

From Immigrant to Inventor

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VI. STUDIES AT THE UNIVERSITY OF CAMBRIDGE

ILLUSTRATIONS FROM PORTRAITS



LONG-CONTINUED struggle with no let-up will wreck a feeble constitution. It produces in a strong and healthy constitution a tuning-up of continuously rising pitch under the tension of which even the strongest constitution may snap in two. My struggle had been going on for nine years when I was returning to Europe on my way to Idvor, hence my pitch was very high. Nervous tension resulting in a lack of poise was the diagnosis of my ailment, according to my English friend in Lucerne, who urged me to abandon the exploration of the beauties of the Alps and seek the solitude of my native village; otherwise, he said, not even all the guardian angels in heaven could prevent me from breaking my neck. A two months' vacation in the soporific atmosphere of Idvor was a blessing; my pitch was lowered through several octaves, and I did not vibrate violently in response to every impulse that came along. I recognized, for instance, that the Serbs of the Voyvodina could wait a little longer for their political salvation, which I confidently expected from their adoption of the American point of view. I also recognized that a knowledge of the modern theories of physics was not indispensable to the happiness of many human beings. There was not a single person in Idvor who cared two straws about these things, and yet most of these good people were happy, as, for instance, Gabriel, who was to be married on St. Michael day. Gabriel did not know much, I said to myself, but the little knowledge he had was very definite. He knew that he loved the girl he was about to marry, and he also knew that his life, following in the footsteps of his peasant

ancestors, had a definite object in view which, as everybody in his village knew, was easily attainable. I knew more than Gabriel did, but my knowledge was not as definite as his. My aim in life was, I thought, much higher than his; but was it attainable? And, if attainable, was it worth the struggle? Two months earlier such a question could not have occurred to me even in a dream. But Gabriel's melody and the dreamy atmosphere of Idvor suggested it.

My mother observed that a change had occurred, but she was not alarmed. I spoke less often of my future plans, and was less anxious about my departure for Cambridge. The wedding celebrations in my native Banat were already ushered in by the gay autumn season, and the beautiful kolo dancers, whirling around the merry bagpipes, engaged my interest much more than when I came to Idvor two months before. One evening my mother recalled an incident which happened in my early boyhood days and which I remembered well. She said something like this:

"Do you remember when Bukovala's mill with its high conical roof was re-thatched?" I said, "Yes," and she continued: "You were then a little shaver, but you certainly remember still the shining tin star which the workmen had planted upon the top of the conical roof after they had finished their work of thatching. The children of Idvor thought that it was a real star from heaven; it looked so bright when the sunlight was shining upon it. One day the tin star disappeared and everybody wondered how anybody could have climbed up that smooth and steep roof and taken the star away. Old Lyubomir, who loved you so dearly and delighted in making sheepskin coats for you, was sure that it was you,

and he suggested that special prayers of thanksgiving be read in church for your miraculous escape. Old Lyubomir was right, as you know, and I always believed that God had saved you for a mission in life much higher than that of young Gabriel, whose happy lot you seem to envy. Blessed America has taught you how to climb a roof much steeper than that of Bukovala's mill, and on its top and all the way up to it you will find many a real star from heaven. You are not far from the top and you cannot stop nor turn back now any more than you could when you saw the peak of Titlis in the distance, but felt too fatigued to finish your climb. Gabriel's magic flute and his mellow sefdalia, song of sighs, have turned your thoughts to things which are now in everybody's mind: to wedding-feasts and kolo dancing, and to other diversions which fill the hearts of Idvor's youth during this merry autumn season. You are dreaming now some of the idle dreams of youth, but when you return to Cambridge you will wake up again and see that all this was a pleasant dream only, which you saw in your restful hours in drowsy Idvor. The real things are waiting for you at Cambridge."

I confessed my weakness and pleaded extenuating circumstances. I tried to persuade her that her tender affection and watchful ministering to what she insisted should be my pleasures and comforts during that summer had transformed a hardy youth into a soft and pampered pet. She answered: "The blacksmith softens his steel before he forges it into a chain; you are just right for the blacksmiths of Cambridge."

When I returned to Cambridge from drowsy little Idvor things looked different from what I saw on my former visit two months before. Things which, in my feverish haste, I scarcely noticed then filled me now with awe. The ancient college buildings inspired a feeling of wonder and of veneration. I saw in them just so many monumental records of the ancient traditions of English learning. I began to understand, I thought, how it happened that a little nation on a little island in the northern Atlantic became the leader in the world's empire of intellect, and the cradle

