavy books by artificial light. Such books being hard to hold, the elbows gradually settle down against the sides of the body, and thus, without thinking about it, the book is held too close to the eyes, or at a bad angle, or the body assumes a bad position.

Frequently rest the eyes by looking up and away from the work, especially at some distant object. One may rest the eyes while thinking over each page or paragraph, and thus really gain time instead of losing it.

Have light that is strong enough. Remember that the law of the intensity of light as affected by distance is that at twice the distance from the source of light the light is only one-fourth as strong. Reading just before sunset is risky. One is tempted to go on, not noticing the gradual diminution of light.

Save the easiest reading for the evening. Newspapers, as a rule, have neither good print nor good paper. If the eyes have much work to do, finish this kind of reading by daylight if possible, and by artificial light read books, which usually have better type and better paper.

In all ways endeavour to favour the eyes by doing the most difficult reading by daylight, and saving the better print and the books that are easier to hold for work by artificial light. Writing is usually much more trying to the eyes than reading. By carefully planning his work the student may economize eyesight, and it is desirable that persons blessed with good eyes should be careful, as well as those who have a natural weakness in the eyes; for it often results that those inheriting weak organs, by taking proper care, may outlast and do more and better work than those naturally stronger, but who through carelessness injure organs by improper use or wrong use.

Reading before breakfast by artificial light is usually bad.

Many eyes are ruined during convalescence. At this time the whole system is often weak, including the eyes. Still, there is a strong temptation to read, perhaps to while away the time, perhaps to make up for lost time in school work. This is a time when a friend may show his friendship by reading aloud to the convalescent.

If one finds himself rubbing his eyes, it is a clear sign that they are irritated. It may be time to stop reading. At any rate, one should find the cause, and not proceed with the work until the irritation ceases. If any foreign object gets into the eye, as a cinder, it is better not to rub the eye, but to draw the lid away from the eyeball and wink repeatedly; the increased flow of tears may dissolve and wash the matter out. If you must rub, rub the other eye. If it be a sharp-cornered cinder, rubbing may merely serve to fix it more firmly in the cornea or the mucous membrane of the inner surface of the eyelid. If it does not soon come out, the lid may be rolled over a pencil, taking hold of the lashes or the edge of the lid. The point of a blunt lead pencil is a convenient and safe instrument with which to remove the particle. Sometimes being out in the wind (especially if unused to it), together with bright sunlight, may irritate the eyes. If after such exposure one finds lamplight irritating, he will do well to go to bed early, or to remain in a dark room.

Be careful to keep the eyes clean. Do not rub the eyes with the fingers. Aside from considerations of etiquette, there is danger of introducing foreign matter that may be harmful. It is very desirable that each person have his individual face towel. By not observing this rule, certain contagious diseases of the eye often spread rapidly.

If there is any continuous trouble with the eyes, consult a reliable oculist. Many persons injure the eyes by not wearing suitable glasses. On the other hand, do not buy glasses of peddlers or of any but reliable specialists. One may ruin the eyes by wearing glasses when they are not needed. Sight is priceless.

THE PROGRESS OF MEDICINE IN THE NINETEENTH CENTURY

JOHN SHAW BILLINGS, M.D.

[Dr. Billings is a surgeon and administrator of the first rank. He is now a director of the New York Public Library. Among his many published works are "Principles of Ventilation and Heating," issued by the *Engineering Record*, New York. The essay which follows appeared in the *Evening Post*, New York. January 12, 1901, copyrighted. It is reprinted in a volume entitled "The Nineteenth Century: a Review of Progress During the Past One Hundred Years," published by G. P. Putnam's Sons, New York, 1901, copyrighted. It is presented here by the kind permission of Dr. Billings, the publisher of the *Evening Post*, and G. P. Putnam's Sons.]

The word "medicine," as used in the title of this paper, includes all branches of the art of prevention and treatment of disease and injuries; all discoveries of methods of diminishing physical pain and of prolonging life, and also that part of modern science which is concerned with accurate knowledge of the structure and functions, normal and abnormal, of the human body, and of the causes of diseases. In other words, it includes not only therapeutics, medical and surgical, but also physiology, pathology, and hygiene.

