



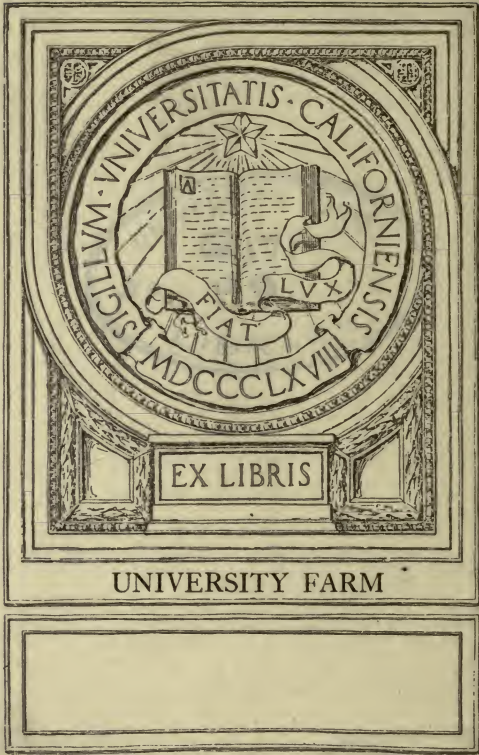
SELECTIONS FROM HUXLEY



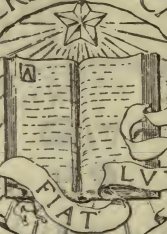
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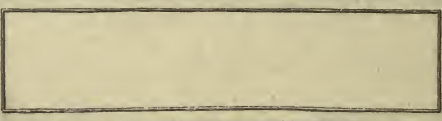


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SELECTIONS FROM HUXLEY

EMBRACING THE AUTOBIOGRAPHY; ON THE
ADVISABLENESS OF IMPROVING NATU-
RAL KNOWLEDGE; A LIBERAL EDU-
CATION AND WHERE TO FIND
IT; ON A PIECE OF CHALK

EDITED

WITH INTRODUCTION AND NOTES

BY

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PREFACE

THE novel, the play, and the poem have for years been regarded as the center of the study of English in our schools; the claims of the essay and the oration have been recognized more recently. Outside of this great body of standard writings in the strictly literary lines there have appeared works of note in other fields which are now considered appropriate for reading in English classes, and which the Committee on College Entrance Requirements in English urges the schools to read. It was the purpose of this Committee that works like the "Selections from Huxley" should serve as stepping-stones to that great body of scientific writings which have made so lasting an impress upon the nineteenth century. Without such knowledge the boy or girl of to-day can hardly hope to be liberally educated.

These "Selections from Huxley" have been placed by the Committee in that group designed for *reading*, and not for *study*. They are not to be overstudied — killed by over-analysis. As one college catalogue has it, the attention of the student "should not be so fixed upon details that he fails to appreciate the main purpose and charm of what he reads." Perhaps with this caution in mind, the student may, through works of this character, acquire a genuine appreciation for the works of our great scientists.

J. P. CUSHING.

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INTRODUCTION

BEGINNINGS OF SCIENTIFIC ACTIVITY IN ENGLAND IN THE NINETEENTH CENTURY

IN the October number of the *Quarterly Review* for the year 1830 there appeared an article commenting favorably upon a work by the mathematician Charles Babbage (1792-1871), entitled, "Reflections on the Decline of Science in England, and on some of its Causes." It appeared that the astronomer John Herschel (1792-1871) was the only living British scientist of note (the great chemist, Sir Humphry Davy, 1778-1829, having recently died), and that the outlook for science was most depressing. There was not then in England a single philosopher bearing a title; Sir Walter Scott was the only author who had been distinguished by any title of honor since the accession of George III (1760). Further, there was not a single philosopher then enjoying a pension or the favor of the sovereign. Remedies were suggested; and from this appeal there arose in 1831 the British Association for the Advancement of Science. This society, which subsequently enjoyed the favor of Queen Victoria and the Prince Consort, has contributed materially to the progress of science not only in England, but also in other countries. Scientific investigation grew in popular as well as in royal favor. During the next twenty years eleven members of the Association received the honors of knighthood, and seventeen received pensions. It was in 1850 that Lyell was knighted, the year after Huxley had published his work on the *Medusæ*. Such, in brief, were the beginnings of scientific activity in England in the

nineteenth century. With the path thus cleared by early leaders, the mid-century scientists advanced with no uncertain step. Lyell, Darwin, Tyndall, Spencer, Faraday, Clerk Maxwell, Kelvin, and Huxley are some of the great names of the period.

HUXLEY'S LIFE

Prominently identified with this movement that stamped the nineteenth century as an age of scientific progress was Thomas Henry Huxley. His life story, as related in his "Autobiography," is a brief record of some of the chief incidents of his career; but his modesty compelled him to omit many interesting and significant features and to touch lightly upon other matters that deserved more than passing notice. As the "Autobiography" was written six years before his death, some account must here be taken of the closing years of his life, as well as of some of the omitted incidents of his earlier manhood.

Born May 4, 1825, at Ealing, near London, the son of a schoolmaster, he was given the education that an ordinary boy of the middle class was accustomed to receive. He was an indifferent student, but an omnivorous reader. Pursuing the study of medicine, he completed the course at the age of twenty, receiving from the Charing Cross Hospital Medical School the degree of M.B., and a gold medal for excellence in Anatomy and Physiology. In the following year (1846) he was appointed assistant-surgeon of the surveying ship *Rattlesnake*, and made a three years' cruise, principally on the eastern coast of Australia. There without books or advisers, at times with his microscope lashed to the mast to steady it, he made a study of jellyfish and polyps. His first important memoir, the result of this investigation, "On the Anatomy and the Affinities of the Family of the Medusæ," called by one writer "the founda-

tion of modern zoölogy," was published by the Royal Society in 1849; two years later he was elected a Fellow, and in the following year (1852), when but twenty-seven years of age, he was awarded the Gold Medal of this same society.

Resigning from the naval service he endeavored to find congenial work, preferably in London. But an opening did not occur for some time. Deluged with invitations "while not earning enough to pay cab-fare," rejected as an applicant for a professorship by Toronto, Aberdeen, Cork, and King's College, tormented by illness, selling his Royal Medal with its two hundred and fifty dollars' worth of gold to assist a brother's widow, Huxley never gave up the fight. When down in the depths, with characteristic boldness and optimism he wrote the following: "I don't know and I don't care whether I shall ever be what is called a great man. I will leave my mark somewhere, and it shall be clear and distinct —

T. H. H. his mark

and free from abominable blur of cant, humbug and self-seeking."

But better times came. In 1854 he was appointed Professor of Natural History and Paleontology in the Royal School of Mines, and Curator of Fossils in the Museum of Practical Geology. His financial circumstances then permitted him to marry, after long years of waiting, Henrietta Anne Heathorn of Sidney, whom he had met in Australia while on the cruise of the *Rattlesnake*. Other important appointments followed, among which were the position of Examiner in the University of London, the Fullerian Professorship in the Royal Institution, and the Croonian Lectureship. Between 1862 and 1884 Huxley served on ten royal

scientific or educational commissions. In 1870 he was elected member of the London School Board; and in 1872 the University of Aberdeen, which some twenty years before had rejected him as a professor, elected him Lord Rector. In 1876 he visited the United States, and gave the inaugural address at Johns Hopkins University. In that memorable oration he delivered this challenge to the American people: "I am not in the slightest degree impressed by your bigness or your material resources, as such. Size is not grandeur; territory does not make a nation. The great issue, about which hangs a true sublimity, and the terror of overhanging fate, is, 'What are you going to do with all these things?' . . . The one condition of success, your sole safeguard, is the moral and intellectual clearness of the individual citizen."

In 1871 he was made Secretary of the Royal Society, and in 1883 its President. In 1879 he received from Cambridge the degree of LL.D.; and in 1885 that of D.C.L. from Oxford. He retired on a pension in 1885; but scientific honors still came to him, — the Copley Medal of the Royal Society in 1888, the Romanes Lectureship at Oxford in 1893, and the Darwin Medal of the Royal Society in 1894. In 1892 he was called by Queen Victoria to the Privy Council. He died at Eastbourne, June 29, 1895.

Concerning Huxley's appearance and personality, Mr G. W. Smalley wrote as follows in *Scribner's Magazine* for October, 1895: "The square forehead, the square jaw, the tense lines of the mouth, the deep flashing dark eyes, the impression of something more than strength he gave you, an impression of sincerity, of solid force, of immovability, yet with the gentleness arising from the serene consciousness of his strength — all this belonged to Huxley and to him alone. The first glance magnetized his audience. The eyes were those of one accustomed to command, of one having authority, and not fearing on occasion to use it. The hair swept care-

lessly away from the broad forehead, and grew rather long behind, yet the length did not suggest, as it often does, effeminacy. He was masculine in everything — look, gesture, speech. Sparing of gesture, sparing of emphasis, careless of mere rhetorical or oratorical art, he had nevertheless the secret of the highest art of all, whether in oratory or whatever else — he had simplicity.”

HUXLEY THE SCIENTIST

“The question of questions for mankind — the problem which underlies all others, and is more deeply interesting than any other — is the ascertainment of the place which Man occupies in nature and of his relation to the universe of things. Whence our race has come; what are the limits of our power over nature and of nature’s power over us; to what goal are we tending: are the problems which present themselves anew and with undiminished interest to every man born into the world.” This was the great problem Huxley kept before him; his immediate aims he stated thus: “To smite all humbugs, however big; to give a nobler tone to science; to set an example of abstinence from personal controversies, and of toleration for everything but lying; to be indifferent as to whether the work is recognized as mine or not, so long as it is done.” This was the life text of a man who went to the bottom of things, a man absolutely simple and natural, a man of genial nature, an eager searcher after truth.

How well Huxley kept to his text, how deeply he carved “T. H. H. his mark” upon the world, is clearly stated by John Fiske in his “Essays Historical and Literary” (Vol. II, ch. vi): “If absolute loyalty to truth, involving complete self-abnegation in face of the evidence, be the ideal aim of the scientific inquirer, there have been few men in whom that ideal has been so perfectly realized as in Huxley. If he were

tempted by some fancied charm of speculation to swerve a hair's breadth from the straight line of fact, the temptation was promptly slaughtered and made no sign. For intellectual integrity, he was a spotless Sir Galahad."

Concerning Huxley's influence, Professor (later Sir) E. Ray Lankester wrote that "apart from the influence exerted by his popular writings, the progress of biology during the present century was largely due to labors of his of which the general public knew nothing, and that he was in some respects the most original and fertile in discovery of all his fellow-workers in the same branch of science." Prominent among these labors were his discovery of the structure of the *Medusæ*, which formed a basis for modern biology; his theory of the origin of the skull, which was a sound starting point for vertebrate morphology and ethnology; his exposition of the pedigree of man, in support of the Darwinian theory of evolution; his wise counsels upon matters of educational interest; and his introduction of the laboratory method of teaching zoölogy.

But these great labors of the scientist are not, perhaps, the things we remember best about him. He was essentially the Explainer, the Expounder of the New Reformation, the "Bull-Dog" Fighter in the great controversy, the Popularizer of modern science to the masses. In spite of the warnings of friends that such action was unbecoming a man of science, Huxley took great pleasure in addressing popular audiences; and some of his most important work, including the three addresses of this volume, lay in that field of activity. He argued that it was a good thing for himself, because he was obliged to put his thoughts in these addresses in the plainest language; and that it was a good thing for science, because he might by his exposition win converts to the Truth. He said, "I want the working class to understand that Science and her ways are great facts for them — that

physical virtue is the base of all other, and that they are to be clean and temperate and all the rest — not because fellows in black with white ties tell them so, but because there are plain and patent laws which they must obey ‘under penalty.’” The inauguration of these popular lectures, the founding of museums, the opening of laboratories, the striving for a sane education of the masses, give him high rank as a man who worked not for self alone. “If I am to be remembered at all,” he once wrote, “I would rather it should be as a man who did his best to help the people than by any other title.”

Bearing the burden of the battle for Evolution, Huxley led a life of fights and skirmishes. It is pleasant while thinking of the assaults made upon his religious belief to read the words of his old friend, Alexander Macmillan: “I tell you there is so much real Christianity in Huxley that if it were parcelled out among all the men, women and children in the British Islands, there would be enough to save the soul of every one of them, and plenty to spare !”

HUXLEY THE WRITER

This volume will probably serve many as an introduction to the writings of great scientists. It is unlike some other forms of literary composition, — the novel, the poem, the play. The so-called literary element does not force itself upon one’s attention; here a scientist is speaking in concise, precise terms. Huxley once said that science and literature are two sides of the same thing; he certainly has taken pains to give us his scientific findings in rare literary style. Sir Spencer Walpole once said that Huxley had a command of style which “made him the greatest master of prose of his time.” To deserve such commendation, Huxley was compelled to practice severe self-discipline. “Sometimes I write

essays half-a-dozen times before I can get them into the proper shape." Always a sufferer from dyspepsia, accusing himself of laziness, he drove himself to work, to systematic work. He became familiar with French and Italian; he taught himself German; he learned Greek at the age of fifty-three in order that he might read Aristotle in the original. Drawing was a favorite study; whatever he worked at, he "visualized clearly" by map, diagram, or picture. He commended the study of Hobbes for dignity, of Swift for clearness, and of Defoe and Goldsmith for simplicity. These are the prominent characteristics that appear in Huxley's writings.

In attempting to give Huxley a place among literary men, the student will probably seek to classify him among those who, having done great deeds, have written about them in simple style. He may recall Dana's "Two Years before the Mast," "The Oregon Trail," Parton's "Masters of Industry," and many biographies of men of action. These tales of endeavor and achievement, these accounts of seeking after truth, hold a high place in the world of literature as the term should be understood.

HUXLEY'S PRINCIPAL WORKS

Family of the *Medusæ* (1849).

Oceanic Hydrozoa (1859).

Evidences as to Man's Place in Nature (1863).

Lectures on the Elements of Comparative Anatomy (1864).

Lessons in Elementary Physiology (1866).

An Introduction to the Classification of Animals (1869).

Lay Sermons, Addresses and Reviews (1870).

A Manual of the Anatomy of the Vertebrated Animals (1871).

Critiques and Addresses (1873).

American Addresses (1877).

Physiography: An Introduction to the Study of Nature (1877).

A Manual of the Anatomy of the Invertebrated Animals (1877).

- The Crayfish: An Introduction to the Study of Zoölogy (1880).
Science and Culture (1881).
A Course of Practical Instruction in Elementary Biology (1881).
The Origin of the Existing Forms of Animal Life (1883).
Essays on some Controverted Questions (1892).
Evolution and Ethics (1893).
(A complete bibliography of Huxley's works is given in the second volume, pp. 480-498, of The Life and Letters of Huxley, 1900.)

BOOKS FOR REFERENCE

- Huxley's Life and Letters, 1900.
Green's Short History of the English People.
Montgomery's Leading Facts of English History.
Smalley's Huxley, in Scribner's Magazine, October, 1895.
Fiske's Essays Historical and Literary (Vol II, Ch. VI).
Clodd's Thomas Henry Huxley.
Huxley's Aphorisms and Reflections.
Darwin's Life and Letters.



SELECTIONS FROM HUXLEY

AUTOBIOGRAPHY

“And when I consider, in one view, the many things which I have upon my hands, I feel the burlesque of being employed in this manner at my time of life. But, in another view, and taking in all circumstances, these things, as trifling as they appear, no less than things of greater importance, seem to be put upon me to do.” 5

—BISHOP BUTLER TO THE DUCHESS OF SOMERSET

THE “many things” to which the Duchess’s correspondent here refers are the repairs and improvements of the episcopal seat at Auckland. I doubt if the great apologist, greater in nothing than in the simple dignity of his character, would 10 have considered the writing an account of himself as a thing which could be put upon him to do whatever circumstances might be taken in. But the good bishop lived in an age when a man might write books and yet be permitted to keep his private existence to himself; in the pre-Boswellian epoch, 15 when the germ of the photographer lay concealed in the distant future, and the interviewer who pervades our age was an unforeseen, indeed unimaginable, birth of time.

At present, the most convinced believer in the aphorism “Bene qui latuit, bene vixit,” is not always able to act up to 20 it. An importunate person informs him that his portrait is about to be published and will be accompanied by a biography which the importunate person proposes to write. The sufferer knows what that means; either he undertakes to revise the “biography” or he does not. In the former case, 25

he makes himself responsible; in the latter, the publication of a mass of more or less fulsome inaccuracies for which he will be held responsible by those who are familiar with the prevalent art of self-advertisement. On the whole, it may
5 be better to get over the "burlesque of being employed in this manner" and do the thing himself.

It was by reflections of this kind that, some years ago, I was led to write and permit the publication of the subjoined sketch.

