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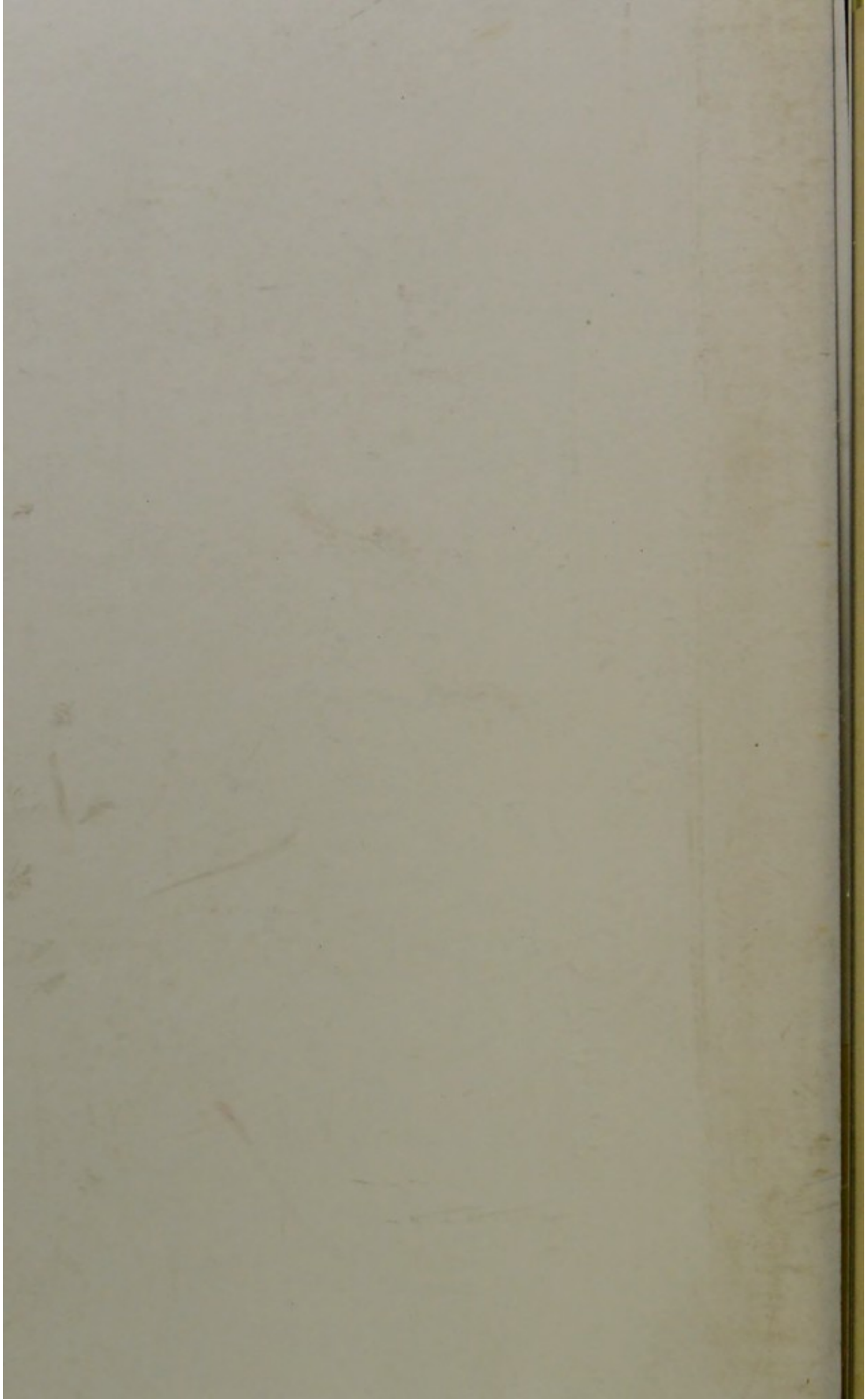
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WHAT IS TECHNOLOGY?

AN INAUGURAL LECTURE

DELIVERED IN THE

UNIVERSITY OF EDINBURGH.

ON NOVEMBER 7, 1855.

BY

GEORGE WILSON, M.D., F.R.S.E.,

REGIUS PROFESSOR OF TECHNOLOGY IN THE UNIVERSITY, AND DIRECTOR OF THE
INDUSTRIAL MUSEUM OF SCOTLAND.

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The Lectures on Technology for the Session 1855-56, will be delivered at 12 o'clock daily, in the Laboratory of the Industrial Museum, behind the Royal College of Surgeons. The subjects chiefly discussed will be, the Economic Production and Application of Heat and Light; the Economic Production and Application of Electricity; the Economic Application of the Photogenic Art; the Principles of Metallurgy and certain allied subjects, as more full explained at pages 21 and 22 of the Introductory Lecture.

* * * Those Manufacturers and others who propose sending Specimens to the Industrial Museum, are requested to communicate with Dr Wilson, who will send them Lists of the objects which are most desired.

Samples illustrating any of the Industrial Arts, will be highly prized, and especially such as explain the progress of a Manufacture through its different stages. Models of Machinery will likewise be very acceptable.



WHAT IS TECHNOLOGY?

GENTLEMEN,

I HAVE been honoured by her Majesty with the first presentation to a Chair which is new to this University, and new to the other Universities of the country. The title of the Chair, also, is as novel as its creation, and the term "Technology," by which it is distinguished, is so unfamiliar to English ears, and so inexpressive to English minds, that I must, at the very outset, explain what the branch of knowledge is which I am called upon to profess.

