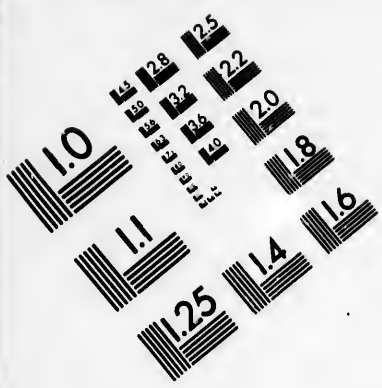

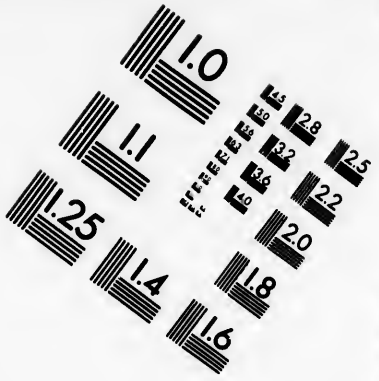

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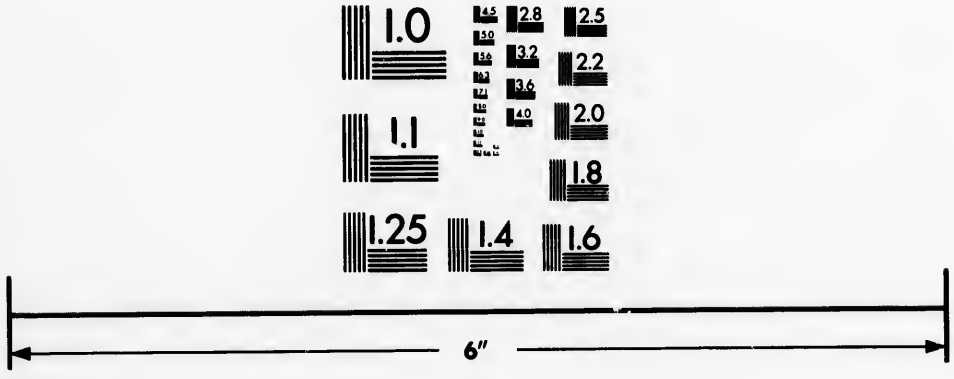

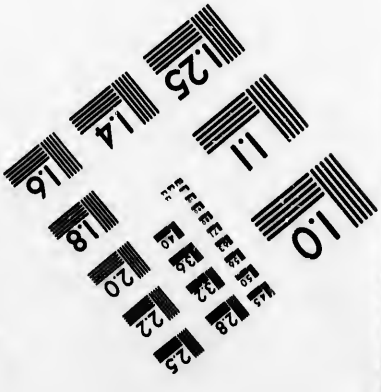

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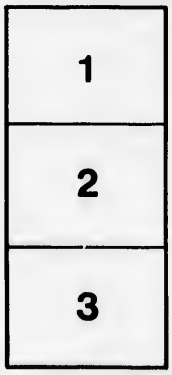
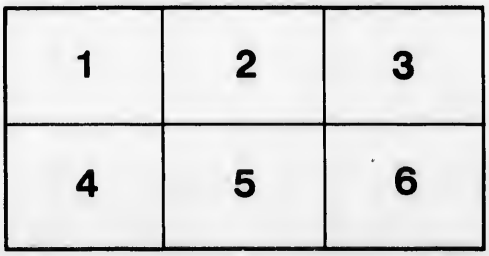




SCHOOL OF PRACTICAL SCIENCE,

PROVINCE OF ONTARIO.

Fourth Session, 1881-1882.

ON THE PRACTICAL USES OF SCIENCE

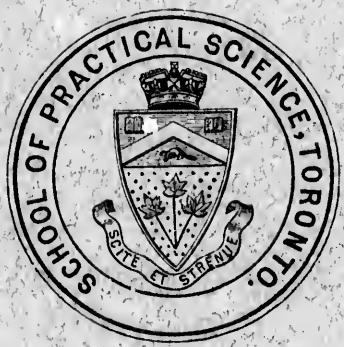
IN THE

DAILY BUSINESS OF LIFE.

THE INAUGURAL LECTURE TO THE EVENING COURSES OF LECTURES FOR WORKING MEN,

BY DANIEL WILSON, LL.D., F.R.S.E.,

President of University College, and Chairman of the Board of the School of Practical Science.



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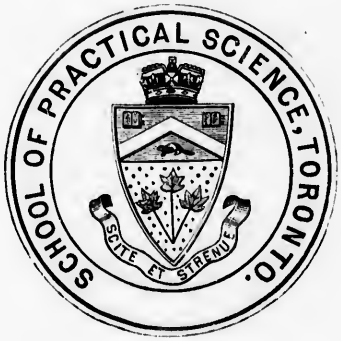

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ON THE PRACTICAL USES OF SCIENCE

IN THE

DAILY BUSINESS OF LIFE.

BY DANIEL WILSON, LL.D., F.R.S.E.