In all these branches of medicine greater progress has been made during the last century than had been made during the previous two thousand years. This progress has been largely due to improvements in methods of investigation and diagnosis, resulting from increase of knowledge in chemistry and physics; to better microscopes and new instruments of precision; to experimental work in laboratories and to the application of scientific method and system in the observation and recording of cases of disease and of the results of different modes of treatment. The introduction of statistical methods in the study of cases of disease and of causes of death; the discovery of general anæsthetics; the adoption of antiseptic [excluding microbes] and aseptic [uninfective] methods in surgery, and the development of modern bacteriology—each marks a point in the history of medicine in the nineteenth century.

The scientific demonstration that some diseases are due to the growth and development of certain specific micro-organisms in the human body dates from about twenty years ago, although the theory of such causal relation is much older. Since 1880 it has been proved that anthrax, Asiatic cholera, cerebro-spinal meningitis, diphtheria, one form of dysentery, erysipelas, glanders, gonorrhœa, influenza, certain epidemics of meat-poisoning, pyæmia and suppuration in general, pneumonia, tetanus, relapsing fever, tuberculosis, bubonic plague, and typhoid fever are due to minute vegetable organisms known as bacteria; that malarial fevers, Texas cattle fever, and certain forms of dysentery are due to forms of microscopic animal organisms known as microzoa; and for most of these diseases the mode of development and means of introduction of the micro-organism into the body are fairly well understood. To the information thus obtained we owe the triumphs of antiseptic and aseptic surgery, a great increase of precision in diagnosis, the use of specific antitoxins [antidotes to organic infection] as remedies and as preventives, and some of the best practical work in public hygiene.

The evidence as to the increased powers of medicine to give relief from suffering and to prolong life is most clear and direct in the records of modern surgery—particularly in some of its special branches. In a large proportion of certain cases in which the surgeon now operates with a fair chance of success, such as calculus in the kidney or gall-bladder, shot-wounds of the abdomen, and tumours of various kinds, there was no hope in the year 1800, and the unhappy sufferer could only expect a certain, though often a lingering and painful, death. In cases of cancer of the face, tongue, breast, or uterus, the persistent pain, extreme disfigurement, and offensive odors which attended them made death a boon to be prayed for, if not deliberately sought, while now such cases, if brought in time to the surgeon, can often be entirely relieved. The knowledge of this fact has become general with the public, and patients no longer defer an operation as long as possible, as was their custom in days of old. Instead of having to look forward to the torture of incisions, manipulations, and stitching, with but small hope of surviving the exhausting suppuration and blood-poisoning which were such common results, the patient now knows that he will inhale a little sweet vapour, and sleep unconscious of the strokes of the surgeon's knife or the pricks of his needle. He may dream wondrous dreams, but he will soon awake to find himself in his bed staring at the trained nurse standing by his side, and wondering vaguely why the operation has not begun. He does not have to look forward to weeks and even months of daily dressings. The surgeon will glance at his temperature record and at the outside of his bandages, but will probably not touch them for a week; and when he does remove them nothing will be seen but a narrow red line without a trace of suppuration. These improved methods not only preserve the mother for her children, and the bread-winner for the family, but they greatly contribute to the public good by shortening the period of enforced idleness and unproductivity after operations.

Some of the greatest triumphs of modern surgery are obtained in cases of disease or injury of the abdominal organs. The removal of ovarian and uterine tumours is now so common and successful that it is not easy to realize that a hundred years ago there was practically no help or hope for such cases. In former days, the lists of deaths contained many cases reported as inflammation or obstruction of the bowels, or as peritonitis. It is now well understood that most of these cases are due to disease of a little worm-like appendix connected with the large intestine on the right side of the lower part of the abdomen, inflammation of which, known as appendicitis, causes excruciating pain, and often produces internal abscesses and death. An operation for the removal of such a diseased appendix is now common, and in most cases successful. The operation for the removal of calculus, or stone, from the urinary bladder dates from over twenty-five hundred years ago, and no one knows who first performed it. Within the last century it has been largely superseded by an operation which crushes the stone to powder within the bladder, and removes this powder without the use of the knife. The removal of calculi from the kidney or from the gall bladder, and the removal of a diseased kidney, are new operations, made possible by improved means of diagnosis, anæsthesia, and antisepsis [determining disease, causing insensibility, and excluding microbes]. Wounds of the intestines were formerly thought to be almost necessarily fatal, and nothing was done for them except to stupify the patient with opium. Now in such cases the abdomen is opened, the lacerations of the bowel are closed, the effused blood and other matters are removed, and in many cases life has thus been preserved.

