EXTRACT OF MR DUTENS INQUIRY INTO THE ORIGIN OF THE DISCOVERIES ATTRIBUTED TO THE MODERNS

by Louis Dutens

An inquiry by Louis Dutens into the true origins of discoveries commonly attributed to modern thinkers, arguing that many scientific and philosophical advances were actually known to the ancients. A fascinating study in the history of ideas.

23 Chapters

Table of Contents

0.2 - Introduction

Introduction

Having, by reason of the largeness of the preceding volumes, which contain much more than I expected, some pages to spare, I am well pleased with an opportunity of inserting here another extract from one of the most ingenious treatises, which, I believe, was ever wrote upon the subject: Mr. Deutens' "Inquiry into the Origin of the Discoveries attributed to the Moderns." I am surprised that I never heard of it till very lately; and I have met with exceeding few that have: although the Latin original I suppose, for i have not seen it) has been published good part of twenty years, and the elegant and judicious translation of it was printed eight or nine years ago. It is true, I am hereby convinced of several mistakes, which I bad been in for many years. But I look upon every such conviction as a valuable acquisition. And I trust, my heart will always say both to God and man," What I know not, teach thou me."

0.4 - The Authors Preface

The Author’s Preface Extract of Mr. Duten’s Inquiry Into the Origin of the Discoveries Attributed to the Moderns IN the comparison between the moderns and ancients, a distinction ought to be made between the arts and sciences, which require long experience and practice to bring them to perfection, and those which depend solely on talent and genius. Without doubt, the former in so long a series of ages, have been extended more and more, and brought to a very high degree of perfection by the moderns, who in this respect surpass the ancients, though the art of printing, and many other discoveries, have not a little contributed to it. We know the astronomers in our days understand much better the nature of the stars, and the whole planetary system, than Hipparchus, Ptolemy, or any other of the ancients. But it may be doubted whether they’ had gone so far unaided by telescopes. The modems have certainly perfected the art of navigation; nay, and discovered new worlds: but yet without the assistance of’ the compass, America, In all probability had still remained unknown. Likewise by long observation and experiments often repeated, we have brought the arts of botany, anatomy, and chirurgery, to the degree of perfection we know behold them in. Many secrets of nature, not to be penetrated in one age, have been laid open in a succession of many. Morality itself hath been perfected by the Christian religion; philosophy hath assumed a new air; and the trifling, childish, and vain cavils of the schools, have at length been put to flight by the reiterated efforts of Ramus, Bacon, Newton, and many others.

I willingly therefore give up to the partisans of the moderns, every advantage I have here enumerated ; but there is no need on that account, to rob the ancients of the share they have had in promoting all these parts of knowledge, by the pains they took to beat out for us the tracks we have pursued. Much less should we assume, as modern discoveries, what the ancients really invented, or illustrated. It also deserves notice, that the most part of the admirable and useful inventions, in which our age glories, such as printing, gunpowder, the compass, telescopes, &c. were not the acquisitions of genius and philosophy. but mere effects of chance. To place in its true light the share the ancients have in whatever we pretend to know, and even in what has been called modern discoveries, is the principal aim of my present undertaking.

Chapter 01 - Of the Circulation of the Blood, and the Fallopian Tubes

Chapter 1 - Of the Circulation of the Blood, and the Fallopian Tubes

1. THE medical art affords striking instances of the injustice done to the ancients, in endeavouring to deprive them of the glory of having made the most important discoveries in it. I shall- produce two or three manifest proofs of' this, dud doubt not but the reader will perceive not only probable hints, but demonstrate evidence, that the ancients clearly taught what we now dispute their having had any knowledge of.

2. It is remarkable with regard to medicine, that none of the siences sooner arrived at perfection; for in the space of two thousand years, elapsed since the time of hippocrates, there has scarcely been added a new aphorism to those of that great man, notwithstanding all the application of so many ingenious men, as have since studied that science.

3. I omit taking notice of some modern authors, who have endeavoured to prove, that the circulation of the blood was known to Solomon, that I may pass tc the more evident proofs of his discovery, which Hippocrates furnishes us with. After examining those passages, no one will deny but this able physician knew, what he expresses so clearly.

4. In truth, it is hard to conceive that he knew nothing of the circulation of the blood, when we hear him say, “That all the veins communicate one with the other, and run into one another: that the veins which spread themselves over the whole body, filling it with spirit, juice and motion, are all of them but branches of one original vein. I protest, I know not, says he, where it begins, or where it ends, for in a circle there is neither beginning nor ending.” A little further he says, “that the heart is the source of the arteries, which carry blood into all parts of the body, communicating to them life and beat; he adds, “that they ire the rivulets which cherish the human body, and convey life to every part of man.” in another part, he says, that the “heart and veins are always in motion.” He comrn pares the course of rivers, which return to their sources in an unaccountable and extraordinary manner, to the circulation of the blood. in apoplexies and such like disorders, which he ascribes to obstructions in the veins, he prescribes bleeding, in order to procure a free motion to the blood and spirits. He says also, “that when the bile enters into the blood, it breaks its consistence, and disorders its regular course. He compares its admirable mechanism to clews of thread, whose filaments overlap each other; and says, that in a body it performs just such a circuit, always terminating where it began."

5.The next to Hippocrates is Plato, who speaks with clearness of the circulation of the blood; (or from the heart, he says, spring the veins and blood, which with rapidity carries itself into all parts : adding, that when the blood thickens, it flows with more difficulty through the veins. Aristotle too, regards the heart as the origin and fountain of the veins and blood. He says, that from the heart there arise two veins, one on the right, and the other on the left side; and he was the first who called this aorta. He held that the arteries had a communication with the veins, and that they were intimately connected together.

6.Julius Pollox, in his “Onomasticon,” describing all the parts of the body, and their uses, among other things, says, in speaking of the arteries, that they are “the passages and canals of the spirits, as the veins are of the blood ;“ and in speaking of’ the heart, he says, that it: “hath two cavities, the one of which communicates with the arteries the other with the veins.” Apulelus, in explaining the doctrine -of-Plato, speaks likewise of the circulation of the blood, and in a few words describes it as clearly as any of the moderns. It is true, he does not expressly mention, that the blood flows from the heart through- the arteries : but on its leaving the heart, he supposes its course along the lungs, to spread itself afterward into all parts of the body.

7.Nemesius, bishop of Emissa, who may be accounted among the ancients, having lived in the fourth century, has a very clear passage to this purpose, wherein he says, “that the motion of the pulse owes: its origin to the heart, and particularly to the left ventricle of that viscus. The cardiac artery expands and contracts itself with very much force, but always with great regularity and harmony of motion. In its expansion it draws in the most subtle parts of the blood from the adjoining veins, and of that blood forms the aliment of the vital spirits : and in its contraction exhales all the fumes brought into it by secret passages from all parts of the body.”

