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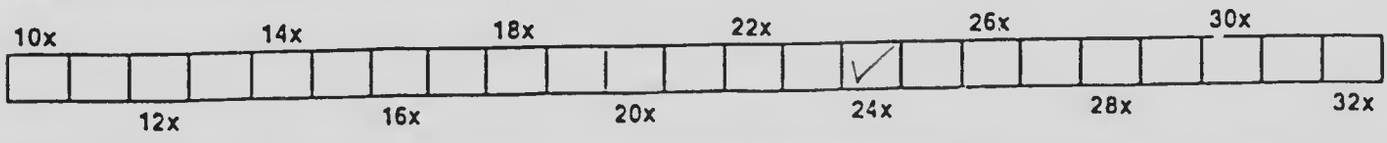

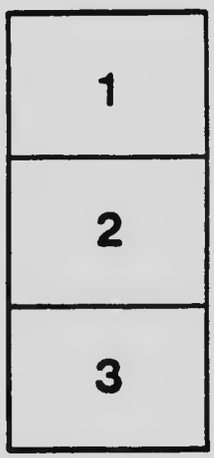

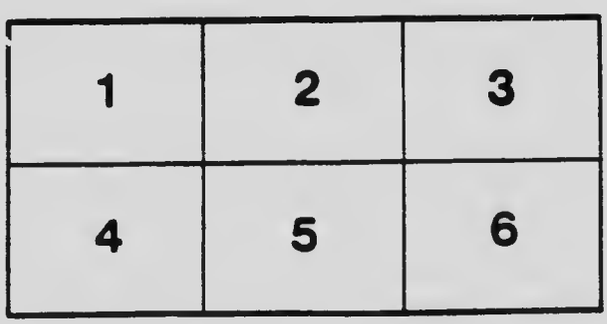

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THE SCIENTIFIC SPIRIT IN MEDICINE.

BY

A. B. MACALLUM, PH.D., SC.D., LL.D., F.R.S.,

Professor of Physiology, University of Toronto.

REPRINTED FROM THE MONTREAL MEDICAL JOURNAL, JANUARY, 1908.

THE SCIENTIFIC SPIRIT IN MEDICINE.

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A. B. MACALLUM, Ph.D., Sc.D., LL.D., F.R.S.,
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In accepting the invitation which you have extended to me to deliver the inaugural address I have been influenced by three considerations.

First of all, the compliment which such an invitation implies calls for the courtesy of acceptance. When one institution representing dignity and tradition of the best kind asks a member of another to occupy the rostrum for the inaugural occasion it is but fitting that he invited should respond in the spirit of the invitation.

Then there is the special nature of the occasion. Between all universities there should be a comity, a fe[illegible]ch those amenities should help to lighten the toil and weariness [illegible]ntellectual highroad. Between Toronto and McGill there has [illegible]een hitherto that freemasonry of spirit that I should like to see prevail. There has been aloofness where there should be comradeship. This does not mean that they should not be rivals. In all things of the mind there ought to be a noble rivalry, a struggle of emulation to excel, that no comradeship ought ever to extinguish or even make appear unnatural. A competition that aims at intellectual excellence should always exist between the two universities and it would be a sorry day for the higher life in this young nation if either went on its way careless of the ideals and intellectual ambitions of the other. The comradeship should make also for generous appraisement of each other's efforts. There may, perhaps, be grounds for criticism of each other's achievements and methods, but there is at the same time no greater influence for making that criticism effective than a generous appreciation of the good things each has done. To this end the representative men from the two universities should mingle freely with one another.

In the third place, there is the desire to express how deeply the members of the University of Toronto felt for the University of McGill in her misfortunes of April last. We have been afflicted enough in this way in the past to appreciate what such losses mean. To have the results of the labours of two generations destroyed in the few hours of a night is a trial for even the most stoic fortitude, and you had

Address delivered at the opening of the 76th Session of the Medical Faculty of McGill University.

without measure the sympathy of my colleagues at Toronto. This is as it should be, for, as between man and man, so between the two universities in their trials:

> There are two things that stand like stone:
> Kindness in another's trouble, Courage in one's own.

To not a few for a time the double disaster brought anxiety. If it had seriously affected the position of McGill the result would have been felt in Toronto, not for this year only, but for generations. No university lives to itself alone, and if it is worthy of the name it ought to be a stimulus to every other. How difficult it is to effect progress of the most enlightened kind when one has only to consider one's own colleagues, and their reluctance to advance is only too patent to those who know the internal history of every university. The forces that make for things as they are would be invincible were it not that the call from within to march forward is reinforced by the challenge from without. In this way the progressive section in one university aids the progressive section in another, but the result is fully felt only if misfortune has not checked the course of either.

Happily, the disaster which has befallen McGill, though of a magnitude sufficient to discourage profoundly, has not daunted her or her Medical Faculty. In this you find an illustration of the old saying, that it is not buildings that constitute a university, but men. The Medical Faculty of McGill University is the eldest institution teaching medicine in this country, and because of its history of unselfish endeavour and sacrifice it has developed a spirit of tradition and association that will impel its members of to-day to hand down to their successors of the next generation the institution not only unimpaired, but also with its traditions enriched and with ideals that will stimulate the noblest endeavours. The outlook, therefore, for McGill is one in which the trials of the present are to be merely incidents, not dire strokes of Fate. I entertain the most earnest wishes for the prosperity of McGill, but a prosperity in which the most progressive ideas will be most potent factors. For ideas are to march in Canada in the next twenty years, and even to-day McGill and Toronto cannot afford to stand still, since standing still involves a helpless and hopeless fall in the rear. In words similar to those of the Red Queen to Alice: "In this country you have to run as fast as you can in order to remain where you are."