By increase of knowledge of the anatomy of the brain, and of the distribution of nerves connected with it, it has become possible in a certain number of cases to determine what part of the brain is suffering from irritation or pressure, and to operate for the removal of the tumour or other substance causing the trouble, with considerable hope of giving permanent relief. A branch of surgery which has developed into an important specialty during the last century is that known as plastic and orthopædic surgery [ameliorating deformities]. The replacing of a lost nose by engrafting other tissue in its place is a very old triumph of surgical art, but operations of this kind have been greatly extended and perfected within the last hundred years, and much can now be done to mitigate the deformity and weakness due to club feet, bandy legs, contracted joints, etc., which formerly were considered to be beyond remedy.

Many of the diseases peculiar to women have been deprived of much of their terrors within a hundred years. In 1800, for every thousand children born, from ten to twenty mothers died. Puerperal fever occurred in epidemics, following certain physicians and nurses, but nothing was known as to its causes or nature. To-day puerperal fever is almost unknown in the hospitals or in the practice of a skilled physician. The death-rate of mothers is less than five per thousand births, and the mechanical obstructions which a century ago would almost certainly have brought about the death of both mother and child, are now so dealt with that more than half of both mothers and children are saved.

The study of the diseases of the eye has greatly developed another specialty during the century, viz., ophthalmology. The investigations of Helmholtz in physiological optics, with his invention of the ophthalmoscope in 1852, effected a revolution in this branch of medical science and art, and have added greatly to human comfort and happiness. A hundred years ago, when the physician saw the eyelids of a new-born babe redden, and swell, and yellow matter ooze from between them, he knew that in a few days or weeks the child would be partially or wholly blind, but he knew nothing of the simple means by which the skilled physician can now prevent such a calamity. It is unfortunately true that this knowledge is not even now sufficiently widely diffused, and that our blind asylums must, for some time to come, continue to receive those that have been deprived of sight during the first months of their life through the ignorance or neglect of those who should have properly cared for them.

While it is certain that the death-rates in the last century were greater than those of the present day, it is not possible to make precise comparisons. The record of deaths in the city of New York begins with 1804, and was necessarily very imperfect until the law of 1851, which required the registration of all deaths; but it shows a death-rate of 30.2 per 1,000 in 1805, which means that the true death-rate must have been between 35 and 40. At present, for a series of five years, it would be about 20, having been below 19 in 1899, so that the death-rate has been diminished by at least one-third. How much of this is due to improved sanitary conditions it is impossible to say. A comparison of the list of causes of death in 1805 with the list of causes for 1900 shows great differences, but much of this is due to changes in name and to more accurate diagnosis.

“Malignant sore throat” and “croup” were well known to anxious parents in 1800, but "diphtheria" caused no anxiety. "Inflammation of the bowels" was common and fatal, but "appendicitis" had not been heard of. "Nervous fever," "continued fever," and "low fever" were on the lists, but not typhoid, which was not clearly distinguished as a special form of disease until 1837, when Dr. Gerhard, an American physician, pointed out the differences between it and typhus, which also prevailed at the commencement of the century.