8.It appears from what we have said, that the circulation of the blood was known to the ancients ; though they did not expatiate upon it: and what reduces to a very small degree the honour that Hervey can claim, in making that discovery, is that Servetus had treated of it very distinctly before him, in the fifth part of his book De Christianismi Restitutione ;“ a work so very scarce, that there are but few who can boast of having seen it in print. Mr. Wotton, in his reflections upon the ancients and moderns, cites this passage of Servetus in which he distinguishes three sorts of spirits of the human body, and says, that blood. “which he calls a vital spirit is dispersed through the body by the anastomosis, or mutual insertion of two vessels, at their extremities, into one another.” Where it deserves observation, that Servetus is the first who employed that term to express the communication between the veins and arteries. He makes the “expanded- air in the lungs contribute to the formation of blood, which comes to them from the right ventricle of the heart, by the canal of the pulmonary artery.

He says, that the blood is there refined and perfected, by the action of the air, which subtilizes it, and blends itself with that vital spirit, which the expanded heart then receives as a fluid pro. per to carry life every where. He maintains, that this conveyance and manner of preparing the blood in the lungs, is evident from the conjunction of the veins with the arteries in this viscus. And be concludes with saying, that the heart having received the blood thus prepare(l by the lungs, sends it forth again by the artery of its left yen. tricle, called the aorta, which distributes it into all parts of the body.” And reas Cesalpinus, who lived likewise in the sixteenth century, hath two passages which completely contain all that we know about the circulation of the blood. “He explains at length how the blood gushing from the right ventricle of the heart through the pulmonary artery, to pass into the lungs, enters by an anastomosis into the pulmonary veins to be conveyed to the left ventricle of the heart, and afterward distributed by the aorta into all parts of the body.”

9.Johannes Leonicenus, says, that the famous Paul Sarpi, otherwise named Father Paul, was he who discovered the circulation of the blood, and first discerned the valves of the veins, which like the suckers of a pump, open to let the blood pass, but shut to prevent its return; and that he communicated this secret to Fabricius ab Aquapendente, professor of medicine, at Padoua, in the

sixteenth century, and successor to Fallopius who discovered it to Hervey, at that time studying physic under him in the university of Padoua.

10. There is another important discovery in anatomy, attributed to Fallopius, which had a more ancient origin; I mean the two ducts which insert themselves into the sides of the womb, and serve to convey the seed or female sperm from the ovaries into the womb, and are called the Fallopian tubes, being shaped almost like a trumpet, and thought to have been discovered by Fallopius of Modena, who died in year 1562. We find them described as follows, by Rufus of Ephesus, “Herophilus,” says he, “imagined that females had no seminal ves sels; but in examining the womb of a beast, I found -arising from the ovaries certain ducts, which entwisted into each other, were entirely varicious, and at their farther extremity, entered into the cavity of the womb. Upon compressing them, there issued from them a glutinous humour, and I am firmly persuaded they are seminal vessels of the very same structure with those in males called the vericous arastata.”

Chapter 02 - Of the Chirurgery of the Ancients

Chapter 02 - Of the Chirurgery of the Ancients

1. AS to the subject of this chapter, I cannot entertain my reader better than by presenting him with an extract of Mr. Bernard’s thoughts upon it, who was first surgeon to king William. Here follows a faithful translation of a part of a memoir, which he imparted to his friend, air. Wotton.

“ If we attend well to what the moderns have added to the surgery of the ancients, we shall be obliged to own that we have not the least right to despise them, as those do who know nothing of them, nor have ever read them; and who give the strongest proofs of their own ignorance and pride, in the manner wherein they presume to treat those great men. I do not say, that the moderns have in no respect contributed to the advancement of surgery; but what I say is this, that the merit of the moderns consists rather in having re-introduced the inventions of the ancients, and set them in a better light, than in any important discoveries that they themselves have made in this science. Whether the art of curing wounds, falling immediately under the observation of sense, has for that reason been the study of men of the earliest times, and by that means sooner acquired a degree of perfection, than the other branches of medicine: or that the most part of those who afterward assumed the profession, were mere empirics, and ignorant of it: which ever of these be the case, it is certain this art has not for some ages past been cultivated, as it might have been: and to prove this, we need only to reflect how few the number of good writers are upon this subject, in comparison of those who have written upon other branches of the arts and sciences.

Whoever is conversant with the writings of the ancients, and has skill to judge of their merit in his own practice, will ingenuously own, that what renders the reading of them more useful than those of the moderns, is, that they are more exact in describing the symptoms and indications of disorders, and more just and precise than the moderns, in distinguishing the different species of ulcers and tumours. if our age has retrenched some superfluities of practice, as it must be owned it has, yet it cannot be shown that these methods came from the ancients. It is much more probable, that they were in a great measure introduced by the ignorant professors of a later date. There is no doubt but that the perfection to which surgery has been carried in these last ages, is principally owing to the discoveries which have been made in anatomy, by means of which we are enabled to give a reason for many of the phenomena, which were before inexplicable. But the most essential parts the art of curing wounds, to which all the other parts ought to give way, remains almost in the very same state, in which the ancients transmitted it to us.

What 1 have said is incontestible: and for proof of it, I appeal to every course of surgery that has been published by the most celebrated among the moderns, all of which appear to be but transcripts of one another, excepting those of greatest note, which are taken from the ancients. Among all the writers of systems, few deny the pre-eminence of Fabricius ab Aquapendente, a man of exquisite learning and judgment, but who is not ashamed to declare that Celsus, among the Latins, Paul Eginetus, among the Greeks, and Albucasis, among the Arabians, are those to whom he is most indebted in the composition of his excellent work. But it will be said, that a great

many methods of Operation are at present in use, which were unknown to the ancients. I fear, on the contrary, that an impartial examination into this would discover many more, and of greater utility, either omitted or discontinued, than of new, which we have introduced: provided their inquiry were entered upon with an impartial and unprejudiced mind,

3. “To begin with the operation for the stone, there is nobody doubts but they bare a right to claim that as their own. Celsus and many others have given us exact descriptions of it ; though it must he owned that the method of operation, deserving the preference in many respects, and known by the name of the grand operation, was the invention of Johannes de Romanis, of Cremona, who lived at Rome in the year 1520, and published his work at Venice in 1535. The instrument that we make use of in trepanning, was doubtless first used by the ancients, and only rendered more perfect by Woodall and Fabricius ab Aquapendente. Tapping likewise is in all respects an invention of theirs. Laryngotomy, or the opening of the larynx in the quinsy, was practised by them with success ; an operation which, though safe and needful, is almost out of use at present.

4.“The cure of the hernia intestinalis, with the distinguishing differences of the several species of that malady, and their method of cure, are exactly described by the ancients. It was they who taught us the cure of the peterygion and cataract, and treated the maladies of the eye as judiciously as any of our modern oculists, who, if they would act with honour, should confess, that they do nothing more but practice over again what those great masters taught. The opening of an artery, and of the jugular vein, is no more a modern invention, than the application of the ligature in the case of an aneurism, which certainly was not well understood even of late by Frederick Ruysch, that celebrated anatothist of Holland. The extirpation of the amygdales, or of the uvula, is not at all a late invention, though it must be owned the efficacious cauteries now used in the case of the former, were neither practised nor known by the ancients. The method we now use of treating the fistula laclirymalis, a cure so nice and difficult, is precisely that of the ancients, with the addition that Fabricius made of the canula for applying the cautery.