of a great civilization. This first impression made upon me by these ancient monuments was greatly amplified as soon as I caught even the first glimpses of the daily activity of Cambridge. The forenoons appeared serious and sombre to an outside observer; everybody wore a black cap and gown and everybody did apparently the same thing, going somewhere in search of sources of learning and inspiration. The intellect of Cambridge seemed to be in full action during the forenoons, and hence the solemn seriousness of the university town during the early half of the day. But the scene changed as if by magic when the midday had passed. The black caps and gowns disappeared, and in their places white flannel trousers and gaily colored blazers and caps adorned the college youths and many college dons. The same youths who in the forenoon, like sombre monks, were making a pilgrimage to some miracle-working fountains of wisdom joined in a gay procession in the afternoon, hastening to the sparkling fountains of athletic recreation. The intellectual activity of the forenoon was succeeded by the physical activity of Cambridge in the afternoon. To a stranger, like myself, who knew practically nothing of the famous university town, the change of scene between morning and afternoon was bewildering. It looked to me as if I saw a monastic-looking procession of serious and thoughtful men suddenly changed into gay groups of lively youths whose only thoughts were on the games which awaited them. By counting the different colors of blazers and caps and the coats of arms which adorned the athletic youths one could easily count the number of different colleges in the old university. These colors and coats of arms had a meaning, I thought, and I asked myself whether they did not, like the ancient college buildings, record the ancient traditions of the venerable seat of learning. They certainly did; they were a part of the symbolic language which told the story of the university's customs and traditions. It was clear to me that while at Cambridge my work was to be done in the morning and evening, and my playing in the afternoon, in accordance with the local customs. I stayed at a hotel for several days and watched

these external pictures of Cambridge life before I called on Mr. Niven of Trinity and on Mr. Oscar Browning of King's. I wished to get some picture of the daily activities at Cambridge before I presented myself to these learned men, and I got it.

Niven was expecting me and was ready with a programme of work which he had promised me in June, and I gladly accepted it. Both Niven and Browning assured me that at that late date lodgings in any college were out of the question, and that I must get lodgings in the town for one academic year at least. It did not matter, because very many students resided outside of the college buildings. I really preferred it, because I did not come to Cambridge to seek the opportunities offered by its college life; I came to study physics and find out how Maxwell answered the question "What is Light?" That was the only definite point in the programme which I brought to Cambridge; the rest was hazy and reminded me often of a Serbian proverb which speaks of a goose groping around in a fog to find its way. But I groped like a goose in a fog when I landed at Castle Garden and finally found my way. The saying, "Where there is a will there is a way," comforted me much.

My residence in lodgings outside of the college precincts had one great advantage. It gave me an opportunity to study English life from what I considered a somewhat novel point of view. It is the point of view which discloses to the foreigner English domestic life through the unique personality of the English landlady. During my eighteen months' stay at the University of Cambridge, I had an opportunity to study her wonderful ways, not only in Cambridge, but also in London, Hastings, Brighton, and Folkestone, where I used to spend my Easter and Christmas vacations. She was the same everywhere: dignified, reticent, punctual, and square; neat and clean in all her ways; willing and anxious to render service, but not a servant; possessing a perfect understanding of her own business which she minded scrupulously, but avoided carefully minding anybody else's business.

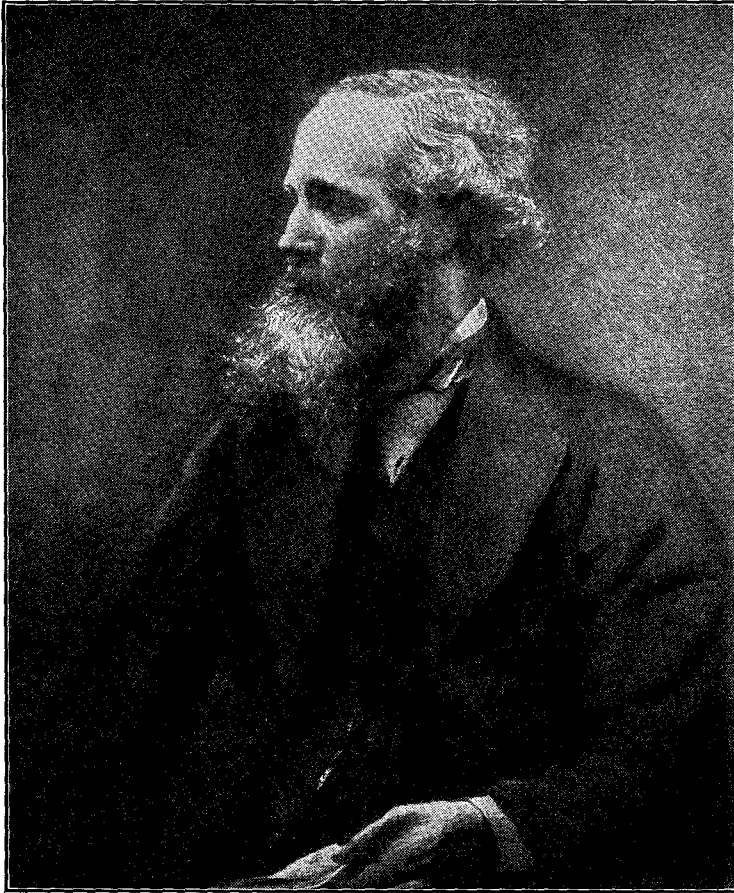
At Mr. Browning's request a Mr. Ling, the leading tenor of King's College choir, took me around to look for lodgings. He

belonged to the town and not to the gown, and was quite anxious to impress me with the many virtues of the town. He transformed our trip into an elaborate inspection tour of the student lodgings, because he was proud of them and considered them a very essential part of the great university. At that time I thought that he, a very enthusiastic townsman, was perhaps exaggerating the importance of this subsidiary instrumentality of the university. But when I got to know the Cambridge landlady and to understand her importance, I became convinced that Mr. Ling was right. I had not been in Cambridge more than a week before I learned the fundamentals of English domestic life, and I admired its wholesome simplicity. My landlady taught me these fundamentals, and in her wonderfully tactful ways she enforced their operation without my being aware that I was led around by her intelligent and forceful hand. I take off my hat to the English landlady, who, in her humble and unostentatious ways, is one of the eloquent interpreters of Anglo-Saxon civilization. She was one of my trusty guides and sympathetic assistants during my strenuous eighteen months at the University of Cambridge.