One hundred years ago the great topic of discussion in our cities on the North Atlantic coast was the means of preventing yellow fever, which had been epidemic in New York and Philadelphia for two years. Physicians were disputing as to whether the disease was contagious and imported, and, therefore, perhaps, preventable by quarantine and disinfection, or was due to some occult condition of the atmosphere (which was the view taken by Noah Webster in his "History of Epidemic and Pestilential Diseases," a work which appeared about the middle of the year 1800, although it is dated 1789). The discussions remind one of the remark that a certain patented form of electric light was surrounded by a cloud of non-luminous verbosity. For example, the Committee of the Medical Society of the State of New York reported that yellow fever may be produced in any country by pestilential effluvia; and Webster concluded that typhus and nervous fevers were due to a "conversion of the perspirable fluids of the body into septic [poisonous] matter"—all of which means that they knew nothing about it. Even now we do not know the cause of yellow fever, or the precise mode of its spread; but we are sufficiently certain that it is due to a specific micro-organism to be confident that its spread can be checked by isolation and disinfection properly applied—and Memphis and New Orleans are witnesses to the truth of this.

In the year 1800, the majority of persons over twenty years old were more or less pitted by small-pox, being the survivors of a much greater number who had suffered from this disease. Dr. Miller in New York had just received from England a thread which had been steeped in the newly discovered vaccine matter, and was about to begin vaccination in this city. To-day there are many physicians who have never seen a case of small-pox, and a face pitted with the marks of this disease is rarely seen.

During the century there have appeared in civilized countries two strange and unfamiliar forms of epidemic disease, namely, Asiatic cholera and the plague, the first coming from the valley of the Ganges, the second from the valley of the Euphrates, and each having a long history. A really new disease was the outbreak in Paris in 1892 of a specific contagious disease transmitted from sick parrots, and known as psittacosis. This little epidemic affected forty-nine persons, and caused sixteen deaths. Typhus fever has almost disappeared, while some diseases have increased in relative frequency, in part, at least, because of medical progress. The children who would have died of small-pox in the eighteenth century now live to be affected with diphtheria or scarlet fever, and the increase in the number of deaths reported as due to cancer is partly due to the fact that a greater proportion of people live to the age most subject to this disease.

A large part of modern progress in medicine is due to improved methods of diagnosis, and to the use of instruments of precision for recording the results of examinations. The use of the clinical thermometer has effected a revolution in medical practice. Our knowledge of diseases of the heart and lungs has been greatly expanded during the century by auscultation [trained listening to sounds] and percussion, and especially by the use of the stethoscope. The test-tube and the microscope warn us of kidney troubles which formerly would not have been suspected, and the mysterious Röntgen rays are called in to aid the surgeon in locating foreign bodies and in determining the precise nature of certain injuries of the bones. Bacteriological examination has become a necessary part of the examination in cases of suspected diphtheria, tuberculosis, or typhoid, and a minute drop of blood under the microscope may furnish data which will enable the skilled physician to predict the result in certain cases of anæmia [bloodlessness], or to make a positive diagnosis as between malaria and other obscure forms of periodic fever.

The means at the command of the physician for the relief of pain now include, not only the general anæsthetics,—chloroform, ether, and nitrous oxide,—but also the hypodermic use of the concentrated alkaloids of opium, belladonna, and other narcotics, and the local use of cocaine; and restful sleep for the weary brain may be obtained by sulphonal, chloral, etc. Some agonizing forms of neuralgic pain are now promptly relieved by the section or excision of a portion of the affected nerve; or it may be forcibly stretched into a condition of innocuous desuetude. Relief to the sufferings of thousands of neurotic women, and of their families and friends, has been produced by the systematic scientific application of the rest cure of Dr. Weir Mitchell.

A hundred years ago the medical advertisement which was most prominent in New York and Philadelphia newspapers was one of a remedy for worms. Many symptoms of nervous and digestive troubles in children were in those days wrongly attributed to worms. Nevertheless, there is good reason to believe that parasitic diseases derived from animals were in those days much more prevalent in this country than they are to-day. Our knowledge of the mode of origin and development of the tapeworm, the *trichina spiralis*, the liver fluke, and the itch insect has been gained during the nineteenth century. Much the same may be said with regard to the peculiar worm known as *anchylostum*, the cause of Egyptian chlorosis, and of the St. Gothard tunnel disease, although prescriptions for this parasite are found in the Papyrus Ebers, written before the time of Pharaoh.

