

# The Motives of Scientific Research

A. Wilmer Duff, M. A., D. Sc., in Worcester Polytechnic Institute, Worcester, Mass., Orator for the Associated Alumni at the U. N. B. Encaenia—Scholarly Address Upon Scientific Subject—Speaker Graduate of U. N. B. Class of 1884.

A. Wilmer Duff, M. A., D. Sc., of Worcester Polytechnic Institute, Worcester, Mass., a distinguished alumnus of the University of New Brunswick of the Class of 1884, delivered the following scholarly address on behalf of the Associated Alumni of the University at the Encaenia exercises, which were held this afternoon.

**Common Problems.**  
When asked by the Alumni Society to speak as its representative at the exercises of today, I hesitated at first, because after many years of absence from Canada I could not feel that I had any close acquaintance with matters peculiar to this province or to Canada at large. But after the great world struggle, in which Canada took such a gallant part, we have come to realize that there are many problems of pressing importance common to men everywhere, and so, having accepted, I felt inclined to speak on some of these wider issues and especially to emphasize the value of that fuller understanding of each other's motives that has come to the English-speaking nations and the supreme importance to the whole world of preserving this good will. But these are topics more suited to a different occasion. If there is any grain of wisdom that a man has to offer to the youth of the next generation on an occasion like this, it is most likely to come from the fruits of his own most familiar experience. I propose, therefore, to speak to you on what may seem a somewhat limited theme, "The Motives of Scientific Work," but I hope to be able to show you that conclusions drawn from this narrower field have an application of some value to all forms of intellectual work and even to work of any kind.

**Not Guilty of Levity.**  
I hope you will not think me guilty of levity in the treatment of a serious theme if I put the matter in a way that would, after all, have appealed to Socrates in his search after human motives. A distinguished astronomer, who is something of a humorist as well as a philosopher, is in the habit of asking his fellow-workers, "If you were cast away on a remote island from which you could never hope to escape, and if you found there a fully equipped observatory and library, would you go to work at astronomy or not?" Now, it is true that no such scientific Robinson Crusoe is likely ever to exist, and a man can never be certain what he would do in very improbable circumstances. Yet, since the question is a somewhat novel and striking variant of the more general and more vague inquiry, "Why do some men, who might be otherwise engaged, pursue research?" It is not without interest, considering the extent to which the world has depended for its progress on scientific discoveries. But how can an adequate answer to such a question be obtained? You would not, I believe, be satisfied with a personal answer from any but one of the greatest investigators who have given a new impetus or direction to the progress of discovery of Nature's secrets. Of these (I speak only of physicists) there are perhaps not more than half a dozen among our contemporaries. Not having them here as witnesses, I propose to offer other evidence which is, I believe, both positive and pertinent. The lives of many of the great of the past, who were perhaps only dimly aware of their own motives, tell us in no uncertain way of the spirit that animated them. If the few facts which I shall narrate are familiar to many of you, I can only plead, in the words of Carlyle, that "Great men, taken in any way, are profitable company. We cannot look, however imperfectly, upon a great man without gaining something from him. On any terms whatever you will not grudge to wander in such neighborhood for a while."

**Isaac Newton.**  
Highest in the roll of physicists stands the name of Isaac Newton. His popular fame rests on his discovery of

the law of gravitation, but, to the physicist he is the great master of the science, who laid broad and deep most of the foundation on which the immense structure of Physical Science has been erected. It is no exaggeration to say that his discoveries in physics, if divided among half a dozen other men, would endow them with immortal names in the history of science. But Newton was not only the greatest of physicists, he was also one of the greatest of pure mathematicians. In a very real sense it may be said that nearly all mathematics and most modern engineering are founded on that bazaar of the non-mathematical among college students, the differential and integral calculus, of which Newton and Leibnitz were independent discoverers. The details of the process by which Newton made his great discoveries and the well-nigh incredible mental activity which they implied would be out of place here. That he was a man of practical sagacity is shown by the fact that he was Master of the Royal Mint and a member of Parliament who took his duties seriously. He was also very active in the administration of Cambridge University and devoted much time to non-scientific subjects, especially theology, on which he wrote several works; he even quaintly expressed the hope that his commentary on the Book of Revelations would live, even if his scientific work should prove to be unimportant.