IN the organisation of the educational system of Ontario ample provision has been made for placing instruction within reach of all. Our Public Schools challenge comparison with those of any other land. For those who can give the requisite time, our High Schools and Collegiate Institutes carry the training onward to a more advanced stage; and beyond this is University College, with other colleges of various kinds, to complete the work for all who have the ability and the perseverance to follow it out, and win the rank of graduates in the faculties of the Provincial University. But there still remains the Department of Technical Education, for the training of skilled workmen to turn scientific education to practical account. The professors in University College include an efficient staff of instructors in the most important branches of science, and it has been wisely arranged to combine this teaching force with that of the very imperfectly equipped School of Science; and so, by their united action, to aim at elevating technical education to a rank in some degree corresponding to other departments of our educational system. Already, with the large number of undergraduates crowding the college lecture rooms, and the amount of work extending over the comprehensive field which is embraced in the University scheme, with its special honour-work in all the five departments of the faculty of Arts, the duties of the college professors are very onerous. Nevertheless, they have willingly undertaken this additional work; and hence the present scheme of supplementary evening courses of lectures of a more elementary character than those of the college, destined, as I confidently trust, to inaugurate a system of practical scientific training which will result in lasting benefit to the Province.

Apart from, and yet not without important relations to some of the controversies begot by political and social changes commanding the attention of all at the present time, this subject of technical instruction, and what is called science education, occupies a very prominent place. The providing of adequate training in the study of pure science is all-import-

ant; for the practical uses ever follow in the wake of the disinterested researches of investigators whose only aim is the mastery of the truths of science. But, while fully recognizing this, the time has come when it is indispensable that some adequate recognition be also extended to education of an essentially technical and practical kind, adapted for all those who are in any way engaged in the application of science to the arts of life. The waste of energy, and the costliness of misdirected industry, as the fruits of unskilled labour, more and more compel the anxious consideration of manufacturers, men of business, and of statesmen of true foresight. Economic industry more than ever demands the careful husbanding of all our resources, including the grand industrial army of mechanics, artisans, and all who bring pith and muscle to the labour-market as an article of hire.

The distinction between skilled and unskilled labour is an all-important one; and one, moreover, which acquires ever new significance with the combined progress of free institutions and a higher civilization. Man is a wondrously constituted vital machine, capable of being turned to account for an infinite variety of purposes. The Roman had fashioned him into the most perfect of military machines, to which he had only to say, "Do this, and he doeth it." The paintings of Egypt, and the sculptured alabaster of Babylon and Nineveh, show the toiling millions labouring in gangs to work out the design of the one overruling will. Stone after stone was quarried, hewn, transported to its site, and piled up, till by sheer brute force the pyramids reared their points skyward, and mountains were built on the desert's sands. Huge blocks of limestone or of granite were fashioned into colossal columns or statues, and transported to Karnak or Thebes, to Nimroud or Khorsabad, there to glorify the supreme taskmaster in obedience to whose mandate the multitude toiled as mere living machines. The result was, undoubtedly, in some respects grand and imposing; even as are some of the great earth-works of the Ohio and the Mississippi valleys: the product, too, of toiling multitudes, yet also embodying in their geometrical structure the evidence of an intelligent overruling will. The ruined temples of Egypt still attest what a marvellous machine man is, when set to work as no other machine can be: a vital organism, animated by intelligent volition, while subordinated to another intellect, for purposes beyond its own highest conceptions.

But the problem which modern civilization has set before it, is to make each man the skilled labourer working intelligently in obedience to his own volition; or in co-operation, like the ingenious architects of the beehive or the ant-hill, for some worthy end. Daily we suffer from unskilled labour: in ventilation, lighting, heating; in the work of the plumber, the gasfitter, the drainer, the builder. Churches and lecture-halls are built in which we cannot hear, and dwellings in which we cannot safely reside.

But knowledge grows, as it has ever done, as the true handmaid of freedom. It was so in the old days of Hellenic liberty, and among the free craftsmen of Florence and Genoa, in the period of the great Italian Republics. It promises once more to be so amid the ampler freedom which we here enjoy.

The skilled artisan may well be encouraged when he recalls in how many cases it has been to men of his own order, with few, if any, advantages of training or culture,—dependent for the most part on self-help,—that we have been indebted for discoveries of highest practical value: from Stephenson, the Newcastle collier; or Franklin, the printer's apprentice, to Faraday—greatest of modern electricians,—a mere journeyman bookbinder. But however welcome such exceptionally-gifted workers must ever be, what we now aim at encouraging is such a widely diffused knowledge of practical science among our workingmen as shall react in all ways in its application to the ordinary requirements of daily life. Among the evidences of a growing demand for the intelligent adaptation of knowledge to practical uses, a special prominence must be given to the Technological Colleges, the Schools of Practical Science, the Agricultural Colleges, and kindred institutions. To those are being added in the great centres of industry, Economic and Industrial Museums, such as the richly furnished galleries of the South Kensington Museum, the Industrial Museums of Edinburgh and Dublin, and kindred institutions in the commercial capitals of the Old and New World. Those truest schools of the people are the practical outgrowth of the International Exhibition of London in 1851, and of subsequent industrial competitions: from that first, and in many respects most striking of all the so-called Crystal Palaces, to the famous Centennial gathering at Philadelphia in 1876. The Palace itself—the model of all subsequent palaces of art, and the inaugurator of an entirely new style of architecture, adapted to the wants and to the achievements of the age,—was, as will be remembered, the device of no trained architect, but of John Paxton, the gardener, whose impromptu sketch on a sheet of blotting paper solved the problem, and gave new life to the movement.