It is in accord with progress that this university should determine to exact henceforth five years in the course of study leading to the degree in medicine, and I congratulate the Medical Faculty on the step

taken. That four years are not sufficient to permit the student to meet all the demands of a modern curriculum is the conclusion of those who have given careful attention to the matter. A quarter of a century ago four years were considered to suffice amply for this purpose, but since then the medical sciences have made extraordinary advances into hitherto unexplored fields and, in consequence, the amount of knowledge which the student is expected to have when he graduates is far in excess of what was required of the student of twenty years ago. To lengthen the period of study to five years was, in my opinion, a wise act, and I believe that, though the Medical Faculty of McGill University may be called upon to make considerable sacrifices because of this change, it will bring not a loss, but a great gain in the end.

The result will, from the outset, be to the advantage of the student. The extension of five years in medical study will enable him to acquire a fuller, ampler knowledge not only of medicine and surgery but as well of the sciences on which they are founded, and he will thus be better fitted to cope with the problems he will meet in his professional career than a training of four years only would enable him to do.

There is, however, one qualification which no length of training merely as such will give him, and he can only attain it by deliberately setting himself to acquire it. He may become an encyclopedia of medical and surgical lore, and he may be successful as things go in the exercise of his calling without that qualification, but if he is to achieve the highest success of which he is capable that qualification is absolutely indispensable to him. That qualification is the Scientific Spirit.

Because of its importance and because also its value to the student in training is not sufficiently understood, I have chosen that qualification as the central topic of my address to you to-day.

There are few things in which there is such a tendency to be inaccurate as in the use of words. The term Science is one of those loosely or wrongly employed. *Scientia*, the Latin word from which it originates, means knowledge in the ordinary and simple sense. To-day, in popular language, science is an oracular personality. Science tells us this, Science has done that, we hear again and again. This is all quite wrong, for it tends to make a cult of a word and the word itself then becomes a fetish. Science is simply organized knowledge, nothing more or less, knowledge not of isolated facts, but of facts put into such relation to one another that all of them and the phenomena involved are explained. In order to relate the facts in a particular subject it is necessary to discover some principle which will run through all of them and unite them. The fall of an apple from the tree, the movement of a pendulum, the shooting meteor, the tides of the ocean, the course

of the earth round the sun, the swing of the sun around some gigantic, far-distant mass, are isolated facts which n- at once be related on the application of the principle of gravitation, which is, according to Helmholtz, the greatest logical advancement of the human mind. Here we have the organized knowledge of gravitation and we see how important a part the principle plays in organizing or relating the knowledge. Similarly, on other subjects we find the facts put into relation to one another by one or more guiding principles ascertained through the use of the reasoning powers of the mind. Consequently, the principles, or generalizations, which enable us to organize knowledge, are all important in Science. The facts must be certain, but without the principles that relate them they are facts simply and a knowledge of them does not constitute Science. Science then is the knowledge of facts organized through the application of principles or generalizations that relate them all.

You will recognize that when we use Science in this sense it has lost for some the power to bemuse, to enchant, to hypnotize, but this is not a disadvantage, for the more sharply do we define our ideas and our conceptions the more serviceable to us do they become.

Having now crystallized what we mean by Science, we may next discuss what is comprehended by the term Scientific Spirit. The man on the street would, perhaps, at once think that it is the mental make-up that concerns itself with matters, or facts, some of which may eventually be of practical application but ordinarily are of no interest to the average individual. In other words, it is a peculiar type of mind that is supposed to be involved. That it is not only the man of the street who thus regards the Scientific Spirit may be made quite evident when one examines the point of view of the lawyer, the clergyman, the merchant, the manufacturer, the man of leisure, and, astounding to note, the majority of the medical profession. To them all, the Scientific Spirit is a thing apart.

Now, it may be admitted that there are apparently many facts in our organized body of knowledge called Science which cannot be utilized in industry or commerce, and mankind could get along without knowing or concerning itself with them. Take a case in illustration and one that thrusts itself on the attention of man month after month, and year after year, from birth to death. The seasons answer this point, for, while they mean so much in the joy of life and the appreciation of this beautiful world, they occur with an almost monotonous regularity. Their phenomena, further, are everywhere manifest, and one would think it difficult or impossible for any individual capable of reasoning to escape the desire to know how they are caused, yet it is doubtful if

more than one out of every ten of those who are supposed to be educated can adequately explain their causation, and it is doubtful if more than one out of every hundred average individuals comprehend how they occur. Some of those who are questioned on the subject may, probably, answer that in winter the sun goes south and in summer returns north, and that explanation contents them; while others not only cannot explain, but even manifest no concern at their inability to do so, and have no desire to know. They have passed through childhood, youth and adolescence to full maturity, yet they have never found it was from the practical point of view of value to know, and they have never felt the inward impulse to know. The causation of the seasons to such is a scientific fact alone, and as it is of no direct service to them or to commerce or industry so far as they are aware, they are indifferent regarding it.

Quite in contrast with this apathy or indifference is the attitude of the individual endowed with the Scientific Spirit. He has within him the compelling desire to know the causes of things, a desire that is not one whit satisfied with a half explanation or one that superficially appears correct. To this end facts are necessary, but the desire to collect facts, simply in itself alone, is no evidence of the presence of the Scientific Spirit, any more than is the desire to collect postage stamps, curios, and beetles, or to make a record of four hundred appendicectomies or ovariotomies. With the Scientific Spirit causation is everything and facts are of importance only when they help to ascertain causation.