The word "Technology" appears to have been first explicitly employed in the sense in which it concerns me, in 1772, by Beckmann, the famous author of the *History of Inventions*, who was for many years "Professor of Economy in the University of Göttingen."¹ Availing himself of the liberty conceded to professors in German Universities, to lecture on any subject within their *Faculty*, he chose the Industrial Arts as the topic of a series of prelections, and entitled the science of these arts—"Technology." The word had long been in use among the Germans in various senses, but since Beckmann's time has been pretty generally accepted as signifying what he denoted by it; and a certain fixity has been given to this meaning by the establishment of Chairs of Technology in several of the German Universities, among others in that of Giessen, where Dr Knapp (since transferred to the corresponding Chair in Munich) acquired great celebrity as professor of this branch of knowledge. Through him the word Technology has been introduced into our language, his well known work, "*Chemical Technology*,

¹ *Knapp's Chemical Technology*. 1848. Vol. i., p. 1.

or *Chemistry applied to the Arts and Manufactures*," having been translated into English in 1848, by Dr Richardson, an able practical chemist of Newcastle, and Dr Ronalds, the accomplished Professor of Chemistry, Queen's College, Galway. This work has just reached a second English edition, so that the word Technology may be supposed to have acquired a certain naturalization amongst us, and such seems to be the opinion of the editors of Knapp's work, who give no definition of it in the new issue, though they did (in translation from Knapp) in their first edition. In this, "Technology" was stated to comprise, "in its literal signification, the systematic definition $\lambda\omicron\gamma\omicron\varsigma$ (logos) of the rational principles upon which all processes employed in the arts $\tau\epsilon\chi\upsilon\epsilon\varsigma$ (technes) are based." This definition is not very gracefully worded, but is sufficiently explicit. The word "Technology" literally signifies the Science of the Arts, or a Discourse or Dissertation on these. This latter meaning is the one given to the word in Dr Hyde Clarke's recent and admirable English Dictionary, the only one in which I have found it.¹ He defines Technology as "a Treatise on the Arts," a description quite just, so far as it goes, but including only one-half of the full signification of the word, for it as much denotes, according to the meaning of its Greek roots, and the custom of our language, the science of the arts as a dissertation upon them.

In this respect, it agrees with all the similar composite words of Greek origin, such as "Theology," which is, with equal propriety, employed to denote the science of the attributes, the ways and works of God, and to denote a dissertation upon these: "Geology," which sometimes signifies the knowledge or existing learning regarding the Physical Earth, and sometimes a discourse upon it: "Conchology," which at one time stands for the doctrine of or about shells, and at another for a treatise upon them.

Technology, then, in the sense in which I have to deal with it, implies the Science, or Doctrine, or Philosophy, or Theory of the Arts. Its object is not Art itself, *i. e.*, the *practice* of Art, but the principles which guide or underlie Art, and by conscious or unconscious obedience to which, the artist secures his ends.

Thus far, the meaning of the word Technology is not far to seek, but it must be taken with two important qualifications, to which I

¹ *New and Comprehensive Dictionary of the English Language, as spoken and written.* By Hyde Clarke, D.C.L. 1855.

now request your attention. The one of these is, that Technology includes only Utilitarian Arts: the other, that it includes only certain of these.

It is by a quite conventional limitation, that the word art, τεχνες, (*technes*), denoted by the first dissyllable of Technology, is held to signify Useful, Utilitarian, Economic, or Industrial Art, for the Useless Arts, such as Legerdemain, or the Art of Conjuring, are eminently technical, and still more so are the worse than Useless Arts, such as cheating at cards, and other sorts of dishonest gambling.

Nor is the limitation less conventional which excludes the Fine Arts from the domain of Technology; for no Arts call for more skilful workmen than Painting, Sculpture, and Music, and none are more technical in their modes of procedure. Far less are the Fine Arts excluded, because they are regarded as useless or hurtful. The Technologist avoids them for exactly the opposite reason. Poetry, Painting, Sculpture, Music, and the Sister Arts, are in the highest degree useful, inasmuch as they minister to the wants of the noblest parts of our nature; but in so ministering they excite such emotions of pleasure, or its inseparable correlative, pain, that the sense of their usefulness is lost in the delight, or awe, or anguish, which they occasion. So much is this the case, that while men thank each other for the gift of bread when they are hungry, or of water when they are thirsty, or of a light to guide them in the dark, they return no thanks for a sweet song, or a great picture, or a noble statue; not that they are unthankful for these, but that the duty of thanksgiving is forgotten in the pleasure of enjoying, or the strangely fascinating pain of trembling before a work of creative genius.

And the artist himself, singularly enough, in a multitude of cases, makes no complaint at this thanklessness, and counts it no compliment to his work to call it useful. The end of Æsthetic or Fine Art, he will tell you, is the realisation of beauty, not utility; as if the latter were rather an accidental or unavoidable and unfortunate accompaniment of the former, than the welcome inseparable shadow which attends it, as the morning and evening twilight, tempering his brightness, go before and after the sun. But such a description of the aim of his labours, though natural to the Artist, is unjust to his Art. The true object of Æsthetic or Fine Art is not Beauty, but *Utility, through or by means of Beauty.*

It may be that the Poet, the Painter, the Sculptor, the Musician,

often think only of the emotional delight which their works will awaken in the hearts of their brethren. But these works, in the very act of delighting, serve those whom they delight. It is surely as useful a thing, on occasion, to fill the eager ear with music, or the longing eye with the glories of form and colour, or the aching heart with thoughts of joy, as it is to fill the hungry stomach with food, or to clothe the naked body.

It is not, then, because the utility of the Fine Arts is questioned, that they are excluded from the domain of Technology. Neither is it because the feeling of their usefulness is lost in that of their delightfulness; but because they are not useful in the sense of being *indispensable*. The Utilitarian Arts do not stand contrasted with them, as loving ugliness or hating beauty: they have no direct concern with either. Their defining characteristic is not that they deal with what is beautiful or unbeautiful, but with what is *essential* to man's physical existence. The Fine Arts are, in a certain sense, superfluous Arts. The savage does not know them. The great mass of civilised mankind pass from the cradle to the grave, almost untouched by their charms. Few men can spend more than a small portion of their lives upon them. Even the greatest artists are such only at long intervals. Shakspeare was not always poetising, or Raphael painting, or Mendelssohn singing. Lengthened seasons of unproductive sadness mark the lives of them all. Like the fabled pelican, they feed others with their life-blood; and it would almost seem as if, in proportion to the delight which they gave to others, they were miserable themselves. Wordsworth, whose own life was a happy exception to this rule, declares of his brethren as a class, that "they learn in suffering what they teach in song." "A thing of beauty," Keats has told us, "is a joy for ever," but no poet has affirmed that it is a joy at all times.

The Industrial Arts are necessary Arts. The most degraded savage must practise them, and the most civilised genius cannot dispense with them. Whatever be our gifts of intellect or fortune, we cannot avoid being hungry, and thirsty, and cold, and weary every day, and we must fight for our lives against the hunger, and thirst, and cold, and weariness, which wage an unceasing war against us. But we can live down the longest day without help from music, or painting, or sculpture, and it is only in certain moods of mind that we demand or can enjoy these noble arts.