Wise and far-sighted statesmen are awakening to the value of the vast, though too frequently wasted, power at the nation's disposal in the millions specially designated as its working men: the industrial armies of civilization. When, indeed, the first of those great international gatherings was in progress, sanguine philanthropists flattered themselves with the dream of universal peace. Nations were no longer to "murmur, snarling at each other's heels." The armed hosts of Austria and Russia, of France and England, were to beat their swords into ploughshares; and, marshalled under true Captains of Industry, were to labour thenceforth for the common good. *Punch* repointed his caustic pencil, and gracefully imperson-

ated Peace in angelic guise, seated on a disused Parrot gun, the touch-hole of which she guarded with her mantle. War was to be thenceforth recognized in its true light as an insane and brutal furor. The common sense of mankind was to hold a fretful world in awe

> "Till the war-drum throb no longer,
> And the battle-flags were furled
> In the parliament of men,
> The federation of the world."

How little, indeed, of the seer is there in our wisest previsions! The years that followed the inauguration of this fancied international Temple of Peace, have witnessed the Crimean War, the Indian Mutiny, the great American fratricidal strife of North and South, the Russo-Turkish War, the Franco-German War, the victory of Sadowa, the capitulation of Sedan. Art and science have indeed triumphed, but too frequently only as enlisted in the service of the War God: contending with perverse ingenuity in devising rival Krupp, Armstrong and Gatling guns, electric tubes, Palliser shells, Moncrief gun-carriages, breech-loaders, mitrailleurs, and the like ingenious devices for wholesale slaughter, until a new hope of peace dawns on the perplexed mind from the very perfection of such deadly engines of war. In all this we see, as it were, the perverse application of ever-growing knowledge and scientific progress to facilitate the wholesale destruction of life. The rude mail-clad baron, or man-at-arms of feudal times, vanished long ago; but in his stead we have now the mail-clad war ship, cased in invulnerable steel, and armed with its battering-ram and rifled guns: strange offspring of science in the novel rivalry in which she has undertaken to forge armour that shall be impenetrable, and to construct guns that no armour can resist! Even thus it may be that "the desire of all nations,"—the peace on earth and good will to men,—is to find its unlooked-for advent; for we will not doubt that through the ages

> "One increasing purpose runs,
> And the thoughts of men are widening
> With the process of the suns."

But, meanwhile, peace has her victories as well as war; and in those peaceful triumphs we may be permitted to revert with pride to the part which the mother country has taken in them also. It has been due in no slight degree to British skill, workmanship, and power of organization, under the conduct of men of true generalship, like the late Thos. Brassey, that the system of railway transport has developed, from its first crude beginnings in the English coal districts, to the grand triumphs of industrial enterprise which, after interlacing the continents of Europe and America with a network of railways, have revived the long-obliterated footprints of primeval civilization, till the shrill notes of the locomotive

re-echo under the shadow of the pyramids, and are familiar to the inert Hindoo beyond the Indus and the Ganges.

This element of scientific locomotion, in all the forms in which it enlists steam power in its service, is the grand revolutionizer of the modern world. The old commonwealth of Christendom, as it emerged out of the Dark Ages, consisted of a multitude of little states, or feudal baronies, standing apart, each eyeing its neighbour with rooted jealousy and distrust. Unskilled labour, enlisted in the service of some successful freebooter, perpetuated the rule of brute-force; and ignorance, with all its attendant privations, ruled supreme.

The Crusades began the needful reform. Peter of Piccardy and Godfrey of Bouillon were the leaders of enthusiastic hosts bent solely on redeeming the sepulchre of Christ from the infidel. Whatever else such expeditions to the scenes of sacred story might accomplish, they inevitably led to the diffusion of knowledge and an enlargement of international relations; to an interchange not only of commodities, but of ideas. The simple aim of the devout Crusader gave way ere long to the pride of knight-errantry and the love of adventure; and this was followed by the more practical aims of commerce. Before the discovery of America, the great trade of the civilized world consisted in the interchange of the products of southern Asia with Europe through the centres of commerce in the Levant. Tyre, once the mistress of the world's commerce, and the chief seat of commercial and manufacturing industry, perished; Alexandria in its turn gave way; Constantinople flourished for a time as the great mart of interchange between the East and the West, but it too sank into decay; while the grand crusading armaments called forth the energy and maritime skill of the northern Italian seaports, from which in time grew up those great centres of intelligent industry of the Middle Ages: the republics of Genoa and Venice; and that later Athens of old Europe, the Florence of Dante and Giotto, of Lorenzo Ghiberti, Michael Angelo, Benvenuto Cellini and Galileo. Little states, inferior in extent to the smallest of our Canadian Provinces—solely as the result of intelligent skilled industry, in the uncurbed energy to which freedom gives birth,—furnished the merchants and manufacturers, the artists, armourers, goldsmiths and bankers, and so became practically the masters of Europe. The little republics of northern Italy, with their trade guilds and merchant princes, were of more weight in the councils of Europe than England under her warlike Edward III., or France under her keen-witted Louis XI.