5. “ As to the real caustic, which makes a considerable article of Surgery, although Casteus, Fienus, and Severinus, have written simply on that subject; yet it is evident from a single aphorism of Hippo crates, that this great physician knew the use of it as well as those who have come after him: and besides, it is frequently spoken of in the writings of all the other ancients, who without doubt used it with great success in many cases where we have left it off, or know not how to apply it. The cure of the varices, by incision, scarcely so much as made mention of now, appears to have been a familiar practice among the ancients, as is manifest from the works of Celsus and Paulus Eginetus; and whoever is conversant in the treatment of varicous ulcers, will agree, that this operation is absolutely necessary for the effectual cure of them. The polypus of the ear is a malady so little understood by the moderns, that we meet but very rarely with the name of it in their writings; and yet the description of its cure has not been omitted by the ancients. They were entirely well acquainted with all kinds of fractures and luxations, and the means of remedying them; as well as with all the sorts of sutures in use amongst us, besides many which we have lost. And though some have advanced that cauteries were unknown to them, we may easily convince ourselves of the contrary, by observing what Celsus and Coelius Aurelianus have said of them, allowing withal that they seem not to have known our method of placing and continuing them.

6.“Nor ought I to omit what is so manifest, that nobody will deny it, that all sorts of amputations, as of limbs, breasts, &c. were performed among them as frequently, and with as great success, as we can pretend to. As to the art of bandaging, so very important and necessary, though much neglected at presents and which the French so much pique themselves upon, as if in this they excelled all others; the ancients knew it to such a degree of perfection, that we do not even flatter ourselves with having added any thing considerable to what Galen hath taught us, in the excellent tract he has written on this subject. And although the moderns claim an advantage over the ancients, in regard to the variety of their instruments, it is nevertheless evident, that they were ignorant and destitute of none that were necessary: nay, it is highly probable, from what Oribasius, nay and many others have said, that they had great variety of them. As to topics, or the remedies which are externally applied, it is certain that we are indebted to them, for having instructed us in the nature and properties of these we now use ; and as to general methods of cure, the ancients have so eminently excelled, particularly in that of treating the wounds of the head, that those of the moderns who have written most judiciously upon it, thought they could do no better service to posterity than comment upon that admirable book which Hippocrates wrote on this subject.

7. “ it would require more leisure and ability than I have,” concludes Mr. Bernard, “to enter into a detail of more particulars, and to show what bath been invented, set aside, or lost in different ages. What I have already advanced, sufficiently makes it appear, that we ought to talk of the ancients with great respect; not that we should blindly yield to their authority, or imagine that they left nothing to be perfected in following ages; but we ought to imitate the celebrated Bartholin. ‘We make but an ill judgment of our own interest,’ says that great man, ‘when we so plunge ourselves in the study of the moderns as to neglect or contemn that of the ancients, whose writings are so necessary to throw light upon every part of the science.’ And in another place he says, ‘I have always shown a particular regard to the opinions and maxims of the moderns, yet never without paying due homage to antiquity, to which we are indebted for the very prime foundations of our art.’”

Chapter 03 - Of Generation

Chapter 3 - Of Generation

1.THERE are two principal sentiments among the moderns, relative to the manner in which generation is effected. Some think that all the parts of the fetus are enclosed in miniature in those eggs contained in the ovaries of the female, which communicate with the womb by the Fallopian tubes; and that the seed of the male is only a sort of matter proper for detaching the egg, cherishing it, and conveying it into the womb, where the germ contained in the egg afterward unfolds its parts: this is the sentiment of Hervey, Redi, and many other celebrated physicians, who maintain that all animals are oviparous, and spring from eggs, which in the animal kingdom are what seed is in the vegetable.

2.The other sentiment is that of Lewenhoek, that all animals, and even men, spring from little animals of extreme minuteness, contained in the seed of the male ; and he looks upon the eggs in the ovary of the female, only as little niduses fit to receive these animalculi, and to contribute to their developement and increase, by imparting to them the nourishment which comes from the vessels of the womb.

3.The first of these systems was for a time generally received, and appeared to be founded on just observations. Those who maintain it. declare, that they have found eggs in the ovaries of every female that came under their notice, often to the number of more than twenty in each ovary, and of the size of a green pea. They draw another of their arguments from the analogy that nature every where observes in all operations, and particularly in the production of plants and animals. Now if this system deservedly confers glory on the inventor of it, it is but just that he should have it who is best entitled to it; and he to whom it appears primarily due is without doubt Empedocles, and next to him Hippocrates, Aristotle, and Macrobins.

4. Plutarch, relating the different opinions of philosophers, as to the' the generation of animals and productions of plants, says, that Empedocles thought they were all of them at first irregular and imperfect, but acquired afterward such a just form as distinguished them in shape and species from one another. And he concludes with saying, that animals are not produced like earth and water, from homogeneous bodies, but generate one another by the mixture of the sexes, and like plants, derive the principle of their origin from the particular seeds or eggs. This is the very same which Aristotle intended to indicate, as the doctrine of Ernpedocles, when he introduces him, as saying, “that whatever was born, was born of a particular seed ;“ and as calling the seeds of plants their eggs, which fall of themselves when they are come to maturity.

5.Herodotus, who lived almost at the same time with Empedocles, relating that a land adjoining to the Nile had produced a great quantity of fish, gives a natural reason for it, upon the principles of Empedocles. What seems to me, says he, to have been the cause of this vast increase of fish, is this, during the time of the Nile’s overflowing, the fishes having left in the mud of its borders, a prodiguous quantity of sperm, or eggs, these disclose themselves after its retreat, covering. the

land with a multitude of fish.

6. Hippocrates, speaking of the formation of an infant, describes a fetus six days old, comparing it to a raw egg without the shell, round, and full of a red transparent liquor. In another place, he shows “how the same thing happens in the generation of an infant, as in the production of a plant.” He says “that nature is always the same, acting uniformly in the generating of men, and of plants, and of every thing else.”

7.Aristotle, with still more precision, describes the egg containing the foetus. He says, “that all animals engender and conceive first a kind of egg, containing a liquor enveloped in a membrane or thin skin, resembling that of an egg shell. This, in another place, he plainly calls an egg; out of one part of which,” lie says, “the foetus is produced ; that is, out of the yolk ; whilst the white part, which is the other, serves to nourish it.”

8.Nothing can be more clear than what Macrobius pronounces on this subject, who positively avers, that of all kinds of animals who copulate, an egg is the first principle of their generation; and in another place, that the egg is the solution or expansion of the seed.