I started my work at Cambridge unattached to any college. But later I made up my mind to attach myself to King's College, yielding to repeated suggestions from my friend, Mr. Oscar Browning. But I did not change my lodgings. King's had less than a hundred students and many dons. Not one of them was a star in physics, and therefore the college had no attractions for me on account of the learning of its dons. But it had a beautiful chapel and a famous choir. The stained-glass windows of King's College chapel were famous as far back as Cromwell's time and they are still so. Every time I attended service in this glorious chapel I went away feeling spiritually uplifted. I attended regularly, although, as a member of the Orthodox faith, I was excused from all religious services. What the other students, belonging to the established church, considered as a stern duty I considered as a rare privilege. The chapel gave me a spiritual tonic whenever I needed one, and I needed it often.

I also yielded to Mr. Browning's suggestions to try for a place in the college boat, which I did and succeeded. Rowing was the only exercise which I took at Cambridge after I had become attached to King's, but before that I took long walks,

of the students at Cambridge was a matter of daily routine, regulated by customs and traditions. But these regulators were different for different groups of students. The student studying for honors arranged his work differently from the



By courtesy of the Columbia University Library.

James Clerk Maxwell (1831-1879).

First Director of the Cavendish Laboratory at Cambridge University.

usually with one of the younger dons or with a student who was engaged in the same book work in which I was engaged. They helped me to make myself familiar with the history of Cambridge and of the surrounding country. Everybody in Cambridge took his daily exercise just as regularly as he took his daily bath and food. I followed the universal custom; it suited me well and, besides, that was the best way to get along in Cambridge.

Physical as well as intellectual activity

arrangement which suited the needs of a Poll student, that is the ordinary student who did not aspire to academic honors. Their previous training was also different. The students who aspired to academic honors in mathematics were quite numerous, more numerous than the students in any other honor class. Cambridge, ever since the time of Newton, had become the nursery of the mathematical sciences in the British Empire. There were about five of these honor groups at Cambridge

in those days. Niven advised me to join the honor group in mathematics, the so-called mathematical tripos group, and he picked out a coach for me. Just as one straight line, only, can be drawn through two points, so the line of the student's intellectual activity at Cambridge was fixed when he had picked out the honor class and the tutor or coach to train him for the examinations prescribed for that honor class. To join the honor class in mathematics meant to work alongside of students who expected to become Cambridge *wranglers*. To understand the meaning of this it suffices to point out that no greater honor was in store for the ambitious youths in the university than to be a *senior wrangler* or to stroke a victorious varsity boat. The preparations for these glorious honors were just as careful as the preparations of a Grecian youth for participation in the Olympian games. I had no ambition to become a Cambridge wrangler, but Niven pointed out that a prospective physicist who wishes to master some day Maxwell's New Electrical Theory must first master a good part of the mathematical work prescribed for students preparing for the Cambridge mathematical tripos examinations.

"Doctor Routh could fix you up in quicker time than anybody," said Niven with a smile, and then he added cautiously, "that is, if Routh consents to your joining his private classes, and if you can manage to keep up the pace of the youngsters who are under his training." Three months before, when I first called on Niven, and when my pitch was very high, I would have resented this; but Idvor had lowered my pitch several octaves and I swallowed Niven's bitter pill without the slightest sign of mental distress. My humility pleased him, because it probably relieved him of some anxiety in connection with the question of managing me.

John Edward Routh, fellow of Peterhouse College, was the most famous mathematical coach that Cambridge University had ever seen. In his lifetime he had coached several hundred wranglers, and for twenty-two consecutive years he had coached the senior wrangler of each year. This is really equivalent to saying that a certain jockey had ridden the Derby winner for twenty-two consecutive years.

He was a senior wrangler himself in 1854, when great James Clerk Maxwell was second wrangler, and he divided with Maxwell the famous Smith's prize in mathematics. To be admitted by Routh into his private classes was flattering, according to Niven, but to be able to keep up with them was a most encouraging sign. Niven was anxiously waiting for that sign. Routh accepted me, but gave me to understand that my mathematical preparation was much below the standard of the boys who come to Cambridge with a view of preparing for the mathematical tripos examinations, and that I would have to do considerable extra reading. He also cautioned me that all this meant very stiff work for a good part of the academic year. I went to Cambridge to study physics and not mathematics, but, according to Niven and Routh, my real desire, as far as they could make it out, was to study mathematical physics, and they assured me that my training with Routh, if I could keep the pace, would soon lay a good foundation for that. Lord Rayleigh lectured on mathematical physics and so did famous Professor Stokes (later Sir George Gabriel Stokes), but according to Routh and Niven I was not prepared to attend any of these lectures, and much less to read Maxwell's famous mathematical treatise on his new electrical theory. Niven reminded me once of my first visit to Cambridge when I insisted that Cambridge without Maxwell had no attractions for me, and he asked me, jokingly, whether Lord Rayleigh's lectures were good enough for me. I answered that they certainly were, but that, unfortunately, I was not good enough for the lectures. "Next year you will be," said Niven, consoling me, and I, unable to suppress my feeling of disappointment, answered: "Let us pray that the starving jackass does not drop dead until the grass is green again." "What's that?" asked Niven, somewhat puzzled. "That is a free translation of a Serbian proverb, and I am the jackass," said I, and refused to furnish any further explanations. But Niven figured it out correctly in the course of the evening and laughed then heartily. He confessed that Serbo-American humor was somewhat involved and required considerable analysis.