The scientific mind wants to know why and how things happen, the average mind does not, except when there is a pecuniary, industrial or commercial advantage involved in knowing. Convince the average man that there is a material advantage to be gained from knowing the how and why of some phenomenon and he will be eager to obtain all possible information about it. If, for example, it could be shown that sun spots dominated the American wheat crop, every speculator in wheat would have his telescope and bit of smoked glass and he might be so keenly interested that he would eventually know more about the solar atmosphere than about the air he breathes. But even when he is stimulated to know by the hope of some practical advantage to be gained, he is not content to proceed as the man endowed with the Scientific Spirit does, but takes short cuts to conclusions and he too often satisfies himself with snap judgments.

We see then that it is the attitude of mind that constitutes the Scientific Spirit, an attitude of mind that desires not only information, but definite and accurate information. The Scientific Spirit approaches every problem in the questioning mood and, unless where human happi-

ness or suffering is involved, is not greatly concerned as to whether the solution is or is not of practical utility. When it has marshalled the facts of a question it may propose an explanation as a theory which will comprehend the why and how of them all, and which will serve until more facts are obtained, and then if the theory does not stand the test of a rigorous examination it will be discarded for another that will.

To that extent the Scientific Spirit is of the theorist order. To a certain type of mind, a type all too common, it is a stigma to be labelled theorist. Theory to such is something to be shunned and, being practical, is the summum of wisdom. There is no doubt that to indulge in speculations and accept explanations that have no regard for ascertained facts, or that are based on no facts at all, is an offence to reason and every effort should be directed to putting a curb on a loose imagination. The extravagant theorist, however, at once declares himself when he divulges his views and so he provides for his own effacement. The practical man, on the other hand, is quite as much an obstacle to real progress as is the extravagant theorist, for he accepts, consciously or unconsciously, the popular explanations or theories, and these are in the majority of cases either inadequate or absolutely wrong. I recall in this connexion several cases in which physicians and surgeons of the self-styled practical order were required to account to the relatives of patients for unfortunate results that occurred under their care, and the explanations given were astonishingly crude. What physician, "practical" or otherwise, can escape the necessity of giving day after day explanations, largely of the nature of theory, to his patients? If he were to refuse, or to say that he does not know, he would soon lose their confidence and, consequently, if he is not in the position to give a rational explanation he is forced to accept the popular one or to formulate one of his own *ad hoc*, and both may be equally superficial and crude. All this justifies the remark which the eminent chemist, Professor Ostwald, once made to me: "The practical man is the worst of all theorists, for he has a bad theory."

The fact that theory is so much in disrepute is in part the result from the past, when facts were fewer and knowledge scantier than now, and, in consequence, the inquiring mind, rather than accept negation or be indifferent, had to resort to explanations, some of them fantastic elaborations, others shrewd guesses, of the phenomena within its ken. That these were intended only as makeshifts was only to have been expected and it is but natural that many of them should now be discarded. Those who are critics of the scientific method point exultingly to the list of these exploded theories and they are sometimes quite vociferous in denouncing what they are pleased to call Pseudo-Science.

I recall with amusement once hearing a celebrated teacher of Greek dwell lovingly on the myths of Plato and immediately thereafter vigorously condemn the foolish theories of the men of science.

What the world would have been to-day without those theories one can but dimly fancy, but possibly we would still be in the Dark Ages. In reality, every theory that aroused opposition or dissent was a factor in stimulating mankind to think, and to think as clearly as it was at the time capable of doing. It has often happened that the individual with a passion to theorize has broken a popular idol and the intellectual life of mankind has gained thereby. Galileo theorized and the belief that the earth is the centre of the universe is extinct. Galvani, Volta and Faraday advanced their theories, and, as a result, we have the sciences of electricity and magnetism, through the aid of which we may some day arrive at a determination of the ultimate constitution of matter. Darwin's views as to the origin of species are not now accepted in toto by biologists, but is his fundamental position challeged to-day even by the man of the street? Can it be questioned that Darwin's theory, although rejected in part, has altered the intellectual outlook of mankind?

On the other hand, we have always with us the individual who is ever ready to extol men of science when they discover something that may be utilized by the inventor, the manufacturer or the engineer but who gives no heed to the long and often painful processes by which the result has been reached. Indeed, the result is too often thought due to a happy stroke of luck. It is this absence of correct information and clear conception as to what Science is, and how it is established, that is responsible in very large part for the loose thought and gullibility that are so prevalent. What to the public as a whole constitute the marvellous results of Science makes a large number of people ready to believe anything fantastical or extraordinary, and, in consequence, there is abroad a superstition of an exceedingly difficult character to combat. I am not referring to such crude matters as spiritualism, astrology, palmistry and clairvoyance, but to the cult of mysticism, that modern hotbed of superstition, and to the obsession that leads many to revel in nebulous conceptions, or to intoxicate themselves with the maunderings and moonings of Christian Science, theosophy and occultism and all the semi-paranoiac creeds that are ever having each its hour.

It is not only the average individual that is affected in this way, but also some of those who consider themselves educated and enlightened. To me it is a matter of wonder why the number of those who are so affected is not greater. Clear-cut ideas and the ability to think clearly

are not general characteristics even amongst the educated, and that is why education as a qualification in the exercise of the franchise has not proved successful as a corrective of the evils of democracy. The want of clear-cut ideas and the inability to think clearly would, perhaps, not matter so much if intellectual honesty were general, but even that is very largely wanting. Mr. Morley, the present Secretary of State for India, declared three years ago at a gathering of convocation of the University of Toronto, that, "he in all his life had been acquainted with only four men of whom he could say that their love of truth was unassailable and impregnable."