The Industrial Arts, then, are named Utilitarian or Useful Arts,

not in invidious contradistinction to the innocent arts regarded as useless, but in emphatic definition of themselves as the indispensable arts of life. Men *must* use them. They *may* or *may not* use the others. The Utilitarian Arts thus bear the same relation to the Fine Arts, as affecting our individual condition, which the root, stem, and leaves of a plant, bear to its flower and fruit. The three first are essential to the existence of the plant, and are more or less active throughout its entire life; the flower (including the fruit) is a rare ornament, appearing only at long intervals, sometimes but once in a hundred years. But the flower, when it does come, repays the long waiting, and the fruit in its bosom, is welcome to all. A year without roses may not blacken the bills of mortality, as a year without potatoes does, but the rose, nevertheless, is a useful plant as well as the potato. And so, there is no antagonism in respect of utility, between the Fine Arts and the Industrial Arts. The former are the *useful* Æsthetic Arts; the latter the *useful* Economic Arts. We concede to the former the special title of Fine or Noble Arts, because their ends are high, their students are few, and excellence in them is rare; and we acknowledge the latter to be Common Arts, whose ends are humble, whose students are countless, and excellence in which is, in many respects, universal. We have few great artists; we have many skilful artizans.

But, though the industrial arts are common, they are not ignoble arts. They minister, indeed, to those physical wants which we share with the lower animals, but we are raised above them as much by being industrial, as by being æsthetic artists. We are the former in virtue of our superior intellect, as we are the latter in virtue of our superior imagination.

Let me ask your attention to this point. I do not wish unwisely to magnify mine office. It is with every-day life, and every-day cares, that Technology, in one aspect, has to do; with man, not as "a little lower than the angels," but "as crushed before the moth," and weaker than the weakest of the beasts that perish; with man as a hungry, thirsty, restless, quarrelsome, naked animal. But it is also the province of Technology to show, that man, because he is this, and just because he is this, is raised by the industrial conquests which he is compelled to achieve, to a place of power and dignity, separating him by an absolutely immeasurable interval from every other animal.

It might appear, at first sight, as if it were not so. As industrial

creatures we often look like wretched copyists of animals, far beneath us in the scale of organisation, and we seem to confess as much by the names which we give them. The mason-wasp, the carpenter-bee, the mining caterpillars, the quarrying sea-slugs, execute their work in a way which we cannot rival or excel. The bird is an exquisite architect; the beaver a most skilful bridge-builder; the silk-worm the most beautiful of weavers; the spider the best of net-makers. Each is a perfect craftsman, and each has his tools always at hand. Those wise creatures, I believe, have minds like our own, to the extent that they have minds, and are not mere living machines, swayed by a blind instinct. They will to do one thing rather than another, and do that one thing in different ways at different times. A bird, for example, selects a place to build its nest upon, and accommodates its form to the particular locality it has chosen; and a bee alters the otherwise invariable shape of its cell, when the space it is working in forbids it to carry out its hexagonal plan. Yet, it is impossible to watch these, or others among the lower animals, and fail to see that, to a great extent, they are mere living machines, saved from the care and anxiety which lie so heavily upon us, by their entire contentment with the present, their oblivion of the past, and their indifference to the future. They do invent, they do design, they do exercise volition in wonderful ways; but their most wonderful works imply neither invention, contrivance, nor volition, but only a placid, pleasant, easily rendered obedience to instincts which reign without rivals, and justify their despotic rule, by the infallible happiness which they secure. There is nothing, accordingly, obsolete, nothing tentative, nothing progressive, in the labours of the most wonderful mechanics among the lower animals. It has cost none of these ingenious artists any intellectual effort to learn its craft, for God gave it to each perfect in the beginning; and within the circle to which they apply, the rules which guide their work are infallible, and know no variation.

No feathered Ruskin appears among the birds, to discuss before them whether their nests should be built on the principles of Grecian or Gothic architecture. No beaver, in advance of his age, patents a diving-bell. No glow-worm advocates, in the hearing of her conservative sisters, the merits of new vesta-lights, or improved lucifer-matches. The silk-worms entertain no propositions regarding the substitution of machinery for bodily labour. The spiders never divide the House on the question of a Ten Hours Working Bill.

The ants are at one on their Corn-laws. The wasps are content with their Game-laws. The bees never alter their tax upon sugar; nor dream of lessening the severities of their penal code: their drones are slaughtered as relentlessly as they were three thousand years ago; nor has a solitary change been permitted since first there were bees, in any of their singular domestic institutions.

To those wise creatures the Author of All has given, not only infallible rules for their work, but unfaltering faith in them. Labour is for them not a doubt, but a certainty. Duty is the same thing as happiness. They never grow weary of life; and death never surprises them. Wonderful combinations of individual volition, pursuing its own ends, and of implicit surrender to Omnipotent will, subduing all opposition, they are most wonderful in the latter respect, and are less to be likened to us, than to perfect self-repairing machines, which swiftly raise our admiration from themselves, to Him who made and who sustains them.

We are industrial for other reasons, and in a different way. Our working instincts are very few; our faith in them still more feeble; and our physical wants far greater than those of any other creature.

Had the assembled lower animals been invited to pronounce upon what medical men call the "Viability," or managers of insurance offices "the Chances of Life," of the first human infant, their verdict would have been swift, perhaps compassionate, but certainly inexorable. The poor little featherless biped, pitied by the downy gosling, and despised by the plumed eaglet, would have been consigned to the early grave, which so plainly in appearance awaited him; and no mighty Nimrod, with endless lion-slaying hunter-sons, would have been seen to dawn in long perspective above the horizon, and claim the fragile infant as their stalwart father.

Yet the heritage of nakedness, which no animal envies us, is not more the memorial of the innocence that once was ours, than it is the omen of the labours which it compels us to undergo. With the intellects of angels, and the bodies of earth-worms, we have the power to conquer, and the need to do it. Half of the Industrial Arts are the result of our being born without clothes; the other half of our being born without tools. I use this language deliberately. The Fine Arts may be gracefully grouped round the five senses. The eye to the painter, the ear to the musician, the tongue to the poet, the hand to the sculptor, and the whole body, the instrument of touch, among all. The Fine Arts thus begin each with

a special sense, and converge towards the body ; the Industrial Arts begin with the body, and diverge towards the special senses.

One of the men of genius of our age, Thomas Carlyle, has written a prose poem, *Sartor Resartus* (literally, the Tailor Re-tailored), in which, in his own peculiar eloquent way, he shows how wonderfully the developments of humanity stand related to our native nakedness, and our need of being clothed. Without pretending to follow or rival him, let me soberly urge, that just because naked we came from our mother's womb, and naked we shall return to the Great Mother of us all, we are industrial as no other beings are or can be.