This, be it remembered, was mainly due to the skill of industrious communities of working-men. Labour was economised by its intelligent application to the desired results. Every workman was master of his craft, and familiar with the kindred arts which contributed to its development. The stone-mason as well as the sculptor was a draftsman; the worker in

brass and iron deemed it indispensable to master the science of metallurgy; the potter and glass-worker were adepts in the varied requirements of ceramic and vitreous art; masters in all of the chemistry that the old alchemists had then placed at their service. There was, in fact, everywhere a wise economy of skilled labour. The workman found a pleasure in his task; and when mere unskilled labour was needed, as in the service of arms, the sturdy craftsmen, who were themselves gallant burgher-soldiers, enlisted the Condotiore to do the hireling task-work on which their skilled labour was too precious a thing to be squandered.

It was a grand step in relation to all later progress when the old isolation of the nations was brought to an end, and commerce renewed the interchange between the East and the West. But what mighty changes have been wrought since the times when the voyagers from Venice or Genoa to the Levant undertook what was to them a far more formidable adventure than the crossing the broad Atlantic, or even the circumnavigation of the globe, would now appear! Bacon symbolized this great factor in all advancement of human knowledge on the title-page of his Novum Organon, nearly two and a half centuries ago, by the figure of a ship sailing through the pillars of Hercules into the outlying ocean beyond which lay our western hemisphere; and beneath it, in the old Latin of the Vulgate, the words of the prophet Daniel: "Many shall run to and fro, and knowledge shall be increased." But no better argument in favour of the encouragement of industrial science can be urged than the loss which we are constantly incurring from the lack of knowledge on the part of the indefatigable pioneers who run to and fro so ceaselessly through our own wide domain, and yet bring back to us such infinitesimal results of their wanderings. The shores and islands of Lake Superior abound in mineral wealth, and include within their limits some of the very richest silver and copper deposits in the world. They reveal, moreover, interesting evidence of the working of their mineral wealth in times long anterior to that voyage of Columbus which prepared the way for our entrance on this rich inheritance. The Arthabaska region abounds with petroleum; the Moose River and its branches yield gypsum in abundance; the Mackenzie River and other localities beyond the fertile prairie lands, the river-beds of British Columbia, and even the sterile shores of the Hudson's Bay, abound in iron, lead, copper, and gold; the great valley of the Saskatchewan discloses abundant traces of the still more precious mineral, coal; and rich seams of anthracite are already reported in Victoria.

Our young adventurers who wander into that great North-West know well how to provide themselves with needful arms and ammunition, stores, camping outfit, and all other accredited requisites of the pioneer; but how many of them could tell gold from mica or pyrites, platina ore from

iron-sand, or diamonds from crystals of quartz? How many on their return could give any intelligent report as to the flora of the district, its peculiar botany, or the economic value of its timber; or furnish the slightest hint as to the geological character, or the mineral resources of the regions which they have traversed? Their eye has been attracted, perchance, by specimens of white glistering stone, but they cannot even guess if it was worthless quartz, a useful limestone, valuable felspar, or prized mineral phosphate of lime. They are wholly unable to say whether the district through which they passed was limestone or sandstone; of the carboniferous age, with possible promise of coal; the bituminous limestones and shales of the Devonian age; or the Laurentian rocks with their great beds of oxide of iron, their vast limestone strata, and, more interesting than all, their strange Eozoon, with its seeming glimpses of the first dawn of life on our planet.