The great majority of mankind, even of its civilized portion, will always accept what is easy to believe, or what are the current views, not whatever is exact or true. The very aim of the Scientific Spirit serves to isolate it from the opinion and sympathy of the day. Any movement that will apparently result in unsettling the general convictions and beliefs of mankind on that account is sure to rouse hostility. When the Royal Society was founded nearly two and a half centuries ago to investigate experimentally natural phenomena, it was regarded by some as an institution designed to wreck the Christian Faith. It was considered to be a sin to investigate Nature. She was supposed to be a personality which was not to be profaned by inquiry. If the curious and inquisitive mind wished to know about her they could go to Aristotle or Galen, who were supposed to impart all about her that ought to be known. Authority was paramount and man ought to be content with its judgments. Even tradition was regarded as sacred, and, to-day, with a large portion of civilized mankind, it counts for more than established facts and carefully tested deductions.

The Scientific Spirit, therefore, cannot have that place and influence in moulding opinion that belongs to it. In some American universities, for example, the manifestation of such a desire counts against any one who aspires to teach in certain secular departments. He is not regarded as safe, and he is accordingly ostracized. When we consider the difficulties that the course of truth encounters one is reminded of an incident related by St. Augustine. On one occasion when his teacher was explaining the course of Creation and how the Almighty had in six days created the heavens and the earth, one student asked if the Almighty had taken just six days to do all this, what was He doing before He created the Universe. He received the crushing reply: "Alta Gehennas scrutantibus parabat." "He was employed in preparing hell fires for those of an inquiring turn of mind."

Science then is merely the body of organized knowledge concerning the world about us and within, the Scientific Spirit is that attitude of

mind which will not content itself with tradition, with authority, and which, further, will not refrain from employing the only method which will bring certainty to knowledge, the method which involves observation, test, trial and experiment. The Scientific Spirit does not confine itself to finding out facts for these themselves may be intellectually valueless, but it strives to bring them all into some relation with each other and all into proper places under that order. Science then is not facts, but the organization of our knowledge of them.

Having now made clear what is understood by the Scientific Spirit I shall next discuss its relation to medicine.

There is probably no line of human development in which the Scientific Spirit is to play in the near future a greater part than in medicine. As to the past all the advances in medicine have had their origin in that intellectual influence.

Medicine began nearly three thousand years ago as a series of observations on disease. It is the current idea that Hippocrates, who lived in the fifth century B.C., laid the foundation of rational medicine by studying the votive tablets and offerings dedicated to Asclepios in gratitude for the cures which he, as a god, effected in the sick who visited and worshipped in his temples. This is a wholly erroneous idea, as even a superficial study of the Coan Prenotions shows. These are a series of aphorisms attributed to Hippocrates, but undoubtedly of a much earlier origin, and probably to present the results of the observations of several generations of rational physicians in the island of Cos. These Coan Prenotions further show that in that remote time the types of disease were carefully studied and the facts collected and related. It was these facts which formed the basis of the physical diagnosis in which Hippocrates and his Coan predecessors were so adept. Hippocrates, indeed, extended and amplified the concepts which were thus handed down to him, but his great service to medicine consisted in impressing on his generation the necessity for accurate observation above all things. He did not reject theory, for he was the originator of the doctrine of Humoral Pathology, but he attached great importance to the phenomena of disease, apparently recognizing that facts must be accumulated before generalizations could be formed. Unfortunately, his precepts on this point were largely ignored by his successors, for they spun theories when they should have observed and recorded.

It is, however, probable that had they fully exploited the methods which he taught the result in the end would have been the same. The absence of definite knowledge regarding the functions of the various organs of the body would have ultimately made the mass of observations sterile of result. The sciences of chemistry and biology had to wait

two thousand years for their modest beginnings, and there could be no considerable advance until the microscope was invented, and so long as oxygen and its properties were unknown.

In those twenty centuries the Scientific Spirit was almost extinct in medicine, and authority and tradition reigned supreme. It was not that the love of learning was less than it is now, for, although the population of the non-Russian portion of Europe at the close of the Middle Ages did not exceed fifty millions there were more students in its universities than there are in those of Germany of to-day. The University of Vienna alone had at the end of the fifteenth century about 7,000 students hailing from every part of Christendom. But it was only tradition that was taught and authority and dogma were unlimited in their tyranny over the human intellect. A revolt now and then occurring was suppressed. How little place there was for the Scientific Spirit, even as late as the sixteenth century, may be gathered from Luther's remark that, "reason is the chief mistress of the devil."

This obscurantism began to give way in medicine, and in the seventeenth century Galen was rejected everywhere for Hippocrates. But it meant for the intellect in medicine the exchange of one servitude for another, for, although the great teacher of Cos may inspire those who read his works in the right spirit, the vast majority of those who resorted to him sought to find in him merely an authority in all things medical. And an authority he became, for edition after edition of his writings issued from the press and those of his Aphorisms alone numbered over 350.