I do not propose to offer you a catalogue of the arts which our unclothedness compels us to foster. The shivering savage in the colder countries, robs the seal and the bear, the buffalo and the deer, of the one mantle which nature has given them. The wild huntsman, by a swift, but simple transmutation, becomes the clothier, the tailor, the tanner, the currier, the leather-dresser, the glover, the saddler, the shoemaker, the tent-maker. And the tent-maker, the arch-architect of one of the great schools of architecture, becomes quickly a house-builder, building with snow where better material is not to be had ; and a ship-builder, constructing out of a few wooden ribs and stretched animal skins, canoes which, as sad experience has too recently shown us, may survive where English ships of oak have gone to destruction, we know not where.

Again : the unchilled savage of the warmer regions seeks a covering, not from the cold, but from the sun, which smites him by day, and the moon, which smites him by night. The palm, the banana, the soft-barked trees, the broad-leaved sedges and long fibred grasses, are spoiled by him, as the beasts of the field are by his colder brother. He becomes a sower, a reaper, a spinner, a weaver, a baker, a brewer, a distiller, a dyer, a carpenter ; and whilst he is these, he bends the pliant stems of his tropical forests into roof-trees and rafters, and clothes them with leaves, and makes for himself a tabernacle of boughs, and so is the arch-architect of a second great school of architecture ; and, by and bye, his twisted branches, and interlaced leaves, grow into Grecian columns with Corinthian acanthus capitals, and Gothic pillars with petrified plants and stony flowers gracefully curling round them.

Once more : in those temperate regions, where large animals and trees do not greatly abound, turfs, or mud, or clay, or stones, or all together, can be fashioned into that outermost garment which we

call a house, and most familiarly connect with the notion of architecture.

It is not, however, his cultivation of the arts which have been named, or of others, that makes man peculiar as an industrial animal. It is the mode in which he practises them. The first step he takes towards remedying his nakedness and helplessness, is in a direction where no other creature has led the way, and none has followed his example. He lays hold of that most powerful of all weapons of peace or war, *Fire*, from which every other animal, unless when fortified by his presence, flees in terror ; and with it alone not only clothes himself, but lays the foundation of a hundred arts.

Man may be defined as the only animal that can strike a light ; the solitary creature that knows how to kindle a fire. This is a very fragmentary definition of the " Paragon of Animals," but it is enough to make him the conqueror of them all. The most degraded savage has discovered how to rub two sticks together, or whirl the point of one in a socket in the other, till the wood is kindled. It is a thoroughly technical process, not easily learned or practised. Judgment, dexterity, and patience, are needed for its performance ; and even the most sagacious of monkeys, though he has a pair of hands more than a man, has never attempted this primitive pyrotechnic art.

Once provided with his kindled brand, the savage technologist soon proves what a sceptre of power he holds in his hands. He tills with it ; by a single touch burning up the withered grass of a past season, and scattering its ashes to fertilize the plains, which will quickly be green again. It serves him as an axe to fell the tallest trees with, and hollows out for him the canoe in which he adventures upon strange seas. It is an all-sufficient defence against the fiercest wild beasts ; and it reduces for him the iron ore of the rocks, and forges it into a weapon of war. I might say, indeed, with truth, that his kindled brand makes the ten-fingered savage, without further help, a farmer, a baker, a cook, a carpenter, a smith, a potter, a brick-maker, a lime-burner and builder ; and, besides much else, a soldier and a sailor. Well did the wise ancients declare that men obtained fire from heaven, but not well that they stole it. It was a gift to them, in compensation for their having no share in the dowry granted to the lower animals, and it has proved an ample compensation.

You may think this sketch of the savage's obligation to fire

fanciful and exaggerated; but, if you consider how every human industrial art stands directly or indirectly related to fire, whilst no animal art does, you will not regard the statement as extravagant. And civilized man, as much as his savage brother, is a fire-worshipper in his practical doings. The great conquering peoples of the world have been those who knew best how to deal with fire. The most wealthy of the active nations are those which dwell in countries richly provided with fuel. No inventions have changed the entire world more than steam and gunpowder. We are what we are, largely because we are the ministers and masters of fire.

Clotheless creatures by birth, we are also tool-less ones. Every other animal is by nature fully equipped and caparisoned for its work; its tools are ready for use, and it is ready to use them. We have first to invent our tools, and then to fashion them, and then to learn how to handle them. Man's marvellous hand is, no doubt, in itself an exquisite instrument of art; but, after all, our hands are less adroit than those of the monkey, who has four, each equivalent to a right hand, whilst the handiest of us is only ambidextrous. Our right hands would be nothing to us, but for our wise heads; for we have to begin two steps farther back, in our industrial labours, than the meanest of the animals, who practise no such craft as that of tool-making, and serve no apprenticeship to any craft. Two-thirds at least of our industrial doings are thus preliminary. Before two rags can be sewed together, we require a needle, which embodies the inventiveness of a hundred ingenious brains, and a hand, which only a hundred botchings and failures have, in the lapse of years, taught to use the instrument with skill.

It is so with all the crafts, and they are inseparably dependent on each other. The mason waits on the carpenter for his mallet, and the carpenter on the smith for his saw; the smith on the smelter for his iron, and the smelter on the miner for his ore. Each, moreover, needs the help of all the others—the carpenter the smith, as much as the smith the carpenter; and both the mason, as much as the mason both. This helplessness of the single craftsman is altogether peculiar to the human artist. The lower animals are all polyartists, and never heard of such a doctrine as that of the division of labour. The same bee, for example, markets, and bakes bee-bread, and manufactures sugar, and makes wax, and builds storehouses, and plans apartments, and nurses the royal infants, and waits upon the Queen, and apprehends thieves, and smites to the death the enemies

of the Amazons. The nightingale, though he is a poet, builds and furnishes his nest without any help from the raven, who despises the fine arts; and the lark does not excuse herself from her household duties, because she is an excellent musician.

Nor are there degrees of skill among the animal artists. The beavers pay no consulting fees to eminent beaver engineers experienced in hydraulics; the coral insects do not offer higher wages to skilled workmen at reef-building; every nautilus is an equally good sailor; and the wasps engaged in "just and necessary wars," offer no bounties to tempt veteran soldiers into their armies. Hence, there will never be Professorships of Technology among any of those craftsmen; for a Professor of Technology could teach them nothing, and they allow no sinecures.