10 I was born about eight o'clock in the morning on the 4th of May, 1825, at Ealing, which was, at that time, as quiet a little country village as could be found within a half-a-dozen miles of Hyde Park Corner. Now it is a suburb of London with, I believe, 30,000 inhabitants. My father was one of
15 the masters in a large semipublic school which at one time had a high reputation. I am not aware that any portents preceded my arrival in this world, but, in my childhood, I remember hearing a traditional account of the manner in which I lost the chance of an endowment of great practical
20 value. The windows of my mother's room were open, in consequence of the unusual warmth of the weather. For the same reason, probably, a neighboring beehive had swarmed, and the new colony, pitching on the window sill, was making its way into the room when the horrified nurse shut down
25 the sash. If that well-meaning woman had only abstained from her ill-timed interference, the swarm might have settled on my lips, and I should have been endowed with that mellifluous eloquence which, in this country, leads far more surely than worth, capacity, or honest work, to the highest places
30 in Church and State. But the opportunity was lost, and I have been obliged to content myself through life with saying what I mean in the plainest of plain language, than which, I suppose, there is no habit more ruinous to a man's prospects of advancement.

Why I was christened Thomas Henry I do not know ; but it is a curious chance that my parents should have fixed for my usual denomination upon the name of that particular Apostle with whom I have always felt most sympathy. Physically and mentally I am the son of my mother so completely — even down to peculiar movements of the hands, which made their appearance in me as I reached the age she had when I noticed them — that I can hardly find any trace of my father in myself, except an inborn faculty for drawing, which unfortunately, in my case, has never been cultivated, a hot temper, and that amount of tenacity of purpose which unfriendly observers sometimes call obstinacy.

My mother was a slender brunette, of an emotional and energetic temperament, and possessed of the most piercing black eyes I ever saw in a woman's head. With no more education than other women of the middle classes in her day, she had an excellent mental capacity. Her most distinguishing characteristic, however, was rapidity of thought. If one ventured to suggest she had not taken much time to arrive at any conclusion, she would say, "I cannot help it, things flash across me." That peculiarity has been passed on to me in full strength ; it has often stood me in good stead ; it has sometimes played me sad tricks, and it has always been a danger. But, after all, if my time were to come over again, there is nothing I would less willingly part with than my inheritance of mother wit.

I have next to nothing to say about my childhood. In later years my mother, looking at me almost reproachfully, would sometimes say, "Ah ! you were such a pretty boy !" whence I had no difficulty in concluding that I had not fulfilled my early promise in the matter of looks. In fact, I have a distinct recollection of certain curls of which I was vain, and of a conviction that I closely resembled that handsome, courtly gentleman, Sir Herbert Oakley, who was vicar

of our parish, and who was as a god to us country folk, because he was occasionally visited by the then Prince George of Cambridge. I remember turning my pinafore wrong side forwards in order to represent a surplice, and preaching
5 to my mother's maids in the kitchen as nearly as possible in Sir Herbert's manner one Sunday morning when the rest of the family were at church. That is the earliest indication I can call to mind of the strong clerical affinities which my friend Mr. Herbert Spencer has always ascribed to me, though
10 I fancy they have for the most part remained in a latent state.

My regular school training was of the briefest, perhaps fortunately, for though my way of life has made me acquainted with all sorts and conditions of men, from the highest to the lowest, I deliberately affirm that the society I fell into
15 at school was the worst I have ever known. We boys were average lads, with much the same inherent capacity for good and evil as any others; but the people who were set over us cared about as much for our intellectual and moral welfare as if they were baby-farmers. We were left to the operation
20 of the struggle for existence among ourselves, and bullying was the least of the ill practices current among us. Almost the only cheerful reminiscence in connection with the place which arises in my mind is that of a battle I had with one of my classmates, who had bullied me until I could stand it no
25 longer. I was a very slight lad, but there was a wild-cat element in me which, when roused, made up for lack of weight, and I licked my adversary effectually. However, one of my first experiences of the extremely rough-and-ready nature of Justice, as exhibited by the course of things in general, arose
30 out of the fact that I — the victor — had a black eye, while he — the vanquished — had none, so that I got into disgrace and he did not. We made it up, and thereafter I was unmolested. One of the greatest shocks I ever received in my life was to be told a dozen years afterwards by the groom who

brought me my horse in a stable yard in Sydney that he was my quondam antagonist. He had a long story of family misfortune to account for his position, but at that time it was necessary to deal very cautiously with mysterious strangers in New South Wales, and on inquiry I found that the unfor- 5
tunate young man had not only been "sent out," but had undergone more than one colonial conviction.

As I grew older, my great desire was to be a mechanical engineer, but the fates were against this and, while very young, I commenced the study of medicine under a medical 10
brother-in-law. But, though the Institute of Mechanical Engineers would certainly not own me, I am not sure that I have not all along been a sort of mechanical engineer *in partibus infidelium*. I am now occasionally horrified to think how very little I ever knew or cared about medicine as the 15
art of healing. The only part of my professional course which really and deeply interested me was physiology, which is the mechanical engineering of living machines; and, notwithstanding that natural science has been my proper business, I am afraid there is very little of the genuine naturalist in me. 20
I never collected anything, and species work was always a burden to me; what I cared for was the architectural and engineering part of the business, the working out of the wonderful unity of plan in the thousands and thousands of diverse living constructions, and the modifications of similar appa- 25
ratuses to serve diverse ends. The extraordinary attraction I felt towards the study of the intricacies of living structure nearly proved fatal to me at the outset. I was a mere boy — I think between thirteen and fourteen years of age — when I was taken by some older student friends of mine to the first 30
post-mortem examination I ever attended. All my life I have been most unfortunately sensitive to the disagreeables which attend anatomical pursuits, but on this occasion my curiosity overpowered all other feelings, and I spent two or

three hours in gratifying it. I did not cut myself, and none of the ordinary symptoms of dissection-poison supervened, but poisoned I was somehow, and I remember sinking into a strange state of apathy. By way of a last chance, I was sent
5 to the care of some good, kind people, friends of my father's, who lived in a farmhouse in the heart of Warwickshire. I remember staggering from my bed to the window on the bright spring morning after my arrival, and throwing open the case-ment. Life seemed to come back on the wings of the breeze,
10 and to this day the faint odor of wood-smoke, like that which floated across the farmyard in the early morning, is as good to me as the "sweet south upon a bed of violets." I soon recovered, but for years I suffered from occasional paroxysms of internal pain, and from that time my constant friend, hypo-
15 chondriacal dyspepsia, commenced his half century of co-tenancy of my fleshly tabernacle.

Looking back on my "Lehrjahre," I am sorry to say that I do not think that any account of my doings as a student would tend to edification. In fact, I should distinctly warn ingenu-
20 ous youth to avoid imitating my example. I worked extremely hard when it pleased me, and when it did not — which was a very frequent case — I was extremely idle (un- less making caricatures of one's pastors and masters is to be called a branch of industry), or else wasted my energies in
25 wrong directions. I read everything I could lay hands upon, including novels, and took up all sorts of pursuits to drop them again quite as speedily. No doubt it was very largely my own fault, but the only instruction from which I ever
30 received from Mr. Wharton Jones, who was the lecturer on physiology at the Charing Cross School of Medicine. The extent and precision of his knowledge impressed me greatly, and the severe exactness of his method of lecturing was quite to my taste. I do not know that I have ever felt so much re-

spect for anybody as a teacher before or since. I worked hard to obtain his approbation, and he was extremely kind and helpful to the youngster who, I am afraid, took up more of his time than he had any right to do. It was he who suggested the publication of my first scientific paper — a very little one — in the *Medical Gazette* of 1845, and most kindly corrected the literary faults which abounded in it, short as it was; for at that time, and for many years afterwards, I detested the trouble of writing, and would take no pains over it.

It was in the early spring of 1846, that, having finished my obligatory medical studies and passed the first M.B. examination at the London University, — though I was still too young to qualify at the College of Surgeons, — I was talking to a fellow-student — the present eminent physician, Sir Joseph Fayrer — and wondering what I should do to meet the imperative necessity of earning my own bread, when my friend suggested that I should write to Sir William Burnett, at that time Director-General for the Medical Service of the Navy, for an appointment. I thought this rather a strong thing to do, as Sir William was personally unknown to me, but my cheery friend would not listen to my scruples, so I went to my lodgings and wrote the best letter I could devise. A few days afterwards I received the usual official circular acknowledgment, but at the bottom there was written an instruction to call at Somerset House on such a day. I thought that looked like business, so at the appointed time I called and sent in my card, while I waited in Sir William's anteroom. He was a tall, shrewd-looking old gentleman, with a broad Scotch accent, and I think I see him now as he entered with my card in his hand. The first thing he did was to return it, with the frugal reminder that I should find it useful on some other occasion. The second was to ask whether I was an Irishman. I suppose the air of modesty about my appeal must have struck him. I satisfied the Director-General that

I was English to the backbone, and he made some inquiries as to my student career, finally desiring me to hold myself ready for examination. Having passed this, I was in Her Majesty's Service, and entered on the books of Nelson's old ship, the *Victory*, for duty at Haslar Hospital, about a couple of months after I made my application.

My official chief at Haslar was a very remarkable person, the late Sir John Richardson, an excellent naturalist, and far-famed as an indomitable Arctic traveler. He was a silent, reserved man, outside the circle of his family and intimates; and, having a full share of youthful vanity, I was extremely disgusted to find that "Old John," as we irreverent youngsters called him, took not the slightest notice of my worshipful self either the first time I attended him, as it was
15 my duty to do, or for some weeks afterwards. I am afraid to think of the lengths to which my tongue may have run on the subject of the churlishness of the chief, who was, in truth, one of the kindest-hearted and most considerate of men. But one day, as I was crossing the hospital square, Sir John
20 stopped me, and heaped coals of fire on my head by telling me that he tried to get me one of the resident appointments, much coveted by the assistant surgeons, but that the Admiralty had put in another man. "However," said he, "I mean to keep you here till I can get you something you will
25 like," and turned upon his heel without waiting for the thanks I stammered out. That explained how it was I had not been packed off to the West Coast of Africa like some of my juniors, and why, eventually, I remained altogether seven months at Haslar.

30 After a long interval, during which "Old John" ignored my existence almost as completely as before, he stopped me again as we met in a casual way, and describing the service on which the *Rattlesnake* was likely to be employed, said that Captain Owen Stanley, who was to command the ship, had

asked him to recommend an assistant surgeon who knew something of science; would I like that? Of course I jumped at the offer. "Very well, I give you leave; go to London at once and see Captain Stanley." I went, saw my future commander, who was very civil to me, and promised to ask that I should be appointed to his ship, as in due time I was. It is a singular thing that, during the few months of my stay at Haslar, I had among my messmates two future Directors-General of the Medical Service of the Navy (Sir Alexander Armstrong and Sir John Watt-Reid), with the present President of the College of Physicians and my kindest of doctors, Sir Andrew Clark.

Life on board Her Majesty's ship in those days was a very different affair from what it is now, and ours was exceptionally rough, as we were often many months without receiving letters or seeing any civilized people but ourselves. In exchange, we had the interest of being about the last voyagers, I suppose, to whom it could be possible to meet with people who knew nothing of firearms — as we did on the south coast of New Guinea — and of making acquaintance with a variety of interesting savage and semicivilized people. But, apart from experience of this kind and the opportunities offered for scientific work, to me, personally, the cruise was extremely valuable. It was good for me to live under sharp discipline; to be down on the realities of existence by living on bare necessities; to find out how extremely well worth living life seemed to be when one woke up from a night's rest on a soft plank, with the sky for canopy and cocoa and weevily biscuit the sole prospect for breakfast; and, more especially, to learn to work for the sake of what I got for myself out of it, even if it all went to the bottom and I along with it. My brother officers were as good fellows as sailors ought to be and generally are, but, naturally, they neither knew nor cared anything about my pursuits, nor understood why I should be so zealous

in pursuit of the objects which my friends, the middies, christened "Buffons," after the title conspicuous on a volume of the *Suites à Buffon*, which stood on my shelf in the chart room.

5 During the four years of our absence, I sent home communication after communication to the "Linnean Society," with the same result as that obtained by Noah when he sent the raven out of his ark. Tired at last of hearing nothing about them, I determined to do or die, and in 1849 I drew up a more
10 elaborate paper and forwarded it to the Royal Society. This was my dove, if I had only known it. But owing to the movements of the ship, I heard nothing of that either until my return to England in the latter end of the year 1850, when I found that it was printed and published, and that a huge
15 packet of separate copies awaited me. When I hear some of my young friends complain of want of sympathy and encouragement, I am inclined to think that my naval life was not the least valuable part of my education.

Three years after my return were occupied by a battle
20 between my scientific friends on the one hand and the Admiralty on the other, as to whether the latter ought, or ought not, to act up to the spirit of a pledge they had given to encourage officers who had done scientific work by contributing to the expense of publishing mine. At last the Admiralty,
25 getting tired, I suppose, cut short the discussion by ordering me to join a ship, which thing I declined to do, and as Rastignac in the *Père Goriot* says to Paris, I said to London "*à nous deux.*" I desired to obtain a Professorship of either Physiology or Comparative Anatomy, and as vacancies occurred I
30 applied, but in vain. My friend, Professor Tyndall, and I were candidates at the same time, he for the Chair of Physics and I for that of Natural History in the University of Toronto, which, fortunately, as it turned out, would not look at either of us. I say fortunately, not from any lack of respect for

Toronto, but because I soon made up my mind that London was the place for me, and hence I have steadily declined the inducements to leave it, which have at various times been offered. At last, in 1854, on the translation of my warm friend Edward Forbes, to Edinburgh, Sir Henry de la Beche, 5 the Director-General of the Geological Survey, offered me the post Forbes vacated of Paleontologist and Lecturer on Natural History. I refused the former point blank, and accepted the latter only provisionally, telling Sir Henry that I did not care for fossils, and that I should give up Natural 10 History as soon as I could get a physiological post. But I held the office for thirty-one years, and a large part of my work has been paleontological.

At that time I disliked public speaking, and had a firm conviction that I should break down every time I opened 15 my mouth. I believe I had every fault a speaker could have (except talking at random or indulging in rhetoric), when I spoke to the first important audience I ever addressed, on a Friday evening at the Royal Institution, in 1852. Yet, I must confess to having been guilty, *malgré moi*, of as much 20 public speaking as most of my contemporaries, and for the last ten years it ceased to be so much of a bugbear to me. I used to pity myself for having to go through this training, but I am now more disposed to compassionate the unfortunate audiences, especially my ever friendly hearers at the 25 Royal Institution, who were the subjects of my oratorical experiments.

The last thing that it would be proper for me to do would be to speak of the work of my life, or to say at the end of the day whether I think I have earned my wages or not. Men are 30 said to be partial judges of themselves — young men may be, I doubt if old men are. Life seems terribly foreshortened as they look back and the mountain they set themselves to climb in youth turns out to be a mere spur of immeasurably higher

ranges when, by failing breath, they reach the top. But if I may speak of the objects I have had more or less definitely in view since I began the ascent of my hillock, they are briefly these: To promote the increase of natural knowledge and to forward the application of scientific methods of investigation to all the problems of life to the best of my ability, in the conviction — which has grown with my growth and strengthened with my strength — that there is no alleviation for the sufferings of mankind except veracity of thought and of action, and the resolute facing of the world as it is when the garment of make-believe by which pious hands have hidden its uglier features is stripped off.

It is with this intent that I have subordinated any reasonable, or unreasonable, ambition for scientific fame which I may have permitted myself to entertain to other ends; to the popularization of science and to the development and organization of scientific education.

In striving for the attainment of these objects, I have been but one among many, and I shall be well content to be remembered, or even not remembered, as such. Circumstances, among which I am proud to reckon the devoted kindness of many friends, have led to my occupation of various prominent positions, among which the Presidency of the Royal Society is the highest. It would be mock modesty on my part, with these and other scientific honors which have been bestowed upon me, to pretend that I have not succeeded in the career which I have followed, rather because I was driven into it than of my own free will; but I am afraid I should not count even these things as marks of success if I could not hope that I had somewhat helped that movement of opinion which has been called the New Reformation.

ON THE ADVISABLENESS OF IMPROVING NATURAL KNOWLEDGE

THIS time two hundred years ago — in the beginning of January, 1666 — those of our forefathers who inhabited this great and ancient city, took breath between the shocks of two fearful calamities: one not quite past, although its fury had abated; the other to come. 5

Within a few yards of the very spot on which we are assembled, so the tradition runs, that painful and deadly maldy, the plague, appeared in the latter months of 1664; and, though no new visitor, smote the people of England, and especially of her capital, with a violence unknown before, in the 10 course of the following year. The hand of a master has pictured what happened in those dismal months; and in that truest of fictions, "The History of the Plague Year," Defoe shows death, with every accompaniment of pain and terror, stalking through the narrow streets of old London, and chang- 15 ing their busy hum into a silence broken only by the wailing of the mourners of fifty thousand dead; by the woeful denunciations and mad prayers of fanatics; and by the madder yells of despairing profligates.

But, about this time in 1666, the death rate had sunk to 20 nearly its ordinary amount; a case of plague occurred only here and there, and the richer citizens who had flown from the pest had returned to their dwellings. The remnant of the people began to toil at the accustomed round of duty, or of pleasure; and the stream of city life bid fair to flow back 25 along its old bed, with renewed and uninterrupted vigor.

The newly kindled hope was deceitful. The great plague,

indeed, returned no more ; but what it had done for the Londoners, the great fire, which broke out in the autumn of 1666, did for London ; and, in September of that year, a heap of ashes and the indestructible energy of the people were all 5 that remained of the glory of five-sixths of the city within the walls.