Abstract science stands far apart from the every-day business of life; and the industrious workman, absorbed in his useful but exacting duties, may claim exemption from any special call to explore its intricate by-ways. Yet let no one give encouragement to the idea that his lack of advantages furnishes an adequate excuse for ignorance. Consider what has been accomplished by many with greatly less advantages than are within reach of the very poorest Canadian boy. I remember the great traveller, Livingstone, whom I knew in his earlier years, as a youth fresh from the weaver's loom, busy in Professor Graham's laboratory in University College, London, preparing himself for his great life-work. You are all familiar with the name of the Cromarty stone-mason, Hugh Miller, and his enlargement of the domain of geological science and palæontology, as the result of his own unaided researches in the Old Red Sandstone, which he first worked as a poor handicraftsman with mallet and chisel. Or, to take examples which appeal more nearly to all of us than such rare and exceptional cases: Consider how much was done under every conceivable disadvantage by another self-taught geologist, Robert Dick, the poor baker of Thurso; and again by the still poorer Thomas Edward, the shoemaker of Banff, as a naturalist. Nor can we safely admit of the idea that any study is profitless. The relations which the abstrusest of the abstract sciences bear to the every-day avocations of industrious communities like our own, are the links of a continuous chain, forged not infrequently by the sagacity of some intelligent artisan like yourselves. The name of James Watt suggests itself to all minds as the ingenious mechanist who transformed the unheeded vapour of the tea-kettle into a mighty force to revolutionise the world. The centenary of the birth of another of England's skilled labourers, George Stephenson, has recently been celebrated. But the generation has not yet wholly passed away that witnessed the first practical application of his sagacious skill. And how

vast are the results due to his mastery of applied mechanics! The revolutions wrought by an Alexander or a Napoleon are evanescent when compared with such comprehensive and enduring triumphs. In a thousand ways the steam-ship and the railway have changed the whole conditions of life. On our own continent they have converted its great rivers and lakes into the vital arteries of the Dominion; and are opening up to millions from the old world an illimitable expanse of rich prairie land, which, but for the fertile genius of Watt and Stephenson, must have remained a profitless wilderness, abandoned to the buffalo and its savage hunters. Yet the germ of the steam-engine, as of the telescope and many another scientific achievement of modern centuries, had dawned on the mind of Roger Bacon in an age incapable of turning his conceptions of science to any useful account. It was an untimely birth. The philosophy of that age exhausted itself in the barren speculations of the scholastic quadrivium, while the artisan was a mere unskilled drudge, if not the poor serf toiling at the bidding of some scarcely more intelligent lord of the soil.

The first steps in the evolutionary process through which the steam-engine at length came into practical use may be traced in the thermometer and the air-pump of the seventeenth century. Then came the application of steam to pumps for mines; next, the river steamer; then the railway locomotive; and then its indispensable handmaiden, the electric telegraph: all begot by the application of forces lying idle around us; yet only needing a Franklin, a Wheatstone or Faraday, a Watt or a Stephenson, to have turned them to the like account centuries before. But knowledge, with the power which is its inevitable concomitant, was wanting; otherwise the grand revolutionizer of this nineteenth century might have been anticipated by earlier generations; and for them, as it has for us, accelerated travel, stimulated industrial and commercial enterprise, and linked together nations hitherto kept apart, not alone by continents and oceans, but by mutual jealousies, the brood of isolation and ignorance. It has promoted the interchange of useful commodities, and of still more useful ideas: quickening thought, stimulating co-operation, and intensifying life, till experience responds to the poet's utterance—

"Better fifty years of Europe than a cycle of Cathay."

Hand in hand with the steam-engine and the railway have advanced the telegraph and the newer telephone. The results only a few years ago would have seemed inconceivable; yet let us not fancy that the triumph is now completed, and so we may fold our hands and sit down in listless epicureanism to its enjoyment. The arena for the skilled workman has not been narrowed, but widened. We, too, may, and ought to be, among the workers,

"Ever reaping something new,
That which they have done but earnest of the things that they shall do."

The ocean steam-ship, with its transit from Europe to America in eight or nine days, is a marvellous triumph, inconceivable even to philosophic minds within our own recollection. The period, indeed, is not very long past since Dr. Lardner demonstrated to the entire satisfaction of himself and others, that is was impossible for a steam-ship to make its way across the Atlantic. Nevertheless, notwithstanding all the marvel of its triumph, the ocean steamer, with its profitless freight of fuel, to be consumed and flung overboard as a waste product ere the voyage is done, falls far short of our ideal of scientific completeness, and will undoubtedly be, sooner or later, recognised as a clumsy, imperfect machine. The requisite revolution has yet to be wrought by means of a condensed fuel which shall free the hold, now monopolized for the engine-room coal. The discovery is looked for which will thus double the capacity of the ocean steamer, correspondingly reduce the cost of transport for goods and travel, and greatly accelerate the speed of the disencumbered ship. The object has been already aimed at by the employment of our abundant mineral oils, to be stored away between the outer and inner plates of the iron ship, and so occupy space at present useless. But that idea is already superseded by the promises of the latest feat of science, the storing of electric force, with all its grand premonitions of future triumph. The rivals of England have in recent years comforted themselves with the assurance that her supremacy in commerce and the industrial arts must end with the exhaustion of her coal fields; and some among her own sons have quailed in the anticipation of such a crisis in no distant future. But long before that result is realized science gives promise of inexhaustible substitutes from the electricity of the earth and the oxygen of the sea. Here, accordingly, are resources which have lain unheeded from the dawn of human history and, yet all the while were as available as now for the service of man. The name electricity—first applied in its modern sense by Gilbert of Colchester in 1600,—perpetuates the history of its simple beginnings. *Electron*, that is, amber. It had been noticed by the observant Greeks upwards of 2,000 years before, that on applying friction to amber what we now know as electric force was the result. The test is one of the very simplest experiments. Rub a piece of amber—or, what will answer equally well, a stick of sealing wax,—briskly on the sleeve of your coat, and then hold it near fragments of paper torn up for the purpose of this experiment. They are seen forthwith to be agitated, while the smaller pieces fly towards the amber or wax, and even adhere to it, until the electrical force subsides. By-and-by glass was substituted for amber, with certain important differences in the electricity thus generated; and so man entered on the intelligent mastery of this marvellous latent force, to which we already owe so many practical triumphs of science, with still greater promises assured. As the outgrowth of that first, and seemingly