The Cambridge colleges, some nineteen in number, resembled our American colleges in many ways. The career of the Cambridge Poll men was essentially the same as that of our American college boys. But our American colleges had no class of students corresponding to the Cambridge honor men. Referring particularly to the honor men who prepared for the so-called mathematical tripos, they came to Cambridge after graduating at some college outside of Cambridge. For instance, Maxwell came to Cambridge from the University of Edinburgh, and Routh came there from the University College, London. Both of them migrated to Cambridge, because their teachers in mathematics, like illustrious De Morgan, the first mathematical teacher of Routh, were mathematicians of distinction, and discovering in their young pupils extraordinary mathematical talents they developed them as far as they could, and then sent them to Cambridge for further development under the training of famous coaches who prepared them for the mathematical tripos. These teachers were usually former Cambridge wranglers, apostles of the Cambridge mathematical school, and they were always on the lookout for a fresh supply of mathematical genius for the nursery which regarded great Newton as its founder. This was the type of boys which I met in Routh's classes. They did not seem to know as much of Greek and Latin, of history and economics, of literature and physical sciences, as I did, but their training in mathematics was far superior to mine. They were candidates for the mathematical tripos, and no American college of those days had a curriculum which could turn out candidates with the preliminary mathematical training which those boys brought to Cambridge.

Routh had warned me that stiff work was before me for a good part of a whole academic year, if I was to keep up with the young mathematical athletes whom he was training, and he was right. I experienced many moments of despondency and even despair, and I needed all the tonic which King's College chapel could give me; I needed it very often, and I got it. Routh was a splendid drill-master even for those students who, like myself,

had no tripos aspirations. He certainly was a wonder, and everything he did was done with ease and grace and in such an offhand manner that I often thought that he considered even the stiffest mathematical problems as mere amusing tricks. Problems over which I had puzzled in vain for many hours he would resolve in several seconds. He was a virtuoso in the mathematical technique, and he prepared virtuosos; he was the great master who trained future senior wranglers. I never felt so small and so humble as I did during the early period of my training with Routh. Vanity and false pride had no place in my heart when I watched Routh demolish one intricate dynamical problem after another with marvelous ease. I felt as a commonplace artist feels when he listens to a Paderewski or to a Fritz Kreisler.

Long before the end of the academic year I finished Routh's preliminary tripos course in dynamics and much of the auxiliary mathematics demanded by it, and became quite skilled in solving dynamical problems. I had much difficulty in keeping pace with Routh's classes, but I succeeded and Niven was pleased. But I was not pleased; I did not think that I found there what I expected to find. In the course of time I discovered that I was not alone in my opinion; many distinguished Cambridge men failed to find in tripos drills the stimulating elements of that scientific spirit which leads to original research. I was a goose which groped around in a fog when I came to Cambridge; but, if I had come from an English college as a promising tripos candidate with my work cut out for me by my superiors and in accordance with old customs and traditions of Cambridge, I would not have discovered that there was in Cambridge at that time an epoch-making movement, the significance of which cannot be overestimated. I shall return to this point later.

Many a time during my early experiences in Routh's drill school I thought of my mother's words which described the steep and slippery climb which awaited me and which was leading, as she expressed it, to real stars from heaven. I felt the steepness of the climb, but I saw no star ahead of me. Routh was a great

master of the mathematical technique, but he was not a creative genius; he was a virtuoso but not a composer. His principal concern was to drill his students in the art of solving those conventional problems which usually formed part of tripos examinations. The poetical element of dynamics, which thrills and enthuses, was absent from his businesslike drills. The only star, I thought, which his students saw ahead of them was a high place in the tripos examinations, and that star did not attract me; recalling my mother's story I called it a tin star. I loved Routh and admired him much, but I did not admire the Cambridge tripos method of laying a foundation for mathematical physics. When Niven discovered my state of mind he sympathized, and he gave me a little book called "Matter and Motion" by Maxwell, a very small book written by a very great author. "You are not up to the mathematics of Maxwell's great electrical treatise," said Niven, as he handed me the little book, "but you will find no difficulties of that kind in this little book, which covers a very great subject." It was first published in America in the *Van Nostrand Magazine*. No magazine ever performed a greater educational service. There was not only much poetical beauty and philosophical depth in this tiny and apparently most elementary book on dynamics, but there were also many illustrations of the close connection between this fundamental science and other departments of physical science. Maxwell's presentation roused, and it also stimulated, the spirit of inquiry. Routh's elaborate system of clever tripos problems in dynamics appeared to me for the first time as little parts, only, of a complex and endless art which had grown out of a simple and beautiful science, the science of dynamics, which first saw the light of day at Trinity College, Cambridge. The exquisite art as practised by Routh and the subtle science as described by Maxwell, the two leading Cambridge wranglers of 1854, disclosed to me the real meaning of Newton, the greatest among the great Cambridge men, the creator of the science of dynamics. I knew then that I had seen one of the real stars of heaven of which my mother spoke.