Our forefathers had their own ways of accounting for each of these calamities. They submitted to the plague in humility and in penitence, for they believed it to be the judgment of 10 God. But, towards the fire they were furiously indignant, interpreting it as the effect of the malice of man, — as the work of the Republicans, or of the Papists, according as their prepossessions ran in favor of loyalty or of Puritanism.

It would, I fancy, have fared but ill with one who, standing 15 where I now stand, in what was then a thickly peopled and fashionable part of London, should have broached to our ancestors the doctrine which I now propound to you — that all their hypotheses were alike wrong ; that the plague was no more, in their sense, Divine judgment, than the fire was the 20 work of any political, or of any religious, sect ; but that they were themselves the authors of both plague and fire, and that they must look to themselves to prevent the recurrence of calamities, to all appearance so peculiarly beyond the reach of human control — so evidently the result of the wrath of 25 God, or of the craft and subtlety of an enemy.

And one may picture to oneself how harmoniously the holy cursing of the Puritan of that day would have chimed in with the unholy cursing and the crackling wit of the Rochesters and Sedleys, and with the revilings of the political fanatics, if 30 my imaginary plain dealer had gone on to say that, if the returns of such misfortunes were ever rendered impossible, it would not be in virtue of the victory of the faith of Laud, or of that of Milton ; and, as little, by the triumph of republican-

ism, as by that of monarchy. But that the one thing needful for compassing this end was, that the people of England should second the efforts of an insignificant corporation, the establishment of which, a few years before the epoch of the great plague and the great fire, had been as little noticed, 5 as they were conspicuous.

Some twenty years before the outbreak of the plague a few calm and thoughtful students banded themselves together for the purpose, as they phrased it, of "improving natural knowl- 10 edge." The ends they proposed to attain cannot be stated more clearly than in the words of one of the founders of the organization: —

"Our business was (precluding matters of theology and state affairs) to discourse and consider of philosophical enquiries, and such as related thereunto: — as Physick, Anatomy, Geometry, Astronomy, Navigation, 15 Staticks, Magneticks, Chymicks, Mechanicks, and Natural Experiments; with the state of these studies and their cultivation at home and abroad. We then discoursed of the circulation of the blood, the valves in the veins, the venæ lacteæ, the lymphatic vessels, the Copernican hypothesis, the nature of comets and new stars, the satellites of Jupiter, the oval 20 shape (as it then appeared) of Saturn, the spots on the sun and its turning on its own axis, the inequalities and selenography of the moon, the several phases of Venus and Mercury, the improvement of telescopes and grinding of glasses for that purpose, the weight of air, the possibility or impossibility of vacuities and nature's abhorrence thereof, the Torricel- 25 lian experiment in quicksilver, the descent of heavy bodies and the degree of acceleration therein, with divers others things of like nature, some of which were then but new discoveries, and others not so generally known and embraced as now they are; with other things appertaining to what hath been called the New Philosophy, which, from the times of 30 Galileo at Florence, and Sir Francis Bacon (Lord Verulam) in England, hath been much cultivated in Italy, France, Germany, and other parts abroad, as well as with us in England."

The learned Dr. Wallis, writing in 1696, narrates, in these words, what happened half a century before, or about 1645. 35 The associates met at Oxford, in the rooms of Dr. Wilkins,

who was destined to become a bishop ; and subsequently coming together in London, they attracted the notice of the king. And it is a strange evidence of the taste for knowledge which the most obviously worthless of the Stuarts shared with his
5 father and grandfather, that Charles the Second was not content with saying witty things about his philosophers but did wise things with regard to them. For he not only bestowed upon them such attention as he could spare from his poodles and his mistresses, but, being in his usual state
10 of impecuniosity, begged for them of the Duke of Ormond ; and, that step being without effect, gave them Chelsea College, a charter, and a mace : crowning his favors in the best way they could be crowned, by burdening them no further with royal patronage or state interference.

15 Thus it was that the half dozen young men, studious of the "New Philosophy," who met in one another's lodgings in Oxford or in London, in the middle of the seventeenth century, grew in numerical and in real strength, until, in its latter part, the "Royal Society for the Improvement of Natural
20 Knowledge" had already become famous, and had acquired a claim upon the veneration of Englishmen, which it has ever since retained, as the principal focus of scientific activity in our islands, and the chief champion of the cause it was formed to support.

25 It was by the aid of the Royal Society that Newton published his "Principia." If all the books in the world, except the Philosophical Transactions, were destroyed, it is safe to say that the foundations of physical science would remain unshaken, and that the vast intellectual progress of the last
30 two centuries would be largely, though incompletely, recorded. Nor have any signs of halting or of decrepitude manifested themselves in our own times. As in Dr. Wallis's days, so in these, "our business is, precluding theology and state affairs, to discourse and consider of philosophical enquiries." But

our "Mathematick" is one which Newton would have to go to school to learn; our "Statics, Mechanics, Magneticks, Chymicks, and Natural Experiments" constitute a mass of physical and chemical knowledge, a glimpse at which would compensate Galileo for the doings of a score of inquisitorial 5 cardinals; our "Physick" and "Anatomy" have embraced such infinite varieties of being, have laid open such new worlds in time and space, have grappled, not unsuccessfully, with such complex problems, that the eyes of Vesalius and of Harvey might be dazzled by the sight of the tree that has 10 grown out of their grain of mustard seed.

The fact is perhaps rather too much, than too little, forced upon one's notice, nowadays, that all this marvellous intellectual growth has a no less wonderful expression in practical life; and that, in this respect, if in no other, the movement 15 symbolized by the progress of the Royal Society stands without a parallel in the history of mankind.

A series of volumes as bulky as the Transactions of the Royal Society might possibly be filled with the subtle speculations of the Schoolmen; not improbably, the obtaining a 20 mastery over the products of mediæval thought might necessitate an even greater expenditure of time and of energy than the acquirement of the "New Philosophy"; but though such work engrossed the best intellects of Europe for a longer time than has elapsed since the great fire, its effects were "writ 25 in water," so far as our social state is concerned.

On the other hand, if the noble first President of the Royal Society could revisit the upper air and once more gladden his eyes with a sight of the familiar mace, he would find himself in the midst of a material civilization more different from that of 30 his day, than that of the seventeenth, was from that of the first, century. And if Lord Brouncker's native sagacity had not deserted his ghost, he would need no long reflection to discover that all these great ships, these railways, these tele-

graphs, these factories, these printing presses, without which the whole fabric of modern English society would collapse into a mass of stagnant and starving pauperism, — that all these pillars of our State are but the ripples and the bubbles upon
5 the surface of that great spiritual stream, the springs of which, only he and his fellows were privileged to see; and seeing, to recognize as that which it behooved them above all things to keep pure and undefiled.

It may not be too great a flight of imagination to conceive
10 our noble *revenant* not forgetful of the great troubles of his own day, and anxious to know how often London had been burned down since his time, and how often the plague had carried off its thousands. He would have to learn that, although London contains tenfold the inflammable matter
15 that it did in 1666; though, not content with filling our rooms with woodwork and light draperies, we must needs lead inflammable and explosive gases into every corner of our streets and houses, we never allow even a street to burn down. And if he asked how this had come about, we should have to ex-
20 plain that the improvement of natural knowledge has furnished us with dozens of machines for throwing water upon fires, any one of which would have furnished the ingenious Mr. Hooke, the first “curator and experimenter” of the Royal Society, with ample materials for discourse before half
25 a dozen meetings of that body; and that, to say the truth, except for the progress of natural knowledge, we should not have been able to make even the tools by which these machines are constructed. And, further, it would be necessary to add, that although severe fires sometimes occur and inflict
30 great damage, the loss is very generally compensated by societies, the operations of which have been rendered possible only by the progress of natural knowledge in the direction of mathematics, and the accumulation of wealth in virtue of other natural knowledge.

But the plague? My Lord Brouncker's observation would not, I fear, lead him to think that Englishmen of the nineteenth century are purer in life, or more fervent in religious faith, than the generation which could produce a Boyle, an Evelyn, and a Milton. He might find the mud of society at the 5 bottom, instead of at the top, but I fear that the sum total would be as deserving of swift judgment as at the time of the Restoration. And it would be our duty to explain once more, and this time not without shame, that we have no reason to believe that it is the improvement of our faith, nor that of our 10 morals, which keeps the plague from our city; but, again, that it is the improvement of our natural knowledge.

We have learned that pestilences will only take up their abode among those who have prepared unswept and ungar- 15 nished residences for them. Their cities must have narrow, unwatered streets, foul with accumulated garbage. Their houses must be ill-drained, ill-lighted, ill-ventilated. Their subjects must be ill-washed, ill-fed, ill-clothed. The London of 1665 was such a city. The cities of the East, where plague has an enduring dwelling, are such cities. We, in later times, 20 have learned somewhat of Nature, and partly obey her. Because of this partial improvement of our natural knowledge and of that fractional obedience, we have no plague; because that knowledge is still very imperfect and that obedience yet incomplete, typhus is our companion and cholera our 25 visitor. But it is not presumptuous to express the belief that, when our knowledge is more complete and our obedience the expression of our knowledge, London will count her centuries of freedom from typhus and cholera, as she now gratefully reckons her two hundred years of ignorance of that 30 plague which swooped upon her thrice in the first half of the seventeenth century.

Surely, there is nothing in these explanations which is not fully borne out by facts? Surely, the principles involved in

them are now admitted among the fixed beliefs of all thinking men? Surely, it is true that our countrymen are less subject to fire, famine, pestilence, and all the evils which result from a want of command over and due anticipation of the course of Nature, than were the countrymen of Milton; and health, wealth, and well-being are more abundant with us than with them? But no less certainly is the difference due to the improvement of our knowledge of Nature, and the extent to which that improved knowledge has been incorporated with the household words of men, and has supplied the springs of their daily actions.

Granting for a moment, then, the truth of that which the depreciators of natural knowledge are so fond of urging, that its improvement can only add to the resources of our material civilization; admitting it to be possible that the founders of the Royal Society themselves looked for no other reward than this, I cannot confess that I was guilty of exaggeration when I hinted, that to him who had the gift of distinguishing between prominent events and important events, the origin of a combined effort on the part of mankind to improve natural knowledge might have loomed larger than the Plague and have outshone the glare of the Fire; as a something fraught with a wealth of beneficence to mankind, in comparison with which the damage done by those ghastly evils would shrink into insignificance.

It is very certain that for every victim slain by the plague, hundreds of mankind exist and find a fair share of happiness in the world, by the aid of the spinning jenny. And the great fire, at its worst, could not have burned the supply of coal, the daily working of which, in the bowels of the earth, made possible by the steam pump, gives rise to an amount of wealth to which the millions lost in old London are but as an old song.

But spinning jenny and steam pump are, after all, but toys, possessing an accidental value: and natural knowledge creates multitudes of more subtle contrivances, the praises of which do not happen to be sung because they are not directly convertible into instruments for creating wealth. 5 When I contemplate natural knowledge squandering such gifts among men, the only appropriate comparison I can find for her is, to liken her to such a peasant woman as one sees in the Alps, striding ever upward, heavily burdened, and with mind bent only on her home; but yet, without effort and without 10 thought, knitting for her children. Now stockings are good and comfortable things, and the children will undoubtedly be much better for them; but surely it would be short-sighted, to say the least of it, to depreciate this toiling mother as a mere stocking machine — a mere provider of physical com- 15 forts?

However, there are blind leaders of the blind, and not a few of them, who take this view of natural knowledge, and can see nothing in the bountiful mother of humanity but a sort of comfort-grinding machine. According to them, the 20 improvement of natural knowledge always has been, and always must be, synonymous with no more than the improvement of the material resources and the increase of the gratifications of men.

Natural knowledge is, in their eyes, no real mother of man- 25 kind, bringing them up with kindness, and, if need be, with sternness, in the way they should go, and instructing them in all things needful for their welfare; but a sort of fairy god-mother, ready to furnish her pets with shoes of swiftness, swords of sharpness, and omnipotent Aladdin's lamps, so that 30 they may have telegraphs to Saturn, and see the other side of the moon, and thank God they are better than their benighted ancestors.

If this talk were true, I, for one, should not greatly care

to toil in the service of natural knowledge. I think I would just as soon be quietly chipping my own flint ax, after the manner of my forefathers a few thousand years back, as be troubled with the endless malady of thought which now in-
5 festes us all, for such reward. But I venture to say that such views are contrary alike to reason and to fact. These who discourse in such fashion seem to me to be so intent upon trying to see what is above Nature, or what is behind her, that they are blind to what stares them in the face, in her.

10 I should not venture to speak thus strongly if my justification were not to be found in the simplest and most obvious facts, — if it needed more than an appeal to the most notorious truths to justify my assertion, that the improvement of natural knowledge, whatever direction it has taken, and how-
15 ever low the aims of those who may have commenced it — has not only conferred practical benefits on men, but, in so doing, has effected a revolution in their conceptions of the universe and of themselves, and has profoundly altered their modes of thinking and their views of right and wrong. I say
20 that natural knowledge, seeking to satisfy natural wants, has found the ideas which can alone still spiritual cravings. I say that natural knowledge, in desiring to ascertain the laws of comfort, has been driven to discover those of conduct, and to lay the foundations of a new morality.

25 Let us take these points separately; and, first, what great ideas has natural knowledge introduced into men's minds?

I cannot but think that the foundations of all natural knowledge were laid when the reason of man first came face
30 to face with the facts of Nature: when the savage first learned that the fingers of one hand are fewer than those of both; that it is shorter to cross a stream than to head it; that a stone stops where it is unless it be moved, and that it drops

from the hand which lets it go; that light and heat come and go with the sun; that sticks burn away in fire; that plants and animals grow and die; that if he struck his fellow-savage a blow he would make him angry, and perhaps get a blow in return, while if he offered him a fruit he would please him and perhaps receive a fish in exchange. When men had acquired this much knowledge, the outlines, rude though they were, of mathematics, of physics, of chemistry, of biology, of moral, economical, and political science, were sketched. Nor did the germ of religion fail when science began to bud. Listen to words which, though new, are yet three thousand years old: —

“ . . . When in heaven the stars about the moon
 Look beautiful, when all the winds are laid,
 And every height comes out, and jutting peak
 And valley, and the immeasurable heavens
 Break open to their highest, and all the stars
 Shine, and the shepherd gladdens in his heart.”¹

If the half-savage Greek could share our feelings thus far, it is irrational to doubt that he went further, to find, as we do, that upon that brief gladness there follows a certain sorrow, — the little light of awakened human intelligence shines so mere a spark amidst the abyss of the unknown and unknowable; seems so insufficient to do more than illuminate the imperfections that cannot be remedied, the aspirations that cannot be realized, of man's own nature. But in this sadness, this consciousness of the limitation of man, this sense of an open secret which he cannot penetrate, lies the essence of all religion; and the attempt to embody it in the forms furnished by the intellect is the origin of the higher theologies.

Thus it seems impossible to imagine but that the foundations of all knowledge — secular or sacred — were laid when intelligence dawned, though the superstructure remained for long ages so slight and feeble as to be compatible with the

¹ Need it be said that this is Tennyson's English for Homer's Greek?

existence of almost any general view respecting the mode of governance of the universe. No doubt, from the first, there were certain phenomena which, to the rudest mind, presented a constancy of occurrence, and suggested that a fixed
5 order ruled, at any rate, among them. I doubt if the grossest of Fetish worshipers ever imagined that a stone must have a god within it to make it fall, or that a fruit had a god within it to make it taste sweet. With regard to such matters as these, it is hardly questionable that mankind from the first
10 took strictly positive and scientific views.

But with respect to all the less familiar occurrences which present themselves, uncultured man, no doubt, has always taken himself as the standard of comparison, as the center and measure of the world; nor could he well avoid doing so.
15 And finding that his apparently uncaused will has a powerful effect in giving rise to many occurrences, he naturally enough ascribed other and greater events to other and greater volitions, and came to look upon the world and all that therein is, as the product of the volitions of persons like himself, but
20 stronger, and capable of being appeased or angered, as he himself might be soothed or irritated. Through such conceptions of the plan and working of the universe all mankind have passed, or are passing. And we may now consider, what has been the effect of the improvement of natural
25 knowledge on the views of men who have reached this stage, and who have begun to cultivate natural knowledge with no desire but that of "increasing God's honor and bettering man's estate."

For example: what could seem wiser, from a mere material
30 point of view, more innocent, from a theological one, to an ancient people, than that they should learn the exact succession of the seasons, as warnings for their husbandmen; or the position of the stars, as guides to their rude navigators? But what has grown out of this search for natural knowledge

of so merely useful a character? You all know the reply. Astronomy, — which of all sciences has filled men's minds with general ideas of a character most foreign to their daily experience, and has, more than any other, rendered it impossible for them to accept the beliefs of their fathers. Astronomy, — which tells them that this so vast and seemingly solid earth is but an atom among atoms, whirling, no man knows whither, through illimitable space; which demonstrates that what we call the peaceful heaven above us, is but that space, filled by an infinitely subtle matter whose particles are seething and surging, like the waves of an angry sea; which opens up to us infinite regions where nothing is known, or ever seems to have been known, but matter and force, operating according to rigid rules; which leads us to contemplate phenomena the very nature of which demonstrates that they have had a beginning, and that they must have an end, but the very nature of which also proves that the beginning was, to our conceptions of time, infinitely remote, and that the end is as immeasurably distant.

But it is not alone those who pursue astronomy who ask for bread and receive ideas. What more harmless than the attempt to lift and distribute water by pumping it; what more absolutely and grossly utilitarian? But out of pumps grew the discussions about Nature's abhorrence of a vacuum; and then it was discovered that Nature does not abhor a vacuum, but that air has weight; and that notion paved the way for the doctrine that all matter has weight, and that the force which produces weight is coextensive with the universe, — in short, to the theory of universal gravitation and endless force, while learning how to handle gases led to the discovery of oxygen, and to modern chemistry, and to the notion of the indestructibility of matter.

Again, what simpler, or more absolutely practical, than the attempt to keep the axle of a wheel from heating when the

wheel turns round very fast. How useful for carters and gig drivers to know something about this; and how good were it, if any ingenious person would find out the cause of such phenomena, and thence educe a general remedy for them. Such
5 an ingenious person was Count Rumford; and he and his successors have landed us in the theory of the persistence, or indestructibility, of force. And in the infinitely minute, as in the infinitely great, the seekers after natural knowledge of the kinds called physical and chemical, have everywhere
10 found a definite order and succession of events which seem never to be infringed.

And how has it fared with "Physick" and Anatomy? Have the anatomist, and physiologist, or the physician, whose business it has been to devote themselves assiduously
15 to that eminently practical and direct end, the alleviation of the sufferings of mankind, — have they been able to confine their vision more absolutely to the strictly useful? I fear they are worst offenders of all. For if the astronomer has set before us the infinite magnitude of space, and the practical
20 eternity of the duration of the universe; if the physical and chemical philosophers have demonstrated the infinite minuteness of its constituent parts, and the practical eternity of matter and of force; and if both have alike proclaimed the universality of a definite and predicable order and succession
25 of events, the workers in biology have not only accepted all these, but have added more startling theses of their own. For, as the astronomers discover in the earth no center of the universe, but an eccentric speck, so the naturalists find man to be no center of the living world, but one amidst endless modi-
30 fications of life; and as the astronomer observes the mark of practically endless time set upon the arrangements of the solar system so the student of life finds the records of ancient forms of existence peopling the world for ages, which, in relation to human experience, are infinite.

Furthermore, the physiologist finds life to be as dependent for its manifestation on particular molecular arrangements as any physical or chemical phenomenon; and, wherever he extends his researches, fixed order and unchanging causation reveal themselves, as plainly as in the rest of Nature. 5

Such are a few of the new conceptions implanted in our minds by the improvement of natural knowledge. Men have acquired the ideas of the practically infinite extent of the universe and of its practical eternity; they are familiar with the conception that our earth is but an infinitesimal fragment of 10 that part of the universe which can be seen; and that, nevertheless, its duration is, as compared with our standards of time, infinite. They have further acquired the idea that man is but one of innumerable forms of life now existing in the globe, and that the present existences are but the last of an 15 immeasurable series of predecessors. Moreover, every step they have made in natural knowledge has tended to extend and rivet in their minds the conception of a definite order of the universe — which is embodied in what are called, by an unhappy metaphor, the laws of Nature — and to narrow the 20 range and loosen the force of men's belief in spontaneity, or in changes other than such as arise out of that definite order itself.

Whether these ideas are well or ill founded is not the question. No one can deny that they exist, and have been the in- 25 evitable outgrowth of the improvement of natural knowledge. And if so, it cannot be doubted that they are changing the form of men's most cherished and most important convictions.

Thus, without for a moment pretending to despise the practical results of the improvement of natural knowledge, and 30 its beneficial influence on material civilization, it must, I think, be admitted, that the great ideas, some of which I have indicated, constitute the real and permanent significance of natural knowledge.

If these ideas be destined, as I believe they are, to be more and more firmly established as the world grows older; if that spirit be fated, as I believe it is, to extend itself into all departments of human thought, and to become coextensive with the range of knowledge; if, as our race approaches its maturity, it discovers, as I believe it will, that there is but one kind of knowledge and but one method of acquiring it; then we, who are still children, may justly feel it our highest duty to recognize the advisableness of improving natural
5 knowledge, and so aid ourselves and our successors in their
10 course towards the noble goal which lies before mankind.

A LIBERAL EDUCATION; AND WHERE TO FIND IT

THE business which the South London Working Men's College has undertaken is a great work ; indeed, I might say, that Education, with which that college proposes to grapple, is the greatest work of all those which lie ready to a man's hand just at present. 5

And, at length, this fact is becoming generally recognized. You cannot go anywhere without hearing a buzz of more or less confused and contradictory talk on this subject — nor can you fail to notice that, in one point at any rate, there is a very decided advance upon like discussions in former days. No- 10 body outside the agricultural interest now dares to say that education is a bad thing. If any representative of the once large and powerful party, which, in former days, proclaimed this opinion, still exists in a semifossil state, he keeps his thoughts to himself. In fact, there is a chorus of voices, al- 15 most distressing in their harmony, raised in favor of the doctrine that education is the great panacea for human troubles, and that, if the country is not shortly to go to the dogs, everybody must be educated.

The politicians tell us, “you must educate the masses be- 20 cause they are going to be masters.” The clergy join in the cry for education, for they affirm that the people are drifting away from church and chapel into the broadest infidelity. The manufacturers and the capitalists swell the chorus lustily. They declare that ignorance makes 25 bad workmen ; that England will soon be unable to turn out cotton goods, or steam engines, cheaper than other people ;

and then, Ichabod ! Ichabod ! the glory will be departed from us. And a few voices are lifted up in favor of the doctrine that the masses should be educated because they are men and women with unlimited capacities of being, doing, and suffering, and that it is as true now, as ever it was, that the people perish for lack of knowledge.

These members of the minority, with whom I confess I have a good deal of sympathy, are doubtful whether any of the other reasons urged in favor of the education of the people are of much value — whether, indeed, some of them are based upon either wise or noble grounds of action. They question if it be wise to tell people that you will do for them, out of fear of their power, what you have left undone, so long as your only motive was compassion for their weakness and their sorrows. And, if ignorance of everything which it is needful a ruler should know is likely to do so much harm in the governing classes of the future, why is it, they ask reasonably enough, that such ignorance in the governing classes of the past has not been viewed with equal horror ?

Compare the average artisan and the average country squire, and it may be doubted if you will find a pin to choose between the two in point of ignorance, class feeling, or prejudice. It is true that the ignorance is of a different sort — that the class feeling is in favor of a different class, and that the prejudice has a distinct favor of wrong-headedness in each case — but it is questionable if the one is either a bit better or a bit worse, than the other. The old protectionist theory is the doctrine of trades unions as applied by the squires, and the modern trades unionism is the doctrine of the squires applied by the artisans. Why should we be worse off under one *régime* than under the other ?

Again, this skeptical minority asks the clergy to think whether it is really want of education which keeps the masses away from their ministrations — whether the most

completely educated men are not as open to reproach on this score as the workmen; and whether, perchance, this may not indicate that it is not education which lies at the bottom of the matter?

Once more, these people, whom there is no pleasing, venture to doubt whether the glory which rests upon being able to undersell all the rest of the world, is a very safe kind of glory — whether we may not purchase it too dear; especially if we allow education, which ought to be directed to the making of men, to be diverted into a process of manufacturing human tools, wonderfully adroit in the exercise of some technical industry, but good for nothing else.

And, finally, these people inquire whether it is the masses alone who need a reformed and improved education. They ask whether the richest of our public schools might not well be made to supply knowledge, as well as gentlemanly habits, a strong class feeling, and eminent proficiency in cricket. They seem to think that the noble foundations of our old universities are hardly fulfilling their functions in their present posture of half clerical seminaries, half race courses, where men are trained to win a senior wranglership, or a double-first, as horses are trained to win a cup, with as little reference to the needs of after life in the case of the man as in that of the racer. And, while as zealous for education as the rest, they affirm that, if the education of the richer classes were such as to fit them to be the leaders and the governors of the poorer; and, if the education of the poorer classes were such as to enable them to appreciate really wise guidance and good governance; the politicians need not fear mob law, nor the clergy lament their want of flocks, nor the capitalists prognosticate the annihilation of the prosperity of the country.

Such is the diversity of opinion upon the why and the wherefore of education. And my hearers will be prepared to expect that the practical recommendations which are put

forward are not less discordant. There is a loud cry for compulsory education. We English, in spite of constant experience to the contrary, preserve a touching faith in the efficacy of acts of Parliament; and I believe we should have compulsory education in the course of next session, if there were the least probability that half a dozen leading statesmen of different parties would agree what that education should be.

Some hold that education without theology is worse than none. Others maintain, quite as strongly, that education with theology is in the same predicament. But this is certain, that those who hold the first opinion can by no means agree what theology should be taught; and that those who maintain the second are in a small minority.

At any rate "make people learn to read, write, and cipher," say a great many; and the advice is undoubtedly sensible as far as it goes. But, as has happened to me in former days, those who, in despair of getting anything better, advocate this measure, are met with the objection that it is very like making a child practice the use of a knife, fork, and spoon, without giving it a particle of meat. I really don't know what reply is to be made to such an objection.

But it would be unprofitable to spend more time in disentangling, or rather in showing up the knots in, the raveled skeins of our neighbors. Much more to the purpose is it to ask if we possess any clew of our own which may guide us among these entanglements. And by way of a beginning, let us ask ourselves — What is education? Above all things, what is our ideal of a thoroughly liberal education? — of that education which, if we could begin life again, we would give ourselves — of that education which, if we could mold the fates to our own will, we would give our children. Well, I know not what may be your conceptions upon this matter but I will tell you mine, and I hope I shall find that our views are not very discrepant.

Suppose it were perfectly certain that the life and fortune of every one of us would, one day or other, depend upon his winning or losing a game at chess. Don't you think that we should all consider it to be a primary duty to learn at least the names and the moves of the pieces; to have a notion of a 5 gambit, and a keen eye for all the means of giving and getting out a check? Do you not think that we should look with a disapprobation amounting to scorn, upon the father who allowed his son, or the state which allowed its members, to grow up without knowing a pawn from a knight? 10

Yet it is a very plain and elementary truth, that the life, the fortune, and the happiness of every one of us, and, more or less, of those who are connected with us, do depend upon our knowing something of the rules of a game infinitely more difficult and complicated than chess. It is a game which has 15 been played for untold ages, every man and woman of us being one of the two players in a game of his or her own. The chess board is the world, the pieces are the phenomena of the universe, the rules of the game are what we call the laws of Nature. The player on the other side is hidden from us. We 20 know that his play is always fair, just, and patient. But also we know, to our cost, that he never overlooks a mistake, or makes the smallest allowance for ignorance. To the man who plays well, the highest stakes are paid, with that sort of overflowing generosity with which the strong shows delight 25 in strength. And one who plays ill is checkmated — without haste, but without remorse.

My metaphor will remind some of you of the famous picture in which Retzsch has depicted Satan playing at chess with man for his soul. Substitute for the mocking fiend in 30 that picture, a calm, strong angel who is playing for love, as we say, and would rather lose than win — and I should accept it as an image of human life.

Well, what I mean by Education, is learning the rules of

this mighty game. In other words, education is the instruction of the intellect in the laws of Nature, under which name I include not merely things and their forces, but men and their ways; and the fashioning of the affections and of the will into an earnest and loving desire to move in harmony with those laws. For me, education means neither more nor less than this. Anything, which professes to call itself education must be tried by this standard, and if it fails to stand the test, I will not call it education, whatever may be the force of authority, or of numbers, upon the other side.

It is important to remember that, in strictness, there is no such thing as an uneducated man. Take an extreme case. Suppose that an adult man, in the full vigor of his faculties, could be suddenly placed in the world, as Adam is said to have been, and then left to do as he best might. How long would he be left uneducated? Not five minutes. Nature would begin to teach him, through the eye, the ear, the touch, the properties of objects. Pain and pleasure would be at his elbow telling him to do this and avoid that; and by slow degrees the man would receive an education, which, if narrow, would be thorough, real, and adequate to his circumstances, though there would be no extras and very few accomplishments.

And if to this solitary man entered a second Adam, or, better still, an Eve, a new and greater world, that of social and moral phenomena, would be revealed. Joys and woes, compared with which all others might seem but faint shadows, would spring from the new relations. Happiness and sorrow would take the place of the coarser monitors, pleasure and pain; but conduct would still be shaped by the observation of the natural consequences of actions; or, in other words, by the laws or the nature of man.

To every one of us the world was once as fresh and new as to Adam. And then, long before we were susceptible of any

other mode of instruction, Nature took us in hand, and every minute of waking life brought its educational influence, shaping our actions into rough accordance with Nature's laws, so that we might not be ended untimely by too gross disobedience. Nor should I speak of this process of education as past, 5 for any one, be he as old as he may. For every man, the world is as fresh as it was at the first day, and as full of untold novelties for him who has the eyes to see them. And Nature is still continuing her patient education of us in that great university, the universe, of which we are all members — Nature 10 having no Test-Acts.

Those who take honors in Nature's university, who learn the laws which govern men and things and obey them, are the really great and successful men in this world. The great mass of mankind are the "Poll," who pick up just enough to 15 get through without much discredit. Those who won't learn at all are plucked; and then you can't come up again. Nature's pluck means extermination.

Thus the question of compulsory education is settled so far as Nature is concerned. Her bill on that question was 20 framed and passed long ago. But, like all compulsory legislation, that of Nature is harsh and wasteful in its operation. Ignorance is visited as sharply as willful disobedience — incapacity meets with the same punishment as crime. Nature's discipline is not even a word and a blow, and the blow first; 25 but the blow without the word. It is left to you to find out why your ears are boxed.

The object of what we commonly call education — that education in which man intervenes and which I shall distinguish as artificial education — is to make good these defects in 30 Nature's methods; to prepare the child to receive Nature's education, neither incapably nor ignorantly, nor with willful disobedience; and to understand the preliminary symptoms of her displeasure, without waiting for the box on the ear.

In short, all artificial education ought to be an anticipation of natural education. And a liberal education is an artificial education which has not only prepared a man to escape the great evils of disobedience to natural laws, but has trained him 5 to appreciate and to seize upon the rewards, which Nature scatters with as free a hand as her penalties.

That man, I think, has had a liberal education, who has been so trained in youth that his body is the ready servant of his will, and does with ease and pleasure all the work that, 10 as a mechanism, it is capable of; whose intellect is a clear, cold, logic engine, with all its parts of equal strength, and in smooth working order; ready, like a steam engine, to be turned to any kind of work, and spin the gossamers as well as forge the anchors of the mind; whose mind is stored with a 15 knowledge of the great and fundamental truths of Nature and of the laws of her operations; one who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of Nature or of 20 art, to hate all vileness, and to respect others as himself.

Such an one and no other, I conceive, has had a liberal education; for he is, as completely as a man can be, in harmony with Nature. He will make the best of her, and she of him. They will get on together rarely; she as his ever benefi- 25 cent mother; he as her mouthpiece, her conscious self, her minister and interpreter.

Where is such an education as this to be had? Where is there any approximation to it? Has any one tried to found such an education? Looking over the length and breadth of 30 these islands, I am afraid that all these questions must receive a negative answer. Consider our primary schools, and what is taught in them. A child learns: —

1. To read, write, and cipher, more or less well; but in a very large proportion of cases not so well as to take pleasure

in reading, or to be able to write the commonest letter properly.

2. A quantity of dogmatic theology, of which the child, nine times out of ten, understands next to nothing.

3. Mixed up with this, so as to seem to stand or fall with it, a few of the broadest and simplest principles of morality. This, to my mind, is much as if a man of science should make the story of the fall of the apple in Newton's garden, an integral part of the doctrine of gravitation, and teach it as of equal authority with the law of the inverse squares. 10

4. A good deal of Jewish history and Syrian geography, and, perhaps, a little something about English history and the geography of the child's own country. But I doubt if there is a primary school in England in which hangs a map of the hundred in which the village lies, so that the children may be practically taught by it what a map means. 15

5. A certain amount of regularity, attentive obedience, respect for others: obtained by fear, if the master be incompetent or foolish; by love and reverence, if he be wise.

So far as this school course embraces a training in the theory and practice of obedience to the moral laws of Nature, I gladly admit, not only that it contains a valuable educational element, but that, so far, it deals with the most valuable and important part of all education. Yet, contrast what is done in this direction with what might be done; with the time given to matters of comparatively no importance; with the absence of any attention to things of the highest moment; and one is tempted to think of Falstaff's bill and "the halfpenny worth of bread to all that quantity of sack."

Let us consider what a child thus "educated" knows, and what it does not know. Begin with the most important topic of all — morality, as the guide of conduct. The child knows well enough that some acts meet with approbation and some with disapprobation. But it has never heard that there lies

in the nature of things a reason for every moral law, as cogent and as well defined as that which underlies every physical law; that stealing and lying are just as certain to be followed by evil consequences, as putting your hand in the fire, or
5 jumping out of a garret window. Again, though the scholar may have been acquainted, in dogmatic fashion, with the broad laws of morality, he has had no training in the application of those laws to the difficult problems which result from the complex conditions of modern civilization. Would it not
10 be very hard to expect any one to solve a problem in conic sections who had merely been taught the axioms and definitions of mathematical science?

A workman has to bear hard labor, and perhaps privation while he sees others rolling in wealth, and feeding their dogs
15 with what would keep his children from starvation. Would it not be well to have helped that man to calm the natural promptings of discontent by showing him, in his youth, the necessary connection of the moral law which prohibits stealing with the stability of society — by proving to him, once
20 for all, that it is better for his own people, better for himself, better for future generations, that he should starve than steal? If you have no foundation of knowledge, or habit of thought, to work upon, what chance have you of persuading a hungry man that a capitalist is not a thief “with a circum-
25 bendibus”? And if he honestly believes that, of what avail is it to quote the commandment against stealing, when he proposes to make the capitalist disgorge?

Again, the child learns absolutely nothing of the history or the political organization of his own country. His general
30 impression is, that everything of much importance happened a very long while ago; and that the Queen and the gentlefolks govern the country much after the fashion of King David and the elders and nobles of Israel — his sole models. Will you give a man with this much information a vote? In

easy times he sells it for a pot of beer. Why should he not? It is of about as much use to him as a chignon, and he knows as much what to do with it, for any other purpose. In bad times, on the contrary, he applies his simple theory of government, and believes that his rulers are the cause of his sufferings — a belief which sometimes bears remarkable practical fruits.

Least of all, does the child gather from this primary "education" of ours a conception of the laws of the physical world, or of the relations of cause and effect therein. And this is the more to be lamented, as the poor are especially exposed to physical evils, and are more interested in removing them than any other class of the community. If any one is concerned in knowing the ordinary laws of mechanics one would think it is the hand laborer, whose daily toil lies among levers and pulleys; or among the other implements of artisan work. And if any one is interested in the laws of health, it is the poor workman, whose strength is wasted by ill-prepared food, whose health is sapped by bad ventilation and bad drainage, and half whose children are massacred by disorders which might be prevented. Not only does our present primary education carefully abstain from hinting to the workman that some of his greatest evils are traceable to mere physical agencies, which could be removed by energy, patience, and frugality; but it does worse — it renders him, so far as it can, deaf to those who could help him, and tries to substitute an Oriental submission to what is falsely declared to be the will of God, for his natural tendency to strive after a better condition.

What wonder then, if very recently, an appeal has been made to statistics for the profoundly foolish purpose of showing that education is of no good — that it diminishes neither misery, nor crime, among the masses of mankind? I reply, why should the thing which has been called education do

either the one or the other? If I am a knave or a fool, teaching me to read and write won't make me less of either one or the other — unless somebody shows me how to put my reading and writing to wise and good purposes.

5 Suppose any one were to argue that medicine is of no use, because it could be proved statistically, that the percentage of deaths was just the same, among people who had been taught how to open a medicine chest, and among those who did not so much as know the key by sight. The argument is absurd;
10 but it is not more preposterous than that against which I am contending. The only medicine for suffering, crime, and all the other woes of mankind, is wisdom. Teach a man to read and write, and you have put into his hands the great keys of the wisdom box. But it is quite another matter whether
15 he ever opens the box or not. And he is as likely to poison as to cure himself, if, without guidance, he swallows the first drug that comes to hand. In these times a man may as well be purblind, as unable to read — lame, as unable to write. But I protest that, if I thought the alternative were a neces-
20 sary one, I would rather that the children of the poor should grow up ignorant of both these mighty arts, than that they should remain ignorant of that knowledge to which these arts are means.

It may be said that all these animadversions may apply to
25 primary schools, but that the higher schools, at any rate, must be allowed to give a liberal education. In fact, they professedly sacrifice everything else to this object.

Let us inquire into this matter. What do the higher schools, those to which the great middle class of the country
30 sends its children, teach, over and above the instruction given in the primary schools? There is a little more reading and writing of English. But, for all that, every one knows that it is a rare thing to find a boy of the middle or upper

classes who can read aloud decently, or who can put his thoughts on paper in clear and grammatical (to say nothing of good or elegant) language. The "ciphering" of the lower schools expands into elementary mathematics in the higher; into arithmetic, with a little algebra, a little Euclid. But 5 I doubt if one boy in five hundred has ever heard the explanation of a rule of arithmetic, or knows his Euclid otherwise than by rote.

Modern geography, modern history, modern literature, the English language, as a language; the whole circle of the 10 sciences, physical, moral, and social, are even more completely ignored in the higher than in the lower schools. Up till within a few years back, a boy might have passed through any one of the great public schools with the greatest distinc- 5 tion and credit, and might never so much as have heard of one 15 of the subjects I have just mentioned. He might never have heard that the earth goes round the sun; that England underwent a great revolution in 1688, and France another in 1789, that there once lived certain notable men called Chaucer, Shakespeare, Milton, Voltaire, Goethe, Schiller. The first 20 might be a German and the last an Englishman for anything he could tell you to the contrary. And as for science, the only idea the word would suggest to his mind would be dex- 25 tery in boxing.

I have said that this was the state of things a few years 25 back, for the sake of the few righteous who are to be found among the educational cities of the plain. But I would not have you too sanguine about the result, if you sound the minds of the existing generation of public schoolboys, on such topics as those I have mentioned. 30

Now let us pause to consider this wonderful state of affairs; for the time will come when Englishmen will quote it as the stock example of the stolid stupidity of their ancestors in the nineteenth century. The most thoroughly commercial

people, the greatest voluntary wanderers and colonists the world has ever seen, are precisely the middle classes of this country. If there be a people which has been busy making history on the great scale for the last three hundred years —
5 and the most profoundly interesting history — history which, if it happened to be that of Greece or Rome, we should study with avidity — it is the English. If there be a people which, during the same period, has developed a remarkable literature, it is our own. If there be a nation whose prosperity depends
10 absolutely and wholly upon their mastery over the forces of Nature, upon their intelligent apprehension of, and obedience to, the laws of the creation and distribution of wealth, and of the stable equilibrium of the forces of society, it is precisely this nation. And yet this is what these wonderful people tell
15 their sons : —

“At the cost of from one to two thousand pounds of our hard earned money, we devote twelve of the most precious years of your lives to school. There you shall toil, or be supposed to toil ; but there you shall not learn one single thing of all those you will most want to know, directly you leave
20 school and enter upon the practical business of life. You will in all probability go into business, but you shall not know where, or how, any article of commerce is produced, or the difference between an export or an import, or the meaning of the word ‘capital.’ You will very likely settle in a colony, but you shall not know whether Tasmania is part of New
25 South Wales, or *vice versa*.

“Very probably you may become a manufacturer, but you shall not be provided with the means of understanding the working of one of your own steam engines, or the nature of the raw products you employ ; and, when you are asked to buy a patent, you shall not have the slightest
30 means of judging whether the inventor is an impostor who is contravening the elementary principles of science, or a man who will make you as rich as Cræsus.

“You will very likely get into the House of Commons. You will have to take your share in making laws which may prove a blessing or a
35 curse to millions of men. But you shall not hear one word respecting the political organization of your country ; the meaning of the controversy between freetraders and protectionists shall never have been

mentioned to you; you shall not so much as know that there are such things as economical laws.

“The mental power which will be of most importance in your daily life will be the power of seeing things as they are without regard to authority; and of drawing accurate general conclusions from particular 5 facts. But at school and at college you shall know of no source of truth but authority; nor exercise your reasoning faculty upon anything but deduction from that which is laid down by authority.

“You will have to weary your soul with work, and many a time eat your bread in sorrow and in bitterness, and you shall not have learned 10 to take refuge in the great source of pleasure without alloy, the serene resting place for worn human nature, — the world of art.”

Said I not rightly that we are a wonderful people? I am quite prepared to allow, that education entirely devoted to these omitted subjects might not be a completely liberal edu- 15 cation. But is an education which ignores them all, a liberal education? Nay, is it too much to say that the education which should embrace these subjects and no others, would be a real education, though an incomplete one; while an education which omits them is really not an education at all, but a 20 more or less useful course of intellectual gymnastics?

For what does the middle class school put in the place of all these things which are left out? It substitutes what is usually comprised under the compendious title of the “classics” — that is to say, the languages, the literature, and the 25 history of the ancient Greeks and Romans, and the geography of so much of the world as was known to these two great nations of antiquity. Now, do not expect me to depreciate the earnest and enlightened pursuit of classical learning. I have not the least desire to speak ill of such occupations, nor any 30 sympathy with those who run them down. On the contrary, if my opportunities had lain in that direction, there is no investigation into which I could have thrown myself with greater delight than that of antiquity.

What science can present greater attractions than philology? How can a lover of literary excellence fail to rejoice in the ancient masterpieces? And with what consistency could I, whose business lies so much in the attempt to decipher the past, and to build up intelligible forms out of the scattered fragments of long extinct beings, fail to take a sympathetic, though an unlearned, interest in the labors of a Niebuhr, a Gibbon, or a Grote? Classical history is a great section of the paleontology of man; and I have the same
10 double respect for it as for other kinds of paleontology — that is to say, a respect for the facts which it establishes as for all facts, and a still greater respect for it as a preparation for the discovery of a law of progress.

But if the classics were taught as they might be taught —
15 if boys and girls were instructed in Greek and Latin, not merely as languages, but as illustrations of philological science; if a vivid picture of life on the shores of the Mediterranean, two thousand years ago, were imprinted on the minds of scholars; if ancient history were taught, not as a weary
20 series of feuds and fights, but traced to its causes in such men placed under such conditions; if, lastly, the study of the classical books were followed in such a manner as to impress boys, with their beauties, and with the grand simplicity of their statement of the everlasting problems of human life,
25 instead of with their verbal and grammatical peculiarities; I still think it as little proper that they should form the basis of a liberal education for our contemporaries, as I should think it fitting to make that sort of paleontology with which I am familiar, the backbone of modern education.

30 It is wonderful how close a parallel to classical training could be made out of that paleontology to which I refer. In the first place I could get up an osteological primer so arid, so pedantic in its terminology, so altogether distasteful to the youthful mind, as to beat the recent famous production of the

head masters out of the field in all these excellences. Next, I could exercise my boys upon easy fossils, and bring out all their powers of memory and all their ingenuity in the application of my osteogrammatical rules to the interpretation, or construing, of those fragments. To those who had reached 5 the higher classes, I might supply odd bones to be built up into animals, giving great honor and reward to him who succeeded in fabricating monsters most entirely in accordance with the rules. That would answer to verse-making and essay-writing in the dead languages. 10

To be sure, if a great comparative anatomist were to look at these fabrications he might shake his head, or laugh. But what then? Would such a catastrophe destroy the parallel? What think you would Cicero, or Horace, say to the production of the best sixth form going? And would not Terence 15 stop his ears and run out if he could be present at an English performance of his own plays? Would Hamlet, in the mouths of a set of French actors, who should insist on pronouncing English after the fashion of their own tongue, be more hideously ridiculous? 20

But it will be said that I am forgetting the beauty, and the human interest, which appertain to classical studies. To this I reply that it is only a very strong man who can appreciate the charms of a landscape, as he is toiling up a steep hill, along a bad road. What with short-windedness, stones, ruts, 25 and a pervading sense of the wisdom of rest and be thankful, most of us have little enough sense of the beautiful under these circumstances. The ordinary schoolboy is precisely in this case. He finds Parnassus uncommonly steep, and there is no chance of his having much time or inclination to 30 look about him till he gets to the top. And nine times out of ten he does not get to the top.

But if this be a fair picture of the results of classical teaching at its best — and I gather from those who have authority

to speak on such matters that it is so — what is to be said of classical teaching at its worst, or in other words, of the classics of our ordinary middle class schools? I will tell you. It means getting up endless forms and rules by heart. 5 It means turning Latin and Greek into English, for the mere sake of being able to do it, and without the smallest regard to the worth, or worthlessness, of the author read. It means the learning of innumerable, not always decent, fables in such a shape that the meaning they once had is dried up into utter 10 trash; and the only impression left upon a boy's mind is, that the people who believed such things must have been the greatest idiots the world ever saw. And it means, finally, that after a dozen years spent at this kind of work, the sufferer shall be incompetent to interpret a passage in an author he 15 has not already got up; that he shall loathe the sight of a Greek or Latin book; and that he shall never open, or think of, a classical writer again, until, wonderful to relate, he insists upon submitting his sons to the same process.

These be your gods, O Israel! For the sake of this net 20 result (and respectability) the British father denies his children all the knowledge they might turn to account in life, not merely for the achievement of vulgar success, but for guidance in the great crises of human existence. This is the stone he offers to those whom he is bound by the strongest 25 and tenderest ties to feed with bread.

If primary and secondary education are in this unsatisfactory state, what is to be said to the universities? This is an awful subject, and one I almost fear to touch with my unhallowed hands; but I can tell you what those say who have 30 authority to speak.

The Rector of Lincoln College, in his lately published, valuable "Suggestions for Academical Organization with especial reference to Oxford," tells us (p. 127):—

“The colleges were, in their origin, endowments, not for the elements of a general liberal education, but for the prolonged study of special and professional faculties by men of riper age. The universities embraced both these objects. The colleges, while they incidentally aided in elementary education, were especially devoted to the highest learning. . . .

“This was the theory of the middle age university and the design of collegiate foundations in their origin. Time and circumstances have brought about a total change. The colleges no longer promote the researches of science, or direct professional study. Here and there college walls may shelter an occasional student, but not in larger proportions than may be found in private life. Elementary teaching of youths under twenty is now the only function performed by the university and almost the only object of college endowments. Colleges were homes for the life study of the highest and most abstruse parts of knowledge. They have become boarding schools in which the elements of the learned languages are taught to youths.”

If Mr. Pattison’s high position, and his obvious love and respect for his university, be insufficient to convince the outside world that language so severe is yet no more than just, the authority of the Commissioners who reported on the University of Oxford in 1850, is open to no challenge. Yet they write: —

“It is generally acknowledged that both Oxford and the country at large suffer greatly from the absence of a body of learned men devoting their lives to the cultivation of science, and to the direction of academical education.

“The fact that so few books of profound research emanate from the University of Oxford, materially impairs its character as a seat of learning, and consequently its hold on the respect of the nation.”

Cambridge can claim no exemption from the reproaches addressed to Oxford. And thus there seems no escape from the admission that what we fondly call our great seats of learning are simply “boarding schools” for bigger boys; that learned men are not more numerous in them than out of them; that the advancement of knowledge is not the object of fellows of colleges; that in the philosophic calm and

meditative stillness of their greenswarded courts, philosophy does not thrive, and meditation bears few fruits.

It is my great good fortune to reckon amongst my friends resident members of both universities, who are men of learning and research, zealous cultivators of science, keeping before their minds a noble ideal of a university, and doing their best to make that ideal a reality; and, to me, they would necessarily typify the universities, did not the authoritative statements I have quoted compel me to believe that they are exceptional and not representative men. Indeed, upon calm consideration, several circumstances lead me to think that the Rector of Lincoln College and the Commissioners cannot be far wrong.

I believe there can be no doubt that the foreigner who should wish to become acquainted with the scientific, or the literary, activity of modern England, would simply lose his time and his pains if he visited our universities with that object.

And, as for works of profound research on any subject, and, above all, in that classical lore for which the universities profess to sacrifice almost everything else, why, a third-rate, poverty-stricken German university turns out more produce of that kind in one year, than our vast and wealthy foundations elaborate in ten.

Ask the man who is investigating any question, profoundly and thoroughly — be it historical, philosophical, philological, physical, literary, or theological; who is trying to make himself master of any abstract subject (except, perhaps, political economy and geology, both of which are intensely Anglican sciences) whether he is not compelled to read half a dozen times as many German, as English books? And whether, of these English books, more than one in ten is the work of a fellow of a college, or a professor of an English university?

Is this from any lack of power in the English as compared with the German mind? The countrymen of Grote and of Mill, of Faraday, of Robert Brown, of Lyell, and of Darwin, to go no further back than the contemporaries of men of middle age, can afford to smile at such a suggestion. England 5 can show now, as she has been able to show in every generation since civilization spread over the West, individual men who hold their own against the world, and keep alive the old tradition of her intellectual eminence.

But, in the majority of cases, these men are what they are 10 in virtue of their native intellectual force, and of a strength of character which will not recognize impediments. They are not trained in the courts of the Temple of Science, but storm the walls of that edifice in all sorts of irregular ways, and with much loss of time and power, in order to obtain 15 their legitimate positions.

Our universities not only do not encourage such men; do not offer them positions, in which it should be their highest duty to do, thoroughly, that which they are most capable of doing; but, as far as possible, university training shuts out of 20 the minds of those among them, who are subjected to it, the prospect that there is anything in the world for which they are specially fitted. Imagine the success of the attempt to still the intellectual hunger of any of the men I have mentioned, by putting before him, as the object of existence, the successful 25 mimicry of the measure of a Greek song, or the roll of Ciceronian prose! Imagine how much success would be likely to attend the attempt to persuade such men, that the education which leads to perfection in such elegancies is alone to be called culture; while the facts of history, the process of 30 thought, the conditions of moral and social existence, and the laws of physical nature, are left to be dealt with as they may, by outside barbarians!

It is not thus that the German universities, from being

beneath notice a century ago, have become what they are now — the most intensely cultivated and the most productive intellectual corporations the world has ever seen.

The student who repairs to them sees in the list of classes
5 and of professors a fair picture of the world of knowledge. Whatever he needs to know there is some one ready to teach him, some one competent to discipline him in the way of learning; whatever his special bent, let him but be able and diligent, and in due time he shall find distinction and a career.
10 Among his professors, he sees men whose names are known and revered throughout the civilized world; and their living example infects him with a noble ambition, and a love for the spirit of work.

The Germans dominate the intellectual world by virtue of
15 the same simple secret as that which made Napoleon the master of old Europe. They have declared *la carrière ouverte aux talents*, and every Bursch marches with a professor's gown in his knapsack. Let him become a great scholar, or man of science, and ministers will compete for his services. In Ger-
20 many, they do not leave the chance of his holding the office he would render illustrious to the tender mercies of a hot canvass, and the final wisdom of a mob of country parsons.

In short, in Germany, the universities are exactly what the Rector of Lincoln and the Commissioners tell us the Eng-
25 lish universities are not; that is to say, corporations "of learned men devoting their lives to the cultivation of science, and the direction of academical education." They are not "boarding schools for youths," nor clerical seminaries; but institutions for the higher culture of men, in which the theo-
30 logical faculty is of no more importance, or prominence, than the rest; and which are truly "universities," since they strive to represent and embody the totality of human knowledge, and to find room for all forms of intellectual activity.

May zealous and clear-headed reformers like Mr. Pattison

succeed in their noble endeavors to shape our universities towards some such ideal as this, without losing what is valuable and distinctive in their social tone! But until they have succeeded a liberal education will be no more obtainable in our Oxford and Cambridge Universities than in our public schools. 5

If I am justified in my conception of the ideal of a liberal education; and if what I have said about the existing educational institutions of the country is also true, it is clear that the two have no sort of relation to one another; that the best of our schools and the most complete of our university trainings 10 give but a narrow, one-sided, and essentially illiberal education — while the worst give what is really next to no education at all. The South London Working Men's College could not copy any of these institutions if it would. I am bold enough to express the conviction that it ought not if it could. 15

For what is wanted is the reality and not the mere name of a liberal education; and this College must steadily set before itself the ambition to be able to give that education sooner or later. At present we are but beginning, sharpening our educational tools, as it were, and, except a modicum of 20 physical science, we are not able to offer much more than is to be found in an ordinary school.

Moral and social science — one of the greatest and most fruitful of our future classes, I hope — at present lacks only one thing in our program, and that is a teacher. A con- 25 siderable want, no doubt; but it must be recollected that it is much better to want a teacher than to want the desire to learn.

Further, we need what, for want of a better name, I must call Physical Geography. What I mean is that which the Germans call "Erdkunde." It is a description of the earth, 30 of its place and relation to other bodies; of its general structure, and of its great features — winds, tides, mountains, plains; of the chief forms of the vegetable and animal worlds,

of the varieties of man. It is the peg upon which the greatest quantity of useful and entertaining scientific information can be suspended.

Literature is not upon the College program; but I hope
5 some day to see it there. For literature is the greatest of
all sources of refined pleasure, and one of the great uses of
a liberal education is to enable us to enjoy that pleasure.
There is scope enough for the purposes of liberal education in
the study of the rich treasures of our own language alone.
10 All that is needed is direction, and the cultivation of a re-
fined taste by attention to sound criticism. But there is
no reason why French and German should not be mastered
sufficiently to read what is worth reading in those languages,
with pleasure and with profit.

15 And finally, by and by, we must have History; treated not
as a succession of battles and dynasties; not as a series of bi-
ographies; not as evidence that Providence has always been
on the side of either Whigs or Tories; but as the develop-
ment of man in times past, and in other conditions than our
20 own.

But, as it is one of the principles of our College to be
self-supporting, the public must lead, and we must follow, in
these matters. If my hearers take to heart what I have said
about liberal education, they will desire these things, and I
25 doubt not we shall be able to supply them. But we must wait
till the demand is made.

ON A PIECE OF CHALK

A LECTURE TO WORKINGMEN

IF a well were to be sunk at our feet in the midst of the city of Norwich, the diggers would very soon find themselves at work in that white substance almost too soft to be called rock, with which we are all familiar as "chalk."

Not only here, but over the whole county of Norfolk, the well-sinker might carry his shaft down many hundred feet without coming to the end of the chalk; and, on the sea-coast, where the waves have pared away the face of the land which breasts them, the scarped faces of the high cliffs are often wholly formed of the same material. Northward, the chalk may be followed as far as Yorkshire; on the south coast it appears abruptly in the picturesque western bays of Dorset, and breaks into the Needles of the Isle of Wight; while on the shores of Kent it supplies that long line of white cliffs to which England owes her name of Albion. 15

Were the thin soil which covers it all washed away, a curved band of white chalk, here broader, and there narrower, might be followed diagonally across England from Lulworth in Dorset, to Flamborough Head in Yorkshire — a distance of over 280 miles as the crow flies. 20

From this band to the North Sea, on the east, and the Channel, on the south, the chalk is largely hidden by other deposits; but, except in the Weald of Kent and Sussex, it enters into the very foundation of all the southeastern counties. 25

Attaining, as it does in some places, a thickness of more than a thousand feet, the English chalk must be admitted to be

a mass of considerable magnitude. Nevertheless, it covers but an insignificant portion of the whole area occupied by the chalk formation of the globe, which has precisely the same general characters as ours, and is found in detached patches, 5 some less, and others more extensive, than the English.

Chalk occurs in northwest Ireland; it stretches over a large part of France, — the chalk which underlies Paris being, in fact, a continuation of that of the London basin; it runs through Denmark, and Central Europe and extends south- 10 ward to North Africa; while eastward, it appears in the Crimea and in Syria, and may be traced as far as the shores of the Sea of Aral, in Central Asia.

If all the points at which true chalk occurs were circumscribed, they would lie within an irregular oval about 3,000 15 miles in long diameter — the area of which would be as great as that of Europe, and would many times exceed that of the largest existing inland sea — the Mediterranean.

Thus the chalk is no unimportant element in the masonry of the earth's crust, and it impresses a peculiar stamp, varying 20 with the conditions to which it is exposed, on the scenery of the districts in which it occurs. The undulating downs and rounded coombs, covered with sweet-grassed turf, of our inland chalk country, have a peacefully domestic and mutton-suggesting prettiness, but can hardly be called either 25 grand or beautiful. But on our southern coasts, the wall-sided cliffs, many hundred feet high, with vast needles and pinnacles standing out in the sea, sharp and solitary enough to serve as perches for the wary cormorant, confer a wonderful beauty and grandeur upon the chalk headlands. And, in 30 the East, chalk has its share in the formation of some of the most venerable of mountain ranges, such as the Lebanon.

What is this widespread component of the surface of the earth? and whence did it come?

You may think this no very hopeful inquiry. You may not unnaturally suppose that the attempt to solve such problems as these can lead to no result, save that of entangling the inquirer in vague speculations, incapable of refutation and of verification.

If such were really the case, I should have selected some other subject than a "piece of chalk" for my discourse. But, in truth, after much deliberation, I have been unable to think of any topic which would so well enable me to lead you to see how solid is the foundation upon which some of the most startling conclusions of physical science rest.

A great chapter of the history of the world is written in the chalk. Few pages in the history of man can be supported by such an overwhelming mass of direct and indirect evidence as that which testifies to the truth of the fragment of the history of the globe, which I hope to enable you to read, with your own eyes, to-night.

Let me add, that few chapters of human history have a more profound significance for ourselves. I weigh my words well when I assert, that the man who should know the true history of the bit of chalk which every carpenter carries about in his breeches-pocket, though ignorant of all other history, is likely, if he will think his knowledge out to its ultimate results, to have a truer, and therefore a better, conception of this wonderful universe, and of man's relation to it, than the most learned student who is deep-read in the records of humanity and ignorant of those of Nature.

The language of the chalk is not hard to learn, not nearly so hard as Latin, if you only want to get at the broad features of the story it has to tell; and I propose that we now set to work to spell that story out together.

We all know that if we "burn" chalk the result is quicklime. Chalk, in fact, is a compound of carbonic acid gas

and lime, and when you make it very hot the carbonic acid flies away and the lime is left.

By this method of procedure we see the lime, but we do not see the carbonic acid. If, on the other hand, you were to powder a little chalk and drop it into a good deal of strong vinegar, there would be a great bubbling and fizzing, and, finally, a clear liquid, in which no sign of chalk would appear. Here you see the carbonic acid in the bubbles; the lime, dissolved in the vinegar, vanishes from sight. There are a
10 great many other ways of showing that chalk is essentially nothing but carbonic acid and quicklime. Chemists enunciate the result of all the experiments which prove this, by stating that chalk is almost wholly composed of "carbonate of lime."

15 It is desirable for us to start from the knowledge of this fact, though it may not seem to help us very far towards what we seek. For carbonate of lime is a widely spread substance, and is met with under very various conditions. All sorts of limestones are composed of more or less pure carbon-
20 ate of lime. The crust which is often deposited by waters which have drained through limestone rocks, in the form of what are called stalagmites and stalactites, is carbonate of lime. Or, to take a more familiar example, the fur on the inside of a tea kettle is carbonate of lime; and for anything chemistry
25 tells us to the contrary, the chalk might be a kind of gigantic fur upon the bottom of the earth kettle, which is kept pretty hot below.

Let us try another method of making the chalk tell us its own history. To the unassisted eye chalk looks simply like
30 a very loose and open kind of stone. But it is possible to grind a slice of chalk down so thin that you can see through it — until it is thin enough, in fact, to be examined with any magnifying power that may be thought desirable. A thin slice of the fur of a kettle might be made in the same way.

If it were examined microscopically, it would show itself to be a more or less distinctly laminated mineral substance, and nothing more.

But the slice of chalk presents a totally different appearance when placed under the microscope. The general mass of it is made up of very minute granules; but embedded in this matrix, are innumerable bodies, some smaller and some larger, but, on a rough average, not more than a hundredth of an inch in diameter, having a well-defined shape and structure. A cubic inch of some specimens of chalk may contain hundreds of thousands of these bodies, compacted together with incalculable millions of the granules.

The examination of a transparent slice gives a good notion of the manner in which the components of the chalk are arranged, and of their relative proportions. But, by rubbing up some chalk with a brush in water and then pouring off the milky fluid, so as to obtain sediments of different degrees of fineness, the granules and the minute rounded bodies may be pretty well separated from one another, and submitted to microscopic examination, either as opaque or as transparent objects. By combining the views obtained in these various methods, each of the rounded bodies may be proved to be a beautifully-constructed calcareous fabric made up of a number of chambers, communicating freely with one another. The chambered bodies are of various forms. One of the commonest is something like a badly-grown raspberry, being formed of a number of nearly globular chambers of different sizes congregated together. It is called *Globigerina*, and some specimens of chalk consist of little else than *Globigerina* and granules.

Let us fix our attention upon the *Globigerina*. It is the spoor of the game we are tracking. If we can learn what it is and what are the conditions of its existence, we shall see our way to the origin and past history of the chalk.

A suggestion which may naturally enough present itself is, that these curious bodies are the result of some process of aggregation which has taken place in the carbonate of lime; that, just as in winter, the rime on our windows simulates the most delicate and elegantly arborescent foliage — proving that the mere mineral water may, under certain conditions, assume the outward form of organic bodies — so this mineral substance, carbonate of lime, hidden away in the bowels of the earth, has taken the shape of these chambered bodies.

I am not raising a merely fanciful and unreal objection. Very learned men, in former days, have even entertained the notion that all the formed things found in rocks are of this nature; and if no such conception is at present held to be admissible, it is because long and varied experience has now shown that mineral matter never does assume the form and structure we find in fossils. If any one were to try to persuade you that an oyster-shell (which is also chiefly composed of carbonate of lime) had crystallized out of sea-water, I suppose you would laugh at the absurdity. Your laughter would be justified by the fact that all experience tends to show that oyster-shells are formed by the agency of oysters, and in no other way. And if there were no better reasons, we should be justified, on like grounds, in believing that *Globigerina* is not the product of anything but vital activity.

Happily, however, better evidence in proof of the organic nature of the *Globigerinæ* than that of analogy is forthcoming. It so happens that calcareous skeletons, exactly similar to the *Globigerinæ* of the chalk, are being formed, at the present moment, by minute living creatures, which flourish in multitudes, literally more numerous than the sands of the seashore, over a large extent of that part of the earth's surface which is covered by the ocean.

The history of the discovery of these living *Globigerinæ*, and of the part which they play in rock building, is singular

enough. It is a discovery which, like others of no less scientific importance, has arisen, incidentally, out of work devoted to very different and exceedingly practical interests.

When men first took to the sea, they speedily learned to look out for shoals and rocks; and the more the burthen of their ships increased, the more imperatively necessary it became for sailors to ascertain with precision the depths of the waters they traversed. Out of this necessity grew the use of the lead and sounding line; and, ultimately, marine-surveying, which is the recording of the form of coasts and of the depth of the sea, as ascertained by the sounding-lead, upon charts.

At the same time, it became desirable to ascertain and to indicate the nature of the sea-bottom, since this circumstance greatly affects its goodness as holding ground for anchors. Some ingenious tar, whose name deserves a better fate than the oblivion into which it has fallen, attained this object by "arming" the bottom of the lead with a lump of grease, to which more or less of the sand or mud, or broken shells, as the case might be, adhered, and was brought to the surface. But, however well adapted such an apparatus might be for rough nautical purposes, scientific accuracy could not be expected from the armed lead, and to remedy its defects (especially when applied to sounding in great depths) Lieut. Brooke, of the American Navy, some years ago invented a most ingenious machine, by which a considerable portion of the superficial layer of the sea bottom can be scooped out and brought up, from any depth to which the lead descends.

In 1853, Lieut. Brooke obtained mud from the bottom of the North Atlantic, between Newfoundland and the Azores, at a depth of more than 10,000 feet, or two miles, by the help of this sounding apparatus. The specimens were sent for examination to Ehrenberg of Berlin, and to Bailey of West Point, and those able microscopists found that this deep-sea

mud was almost entirely composed of the skeletons of living organisms — the greater proportion of these being just like the *Globigerinæ* already known to occur in the chalk.

Thus far, the work had been carried on simply in the interests of science, but Lieut. Brooke's method of sounding acquired a high commercial value, when the enterprise of laying down the telegraph cable between this country and the United States was undertaken. For it became a matter of immense importance to know, not only the depth of the sea over the whole line along which the cable was to be laid, but the exact nature of the bottom, so as to guard against chances of cutting or fraying the strands of that costly rope. The Admiralty consequently ordered Captain Dayman, an old friend and shipmate of mine, to ascertain the depth over the whole line of the cable, and to bring back specimens of the bottom. In former days, such a command as this might have sounded very much like one of the impossible things which the young prince in the Fairy Tales is ordered to do before he can obtain the hand of the Princess. However, in the months of June and July, 1857, my friend performed the task assigned to him with great expedition and precision, without, so far as I know, having met with any reward of that kind. The specimens of Atlantic mud which he procured were sent to me to be examined and reported upon.¹

The result of all these operations is, that we know the contours and the nature of the surface-soil covered by the North Atlantic, for a distance of 1,700 miles from east to west, as well as we know that of any part of the dry land.

It is a prodigious plain — one of the widest and most even plains in the world. If the sea were drained off, you might

¹ See Appendix to Captain Dayman's "Deep-sea Soundings in the North Atlantic Ocean, between Ireland and Newfoundland, made in H. M. S. Cyclops. Published by order of the Lords Commissioners of the Admiralty, 1858." They have since formed the subject of an elaborate Memoir by Messrs. Parker and Jones, published in the Philosophical Transactions for 1865.

drive a wagon all the way from Valentia, on the west coast of Ireland, to Trinity Bay, in Newfoundland. And, except upon one sharp incline about 200 miles from Valentia, I am not quite sure that it would even be necessary to put the skid on, so gentle are the ascents and descents upon that long route. 5 From Valentia the road would lie downhill for about 200 miles to the point at which the bottom is now covered by 1,700 fathoms of sea-water. Then would come the central plain, more than a thousand miles wide, the inequalities of the surface of which would be hardly perceptible, though 10 the depth of water upon it now varies from 10,000 to 15,000 feet; and there are places in which Mont Blanc might be sunk without showing its peak above water. Beyond this, the ascent on the American side commences, and gradually leads, for about 300 miles, to the Newfoundland shore. 15

Almost the whole of the bottom of this central plain (which extends for many hundred miles in a north and south direction) is covered by a fine mud, which, when brought to the surface, dries into a grayish white friable substance. You can write with this on a blackboard, if you are so inclined; 20 and, to the eye, it is quite like very soft, grayish chalk. Examined chemically, it proves to be composed almost wholly of carbonate of lime; and if you make a section of it, in the same way as that of the piece of chalk was made, and view it with the microscope, it presents innumerable *Globigerinæ* 25 embedded in a granular matrix.

Thus this deep-sea mud is substantially chalk. I say substantially, because there are a good many minor differences; but as these have no bearing on the question immediately before us, — which is the nature of the *Globigerinæ* of the 30 chalk, — it is unnecessary to speak of them.

Globigerinæ of every size, from the smallest to the largest, are associated together in the Atlantic mud, and the chambers of many are filled by a soft animal matter. This soft

substance is, in fact, the remains of the creature to which the *Globigerina* shell, or rather skeleton, owes its existence — and which is an animal of the simplest imaginable description. It is, in fact, a mere particle of living jelly, without defined parts of any kind — without a mouth, nerves, muscles, or distinct organs, and only manifesting its vitality to ordinary observation by thrusting out and retracting from all parts of its surface long filamentous processes, which serve for arms and legs. Yet this amorphous particle, devoid of every-
10 thing, which, in the higher animals, we call organs, is capable of feeding, growing, and multiplying; of separating from the ocean the small proportion of carbonate of lime which is dissolved in sea-water; and of building up that substance into a skeleton for itself, according to a pattern which can be
15 imitated by no other known agency.

The notion that animals can live and flourish in the sea, at the vast depths from which apparently living *Globigerinæ* have been brought up, does not agree very well with our usual conceptions respecting the conditions of animal life; and it is not so absolutely impossible as it might at first sight
20 appear to be, that the *Globigerinæ* of the Atlantic sea-bottom do not live and die where they are found.

However, the important points for us are, that the living *Globigerinæ* are exclusively marine animals, the skeletons
25 of which abound at the bottom of deep seas; and that there is not a shadow of reason for believing that the habits of the *Globigerinæ* of the chalk differed from those of the existing species. But if this be true, there is no escaping the conclusion that the chalk itself is the dried mud of an ancient
30 deep sea.

The evidence furnished by the hewing, facing, and superposition of the stones of the Pyramids, that these structures were built by men, has no greater weight than the evidence that the chalk was built by *Globigerinæ*; and the belief that

those ancient pyramid-builders were terrestrial and air-breathing creatures like ourselves, is it not better based than the conviction that the chalk-makers lived in the sea.

But as our belief in the building of the Pyramids by men is not only grounded on the internal evidence afforded by 5 these structures, but gathers strength from multitudinous collateral proofs, and is clinched by the total absence of any reason for a contrary belief; so the evidence drawn from the *Globigerinæ* that the chalk is an ancient sea-bottom, is fortified by innumerable independent lines of evidence; and our 10 belief in the truth of the conclusion to which all positive testimony tends, receives the like negative justification from the fact that no other hypothesis has a shadow of foundation.

It may be worth while briefly to consider a few of these collateral proofs that the chalk was deposited at the bottom 15 of the sea.

The great mass of the chalk is composed, as we have seen, of the skeletons of *Globigerinæ*, and other simple organisms, embedded in granular matter. Here and there, however, this hardened mud of the ancient sea reveals the remains of 20 higher animals which have lived and died, and left their hard parts in the mud, just as the oysters die and leave their shells behind them, in the mud of the present seas.

There are, at the present day, certain groups of animals which are never found in fresh waters, being unable to live 25 anywhere but in the sea. Such are the corals; those coral-lines which are called *Polyzoa*; those creatures which fabricate the lamp shells, and are called *Brachiopoda*; the pearly *Nautilus*, and all animals allied to it; and all the forms of sea-urchins and starfishes. 30

Not only are all these creatures confined to salt water at the present day; but, so far as our records of the past go, the conditions of their existence have been the same: hence, their occurrence in any deposit is as strong evidence as can

be obtained, that that deposit was formed in the sea. Now the remains of animals of all the kinds which have been enumerated, occur in the chalk, in greater or less abundance; while not one of those forms of shell-fish which are characteristic of fresh water has yet been observed in it.

When we consider that the remains of more than three thousand distinct species of aquatic animals have been discovered among the fossils of the chalk, that the great majority of them are of such forms as are now met with only in the
10 sea, and that there is no reason to believe that any one of them inhabited fresh water — the collateral evidence that the chalk represents an ancient sea-bottom acquires as great force as the proof derived from the nature of the chalk itself. I think you will now allow that I did not overstate my case
15 when I asserted that we have as strong grounds for believing that all the vast area of dry land, at present occupied by the chalk, was once at the bottom of the sea, as we have for any matter of history whatever; while there is no justification for any other belief.

20 No less certain it is that the time during which the countries we now call southeast England, France, Germany, Poland, Russia, Egypt, Arabia, Syria, were more or less completely covered by a deep sea, was of considerable duration.

We have already seen that the chalk is, in places, more
25 than a thousand feet thick. I think you will agree with me, that it must have taken some time for the skeletons of animalcules of a hundredth of an inch in diameter to heap up such a mass as that. I have said that throughout the thickness of the chalk the remains of other animals are scattered.
30 These remains are often in the most exquisite state of preservation. The valves of the shell-fishes are commonly adherent; the long spines of some of the sea-urchins, which would be detached by the smallest jar, often remain in their places. In a word, it is certain that these animals have lived and died

when the place which they now occupy was the surface of as much of the chalk as had then been deposited; and that each has been covered up by the layer of *Globigerina* mud, upon which the creatures embedded a little higher up have, in like manner, lived and died. But some of these remains 5 prove the existence of reptiles of vast size in the chalk sea. These lived their time, and had their ancestors and descendants, which assuredly implies time, reptiles being of slow growth.

There is more curious evidence, again, that the process 10 of covering up, or, in other words, the deposit of *Globigerina* skeletons, did not go on very fast. It is demonstrable that an animal of the cretaceous sea might die, that its skeleton might lie uncovered upon the sea-bottom long enough to lose all its outward coverings and appendages by putrefaction; 15 and that, after this had happened another animal might attach itself to the dead and naked skeleton, might grow to maturity, and might itself die before the calcareous mud had buried the whole.

Cases of this kind are admirably described by Sir Charles 20 Lyell. He speaks of the frequency with which geologists find in the chalk a fossilized sea-urchin, to which is attached the lower valve of a *Crania*. This is a kind of shell-fish, with a shell composed of two pieces, of which, as in the oyster, one is fixed and the other free. 25

“The upper valve is almost invariably wanting, though occasionally found in a perfect state of preservation in the white chalk at some distance. In this case, we see clearly that the sea-urchin first lived from youth to age, then died and lost its spines, which were carried away. Then the young *Crania* adhered to the bared shell, grew and perished 30 in its turn; after which, the upper valve was separated from the lower, before the Echinus became enveloped in chalky mud.”¹

A specimen in the Museum of Practical Geology, in London, still further prolongs the period which must have elapsed

¹ “Elements of Geology,” by Sir Charles Lyell, Bart., F. R. S., p. 23.

between the death of the sea-urchin, and its burial by the *Globigerinæ*. For the outward face of the valve of a *Crania*, which is attached to a sea-urchin (*Micraster*), is itself overrun by an incrusting coralline, which spreads thence over 5 more or less of the surface of the sea-urchin. It follows that, after the upper valve of the *Crania* fell off, the surface of the attached valve must have remained exposed long enough to allow of the growth of the whole coralline, since corallines do not live embedded in mud.

10 The progress of knowledge may, one day, enable us to deduce from such facts as these the maximum rate at which the chalk can have accumulated, and thus to arrive at the minimum duration of the chalk period. Suppose that the valve of the *Crania* upon which a coralline has fixed itself in the way just 15 described, is so attached to the sea-urchin that no part of it is more than an inch above the face upon which the sea-urchin rests. Then, as the coralline could not have fixed itself, if the *Crania* had been covered up with chalk mud, and could not have lived had itself been so covered, it follows, that an 20 inch of chalk mud could not have accumulated within the time between the death and decay of the soft parts of the sea-urchin and the growth of the coralline to the full size which it has attained. If the decay of the soft parts of the sea-urchin; the attachment, growth to maturity, and decay of 25 the *Crania*; and the subsequent attachment and growth of the coralline, took a year (which is a low estimate enough), the accumulation of the inch of chalk must have taken more than a year: and the deposit of a thousand feet of chalk must, consequently, have taken more than twelve thousand 30 years.

The foundation of all this calculation is, of course, a knowledge of the length of time the *Crania* and the coralline needed to attain their full size; and, on this head, precise knowledge is at present wanting. But there are circumstances which

tend to show, that nothing like an inch of chalk has accumulated during the life of a *Crania*; and, on any probable estimate of the length of that life, the chalk period must have had a much longer duration than that thus roughly assigned to it.

5

Thus, not only is it certain that the chalk is the mud of an ancient sea-bottom; but it is no less certain, that the chalk sea existed during an extremely long period, though we may not be prepared to give a precise estimate of the length of that period in years. The relative duration is clear, 10 though the absolute duration may not be definable. The attempt to affix any precise date to the period at which the chalk sea began, or ended, its existence, is baffled by difficulties of the same kind. But the relative age of the cretaceous epoch may be determined with as great ease and 15 certainty as the long duration of that epoch.

You will have heard of the interesting discoveries recently made, in various parts of Western Europe, of flint implements, obviously worked into shape by human hands, under circumstances which show conclusively that man is a very 20 ancient denizen of these regions.

It has been proved that the old populations of Europe, whose existence has been revealed to us in this way, consisted of savages, such as the Esquimaux are now; that, in the country which is now France, they hunted the reindeer, and 25 were familiar with the ways of the mammoth and the bison. The physical geography of France was in those days different from what it is now — the river Somme, for instance, having cut its bed a hundred feet deeper between that time and this; and, it is probable, that the climate was more like that of 30 Canada or Siberia, than that of Western Europe.

The existence of these people is forgotten even in the traditions of the oldest historical nations. The name and fame

of them had utterly vanished until a few years back ; and the amount of physical change which has been effected since their day, renders it more than probable that, venerable as are some of the historical nations, the workers of the chipped flints of 5 Hoxne or of Amiens are to them, as they are to us, in point of antiquity.

But, if we assign to these hoar relics of long-vanished generations of men the greatest age that can possibly be claimed for them, they are not older than the drift, or boulder clay, 10 which, in comparison with the chalk, is but a very juvenile deposit. You need go no further than your own seaboard for evidence of this fact. At one of the most charming spots on the coast of Norfolk, Cromer, you will see the boulder clay forming a vast mass, which lies upon the chalk, and must 15 consequently have come into existence after it. Huge boulders of chalk are, in fact, included in the clay and have evidently been brought to the position they now occupy, by the same agency as that which has planted blocks of syenite from Norway side by side with them.

20 The chalk, then, is certainly older than the boulder clay. If you ask how much, I will again take you no further than the same spot upon your own coasts for evidence. I have spoken of the boulder clay and drift as resting upon the chalk. That is not strictly true. Interposed between the chalk and 25 the drift is a comparatively insignificant layer, containing vegetable matter. But that layer tells a wonderful history. It is full of stumps of trees standing as they grew. Fir trees are there with their cones, and hazel bushes with their nuts ; there stand the stools of oak and yew trees, beeches and alders. 30 Hence this stratum is appropriately called the "forest-bed."

It is obvious that the chalk must have been upheaved and converted into dry land, before the timber trees could grow upon it. As the bolls of some of these trees are from two to three feet in diameter, it is no less clear that the dry land thus

formed remained in the same condition for long ages. And not only do the remains of stately oaks and well-grown firs testify to the duration of this condition of things, but additional evidence to the same effect is afforded by the abundant remains of elephants, rhinoceroses, hippopotamuses, and 5 other great wild beasts, which it has yielded to the zealous search of such men as the Rev. Mr. Gunn.

When you look at such a collection, as he has formed, and bethink you that these elephantine bones did veritably carry their owners about, and these great grinders crunch, in the 10 dark woods of which the forest-bed is now the only trace, it is impossible not to feel that they are as good evidence of the lapse of time as the annual rings of the tree stumps.

Thus there is a writing upon the wall of cliffs at Cromer, and whoso runs may read it. It tells us, with an authority 15 which cannot be impeached, that the ancient sea-bed of the chalk sea was raised up, and remained dry land, until it was covered with forest, stocked with the great game whose spoils have rejoiced your geologists. How long it remained in that condition cannot be said; but "the whirligig of time brought 20 its revenges" in those days as in these. That dry land, with the bones and teeth of generations of long-lived elephants, hidden away among the gnarled roots and dry leaves of its ancient trees, sank gradually to the bottom of the icy sea, which covered it with huge masses of drift and boulder clay. 25 Sea beasts, such as the walrus, now restricted to the extreme north, paddled about where birds had twittered among the topmost twigs of the fir-trees. How long this state of things endured we know not, but at length it came to an end. The upheaved glacial mud hardened into the soil of modern Nor-30 folk. Forests grew once more, the wolf and the beaver replaced the reindeer and the elephant; and at length what we call the history of England dawned.

Thus you have, within the limits of your own county,

proof that the chalk can justly claim a very much greater antiquity than even the oldest physical traces of mankind. But we may go further and demonstrate by evidence of the same authority as that which testifies to the existence of the 5 father of men, that the chalk is vastly older than Adam himself.

The Book of Genesis informs us that Adam, immediately upon his creation, and before the appearance of Eve, was placed in the Garden of Eden. The problem of the geographical 10 position of Eden has greatly vexed the spirits of the learned in such matters, but there is one point respecting which, so far as I know, no commentator has ever raised a doubt. This is, that of the four rivers which are said to run out of it, Euphrates and Hiddekel are identical with the 15 rivers now known by the names of Euphrates and Tigris.

But the whole country in which these mighty rivers take their origin, and through which they run, is composed of rocks which are either of the same age as the chalk, or of later date. So that the chalk must not only have been formed, 20 but, after its formation, the time required for the deposit of these later rocks, and for their upheaval into dry land, must have elapsed, before the smallest brook which feeds the swift stream of "the great river, the river of Babylon," began to flow.

25 Thus, evidence which cannot be rebutted, and which need not be strengthened, though if time permitted I might indefinitely increase its quantity, compels you to believe that the earth, from the time of the chalk to the present day, has been the theater of a series of changes as vast in their amount, as 30 they were slow in their progress. The area on which we stand has been first sea and then land, for at least four alternations; and has remained in each of these conditions for a period of great length.

Nor have these wonderful metamorphoses of sea into land, and of land into sea, been confined to one corner of England. During the chalk period, or "cretaceous epoch," not one of the present great physical features of the globe was in existence. Our great mountain ranges, Pyrenees, Alps, Himalayas, Andes, have all been upheaved since the chalk was deposited, and the cretaceous sea flowed over the sites of Sinai and Ararat.

All this is certain, because rocks of cretaceous, or still later, date have shared in the elevatory movements which gave rise to these mountain chains; and may be found perched up, in some cases, many thousand feet high upon their flanks. And evidence of equal cogency demonstrates that, though, in Norfolk, the forest-bed rests directly upon the chalk, yet it does so, not because the period at which the forest grew immediately followed that at which the chalk was formed, but because an immense lapse of time, represented elsewhere by thousands of feet of rock, is not indicated at Cromer.

I must ask you to believe that there is no less conclusive proof that a still more prolonged succession of similar changes occurred, before the chalk was deposited. Nor have we any reason to think that the first term in the series of these changes is known. The oldest sea beds preserved to us are sands, and mud, and pebbles, the wear and tear of rocks which were formed in still older oceans.

But, great as is the magnitude of these physical changes of the world, they have been accompanied by a no less striking series of modifications in its living inhabitants.

All the great classes of animals, beasts of the field, fowls of the air, creeping things, and things which dwell in the waters, flourished upon the globe long ages before the chalk was deposited. Very few, however, if any, of these ancient forms of animal life were identical with those which now live.

Certainly not one of the higher animals was of the same species as any of those now in existence. The beasts of the field, in the days before the chalk, were not our beasts of the field, nor the fowls of the air such as those which the eye of man has seen
5 flying, unless his antiquity dates infinitely further back than we at present surmise. If we could be carried back into those times, we should be as one suddenly set down in Australia before it was colonized. We should see mammals, birds, reptiles, fishes, insects, snails, and the like, clearly recognizable
10 as such, and yet not one of them would be just the same as those with which we are familiar, and many would be extremely different.

From that time to the present, the population of the world has undergone slow and gradual, but incessant, changes.
15 There has been no grand catastrophe — no destroyer has swept away the forms of life of one period, and replaced them by a totally new creation; but one species has vanished and another has taken its place; creatures of one type of structure have diminished, those of another have increased, as time has
20 passed on. And thus, while the differences between the living creatures of the time before the chalk and those of the present day appear startling, if placed side by side, we are led from one to the other by the most gradual progress, if we follow the course of Nature through the whole series of
25 those relics of her operations which she has left behind.

And it is by the population of the chalk sea that the ancient and the modern inhabitants of the world are most completely connected. The groups which are dying out flourish, side by side, with the groups which are now the dominant
30 forms of life.

Thus the chalk contains remains of those strange flying and swimming reptiles, the pterodactyl, the ichthyosaurus, and the plesiosaurus, which are found in no later deposits, but abounded in preceding ages. The chambered shells called

ammonites and belemnites which are so characteristic of the period preceding the cretaceous, in like manner die with it.

But, amongst these fading remainders, of a previous state of things, are some very modern forms of life, looking like Yankee pedlars among a tribe of Red Indians. Crocodiles of modern type appear ; bony fishes, many of them very similar to existing species, almost supplant the forms of fish which predominate in more ancient seas ; and many kinds of living shell-fish, first become known to us in the chalk. The vegetation acquires a modern aspect. A few living animals are not even distinguishable as species, from those which existed at that remote epoch. The *Globigerina* of the present day, for example, is not different specifically from that of the chalk ; and the same may be said of many other *Foraminifera*. I think it probable that critical and unprejudiced examination will show that more than one species of much higher animals have had a similar longevity ; but the only example which I can at present give confidently is the snake's-head lamp-shell (*Terebratulina caput serpentis*), which lives in our English seas and abounded (as *Terebratulina striata* of authors) in the chalk.

The longest line of human ancestry must hide its diminished head before the pedigree of this insignificant shell-fish. We Englishmen are proud to have an ancestor who was present at the Battle of Hastings. The ancestors of *Terebratulina caput serpentis* may have been present at a battle of *Ichthyosauria* in that part of the sea which, when the chalk was forming, flowed over the site of Hastings. While all around has changed, this *Terebratulina* has peacefully propagated its species from generation to generation, and stands to this day, as a living testimony to the continuity of the present with the past history of the globe.

Up to this moment I have stated, so far as I know, nothing

but well-authenticated facts, and the immediate conclusions which they force upon the mind.

But the mind is so constituted that it does not willingly rest in facts and immediate causes, but seeks always after a
5 knowledge of the remoter links in the chain of causation.

Taking the many changes of any given spot of the earth's surface, from sea to land and from land to sea, as an established fact, we cannot refrain from asking ourselves how these changes have occurred. And when we have explained them,
10 as they must be explained by the alternate slow movements of elevation and depression which have affected the crust of the earth, we go still further back, and ask, Why these movements?

I am not certain that any one can give you a satisfactory
15 answer to that question. Assuredly I cannot. All that can be said, for certain, is, that such movements are part of the ordinary course of nature, inasmuch as they are going on at the present time. Direct proof may be given, that some parts
20 of the land of the northern hemisphere are at this moment insensibly rising and others insensibly sinking; and there is indirect, but perfectly satisfactory, proof, that an enormous area now covered by the Pacific has been deepened thousands of feet, since the present inhabitants of that sea came into
existence.

25 Thus there is not a shadow of a reason for believing that the physical changes of the globe, in past times, have been effected by other than natural causes.

Is there any more reason for believing that the concomitant modifications in the forms of the living inhabitants of the globe
30 have been brought about in other ways?

Before attempting to answer this question, let us try to form a distinct mental picture of what has happened, in some special case.

The crocodiles are animals which, as a group, have a very

vast antiquity. They abounded ages before the chalk was deposited; they throng the rivers in warm climates, at the present day. There is a difference in the form of the joints of the backbone, and in some minor particulars, between the crocodiles of the present epoch and those which lived before ⁵ the chalk; but, in the cretaceous epoch, as I have already mentioned, the crocodiles had assumed the modern type of structure. Notwithstanding this, the crocodiles of the chalk are not identically the same as those which lived in the times called "older tertiary," which succeeded the cretaceous ¹⁰ epoch; and the crocodiles of the older tertiaries are not identical with those of the newer tertiaries, nor are these identical with existing forms. I leave open the question whether particular species may have lived on from epoch to epoch. But each epoch has had its peculiar crocodiles; though all, since ¹⁵ the chalk, have belonged to the modern type, and differ simply in their proportions, and in such structural particulars as are discernible only to trained eyes.

How is the existence of this long succession of different species of crocodiles to be accounted for? ²⁰

Only two suppositions seem to be open to us — either each species of crocodile has been specially created, or it has arisen out of some preëxisting form by the operation of natural causes.

Choose your hypothesis; I have chosen mine. I can find ²⁵ no warranty for believing in the distinct creation of a score of successive species of crocodiles in the course of countless ages of time. Science gives no countenance to such a wild fancy; nor can even the perverse ingenuity of a commentator pretend to discover this sense, in the simple words in which ³⁰ the writer of Genesis records the proceedings of the fifth and sixth days of the Creation.

On the other hand, I see no good reason for doubting the necessary alternative, that all these varied species have

been evolved from preëxisting crocodilian forms, by the operation of causes as completely a part of the common order of nature, as those which have effected the changes of the inorganic world.

5 Few will venture to affirm that the reasoning which applies to crocodiles loses its force among other animals, or among plants. If one series of species has come into existence by the operation of natural causes, it seems folly to deny that all may have arisen in the same way.

10 A small beginning has led us to a great ending. If I were to put the bit of chalk with which we started into the hot but obscure flame of burning hydrogen, it would presently shine like the sun. It seems to me that this physical metamorphosis is no false image of what has been the result of our subject-
15 ing it to a jet of fervent, though nowise brilliant, thought to-night. It has become luminous, and its clear rays, penetrating the abyss of the remote past, have brought within our ken some stages of the evolution of the earth. And in the shifting "without haste, but without rest" of the land and
20 sea, as in the endless variation of the forms assumed by living beings we have observed nothing but the natural product of the forces originally possessed by the substance of the universe.

NOTES

AUTOBIOGRAPHY

This autobiography was written in 1889, six years before Huxley's death. It was published in L. Engel's "From Handel to Hallè," London, 1890; and in Huxley's "Methods and Results," London, 1893 (New York, 1902). It was intended to accompany his portrait in a series of celebrated men. The first two paragraphs indicate the writer's distaste at being obliged to write about himself. How Huxley felt about this is well told in the following letter:

MY DEAR MR. ENGEL, —

You are really the most pertinaciously persuasive of men. When you first wrote to me, I said I would have nothing whatever to do with anything you might please to say about me, that I had a profound objection to write about myself, and that I could not see what business the public had with my private life. I think I even expressed to you my complete sympathy with Dr. Johnson's desire to take Boswell's life when he heard of the latter's occupation with his biography.

Undeterred by all this, you put before me the alternative of issuing something that may be all wrong, unless I furnish you with something authoritative; I do not say all right, because autobiographies are essentially works of fiction, whatever biographies may be. So I yield, and send you what follows, in the hope that those who find it to be mere egotistical gossip will blame you and not me.

I am

Yours faithfully,

T. H. HUXLEY

16 Bishop Butler: Joseph Butler (1692-1752), Bishop of Durham. He was one of the leaders of the Church of England in the eighteenth century, and author of important religious works.

15 pre-Boswellian: before Boswell. James Boswell (1740-1795) was the author of the celebrated "Life of Samuel Johnson," one of the greatest of biographies. Lockhart's "Life of Scott" is another in the same class. It is pertinent here to mention "The Life and Letters of Thomas Henry Huxley," by his son, Leonard Huxley, which is considered a model.

1 20 **bene qui latuit, bene vixit** (Ovid) : he, who has kept himself well hidden, has lived well.

2 27 **mellifluous eloquence** : perhaps written with the aged Greek hero Nestor in mind, from whose lips, according to the "Iliad," flowed speech sweeter than honey.

4 2 **Prince George of Cambridge** : grandson of George III.

4 9 **Mr. Herbert Spencer** (1820-1903) : one of the leading English philosophers and scientists of the nineteenth century, the author of the "Synthetic Philosophy."

5 1 **Sydney** : this man, who was "sent out," or deported, to Sydney for some crime, furnishes an illustration of the penal system of those days.

5 13 **in partibus infidelium** : in the regions of the unbelievers.

6 17 **Lehrjahre** : years of study.

7 10 **early spring of 1846** : Huxley was then a candidate for the degree of M.D., and not twenty-one years of age !

7 19 **strong** : "fresh."

8 4 **Nelson** : Horatio Nelson (born 1758), England's greatest naval hero, died in the hour of triumph on board the *Victory* at the battle of Trafalgar, October 21, 1805.

9 8 **Directors-General** : note the method of forming the plural.

10 3 **Suites à Buffon** : sequels to Buffon (George Louis Leclerc Buffon, 1707-1788, a celebrated French naturalist).

10 6 **Linnean Society** : an English scientific society.

10 10 **Royal Society** : explained at considerable length in the address "On Improving Natural Knowledge" (see pp. 15 ff.).

10 27 **à nous deux** : this means that we two, London and I, are to fight it out. — **Père Goriot** is a famous novel by Honoré de Balzac (1799-1850).

10 30 **Tyndall, John** (1820-1893) ; a celebrated English scientist, noted for his researches in radiant heat, light, sound, magnetism, and electricity.

11 20 **malgré moi** : in spite of myself.

ON IMPROVING NATURAL KNOWLEDGE

This Lay Sermon was delivered in St. Martin's Hall, near Trafalgar Square, London, January 7, 1866 ; it was published in Huxley's "Lay Sermons, Essays and Reviews," 1871.

13 13 **Defoe** : Daniel Defoe (1659-1731) ; English journalist and novelist, best known as the author of "Robinson Crusoe."

14 28 **Rochesters and Sedleys** : the second Earl of Rochester and Sir Charles Sedley, noted wits, poets, and profligates in the reign of Charles II.

14 32 **Laud** : William Laud, Archbishop of Canterbury (born 1573),

a strong supporter of Charles I. He was impeached by the Long Parliament, and beheaded in 1645.

15 19 Copernican hypothesis : Nicholas Copernicus (1473-1543) was a noted Polish and German astronomer. Among his conclusions were : That the moon alone revolves about the earth ; the earth is a planet whose orbit lies between Venus and Mars ; the planets revolve about the sun ; and the apparent revolution of the heavens is due to the rotation of the earth on its axis. (Students may find interest in studying about Aristarchus, the Greek philosopher, 250 B.C.)

15 22 selenography : science that treats of the physical conditions of the moon ; akin to physical geography.

15 25 Torricellian experiment : the discovery by the Italian physicist, Evangelista Torricelli (1608-1647) of the principle of the barometer.

15 31 Galileo (1564-1642) : Italian astronomer ; constructed a thermometer and a telescope ; defended the Copernican theory (see note on l. 19 above), and was compelled by the Inquisition to renounce these views.

15 31 Sir Francis Bacon (1561-1626) : English statesman and philosopher ; founder of the modern inductive philosophy. Bacon's great philosophical work, "Instauratio Magna" ("Great Restoration of the Sciences"), was written in Latin ; and the best known part, "Novum Organum" ("New Method") was published in 1620. Sir John Herschel, the eminent astronomer, wrote as follows of Bacon and his work : "By the discoveries of Copernicus, Kepler, and Galileo, the errors of the Aristotelian philosophy were effectually overturned on a plain appeal to the facts of nature ; but it remained to show, on broad and general principles, how and why Aristotle was in the wrong ; to set in evidence the peculiar weakness of his method of philosophizing, and to substitute in its place a stronger and better. This important task was executed by Francis Bacon, Lord Verulam, who will therefore justly be looked upon in all future ages as the great reformer of philosophy."

17 1 Sir Isaac Newton (1642-1721) : English philosopher ; established the law of universal gravitation. Newton has been called the most remarkable mathematician and natural philosopher of his own or perhaps any other age. His work upon reflecting telescopes led in 1671 to his election to the Royal Society. Urged on by the scientist Halley (of comet fame) he produced a treatise embodying his results upon gravitation. This was the famous Principia (*Philosophiæ Naturalis Principia Mathematica*) "The Mathematical Principles of Natural Philosophy." It was accepted by the Royal Society in 1686, and published in the summer of the following year.

17 9 Vesalius (1514-1564) : a noted Belgian anatomist.

17 10 Harvey, William (1578-1564) : an English physiologist who discovered the circulation of the blood.

17 32 Lord Brouncker : President of the Royal Society, 1662.

18 10 revenant : French for ghost.

19 4 Boyle, Robert (1627-1691) : an English chemist noted for his discovery of the law of the elasticity of the air.

19 4 Evelyn, John (1620-1706) : English author, noted for his "Diary," which contains an account of the men and manners of his time.

20 28 spinning jenny : a machine invented for spinning a number of threads at once, and named by the inventor, John Hargreaves, after his wife, Jenny. Some writers connect this word *jenny* with *gin* (cotton gin), and the second syllable of the word *engine*.

26 5 Count Rumford : born Benjamin Thompson, in Rumford, New Hampshire, 1738. He was educated at Harvard College ; acquitted during the American Revolution of the charge of loyalty to the King ; removed to England, and became famous as a physicist. The Rumford Professorship of Science at Harvard was founded by him. He died in 1814.

A LIBERAL EDUCATION

"**A Liberal Education: and where to find it**" : This address was delivered January 4, 1868, at the South London Working Men's College. It was first published in Huxley's "Lay Sermons, Essays and Reviews," 1871.

30 1 Ichabod : 1 Samuel iv, 21. See Whittier's poem "Ichabod," beginning, —

"So fallen ! so lost ! the light withdrawn which once he wore !
The glory from his gray hairs gone Forevermore !"

31 15 public schools : these are not public schools as the term is understood in America. The "public schools" here meant are the great schools of which Rugby and Eton are examples.

31 21 senior wrangler : the winner at Cambridge of the highest mathematical honors.

31 21 double-first : an Oxford candidate for degree wins a "double-first" when he receives first-class honors in both classics and mathematics.

32 19 knife, fork, and spoon : an argument for manual training ?

33 29 Retzsch, Friedrich August Moritz (1779-1857) : German painter and designer of distinction.

33 33 This discussion of education and of a liberally educated man (see p. 36) is well worthy of careful study.

35 11 Test-Acts: Huxley drives his point by giving a twist to the climax that a popular audience is certain to appreciate. The Test Act of 1673 required all persons holding public office to take the oaths of supremacy and allegiance, and to conform with the Church of England.

35 15 Poll: the great mass of students. The word is sometimes used to mean "head" (e.g. the "poll tax" in some states).

35 17 plucked: "flunked," in the parlance of American students.

37 10 law of inverse squares: the attraction of two bodies varies inversely as the square of the distance.

37 15 hundred: a political division in England supposed originally to have contained one hundred families, or freemen.

38 10 conic sections: that branch of geometry that treats of the ellipse, the parabola and the hyperbola.

38 24 with a circumbendibus: (dog Latin), with a way of getting around it.

44 8 Niebuhr, Barthold Georg (1776-1831): noted German historian, author of the "History of Rome."

44 8 Gibbon, Edward (1737-1794): celebrated English historian, author of "The Decline and Fall of the Roman Empire."

44 8 Grote, George (1794-1871): distinguished English historian, author of "The History of Greece."

44 28 paleontology: the science which treats of the animal life of the earth, or of the fossil remains of such life.

44 32 osteological: relating to the bones.

45 15 sixth form: highest (or senior) class in an English public school.

46 31 Rector of Lincoln College: Mark Pattison (1813-1884); English educator, Rector of Lincoln College, Oxford University.

49 3 Mill, John Stuart (1806-1873): English political economist. — **Faraday, Michael (1791-1867):** English chemist and naturalist.

49 3 Robert Brown (1773-1858): English botanist; prominently identified with the botanical work of the British Museum, 1827.

50 16 la carrière ouverte aux talents: "a free field."

50 17 Bursch: fellow.

A PIECE OF CHALK

This lecture was delivered to the workingmen of Norwich in 1868.

53 5 Norfolk: an eastern county, jutting out into the North Sea.

53 9 scarped: cut down perpendicularly.

53 11 Yorkshire: a large northern county, famous in English history. It is bounded by Lancashire on the west, the North Sea on the east, the river Humber to the south, and Durham and Westmoreland on the north.

53 13 Dorset: a southern county; Hampshire lies to the east, and south of it, the Isle of Wight. — **Needles**: pointed rocks of chalk rising from the water at the western end of the Isle of Wight; a dangerous locality for seamen.

53 15 Albion: (Latin *albus*, white); a name given to England, chiefly in poetry. Note Cæsar's account of the appearance of the coast of England. — **19 Flamborough Head**: Yorkshire, juts out into the North Sea.

53 23 weald: a great oval-shaped chalk area including parts of the four southeastern counties.

53 23 Kent: a southeastern coast county; Dover is in Kent.

56 22 stalagmites and stalactites: found principally in caves (*e.g.* Mammoth Cave, Kentucky); made by deposits from water trickling through and partially dissolving limestone. Stalactites hang down like rocky icicles; stalagmites resemble inverted stalactites.

57 2 laminated: consisting of or covered with thin scales or plates.

57 7 matrix: die or mold in which anything is formed. (*Matrices* of type.)

57 28 Globigerina (plural, *-æ*): consult Huxley's description on page 62.

57 32 spoor: the track or trail of a wild animal.

60 7 telegraph cable: first laid in 1858 by Cyrus W. Field of New York; it failed to work after a few weeks. A second cable was laid by Mr. Field in 1866, a great undertaking. Lord Kelvin was the scientist in charge of this work. Since that time communication with Europe has not been interrupted for a single day.

62 8 filamentous: like a thread.

62 9 amorphous: shapeless; having no determinate form.

65 20 Sir Charles Lyell (1797-1875): the noted English geologist; delivered the Lowell Lectures in Boston in 1841, and traveled extensively in this country. — **32 echinus**: sea urchin.

68 5 Hoxne, Amiens: Hoxne in England and Amiens in France where rude flint instruments have been discovered.

68 19 syenite: granite.

69 7 Mr. Gunn: Robert Campbell Gunn (1808-1881): an English naturalist, noted for the collection of birds, mammals, etc., which he made in Tasmania and sent to the British Museum.

69 20 whirligig of time: from Shakespeare's "Twelfth Night," V, i.

72 32 pterodactyl, ichthyosaurus, plesiosaurus: prehistoric monsters.

73 14 Foraminifera: shell-covered bodies.

75 10 tertiary: the third order or rank. In geology the era that followed the secondary interval of time in the formation of the earth's crust.

76 19 without haste, but without rest: a translation of the familiar German motto, *Ohne Hast, Ohne Rast*.

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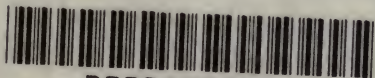
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