9.The system of animalcules or spermatic vermiculi has hindered that of generation by the means of eggs, from gaining the unanimous suffrage of the naturalists. Mr. de Plantades, secretary of the academy of Montpelier, was the first among the moderns who renewed this conjecture of the ancients. Lewenhoek and others confirmed this conjecture by observations so accurate, that they divided the sentiments of naturalists between their own opinion of men’s proceeding from spermatic animalcula, and that of Hervey, which derives all generation from eggs. We have already seen that this letter opinion sprung from Hippocrates, Aristotle, &c. And the other of the existence of spermatic vermiculi, is as clearly taught by Plato, Hippocrates, Aristotle, arid other ancient philosophers, as if they had seen them. We can never sufficiently extol the extreme penetration of those great geniuses, who, guided solely by reason, arrived so long before us, where we, after all our nice experiments and laborious researches, are glad to rest.

10.Democritus is the first of the Grecian philosophers, who bath spoken of certain worms, which assume at length the human form; but no author transmitted to us, has entered into a detail of this opinion; though Epicurus, Diodorus, Siculus and Euripides, seem to hint at it. Epicurus thought that the generation of animals was effected by the continual transformation of one into another. Anaxagoras, had said the same, as well as Euripides, quoted by Plutarch, Galen, Eusebius and Philo. But Democritus, in explaining himself more precisely, taught that men, in their first original, appeared in the form of small worms, which, in all probability, he conceived to be contained in the seminal juice of the male; for it is natural to suppose, that in this idea he agreed with Hippocrates, who insinuates, that the “seed of animals is filled with animalcula, whose parts unfold themselves and grow all at a time.”

11. That illustrious physician, without all doubt, held conferences upon this subject with Democritus, whom he found engaged in the dissection of animals, when be went first to visit him, and long enjoyed the utmost satisfaction in his company upon matters entirely philosophical. Aristotle seems to hint at Democritus, when treating of the first formation of men, he says, that some have thought that “the first men,” after having sprung out of the earth, “began their existence in the form of little worms ;“ and in another place, he speaks of Democritus as having believed,

that “in the generation of man, the exterior parts of the foetus are first formed ;“ so that it is even then of human shape, and therefore even in that condition may be looked upon as a “little man.”

12.Hippocrates advanced, that nothing in nature absolutely perished; “that nothing, taking it altogether, was produced anew nothing born but what had a prior existence ;“ that what we call birth is only “such an enlargement as brings from darkness to light,” or renders visible” those small animalcula which were before imperceptible." He says a little farther, it is impossible that what is not, should be born, there being nothing that can contribute to the generation of what has no existence. But he maintains, “that every thing increases much as it can, from the lowest to the highest degree of magnitude." These principles he afterward applies to human generation. Re says, that “the largest sizes arise out of the lesser ;“ that “ all the parts successively expand themselves, and grow and increase proportionally in the same series of time ; that none of them in reality takes the start of another, so as to be quicker or slower in their growth; but that those which are naturally larger, sooner appear to the eye than those which are smaller, though they by no means preceded them in existence.” In short, in the beginning of this book of Hippocrates, we meet with a train of reasoning entirely just and solid, the natural consequences of which is, that at the beginning of the world, the seeds containing the first lineaments of plants and animals came into existence, though their extreme minuteness hinders them from being seen. Whence he concludes, as we have already had occasion to observe, that “the birth of animals is only such an enlargement of them, as makes them pass from darkness into light.”

13.It may be objected, that we have already represented Hippocrates and Aristotle as favouring the system of generation by eggs; and that we now seem to ascribe a contrary opinion to them. But it ought to be remarked, that in reality, these two philosophers favoured the former system: for Aristotle only relates the other opinion as introductory to the establishment of his own; and Hippocrates contents himself with insinuating the notion, that there may be animalcula in the male seed, without taking it upon him ‘to establish it as a truth. Besides, he might have admitted of spermatic vermiculi in the sense that some moderns do, in order to reconcile the two systems, regarding the eggs as niduses proper for the reception of the spermatic vermiculi, and containing matter necessary for contributing to their growth. In this case, the spermatic worm will be the real foetus, the substance of the egg its nourishment, and the membranes of it its wrappers.

14. Plato bath still more clearly spoken of those small animals which become men; for after having compared “the womb to a fertile field,” in which the scattered seed produces fruit; he says, that “the animalcula, which there receive their growth, are at first so extremely small as not to be perceptible to the eye, but coming gradually to unfold themselves and expand, by means of the food prepared for them in the womb, they afterward spring firth into day in all the perfection of birth.” Nor can it be denied, that Seneca had a very distinct idea of this system of human generation by animalcula. when we find bins teaching, that “ the human form before birth, Was comprised in the seed, where all the members of the body were con-centered and shrouded up in a little indiscernible place.” Which Tertullian bath expressed in few words, when he says, “the seed bath life in it from the very first.”

15.The discovery respecting the multiplicity of animation of which the polypus is capable, is what nobody makes any difficulty of regarding as due to the moderns, though Aristotle and St. Augustine speak of it as clearly as any of the moderns, as a thing which they knew from their own

experience. The latter relates in his book concerning “the dimension of the soul," that one of his friends performed the experiment before him, cutting a polypus in two; and that immediately the two parts thus separated betook themselves to flight, moving the one, one way, and the other another. That great man adds, that this experiment suddenly threw him into such amazement, that for some time he knew not what to think of the nature of the soul. Aristotle, speaking of insects, says almost the same thing; for without naming the creature he speaks of, he observes, that “there are of these animals or insects, as well as of plants and trees, that propagate themselves by shoots :“ and as what were but the parts of a tree before, become thus distinct and separate trees: so in cutting one of these animals, says Aristotle, the pieces which before composed but one animal, become of a sudden so many different individuals.

Chapter 04 - Of the Sexual System of Plants

Chapter 4 - Of the Sexual System of Plants

1.NOBODY at present doubts but that plants propagate themselves, as animals do, by means of organs, some male and others female; that in a great many plants these two kinds of organs are found united, which plants are then among naturalists distinguished by the name of hermaphrodites; and that in other plants the two sexes are so separated, that the male are on one stem. and the female on another. This system is founded, first, on the analogy there is between the eggs of animals and the seed of plants. both serving equally to the same end, that of propagating a similar race: secondly, on the remarks that have been made, that when the seed of the female plant is not impregnated with the prolific powder of the male, it bears no fruit; insomuch, that as often as the communication between the sexual parts of plants has been intercepted, they have always proved barren. The authors of this system, after exactly anatomizing all the parts of the plant assign to each a name, founded on its use and analogy to the parts of an animal. Thus as to the male organs, the filaments are the spermatic vessels, their antheres, or tops, the testicles ; and as to the female, the style answers to the vagina, the germ to the ovary, and the pericarpium, or fecundated ovary, to the womb.