But without the light of Maxwell I would not have seen the light of Newton. It will be seen further below that Maxwell and Routh, Cambridge wranglers of 1854, were the representatives of different mental attitudes in Cambridge: Maxwell was the apostle of the new and Routh of the old spirit of Cambridge. Niven was very fond of reminding me of my first visit when I told him that Cambridge without Maxwell had no attraction for me. After reading Maxwell's little classic I told Niven that my opinion was, after all, not as funny and strange as he represented it.

A short digression is timely now. I went to Trinity College occasionally to spend a Sunday evening with Mr. Niven. One Sunday evening I walked around the historical Trinity quadrangle, waiting until Mr. Niven returned to his rooms from the evening service in the college chapel. The mysterious-looking light streaming through the stained-glass windows of the chapel and the heavenly music radiating from the invisible choir and organ commanded my attention. I stood motionless like a solitary spectre in the middle of the deserted and sombre quadrangle, and gazed, and listened, and dreamed. Yes, I dreamed of great Newton, the greatest of all Trinity dons, and I saw how, two centuries before, he was treading over the same spot where I was standing whenever he was returning from a Sunday evening service in the very chapel at which I was gazing. I also dreamed of Maxwell, another great Trinity don, and remembered that, five years before, the very same choir and organ to which I was listening paid their last tribute to this great Cambridge man, when his earthly remains left the grief-stricken university on their last pilgrimage to Maxwell's native Scotland. But I knew that his spirit had remained at Cambridge to inspire forever the coming generations of ambitious students.

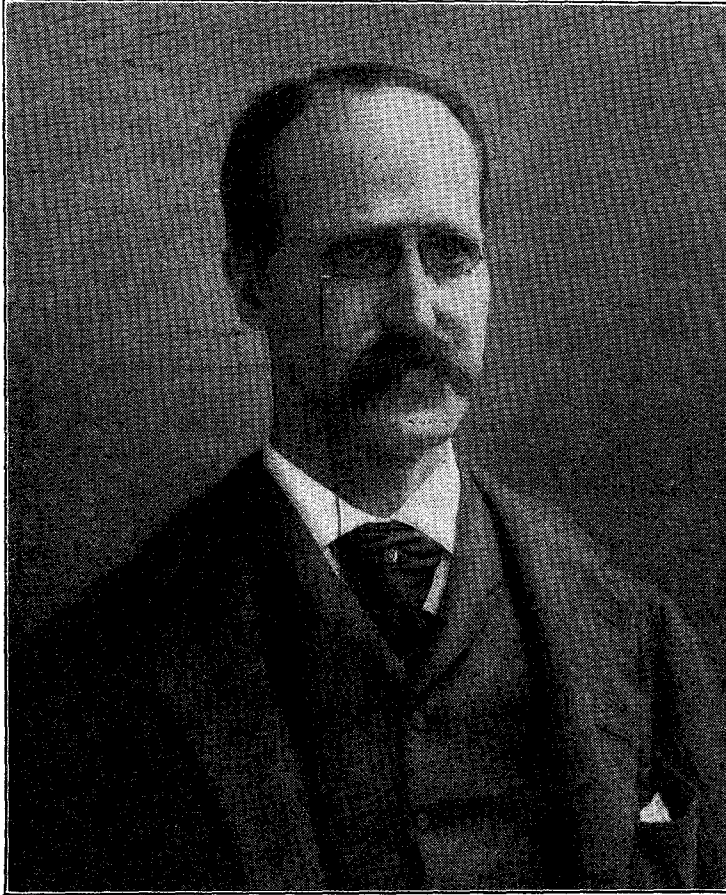
I dreamed of other great Trinity College men whose spirits seemed to hover about the sombre quadrangle rejoicing in the heavenly light and sound which radiated from the historical chapel where Newton and Maxwell worshipped in days gone by. I longed for the day when my alma mater, Columbia College, and other

colleges in America could offer such an inspiring scene to its students, and I wondered how soon that day would come. Niven told me the following story which, he thought, might answer this question:

A don of Magdalen College, Oxford,

which held me chained to Cambridge in spite of the fact that I did not believe that the Cambridge tripos method of laying a foundation in mathematical physics was fitting my particular case.

Students shift from university to uni-



Henry Augustus Rowland (1848-1901).