**Power of Mental Concentration.**  
Turning now to the question of how Newton was able to accomplish so much in science, we may note first the extraordinary power of mental concentration which he possessed. He even expressed the opinion that this was the only exceptional talent which he possessed. At times, in his immersion in profound reasoning and calculation, he became quite oblivious of time and space and even omitted his ordinary meals without being in the least aware of it. It is said on his own authority that on one occasion he passed five days without sleep, but it is probable that an abnormal physical condition had something to do with the circumstance. Now it is evident that such concentration on one subject could come only from the profound satisfaction which the occupation afforded. Indeed nothing can be more evident than that Newton's chief impulse in his scientific work was the pleasure he derived from the game he played with Nature to wrest her secrets from her. The thought of any material profit from the occupation or even any desire of the fame of accomplishment must have been a distraction that would have made such absolute concentration an impossibility. If there is any doubt about this, it is settled by an incident that took place early in Newton's career. When he had published the first instalment of his great work on Optics, he became involved in a dispute with Lucas, a mathematical professor at Liege. After conducting the controversy for some time with great patience and courtesy, he wrote to a friend "I see I have made myself a slave to philosophy, but if I get free of Mr. Lucas' business, I will resolutely bid adieu to it eternally, excepting what I do for my own private satisfaction or leave to come out after me; for I see that a man must resolve to put out nothing new, or to become a slave to defend it. Philosophy is such an impertinently litigious lady that a man has as good be engaged in lawsuits as have to do with her."

Luckily, he was persuaded to break this resolution.

**Henry Cavendish.**  
Let us turn now to his most eminent successor in the 18th century. With one possible exception, probably no physicist ever lived so completely for the pleasure of research as Henry Cavendish. Brother of a Duke of

Devonshire and, by virtue of fortunes bequeathed to him, possibly the wealthiest man of his time, in his three London houses Cavendish lived, with slight exceptions, the life of a hermit. Every Thursday he dined with his fellow members of the Royal Society. His dinners on other days were ordered by a note placed on his hall table and his servants were directed to keep out of his sight on pain of dismissal. The only relative he saw was his nephew and heir, and him he only saw for a few minutes once a year. About once a year also his tailor visited him by appointment, when his services had become indispensable. The only evidence that Cavendish was not a complete sybarite of science is the fact that at regular hours on certain days he attended at one of his houses, where he kept his books, to lend them to anyone who could use them intelligently. Some of his investigations were communicated by Cavendish to the Royal Society, and these easily gained him the reputation of being one of the greatest living scientists, but the most of his discoveries were completely described in documents which were sealed and filed away in his study and were not published until nearly a hundred years later, when it was found that he had anticipated many of the important discoveries made later by Michael Faraday, William Black and others. When we contemplate the life, possessions and position of this singular man of genius, we must admit that the keen pleasure he derived from research was almost the single impelling motive in his life, while there is no evidence that he was constitutionally lacking in any of the ordinary capacities for pleasure.

**Lord Kelvin.**  
Among the leaders of physics in the 19th century I choose William Thomson, Lord Kelvin, as a representative. Any of his great contemporaries, Faraday, Maxwell or Helmholtz, would serve my purpose equally well, but Kelvin's life is a singularly agreeable one to contemplate. While popularly known as the creator of the Atlantic cable, in the extraordinary range of his work he recalls and even excelled Newton, for since Newton's time a new and very important branch, that of electric currents, has been added to physics by the discoveries of Volta and Faraday. In fact, the range of physics has now become so wide that it is impossible that Newton and Kelvin will have a successor to bridge the science as a Colossus. It would be difficult to think of any respect in which Kelvin's life would not be considered successful. His discoveries in physics brought him such reverence from fellow-physicists and the general public that wherever he went in his numerous journeys in Europe and in America, which he visited several times (he was chairman of the commission to utilize Niagara's reception was that of a prince of science. His practical sagacity as well as his scientific knowledge and singular tact led to his appointment as chairman or member of numerous commissions for the improvement of conditions in England. As a by-product of his purely scientific activity Kelvin acquired great wealth from royalties on scores of instruments of the most intensely practical nature. Finally, that nothing should be lacking to the outward success of such a career, he was raised to that most coveted of social positions, membership in the House of Lords, though it is amusing to note that it led to a foreigner writing to England to ask who was "this Kelvin who was claiming to have invented all of Sir William Thomson's instruments." Kelvin's success as a scientist was only equalled by his gentleness, courtesy and humor (and these the present speaker has some cause to remember, as he worked for a time where Kelvin was a frequent visitor) and in consequence he possessed a host of warm friends in all ranks of society. Hence it will be admitted that Kelvin's life was nearly one of perfect success. If we now inquire what was the motive of his immense activity, we must admit that he enjoyed the fame and glory that came to him, that he did not despise any of the good things of life, and further, that in the work for the good of his fellows a strong sense of duty played an important part; but the excitement, glee, and humor that permeate his prodigious scientific correspondence show that it was the game of research that filled him with the deepest delight. If landed by shipwreck on the "astronomer's island," Kelvin would probably have at once taken out his little green notebook and added some notes that had just occurred to him on his most recent investigation, as he was accustomed absent-mindedly to do among his guests on his own yacht.