But in that same century the light began to come from another source. It was the century of the foundation of the Royal Society. It was the century also of Harvey, Malphighi, Borelli, Grew, Glisson, Willis, Vieussens, Wharton, Sylvius, de Graaf, Swammerdam, Leeuwenhoek, Bartholinus, Mayow, Redi, Boyle, Galileo and Newton, in whom the Scientific Spirit flourished as it never did before. These natural philosophers, as they were called, isolated and scattered over Europe, were not stimulated by the hope of fame or the reward of place to study nature, they were all driven by that internal force, intellectual curiosity, the Scientific Spirit, to seek to know and, considering the difficulties they had to meet, difficulties which came on the one hand from the fact that they were breaking absolutely new paths into the unknown, and on the other, from the hostility of their environment, one is led to regard their attitude of mind and their unwearied search for truth as never to be excelled. It was they who laid the foundations of astronomy, chemistry, physics, biology, anatomy, physiology and pathology.

It is a remarkable fact that in the next century there follow d a halt after so brilliant a beginning, and though some progress in all these sciences was made, substantial advances began only about the middle of the nineteenth century. Then the Scientific Spirit developed as it did in the sixteenth century, and we are now at its flood tide which will never again ebb. In the last half century the development of the sciences, chemistry, biology, physiology and pathology was an extraordinary stimulus to the development of medicine. If we strike out of the record of the last two hundred years all the additions to medicine and surgery due to the development of the sciences named, comparatively little of value would remain.

In consequence of all this development of the sciences, physical diagnosis became more exact, the phenomena of disease were more accurately determined and clear ideas were attained as to the processes involved in disease. Because of all the aid furnished by the sciences it is possible for the practitioner of medicine of to-day to deal with disease in a way that no physician either in the days of Hippocrates or of a century ago could have imagined possible. It is, indeed, doubtful if even the most far-seeing physician of 1870 could have forecast the development which has taken place in the last thirty years.

All this progress has depended on the simple methods which the average physician with a moderate amount of laboratory training has been able to follow and even employ. The results of these methods he can understand and thus he is in a position to keep step with advancing knowledge. These simple methods are still serviceable in clearing up dark points, as witness the discovery by Schaudinn of the Spirochæta of syphilis, and the identification of Trypanosoma as the cause of sleeping sickness. Here are two great achievements of the last five years which are of vast importance, not only to medicine, but also to humanity, for in the one case we may now be in a position to control a scourge that has afflicted the human race since the close of the Paleolithic Period, and in the other we are at the beginning of a struggle, defeat in which may render the Tropics uninhabitable to man, white, black or yellow.

These simple methods will always be used in the practice of medicine, but so far as extending the bounds of knowledge is concerned they have already been exploited for nearly all they are capable of yielding, and now is beginning the period of diminishing returns. Progress of a substantial kind will have to depend on the discovery of new methods, on the exploitation of other lines of work, as well as on the breaking of hitherto unprojected paths into the unknown.

What are those lines, in what direction does their trend appear to be now?

This is a question which I think is of transcendant importance to those interested in medical education, and it behoves us who are concerned to scan closely the distant prospect and take the bearings of our course.

It is almost trite to say that there has been in the last twenty years an extraordinary expansion in the sciences ancillary to medicine, but it is difficult to realize adequately how extensive that widening of knowledge has been and we can only approximate it by the adventitious aid of figures. In the last three years the number of original papers published in pathology, hygiene, physiology, pharmacology and bio-chemistry was about 17,000. In 1904-5-6 the number of bio-chemistry alone was over 9,000,—in 1906 it was nearly 4,000. The numbers of bio-chemical papers published in the eighties were only a few hundred annually. One gathers from this what energy is now being expended in the investigation of the chemistry of living matter, not alone of the normal, but of the pathological as well. The number of the papers published is an indication of the army of workers that is engaged. If we credit every worker with two publications annually we would infer that in bio-chemistry alone there must be approximately 2,000 researchers. Twenty-five years ago the number of investigators in all the departments of Science did not exceed three thousand.

In pathology the output has also been enormous, and especially on its chemical side. Formerly pathology concerned itself chiefly with the morphological side of disease. Now there lies before it all the chemical problems which are of a far weightier interest in that they concern the ultimate causation of disease.

The advance in bacteriology in the last few years has been more and more developed along the chemical side, for the aim of research in this department has been to determine the nature of bacterial products and how they are disposed of in the animal cell. Considering the number of species of pathogenic bacteria and the polyphasic activity of living matter, it is not unreasonable to assume that the chemistry of microorganisms causing disease will enlist the enthusiasm of armies of researchers.

All this shows that the development of the next two or three decades is to be along chemical lines, with methods transcending those now in use and with a basis of knowledge that is to be broader, deeper and surer than we now possess.

The reason for the coming advance is that which has promoted the development of the last ten years. It is clearly recognized by those

who concern themselves with such problems that the essential phenomena of disease are fundamentally the result of chemical interaction, that when an organ or a tissue becomes affected with disease the processes involved are all chemical or physico-chemical. In the case of diabetes mellitus, for example, the complicated chemical processes that are involved in the utilization of the sugar of the body are altered or do not occur, and, in consequence, nutrition is disorganized. In inflammation, in pneumonia, in typhoid fever, and tuberculosis the processes, although due to microorganisms, are themselves fundamentally chemical just as much as those in gout, rheumatism and rickets. In fact, there is no abnormal condition of the body or of any of its organs, not excluding even the malignant growths, that is not fundamentally of chemical causation.

I desire to emphasize the chemical causation of disease because, in the first place, although it is in many quarters tacitly or openly accepted, it is not allowed in reality its right place in any survey of disease, and, in the second place, because this is the line along which medicine is yet to win its great triumphs. It is the recognition of the overwhelming importance of physiological and pathological chemistry to the science of disease that has caused the extraordinary increase in the army of workers in this field.