First Director of the Physics Laboratory of Johns Hopkins University.

was asked by an American friend how long it would take to raise, in America, a lawn like the famous lawn of Magdalen College. "I do not know," said the don, "but it took us over two centuries to do it here in Oxford." Niven implied, of course, that it will take much more than two centuries to create at any American college that atmosphere which surrounded me at the Trinity College quadrangle on that memorable Sunday evening. It was the mysterious charm of that atmosphere

versity in continental Europe, migrating to places where they are attracted by the reputations of teachers who happen to be there. I went to Cambridge because I thought that Maxwell was there. But at Cambridge, and at Oxford too, it was not only the teacher who was there but also the teachers who had lived there during generations long past which determined the choice made by ambitious students. The great teachers in the mathematical sciences when I was there were Lord

Rayleigh, the successor of Maxwell; John Crouch Adams, who, with Leverrier in France, shared in the great distinction of calculating from the perturbations in the orbit of Uranus the position of the still unknown planet Neptune; George Gabriel Stokes, the greatest mathematical physicist in Europe at that time, and the occupant of the professorial chair once held by great Newton. But that which brought the students in mathematical sciences to Cambridge was not only the lustre of the reputations of these great professors, but also the existence at Cambridge of a historical educational policy in the development of which many great Cambridge mathematicians of generations long past had made lasting contributions. The mathematical tripos was the most concrete expression of this traditional policy.

It can be inferred from what I have already said that this traditional policy did not suit me. I do not think that it would have suited any American student of those days who had a taste for physics. I said once to a Cambridge friend that my landlady, Routh, and rowing shaped the daily events of my life. He saw my point and admitted that each one of them represented a powerful determining factor in the life of a Cambridge student who was preparing for the mathematical tripos examinations. Each one of them had its deep roots in ancient traditions from which it was difficult to deviate. Routh was a rare product and a loyal apostle of the tradition called the Mathematical Tripos. It was perhaps the most powerful of all Cambridge traditions and stood as immovable as the rock of Gibraltar; its great strength was the fact that it had produced many distinguished men of science. But nevertheless some of the greatest living Cambridge physicists of those days felt that it had defects and called for remedies. It was claimed that its method, having no direct connection with the nascent problems of scientific research, was artificial and unproductive.

Sir William Thomson, known later as Lord Kelvin, was among the first who called for speedy remedies. He was the second wrangler in 1845 and Stephen Parkinson was the senior wrangler. Thomson left Cambridge and went to

Paris to get from the famous physicist Regnault what he could not get at Cambridge. After a year, when only twenty-two years old, he accepted a professorship in physics and directorship in physical research at the University of Glasgow. The long-headed Scotch were fully thirty years ahead of Cambridge in establishing a research laboratory in physics. Here Thomson worked out the scientific elements of the first Atlantic cable, and invented the instruments necessary for its operation. When I was in Cambridge the name of Thomson was attached to most measuring instruments employed in the electrical industries at that time, and he was also one of the leaders of abstract scientific thought. He represented in the popular mind the new spirit of Cambridge. Stephen Parkinson, Thomson's superior in the tripos test of 1845, was still in Cambridge when I was there and he had to his credit a text-book on geometrical optics, with stereotyped problems, suitable for tripos examinations. He was not among those who called for a change in the traditional mathematical tripos examinations at Cambridge. Maxwell, undoubtedly inspired by Thomson, was one of the earliest leaders of the Cambridge movement which demanded a modification of the mathematical tripos, favoring more the spirit of research and less the art of solving cleverly formulated mathematical problems. The Cavendish Physics Laboratory, organized by Maxwell and first opened in 1874, was, according to Niven, a concrete expression of this movement.

A similar movement was taking place in the United States in those days. Among its leaders were President Barnard of Columbia College, and Joseph Henry, the first and the most distinguished secretary of the Smithsonian Institution. The date of the foundation of Johns Hopkins University falls within the early period of this movement. Niven told me that what Maxwell had been doing in the Cavendish Laboratory at Cambridge was also being done by Maxwell's friend, Professor Rowland, at Johns Hopkins, founded in Baltimore in 1876. Maxwell thought very highly of his young American friend, and undoubtedly recommended him strongly to the physics professorship at Johns

Hopkins. Just as the establishment of the Cavendish Physics Laboratory in Cambridge marks the beginning of a great epoch in the development of physics in Cambridge and in Great Britain, so the organization of the physics laboratory at Johns Hopkins by Rowland marks a new and most fruitful era of scientific research in the United States. Rowland's influence had not yet been felt at Columbia College when I was a student there, nor at many other American colleges of those days. But the forward movement soon commenced, and the people of this country do not understand yet as fully as they ought to how much they owe to the late Henry Augustus Rowland, whom I had the honor of knowing personally and whose friendship I enjoyed for several years. One of the aims of this simple narrative is to throw more light upon some obscure spots of this kind which need more illumination, and particularly upon the work of men like "Rowland of Troy, the doughty knight," as Maxwell referred to him in his verses.

Another historical fact must be mentioned here which is very characteristic of the state of the science of physics in those days, and which is closely connected with the progress of this science as it appeared to me in the course of the last forty years. I mention now another great American physicist whose name, like that of Rowland, I first heard mentioned at Cambridge at that time, and that was Professor Josiah Willard Gibbs, of Yale. I know that many of my young colleagues will find it strange that I never had heard of Lord Rayleigh, of England, before I graduated at Columbia. What will they say when they hear that at that time I never had heard of famous Willard Gibbs, of Yale, New Haven, U. S. A.? Will they charge me with extraordinary ignorance for which Columbia of those days was to blame? That would be unjust, as the following story will prove. One evening, after dinner, I was enjoying at the University Club, New York, the company of some twelve Yale graduates, and one of them was the learned Professor William Welch, dean of the Johns Hopkins Medical School. He was then president of the National Academy of Sciences. Most of my Yale friends present were of

about my age or even older. I offered to wager that the majority of them would fail to give the name of the scientist who, in Doctor Welch's opinion and in mine, was the greatest scientist that Yale had ever graduated. Not one of them mentioned Willard Gibbs. When I mentioned his name they frankly confessed that they had never heard of him before. Neither they nor Yale College of those days were to blame. Did my fellow students at Cambridge, who were training for the mathematical tripos, ever hear of him before they came to Cambridge? If they did, it was by accident, just as I heard of it by accident. Such was the spirit of the times in those days; and it was against this spirit that President Barnard of Columbia took up arms. He considered its existence a national calamity. But I shall return to this point later.