**Great Contrast.**  
No greater contrast to Kelvin's career could be found than that of the greatest of American physicists, Willard Gibbs of New Haven. The details of his life need not detain us long. Gibbs lived and died an obscure professor of physics on a small salary in Yale University. In fact, for the first ten years of his professorship he received no salary whatever. He did not attend scientific meetings or discuss the work he had in hand with fellow-workers. He published the greatest of his work as obscurely as possible in the proceedings of the Connecticut Academy of Sciences. But, even so, it was discovered after many years by two of the greatest of his contemporaries, Clerk Maxwell in England, and Boltzmann, in Vienna. Later the papers were translated into German and French, but Gibbs never republished them, and until his works were published after his death they were read in German and French by Gibbs' fellow countrymen. If I say they were on the Phase Rule I shall convey no meaning to anyone but a physicist or a chemist, but I may add that they form the theoretical groundwork of

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the great modern branch of physics and chemistry called physical chemistry, and are being applied daily to the most important practical investigations in metallurgy and applied chemistry. Near the end of his life Gibbs published a book of great originality on Statistical Mechanics, the value of which was not recognized until later, and again it was the product of prolonged study of which, I believe, no one was aware. I can quote no words of Gibbs to show the motive of his life-long study of the most difficult problems of science, but when we consider the absolute lack of ostentation, ambition, or desire of reward of any kind that his life and method of working reveal, it must be evident that the pure pleasure of such work was the source of his inspiration. Indeed, it is not clear but that any man of not uncommon ability might accomplish as great results, if working with similar serenity of concentration in the field that interests him most. Life on the "astronomer's island" would have had some compensations for Gibbs.

**Simon Newcomb.**  
Of a different type and temperament was Simon Newcomb. Born in Nova Scotia and resident, I believe, for a time in New Brunswick, he went at an early age to the United States and ultimately became the greatest astronomer of his day. It is a curious fact that astronomy is the only branch of pure science in which America leads the world, and it is, on the whole, the one least capable of practical application, a point that is worthy of consideration by those who think that the conditions of life on this continent are hostile to idealism. No one who ever saw Newcomb could doubt that behind the glare of his eyes and the singular intensity of attitude of his burly figure lay a character of uncommon strength and intensity of purpose or that he would have been found in the front line of almost any profession that he might have chosen. James Bryce said that if Newcomb had turned his attention to business he would have amassed a great fortune. Yet he remained content through life with a professorship of mathematics in the Navy, devoting his spare time to as-

tronomy and physics. Of his career speak, but it may be of interest to quote his own somewhat rhetorical account of his aims and motives. "To this work," he said on one occasion, speaking of celestial mechanics, "I was especially attracted because its preparation seemed to embody the highest intellectual power to which man has ever attained. The matter used to present itself to me somewhat in this way. Supply any man with the fundamental data of astronomy, the time at which the stars and planets come to the meridian of a place, and other matters of this kind. He is informed that each of these bodies whose observation he is to use is attracted to all the others with a force that varies as the inverse square of their distance apart. From these data he has to weigh the bodies, predict their motions in all future time, compute their orbits, determine what changes of form and position these orbits will undergo through thousands of ages, and make maps showing exactly over what cities and towns on the surface of the earth an eclipse of the sun will pass fifty years hence, or over what regions it did pass thousands of years ago."