insignificant, manifestation of electrical phenomena by means of friction applied to amber, the electric telegraph has superseded all the older methods of communicating by bale-fire, semaphore, or other process of message-sending by signals; and now advances hand in hand with the steamship and the railway, accelerating the practical uses of both in the service of commerce. Fact and fancy meet together in as strange conjunction as in "Alice's Wonderland," realizing for us "The Fairy Tales of Science." In the visions of "A Midsummer Night's Dream," *Puck* engages to "put a girdle round the earth in forty minutes;" as again, in the romantic idealism of Shakspeare's exquisite comedy of "The Tempest," Ariel, when recounting his fulfilment of Prospero's errand, exclaims:—

> "Jove's lightnings, the precursors
> Of the dread thunder-claps, more momentary
> And sight-outrunning were not!"

But the realities of modern science outrival the brightest fancies of the poet; for it has made the lightning its message-bearer, and now aims at literally harnessing it to its car. The first steps in the discovery of this novel force were simple enough. But electricity produced by friction is evanescent. Two more centuries had to elapse, and then came the practical device of Volta of Pavia, whose name is permanently associated with voltaic electricity. He had already shown that the electric spark could be employed to kindle gases, and so led Cavendish and Priestly to the important discovery that water is not an element. Next followed Galvani of Bologna, who, according to the long-accredited story, while prosecuting certain physiological researches, was struck by the remarkable action produced by his electric machine on the limbs of some frogs which his wife was preparing for the table. Hence galvanism, and the recognition of the presence of electrical currents in the human and in all animal bodies. Those discoveries belong to the closing years of the past century. It was not till the year 1800 that Volta devised the battery which bears his name, and so furnished the means of producing by chemical decomposition a continuous stream of electricity, fit to be enlisted as the world's message-bearer, and so to open up the way to all later triumphs.

But you must note in all this how much has depended on the intelligent observation of what was all the while within reach of every one alike. It is the old story of "Eyes and no eyes." And yet rather when we contemplate ourselves as thus surrounded with mighty unseen, silent forces—the essential element of combustion in the ocean; the earth itself one grand electric machine,—may we not rather compare ourselves to the faithless servant of the prophet, looking in vain from Dothan's beleaguered walls for hope or aid, until with instructed vision he could discern the angelic hosts and the chariots of fire which all the while had surrounded

them on every side? We too need to have our eyes opened that we may see how we are environed by a multitude of forces not less marvellous, and to learn that we only need the insight which science offers freely to all, to discern their true value and practical uses. How many, therefore, are the hindrances and privations to which we submit from the lack of knowledge easily accessible to us. It is to the acquisition of this that you are now invited. Wholly apart from any immediate practical application, or commercial value, the mere pleasure which the acquisition confers is an abundant reward for any labour that it involves. But some comprehension of the practical operations of science is becoming indispensable to every man who aspires to be anything more than the mere unskilled drudge. The age is one of unparalleled progress. Science advances so fast that we have ceased to wonder at its strangest feats. Telegraphy flashes its messages from continent to continent, and we no longer marvel as we read in our daily extra of occurrences which transpired an hour before, not in Europe only, but in India or at the Cape. Nay, more: by means of the telephone we hold actual converse with distant cities, and are even prepared to learn without surprise of the Atlantic cable being superseded by an oceanic telephone. When we realize in all its comprehensive bearings the revolution which has been wrought within a few brief years by this practical annihilation of time and space, and consider in how many ways it might have influenced the world's past, we may well ask what were the impediments to the earlier mastery of such momentous discoveries: not that we may thereby censure the blindness of other generations, but that we may be stimulated to win for ourselves all that lies within our reach; to enlarge to the utmost the acquisitions of the present, and so, as it were, to anticipate the future. The electric force on which such grand results depend was not only as available in any earlier century as now, but it had already been brought into use in the mariner's compass. Relying on the ever faithful magnetic needle, Columbus boldly steered into the unexplored Atlantic, and found for Leon and Castile a New World. The date was 1492; the Old World's mediæval centuries had already been startled from their lethargy by the shock of ruined empires; and our western hemisphere—like the Sleeping Beauty of the nursery tale,—awaited but the touch of the bold adventurer to start into the life which has since then helped to quicken the Old World as well as the New. But all this was the work of skilled labour. The rude sailor of mediæval centuries had given place to well-instructed navigators, such as Henry of Portugal and Columbus of Genoa. They had learned the use of the compass and the astrolabe; had fully mastered the mathematics as well as the astronomy of their age; and applying both to the problem of ocean navigation, had determined for themselves the spherical form of the globe and the consequent possibility of reaching the shores of Asia, which lay

in the remotest east, by pursuing a western route. Among all the examples of scientific faith, none can surpass the unfaltering persistency with which Columbus steered onward into the unknown west, in the assured belief that—undreaming of an intervening continent,—he must thereby reach the coast of Asia: the India which he was in search of, and which he believed he had actually found when he first sighted land.