2. Linnaeus has the honour of having completed this system, by. reducing all trees and plants to particular classes, distinguished by the number of their stamina, or male organs. Zaluzianski seems to have been the first among the moderns, who clearly distinguished from one another the male, female, and the hermaphroditical plants. About a hundred years after him, Sir Samuel Millington and Dr. Grew communicated to the Royal Society of London. their observations on the impregnating dust of the stamina. Camerarius, towards the end of the last century, observed, that upon plucking off the stamina of some male plants, such as the mulberry-tree the maize, the buds that ought to have produced fruit, came not to maturity. Malpighi and Vaillant have also carefully considered this fecundating dust; the latter of whom seems to have been the first eye-witness of this secret of nature. Many authors afterward applied themselves to improve this system.

3.We are now to examine whether the ancients knew any thing of this, or whether they only speak of it in a vague and indecisive manner. I agree, that they do not give so exact an account of the anatomy of every part of the flower of a plant as the moderns do; at least, no such work of theirs hath reached our times. They are even sometimes so far mistaken, as to apply some of the parts to purposes they do not serve. But in this they are more excusable than some of our ablest moderns, who have fallen into great errors on this subject, notwithstanding all the instructions, experiments and observations of their cotemporaries. The ablest botanist of his age, Mr. de Tournefort, who could not be ignorant of what had been advanced by Millington, Grew, Malpighi and Camerarius, yet maintains, that the stamina of flowers serve only to secrete or void the less useful parts of the nutritive juices, and are only the excretory vessels belonging to the calix of the flower.

4.Having made this concession, I may with the more safety affirm, that this one circumstance excepted, of which I have here made mention, the ancients perfectly understood the sexual difference in plants, the fecundation of the fruits of the female by the dust of the flowers of the male, and had a distinct idea of the two sexes, as having place in different individuals.

5.Theophrastus says, that trees may he distinguished into several classes, on account of their great variety ; but that the most universal difference among them is that of their gender ; whether male or female. And Aristotle observes, that we ought not to fancy that the intermingling of sexes in plants is the same as among animals.

6.There were it seems, various Opinions among the ancients, as to the manner in which plants should be admitted to have a difference of sex. Some looked upon them as complete in that respect, each individual containing in itself the powers of both sexes. Empedocles endeavoured to solve this, whether in plants the male was distinct from the female; “or, whether the sexes were united in each of the species : and he concluded, that plants were hermaphroditical ; that is a composition of both sexes.” Aristotle doubted, whether he ought to admit, that the two sexes combined in the same plant, or should pronounce that they existed separately.

7.True it is, this author errs widely in his manner of distinguishing the male from the female plant ; for he thought the difference to consist in this, that the male was larger and stronger, the female weaker, but more fruitful. He said also that the male was more dry, and came sooner to maturity than the female. But it should be observed, it is not upon the testimony of Aristotle that we attempt to show, the ancients knew the sexual system of plants. This is what only appears confused in his writings; for he employs himself rather in giving the sentiments of others, than in advancing reasons of his own.

8.Empedocles thought that whatever grew, drew its origin from seed, which he compares to eggs in this respect; that it originally contains in it a nutritive aliment, which it immediately communicates to the root. And Aristotle reasoning on this sentiment of Empedocles, says, “ that in plants the two sexes are united,” which makes them capable of propagating themselves ; but instead of a foetus they produce seed, which is the fruit of their generative faculty. And on this account, Empedocles called plants oviparous for time seed, or” egg,” said he, “ is the fruit of the generative faculty, one part of which serves to form the plant, and the other to nourish the germ and root ; in animals of different sexes, we see that nature, when they would procreate, impels them to unite, and like plants to become one ; that from this combination of two, there may spring up another animal.”

9.As to the manner in which fruits were impregnated, the ancients were not ignorant, that it was by means of the prolific dust contained in the flower of the male ; and they carried the accuracy of their observations so far as to remark that the fruits of trees never come to maturity, till they have been cherished with dust. Upon this, Aristotle says, “that if one shake the dust of a branch of the male palm over the female, her fruits Will quickly ripen; and that when the wind sheds this dust of the male upon the female, her fruits ripen apace.”

10.Theophrastus, treating of the same subject, says, “they bring the male to the female palm in order to make her produce fruits: The manner in which they proceed is this : When the male is in flower, they select a branch abounding in that downy dust which resides in the flower, and shake this over the fruit of the female. This operation prevents the fruit from becoming abortive, and

brings it soon to perfect maturity.” “ Naturalisis’ says Pliny, “ admit the distinction of sex not only in trees, but in herbs, and in all plants. Yet this is no where more observable,” adds he, “ than in palms he females of which never propagate hut when they are fecundated by the dust of the male.” He calls the female palms, deprived of male assistance, barren widows. He compares the conjunction of these plants to that of animals ; and says, that to generate fruit, the female needs only the aspersion of the dust of the flowers of the male.

Chapter 05 - Of the Chemistry of Tile Ancients

Chapter 5 - Of the Chemistry of Tile Ancients

1.IF we will be guided by the greatest number of etymologists the needs no deep research to demonstrate the antiquity of chemistry. Its name seems to declare its origin. It is agreed almost by all, that it was first cultivated in Egypt. the country of Cham, of whom it is supposed to have taken its name, Chemia, sive Chamia, the science of Cham. In the 105th psalm, Egypt is called, “the land of Cham." According to Bock-hart, the Coptes still call themselves Chemia, or Chami; and Plutarch. in his isis and osiris, speaking of a district of Egypt, names it Chamia, quasi Chimia. But without entering here into a philological discussion, I shall content myself with considering whether the ancients were chemists, and to what degree; and hope to make it appear, that they not only knew all of that art, which we do, but had such insight in it, as we have not at present.*

*must be allowed, that the excellent remarks in this treatise, reflect much light and credit on the ancients; but it should be borne in mind, that they apply to a period, which is now itself enrolled with antiquity. Chemistry particularly, at the time these remarks were made, was a mere confused jumb1e of experiment and arrangement, and scarce deserved the dignifying title of art or science. Within a very few years, the discoveries and improvements, have been so nu

2 The first instance that occurs for ascertaining the antiquity of the science, is of a very remote date. Nobody, I think, will doubt, hut Tubal-Cain, and those who with him found out the way of working in brass and iron, must have been able chemists. It was impossible to work upon these metals, without knowing the art of digging them out of the mine, of excavating them, and of refining arid separating them from the ore, all which are chemical operations, and must have been at first invented by those who excelled in the art, however afterward they might be put in practice by the meanest artizans. Those who are engaged in the working of copper mines, for instance, and know that the metal must pass above a dozen times through the fire, before it can acquire its proper colour and ductility, will easily enter into this sentiment. It is needless to bring together here all the passages of heathen historians, which speak of Vulcan, in the same manner as the sacred author does of Tubal-Cain, and to show the reader from the resemblance, and as it were identity of names, that all of them relate to one and the same person. It is enough to observe that those authors represent Vulcan as skilled in operating upon iron, copper, gold, silver, and all the other bodies capable of sustaining the action of lire.