The limits of this article permit of but a brief reference to the progress in preventive medicine during the century. The studies made in England of the results of the cholera epidemic of 1849, and the experience gained in the English army during the Crimean war, led to some of the most important advances in sanitary science, more especially to the demonstration of the importance of pure water supplies, and of proper drainage and sewerage. During our Revolutionary War, and the Napoleonic wars, the losses to the armies from disease greatly exceeded those from wounds; and hospital fever—in other words, typhus—was dreaded by a general almost more than the opposing forces. During the wars of the last twenty-five years, typhus and hospital gangrene have been unknown, but some extensive outbreaks of typhoid fever have occurred, showing that our knowledge of the causes and mode of transmission of this disease has not been practically applied to the extent to which it should have been; this remark applies also to some of the most fatal diseases in civil life. In the United States diphtheria and typhoid fever each causes from twenty to thirty thousand deaths a year, while more than one hundred thousand deaths are annually due to consumption. Yet for each of these diseases we know the specific germ, the channels through which it is usually conveyed, and the means by which this conveyance can be to a great extent prevented. The ravages of these diseases are, therefore, largely due to the fact that the great mass of the people are still ignorant of these subjects. Antitoxin is not yet used for either prevention or treatment in diphtheria to anything like the extent which our knowledge of its powers demands.

Our better knowledge of the causes of certain infectious and contagious diseases, and of the mode of their spread, has been of great importance to the world from a purely commercial point of view, since it has led to the doing away with many unnecessary obstructions to traffic and travel which were connected with the old systems of quarantine, while the security which has been gained from the modern method of cleansing and disinfection is decidedly greater than that secured by the old methods. A striking illustration of the effect of these improvements is seen in the manner in which the news of the recent outbreak of plague in Glasgow was received in England and throughout Europe. One hundred years ago the city would have been almost deserted, and terror would have reigned in all England. To-day it is well understood that the disease spreads by a bacillus which is not conveyed through the air. No one fears a repetition of the ghastly scenes of the Black Death in the fourteenth century. In like manner, and for the same reasons, Asiatic cholera has lost most of its terrors.

The benefits to the public of modern progress in medicine have been greatly enlarged by the establishment of many small hospitals, and by the steady increase in the employment of specially trained nurses in private practice, even in rural districts. The results of a case of typhoid or of pneumonia often depend as much upon the nurse as upon the doctor; and affection cannot take the place of skill in either. For the great mass of the people, cases of severe illness or injury, or those requiring major surgical operations, can be treated more successfully in well-appointed hospitals than in private houses, and as this is becoming generally understood the old feeling against entering a hospital for treatment is rapidly disappearing. Improvement in hospital construction and management has kept pace with progress in medical knowledge; and in future such institutions seem destined to play an increasingly important part in municipal and village life.

All progress in civilization is attended with injury to some individuals. Trained nurses have deprived some unskilled labour of employment; hospitals have injured the business of some physicians; pure-water supplies, good sewers, food inspection, vaccination,—in short, all effective measures in public hygiene,—interfere with the trade side of medical practice; but upon the whole the public at large benefits by all these things. In one sense they seem opposed to the general law of evolution, in that they prolong the life of the unfit; but in a broader sense they work in accordance with this law by increasing the power of the strong to protect and care for the weak.

All told, the most important feature in the progress of medicine during the century has been the discovery of new methods of scientific investigation, more especially in the fields of bacteriology and pathology. These methods have been as yet only partially applied, and great results are to be hoped from their extension in the near future. They will not lead to the discovery of an elixir of life, and the increasing feebleness of old age will continue to be the certain result of living a long time, for the tissues and organs of each man have a definitely limited term of duration peculiar to himself; but many of the disorders which make life a burden in advancing years can now be palliated, or so dealt with as to secure comparative comfort to the patient, so that "if by reason of strength" life can be prolonged beyond threescore years and ten it no longer necessarily involves labour and sorrow.

[The end of *Little Masterpieces of Science: Health and Healing* edited by George Iles]