The industrialness, then, of man, of which Technology is the fruit and the exposition, is carried out in a way quite peculiar to himself, and singularly illustrative of his combined weakness and greatness. The most helpless, physically, of animals, and yet the one with the greatest number of pressing appetites and desires, he has no working instincts, to secure (at least after infancy) the gratification of his most pressing wants, and no tools which such instincts can work by. He is compelled, therefore, to fall back upon the powers of his reason and understanding, and make his intellect serve him instead of a crowd of instinctive impulses, and his intellect-guided hand instead of an apparatus of tools. Before that hand, armed with the tools which it has fashioned, and that intellect, which marks man as made in the image of God, the instincts and weapons of the entire animal creation are as nothing. He reigns, by right of conquest, as indisputably as by right of inheritance, the king of this world. And yet, a strange aspect of imperfection and incompleteness belongs to our human works, and a dark shadow hangs over them all. We can as little realise our ideal in industrial as in æsthetic art. As masons, carpenters, bridge-builders, railway-makers, and the like, our labours never content us. We blunder through our work, groping in the dark by the help of imperfect lights, often committing the greatest errors, failing in our object, or, whilst gaining it, involving ourselves in fearful suffering or even in destruction. If it were not so, there would be no need for Chairs of Technology; but it is a humiliating and sorrowful confession that such should be the case. The preventable human suffering, and the needless loss of human life, which are occasioned by our industrial doings, are in amount alto-

gether appalling. There is not a public building, I suppose, which is not sprinkled with the blood of slain workmen. Every railway is inaugurated, as if we were pagans, by the sacrifice of human victims. Our ships bury every year in the sea thousands whose lives are not half spent, and, as Jeremy Taylor long ago said, "you can go nowhere but you tread on dead men's bones."

I do not refer here to injuries or deaths occasioned by great physical agencies, such as changes in temperature, or storms, which influence the lower animals as much as us, or to anything coming, with reasonable fairness, under the title, always questionable, of "*accident*;" or to such as are determined by moral causes, as inattention and carelessness. My reference is solely to those which proceed from our imperfect, though honest, observation of phenomena; our similarly imperfect knowledge of the physical laws, which we try to guide whilst we obey them; and our similarly imperfect application of these laws in practice, to the extent that we know them. For example: no more marvellous industrial work was ever achieved by man, than that of hanging a steel needle, rubbed with a piece of black iron ore, on the deck of a ship, and sailing by its guidance in search of unknown lands, across unknown seas. This needle—the mariner's compass—has been one of the greatest revolutionising agents of the world. Yet, we know so very little of the laws of magnetism, although, as sailors, we unreservedly submit to them, that the steel needle, which, unlike us, knows and obeys them all, has often unwittingly led goodly fleets to destruction, and innocently consigned navies to their fate. At this moment, the seamen of the world are aghast at the certainty, that their compasses, especially in iron vessels, have often betrayed them; and our men of science, anxiously communing with each other, are painfully struggling to be better ministers and interpreters of the mysterious needle. Now, contrast our condition in this matter with that of the birds of passage. We trust to magnetism, as a swallow does to an instinct, that will guide us north, if we would go north, and south, if we would go south; and yet it fails us when we need it most, and dashes us against some Arctic iceberg, when we thought we were heading towards Tropical seas. The birds of passage are never misled in this way; their unerring instinct, which is God's finger pointing the way, bids them go, and they go; and return, and they return. They hold, we may be sure, our magnetic needles in small estimation, and they well may, for instinct here has the victory over

intellect; and the wild geese who, at this season, are careering southwards, by compasses which never go wrong, have plainly greatly the advantage of us. All the suffering and death which are occasioned by our ignorance of physical laws, are dark stains upon our science, as well as griefs to humanity. From the moment that we quit the guidance of instinct, for that of interpreting, devising, and constructing intellect, we are bound to employ the last to the full. The deaths of thousands lie at the door of imperfect science; and, therefore, the necessity for Industrial Museums and Chairs like this.

Two observations further will complete this prolonged reference to the contrast between man and the lower animals, in the matter of industrialness.

The one is, that our individuality asserts itself for good and for evil, as that of the lower animals does not. The difference between the nature and extent of the endowments of two individuals of the same species of animals is very small, so that even were they able and disposed to exchange knowledge, neither would gain or lose by the barter. But the difference in endowment of any two men is always considerable, oftentimes great, and sometimes immeasurable. Accordingly, the amount of industrial labour performed by an aggregate of animals such as a hive of bees, is far more the sum (as distinguished from the mean) of the entire skill, activity, and industry of the whole bees, than the amount of labour of any section of men is. With us, the sum total of work is secured by a division of labour, including that of brain, as well as that of hand, where one man may furnish 95 per cent. of the intellect determining the work, and a thousand other men may divide the remaining 5 per cent. among them.

James Watt's Steam Engine, for example, John Dalton's Atomic Theory, George Stephenson's Railway Locomotive, and Christian Oersted's Electric Telegraph, furnished something like 99 per cent. of the thought and work, which have changed, in half a century, the condition of every mechanical manufacture, and of every chemical art; which have brought the ends of the earth together; have abridged beyond all former expectation, Space, and abbreviated as unexpectedly, Time.

We require, accordingly, perpetually to transfer knowledge from the wise to the unwise; from the more wise to the less wise; and such a Chair as this, with its associated Museum, is what, in com-

mercial language, would be called an *entrepot* or exchange for effecting such transfers.

The second and concluding observation which I have to make on this point is, that as Human, unlike Animal knowledge, is essentially progressive, we have new industrial problems continually to solve. The difficulty with the compass-needle, already referred to, was not largely encountered till iron was substituted for wood in the construction of ships. Every new discovery and improvement alters the significance and industrial importance of all which have preceded it; so that men, in employing the knowledge of their forefathers, cannot deal with it as so much gold of standard worth, but only as so much moveable property which is of continually fluctuating value. One of the great objects of a Chair of Technology, is to enable this value to be continually struck and made known to all.