A more hopeless problem than this could not be presented to the ordinary human intellect. There are tens of thousands of men who could be successful in all walks of life, thousands who could gain wealth, hundreds who could wield empires for one who could take up this astronomical problem with any hope of success. The men who have done it are therefore among the select few of the human race, an aristocracy ranking above all others in the scale of being. The Astronomical ephemeris is the last practical outcome of their productive genius."

**Mixture of Motives.**

Here, however, I must guard myself against being misunderstood. Men act, even in the simplest of matters from a mixture of motives. I have not intended to suggest that even a Cavendish or a Gibbs is a man of but one motive even in his scientific work. I have merely emphasized what I believe to be the chief of many motives that play their part in scientific research. Something must also be attributed to an aspect of the social sense, if I may call it so, the feeling that one is taking part in the march of any army of workers the world over and is, through correspondence, publication or scientific meetings, holding converse with his fellow workers everywhere. Man is a thinking being and delights in the exchange of thought. The publication of a piece of research is also a source of pleasure as marking a more or less definite completion of an undertaking. The sense of a duty one owes to the world and the duty of making the best of his own gifts play their part and help to produce that mental serenity without which the highest intellectual achievement seems impossible. Yet, after making all due allowance for these other motives, one does not get far away from the element of elevated enjoyment as the chief motive in scientific work.

**Exercise of Active Imagination.**  
But while you may be inclined to grant all this as regards the generals and captains of the research army, you may very properly ask whether it applies to the much larger number of those in the ranks who plan no great

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scientific campaign and expect no niche in the temple of Fame. A considerable acquaintance with the sappers and miners in science leads me to believe that, while some of those who enter on research are animated largely by the desire of promotion or reputation, yet their persistence and success in such work depends chiefly on the immediate satisfaction it affords, and the value of the contributions they make to the advance of knowledge is pretty strictly in proportion to the pleasure they derive from the process. Purely scientific research is, in fact, an exercise of the active imagination, controlled and directed by the reason, and the chief rewards of such work are in the work itself.

**Not Practical Application.**  
One motive, however, which is some times popularly thought to be the chief motive in science, must be nearly entirely excluded. Few if any great discoveries have been made by men who had in mind some immediate practical application of the discovery. The practical applications of a fundamental discovery in Science are usually found by a later generation. Faraday's discovery of induced currents of electricity preceded by half a century the beginnings of Electrical Engineering which is founded wholly on that discovery. Maxwell, who predicted electromagnetic waves, and Hertz, who realized them, did not live to see the success of wireless telegraphy. In fact, while the discoveries of Science, pure and applied, are in a very real sense the only additions that are, from time to time, made to the permanent wealth of the world, it cannot even be claimed by the most enthusiastic followers of Science that the immediate applications of its discoveries are always of a beneficial nature. Do not know that anyone has ever misused the law of gravitation, unless it be the airplane bomber, but gunpowder is a doubtful blessing, at least to the man at the wrong end of the gun, and improved methods of working in steel make more deadly cannon as well as telephone, following the fast mail as safer bridges. The telegraph and train, have probably been the prime factors in making it possible for men to form those great combinations, (Continued on page 2.)

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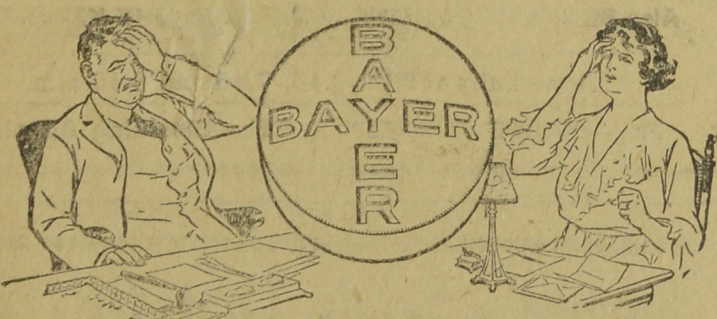
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