The activity of these researchers will inevitably result in solving many of the problems which now appear so difficult and obscure. It will involve also such an addition to knowledge in this department that the whole subject will be revolutionized. Every advance in the science of disease means a limitation of the present crude treatment of disease, a growing disuse of the drugs and chemicals to which the physician of to-day resorts, and it will render possible more and more either the preparation and employment of the very compounds that the living cells of the body produce for their own defence against disease, or when the nutrition alone is disorganized, as in the case of pancreatic diabetes, the replacement of those processes which the normal cells undergo. In other words medicine will become less empiric and more rational the more we know of the chemical changes that occur in the normal as well as in the diseased cell.

The physician of twenty years from now, if he wishes to profit from all these advances and to keep step with progress, must have an amount of knowledge of physiological and pathological chemistry far in excess of what he is ordinarily required to have to-day. If he does not have that knowledge he is not merely behind his time, he is intellectually marooned.

We are now at the stage of transition between the old and new phases of medicine. From now on, while the old methods which have been

of service will be retained, new ones of an intricate order will be employed and a deeper, more accurate knowledge of the functions and processes of living matter will be the result.

Such a development is only in accord with our age and with the development in the other sciences. The alchemist had his furnaces, his crucibles, his retorts, his simple salts and reagents. With these he established the beginnings of chemistry, but it was only when the balance was introduced that exactness began to play its part. To-day the old methods are still used in certain simple chemical operations, but the vast body of organized knowledge called chemistry is the result of the employment of methods which were not even dreamt of by the chemists of the eighteenth century, not to speak of the alchemists.

The same may be said of physics and electricity. When Helmholtz visited Faraday in his laboratory in 1853 he found that the latter's apparatus consisted of a few wires and some bits of old wood and iron. What a far cry from such an equipment, with its simple methods, to the outfit of an electrical laboratory, such as you have to-day in your university grounds, with its problems, the solutions of which are or may be as important fundamentally as any result that Faraday obtained!

What is the warrant for this prediction of progress in medicine? It is the Scientific Spirit which alone has promoted all the advances medicine has made in the past. It is not material that only a few are possessed of that Scientific Spirit, for only an infinitesimal portion of mankind has ever manifested it, and nevertheless all progress is due to it. The number of researchers in these lines, as has already been pointed out, is greater than it has ever been before, and to those of to-day will succeed to-morrow a still greater number. Then there is the nature of one of the problems involved. Life as manifested in the single animal or vegetable cell is an inscrutable mystery, or it appears so to be, but the human mind will never recognize any obstacle to its progress, and as the problem is of transcendent interest it will ever attempt the solution of the secret. Medicine, therefore, will inevitably gain enormously, for every fact won regarding the constitution of living matter and the solution of the secret is a contribution to rational medicine.

The bearing of all this on the courses of medical training designed to fit the student for the practice of medicine during the two coming generations is obvious. The student who thinks that the practice of medicine in the future will not be much different from what it is now will certainly be disillusioned. He should recognize that a change is coming and that he must do his best to orient himself with regard to it. Of course, this change will not take place all at once, but it will

be accomplished in the next twenty-five years, and it will be a much more profound one than any which has yet taken place in the history of medicine.

One of the defects of every medical curriculum of to-day is that it is constructed with the idea of turning out the student at the end of four or five years of study as a finished product in all departments. I hold that to be a profound mistake. That result is unattainable even with the exceptionally able student. As the practice of medicine was thirty years ago it was possible to equip a student of fairly average ability with a large amount of the knowledge he needed afterwards in the exercise of his calling. I do not say that he was so equipped in every instance, for the instruction at the bedside was not nearly as efficient as it is now. To-day there is more earnestness in those who instruct and the teaching is vastly better than it has ever been, but in proportion to what he is subsequently supposed to know the student acquires less in the four or five years of his course than the student of thirty years ago was compelled to know. He knows much more of the sciences, his proficiency in clinical medicine and surgery is much greater, and yet, though he may be a credit to the institution which gives him his training he is not the peer of his type of thirty years ago.

Now this is not the fault of one teacher or group of teachers. The clinical teacher is apt to think that he has not enough of time, that the sciences are crowding too much on the attention of the student and leave him little opportunity for training in the professional subjects. The clinical teacher everywhere is prone to assume that the student should, after two or three years, show as much insight in regard to the practical side of medicine as he, the teacher, has, who has been training himself for ten, twenty or thirty years. The student would be a genius, nay, an astounding marvel, if he could measure up to that standard.

Even if five years were devoted to the clinical side the student would still not be a finished product. As it is, he is supposed to acquire a good knowledge of the sciences and at the same time the knowledge and experience in clinical medicine and surgery that those who are much senior to him did not have when they graduated. Take a concrete illustration. Thirty years ago the physiology of the nervous system was an unknown, or almost unknown department, and, of course, clinical neurology was chaos itself. To-day much still remains to be ascertained, but what has been explored and determined is such that to know it well requires years of attention. Is it possible to train a student in five years in clinical medicine generally so that he will readily diagnose a case of disseminated sclerosis, of disease of the cerebellum, of syringomyelia or of anterior poliomyelitis?

The fact is that while the clinical teacher is doing right in training as he does, the motive and expectation prompting it all is wrong. No institution with teachers and staff, all of the genius order, would justify that expectation. It is not possible to turn out a thoroughly scientific physician after five years of training, and it is as impossible to equip thoroughly a student with the clinical lore and experience so as to enable him to deal intelligently with all the cases that he meets in the first few years of practice. Further, as the years pass, the discrepancy between the [illegible] and the achievement of the teacher in this respect must grow greater and greater.