The aim of Technology, then, is sufficiently defined as the science of Utilitarian Art; but, as stated already, it is only certain departments of Utilitarian Art which it embraces. Thus the most useful perhaps of all the necessary arts—that of Medicine—is excluded, and exactly because it is so useful: its pre-eminent utility demanding its assignment to a profession, whose sole business it shall be, and its great difficulty requiring a whole band of preceptors and practitioners to undertake its teaching. Other arts are, in whole or part, excluded for similar reasons. But without seeking to specify what they are, it will be sufficient to state, that the arts included in the domain of Technology, are the Industrial Arts, or Handicrafts, specially so called. These admit of a simple division into MECHANICAL and CHEMICAL ARTS, according as they are mainly related to Physics or to Chemistry. The division is of necessity a very imperfect one, but it is sufficiently precise for the ends of Industrial Art; and Technology has equal concern with both sections.

The range of subjects thus left free to me is so vast, that even were I presumptuous enough to attempt to traverse its immense domain, I could but touch superficially on each Art, and would require years to do even that. Plainly, then, I must restrict myself to certain Departments of Industrial Art. Yet here, the difficulty largely felt by the public and referred to by the Reverend Principal, in his opening address, occurs, How shall I limit myself to selected arts, and not encroach upon the subjects taught from the

existing University Chairs? In short, I have to face the dilemma:—How shall I faithfully fulfil my commission, as Professor of Technology, and yet faithfully respect the rights of my brother professors?

In reference to this, let me urge, 1st, that you must not interpret the word Technology by its dictionary-meaning, for, like multitudes of other words, its intended signification is much more limited than it might justly be made to bear. It is not, in this respect, however, distinguished from the titles of the other Chairs in this University. My brother-professors have nearly all commissions nominally as wide as my own, and these have been restricted in meaning only by common consent, by traditional custom, or conventional use and wont. My learned colleague, Professor Pillans, might, as Professor of Humanity, *i.e.*, of the humanizing arts and sciences, claim to teach any or all of the subjects taught from the Chairs of his brethren; and it would be enough for him to quote the one line of the Roman author, *Nihil humani me alienum puto*, and to say, I consider nothing humanizing foreign to my Chair. Professor Kelland might appeal to Professor Blackie to testify that *Mathematics* means, etymologically, *Learning*, and affirm that the wide world of acquired knowledge was open to him as prelector, if he pleased. Sir William Hamilton (whom I do not speak of as colleague, though he kindly welcomes me as such, because I will be content all my days to consider myself his pupil), might simply, as commissioned Professor of Metaphysics, and not because of his boundless learning,—on the one hand, not only ignore Professor Macdougall's genial eloquence, and claim Moral Philosophy as within his province, and further dispossess more than one of the Professors of Theology, for at least great part of each Session, of their Chairs,—but, on the other hand, as Teacher of Psychology, take from the Professors of Natural History, Anatomy, Physiology, and nearly all the branches of Medicine, those discussions of mental phenomena in which they so largely and so fitly engage.

There is room, no doubt, for reprisals. Dr Bennett is favoured with a double commission, as Professor of the Institutes of Medicine or Physiology, and each commission would virtually entitle him to discuss the subjects supposed to be sacred to half a dozen other Chairs.

Sir William Hamilton would be the first to acknowledge Logic as an Institute of Medicine; Professor Blackie, I think, recommends

Greek, as such, to every physician ; Professor Donaldson would have them all study Music ; Dr Balfour, Botany ; Dr Gregory, Chemistry. Dr Bennett, then, might profess these branches, and many more, which I need not particularize, and if he did not find himself sufficiently occupied with their profession, his alternative commission, *Physiology*, might be shown, without much appeal to Greek, to be equivalent in meaning to Natural Philosophy or Natural History, either or both of which he might accordingly begin to teach. The distinguished Professor of Natural Philosophy would, of course, be entitled to make a corresponding translation of the name of his branch of knowledge, and teach Physiology if he willed, although in truth, Natural Philosophy, *i.e.*, the Philosophy of Nature, might, without any stretching, amply cover the whole circle of the sciences, and entitle Professor Forbes to discuss, in his own admirable way, every one of them if he pleased. The same *mutatis mutandis* may be said of Natural History, and similar remarks might be made on other Chairs ; but I will name no more, because, in truth, there is not a single professor in any Faculty of this University, who has not a very wide and liberal commission. Nor is it so only nominally. Every professor in the Faculty of Medicine is continually discussing, to a greater or less extent, the subjects specially taught from all the other Medical Chairs. Anatomy, Chemistry, Physiology, Pathology, are more or less expounded by them all. The Professors of Chemistry and Natural Philosophy must largely consider the same phenomena and laws. Light, Heat, Electricity, Magnetism, Actinism, are included within the domain otherwise peculiar to each ; and it must be left greatly to the judgment of each professor, and to mutual arrangement among them all, to determine how much or how little of these common subjects any one will appropriate. It is notorious, accordingly, that whenever a Chair in this or any other University changes its possessor, the subject taught is changed, as well as the style of teaching it. It is not possible, nor is it desirable, that it should be otherwise. Apart from the peculiarities which each man's individuality must impress upon his teaching, as upon everything else which he does, and the immense changes which every year induces in nearly all the branches of human knowledge, we continually forget that, in reality, as there is but one God, the Author of all, so there is but one Science, the expression of His power. What we call sciences are but angular fragments struck from the sphere of Omniscience, to which fresh chips from time to time are added.

Each student speaks of his fragment as if it were a perfect whole, like a symmetrical crystal, or geometrical solid; but the lines which bound it have in reality as little absolute value as the lines on a political map, where to-day we find a Poland, and to-morrow none: where one year there is a mighty British colony across the Atlantic, and next year an Independent America: where at sunrise there may be a Crimea in Russia, and at sunset a Crimea in France and England.

There is nothing, then, exceptional in the liberality of my commission; but this Chair, nevertheless, has a thoroughly definite aim. It is not in the simple capacity of teacher of the industrial applications of science that I occupy it, but as Director of the Industrial Museum of Scotland. You are all, I presume, aware, that the long—and I may say universally—expressed desire, that we should possess a National Museum, alike of the objects of Natural History and of the products of Industrial Art, is in course of realisation. Ground has been purchased by Government in the immediate vicinity of the University, and in due season a suitable edifice will be erected to receive the collections. The objects of Natural History, of which there is already a splendid series within these walls, will be under the special charge of Professor Allman (who comes amongst us regretted by those who have lost him as a colleague and a teacher, and commended to the professors and pupils of this University as one whom they will love and esteem the more the better they know him); whilst the products of Industrial Art will be under my care. Some time must elapse before the new Museum can be completed, but the buildings at present occupying the site on which it will stand are consigned to me, for the reception of industrial products; and, from the liberality with which the manufacturers of the country are responding to appeals for donations, and by the judicious expenditure of the money put at my disposal for the purchase of specimens, I trust, before long, to have something considerable to show. The nucleus of the Industrial Museum already exists, and will daily enlarge.