I will now describe the accident just mentioned, because it is closely connected with the main thread of my narrative. In the beginning of the Easter term, the third term of my training under Routh, I had caught up with my class and had spare time for outside reading. Niven was greatly impressed by my enthusiastic eulogies of Maxwell's little book, "Matter and Motion," and he suggested that I take up the reading of another of Maxwell's little classics, "Theory of Heat." It was written with the same elegant simplicity as his "Matter and Motion." This little text-book on heat was the first to give me a living physical picture of the mode of operation by which heat is transformed into mechanical work, an operation which I watched so often in the Cortlandt Street boiler-room. I watched it, but I never dreamed that the operation could be described as Maxwell described it. According to him it may be considered as the resultant action of non-coordinated activities of an immense number of busy little molecules, each of which, as far as human observers can tell, moves about lustily according to its own sweet will. But, behold the miracle: the average activity of the countless crowd obeys with mathematical accuracy the fundamental law for heat transformations, the so-called second law of thermodynamics discovered by Sadi Carnot, the great

French engineer. It was Maxwell's little classic which also informed me that in all cases of very large numbers of individuals, whether they be active molecules or busy human beings, exhibiting as far as an observer can tell non-co-ordinated activities, we must apply the so-called statistical method of inquiry, that is the method which statisticians employ in recording the activity of a nation. Newton's dynamics, which at that time had been the food of Cambridge for two centuries, said nothing about that. It was a new idea in the heads of new men, who, under the leadership of Maxwell, were creating a new and far-reaching science. Up to that time Tyndall's poetical description of "Heat as a Mode of Motion" was my gospel regarding thermal phenomena, but Maxwell's plain and modest text-book, intended to stimulate the imagination of the inquisitive mind of the young student, was the first to assist me in forming my own judgment on the doctrines described by Tyndall and illustrated by beautiful experiments. Routh's training-table of tripos athletes offered no such morsels of stimulating food, because these athletes were training for tripos examinations and not for research in physics. I will say now that it was in Maxwell's theory of heat where I first saw the name of Willard Gibbs, and I heard from Niven that Maxwell held Gibbs in very high esteem. I must also say that Gibbs was the first in this country to write a splendid treatise on statistical mechanics.

When the Easter term approached its end in May I began to think of my summer vacation. I needed one. Seven months of steady drilling under Routh, supplemented by extra reading prescribed by him, and also by the reading of Maxwell's inspiring books, had produced results with which I was satisfied, and so was Mr. Niven, my Trinity College mentor. I certainly did not feel any more like a goose wandering in a fog; I saw much light ahead and felt much more confident that I saw the goal for which I was steering. But my pitch was very high and I needed de-tuning. I finally decided to visit some little place in France and selected Pornic, on the French Atlantic coast, in the department called Loire

Inférieure. I knew nothing about it except what I read in Baedeker, but it looked to me like a quiet little place where in addition to complete change of scene I should have a good chance to learn French. The names of Laplace, La Grange, and Ampère were mentioned so often and with so much veneration by Maxwell, that I felt ashamed of my ignorance of the language of France. Pornic was only a day's journey from Cambridge, and off I went with no other books in my bag except Campbell's "Life of Maxwell" and a French grammar.

The Pornic landlady was not up to the standard of my Cambridge landlady, but I did not complain nor make any invidious comparisons; the English were not very popular in those days on the Atlantic coast of France, where the oldest fishermen had not yet forgotten the operations of the English fleet during the Napoleonic wars. I was the only stranger in town and when it became known that I was an American who came to Pornic to study the language of France the village was mine. I engaged the village schoolmaster to give me French conversation lessons. I met him in his garden every evening and we talked to our hearts' content. He was a most entertaining little fellow, with a bald head, a red nose, and a big snuff-box to which he appealed very frequently for a fresh supply of interesting topics of conversation. He boasted among the villagers that his reputation as a French scholar had reached the United States and, *voilà*, that brought me to Pornic. I never denied it, but on the contrary I often walked through the village streets with the good old *maître d'école* and listened most attentively to his French accents as if they were the rarest pearls of wisdom.