In thus treating of the uses of science in the daily business of life, I have purposely given a prominence to those great factors in the progress of the civilized world, the discovery or application of which has been more or less due to the intelligent labours of skilled mechanics or self-trained discoverers. But it is more and more coming to be seen and felt that the wealth of nations depends on the highest application of knowledge and skill in every department of industry. The old proverb which bids the shoemaker stick to his last, is no longer accepted as an absolute embodiment of sound political economy. On the contrary, it is a very noticeable characteristic of this New World that men have cast off many an old prejudice, and, among the rest, are accustomed to view not only without suspicion, but with genuine admiration, the gifted man of humblest lot, "who breaks his birth's invidious bar." The great missionary and linguist, Wm. Carey, was sneered at by his clerical reviewer as a cobbler! His name ranks now among the benefactors of India and of the world. Yet, in a sense, it is better that the cobbler do stick to his own craft; that each one of us, having chosen his special work, throw his whole energy into it, bringing all possible skill and knowledge to its improvement, and so making the very best of possible shoes, or whatever else we undertake, instead of working in shoddy and Devil's dust, and earning in the end the Devil's wages, as all such workmanship deserves, and is sure to do. Years ago, as you are aware, the attempt was made to organize in Toronto what was at first styled a College of Technology. Without adequate advice, the Mechanics' Institute building in Church Street was purchased and fitted up. But that proved to be altogether unsuitable. As you will find stated in the School prospectus, it could not afford the laboratory and other accommodation required for instruction of the special nature aimed at; and moreover was not furnished with the requisite appliances or apparatus. It became necessary, therefore, that a new building should be erected, and for this a site was given by the University of Toronto, on its own grounds, and in such close proximity to University College as to admit of effective co-operation, and a wise economy of their joint resources. Here accordingly we are met to-night in what may be fitly designated the working man's branch of the Provincial University. By the united action thus effected it was rightly considered that an economical mode could be adopted for establishing an institution which, without attempting to rival the larger and more expensive schools of science of

Europe or of the United States, in the technical training of its students, would nevertheless supply a want in our educational system, and afford facilities for practical scientific education, with a direct bearing on the professions or occupations which the students might wish to follow. It would thus, in fact, become a *School of Practical Science*, and as such would secure benefits amply justifying the expenditure requisite for its establishment and maintenance. Such, then, is this People's College; it remains to be seen how far those for whom such practical advantages are thus supplied will be found prepared to avail themselves of them, and so encourage us in giving permanence to a movement which, so far as the professors of University College are concerned, must involve a great addition to the amount of work already devolving on them.

The aim of the School of Practical Science, as you will see by a careful study of the syllabus of its courses of instruction, is to train intelligent workmen for all the ordinary applications of skilled labour. The courses of evening lectures which are now to be proceeded with, are not at all designed to be popular in the sense of providing a mere evening's amusement, as is the avowed purpose of most of the lecture courses announced for our winter evenings. Their aim is to offer to the intelligent artisan, and to all other practical students, the elementary knowledge requisite to start them on lines of enquiry leading to systematic research in every branch of technology specially adapted to useful handicrafts. The knowledge thus communicated in relation to Chemistry, Geology, and Natural History, to Natural Philosophy and Mechanics, though necessarily—in so far as these evening lectures are concerned,—elementary, will be carried so far as to be of practical utility to the machinist, the brass-founder, the plumber, the carpenter and builder; while it will, it is hoped, prove in some cases only the introduction to more advanced studies. Those who may hereafter be tempted to devote the requisite time to it, will find, in the daily work of this School of Practical Science, Applied Mathematics taught by experimental instruction in the laws of Statics and Dynamics, with special reference to structures and machines; and of Optics and Acoustics in all their most important practical bearings. The department of Engineering embraces both field and office work, chain, compass, and theodolite surveys, and plotting in setting out and levelling. It includes methods of keeping field notes, determination of heights and distances, of the meridian, local time and latitude, longitudinal and cross sections, setting out straight lines, curves and levels; mensuration, including lines, surfaces, and solids, timber, masonry, iron and earthwork; capacities of reservoirs, discharge of streams, etc. It deals with applied mechanics generally; treats of the strength of materials, and the methods and processes of construction; with much else of essential value to hundreds of the working men of Ontario. So, in like manner, the elementary

courses of lectures on Chemistry, to be given in successive evenings during the present winter, will form a fit beginning to the medical or veterinary student, to the druggist, the painter, the metal-worker, and others in the study of that most useful science. Without going further, he will find that he has acquired much valuable information; while to those who aim at a more extended and practical mastery of chemistry, the detailed instruction in the daily work of the laboratory as taught in the morning classes devoted to Applied Chemistry will introduce them to a knowledge of the metallurgy of iron and steel, of lead, copper, silver, and gold; or again, to the chemical constituents of mortars, cements, artificial stones, etc.; to paints, and all preservatives of wood, stone, and iron.