With the Industrial Museum, this Chair stands in organic connection. My office, as Professor of Technology, is to be interpreter of the significance of that Museum, and expositor of its value to you, the Students of this University. The Museum, indeed, is intended to serve non-academic as well as academic Students, and to benefit the entire community of Scotland, as well as every stranger who

may enter its doors. Ample provision will be made for the general public profiting to the full by the Museum, as soon as the magnitude of the collection, and the command of suitable apartments, enable the specimens to be duly arranged. With the performance of this duty, the Board of Trade, through its Department of Science, is charged, and I shall carry out their instructions as Director of the Museum. But the object of this Chair is, to unite that Museum with this ancient University, so that its Students may profit by the alliance; and my special duty is, to make that Museum the text of my prelections to you. Thus far my text is sufficiently definite; but as I must, to the best of my power, make available the continued additions, from time to time, of industrial objects to the Museum to those who study here, it would be idle for me narrowly to restrict my commission. I must, so far as I can, and in all legitimate ways that I can, turn the Museum to the largest account as a means of education. But, as the Museum is only in its germ, it would be premature, as in truth it is impossible, for me to attempt to circumscribe the mode in which its future development will affect the teachings of the Professor of Technology. Three principles, however, may be announced, which will show in what way its duties will be limited in my hands,—

1st, It is not intended that desultory prelections shall be given on the present or future contents of the Museum. On the other hand, a systematic course of lectures will be delivered on the Applications of Science to the Industrial Arts—so that the Museum will minister to the Chair, not the Chair wait upon the Museum; and accordingly I will attempt such a course this winter, without waiting for specimens to accumulate.

2d, The subjects of lecture will be arranged so as to interfere as little as possible with the lectures delivered from the other Chairs of this University.

3d, The chemical, much more than the mechanical industrial arts, will form the subject of my lectures.

As for the first of these principles, I think it unnecessary to say one word in defence of the superiority of systematic over desultory lectures. As for the second, as this Chair was founded, not to supplant but to supplement the existing Chairs, it will be my solicitous care not to overstep its legitimate sphere. And that I shall be able to do so, I think, will best appear from a somewhat fuller reference to the third principle, and to the subjects which will be taught from

this Chair, premising that it will not be possible to include all or most of these in any single course.

A prominent place will be given to the consideration of the economic production and application of heat and light, with which nearly every industrial art, whether chemical or mechanical, is essentially connected. This will imply the discussion of the physical and chemical properties of the natural and artificial fuels—wood, peat, coal, coke, charcoal, the vegetable and animal oils, fats, waxes, and allied bodies; the processes of gas-making and candle-making; the structure of lamps, blow-pipes, fire-places and furnaces; the consumption of smoke, the removal of the noxious products of combustion, the ventilation and heating of apartments; the use of sulphur, phosphorus, and certain of the metals, as fuels; the preparation of coloured signal-lights; the production of self-lighting arrangements; the manufacture of lucifer-matches; the manufacture of gunpowder, gun-cotton, and other explosives.

The consideration of these subjects will require the discussion of several connected ones—as with the manufacture of wood-charcoal, that of wood-vinegar, wood-spirit, creosote; with gas-making, the manufacture of tar, pitch, pitch-oil, naphtha, and the salts of harts-horn; with candle-making, that of the fatty acids of glycerine, and perhaps the manufacture of soap. This episodic list, indeed, might be extended immensely.

A Second great division will be the economic development of electricity, and its application to the production of light, the manufacture of pigments and other chemical products, the casting of metals, and their reduction in special cases from artificial ores, the firing of mine-charges, the working of the telegraph, the construction of machines for the therapeutic employment of galvanism, and certain other uses.

A Third division, of more limited value, but at present of great and increasing interest, will be the economic applications of light, as employed in the different modifications of Photogenic Art. This has hitherto been more an object of interest as a Fine Art, than as an Industrial one; but every day is adding to its value as furnishing an infallible, incorruptible, and most faithful copyist; and as it is intended to employ it largely in furnishing drawings for the Industrial Museum, it will receive special consideration at my hands.

A Fourth great division will be that of metallurgy, including the

collection, preparation, and reduction of native metallic ores, and the economic applications of the metals and their alloys.

A Fifth will be that of building materials—stone, brick, lime, mortar, cement, wood, and the like.

A Sixth will include those ancient and graceful industrial arts, the art of the potter and that of the glass-blower.

A Seventh, ramifying widely, will include the textile manufactures, and the arts related to cotton, linen, silk, wool, and other fibres. Under this, apart from the beautiful mechanical processes of carding, spinning, knitting, weaving, and the like, will come the important chemical arts of bleaching, dyeing, and calico-printing; and the transition will be direct to that pre-eminent industrial art, paper-making, which, in its turn, will lead to the consideration of the Graphic Arts—drawing, printing, wood-cutting, engraving, lithography, glass-etching and staining, water-colour, oil-fresco, encaustic, and other kinds of painting; the properties of drawing materials, canvas, wood, metal, stucco; the chemistry of inks, pigments, varnishes, and the like.

An Eighth division will include the arts relating to food, omitting, except indirectly, Agriculture, to which Professor John Wilson will do all justice, and embracing the manufacture of sugar, of starch, of gum, of animal jelly, of extract of meat; the preservation of vegetable and animal substances from decay; the arts of cooking, baking, brewing, wine-making, and distilling.

A Ninth will include the arts related to animal products, employed otherwise than for food, embracing furs, feathers, bristles, horns, bones, teeth, shells, etc.; and include the manufacture of size, glue, gelatine, parchment, leather, and the crafts of the shoe-maker, hat-maker, saddler, book-binder, gold-beater, comb-maker, brush-maker, ivory-carver, button-maker, and many another ancient guild.

And, without multiplying divisions further, let me consign to a Tenth miscellaneous one, the manufacture of the mineral acids, alkalis, and other largely used chemical re-agents, as well as all the industrial arts for which a place has not been found in the preceding sections.

The programme thus slightly sketched, touches on every side, upon subjects discussed by other professors; but it only touches upon them. My teaching will, in general, begin, where theirs is deliberately arrested, not as exhausted, but as designedly proceeding no further.