3.I likewise pass over whatever carries in it the air of fable: such as the story of the golden fleece; the golden apples that grew in the gardens of the ilesperides ; the reports of Manethon and Josephus with relation to Seth’s pillars ; and come to facts real and established: and for the sake of chronology, I shall still adhere to the sacred text, in contemplating an action of Moses, who having broken the golden calf, reduced it into powder to be mingled with water, and given to the Israelites to drink; in one word, rendered the gold potable : an operation so difficult, that it is entirely impracticable to most of the chemists of our days, and owned by Boerhave to be of so exalted a kind, that it is unknown at present to the most skilful. Yet it must be admitted, that it hath

been looked upon by some able chemists as practicable, who at the same time acknowledge it to be a most remarkable proof of Moses' eminent skill in all the wisdom of Egypt. For how, without the aid of chemistry, could Moses have dissolved the golden calf, and that too without applying corrosives, which would have poisoned all who had afterward drank of the waters Yet this was to be done, and in a short time too, though there be but one way of doing it. Frederick the third, king of Denmark, curious to put this operation in practice, engaged some able chemists to attempt it. After many trials they at last succeeded, but it was in merous and important, as to give a new character to this department of science, and exalt it to a degree beyond all comparison with antiquity. See notes and observations at the end of the volume. following the method of Moses, by first reducing the gold into small parts by means of fire, and then pounding in a mortar, (along with water) till it was so far dissolved, us to become potable. This fact cannot be called in question, nor has it any thing supernatural in it We know that Moses was instructed in all the learning of the Egyptians, among whom the sciences were cultivated with all manner of success, and from whom the most eminent philosophers of Greece derived their knowledge.

4.How they formed that cement, which they applied in rearing those monuments that still subsist, remains a secret to us ; though it be past all doubt, that they prepared it in a chemical way, so hidden however to us, that we daily lament the loss of it. The numberless mummies which still endure, after so long a course of ages, ought to ascertain to the Egyptians the glory of having carried chemistry to a degree of perfection attained but by few. In their mummies alone, there is such a series of operations, that some of them still remain unknown, notwithstanding all the attempts of some of the ablest moderns to recover them. The art of embalming bodies, and preserving them for many ages, is absolutely lost; and never could have been carried so far as it was by the Egyptians, without the greatest skill in chemistry.*

All the essays to restore this art, have proved ineffectual, nor have the reiterated analyses made of mummies, to discover the ingredients of which they were composed, had any better success. Some moderns have attempted, by certain preparations, to preserve dead bodies entire, but to no purpose. The mummies of Lewis de Bus, who was regarded as eminent in that way, are already in a state of corruption. There were also in those mummies of Egypt, many things besides, which full within the verge. of chemistry: such as their gilding so very fresh, as if it were but of fifty years standing; and their stained silk, so vivid in its colours, though after a series of thirty ages. In the museum at London, there is a mummy covered all over with fillets of granated glass, various in colour, which shows that this people at that time, understood not only the making of glass, but could paint it to their liking, it may be remarked here, that the ornaments of glass with which that mummy is bedecked, are tinged with the same colours, and set off in the same taste, as the dyes in which -almost all other mummies are painted; so that it is probable, this kind of ornaments being very expensive, was reserved for personages of the first rank only whilst others, who could not afford this, contented themselves with an imitation of it in painting.

*The art of making mummies, has been represented by some travellers, as a mere local advantage of the soil and climate of Egypt, where the exhalations arising from the surface of the country, constitute such a body in the atmosphere, as even to prevent the vapours from forming and descending in rain. The remarks tend to impart an idea, that these exhalations are so rapid, as to carry off the humours from a dead body to such a degree, as to prevent putrefaction taking place. These exhalations are represented to be of a kind of petrifying quality, whereby the flesh of

a dead body is converted into a kind of stone. home experiments were tried in some of the desert sands, on the dead bodies of some small animals, which seemed to confirm the opinion.

5. It would be easy to make a more extensive enumeration of the particulars of the chemical process, which concurred to the composition of a mummy ; but I proceed to take notice of their manner of painting upon linen, which if I mistake not, is still a secret to us. After having drawn the outlines of their design upon the piece of linen, they fill each compartment of it with different sorts of gums, prepared to absorb the various colours; so that none of them could be distinguished from the whiteness of the cloth. Then they dipped it for a moment in a caldron full of boiling liquor, proper for the purpose: and anew it thence painted in all the colours they intended. And what was remarkable, the colours neither decayed by time, nor moved in the washing: the caustic, impregnating the liquor wherein it was dipped, having penetrated and fixed every colour intimately through the whole contexture of the cloth. This single instance is sufficient to give us a very high conception of the progress that chemistry had made among the Egyptians, though their history affords a thousand others of the kind, not to be wondered at among a people so very active and industrious, where even the lame, the blind and the maimed, were in constant employment, and so little subject to envy, that they inscribed their discoveries in the arts and sciences, upon pillars reared in holy places, in order to omit nothing that might contribute to the public utility. The emperor Adrian attests this first part of their character, in a letter written to the consul Servianus, upon presenting him with three very curious cups of glass, which, like a pigeon’s neck, reflected, on whatever side they were viewed, a variety of colours representing those of the precious stone called obsidianum, which some commentators have imagined to be the cat’s-eye, and others the opal.

6.This art of imitating precious stones, was not peculiar to the Egyptians; the Greeks, who indeed derived their knowledge from those great masters, were also very skilful in this branch of chemistry. They could give to a composition of chrystal, all the different tints of any precious stone they wanted to imitate. Pliny, Theophrastus, and many others, give instances of this; but they most remarkably excelled in an exact imitation of the ruby, the hyacinth, the emerald, and the sapphire.

7. Chemistry being a principal branch of medicine, it will not be amiss to mention some particulars, wherein the Egyptians have contributed to the perfection of that science. I set aside the history of Esculapius, who was instructed by Mercury or Hermes. Their pharmacy depended much upon chemistry; witness their manner of extracting oil, and preparing opium, for alleviating of acute pains or relieving the mind from melancholy thoughts. Homer seems to have had this last in view, when he introduces Helen as ministering to Telernachus a medical preparation of this kind. They also made a composition or preparation of clay or fuller’s earth, adapted to the relief of many disorders. particularly to render the fleshy parts dry, and thence to cure the dropsy and the hemorrhoides. They knew all the different ways of composing salts, nitre, and alum, sal cyreniac or ammoniac, so called from being found in the environs of the temple of Jupiter Ammon. They made use of the litharge of silver, the rust of iron, and calcined alum, in the cure of ulcers, cuts, biles, deflux ions of the eyes, pains of the head, &c. and of pitch against the bite of serpents.

They successfully applied caustics. They knew every different way of preparing plants, or herbs, or grain, whether for medicine or beverage. Beer in particular, had its origin among them. Their ungents were of the highest estimation, and most lasting; and their using remedies, taken from

metallic substances, is so manifest in the writings of Pliny and Dioscorides, that it would be needless to enter upon them here. Dioscorides often makes mention. of their metallic preparations, such as burnt lead, ceruse, verdigrise, and burnt antimony; all which they made use of in their plasters, and other external applications. It should be observed here, that I have had nothing in view, but the pharmacy of the Egyptians; otherwise I might have made mention of the Theriac, that famous composition of Andromachus the physician of Nero, which has at all times been in high estimation, and is now in as much repute as ever. What little I have advanced respecting the medicinal chemistry of the ancients, must suffice upon this occasion ; the Greeks and Romans presenting a field too vast to be comprised in a tract of this kind.

Hippocrates especially, the cotemporary and friend of Democritus was remarkably assiduous in the cultivation of chemistry. A learned man has composed an entire book on the extensive comprehension he had of it, whereby it appears, that he not only understood the general principles of it, but was an adept in many of its most useful parts. Passages are quoted from Plato, that are received as axioms in chemistry. Galen knew that the energy of fire might be applied to many useful purposes, and that by the instrumentality of it, many secrets in nature were to be discovered, which otherwise must for ever be hid: and he gives many instances of this in several places of his works. Dioscorides had transmitted to us many of the mineral operations of the ancients, and in particular that of extracting quicksilver from cinnabar, which is in effect an exact description of distillation.

8.The merit of the ancients in having arrived at the knowledge of this important operation of chemistry, has been much called in question; which makes it requisite to give particular attention to this passage of Dioscorides, which not only indicates the practice of distillation among the ancients, but shows that this branch of chemistry derived from the Greek language the name of its principal instrument, the alembic. The word ambix, according to Athenaeus, meant the cover of a pot, or any vessel wherein liquids were set a boiling, and the Arabs adopted this word in applying it to the same subject, only adding the syllable alto the beginning of it, a syllable that enters into the beginning of most of their words, whence sprung the word alembic. Pliny also gives the same explanation as Dioscorides does, of the manner of extracting quicksilver from cinnabar by distillation. And Seneca describes an instrument exactly resembling the alembic, and which seems to have been applied to the same use. But there are other indications, besides, full as sure as those, that distillation had place among the ancients. For without reckoning that brewing of beer implies the use of a still, we find Aristotle observes that oil could be extracted from sea salt; which never could be done without distillation. Hippocrates describes the process of that operation; talks of vapours arising from the boiling fluid, which meeting with resistance, stop and condense till they fall in drops from the body to which before they clung in the form of vapours. And Zosimus of Panopohis, not only desires his students to furnish themselves with alembics, but gives them directions how to use them, and places before their eyes draughts of such as best deserve to be employed in practice.

9.To proceed to other particulars of general chemistry; the ancients, among other things were acquainted with lixivial salt, or sal alcali, one of the prime principles of bodies. Sal alcali means properly the salt extracted by fire from the Egyptian plant kali, but as it is extracted also from other vegetables, though in less quantity. chemists extend the name to all those salts, which like that of this plant, attract and imbibe acids, and by their contexture penetrate into them, and closely unite

with them. These salts are termed promiscuously, lixivial salt, sal alcali, rock salt, &c. It is of them Aristotle speaks, when he says, that in Umbria the burnt ashes of rushes and reeds, boiled in water, yield a great quantity of salt. Theophrastus observes the same of Umbria. Varra relates, that some who dwell on the borders of the Rhine, having neither sea nor pit salt, supply themselves with it by means of the saline cinders of burnt plants. Pliny assures us, that ashes are impregnated with salts, and speaks in particular of the nitrous ashes of burnt oak; adding that these salts are used in medicine, and that a dose of lixivial ashes is an excellent remedy. in short, Hippocrates, Celsus, Dioscorides, and especially Galen, often recommended the medical use of sal alcali; and their writings are filled with passages, which show that they all understood it. To the mixture of acids and alcali it was, that Plato ascribes fermentation; and Solomon seems to have known this effect of them when he brings as an instance of it, vinegar, and the nitre of Egypt.

10. Another convincing proof of the ability of the ancients in chemistry, the experiment with which Cteopatra entertained Marc Antony, in dissolving before him, in a kind of vinegar, a pearl of very great value. I say, in a kind of vinegar; for at present we know not of any that can produce this effect; but as the fact itself is so well attested, we must thence conclude that the queen added something to the vinegar, omitted by the historian: and that Phacas, who was her physician, assisted her at that time with his aid, enabling her thus to gain the wager which she had laid with Marc Antony, that she would exceed him in the costliness of her entertainment. But even the queen herself was a great adept in this art, as appears from some of her performances, still preserved in the libraries of Paris, Venice, and the Vatican. And Pliny informs us of the emperor Caius, that by means of fire he extracted some gold from a quantity of orpiment.

11.The method of rendering glass ductile, is a secret still uncomprehended by us, though formerly well known to the ancients. The authors who lived at the very time when this was done, speak of it so circumstantially, that it is impossible to doubt of it. They are Pliny, Petronius, lbn, Abd Alhokin, John of Salisbury, Isidorus, and others. Pliny speaks only of the flexibility of glass, which he says; was found out in the time of Tiberius: but that the emperor fearing lest gold and silver, those most precious metals, should thereby fall in their value, so as to become contemptible, ordered the residence, workhouse, and tools of the ingenious artisan to be destroyed, and thus cut off this art in its rise. Petronius goes farther, and says, that in the time of Tiberius there was an artificer, who made vessels of glass, which were in their composition and fabric as strong and durable as silver or gold; and that being introduced into the presence of the emperor, he presented him with a vase of this kind, such as he thought worthy of his acceptance ; and that meeting with the praise his invention deserved, and finding his present so favourably received, he, to increase the admiration of the spectators, and further to ingratiate himself with the emperor, laid hold on the vase, throwing it with such violence on the floor, that had it been of brass, it must have been injured by the blow; that he took it up again whole, but dimpled a little, which he immediately repaired with a hammer he took from his breast: and that while he was in expectation of some very ample reward in recompense of his ingenuity, the emperor asked him whether any body else was acquainted with this method of preparing glass, and being assured that no other was, immediately ordered his head to be cut off, lest gold and silver, added he, should become as base as the dirt we tread upon. In these two testimonies, we see how this discovery came so soon to be lost. if whatever is new, be with so much difficulty established. notwithstanding every encouragement, how was it possible for this to endure, when so suddenly surprised by inevitable fate! Dion Cassius, on this

head, confirms the attestations of Pliny and Pletronius. John of Salisbury and Isidorus, relate this same fact, in the same way. As to the Arabian Ibn Abd Aihokin, he speaks of malleable glass as a thing known in the flourishing times of Egypt; but he himself is so unknown, that I know not how to rest on his authority. Greaves, who makes mention of him as a celebrated chronologist among the Arabians, cites from him the passage, wherein it is said, that Saurid king of Egypt, who built three pyramids, deposited in them, among other precious things, malleable glass, &c. I ought not to leave this subject, without mentioning the attempts made by the moderns to render glass pliant and malleable. There is a chemical composition, well known, formed of silver dissolved in acid spirits, which is called cornu lunae, a transparent body, easily put into fusion, and very like horn or glass, and which will bear the hammer. Borrichius makes mention of an experiment of his own, tending to prove the possibility of rendering glass ductile; it consisted in composing a pliant and malleable salt, for the making of which he gives the receipt; concluding from thence, that as glass for the most part is only a mixture of salt and sand, and as the salt may be rendered ductile, it ought not to be looked upon as impossible that glass may be made malleable. And be imagines, that the Roman artificer, spoken of by Pliny, and Petronius, may have assumed antimony as the principal ingredient of his glass.

Besides we may observe, that nature bath formed many bodies, having an analogy to that of glass ; such as the horns of animals, amber, the Russian talc, and several others, all which are transparent, and at the same time pliant and malleable. Descartes also takes notice, that salt may be rendered malleable, and for that very reason intimates, that it is possible to succeed in giving the same property to glass. And Morhoff assures us, that the celebrated Boyle was also of this opinion. In speaking of glass I may add, that the art of painting, so far as it depends upon chemistry, was carried formerly to a much higher degree of perfection, than it is at present. Of this we have striking instances in the windows of some ancient churches, where paintings present themselves in the most vivid colours, without detracting from the transparency of the glass; and which, as Boerhaave observes, are hardly to be imitated at present, we having lost the secret to a degree, that there are scarce any hopes of ever recovering it. The enamelling and mosaic works of the ancients, yield the same kind of evidence of their skill in chemistry ; of the former of which many instances occur in the works of Pliny and others.

12.Having spoken of the chemistry of the Egyptians, and of that of the Greeks and Romans. who derived their instructions from these most masters; it would not be pardonable to omit mentioning critus, the parent of experimental philosophy. This great man, for the sake of acquiring wisdom, travelled into Egypt, and made his abode with the priests of the country, as we are informed by Dio genes, Laertius, Strabo, Clemens Alexandrinus, Eusebius, and Synesius. Vitruvius tells us, that he wrote many books on natural philosophy, and was wont to put his seal upon those experiments which he had tried himself. Diogenes Laertius says the same. Petronius affirms, that he extracted the juice of every simple, and was so wholly taken up in experiments, that there was not a quality belonging to the mineral or vegetable kingdoms that escaped his notice. and Seneca asserts, that he was the inventor of reverberating furnaces' the first who gave a softness to ivory, and imitated nature in her production of precious stones, particularly the emerald.

13.I shall finish this chapter with an assertion, that perhaps will seem paradoxical: that the ancients knew the use of gunpowder. Virgil and his commentators Servius, Byginus, Eustathius, La Cerda, Valerius Flaccus, and many other authors, speak in such a manner of Salmoneus' attempts to

imitate thunder, as suggest to us that this prince used for that purpose a composition of the nature of gunpowder. Eustathius in particular speaks of him on this occasion, as being so expert in mechanics, that he formed machines which imitated the noise of thunder: and the writers of fable, whose surprise in this respect may be compared to that of the Mexicans when they first beheld the fire arms of the Spaniards, give out, that Jupiter, incensed at the audacity of this prince, slew him with lightning as he was employing himself in launching his thunder. But it is much more natural to suppose, that this unfortunate prince, the inventor of gunpowder, gave rise to these fables, by having accidentally fallen a victim to his own experiments. Dion and Joannes Antiochenus report of Caligula, that this emperor imitated thunder and lightning by means of certain machines, which at the same time emitted stones. Themistius informs us, that the Brachmans encountered one another with thunder and lightning, which they had the art of launching from on highat a considerable distance. Agathias, the historian, reports of Anthemius Traliensis, that having fallen out with his neighbour Zeno the rhetorician, he set fire to his house with thunder and lightning. Philostratus, speaking of the Indian sages, says, that when they were attacked by their enemies, they did not leave their walls to fight them, but put them to flight by thunder and lightning. And in another place he relates, that Hercules and Bacchus attempting to assail them in a fort where they were entrenched, were so roughly received by reiterated strokes of thunder and lightning, launched upon them from on high by the besieged, that they were obliged to retire, leaving behind them an everlasting monument of the rashness of their enterprise. It appears from all these passages, that the effects ascribed to these engines of war, especially those of Caligula, Anthemius, and the Indians, could be only brought about by gunpowder. And what is still more, we find in Julius Africanus a receipt for a composition to be thrown upon an enemy, which very nearly resembles that powder. But what places this beyond all doubt, is a clear and positive passage of an author called Marcus Graecus, whose work in manuscript is in the royal library at Paris, entitled, Liber ignium. Dr. Mead had the same also in manuscript. The author describes several ways of encountering an enemy, by launching fire upon him; and among others gives the following: mix together one pound of live sulphur, two of charcoal of willow, and six of saltpetre; reducing them to a very fine powder in a marble mortar.

He adds, that a certain quantity of this is to be put into a long, narrow, and well compacted cover, and so discharged into the air. Here we have the description of a rocket. The cover with which thunder is imitated, he represents as short, thick, but half filled, and strongly bound with packthread; which is exactly the form of a cracker. He then treats of different methods of preparing the match, and how one squib may set fire to another in the air, by having it enclosed within it. In short, he speaks as clearly of the composition and effects of gunpowder, as any body in our times could do. I own, I have not yet been able precisely to determine when this author lived, but probably it was before the time of the Arabian physician Mesue, who speaks of him, and who flourished in the beginning of the ninth century. Nay, there is reason to believe, that he is the same of whom Galen speaks. We see also by two passages, one of Aristotle, ‘the other of Pliny, that the art of making steel, and of tempering it, was known even in their time.

14. It has been sometimes objected to the facts I produce, that had the state of things been really so, their own utility would have preserved them from the outrages of time; our present ignorance therefore is alleged as of sufficient force, to invalidate whatever has been reported of the acquisitions of former times. But how frivolous this objection is, appears not only from the cause

assigned of our having lost the secret of rendering glass malleable, but also from those monuments which still remain, and are daily before our eyes, of the superiority of the ancients in many parts of chemistry: such as the Egyptian mummies, the paintings on glass, the perpetual lamps, &c. not to mention, that there are now many secrets, practised in different nations, and unknown in others, such as the Russian way of preparing leather, that of the Turks in tempering steel, that of the Chinese in making porcelain, the lacquer of the Japanese, and the dye of the Gobelins.

Chapter 06 - Of Sensible Qualities

Chapter 6 - Of Sensible Qualities

1.THERE is no part of philosophy which has made less progress among the vulgar, than that which treating of sensible qualities, dismisses them entirely from body, to make them reside in the mind. The most eminent philosophers of antiquity have acknowledged this truth; it sprung naturally from their principles, and they deduce the same consequences from it. Democritus, Socrates, Aristippus, