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PRACTICAL EDUCATION, VOLUME II

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Practical Education, Volume II

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CHAPTER XIII

ON GRAMMAR, AND CLASSICAL LITERATURE

As long as gentlemen feel a deficiency in their own education, when they have not a competent knowledge of the learned languages, so long must a parent be anxious, that his son should not be exposed to the mortification of appearing inferiour to others of his own rank. It is in vain to urge, that language is only the key to science; that the names of things are not the things themselves; that many of the words in our own language convey scarcely any, or at best but imperfect, ideas; that the true genius, pronunciation, melody, and idiom of Greek, are unknown to the best scholars, and that it cannot reasonably be doubted, that if Homer or Xenophon were to hear their works read by a professor of Greek, they would mistake them for the sounds of an unknown language. All this is true; but it is not the ambition of a gentleman

to read Greek like an ancient Grecian, but to understand it as well as the generality of his contemporaries; to know whence the terms of most sciences are derived, and to be able, in some degree, to trace the progress of mankind in knowledge and refinement, by examining the extent and combination of their different vocabularies.

In some professions, Greek is necessary; in all, a certain proficiency of Latin is indispensable; how, therefore, to acquire this proficiency in the one, and a sufficient knowledge of the other, with the least labour, the least waste of time, and the least danger to the understanding, is the material question. Some school-masters would add, that we must expedite the business as much as possible: of this we may be permitted to doubt. *Festina lente* is one of the most judicious maxims in education, and those who have sufficient strength of mind to adhere to it, will find themselves at the goal, when their competitors, after all their bustle, are panting for breath, or lashing their restive steeds. We see some untutored children start forward in learning with rapidity: they seem to acquire knowledge at the very time it is wanted, as if by intuition; whilst others, with whom infinite pains have been taken, continue in dull ignorance; or, having accumulated a mass of learning, are utterly at a loss how to display, or how to use their treasures. What is the reason of this phenomenon? and to which class of children would a parent wish his son to belong? In a certain number of years, after having spent eight hours a day in "durance vile," by the influence of

bodily fear, or by the infliction of bodily punishment, a regiment of boys may be drilled by an indefatigable usher into what are called scholars; but, perhaps, in the whole regiment not one shall ever distinguish himself, or ever emerge from the ranks. Can it be necessary to spend so many years, so many of the best years of life, in toil and misery? We shall calculate the waste of time which arises from the study of ill written, absurd grammar, and exercise-books; from the habits of idleness contracted by school-boys, and from the custom of allowing holydays to young students; and we shall compare the result of this calculation with the time really necessary for the attainment of the same quantity of classical knowledge by rational methods. We do not enter into this comparison with any invidious intention, but simply to quiet the apprehensions of parents; to show them the possibility of their children's attaining a certain portion of learning within a given number of years, without the sacrifice of health, happiness, or the general powers of the understanding.

At all events, may we not begin by imploring the assistance of some able and friendly hand to reform the present generation of grammars and school-books? For instance, is it indispensably necessary that a boy of seven years old should learn by rote, that "relative sentences are independent, *i. e.* no word in a relative sentence is governed either of verb, or adjective, that stands in another sentence, or depends upon any appurtenances of the relative; and that the English word 'That' is always a relative when it may be turned into *which* in good sense, which must be tried

by reading over the English sentence *warily*, and judging how the sentence will bear it, but when it cannot be altered, salvo sensu, it is a conjunction?" Cannot we, for pity's sake, to assist the learner's memory, and to improve his intellect, substitute some sentences a little more connected, and perhaps a little more useful, than the following?

"I have been a soldier – You have babbled – Has the crow ever looked white? – Ye have exercised – Flowers have withered – We were in a passion – Ye lay down – Peas were parched – The lions did roar a while ago."

In a book of Latin exercises,[1] the preface to which informs us, that "it is intended to contain such precepts of morality and religion, as ought most industriously to be inculcated into the heads of all learners, contrived so as that children may, as it were, insensibly suck in such principles as will be of use to them afterwards in the manly conduct and ordering of their lives," we might expect somewhat more of pure morality and sense, with rather more elegance of style, than appear in the following sentences:

"I struck my sister with a stick, and was forced to flee into the woods; but when I had tarried there awhile, I returned to my parents, and submitted myself to their mercy, and they forgave me my offence."

"When my dear mother, unknown to my father, shall send me money, I will pay my creditors their debts, and provide a supper

[1] Garretson's Exercises, the tenth edition.

for all my friends in my chamber, without my brother's consent, and will make presents to all my relations."

So the measure of maternal tenderness is the sum of money, which the dear mother, unknown to her husband, shall send to her son; the measure of the son's generosity is the supper he is to give to all his friends in his chamber, exclusive of his poor brother, of whose offence we are ignorant. His munificence is to be displayed in making presents to all his relations, but in the mean time he might possibly forget to pay his debts, for "justice is a slow-paced virtue, and cannot keep pace with generosity."

A reasonable notion of punishment, and a disinterested love of truth, is well introduced by the following picture. "My master's countenance was greatly changed when he found his beloved son guilty of a lie. Sometimes he was pale with anger; sometimes he was red with rage; and in the mean time, he, poor boy, was trembling, (for what?) for fear of punishment." Could the ideas of punishment and vengeance be more effectually joined, than in this portrait of the master red with rage? After truth has been thus happily recommended, comes honesty. "Many were fellow-soldiers with valiant Jason when he stole the golden fleece: many were companions with him, but he bore away the glory of the enterprise."

Valour, theft, and glory, are here happily combined. It will avail us nothing to observe, that the golden fleece has an allegorical meaning, unless we can explain satisfactorily the nature of an allegorical theft; though to our classical taste this

valiant Jason may appear a glorious hero, yet to the simple judgment of children, he will appear a robber. It is fastidious, however, to object to Jason in the exercise-book, when we consider what children are to hear, and to hear with admiration, as they advance in their study of poetry and mythology.

Lessons of worldly wisdom, are not forgotten in our manual, which professes to teach "*the manly conduct and ordering of life*" to the rising generation. "Those men," we are told, "who have the most money, obtain the greatest honour amongst men." But then again, "a poor man is as happy without riches, *if* he can enjoy contentedness of mind, as the richest earl that coveteth greater honour." It may be useful to put young men upon their guard against hypocrites and knaves; but is it necessary to tell school-boys, that "it concerneth me, and all men, to look to ourselves, for the world is so full of knaves and hypocrites, that he is hard to be found who may be trusted?" That "they who behave themselves the most warily of all men, and live more watchfully than others, may happen to do something, which (if it be divulged) may very much damnify their reputation?" A knowledge of the world may be early requisite; but is it not going too far, to assure young people, that "the nations of the world are at this time come to that pass of wickedness, that the earth is like hell, and many men have degenerated into devils?"

A greater variety of ridiculous passages from this tenth edition of Garretson's Exercise-book, might be selected for the reader's entertainment; but the following specimens will be sufficient to

satisfy him, that by this original writer, natural history is as well taught as morality:

Man. "Man is a creature of an upright body; he walketh upright when he is on a journey; and when night approaches, he lieth flat, and sleepeth."

Horses. "A journey an hundred and fifty miles long, tireth an horse that hath not had a moderate feed of corn."

Air, Earth, Fire, and Water. "The air is nearer the earth than the fire; but the water is placed nearest to the earth, because these two elements compose but one body."

It is an easy task, it will be observed, to ridicule absurdity. It is easy to pull down what has been ill built; but if we leave the ruins for others to stumble over, we do little good to society. Parents may reasonably say, if you take away from our children the books they have, give them better. They are not yet to be had, but if a demand for them be once excited, they will soon appear. Parents are now convinced, that the first books which children read, make a lasting impression upon them; but they do not seem to consider spelling-books, and grammars, and exercise-books, as books, but only as tools for different purposes: these tools are often very mischievous; if we could improve them, we should get our work much better done. The barbarous translations, which are put as models for imitation into the hands of school-boys, teach them bad habits of speaking and writing, which are sometimes incurable. For instance, in the fourteenth edition of Clarke's Cornelius Nepos, which the preface informs us was

written by a man full of indignation for the common practices of grammar-schools, by a man who laments that youth should spend their time "in tossing over the leaves of a dictionary, and hammering out such a language as the Latin," we might expect some better translation than the following, to form the young student's style:

"No body ever heard any other entertainment for the ears at *his* (Atticus's) meals than a reader, which we truly think very pleasant. Nor was there ever a supper at his house without some reading, that their guests might be entertained in their minds as well as their stomachs; *for* he invited those whose manners were not different from his own."

"He (Atticus) likewise had a touch at poetry, that he might not be unacquainted with this pleasure, we suppose. *For* he has related in verses the lives of those who excelled the Roman people in honour, and the greatness of their exploits. *So* that he has described under each of their images, their actions and offices in no more than four or five verses, *which* is scarcely to be believed *that* such great things could be so briefly delivered."

Those who, in reading these quotations, have perhaps exclaimed, "Why must we go through this farrago of nonsense?" should reflect, that they have now wasted but a few minutes of their time upon what children are doomed to study for hours and years. If a few pages disgust, what must be the effect of volumes in the same style! and what sort of writing can we expect from pupils who are condemned to such reading? The analogy

of ancient and modern languages, differs so materially, that a literal translation of any ancient author, can scarcely be tolerated. Yet, in general, young scholars are under a necessity of *rendering* their Latin lessons into English word for word, faithful to the taste of their dictionaries, or the notes in their translations. This is not likely to improve the freedom of their English style; or, what is of much more consequence, is it likely to preserve in the pupil's mind a taste for literature? It is not the time that is spent in pouring over lexicons, it is not the multiplicity of rules learnt by rote, nor yet is it the quantity of Latin words crammed into the memory, which can give the habit of attention or the power of voluntary exertion: without these, you will never have time enough to teach; with them, there will always be time enough to learn. – One half hour's vigorous application, is worth a whole day's constrained and yawning study. If we compare what from experience we know can be done by a child of ordinary capacity in a given time, with what he actually does in school-hours, we shall be convinced of the enormous waste of time incident to the common methods of instruction. Tutors are sensible of this; but they throw the blame upon their pupils – "You might have learned your lesson in half the time, if you had chosen it." The children also are sensible of this; but they are not able or willing to prevent the repetition of the reproach. But exertion does not always depend upon the will of the boy; it depends upon his previous habits, and upon the strength of the immediate motive which acts upon him. Some children of quick abilities, who have

too much time allotted for their classical studies, are so fully sensible themselves of the pernicious effect this has upon their activity of mind, that they frequently defer *getting their lessons* to the last moment, that they may be forced by a sufficient motive to exert themselves. In *classes* at public schools, the quick and the slow, the active and indolent, the stumbling and sure-footed, are all yoked together, and are forced to keep pace with one another: stupidity may sometimes be dragged along by the vigour of genius; but genius is more frequently chained down by the weight of stupidity. We are well aware of the difficulties with which the public preceptor has to contend; he is often compelled by his situation to follow ancient usage, and to continue many customs which he wishes to see reformed. Any reformation in the manner of instruction in these public seminaries, must be gradual, and will necessarily follow the conviction that parents may feel of its utility. Perhaps nothing can be immediately done, more practicably useful, than to simplify grammar, and to lighten as much as possible the load that is laid upon the memory. Without a multiplicity of masters, it would be impossible to suit instruction to the different capacities, and previous acquirements, of a variety of pupils; but in a private education, undoubtedly the task may be rendered much easier to the scholar and to the teacher; much jargon may be omitted; and what appears from want of explanation to be jargon, may be rendered intelligible by proper skill and attention. During the first lessons in grammar, and in Latin, the pupil need not be disgusted with literature,

and we may apply all the principles which we find on other occasions successful in the management of the attention.[2] Instead of keeping the attention feebly obedient for an idle length of time, we should fix if decidedly by some sufficient motive for as short a period as may be requisite to complete the work that we would have done. As we apprehend, that even where children are to be sent to school, it will be a great advantage to them to have some general notions of grammar, to lead them through the labyrinth of common school books, we think that we shall do the public preceptor an acceptable service, if we point out the means by which parents may, without much labour to themselves, render the first principles of grammar intelligible and familiar to their children.

We may observe, that children pay the strictest attention to the analogies of the language that they speak. Where verbs are defective or irregular, they supply the parts that are wanting with wonderful facility, according to the common form of other verbs. They make all verbs regular. I go*ed*, I read*ed*, I writ*ed*, &c. By a proper application of this faculty, much time may be saved in teaching children grammar, much perplexity, and much of that ineffectual labour which stupifies and dispirits the understanding. By gentle degrees, a child may be taught the relations of words to each other in common conversation, before he is presented with the first sample of grammatical eloquence in Lilly's Accidence. "There be eight parts of speech."

[2] V. Chapter on Attention.

A phrase which in some parts of this kingdom would perhaps be understood, but which to the generality of boys who go to school, conveys no meaning, and is got by heart without reflection, and without advantage. A child can, however, be made to understand these formidable parts of speech, if they are properly introduced to his acquaintance: he can comprehend, that some of the words which he hears express *that something is done*; he will readily perceive, that if something is done, somebody, or something must do it: he will distinguish with much facility the word in any common sentence which expresses an action, and that which denotes the agent. Let the reader try the experiment immediately upon any child of six or seven years old who has *not* learned grammar, and he may easily ascertain the fact.

A few months ago, Mr. – gave his little daughter H – , a child of five years old, her first lesson in English grammar; but no alarming book of grammar was produced upon the occasion, nor did the father put on an unpropitious gravity of countenance. He explained to the smiling child the nature of a verb, a pronoun, and a substantive.

Then he spoke a short familiar sentence, and asked H – , to try if she could find out which word in it was a verb, which a pronoun, and which a substantive. The little girl found them all out most successfully, and formed no painful associations with her first grammatical lesson. But though our pupil may easily understand, he will easily forget our first explanations; but provided he understands them at the moment, we should

pardon his forgetfulness, and we should patiently repeat the same exercise several days successively; a few minutes at each lesson will be sufficient, and the simplest sentences, such as children speak themselves, will be the best examples. Mr. – , after having talked four or five times, for a few minutes at a time, with his son S – , when S – was between five and six years old, about grammar, asked him if he knew what a pronoun meant? The boy answered, "A word that is said instead of a substantive." As these words might have been merely remembered by rote, the father questioned his pupil further, and asked him to name any pronoun that he recollected. S – immediately said, "*I* a pronoun." "Name another," said his father. The boy answered after some pause, as if he doubted whether it was or was not a pronoun, *A*. Now it would have been very imprudent to have made a sudden exclamation at the child's mistake. The father, without showing any surprise, gently answered, "No, my dear, *a* does not stand in the place of any substantive. We say *a man*, but the word *a* does not mean a *man*, when it is said by itself – Does it?"