The question which may now be asked is what ought to be the aim? I hold that the first requisite in the attainment of the student is not quantity but quality. To know a great many things in medicine is of no value if there is not therewith the ability to apply the knowledge in concrete cases. The quality demanded involves a special training, a training that should develop precision of thought, the rigidly logical power of the mind and the capacity to recognize whether the facts ascertained in a particular case are adequate to afford the basis for either a generalization or a diagnosis. To attain that result is to develop the Scientific Spirit.

That Spirit is to be developed in the student of medicine by a rigid training in all those subjects which permit exactness, in the sciences, for instance. The sciences serve a double purpose in medical education. A knowledge of them is the basis of the art and practice of medicine. I have already pointed out that it was the development of physiology, pathology and bacteriology that brought about the great advances of the last thirty years. What medicine and surgery would now be had they not progressed is not difficult to imagine. Without a knowledge of them no physician can attain the first rank or be even mediocre in the pursuit of his calling. The sciences are then absolutely indispensable in medicine as enabling the student to understand the fundamental phenomena of disease. They are of inestimable value from another point of view. As they are the subjects in which exactness is possible they can be made to serve to bring out all the powers of the student in regard to precision of thought and observation and a right training in them ought to endow the student of medicine with a dexterity that he can get in no other way.

The training in the sciences of the medical course then must serve to develop the Scientific Spirit. If a student does not, when he is being so trained, attain that clearness of mind, that capacity to relate facts to one another and to apply them in concrete cases he has failed in the absolutely essential thing in medicine. Lacking this power and pre-

cision he will not acquire it in any training at the bedside. On the other hand, if he is properly trained in the laboratory he readily acquires and applies the methods of clinical medicine and surgery.

The sciences then should be carefully cultivated by the student in the undergraduate course, not to the exclusion of the other subjects which are known as professional, but as necessary to the latter and in order that the Scientific Spirit may be developed.

The great difficulty in this matter that is soon to confront us is how to adjust the courses to each other so that there will result the greatest advantage to the student. If bio-chemistry is to play the part I have predicted for it, it will mean a serious addition to the curriculum already heavily loaded, and, of course, there must be a curtailment of time given either to the other sciences or to the professional subjects in order to allow room for it. I have no doubt that a certain amount of readjustment is necessary in the sciences, but the introduction of the new subject should not be made wholly at their expense, for some of the time necessary should be provided for in the increased time demanded of the student.

Of course a proposition like this will at once be objected to by the clinical teacher and, perhaps, also by the student. The latter may ask where he is going to get the clinical experience which he requires in the practice of medicine. The answer to this is, that all the remainder of his life is to be a training in clinical medicine and surgery. If then, at graduation, his knowledge of these subjects is not as ample as he would wish it to be, he can and will remedy the deficiency. If, on the other hand, he has not had at graduation a good training in the sciences grouped under medicine, in ninety-nine cases out of every hundred he never will. Once graduated from the medical school he will not feel any desire to go back to laboratories for an adequate knowledge of the sciences, and if he does return, he will not have the patience which will carry him through the necessary routine and drudgery to that end. I would not say that such a student would be a failure in his profession. If, however, he devotes himself to medicine he may not in the future be more than a superior to the nurse of his patient. If he specializes in surgery, he may, perhaps, be what is called a brilliant operator, and may be able to show neat joints, clever anastomoses, good amputation stumps and other prized results. The plumber also can make neat joints and clever connexions in drainage pipes, and, like the surgeon, thereby save life and make for its comfort and security. What student, however, amongst my hearers to-day aims only at being merely a superior nurse or a surgeon of the plumber type?

It is a recognized maxim that if you wish to develop a violinist you must catch him early, and the earlier the better. It is a fixed law of our mental life that there is a special time for everything. My own observations on the careers of students conducted during the last twenty-five years leads me to believe that this is particularly true also in science. If the student wishes to develop the scientific mind in the highest degree he should begin not as early as he who wishes to become proficient with the violin, but certainly before the twenty-fifth year of age. After thirty the habits of the mind tend to become fixed and there is little margin for the free movement that a full scientific training of the mind requires. The mind of the individual is in respect of scientific discipline at its maximum of plasticity and receptivity between the age of eighteen and that of thirty, and that period of life should, in the student of medicine be given over largely to the acquisition of a knowledge of the sciences and to the development of the scientific mind.

But I think some one will say to himself that the speaker has in his mind only the preparations of recruits for the research laboratories. Not at all. What I have said hitherto bears only on the training of those who are going to practice the profession of medicine. Not only the call of humanity, but also the interest of the future physician demand the precision and the clear-cut ideas that come from an adequate training in the sciences. Why should the laboratory be supposed to monopolize the Scientific Spirit, the desire and the efforts to know accurately why and how? Is it not a serious reflection on the medical profession to maintain that there is and ought to be a great gulf fixed between the laboratory worker and the skilled physician?

I am not beset with anxiety for the army of laboratory workers, for I am certain that if the vast majority of the students are scientifically trained for professional practice the laboratory will take care of itself. It will always have recruits, and in the future more than now. Nor would I have you think that the laboratory is the only place where scientific work may be done. In the wide field of medicine there is an unlimited opportunity for the exercise of scientific precision. That this is so may be taken on the word of no less than Dr. James Mackenzie, of Burnley, England, whose article on this subject in the July issue of the *Western Canada Medical Journal* will amply repay perusal. In 1881, at the International Medical Congress, Dr. John S. Billings pointed out that the vast majority of the 20,000 papers and publications on medicine issued from the press in 1879 were worthless simply because of the lack of accuracy in the observations. Does the vast mass of literature on medicine now annually issued show any improvement in this

respect? To judge from Dr. Mackenzie's observations it does not, for he claims that the exponents of medical science ignore the necessity for making accurate observations, and goes on to say: "Although they talk of their careful methods of observation, a critical study of medical writings will reveal the fact that they bristle with evidences of inaccurate observations. What they call observations are but a mixture of imperfect observations and unwarranted assertion. While they imagine that they are stating a fact they are actually at the same time recording an opinion."

If Dr. Mackenzie is right, and I believe he is, there is very great need for improvement. When medical literature teems with mistakes in observation and errors in diagnosis, what should be expected in those who do not record their observations? Is there any excuse for the mistakes that are sometimes made, except that those who make them are not trained as they should be?

It is evident that what is wanted is accuracy, and accuracy all the time. Clinical experience is of absolutely little value if it is not accompanied by the desire and will to be thorough and precise.

The habit of being thorough and precise can only be formed in the undergraduate course and under the direction and watchful control of the various teachers. That habit is every whit as valuable as, if not more so than, the most systematized information which he can acquire in his medical course. When that habit is firmly established in the student it is a permanent guarantee that he is in possession of the Scientific Spirit, the Spirit that does not care for shams and make-believes, or anything but the truth. With that habit, and actuated by that Spirit, he can conduct research in his ordinary medical practice that may be as valuable as any output of the laboratory. Dr. Mackenzie points out that there is still an immense field in practical medicine outside of hospitals and laboratories which only awaits researchers of the proper kind. That work is of no value unless it is properly done, and those who do it will be rewarded as fully as they would be if they devoted their lives to the most fruitful research in a laboratory.

To the student then I would say: Prepare for the future by training yourself in being exact and in getting exact ideas. Take stock of the fact that the development of medicine is to be along the lines of biochemistry, normal and pathological. Acquire a knowledge of this science and of physiology and pathology, for it will be of immense service to you in after years in enabling you to keep in touch with the advances on the scientific side of medicine. Appreciate and carefully undergo the training that the laboratories can give you, and at the bedside be content with nothing but facts and rigidly examined deduc-

tions therefrom. Never follow a method in diagnosis or in your observations if you can avail yourself of even a slightly better one. Early train yourself to be adept in the use of all the instruments that aid in precision, the microscope, the thermometer, hæmocytometer, the hæmoglobinometer, the stethoscope, the hæmometer, the ophthalmoscope and the laryngoscope. It may be that the locality where you will pursue your professional career will be far from any centre where specialists are to be consulted and you must do your utmost for the poor in your constituency. If you are incompetent the rich may escape the consequences, but the poor cannot.

You have, above all, one duty to yourself, and that is to cultivate to the utmost the powers of mind which you possess, and do not think that done when you graduate. Continue the training until you are passed the meridian at least. The average individual takes short views, forecasting not more than two or three years ahead. The medical student should look twenty and even thirty years ahead. One of the former teachers in this Faculty is credited with saying that a man's best work is done at forty. What, however, is that best work? Is it some great achievement in statesmanship, commerce, or industry, some great executive or professional performance, or some great discovery in science? Not at all. These are in themselves more or less accidents, and the opportunity to do them may not occur in the lifetime of the many. The greatest achievement of which the individual is capable is the training of his intellectual powers to the utmost in all his years up to the fortieth. That is his best work, and if it is not done before his fortieth year, the end of the plastic period of his life, it is not done and cannot be done afterwards. Having done that best work, the output of the rest of his life is the result and the measure of the extent of that best work. The individual who trains himself to the utmost till he is forty may feel tranquil that he will not fail of his reward. Even in the training itself there is the reward, and in later years of life there is no satisfaction so deep as that which comes from the conviction that you have done the utmost of which your mental life is capable.

And I would advise you further to conserve to the utmost your physical powers. I think that our modern systems of education are on the whole not sufficiently insistent in this respect. A well balanced physical development should accompany the mental, not only to aid the latter but also to aid in moral culture. I believe that the daily expenditure of physical energy, whether it be in toil or in athletics, exercises a very powerful moral influence in the formation of character. When one hears toil called a curse, one loses patience for if it is not unmitigated

and excessive, toil is not a curse but a blessing to man. Those who toil with their hands are amongst the most moral portion of mankind, and this was recognized by one of the oldest Greek writers, Hesiod, for, as he put it: "In the path of noble manhood the gods have placed sweat."

Further, remember that your life is all before you. It has been said that there is no more severe critic than the young man, and that there is none more unjust. If your mental make-up is worth anything at all your opinions and your standards of things will inevitably alter with the years. It is, therefore, the part of wisdom to be as little dogmatic as possible. Honour your teachers and love and be thoroughly loyal to your university, for only in that spirit may you share in the best that she imparts. Once more, and finally, cultivate your mental powers to the utmost and therewith the Scientific Spirit. Follow all your life, wherever it may lead, "the high, white Star of Truth." As the years go by there are many interests lost, often with the result that life becomes dull and commonplace, and the individual a spent force. If, however, intellectual curiosity, the Scientific Spirit, is cultivated it increases in strength with the years and departs only with life. And it brings at least one reward. The ancient Peripatetic Philosophers truly held that, while there are many things that contribute to a happy life, mental excellence is the best of all.

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J. GEORGE ADAMI, WILLIAM GARDNER,
GEO. E. ARMSTRONG H. A. LAFLEUR,
A. D. BLACKADER, JOHN McCRAE,
G. GORDON CAMPBELL, F. J. SHEPHERD,
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