When the villagers found out that I was not only an American but also a student of a great English university, then the stock of the little schoolmaster rose sky-high. My landlady informed me that the old curé had become quite jealous of the little man's rapid rise in the community. An old but renovated Norman castle was a part of Pornic; it stood on the very edge of the steep coast and it was inhabited in summer by a rich merchant of Nantes. The castle had a thick

grove of stately old trees, and there the nightingales revelled every night. On moonlight nights I spent many watchful hours listening to their mellow notes, accompanied by the solemn rhythm of the Atlantic waves striking gently upon the cliffs of the rocky coast, which appeared in my imagination, as I listened, like towering pipes of a giant organ. In daytime I selected lonely spots on the coast and there I spent my days from early morning till late in the afternoon memorizing my French grammar and vocabulary. Every evening I practised for an hour or so in conversation with my beloved *maitre d'école*. This advanced my knowledge of French very rapidly and before one month was over I could converse tolerably well. My circle of acquaintances expanded rapidly as my knowledge of French increased, until it took in the nightingale grove, including the family of the merchant from Nantes. Between my friends in the nightingale grove and my schoolmaster's garden my conversation in French became so fluent that it astonished the natives. They pronounced it perfect. But discounting this enthusiastic estimate by even fifty per cent I was still secure in my belief that I was enriched by a good knowledge of the language of a great civilization. A two months' visit to Pornic was originally planned; its end was very near, and my trip was a success. I bade good-by to my friends in little Pornic and arrived in Paris on the following day, the fourteenth of July, 1884.

Paris was gay, celebrating the national holiday of France, the anniversary of the storming of the Bastille in 1789. This gave me a chance to see many of the striking characteristics of the gay side of Paris in a single day. The next day, while visiting the great Sorbonne and the Collège de France in the Quartier Latin, I found a great treasure in a second-hand bookshop: La Grange's great treatise, "*Mechanique Analytique*," first published under the auspices of the French Academy in 1778. La Grange, the Newton of France! There was no student of dynamics who had not heard of his name and of his great treatise. My two months' stay in Pornic enabled me to appreciate fully the beauty of the language

of this great work, and my training with Routh eliminated many difficulties of the mathematical technique. I was convinced of that in my very first attempts in Paris at deciphering some of its inspiring pages. I described this short stay in France at some length, because I wish to refer to it later for the purpose of showing how little things can exert a big influence in the shaping of human life.

I had promised my mother to visit her again during that summer and off I went, deserting without delay the gay scenes of Paris. On my journey to Idvor I wasted no time looking to the right or to the left of my speeding train; villages and towns, rivers and mountains, and the busy folks in the yellow fields who were gathering in the blessings of the harvest season appeared like so many passing pictures which did not interest me. La Grange was talking to me, and I had neither eyes nor ears for anybody or for anything else. Oh, how happy I was when I saw Idvor in the distance, where I knew I should be free for nearly two months during that summer to read and to reflect, free from all restraints of the Cambridge routine. By the end of that heavenly vacation I had mastered a good part of La Grange's classical treatise, and in addition I re-read carefully Campbell's "*Life of Maxwell*," and I understood many things which I saw in Cambridge but did not understand before. The Cambridge movement which I described above was clearly revealed to me in the course of that summer, by a careful study of Campbell's "*Life of Maxwell*."

Idvor was never rich in books nor in people who paid much attention to books. To think that a native of Idvor would ever read a La Grange in his humble peasant home seemed incredible. The natives of Idvor noticed that, during my second visit, I was much less communicative than during the first, on account of my devotion to what they considered as some strange books, which to those who saw them suggested sacred books. The company of La Grange and of Maxwell kept me a prisoner in my mother's garden. I told my mother that Maxwell and La Grange were two great saints in the world of science, and she considered my reading

during that summer as a study of the lives of saints. That made her happy, but it puzzled the good people of Idvor. Studies of this kind they associated with priests and bishops, and noticing that I paid much less attention to bagpipes and kolo dancers and to other worldly things, they began to whisper about that Misha was getting ready to enter monastic life. What a pity, they said, to gather so much knowledge in great America and then bury it in a monastery!

My mother paid no attention to these idle whisperings. She knew better. When I described to her the ancient college buildings and the beautiful chapels of Cambridge, and the religious life of the students and of the dons, she listened spellbound. When I related to her the many traditions of the old university, and informed her that one learns there, not only from the teachers who were living there at that time, but also from great teachers who had long departed, a luminous expression in her eyes told me that

she was about to reveal to me an original thought. "I go to church, my son," she said, "not so much because I expect the priest to reveal to me some new divine truth, but because I wish to look at the icons of saints. That reminds me of their saintly work, and through the contemplation of their work I communicate with God. Cambridge is a great temple consecrated to the *eternal truth*; it is filled with icons of the great saints of science. The contemplation of their saintly work will enable you to communicate with the spirit of *eternal truth*."

With this thought in her mind my mother was most happy when I bade her good-by and, repeating her own words, told her that I must go back to "Cambridge, the great temple which is consecrated to the *eternal truth*." "Go back, my son," she said, "and may God be praised forever for the blessings which you have enjoyed and will continue to enjoy in your life among the saints of Cambridge."

(To be continued.)

The Night Path

BY FLORENCE HINES BUNTEN

I CANNOT wait the coming of the spring
Nor plant my garden, for the high gods say
That I must close my house and bolt the door
And take a journey—and I do not know the way.

I know that I shall not return again
When they shall take the key and bid me go.
They do not pity me, nor understand
Why I should love my house and miss it so.

Some say there is a mansion where I go,
A palace in my little house's stead;
Some say the pathway ends in soundless night;
What matter?—I can only bend my head.

I go into the terror of the dark.
No friend shall walk beside me, for none may,
Though he should sob his heart out. So alone
I take a journey—and I do not know the way.