S –. No.

Father. Then try if you can find out a word that does.

S –. He, and *Sir*.

Sir does stand, in conversation, in the place of a man, or gentleman; therefore the boy, even by this mistake, showed that he had formed, from the definition that had been given to him, a general idea of the nature of a pronoun, and at all events he exercised his understanding upon the affair, which is the

principal point we ought to have in view.

An interjection is a part of speech familiar to children. Mr. Horne Tooke is bitter in his contempt for it, and will scarcely admit it into civilized company. "The brutish inarticulate interjection, which has nothing to do with speech, and is only the miserable refuge of the speechless, has been permitted to usurp a place amongst words, &c." – "The neighing of a horse, the lowing of a cow, the barking of a dog, the purring of a cat; sneezing, coughing, groaning, shrieking, and every other involuntary convulsion with oral sound, have almost as good a title to be called parts of speech, as interjections have."

Mr. Horne Tooke would have been pleased with the sagacity of a child of five years old (S –) who called *laughing* an interjection. Mr. – gave S – a slight pinch, in order to produce "an involuntary convulsion with oral sound." And when the interjection Oh! was uttered by the boy, he was told by his father, that the word was an interjection; and, that "any word or noise, that expresses a sudden feeling of the mind, may be called an interjection." S – immediately said, "is laughing an interjection, then?" We hope that the candid reader will not imagine, that we produce these *sayings* of children of four or five years old, without some sense of the danger of ridicule; but we wish to give some idea of the sort of simple answers which children are likely to make in their first grammatical lessons. If too much is expected from them, the disappointment, which must be quickly felt, and will be quickly shown by the

preceptor, will discourage the pupil. We must repeat, that the first steps should be frequently retraced: a child should be *for some weeks* accustomed to distinguish an active verb, and its agent, or nominative case, from every other word in a sentence, before we attempt to advance. The objects of actions are the next class of words that should be selected.

The fanciful, or at least what appears to the moderns fanciful, arrangement of the cases amongst grammarians, may be dispensed with for the present. The idea, that the nominative is a direct, upright *case*, and that the genitive declines with the smallest obliquity from it; the dative, accusative, and ablative, falling further and further from the perpendicularity of speech, is a species of metaphysics not very edifying to a child. Into what absurdity men of abilities may be led by the desire of explaining what they do not sufficiently understand, is fully exemplified in other sciences as well as grammar.

The discoveries made by the author of Epea Pteroenta, show the difference between a vain attempt to substitute analogy and rhetoric in the place of demonstration and common sense. When a child has been patiently taught in conversation to analyze what he says, he will take great pleasure in the exercise of his new talent; he will soon discover, that the cause of the action does not always come before the verb in a sentence, that sometimes it follows the verb. "John beats Thomas," and "Thomas is beaten by John," he will perceive mean the same thing; he may, with very little difficulty, be taught the difference between a verb active and

a verb passive; that one brings first before the mind the person or thing which performs the action, and the other represents in the first place the person or thing upon whom the action is performed. A child of moderate capacity, after he has been familiarized to this general idea of a verb active and passive, and after he has been taught the names of the cases, will probably, without much difficulty, discover that the nominative case to a passive verb becomes the accusative case to a verb active. "School-masters are plagued by boys." A child sees plainly, that school-masters are the persons upon whom the action of plaguing is performed, and he will convert the sentence readily into "boys plague school-masters."

We need not, however, be in any hurry to teach our pupil the names of the cases; technical grammar may be easily learned, after a general idea of rational grammar has been obtained. For instance, *the verb* means only *the word*, or the principal word in a sentence; a child can easily learn this after he has learnt what is meant by a sentence; but it would be extremely difficult to make him comprehend it before he could distinguish a verb from a noun, and before he had any idea of the structure of a common sentence. From easy, we should proceed to more complicated, sentences. The grammatical construction of the following lines, for example, may not be immediately apparent to a child:

"What modes of sight between each vast extreme,
The mole's dim curtain, and the lynx's beam;

Of smell the headlong lioness between,
And hound sagacious on the tainted green."

"*Of Smell.*" A girl of ten years old (C –) was asked if she could tell what substantive the word "*of*" relates to; she readily answered, "*modes.*" C – had learned a general idea of grammar in conversation, in the manner which we have described. It is asserted from experience, that this method of instructing children in grammar by conversation, is not only practicable, but perfectly easy, and that the minds of children are adapted to this species of knowledge. During life, we learn with eagerness whatever is congenial with our present pursuits, and the acquisition of language is one of the most earnest occupations of childhood. After distinct and ready knowledge of the verb and nominative case has been acquired, the pupil should be taught to distinguish the object of an action, or, in other words, the objective or accusative case. He should be exercised in this, as in the former lessons, repeatedly, until it becomes perfectly familiar; and he should be encouraged to converse about these lessons, and to make his own observations concerning grammar, without fear of the preceptor's peremptory frown, or positive reference to "*his rules.*" A child of five years old, was asked what the word "*Here!*" meant; he answered, "It means to give a thing."

"When I call a person, as, John! John! it seems to me," said a boy of nine years old (S –) "it seems to me, that the vocative case is both the verb and its accusative case." A boy who had ever been

checked by his tutor for making his own observations upon the mysterious subject of grammar, would never have dared to have thought, or to have uttered a new thought, so freely. – Forcing children to learn any art or science by rote, without permitting the exercise of the understanding, must materially injure their powers both of reasoning and of invention. We acknowledge that Wilkins and Tooke have shown masters how to teach grammar a little better than it was formerly taught. Fortunately for the rising generation, all the words under the denomination of adverbs, prepositions, and conjunctions, which were absolute nonsense to us, may be easily explained to them, and the commencement of instruction need no longer lay the foundation of implicit acquiescence in nonsense. We refer to Mr. Horne Tooke's "Epea Pteroenta," forbearing to dilate upon the principles of his work, lest we should appear in the invidious light of authors who rob the works of others to adorn their own. We cannot help expressing a wish, that Mr. Horne Tooke would have the philanthropic patience to write an elementary work in a *simple style*, unfolding his grammatical discoveries to the rising generation.

When children have thus by gentle degrees, and by short and clear conversations, been initiated in general grammar, and familiarized to its technical terms, the first page of tremendous Lilly will lose much of its horror. It has been taken for granted, that at the age of which we have been speaking, a child can read English tolerably well, and that he has been used to employ a dictionary. He may now proceed to translate from some easy

books a few short sentences: the first word will probably be an adverb or conjunction; either of them may readily be found in the Latin dictionary, and the young scholar will exult in having translated one word of Latin; but the next word, a substantive or verb, perhaps will elude his search. Now the grammar may be produced, and something of the various terminations of a noun may be explained. If *musam* be searched for in the dictionary, it cannot be found, but *musa* catches the eye, and, with the assistance of the grammar, it may be shown, that the meaning of words may be discovered by the united helps of the dictionary and grammar. After some days patient continuation of this exercise, the use of the grammar, and of its uncouth collection of words and syllables, will be apparent to the pupil: he will perceive that the grammar is a sort of appendix to the dictionary. The grammatical formulæ may then, by gentle degrees, be committed to memory, and when once got by heart, should be assiduously preserved in the recollection. After the preparation which we have recommended, the singular number of a declension will be learnt in a few minutes by a child of ordinary capacity, and after two or three days repetition, the plural number may be added. The whole of the first declension should be well fixed in the memory before a second is attempted. During this process, a few words at every lesson may be translated from Latin to English, and such nouns as are of the first declension, may be compared with *musa*, and may be declined according to the same form. Tedious as this method may appear, it will in the end be found

expeditious. Omitting some of the theoretic or didactic part of the grammar, which should only be read, and which may be explained with care and patience, the whole of the declensions, pronouns, conjugations, the list of prepositions and conjunctions, interjections, some adverbs, the concords, and common rules of syntax, may be comprised with sufficient repetitions in about two or three hundred lessons of ten minutes each; that is to say, ten minutes application of the scholar in the presence of the teacher. A young boy should never be set to learn a lesson by heart when alone. Forty hours! Is this tedious? If you are afraid of losing time, begin a few months earlier; but begin when you will, forty hours is surely no great waste of time: the whole, or even half of this short time, is not spent in the labour of getting jargon by rote; each day some slight advance is made in the knowledge of words, and in the knowledge of their combinations. What we insist upon is, that *nothing should be done to disgust the pupil*: steady perseverance, with uniform gentleness, will induce habit, and nothing should ever interrupt the regular return of the daily lesson. If absence, business, illness, or any other cause, prevent the attendance of the teacher, a substitute must be appointed; the idea of relaxation on Sunday, or a holyday, should never be permitted. In most public seminaries above one third, in some nearly one half, of the year is permitted to idleness: it is the comparison between severe labour and dissipation, that renders learning hateful.

Johnson is made to say by one of his female biographers,[3] that no child loves the person who teaches him Latin; yet the author of this chapter would not take all the doctor's fame, and all the lady's wit and riches, in exchange for the hourly, unfeigned, unremitting friendship, which he enjoys with a son who had no other master than his father. So far from being laborious or troublesome, he has found it an agreeable employment to instruct his children in grammar and the learned languages. In the midst of a variety of other occupations, half an hour every morning for many years, during the time of dressing, has been allotted to the instruction of boys of different ages in languages, and no other time has been spent in this employment. Were it asserted that these boys made *a reasonable progress*, the expression would convey no distinct meaning to the reader; we shall, therefore, mention an experiment tried this morning, November 8th, 1796, to ascertain the progress of one of these pupils. Without previous study, he translated twenty lines of the story of Ceyx and Alcyone, from Ovid, consulting the dictionary only twice: he was then desired to translate the passage which he had read into English verse; and in two or three hours he produced the following version. Much of the time was spent in copying the lines fairly, as this opportunity was taken of exciting his attention to writing and spelling, to associate the habit of application with the pleasure of voluntary exertion. The *curious* may, if they think it worth their while, see the various *readings* and corrections of the translation

[3] Mrs. Piozzi.

(V. Chapter on Conversation, and Anecdotes of Children) which were carefully preserved, not as "*Curiosities of Literature*," but for the sake of truth, and with a desire to show, that the pupil had the patience to correct. A *genius* may hit off a few tolerable lines; but if a child is willing and able to criticise and correct what he writes, he shows that he selects his expressions from choice, and not from chance or imitation; and he gives to a judicious tutor the certain promise of future improvement.

"Far in a vale there lies a cave forlorn,
Which Phœbus never enters eve or morn,
The misty clouds inhale the pitchy ground,
And twilight lingers all the vale around.
No watchful cocks Aurora's beams invite;
No dogs nor geese, the guardians of the night:
No flocks nor herds disturb the silent plains;
Within the sacred walls mute quiet reigns,
And murmuring Lethe soothing sleep invites;
In dreams again the flying past delights:
From milky flowers that near the cavern grow,
Night scatters the collected sleep below."

S – , the boy who made this translation, was just ten years old; he had made but three previous attempts in versification; his reading in poetry had been some of Gay's fables, parts of the Minstrel, three odes of Gray, the Elegy in a Country Church-yard, the Tears of Old May-day, and parts of the second volume

of Dr. Darwin's Botannic Garden; Dryden's translations of the fable of Ceyx and Alcyone he had never seen; the book had always been locked up. Phædrus and Ovid's Metamorphoses were the whole of his Latin erudition. These circumstances are mentioned thus minutely, to afford the inquisitive teacher materials for an accurate estimate of the progress made by our method of instruction. Perhaps most boys of S – 's age, in our great public seminaries, would, upon a similar trial, be found superior. Competition in the art of translation is not our object; our object is to show, that half an hour a day, steadily appropriated to grammar and Latin, would be sufficient to secure a boy of this age, from any danger of ignorance in classical learning; and that the ease and shortness of his labour will prevent that disgust, which is too often induced by forced and incessant application. We may add, that some attention to the *manner* in which the pupils repeat their Latin lessons, has been found advantageous: as they were never put in bodily fear, by the impatience of a pedagogue, they had leisure and inclination to read and recite, without awkward gestures and discordant tones. The whining tones and convulsive gestures often contracted by boys during the agony of repeating their long lessons, are not likely to be advantageous to the rising generation of orators. Practice, and the strong motive of emulation, may, in a public seminary, conquer these bad habits. After the pupil has learned to speak ill, he *may* be taught to speak well; but the chances are against him: and why should we have the trouble of breaking bad

habits? It is much easier to prevent them. In private education, as the preceptor has less chance of curing his pupil of the habit of speaking ill, he should be peculiarly attentive to give the child constant habits of speaking and reading well. It is astonishing, that parents, who are extremely intent upon the education of their children, should overlook some of the essential means of success. A young man with his head full of Latin and law, will make but a poor figure at the bar, or in parliament, if he cannot enunciate distinctly, and if he cannot speak good English extempore, or produce his learning and arguments with grace and propriety. It is in vain to expect that a boy should speak well in public, who cannot, in common conversation, utter three connected sentences without a false concord or a provincial idiom; he may be taught with much care and cost to speak *tripod* sentences;[4] but bring the young orator to the test, bring him to actual business, rouse any of his passions, throw him off his guard, and then listen to his language; he will forget instantly his reading master, and all his rules of pronunciation and rhetoric, and he will speak the language to which he has been most accustomed. No master will then be near him to regulate the pitch and tones of his voice. We cannot believe that even Caius Gracchus could, when he was warmed by passion, have listened to Licinius's pitch-pipe.[5] Example, and constant attention to their manner of speaking in common conversation, we apprehend to be the most certain

[4] V. Blair.

[5] V. Plutarch.

methods of preparing young men for public speakers. Much of the time that is spent in teaching boys to walk upon stilts, might be more advantageously employed in teaching them to walk well without them. It is all very well whilst the pupil is under the protection of his preceptor. The actor on the stage is admired whilst he is elevated by the cothurnus; but young men are not to exhibit their oratorical talents always with the advantages of stage effect and decorations. We should imagine, that much of the diffidence felt by young men of abilities, when they first rise to speak in public, may be attributed to their immediate perception of the difference between scholastic exhibitions and the real business of life; they feel that they have learned to speak two languages, which must not, on any account, be mixed together; the one, the vulgar language of common conversation; the other, the refined language of oratorical composition: the first they are most inclined to use when they are agitated; and they are agitated when they rise to speak before numbers: consequently there is an immediate struggle between custom and institution. Now, a young man, who in common conversation in his own family has never been accustomed to hear or to speak vulgar or ungrammatical language, cannot possibly apprehend that he shall suddenly utter ridiculous expressions; he knows, that, if he speaks at all, he shall at least speak good English; and he is not afraid, that, if he is pursued, he shall be obliged to throw away his cumbrous stilts. The practice of speaking in public, we are sensible, is a great advantage; but the habit of speaking accurately

in private, is of still greater consequence: this habit depends upon the early and persevering care of the parent and the preceptor. There is no reason why children should not be made at the same time good scholars and good speakers; nor is there any reason why boys, whilst they learn to write Latin, should be suffered to forget how to write English.

It would be a great advantage to the young classical scholar, if his Latin and English literature were mixed; the taste for ancient authors and for modern literature, ought to be cultivated at the same time; and the beauties of composition, characteristic of different languages, should be familiarized to the student. Classical knowledge and taste afford such continual and innocent sources of amusement, that we should be extremely sorry that any of our pupils should not enjoy them in their fullest extent; but we do not include a talent for Latin composition amongst the *necessary* accomplishments of a gentleman. There are situations in life, where facility and elegance in writing Latin may be useful, but such situations are not common; when a young man is intended for them, he may be trained with more particular assiduity to this art; perhaps for this purpose the true Busbyean method is the best. The great Latin and Greek scholars of the age, have no reason to be displeased by the assertion, that classical proficiency equal to their own, is not a *necessary* accomplishment in a gentleman; if their learning become more rare, it may thence become more valuable. We see no reason why there should not be Latinists as well as special pleaders.

We have not laid down any course of classical study; those who consider the order in which certain authors are read, as of material consequence in the education of scholars, may consult Milton, Mrs. Macaulay, "Milne's Well-bred Scholar," &c. where they will find precise directions.

We have *lately* seen a collection of exercises for boys,[6] which in some measure supplies the defect of Mr. Garretson's curious performance. We wish most earnestly that dictionaries were improved. The author of "Stemmata Latinitatis," has conferred an essential service on the public; but still there is wanting a dictionary for schools, in which elegant and proper English might be substituted for the barbarous translations now in use. Such a dictionary could not be compiled, we should think, without an attention to the course of books that are most commonly used in schools. The first meanings given in the dictionary, should suit the first authors that a boy reads; this may probably be a remote or metaphoric meaning: then the radical word should be mentioned, and it would not cost a master any great trouble to trace the genealogy of words to the parent stock.

Cordery is a collection of such mean sentences, and uninstructive dialogue, as to be totally unfit for boys. Commenius's "Visible World displayed," is far superior, and might, with proper alterations and better prints, become a valuable *English* school-book. Both these books were intended for countries where the Latin language was commonly spoken,

[6] Valpy's Exercises.

and consequently they are filled with the terms necessary for domestic life and conversation: for this very reason they are not good introductions to the classics. Selections from Bailey's Phædrus, will be proper for young beginners, upon account of the glossary. We prefer this mode of assisting them with glossaries to the use of translations, because they do not induce indolent habits, and yet they prevent the pupil from having unnecessary labour. Translations always give the pupil more trouble in the end, than they save in the beginning. The glossary to Bailey's Phædrus, which we have just mentioned, wants much to be modernized, and the language requires to be improved. Mr. Valpy's "Select Sentences," would be much more useful if they had a glossary annexed. As they are, they will, however, be useful after Phædrus. Ovid's Metamorphoses, with all its monstrous faults, appears to be the best introduction to the Latin classics, and to heathen mythology. Norris's Ovid may be safely put into the hands of children, as it is a selection of the least exceptionable fables. To accustom boys to read poetry and prose nearly at the same period, is advantageous. Cornelius Nepos, a *crabbed* book, but useful from its brevity, and from its being a proper introduction to Grecian and Roman history, may be read nearly at the same time with Ovid's Metamorphoses. After Ovid, the pupil may begin Virgil, postponing some of the Eclogues, and all the Georgics.

We recommend that some English books should be put into the hands of boys whilst they are going through Phædrus,

Ovid, and Cornelius Nepos, which may suit with the ideas they acquire from these Latin authors. Plutarch's Lives, for instance, will be useful and interesting. When we mention Plutarch's Lives, we cannot help recollecting how many great people have acknowledged the effect of this book in their early education. Charles the Twelfth, Rousseau, Madame Roland, Gibbon, we immediately remember, and we are sure we have noticed many others. An abridgment of Plutarch, by Mrs. Helme, which we have looked into, appears (the preface excepted) to be well written; and we see another abridgment of Plutarch advertised, which we hope may prove serviceable: good prints to a Plutarch for children, would be very desirable.

As an English introduction to mythology, we recommend the first volume of Lord Chesterfield's Letters, as a most elegant view of heathen mythology. But if there be any danger that the first volume should introduce the remainder of Lord Chesterfield's work to the inexperienced reader, we should certainly forbear the experiment: it would be far better for a young man never to be acquainted with a single heathen deity, than to purchase Lord Chesterfield's classical knowledge at the hazard of contamination from his detestable system of morals. Without his Lordship's assistance, Mrs. Monsigny's Mythology can *properly* initiate the young pupil of either sex into the mysteries of ancient fables. The notes to Potter's Æschylus, are also well suited to our purpose. In Dr. Darwin's "Botanic Garden," there are some beautiful poetic allusions to ancient

gems and ancient fables, which must fix themselves in the memory or in the imagination of the pupil. The sooner they are read, the better; we have felt the advantage of putting them into the hands of a boy of nine or ten years old. The ear should be formed to English as well as to Latin poetry.

Classical poetry, without the knowledge of mythology, is unintelligible: if children study the one, they must learn the other. Divested of the charms of poetry, and considered without classical prepossession, mythology presents a system of crimes and absurdities, which no allegorical, metaphysical, or literal interpreters of modern times, can perfectly reconcile to common sense, or common morality; but our poets have naturalized ancient fables, so that mythology is become essential even to modern literature. The associations of taste, though arbitrary, are not easily changed in a nation whose literature has attained to a certain pitch of refinement, and whose critical judgments must consequently have been for some generations traditional. There are subjects of popular allusion, which poets and orators regard as common property; to dispossess them of these, seems impracticable, after time has sanctioned the prescriptive right. But new knowledge, and the cultivation of new sciences, present objects of poetic allusion which, skilfully managed by men of inventive genius, will oppose to the habitual reverence for antiquity, the charms of novelty united to the voice of philosophy.[7]

[7] V. Darwin's Poetry.

In education we must, however, consider the actual state of manners in that world in which our pupils are to live, as well as our wishes or our hopes of its gradual improvement.[8] With a little care, preceptors may manage so as to teach mythology without in the least injuring their pupils. Children may be familiarized to the strange manners and strange personages of ancient fable, and may consider them as a set of beings who are not to be judged by any rules of morality, and who have nothing in common with ourselves. The caricatura of some of the passions, perhaps, will not shock children who are not used to their natural appearance; they will pass over the stories of love and jealousy, merely because they do not understand them. We should rather leave them completely unintelligible, than attempt, like Mr. Riley, in his mythological pocket dictionary for youth, to elucidate the whole at once, by assuring children that Saturn was Adam, that Atlas is Moses, and his brother Hesperus, Aaron; that Vertumnus and Pomona were Boaz and Ruth; that Mars *corresponds* with Joshua; that Apollo *accords* with David, since they both played upon the harp; that Mercury can be no other than our Archangel Michael, since they both have wings on their arms and feet; that, in short, to complete the concordance, Momus is a striking likeness of Satan. The ancients, Mr. Riley allows, have so much disfigured these personages, that it is hard to know many of

[8] Since the above was written, we have seen a letter from Dr. Aikin to his son on the *morality* and *poetic merit* of the fable of Circe, which convinces us that the observations that we have hazarded are not premature.

the portraits again at first sight; however, he is persuaded that "the young student will find a peculiar gratification in tracing the likeness," and he has kindly furnished us with a catalogue to explain the exhibition, and to guide us through his new pantheon.

As books of reference, the convenient size, and compressed information, of *pocket* mythological dictionaries, will recommend them to general use; but we object to the miserable prints with which they are sometimes disgraced. The first impression made upon the imagination[9] of children, is of the utmost consequence to their future taste. The beautiful engravings[10] in Spence's Polymetis, will introduce the heathen deities in their most graceful and picturesque forms to the fancy. The language of Spence, though classical, is not entirely free from pedantic affectation, and his dialogues are, perhaps, too stiff and long winded for our young pupils. But a parent or preceptor can easily select the useful explanations; and in turning over the prints, they can easily associate some general notion of the history and attributes of the gods and goddesses with their forms: the little eager spectators will, as they crowd round the book, acquire imperceptibly all the necessary knowledge of mythology, imbibe the first pleasing ideas of taste, and store their imagination with classic imagery. The same precautions that are necessary to educate the eye, are also necessary to form the ear

[9] Chapter on Imagination.

[10] We speak of these engravings as *beautiful*, for the times in which they were done; modern artists have arrived at higher perfection.

and understanding of taste. The first mythological descriptions which our pupils read, should be the best in their kind. Compare the following account of Europa in a pocket dictionary, with her figure in a poetical gem – "Europa, the daughter of Agenor, king of the Phœnicians, and sister of Cadmus. This princess was so beautiful, that, they say, one of the companions of Juno had robbed her of a pot of paint to bestow on this lady, which rendered her so handsome. She was beloved of Jupiter, who assumed the shape of a bull to run away with her, swam over the sea with her on his back, and carried her into that part of the world now called Europe, from her name." So far the dictionary; now for the poet.

"Now lows a milk-white bull on Afric's strand,
And crops with dancing head the daisy'd land;
With rosy wreathes Europa's hand adorns
His fringed forehead and his pearly horns;
Light on his back the sportive damsel bounds,
And, pleas'd, he moves along the flowery grounds;
Bears with slow step his beauteous prize aloof,
Dips in the lucid flood his ivory hoof;
Then wets his velvet knees, and wading laves
His silky sides, amid the dimpling waves.
While her fond train with beckoning hands deplore,
Strain their blue eyes, and shriek along the shore:
Beneath her robe she draws her snowy feet,
And, half reclining on her ermine seat,
Round his rais'd neck her radiant arms she throws,

And rests her fair cheek on his curled brows;
Her yellow tresses wave on wanton gales,
And high in air her azure mantle sails."[11]

[11] Darwin. V. Botanic Garden.

CHAPTER XIV

ON GEOGRAPHY AND CHRONOLOGY

The usual manner of teaching Geography and Chronology, may, perhaps, be necessary in public seminaries, where a number of boys are to learn the same thing at the same time; but what is learned in this manner, is not permanent; something besides merely committing names and dates to the memory, is requisite to make a useful impression upon the memory. For the truth of this observation, an appeal is made to the reader. Let him recollect, whether the Geography and Chronology which he learned whilst a boy, are what he now remembers – Whether he has not obtained his present knowledge from other sources than the tasks of early years. When business, or conversation, calls upon us to furnish facts accurate as to place and time, we retrace our former heterogeneous acquirements, and select those circumstances which are connected with our present pursuit, and thus we form, as it were, a nucleus round which other facts insensibly arrange themselves. Perhaps no two men in the world, who are well versed in these studies, connect their knowledge in the same manner. Relation to some particular country, some favourite history, some distinguished

person, forms the connection which guides our recollection, and which arranges our increasing nomenclature. By attending to what passes in our own minds, we may learn an effectual method of teaching without pain, and without any extraordinary burden to the memory, all that is useful of these sciences. The details of history should be marked by a few chronological æras, and by a few general ideas of geography. When these have been once completely associated in the mind, there is little danger of their being ever disunited: the sight of any country will recall its history, and even from representations in a map, or on the globe, when the mind is wakened by any recent event, a long train of concomitant ideas will recur.

The use of technical helps to the memory, has been condemned by many, and certainly, when they are employed as artifices to supply the place of real knowledge, they are contemptible; but when they are used as indexes to facts that have been really collected in the mind; when they serve to arrange the materials of knowledge in appropriate classes, and to give a sure and rapid clue to recollection, they are of real advantage to the understanding. Indeed, they are now so common, that pretenders cannot build the slightest reputation upon their foundation. Were an orator to attempt a display of long chronological accuracy, he might be wofully confounded by his opponent's applying at the first pause,

[12]Els*luk* he would have said!

Ample materials are furnished in Gray's Memoria Technica, from which a short and useful selection may be made, according to the purposes which are in view. For children, the little ballad of the Chapter of Kings, will not be found beneath the notice of mothers who attend to education. If the technical terminations of Gray are inserted, they will never be forgotten, or may be easily recalled.[13] We scarcely ever forget a ballad if the tune is popular.

For pupils at a more advanced age, it will be found advantageous to employ technical helps of a more scientific construction. Priestley's Chart of Biography may, from time to time, be hung in their view. Smaller charts, upon the same plan, might be provided with a few names as land-marks; these may be filled up by the pupil with such names as he selects from history; they may be bound in octavo, like maps, by the middle, so as to unfold both ways – Thirty-nine inches by nine will be a convenient size. Prints, maps, and medals, which are part of the constant furniture of a room, are seldom attended to by young people; but when circumstances excite an interest upon any particular subject, then is the moment to produce the symbols which record and communicate knowledge.

Mrs. Radcliffe, in her judicious and picturesque Tour through

[12] V. Gray's Memoria Technica, and the Critic.

[13] Instead ofWilliam the conqueror long did reign,And William his son by an arrow was slain.Read,William the Consau long did reign,And Rufkoi his son by an arrow was slain.And so on from Gray's Memoria Technica to the end of the chapter.

Germany, tells us, that in passing through the apartments of a palace which the archduchess Maria Christiana, the sister of the late unfortunate queen of France, had left a few hours before, she saw spread upon a table a map of all the countries then included in the seat of the war. The positions of the several corps of the allied armies were marked upon this chart with small pieces of various coloured wax. Can it be doubted, that the strong interest which this princess must have taken in the subject, would for ever impress upon her memory the geography of this part of the world?

How many people are there who have become geographers since the beginning of the present war. Even the common newspapers disseminate this species of knowledge, and those who scarcely knew the situation of Brest harbour a few years ago, have consulted the map with that eagerness which approaching danger excites; they consequently will tenaciously remember all the geographical knowledge they have thus acquired. The art of creating an interest in the study of geography, depends upon the dexterity with which passing circumstances are seized by a preceptor in conversation. What are maps or medals, statues or pictures, but technical helps to memory? If a mother possess good prints, or casts of ancient gems, let them be shown to any persons of taste and knowledge who visit her; their attention leads that of our pupils; imitation and sympathy are the parents of taste, and taste reads in the monuments of art whatever history has recorded.

In the Adele and Theodore of Madame de Silleri, a number of adventitious helps are described for teaching history and chronology. There can be no doubt that these are useful; and although such an apparatus cannot be procured by private families, fortunately the print-shops of every provincial town, and of the capital in particular, furnish even to the passenger a continual succession of instruction. Might not prints, assorted for the purposes which we have mentioned, be *lent* at circulating libraries?

To assist our pupils in geography, we prefer a globe to common maps. Might not a cheap, portable, and convenient globe, be made of oiled silk, to be inflated by a common pair of bellows? Mathematical exactness is not requisite for our purpose, and though we could not pretend to the precision of our best globes, yet a balloon of this sort would compensate by its size and convenience for its inaccuracy. It might be hung by a line from its north pole, to a hook screwed into the horizontal architrave of a door or window; and another string from its south pole might be fastened at a proper angle to the floor, to give the requisite elevation to the axis of the globe. An idea of the different projections of the sphere, may be easily acquired from this globe in its flaccid state, and any part of it might be consulted as a map, if it were laid upon a convex board of a convenient size. Impressions from the plates which are used for common globes, might be taken to try this idea without any great trouble or expense; but we wish to employ a much larger scale, and to

have them five or six feet diameter. The inside of a globe of this sort might be easily illuminated, and this would add much to the novelty and beauty of its appearance.

In the country, with the assistance of a common carpenter and plasterer, a large globe of lath and plaster may be made for the instruction and entertainment of a numerous family of children. Upon this they should leisurely delineate from time to time, by their given latitudes and longitudes, such places as they become acquainted with in reading or conversation. The capital city, for instance, of the different countries of Europe, the rivers, and the neighbouring towns, until at last the outline might be added: for the sake of convenience, the lines, &c. may be first delineated upon a piece of paper, from which they may be accurately transferred to their proper places on the globe, by the intervention of black-leaded paper, or by pricking the lines through the paper, and pouncing powdered blue through the holes upon the surface of the globe.

We enter into this detail because we are convinced, that every addition to the active manual employment of children, is of consequence, not only to their improvement, but to their happiness.

Another invention has occurred to us for teaching geography and history together. Priestley's Chart of History, though constructed with great ingenuity, does not invite the attention of young people: there is an intricacy in the detail which is not obvious at first. To remedy what appears to us a difficulty, we

propose that eight and twenty, or perhaps thirty, octavo maps of the globe should be engraved; upon these should be traced, in succession, the different situations of the different countries of the world, as to power and extent, during each respective century: different colours might denote the principal divisions of the world in each of these maps; the same colour always denoting the same country, with the addition of one strong colour; red, for instance, to distinguish that country which had at each period the principal dominion. On the upper and lower margin in these maps, the names of illustrious persons might be engraven in the manner of the biographical chart; and the reigning opinions of each century should also be inserted. Thus history, chronology, and geography, would appear at once to the eye in their proper order, and regular succession, divided into centuries and periods, which easily occur to recollection.

We forbear to expatiate upon this subject, as it has not been actually submitted to experiment; carefully avoiding in the whole of this work to recommend any mode of instruction which we have not actually put in practice. For this reason, we have not spoken of the abbé Gaultier's method of teaching geography, as we have only been able to obtain accounts of it from the public papers, and from reviews; we are, however, disposed to think favourably beforehand, of any mode which unites amusement with instruction. We cannot forbear recommending, in the strongest manner, a few pages of Rollin in his "Thoughts

upon Education,"[14] which we think contain an excellent specimen of the manner in which a well informed preceptor might lead his pupils a geographical, historical, botanical, and physiological tour upon the artificial globe.

We conclude this chapter of hints, by repeating what we have before asserted, that though technical assistance may be of ready use to those who are really acquainted with that knowledge to which it refers, it never can supply the place of accurate information.

The causes of the rise and fall of empires, the progress of human knowledge, and the great discoveries of superior minds, are the real links which connect the chain of political knowledge.

[14] Page 24.

CHAPTER XV

ON ARITHMETIC

The man who is ignorant that two and two make four, is stigmatized with the character of hopeless stupidity; except, as Swift has remarked, in the arithmetic of the customs, where two and two do not always make the same sum.

We must not judge of the understanding of a child by this test, for many children of quick abilities do not immediately assent to this proposition when it is first laid before them. "Two and two make four," says the tutor. "Well, child, why do you stare so?"

The child stares because the word *make* is in this sentence used in a sense which is quite new to him; he knows what it is to make a bow, and to make a noise, but how this active verb is applicable in the present case, where there is no agent to perform the action, he cannot clearly comprehend. "Two and two *are* four," is more intelligible; but even this assertion, the child, for want of a distinct notion of the sense in which the word *are* is used, does not understand. "Two and two *are called* four," is, perhaps, the most accurate phrase a tutor can use; but even these words will convey no meaning until they have been associated with the pupil's perceptions. When he has once perceived the

combination of the numbers with real objects, it will then be easy to teach him that the words *are called*, *are*, and *make*, in the foregoing proposition, are synonymous terms.

We have chosen the first simple instance we could recollect, to show how difficult the words we generally use in teaching arithmetic, must be to our young pupils. It would be an unprofitable task to enumerate all the puzzling technical terms which, in their earliest lessons, children are obliged to hear, without being able to understand.

It is not from want of capacity that so many children are deficient in arithmetical skill; and it is absurd to say, "such a child has no genius for arithmetic. Such a child cannot be made to comprehend any thing about numbers." These assertions prove nothing, but that the persons who make them, are ignorant of the art of teaching. A child's seeming stupidity in learning arithmetic, may, perhaps, be a proof of intelligence and good sense. It is easy to make a boy, who does not reason, repeat by rote any technical rules which a common writing-master, with magisterial solemnity, may lay down for him; but a child who reasons, will not be thus easily managed; he stops, frowns, hesitates, questions his master, is wretched and refractory, until he can discover why he is to proceed in such and such a manner; he is not content with seeing his preceptor make figures and lines upon a slate, and perform wondrous operations with the self-complacent dexterity of a conjurer. A sensible boy is not satisfied with merely seeing the total of a given sum, or the answer to a

given question, *come out right*; he insists upon knowing why it is right. He is not content to be led to the treasures of science blindfold; he would tear the bandage from his eyes, that he might know the way to them again.

That many children, who have been thought to be slow in learning arithmetic, have, after their escape from the hands of pedagogues, become remarkable for their quickness, is a fact sufficiently proved by experience. We shall only mention one instance, which we happened to meet with whilst we were writing this chapter. John Ludwig, a Saxon peasant, was dismissed from school when he was a child, after four years ineffectual struggle to learn the common rules of arithmetic. He had been, during this time, beaten and scolded in vain. He spent several subsequent years in common country labour, but at length some accidental circumstances excited his ambition, and he became expert in all the common rules, and mastered the rule of three and fractions, by the help of an old school book, in the course of one year. He afterwards taught himself geometry, and raised himself, by the force of his abilities and perseverance, from obscurity to fame.

We should like to see the book which helped Mr. Ludwig to conquer his difficulties. Introductions to Arithmetic are, often, calculated rather for adepts in science, than for the ignorant. We do not pretend to have discovered any shorter method than what is common, of teaching these sciences; but, in conformity with the principles which are laid down in the former part of this work, we have endeavoured to teach their rudiments without disgusting

our pupils, and without habituating them to be contented with merely technical operations.

In arithmetic, as in every other branch of education, the principal object should be, to preserve the understanding from implicit belief; to invigorate its powers; to associate pleasure with literature, and to induce the laudable ambition of progressive improvement.

As soon as a child can read, he should be accustomed to count, and to have the names of numbers early connected in his mind with the combinations which they represent. For this purpose, he should be taught to add first by things, and afterwards by signs or figures. He should be taught to form combinations of things by adding them together one after another. At the same time that he acquires the names that have been given to these combinations, he should be taught the figures or symbols that represent them. For example, when it is familiar to the child, that one almond, and one almond, are called two almonds; that one almond, and two almonds, are called three almonds, and so on, he should be taught to distinguish the figures that represent these assemblages; that 3 means one and two, &c. Each operation of arithmetic should proceed in this manner, from individuals to the abstract notation of signs.

One of the earliest operations of the reasoning faculty, is abstraction; that is to say, the power of classing a number of individuals under one name. Young children call strangers

either men or women; even the most ignorant savages[15] have a propensity to generalize.

We may err either by accustoming our pupils too much to the consideration of tangible substances when we teach them arithmetic, or by turning their attention too much to signs. The art of forming a sound and active understanding, consists in the due mixture of facts and reflection. Dr. Reid has, in his "Essay on the Intellectual Powers of Man," page 297, pointed out, with great ingenuity, the admirable economy of nature in limiting the powers of reasoning during the first years of infancy. This is the season for cultivating the senses, and whoever, at this early age, endeavours to force the tender shoots of reason, will repent his rashness.

In the chapter "on Toys," we have recommended the use of plain, regular solids, cubes, globes, &c. made of wood, as playthings for children, instead of uncouth figures of men, women and animals. For teaching arithmetic, half inch cubes, which can be easily grasped by infant fingers, may be employed with great advantage; they can be easily arranged in various combinations; the eye can easily take in a sufficient number of them at once, and the mind is insensibly led to consider the assemblages in which they may be grouped, not only as they relate to number, but as they relate to quantity or shape; besides, the terms which are borrowed from some of these shapes, as squares, cubes, &c. will become familiar. As these children

[15] V. A strange instance quoted by Mr. Stewart, "On the Human Mind," page 152.

advance in arithmetic to square or cube, a number will be more intelligible to them than to a person who has been taught these words merely as the formula of certain rules. In arithmetic, the first lessons should be short and simple; two cubes placed *above* each other, will soon be called two; if placed in any other situations near each other, they will still be called two; but it is advantageous to accustom our little pupils to place the cubes with which they are taught in succession, either by placing them upon one another, or laying in columns upon a table, beginning to count from the cube next to them, as we cast up in addition. For this purpose, a board about six inches long, and five broad, divided into columns perpendicularly by slips of wood three eighths of an inch wide, and one eighth of an inch thick, will be found useful; and if a few cubes of colours *different from those already mentioned*, with numbers on their six sides, are procured, they may be of great service. Our cubes should be placed, from time to time, in a different order, or promiscuously; but when any arithmetical operations are to be performed with them, it is best to preserve the established arrangement.

One cube and one other, are called two.

Two what?

Two cubes.

One glass, and one glass, are called two glasses. One raisin, and one raisin, are called two raisins, &c. One cube, and one glass, are called what? *Two things* or two.

By a process of this sort, the meaning of the abstract term *two*

may be taught. A child will perceive the word *two*, means the same as the words *one and one*; and when we say one and one are called two, unless he is prejudiced by something else that is said to him, he will understand nothing more than that there are two names for the same thing.

"One, and one, and one, are called three," is the same as saying "that three is the name for one, and one, and one." "Two and one are three," is also the same as saying "that three is the name of *two and one*." Three is also the name of one and two; the word three has, therefore, three meanings; it means one, and one, and one; *also*, two and one; also, one and two. He will see that any two of the cubes may be put together, as it were, in one parcel, and that this parcel may be called *two*; and he will also see that this parcel, when joined to another single cube, will *make* three, and that the sum will be the same, whether the single cube, or the two cubes, be named first.

In a similar manner, the combinations which form *four*, may be considered. One, and one, and one, and one, are four.

One and three are four.

Two and two are four.

Three and one are four.

All these assertions mean the same thing, and the term *four* is equally applicable to each of them; when, therefore, we say that two and two are four, the child may be easily led to perceive, and indeed to *see*, that it means the same thing as saying one *two*, and one *two*, which is the same thing as saying two *two's*,

or saying the word *two* two times. Our pupil should be suffered to rest here, and we should not, at present, attempt to lead him further towards that compendious method of addition which we call multiplication; but the foundation is laid by giving him this view of the relation between two and two in forming four.

There is an enumeration in the note[16] of the different combinations which compose the rest of the Arabic notation, which consists only of nine characters.

Before we proceed to the number ten, or to the new series of numeration which succeeds to it, we should make our pupils perfectly masters of the combinations which we have mentioned, both in the direct order in which they are arranged, and in various modes of succession; by these means, not only the addition, but the subtraction, of numbers as far as nine, will be perfectly familiar to them.

It has been observed before, that counting by realities, and by signs, should be taught at the same time, so that the ear, the eye, and the mind, should keep pace with one another; and that technical habits should be acquired without injury to the understanding. If a child begins between four and five years of age, he may be allowed half a year for this essential, preliminary step in arithmetic; four or five minutes application every day, will be sufficient to teach him not only the relations of the first decade in numeration, but also how to write figures with accuracy and expedition.

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[16] **NOTE.**

The next step, is, by far the most difficult in the science of arithmetic; in treatises upon the subject, it is concisely passed over under the title of Numeration; but it requires no small degree of care to make it intelligible to children, and we therefore recommend, that, besides direct instruction upon the subject, the child should be led, by degrees, to understand the nature of classification in general. Botany and natural history, though they are not pursued as sciences, are, notwithstanding, the daily occupation and amusement of children, and they supply constant examples of classification. In conversation, these may be familiarly pointed out; a grove, a flock, &c. are constantly before the eyes of our pupil, and he comprehends as well as we do what is meant by two groves, two flocks, &c. The trees that form the grove are each of them individuals; but let their numbers be what they may when they are considered as a grove, the grove is but one, and may be thought of and spoken of distinctly, without any relation to the number of single trees which it contains. From these, and similar observations, a child may be led to consider *ten* as the name for a *whole*, an *integer*; a *one*, which may be represented by the figure (1): this same figure may also stand for a hundred, or a thousand, as he will readily perceive hereafter. Indeed, the term one hundred will become familiar to him in conversation long before he comprehends that the word *ten* is used as an aggregate term, like a dozen, or a thousand. We do not use the word ten as the French do *une dizaine*; ten does not, therefore, present the idea of an integer till we learn arithmetic.

This is a defect in our language, which has arisen from the use of duodecimal numeration; the analogies existing between the names of other numbers in progression, is broken by the terms eleven and twelve. *Thirteen*, *fourteen*, &c. are so obviously compounded of three and ten, and four and ten, as to strike the ears of children immediately, and when they advance as far as twenty, they readily perceive that a new series of units begins, and proceeds to thirty, and that thirty, forty, &c. mean three tens, four tens, &c. In pointing out these analogies to children, they become interested and attentive, they show that species of pleasure which arises from the perception of *aptitude*, or of truth. It can scarcely be denied that such a pleasure exists independently of every view of utility and fame; and when we can once excite this feeling in the minds of our young pupils at any period of their education, we may be certain of success.

As soon as distinct notions have been acquired of the manner in which a collection of ten units becomes a new unit of a higher order, our pupil may be led to observe the utility of this invention by various examples, before he applies it to the rules of arithmetic. Let him count as far as ten with black pebbles,[17] for instance; let him lay aside a white pebble to represent the collection of ten; he may count another series of ten black pebbles, and lay aside another white one; and so on, till he has collected ten white pebbles: as *each* of the ten white pebbles represents ten black pebbles, he will have counted one hundred;

[17] The word calculate is derived from the Latin calculus, a pebble.

and the ten white pebbles may now be represented by a single red one, which will stand for one hundred. This large number, which it takes up so much time to count, and which could not be comprehended at one view, is represented by a single sign. Here the difference of colour forms the distinction: difference in shape, or size, would answer the same purpose, as in the Roman notation X for ten, L for fifty, C for one hundred, &c. All this is fully within the comprehension of a child of six years old, and will lead him to the value of written figures by the *place* which they hold when compared with one another. Indeed he may be led to invent this arrangement, a circumstance which would encourage him in every part of his education. When once he clearly comprehends that the third place, counting from the right, contains only figures which represent hundreds, &c. he will have conquered one of the greatest difficulties of arithmetic. If a paper ruled with several perpendicular lines, a quarter of an inch asunder, be shown to him, he will see that the spaces or columns between these lines would distinguish the value of figures written in them, without the use of the sign (0) and he will see that (0) or zero, serves only to mark the place or situation of the neighbouring figures.

An idea of decimal arithmetic, but without detail, may now be given to him, as it will not appear extraordinary to *him* that a unit should represent ten by having its place, or column changed; and nothing more is necessary in decimal arithmetic, than to consider that figure which represented, at one time, an integer, or whole,

as representing at another time the number of *tenth parts* into which that whole may have been broken.

Our pupil may next be taught what is called numeration, which he cannot fail to understand, and in which he should be frequently exercised. Common addition will be easily understood by a child who distinctly perceives that the perpendicular columns, or places in which figures are written, may distinguish their value under various different denominations, as gallons, furlongs, shillings, &c. We should not tease children with long sums in avoirdupois weight, or load their frail memories with tables of long-measure, and dry-measure, and ale-measure in the country, and ale-measure in London; only let them cast up a few sums in different denominations, with the tables before them, and let the practice of addition be preserved in their minds by short sums every day, and when they are between six and seven years old, they will be sufficiently masters of the first and most useful rule of arithmetic.

To children who have been trained in this manner, subtraction will be quite easy; care, however, should be taken to give them a clear notion of the mystery of *borrowing* and *paying*, which is inculcated in teaching subtraction.

"Six from four I can't, but six from ten, and four remains; four

and four *is* eight."

And then, "One that I borrowed and four are five, five from nine, and four remains."

This is the formula; but is it ever explained – or can it be? Certainly not without some alteration. A child sees that six cannot be subtracted (taken) from four: more especially a child who is familiarly acquainted with the component parts of the names six and four: he sees that the sum 46 is less than the sum 94, and he knows that the lesser sum may be subtracted from the greater; but he does not perceive the means of separating them figure by figure. Tell him, that though six cannot be deducted from four, yet it can from fourteen, and that if one of the tens which are contained in the (9) ninety in the uppermost row of the second column, be supposed to be taken away, or borrowed, from the ninety, and added to the four, the nine will be reduced to 8 (eighty), and the four will become fourteen. *Our* pupil will comprehend this most readily; he will see that 6, which could not be subtracted from 4, may be subtracted from fourteen, and he will remember that the 9 in the next column is to be considered as only (8). To avoid confusion, he may draw a stroke across the (9) and write 8 over[18] it [8 over (9)] and proceed to the remainder of the operation. This method for beginners is certainly very distinct, and may for some time, be employed with advantage; and after its rationale has become familiar, we may explain the common method which depends upon this consideration.

[18] This method is recommended in the Cours de Math, par Camus, p. 38.

"If one number is to be deducted from another, the remainder will be the same, whether we add any given number to the smaller number, or take away the same given number from the larger." For instance:

Let the larger number be	9
And the smaller	4
If you deduct 3 from the larger it will be	6
From this subtract the smaller	4
The remainder will be	2
Or if you add 3 to the smaller number, it will be	7
Subtract this from the larger number	9
The remainder will be	2

Now in the common method of subtraction, the *one* which is borrowed is taken from the uppermost figure in the adjoining column, and instead of altering that figure to *one* less, we add one to the lowest figure, which, as we have just shown, will have the same effect. The terms, however, that are commonly used in performing this operation, are improper. To say "one that I borrowed, and four" (meaning the lowest figure in the adjoining column) implies the idea that what was borrowed is now to be repaid to that lowest figure, which is not the fact. As to multiplication, we have little to say. Our pupil should be furnished, in the first instance, with a table containing the addition of the different units, which form the different products of the multiplication table: these he should, from time to time,

add up as an exercise in addition; and it should be frequently pointed out to him, that adding these figures so many times over, is the same as multiplying them by the number of times that they are added; as three times 3 means 3 added three times. Here one of the figures represents a quantity, the other does not represent a quantity, it denotes nothing but the times, or frequency of repetition. Young people, as they advance, are apt to confound these signs, and to imagine, for instance, in the rule of three, &c. that the sums which they multiply together, mean quantities; that 40 yards of linen may be multiplied by three and six-pence, &c. – an idea from which the misstatements in sums that are intricate, frequently arise.

We have heard that the multiplication table has been set, like the Chapter of Kings, to a cheerful tune. This is a species of technical memory which we have long practised, and which can do no harm to the understanding; it prevents the mind from no beneficial exertion, and may save much irksome labour. It is certainly to be wished, that our pupil should be expert in the multiplication table; if the cubes which we have formerly mentioned, be employed for this purpose, the notion of *squaring* figures will be introduced at the same time that the multiplication table is committed to memory.

In division, what is called the Italian method of arranging the divisor and quotient, appears to be preferable to the common one, as it places them in such a manner as to be easily multiplied by each other, and as it agrees with algebraic notation.

The usual method is this:

Divisor

71)83467(1175

Italian method:

Dividend

83467	71
	1175

The rule of three is commonly taught in a manner merely technical: that it may be learned in this manner, so as to answer the common purposes of life, there can be no doubt; and nothing is further from our design, than to depreciate any mode of instruction which has been sanctioned by experience: but our purpose is to point out methods of conveying instruction that shall improve the reasoning faculty, and habituate our pupil to think upon every subject. We wish, therefore, to point out the course which the mind would follow to solve problems relative to proportion without the rule, and to turn our pupil's attention

to the circumstances in which the rule assists us.

The calculation of the price of any commodity, or the measure of any quantity, where the first term is one, may be always stated as a sum in the rule of three; but as this statement retards, instead of expediting the operation, it is never practised.

If one yard costs a shilling, how much will three yards cost?

The mind immediately perceives, that the price added three times together, or multiplied by three, gives the answer. If a certain number of apples are to be equally distributed amongst a certain number of boys, if the share of one is one apple, the share of ten or twenty is plainly equal to ten or twenty. But if we state that the share of three boys is twelve apples, and ask what number will be sufficient for nine boys, the answer is not obvious; it requires consideration. Ask our pupil what made it so easy to answer the last question, he will readily say, "Because I knew what was the share of one."

Then you could answer this new question if you knew the share of one boy?

Yes.

Cannot you find out what the share of one boy is when the share of three boys is twelve?

Four.

What number of apples then will be enough, at the same rate, for nine boys?

Nine times four, that is thirty-six.

In this process he does nothing more than divide the second

number by the first, and multiply the quotient by the third; 12 divided by 3 is 4, which multiplied by 9 is 36. And this is, in truth, the foundation of the rule; for though the golden rule facilitates calculation, and contributes admirably to our convenience, it is not absolutely necessary to the solution of questions relating to proportion.

Again, "If the share of three boys is five apples, how many will be sufficient for nine?"

Our pupil will attempt to proceed as in the former question, and will begin by endeavouring to find out the share of one of the three boys; but this is not quite so easy; he will see that each is to have one apple, and part of another; but it will cost him some pains to determine exactly how much. When at length he finds that one and two-thirds is the share of one boy, before he can answer the question, he must multiply one and two-thirds by nine, which is an operation *in fractions*, a rule of which he at present knows nothing. But if he begins by multiplying the second, instead of dividing it previously by the first number, he will avoid the embarrassment occasioned by fractional parts, and will easily solve the question.

3 : 5 : 9 : 15

Multiply 5

by 9

it makes 45

which product 45, divided by 3, gives 15.

Here our pupil perceives, that if a given number, 12, for instance, is to be divided by one number, and multiplied by another, *it will come to the same thing*, whether he begins by dividing the given number, or by multiplying it.

12 divided by 4 is 3, which
multiplied by 6 is 18;
And
12 multiplied by 6 is 72, which
divided by 4 is 18.

We recommend it to preceptors not to fatigue the memories of their young pupils with sums which are difficult only from the number of figures which they require, but rather to give examples *in practice*, where aliquot parts are to be considered, and where their ingenuity may be employed without exhausting their patience. A variety of arithmetical questions occur in common conversation, and from common incidents; these should be made a subject of inquiry, and our pupils, amongst others, should try

their skill: in short, whatever can be taught in conversation, is clear gain in instruction.

We should observe, that every explanation upon these subjects should be recurred to from time to time, perhaps every two or three months; as there are no circumstances in the business of every day, which recall abstract speculations to the minds of children; and the pupil who understands them to-day, may, without any deficiency of memory, forget them entirely in a few weeks. Indeed, the perception of the chain of reasoning, which connects demonstration, is what makes it truly advantageous in education. Whoever has occasion, in the business of life, to make use of the rule of three, may learn it effectually in a month as well as in ten years; but the habit of reasoning cannot be acquired late in life without *unusual* labour, and uncommon fortitude.

CHAPTER XVI

GEOMETRY

There is certainly no royal road to geometry, but the way may be rendered easy and pleasant by timely preparations for the journey.

Without any previous knowledge of the country, or of its peculiar language, how can we expect that our young traveller should advance with facility or pleasure? We are anxious that our pupil should acquire a taste for accurate reasoning, and we resort to Geometry, as the most perfect, and the purest series of ratiocination which has been invented. Let us, then, sedulously avoid whatever may disgust him; let his first steps be easy, and successful; let them be frequently repeated until he can trace them without a guide.

We have recommended in the chapter upon Toys, that children should, from their earliest years, be accustomed to the shape of what are commonly called regular solids; they should also be accustomed to the figures in mathematical diagrams. To these should be added their respective names, and the whole language of the science should be rendered as familiar as possible.

Mr. Donne, an ingenious mathematician of Bristol, has published a prospectus of an Essay on Mechanical Geometry: he has executed, and employed with success, models in wood and metal for demonstrating propositions in geometry in a *palpable* manner. We have endeavoured, in vain, to procure a set of these models for our own pupils, but we have no doubt of their entire utility.

What has been acquired in childhood, should not be suffered to escape the memory. Dionysius[19] had mathematical diagrams described upon the floors of his apartments, and thus recalled their demonstrations to his memory. The slightest addition that can be conceived, if it be continued daily, will imperceptibly, not only preserve what has been already acquired, but will, in a few years, amount to as large a stock of mathematical knowledge as we could wish. It is not our object to make mathematicians, but to make it easy to our pupil to become a mathematician, if his interest, or his ambition, make it desirable; and, above all, to habituate him to clear reasoning, and close attention. And we may here remark, that an early acquaintance with the accuracy of mathematical demonstration, does not, within our experience, contract the powers of the imagination. On the contrary, we think that a young lady of twelve years old, who is now no more, and who had an uncommon propensity to mathematical reasoning, had an imagination remarkably vivid and inventive.[20]

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[19] Plutarch. – Life of Dion.

[20] V. Rivuletta, a little story written *entirely* by her in 1786.

We have accustomed our pupils to form in their minds the conception of figures generated from points and lines, and surfaces supposed to move in different directions, and with different velocities. It may be thought, that this would be a difficult occupation for young minds; but, upon trial, it will be found not only easy to them, but entertaining. In their subsequent studies, it will be of material advantage; it will facilitate their progress not only in pure mathematics, but in mechanics and astronomy, and in every operation of the mind which requires exact reflection.

To demand steady thought from a person who has not been trained to it, is one of the most unprofitable and dangerous requisitions that can be made in education.

> "Full in the midst of Euclid dip at once,
> And petrify a genius to a dunce."

In the usual commencement of mathematical studies, the learner is required to admit that a point, of which he sees the prototype, a dot before him, has neither length, breadth, nor thickness. This, surely, is a degree of faith not absolutely necessary for the neophyte in science. It is an absurdity which has, with much success, been attacked in "Observations on the Nature of Demonstrative Evidence," by Doctor Beddoes.

We agree with the doctor as to the impropriety of calling a visible dot, a point without dimensions. But, notwithstanding

the high respect which the author commands by a steady pursuit of truth on all subjects of human knowledge, we cannot avoid protesting against part of the doctrine which he has endeavoured to inculcate. That the names point, radius, &c. are derived from sensible objects, need not be disputed; but surely the word centre can be understood by the human mind without the presence of any visible or tangible substance.

Where two lines meet, their junction cannot have dimensions; where two radii of a circle meet, they constitute the centre, and the name centre may be used for ever without any relation to a tangible or visible point. The word boundary, in like manner, means the extreme limit we call a line; but to assert that it has thickness, would, from the very terms which are used to describe it, be a direct contradiction. Bishop Berkely, Mr. Walton, Philathetes Cantabrigiensis, and Mr. Benjamin Robins, published several pamphlets upon this subject about half a century ago. No man had a more penetrating mind than Berkely; but we apprehend that Mr. Robins closed the dispute against him. This is not meant as an appeal to authority, but to apprize such of our readers as wish to consider the argument, where they may meet an accurate investigation of the subject. It is sufficient for our purpose, to warn preceptors not to insist upon their pupils' acquiescence in the dogma, that a point, represented by a dot, is without dimensions; and at the same time to profess, that we understand distinctly what is meant by mathematicians when they speak of length without breadth, and of a superfices without

depth; expressions which, to our minds, convey a meaning as distinct as the name of any visible or tangible substance in nature, whose varieties from shade, distance, colour, smoothness, heat, &c. are infinite, and not to be comprehended in any definition.

In fact, this is a dispute merely about words, and as the extension of the art of printing puts it in the power of every man to propose and to defend his opinions at length, and at leisure, the best friends may support different sides of a question with mutual regard, and the most violent enemies with civility and decorum. Can we believe that Tycho Brahe lost half his nose in a dispute with a Danish nobleman about a mathematical demonstration?

CHAPTER XVII

ON MECHANICS

Parents are anxious that children should be conversant with Mechanics, and with what are called the Mechanic Powers. Certainly no species of knowledge is better suited to the taste and capacity of youth, and yet it seldom forms a part of early instruction. Every body talks of the lever, the wedge, and the pulley, but most people perceive, that the notions which they have of their respective uses, are unsatisfactory, and indistinct; and many endeavour, at a late period of life, to acquire a scientific and exact knowledge of the effects that are produced by implements which are in every body's hands, or that are absolutely necessary in the daily occupations of mankind.

An itinerant lecturer seldom fails of having a numerous and attentive auditory; and if he does not communicate much of that knowledge which he endeavours to explain, it is not to be attributed either to his want of skill, or to the insufficiency of his apparatus, but to the novelty of the terms which he is obliged to use. Ignorance of the language in which any science is taught, is an insuperable bar to its being suddenly acquired; besides a precise knowledge of the meaning of terms, we must

have an instantaneous idea excited in our minds whenever they are repeated; and, as this can be acquired only by practice, it is impossible that philosophical lectures can be of much service to those who are not familiarly acquainted with the technical language in which they are delivered; and yet there is scarcely any subject of human inquiry more obvious to the understanding, than the laws of mechanics. Only a small portion of geometry is necessary to the learner, if he even wishes to become master of the more difficult problems which are usually contained in a course of lectures, and most of what is practically useful, may be acquired by any person who is expert in common arithmetic.

But we cannot proceed a single step without deviating from common language; if the theory of the balance, or the lever, is to be explained, we immediately speak of *space* and *time*. To persons not versed in literature, it is probable that these terms appear more simple and unintelligible than they do to a man who has read Locke, and other metaphysical writers. The term *space* to the bulk of mankind, conveys the idea of an interval; they consider the word *time* as representing a definite number of years, days, or minutes; but the metaphysician, when he hears the words *space* and *time*, immediately takes the alarm, and recurs to the abstract notions which are associated with these terms; he perceives difficulties unknown to the unlearned, and feels a confusion of ideas which distracts his attention. The lecturer proceeds with confidence, never supposing that his audience can be puzzled by such common terms. He means by *space*, the

distance from the place whence a body begins to fall, to the place where its motion ceases; and by time, he means the number of seconds, or of any determinate divisions of *civil* time which elapse from the commencement of any motion to its end; or, in other words, the duration of any given motion. After this has been frequently repeated, any intelligent person perceives the sense in which they are used by the tenour of the discourse; but in the interim, the greatest part of what he has heard, cannot have been understood, and the premises upon which every subsequent demonstration is founded, are unknown to him. If this be true, when it is affirmed of two terms only, what must be the situation of those to whom eight or ten unknown technical terms occur at the commencement of a lecture? A complete knowledge, such a knowledge as is not only full, but familiar, of all the common terms made use of in theoretic and practical mechanics, is, therefore, absolutely necessary before any person can attend public lectures in natural philosophy with advantage.

What has been said of public lectures, may, with equal propriety, be applied to private instruction; and it is probable, that inattention to this circumstance is the reason why so few people have distinct notions of natural philosophy. Learning by rote, or even reading repeatedly, definitions of the technical terms of any science, must undoubtedly facilitate its acquirement; but conversation, with the habit of explaining the meaning of words, and the structure of common domestic implements, to children, is the sure and effectual method of preparing the mind for the

acquirement of science.

The ancients, in learning this species of knowledge, had an advantage of which we are deprived: many of their terms of science were the common names of familiar objects. How few do we meet who have a distinct notion of the words radius, angle, or valve. A Roman peasant knew what a radius or a valve meant, in their original signification, as well as a modern professor; he knew that a valve was a door, and a radius a spoke of a wheel; but an English child finds it as difficult to remember the meaning of the word angle, as the word parabola. An angle is usually confounded, by those who are ignorant of geometry and mechanics, with the word triangle, and the long reasoning of many a laborious instructer has been confounded by this popular mistake. When a glass pump is shown to an admiring spectator, he is desired to watch the motion of the valves: he looks "above, about, and underneath;" but, ignorant of the word *valve*, he looks in vain. Had he been desired to look at the motion of the little doors that opened and shut, as the handle of the pump was moved up and down, he would have followed the lecturer with ease, and would have understood all his subsequent reasoning. If a child attempts to push any thing heavier than himself, his feet slide away from it, and the object can be moved only at intervals, and by sudden starts; but if he be desired to prop his feet against the wall, he finds it easy to push what before eluded his little strength. Here the use of a fulcrum, or fixed point, by means of which bodies may be moved, is distinctly understood. If two

boys lay a board across a narrow block of wood, or stone, and balance each other at the opposite ends of it, they acquire another idea of a centre of motion. If a poker is rested against a bar of a grate, and employed to lift up the coals, the same notion of a centre is recalled to their minds. If a boy, sitting upon a plank, a sofa, or form, be lifted up by another boy's applying his strength at one end of the seat, whilst the other end of the seat rests on the ground, it will be readily perceived by them, that the point of rest, or centre of motion, or fulcrum, is the ground, and that the fulcrum is not, as in the first instance, between the force that lifts, and the thing that is lifted; the fulcrum is at one end, the force which is exerted acts at the other end, and the weight is in the middle. In trying, these simple experiments, the terms *fulcrum*, *centre of motion*, &c. should be constantly employed, and in a very short time they would be as familiar to a boy of eight years old as to any philosopher. If for some years the same words frequently recur to him in the same sense, is it to be supposed that a lecture upon the balance and the lever would be as unintelligible to him as to persons of good abilities, who at a more advanced age hear these terms from the mouth of a lecturer? A boy in such circumstances would appear as if he had a genius for mechanics, when, perhaps, he might have less taste for the science, and less capacity, than the generality of the audience. Trifling as it may at first appear, it will not be found a trifling advantage, in the progress of education, to attend to this circumstance. A distinct knowledge of a few terms,

assists a learner in his first attempts; finding these successful, he advances with confidence, and acquires new ideas without difficulty or disgust. Rousseau, with his usual eloquence, has inculcated the necessity of annexing ideas to words; he declaims against the splendid ignorance of men who speak by rote, and who are rich in words amidst the most deplorable poverty of ideas. To store the memory of his pupil with images of things, he is willing to neglect, and leave to hazard, his acquirement of language. It requires no elaborate argument to prove that a boy, whose mind was stored with accurate images of external objects, of experimental knowledge, and who had acquired habitual dexterity, but who was unacquainted with the usual signs by which ideas are expressed, would be incapable of accurate reasoning, or would, at best, reason only upon particulars. Without general terms, he could not abstract; he could not, until his vocabulary was enlarged, and familiar to him, reason upon general topics, or draw conclusions from general principles: in short, he would be in the situation of those who, in the solution of difficult and complicated questions relative to quantity, are obliged to employ tedious and perplexed calculations, instead of the clear and comprehensive methods that unfold themselves by the use of signs in algebra.

It is not necessary, in teaching children the technical language of any art or science, that we should pursue the same order that is requisite in teaching the science itself. Order is required in reasoning, because all reasoning is employed in deducing

propositions from one another in a regular series; but where terms are employed merely as names, this order may be dispensed with. It is, however, of great consequence to seize the proper time for introducing a new term; a moment when attention is awake, and when accident has produced some particular interest in the object. In every family, opportunities of this sort occur without any preparation, and such opportunities are far preferable to a formal lecture and a splendid apparatus for the first lessons in natural philosophy and chemistry. If the pump belonging to the house is out of order, and the pump-maker is set to work, an excellent opportunity presents itself for variety of instruction. The centre pin of the handle is taken out, and a long rod is drawn up by degrees, at the end of which a round piece of wood is seen partly covered with leather. Your pupil immediately asks the name of it, and the pump-maker prevents your answer, by informing little master that it is called a sucker. You show it to the child, he handles it, feels whether the leather is hard or soft, and at length discovers that there is a hole through it which is covered with a little flap or door. This, he learns from the workmen, is called a clack. The child should now be permitted to plunge *the piston* (by which name it should *now* be called) into a tub of water; in drawing it backwards and forwards, he will perceive that the clack, which should now be called the valve, opens and shuts as the piston is drawn backwards and forwards. It will be better not to inform the child how this mechanism is employed in the pump. If the names sucker and piston, clack and

valve, are fixed in his memory, it will be sufficient for his first lesson. At another opportunity, he should be present when the fixed or lower valve of the pump is drawn up; he will examine it, and find that it is similar to the valve of the piston; if he sees it put down into the pump, and sees the piston put into its place, and set to work, the names that he has learned will be fixed more deeply in his mind, and he will have some general notion of the whole apparatus. From time to time these names should be recalled to his memory on suitable occasions, but he should not be asked to repeat them by rote. What has been said, is not intended as a lesson for a child in mechanics, but as a sketch of a method of teaching which has been employed with success.

Whatever repairs are carried on in a house, children should be permitted to see: whilst every body about them seems interested, they become attentive from sympathy; and whenever action accompanies instruction, it is sure to make an impression. If a lock is out of order, when it is taken off, show it to your pupil; point out some of its principal parts, and name them; then put it into the hands of a child, and let him manage it as he pleases. Locks are full of oil, and black with dust and iron; but if children have been taught habits of neatness, they may be clock-makers and white-smiths, without spoiling their clothes, or the furniture of a house. Upon every occasion of this sort, technical terms should be made familiar; they are of great use in the every-day business of life, and are peculiarly serviceable in giving orders to workmen, who, when they are spoken to in a language that they

are used to, comprehend what is said to them, and work with alacrity.

An early use of a rule and pencil, and easy access to prints of machines, of architecture, and of the implements of trades, are of obvious use in this part of education. The machines published by the Society of Arts in London; the prints in Desaguliers, Emerson, le Spectacle de la Nature, Machines approuvées par l'Académie, Chambers's Dictionary, Berthoud sur l'Horlogerie, Dictionaire des Arts et des Métiers, may, in succession, be put into the hands of children. The most simple should be first selected, and the pupils should be accustomed to attend minutely to one print before another is given to them. A proper person should carefully point out and explain to them the first prints that they examine; they may afterwards be left to themselves.

To understand prints of machines, a previous knowledge of what is meant by an elevation, a profile, a section, a perspective view, and a (vue d'oiseau) bird's eye view, is necessary. To obtain distinct ideas of sections, a few models of common furniture, as chests of drawers, bellows, grates, &c. may be provided, and may be cut asunder in different directions. Children easily comprehend this part of drawing, and its uses, which may be pointed out in books of architecture; its application to the common business of life, is so various and immediate, as to fix it for ever in the memory; besides, the habit of abstraction, which is acquired by drawing the sections of complicated architecture or machinery, is highly advantageous to the mind. The parts which

we wish to express, are concealed, and are suggested partly by the elevation or profile of the figure, and partly by the connection between the end proposed in the construction of the building, machine, &c. and the means which are adapted to effect it.

A knowledge of perspective, is to be acquired by an operation of the mind directly opposite to what is necessary in delineating the sections of bodies; the mind must here be intent only upon the objects that are delineated upon the retina, exactly what we see; it must forget or suspend the knowledge which it has acquired from experience, and must see with the eye of childhood, no further than the surface. Every person, who is accustomed to drawing in perspective, sees external nature, when he pleases, merely as a picture: this habit contributes much to form a taste for the fine arts; it may, however, be carried to excess. There are improvers who prefer the most dreary ruin to an elegant and convenient mansion, and who prefer a blasted stump to the glorious foliage of the oak.

Perspective is not, however, recommended merely as a means of improving the taste, but as it is useful in facilitating the knowledge of mechanics. When once children are familiarly acquainted with perspective, and with the representations of machines by elevations, sections, &c. prints will supply them with an extensive variety of information; and when they see real machines, their structure and uses will be easily comprehended. The noise, the seeming confusion, and the size of several machines, make it difficult to comprehend and combine their

various parts, without much time, and repeated examination; the reduced size of prints lays the whole at once before the eye, and tends to facilitate not only comprehension, but contrivance. Whoever can delineate progressively as he invents, saves much labour, much time, and the hazard of confusion. Various contrivances have been employed to facilitate drawing in perspective, as may be seen in "Cabinet de Servier, Memoires of the French Academy, Philosophical Transactions, and lately in the Repertory of Arts." The following is simple, cheap, and *portable*.

PLATE 1. FIG. 1

A B C, three mahogany boards, two, four, and six inches long, and of the same breadth respectively, so as to double in the manner represented.

PLATE 1. FIG. 2

The part A is screwed, or *clamped* to a table of a convenient height, and a sheet of paper, one edge of which is put under the piece A, will be held fast to the table.

The index P is to be set (at pleasure) with it sharp point to any part of an object which the eye sees through E, the eye-piece.

The machine is now to be doubled as in Fig. 2, taking care

that the index be not disturbed; the point, which was before perpendicular, will then approach the paper horizontally, and the place to which it points on the paper, must be marked with a pencil. The machine must be again unfolded, and another point of the object is to be ascertained in the same manner as before; the space between these points may be then connected with a line; fresh points should then be taken, marked with a pencil, and connected with a line; and so on successively, until the whole object is delineated.

Besides the common terms of art, the technical terms of science should, by degrees, be rendered familiar to our pupils. Amongst these the words Space and Time occur, as we have observed, the soonest, and are of the greatest importance. Without exact definitions, or abstract reasonings, a general notion of the use of these terms may be inculcated by employing them frequently in conversation, and by applying them to things and circumstances which occur without preparation, and about which children are interested, or occupied. "There is a great space left between the words in that printing." The child understands, that *space* in this sentence means white paper between black letters. "You should leave a greater space between the flowers which you are planting" – he knows that you mean more *ground*. "There is a great space between that boat and the ship" – space of water. "I hope the hawk will not be able to catch that pigeon, there is a great space between them" – space of air. "The men who are pulling that sack of corn into the granary,

have raised it through half the space between the door and the ground." A child cannot be at any loss for the meaning of the word space in these or any other practical examples which may occur; but he should also be used to the word space as a technical expression, and then he will not be confused or stopped by a new term when employed in mechanics.

The word *time* may be used in the same manner upon numberless occasions to express the duration of any movement which is performed by the force of men, or horses, wind, water, or any mechanical power.

"Did the horses in the mill we saw yesterday, go as fast as the horses which are drawing the chaise?" "No, not as fast as the horses go at present on level ground; but they went as fast as the chaise-horses do when they go up hill, or as fast as horses draw a waggon."

"How many times do the sails of that wind-mill go round in a minute? Let us count; I will look at my watch; do you count how often the sails go round; wait until that broken arm is uppermost, and when you say *now*, I will begin to count the *time*; when a minute has past, I will tell you."

After a few trials, this experiment will become easy to a child of eight or nine years old; he may sometimes attend to the watch, and at other times count the turns of the sails; he may easily be made to apply this to a horse-mill, or to a water-mill, a corn-fan, or any machine that has a rotatory motion; he will be entertained with his new employment; he will compare the

velocities of different machines; the meaning of this word will be easily added to his vocabulary.

"Does that part of the arms of the wind-mill which is near the *axle-tree*, or *centre*, I mean that part which has no cloth or sail upon it, go as fast as the ends of the arms that are the farthest from the centre?"

"No, not near so fast."

"But that part goes as often round in a minute as the rest of the sail."

"Yes, but it does not go as fast."

"How so?"

"It does not go so *far* round."

"No, it does not. The *extremities* of the *sails go through more space in the same time* than the part near the centre."

By conversations like these, the technical meaning of the word *velocity* may be made quite familiar to a child much younger than what has been mentioned; he may not only comprehend that velocity means time and space considered together, but if he is sufficiently advanced in arithmetic, he may be readily taught how to express and compare in numbers *velocities* composed of certain portions of time and space. He will not inquire about the abstract meaning of the word *space*; he has seen space measured on paper, on timber, on the water, in the air, and he perceives distinctly that it is a term equally applicable to all distances that can exist between objects of any sort, or that he can see, feel, or imagine.

Momentum, a less common word, the meaning of which is not quite so easy to convey to a child, may, by degrees, be explained to him: at every instant he feels the effect of momentum in his own motions, and in the motions of every thing that strikes against him; his feelings and experience require only proper terms to become the subject of his conversation. When he begins to inquire, it is the proper time to instruct him. For instance, a boy of ten years old, who had acquired the meaning of some other terms in science, this morning asked the meaning of the word momentum; he was desired to explain what he thought it meant.

He answered, "Force."

"What do you mean by force?"

"Effort."

"Of what?"

"Of gravity."

"Do you mean that force by which a body is drawn down to the earth?"

"No."

"Would a feather, if it were moving with the greatest conceivable swiftness or velocity, throw down a castle?"

"No."[21]

"Would a mountain torn up by the roots, as fabled in Milton, if it moved with the least conceivable velocity, throw down a

[21] When this question was sometime afterwards repeated to S – , he observed, that the feather would throw down the castle, if its swiftness were so great as to make up for its want of weight.

castle?"

"Yes, I think it would."

The difference between an uniform, and an uniformly accelerated motion, the measure of the velocity of falling bodies, the composition of motions communicated to the same body in different directions at the same time, and the cause of the curvilinear track of projectiles, seem, at first, intricate subjects, and above the capacity of boys of ten or twelve years old; but by short and well-timed lessons, they may be explained without confounding or fatiguing their attention. We tried another experiment whilst this chapter was writing, to determine whether we had asserted too much upon this subject. After a conversation between two boys upon the descent of bodies towards the earth, and upon the measure of the increasing velocity with which they fall, they were desired, with a view to ascertain whether they understood what was said, to invent a machine which should show the difference between an uniform and an accelerated velocity, and in particular to show, by occular demonstration, "that if one body moves in a given time through a given space, with an uniform motion, and if another body moves through the same space in the same time with an uniformly accelerated motion, the uniform motion of the one will be equal to half the accelerated motion of the other." The eldest boy, H – , thirteen years old, invented and executed the following machine for this purpose:

Plate I, Fig. 3. *b* is a bracket 9 inches by 5, consisting of a back

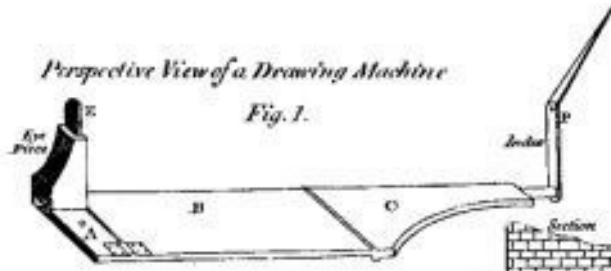
and two sides of hard wood: two inches from the back two slits are made in the sides of the bracket half an inch deep, and an eighth of an inch wide, to receive the two wire pivots of a roller; which roller is composed of a cylinder, three inches long and half an inch diameter; and a cone three inches long and one inch diameter in its largest part or base. The cylinder and cone are not separate, but are turned out of one piece; a string is fastened to the cone at its base *a*, with a bullet or any other small weight at the other end of it; and another string and weight are fastened to the cylinder at *c*; the pivot *p* of wire is bent into the form of a handle; if the handle is turned either way, the strings will be respectively wound up upon the cone and cylinder; their lengths should now be adjusted, so that when the string on the cone is wound up as far as the cone will permit, the two weights may be at an equal distance from the bottom of the bracket, which bottom we suppose to be parallel with the pivots; the bracket should now be fastened against a wall, at such a height as to let the weights lightly touch the floor when the strings are unwound: silk or *bobbin* is a proper kind of string for this purpose, as it is woven or plaited, and therefore is not liable to twist. When the strings are wound up to their greatest heights, if the handle be suddenly let go, both the weights will begin to fall at the same moment; but the weight 1, will descend at first but slowly, and will pass through but small space compared with the weight 2. As they descend further, No. 2 still continues to get before No. 1; but after some time, No. 1 begins to overtake No. 2, and at last they come to the ground

together. If this machine is required to show exactly the space that a falling body would describe in given times, the cone and cylinder must have grooves cut spirally upon their circumference, to direct the string with precision. To describe these spiral lines, became a new subject of inquiry. The young mechanics were again eager to exert their powers of invention; the eldest invented a machine upon the same principle as that which is used by the best workmen for cutting clock fusees; and it is described in Berthoud. The youngest invented the engine delineated, Plate 1, Fig. 4.

The roller or cone (or both together) which it is required to cut spirally, must be furnished with a handle, and a toothed wheel *w*, which turns a smaller wheel or pinion *w*. This pinion carries with it a screw *s*, which draws forward the puppet *p*, in which the graver of chisel *g* slides *without shake*. This graver has a point or edge shaped properly to form the spiral groove, with a shoulder to regulate the depth of the groove. The iron rod *r*, which is firmly fastened in the puppet, slides through mortices at *mm*, and guides the puppet in a straight line.

Perspective View of a Drawing Machine

Fig. 1.



Section of a Drawing Machine

Fig 2.

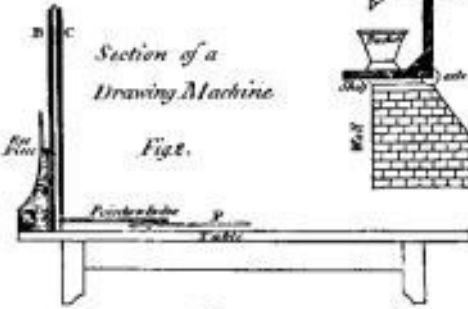
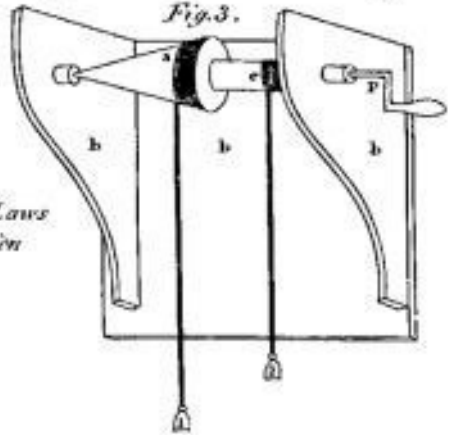


Fig. 3.



Machine for shewing the Laws of accelerated Motion

The rest of the machine is intelligible from the drawing.

A simple method of showing the nature of compound forces was thought of at the same time. An ivory ball was placed at the corner of a board sixteen inches broad, and two feet long; two other similar balls were let fall down inclined troughs against the first ball in different directions, but at the same time. One fell in a direction parallel to the length of the board; the other ball fell back in a direction parallel to its breadth. By raising the troughs, such a force was communicated to each of the falling balls, as was sufficient to drive the ball that was at rest to that side or end of the board which was opposite, or at right angles, to the line of its motion.

When both balls were let fall together, they drove the ball that was at rest diagonally, so as to reach the opposite corner. If the same board were placed as an inclined plane, at an angle of five or six degrees, a ball placed at one of its uppermost corners, would fall with an accelerated motion in a direct line; but if another ball were made (by descending through an inclined trough) to strike the first ball at right angles to the line of its former descent, at the moment when it began to descend, it would not, as in the former experiment, move diagonally, but would describe a curve.

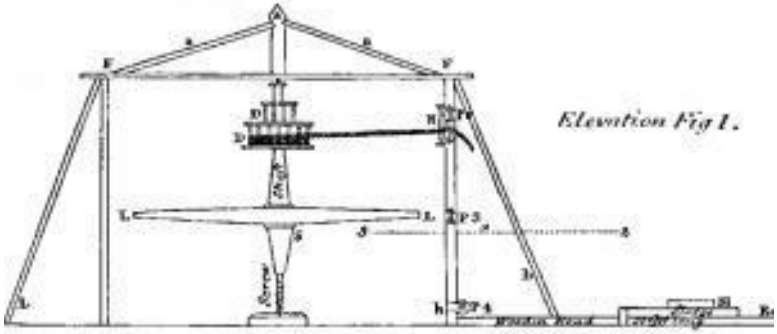
The reason why it describes a curve, and why that curve is not circular, was easily understood. Children who are thus induced to

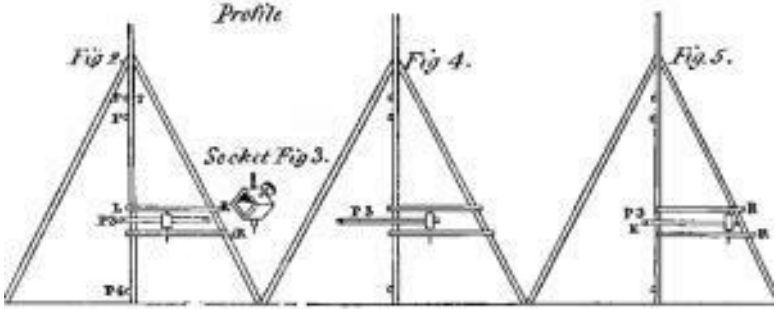
invent machines or apparatus for explaining and demonstrating the laws of mechanism, not only fix indelibly those laws in their own minds, but enlarge their powers of invention, and preserve a certain originality of thought, which leads to new discoveries.

We therefore strongly recommend it to teachers, to use as few precepts as possible in the rudiments of science, and to encourage their pupils to use their own understandings as they advance. In mechanism, a general view of the powers and uses of engines is all that need be taught; where more is necessary, such a foundation, with the assistance of good books, and the examination of good machinery, will perfect the knowledge of theory and facilitate practice.

At first we should not encumber our pupils with accurate demonstration. The application of mathematics to mechanics is undoubtedly of the highest use, and has opened a source of ingenious and important inquiry. Archimedes, the greatest name amongst mechanic philosophers, scorned the mere practical application of his sublime discoveries, and at the moment when the most stupendous effects were producing by his engines, he was so deeply absorbed in abstract speculation as to be insensible to the fear of death. We do not mean, therefore, to undervalue either the application of strict demonstration to problems in mechanics, or the exhibition of the most accurate machinery in philosophical lectures; but we wish to point out a method of giving a general notion of the mechanical organs to our pupils, which shall be immediately obvious to their comprehension, and

which may serve as a sure foundation for future improvement. We are told by a vulgar proverb, that though we believe what we see, we have yet a higher belief in what we *feel*. This adage is particularly applicable to mechanics. When a person perceives the effect of his own bodily exertions with different engines, and when he can compare in a rough manner their relative advantages, he is not disposed to reject their assistance, or expect more than is reasonable from their application. The young theorist in mechanics thinks he can produce a perpetual motion! When he has been accustomed to refer to the plain dictates of common sense and experience, on this, as well as on every other subject, he will not easily be led astray by visionary theories.


Elevation Fig 1.


Profile
Fig 2
Socket Fig 3.
Fig 4.
Fig 5.

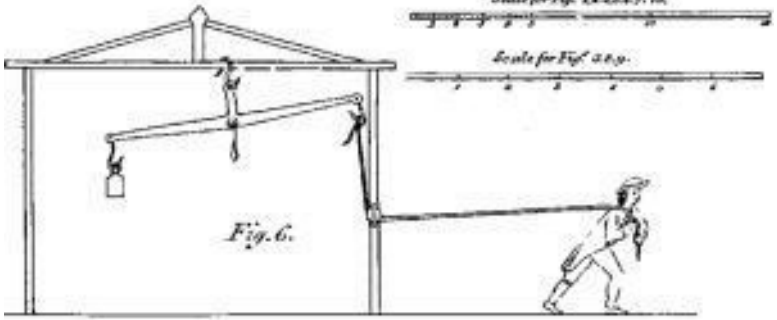


Fig. 6.

Plate 2.

To bring the sense of feeling to our assistance in teaching the uses of the mechanic powers, the following apparatus was constructed, to which we have given the name Panorganon.

It is composed of two principal parts: a frame to contain the moving machinery; and a *capstan* or *windlass*, which is erected on a *sill* or plank, that is sunk a few inches into the ground: the frame is by this means, and by six braces or props, rendered steady. The cross rail, or *transom*, is strengthened by braces and a king-post to make it lighter and cheaper. The *capstan* consists of an upright shaft, upon which are fixed two *drums*; about which a rope may be wound up, and two levers or arms by which it may be turned round. There is also a screw of iron coiled round the lower part of the shaft, to show the properties of the screw as a mechanic power. The rope which goes round the *drum* passes over one of the pulleys near to the top of the frame, and under another pulley near the bottom of the frame. As two *drums* of different sizes are employed, it is necessary to have an upright roller to conduct the rope in a proper direction to the pulleys, when either of the *drums* is used. Near the frame, and in the direction in which the rope runs, is laid a platform or road of deal boards, one board in breadth, and twenty or thirty feet long, upon which a small sledge loaded with different weights may be drawn. Plate 2. Fig. 1.

F. F. The frame.

b. b. Braces to keep the frame steady.

a. a. a. Angular braces to strengthen the transom; and also a *king-post.*

S. A round, taper shaft, strengthened above and below the mortises with iron hoops.

L L. Two arms, or levers, by which the shaft, &c. are to be moved round.

D D. The drum, which has two rims of different circumferences.

R. The roller to conduct the rope.

P. The pulley, round which the rope passes to the larger drum.

P 2. Another pulley to answer to the smaller drum.

P 3. A pulley through which the rope passes when experiments are tried with levers, &c.

P 4. Another pulley through which the rope passes when the sledge is used.

Ro. The road of deal boards for the sledge to move on.

Sl. The sledge, with pieces of hard wood attached to it, to guide it on the road.

Uses of the Panorganon

As this machine is to be moved by the force of men or children, and as their force varies not only with the strength and weight of each individual, but also according to the different manner in which that strength or weight is applied; it is, in

the first place, requisite to establish one determinate mode of applying human force to the machine; and also a method of determining the relative force of each individual whose strength is applied to it.

To estimate the force with which a person can draw horizontally by a rope over his shoulder

EXPERIMENT I

Hang a common long scale-beam (without scales or chains) from the top or *transom* of the frame, so as that one end of it may come within an inch of one side or post of the machine. Tie a rope to the hook of the scale-beam, where the chains of the scale are usually hung, and pass it through the pulley P 3, which is about four feet from the ground; let the person pull this rope from 1 towards 2, turning his back to the machine, and pulling the rope over his shoulder – Pl. 2. Fig. 6. As the pulley may be either too high or too low to permit the rope to be horizontal, the person who pulls it should be placed ten or fifteen feet from the machine, which will lessen the angular direction of the cord, and the inaccuracy of the experiment. Hang weights to the other end of the scale-beam, until the person who pulls can but just walk forward, pulling fairly without propping his feet against any

thing. This weight will estimate the force with which he can draw horizontally by a rope over his shoulder.[22] Let a child who tries this, walk on the board with dry shoes; let him afterwards chalk his shoes, and afterwards try it with his shoes soaped: he will find that he can pull with different degrees of force in these different circumstances; but when he tries the following experiments, let his shoes be always dry, that his force may be always the same.

To show the power of the three different sorts of levers

EXPERIMENT II

Instead of putting the cord that comes from the scale-beam, as in the last experiment, over the shoulder of the boy, hook it to the end 1 of the lever L, Fig. 2. Plate 2. This lever is passed through a socket – Plate 2. Fig. 3. – in which it can be shifted from one of its ends towards the other, and can be fastened at any place by the screw of the socket. This socket has two gudgeons, upon which it, and the lever which it contains, can turn. This socket and its

[22] Were it thought necessary to make these experiments perfectly accurate, a segment of a pulley, the radius of which is half the length of the scale-beam, should be attached to the end of the beam; upon which the cord may apply itself, and the pulley (P 3) should be raised or lowered, to bring the rope horizontally from the man's shoulder when in the attitude of drawing.

gudgeons can be lifted out of the holes in which it plays, between the rail R R, Plate 2. Fig. 2. and may be put into other holes at R R, Fig. 5. Loop another rope to the other end of this lever, and let the boy pull as before. Perhaps it should be pointed out, that the boy must walk in a direction contrary to that in which he walked before, viz. from 1 towards 3. The height to which the weight ascends, and the distance to which the boy advances, should be carefully marked and measured; and it will be found, that he can raise the weight to the same height, advancing through the same space as in the former experiment. In this case, as both ends of the lever moved through equal spaces, the lever only changed the direction of the motion, and added no mechanical power to the direct strength of the boy.

EXPERIMENT III

Shift the lever to its extremity in the *socket*; the middle of the lever will be now opposite to the pulley, Pl. 2. Fig. 4. – hook to it the rope that goes through the pulley P 3, and fasten to the other end of the lever the rope by which the boy is to pull. This will be *a lever of the second kind*, as it is called in books of mechanics; in using which, *the resistance is placed between the centre of motion or fulcrum, and the moving power*. He will now raise double the weight that he did in Experiment II, and he will advance through double the space.

EXPERIMENT IV

Shift the lever, and the socket which forms the axis (without shifting the lever from the place in which it was in the socket in the last experiment) to the holes that are prepared for it at R R, Plate 2. Fig. 5. The free end of the lever E will now be opposite to the rope, and to the pulley (over which the rope comes from the scale-beam.) Hook this rope to it, and hook the rope by which the boy pulls, to the middle of the lever. The effect will now be different from what it was in the two last experiments; the boy will advance only half as far, and will raise only half as much weight as before. This is called *a lever of the third sort.* The first and second kinds of levers are used in quarrying; and the operations of many tools may be referred to them. The third kind of lever is employed but seldom, but its properties may be observed with advantage whilst a long ladder is raised, as the man who raises it, is obliged to exert an increasing force until the ladder is nearly perpendicular. When this lever is used, it is obvious, from what has been said, that the power must always pass through less space than the thing which is to be moved; it can never, therefore, be of service in gaining power. But the object of some machines, is to increase velocity, instead of obtaining power, as in a sledge-hammer moved by mill-work. (V. the plates in Emerson's Mechanics, No. 236.)

The experiments upon levers may be varied at pleasure,

increasing or diminishing the mechanical advantage, so as to balance the power and the resistance, to accustom the learners to calculate the relation between the power and the effect in different circumstances; always pointing out, that whatever excess there is in the power,[23] or in the resistance, is always compensated by the difference of space through which the inferiour passes.

The experiments which we have mentioned, are sufficiently satisfactory to a pupil, as to the immediate relation between the power and the resistance; but the different spaces through which the power and the resistance move when one exceeds the other, cannot be obvious, without they pass through much larger spaces than levers will permit.

EXPERIMENT V

Place the sledge on the farthest end of the wooden road – Plate 2. Fig. 1. – fasten a rope to the sledge, and conduct it through the lowest pulley P 4, and through the pulley P 3, so as that the boy may be enabled to draw it by the rope passed over his shoulder. The sledge must now be loaded, until the boy can but just advance with short steps steadily upon the wooden road; this must be done with care, as there will be but just room for him beside the rope. He will meet the sledge exactly on the middle of

[23] The word *power* is here used in a popular sense, to denote the strength or efficacy that is employed to produce an effect by means of any engine.

the road, from which he must step aside to pass the sledge. Let the time of this experiment be noted. It is obvious that the boy and the sledge move with equal velocity; there is, therefore, no mechanical advantage obtained by the pulleys. The weight that he can draw will be about half a hundred, if he weigh about nine stone; but the exact force with which the boy draws, is to be known by Experiment I.

The wheel and axle

This organ is usually called in mechanics, *The axis in peritrochio*. A *hard* name, which might well be spared, as the word windlass or capstan would convey a more distinct idea to our pupils.

EXPERIMENT VI

To the largest drum, Plate 2. Fig. 1. fasten a cord, and pass it through the pulley P downwards, and through the pulley P 4 to the sledge placed at the end of the wooden road, which is farthest from the machine. Let the boy, by a rope fastened to the extremity of one of the arms of the capstan, and passed over his shoulder, draw the capstan round; he will wind the rope round the drum, and draw the sledge upon its road. To make the sledge advance twenty-four feet upon its road, the boy must have walked

circularly 144 feet, which is six times as far, and he will be able to draw about three hundred weight, which is six times as much as in the last experiment.

It may now be pointed out, that the difference of space, passed through by the power in this experiment, is exactly equal to the difference of weight, which the boy could draw without the capstan.

EXPERIMENT VII

Let the rope be now attached to the smaller drum; the boy will draw nearly twice as much weight upon the sledge as before, and will go through double the space.

EXPERIMENT VIII

Where there are a number of boys, let five or six of them, whose power of drawing (estimated as in Experiment I) amounts to six times as much as the force of the boy at the capstan, pull at the end of the rope which *was* fastened to the sledge; they will balance the force of the boy at the capstan: either they, or he, by a sudden pull, may advance, but if they pull fairly, there will be no advantage on either part. In this experiment, the rope should pass through the pulley P 3, and should be coiled round the larger drum. And it must be also observed, that in all experiments upon

the motion of bodies, in which there is much friction, as where a sledge is employed, the results are never so uniform as in other circumstances.

The Pulley

Upon the pulley we shall say little, as it is in every body's hands, and experiments may be tried upon it without any particular apparatus. It should, however, be distinctly inculcated, that the power is not increased by a fixed pulley. For this purpose, a wheel without a rim, or, to speak with more propriety, a number of spokes fixed in a nave, should be employed. (Plate 2. Fig. 9.) Pieces like the heads of crutches should be fixed at the ends of these spokes, to receive a piece of girth-web, which is used instead of a cord, because a cord would be unsteady; and a strap of iron with a hook to it should play upon the centre, by which it may at times be suspended, and from which at other times a weight may be hung.

EXPERIMENT IX

Let the skeleton of a pulley be hung by the iron strap from the transom of the frame; fasten a piece of web to one of the radii, and another to the end of the opposite radius. If two boys of equal weight pull these pieces of girth-web, they will

balance each other; or two equal weights hung to these webs, will be in equilibrio. If a piece of girth-web be put round the uppermost radius, two equal weights hung at the ends of it will remain immoveable; but if either of them be pulled, or if a small additional weight be added to either of them, it will descend, and the web will apply itself successively to the ascending radii, and will detach itself from those that are descending. If this movement be carefully considered, it will be perceived, that the web, in unfolding itself, acts in the same manner upon the radii as two ropes would if they were hung to the extremities of the opposite radii in succession. The two radii which are opposite, may be considered as a lever of the first sort, where the centre is in the middle of the lever; as each end moves through an equal space, there is no mechanical advantage. But if this skeleton-pulley be employed as a common *block* or *tackle*, its motions and properties will be entirely different.

EXPERIMENT X. PLATE 2. FIG. 9

Nail a piece of girth-web to a post, at the distance of three or four feet from the ground; fasten the other end of it to one of the radii. Fasten another piece of web to the opposite radius, and let a boy hold the skeleton-pulley suspended by the web; hook weights to the strap that hangs from the centre. The end of the radius to which the fixed girth-web is fastened, will remain immoveable; but, if the boy pulls the web which he holds in his hand upwards,

he will be able to lift nearly double the weight, which he can raise from the ground by a simple rope, without the machine, and he will perceive that his hand moves through twice as great a space as the weight ascends: he has, therefore, the mechanical advantage which he would have by a lever of the second sort, as in Experiment iii. Let a piece of web be put round the under radii, let one end of it be nailed to the post, and the other be held by the boy, and it will represent the application of a rope to a moveable pulley; if its motion be carefully considered, it will appear that the radii, as they successively apply themselves to the web, represent a series of levers of the second kind. A pulley is nothing more than an infinite number of such levers; the cord at one end of the diameter serving as a fulcrum for the *organ* during its progress. If this *skeleton-pulley* be used horizontally, instead of perpendicularly, the circumstances which have been mentioned, will appear more obvious.

Upon the wooden road lay down a piece of girth-web; nail one end of it to the road; place the pulley upon the web at the other end of the board, and, bringing the web over the radii, let the boy, taking hold of it, draw the loaded sledge fastened to the hook at the centre of the pulley: he will draw nearly twice as much in this manner as he could without the pulley.[24]

Here the web lying on the road, shows more distinctly, that it

[24] In all these experiments with the skeleton-pulley, somebody must keep it in its proper direction; as from its structure, which is contrived for illustration, not for practical use, it cannot retain its proper situation without assistance.

is quiescent where the lowest radius touches it; and if the radii, as they tread upon it, are observed, their points will appear at rest, whilst the centre of the pulley will go as fast as the sledge, and the top of each radius successively (and the boy's hand which unfolds the web) will move twice as fast as the centre of the pulley and the sledge.

If a person, holding a stick in his hand, observes the relative motions of the top, and the middle, and the bottom of the stick, whilst he inclines it, he will see that the bottom of the stick has no motion on the ground, and that the middle has only half the motion of the top. This property of the pulley has been dwelt upon, because it elucidates the motion of a wheel rolling upon the ground; and it explains a common paradox, which appears at first inexplicable. "The bottom of a rolling wheel never moves *upon* the road." This is asserted only of a wheel moving over hard ground, which, in fact, may be considered rather as laying down its circumference upon the road, than as moving upon it.

The inclined Plane and the Wedge

The *inclined plane* is to be next considered. When a heavy body is to be raised, it is often convenient to lay a sloping artificial road of planks, up which it may be pushed or drawn. This mechanical power, however, is but of little service without the assistance of wheels or rollers; we shall, therefore, speak of it as it is applied in another manner, under the name of *the wedge*,

which is, in fact, a moving inclined plane; but if it is required to explain the properties of the inclined plane by the panorganon, the wooden road may be raised and set to any inclination that is required, and the sledge may be drawn upon it as in the former experiments.

Let one end of a lever, N. Plate 2. Fig. 7. with a wheel at one end of it, be hinged to the post of the frame, by means of a gudgeon driven or screwed into the post. To prevent this lever from deviating sideways, let a slip of wood be connected with it by a nail, which shall be fast in the lever, but which moves freely in a hole in the rail. The other end of this slip must be fastened to a stake driven into the ground at three or four feet from the lever, at one side of it, and towards the end in which the wheel is fixed (Plate 2. Fig 10. which is a *vue d'oiseau*) in the same manner as the treadle of a common lathe is managed, and as the treadle of a loom is sometimes guided.[25]

[25] In a loom this secondary lever is called *a lamb*, by mistake, for *lam*; from *lamina*, a slip of wood.

Конец ознакомительного фрагмента.