So also is it with the departments of Natural History and Geology. Practical Biology will embrace the use of the microscope, the study of animal and vegetable tissues; and, in the morning classes, includes Botany, Zoology, and Comparative Anatomy. As a branch of Natural History, not without some practical bearing on important questions of the present day, the lectures on Ethnology will embrace anthropology; the special characteristics of the human skull, its bones and sutures; structure and functions of the brain; typical race-forms of head; the hair, colour, and other distinctive ethnical elements; succession of races; physical evidences of diversity of race; and the general bearing of philological evidence on the same subject. Geology includes in its laboratory work the use of the blow-pipe, assaying of ores and metals, with the general study of the geology and economic minerals of Canada, and the special characteristics of metallic veins and other mineral deposits. At the same time, it would be to mislead you if I left you to assume that the practical laboratory, with all the processes of the assayer and the analyst, can be brought within reach of all in any easy and popular fashion. The work is laborious, the needful apparatus costly, and only those who can give the requisite time must expect to master the processes of analysis, or be able to do thoroughly the useful work of the assayer. There is no royal road of easy, unlaborious tread to any kind of useful knowledge; but even a little knowledge is useful, and in not a few cases it proves the incentive to the acquisition of more. I fully anticipate, however, that the course of lectures about to be given by Dr. Ellis, on Inorganic Chemistry, will be followed up hereafter with facilities introductory to practical laboratory work; and in the department of Natural History the Professor has already completed arrangements for including the use of the microscope in the work of his evening lectures this winter.

With the affiliation of University College and the School of Practical Science, it has devolved on me, in my special relation to both, to introduce this series of evening lectures designed to advance technical education, and to bring it more within the reach of the working classes. In some respects

it lies apart from my ordinary duties, and the work I am best fitted to do; so that you might perhaps be tempted to recall for my own guidance the wise maxim which bids the cobbler stick to his last. Nevertheless, special circumstances long ago made me in some degree familiar with this kind of work, so far at least as to lead me to take a special interest in it. My late brother, Dr. George Wilson, distinguished as a man of science, and a lecturer of rare ability, occupied the first chair of Technology founded in any British University; after having for years conducted with marked success the department of Chemistry in the Edinburgh School of Art: one of the earliest and most successful of the British Schools of Practical Science. Its influence in the training of skilled mechanics is widely recognized; and in its laboratory and lecture-room, as well as in those to which my brother transferred his practical teachings at a later date, I learned to estimate as of highest worth the influence of such Schools of Science for the people. The institution which now offers you similar facilities, though liberally provided for so far, still requires important additions both to its equipments and teaching staff, to make it what such a People's College for Ontario ought to be; but if the working men, in the amplest sense which that term implies, show an adequate appreciation of its advantages, we cannot entertain a doubt that it will be adequately furnished with all that may prove to be requisite for purposes of such practical value not only to this Province, but to the Dominion of Canada.

Our country stands peculiarly in need of such practical scientific training. With immense public works now in progress, stretching across the continent from the St. Lawrence to the shores of the Pacific; with agricultural and mining resources unsurpassed by those of any country in the world; and just entering on the organization of many new branches of manufacturing industry: it remains to be seen whether we are prepared to continue dependent on imported skill, or to train our own miners and analysts, our engineers and machinists, our potters, glass-workers, and alchemists of all sorts; and so to turn to account a phalanx of skilled Canadian workmen, marshalled under our own Captains of Industry, to solve the grand problem of our young country's destiny, and to prove the Dominion of Canada not unworthy of the good old British stock from which it has sprung.

It is not without a special purpose that, while aiming at directing your attention to the value of science as part of the training indispensable for the skilled workman, I have given prominence to those mighty forces which lay for so many centuries unheeded and valueless. Education, technical or otherwise, is the grand lever by means of which we can hope to move the inert mass, combine our scattered resources, and make the powers of nature subservient to our needs. All knowledge—the profoundest culture, the most abstruse learning,—has its practical uses,

though these may be slow to manifest themselves; but much of that science wherein lies true power is within reach of all; and every fresh acquisition of knowledge is a vantage ground from whence to win new conquests. Once you have mastered any branch of science in its practical bearings, you are like the wise Prospero, with his Ariel and other spirits of the elements at his bidding, each one of them ready to your hand to enlist the forces of nature in the commonest services of daily life.