I will require, for example, again and again, to insist upon the existence of certain laws of quantitative chemical combination, which every workman, whether burning fuel, consuming smoke, reducing metallic ores, gilding pins, working a telegraph, bleaching a piece of linen, dyeing a feather, distilling an acid, making a square of soap, tanning a piece of skin, or executing a hundred other things, should obey. But I will briefly and dogmatically announce those laws as things certain, leaving it to my accomplished colleague, the Professor of Chemistry (who so largely possesses the power over arithmetical numbers hereditary in the family of the Gregories), to discuss critically the grounds on which chemists acknowledge the existence of combining ratios or equivalents, and to explain what arguments can be urged, in defence or denial of the existence of atoms, and the vindication of an atomic theory. To him will also belong the scientific definition of an element, a metal, a metalloid, an acid, a base, a salt, a radical, a basyle, and many other things, which I shall refer to as acknowledged chemical existences.

The wonderful laws every day additionally beautifying the face of organic chemistry, it will be his, I could almost say, enviable duty to expound. For me, starch will be simply starch, and sugar, sugar, alcohol, alcohol, and vinegar, vinegar. Dr Gregory will retain the privilege of expatiating on these, and all other such compounds as members of curiously related series; and of discussing all the marvellous principles of arrangement, which men of genius have discovered to connect together these common things. Moreover, I am certain, that after Dr Gregory has, to the extent of his great learning on such subjects, lectured to the full on carbon, hydrogen, oxygen, sulphur, and phosphorus, he will still leave ample materials for me as expounder of the economics of combustion. His treatment of the metals will pave the way for my metallurgical discussions; his discussion of chlorine for that of bleaching, and so on with other chemical arts.

Again, I cannot discuss the uses of fuel without continually referring to the thermometer. But I shall accept it as an accredited, and for practical purposes, a perfect instrument. The nature of heat; the laws of conduction; the laws of expansion; the question of the relation of the quantity of heat to its intensity; of the extent to which, in any sense, we can measure heat; the conditions essential to a perfect heat-measurer, and the many other problems of the science of thermotics, which have in their issues, the most important

practical bearings, will remain for the discussion of Professor Forbes, who is so great an authority upon them. And so also with the largest part of the sciences of optics, electricity, magnetism, pneumatics, and many more, of which only certain portions come within my scope, and those only in so far as they are related to the useful arts. Again, the vegetable products, I shall take up at the point where Dr Balfour, Dr Gregory, and Professor John Wilson leave them, entering for example into no discussion regarding the botanical relations of the textile fibres, the paper-yielding plants, or those producing oils, starch, sugar, or dye-stuffs; leaving their chemical relations to the professor of chemistry, and their modes of cultivation to the professor of agriculture. Animal and mineral products I shall accept in the same manner from the hands of Professor Allman, and such ambiguous question, as "What is coal?"—I shall be content to answer in the most catholic and expansive way, so that all the scientific sectaries whom it has called into existence, myself among the number, may sit together round the same hearth, and be warmed by it.

In truth, my own domain is so vast, and so little explored, that I have no need, as I have no wish, to go foraying beyond it. Would only that, like Cowper's Selkirk, I could with a kingly consciousness of power to rule, declare that I am "monarch of all I survey," even though I cannot add, "My right there is none to dispute!" My kingdom, however, is not an island washed by the uncoveted sea on every side, but part of a mighty continent, divided amongst great, though friendly potentates. On their territories I cast no wistful eyes: there is no scientific Turkey, or Hayti, or Cuba, which I desire to annex to my stately empire. If there be on all sides debateable Border-land, it shall at least be made neutral ground, and if any one of my brother monarchs thinks that use and wont entitle him to possess it, or that he can turn it to better account than I can, I will say to him as Abram did to Lot, "Is not the whole land before thee? If thou wilt take the left hand, then I will go to the right; or if thou depart to the right hand, then I will go to the left."

The term "*Technology*" which distinguishes this Chair, can only slowly grow into an acceptable word. The title is not of my advising or selecting, but I can suggest no better. *Industrial Art Science*, even if it were explicit, which it is not, is far too long a word, and does not suit the genius of our language. *Applied Science*,

a name which some academic institutions have adopted, is liable to the same objection, and, moreover is a misnomer; for *applied science* is but a clumsy circumlocution for art or practice, as *Theorised or Generalised Art or Practice*, would simply signify science.

The great objection to the word is a phonetic one. Its sound is harsh and unwelcome, a thing to be regretted in the case of any term intended for general use, but, especially in the case of one which, referring to every-day life and homely things, should sound softly in the ear, and be "familiar in our mouths as household words."

In conclusion, suffer me a reference to two things. There are few occasions, on which it is becoming for an individual to refer publicly, to what the French have taught us to call his antecedents; but I may be allowed a word on mine here. I came to this University some twenty-two years ago, fresh from the Edinburgh High School, without any prestige in my favour, any recommendations to pave my way, or introductions which should conciliate the good will of a single professor. A mere school-boy I entered these walls, to pursue, like a hundred others, the difficult study of medicine, without any extrinsic advantages. I look back now with unfeigned gratefulness to the services rendered me by so many of the professors. I stand indebted to a long list of them, for help and encouragement at a time when these are most needed and most prized, and but for the kindness of more than one of their number, I would not be here to address you as their colleague to-day.

I speak thus not to pay this University a passing compliment, for it does not need it; still less to imply that my case was exceptional for it was not so at all; but simply that I may bind myself in your hearing, to help the nameless and friendless students who become my pupils, as I was helped by my preceptors, when I was nameless and friendless.

Lastly, let me commend this new Chair to your good will and kindly aid. With its associated Industrial Museum, it constitutes a great additional centre of knowledge from which light will spread over this land, and over the world. I can but sow the seed. I have sown it to-day;—I am honoured to do thus much; but the prediction, true in reference to all matters, is that "one soweth and another reapeth." I am not so selfish, or so thoughtless, as to wish it were otherwise. Institutions, like all other things, grow faster in

these days, than they did of old ; but perennial things are still slow of growth, and the most enduring the slowest of all. We must be content to pluck the first fruits, and leave the full harvest to be gathered by those who follow. But that its first and last fruits, may alike conduce to the glory of God and the good of man, is my prayer ; and, therefore, we will confide it to Him, who, eighteen hundred years ago, dignified and made honourable the humblest craft, by permitting Himself to be called the son of the carpenter, and who now stretches forth His divine hand to bless all honest, earnest labour.



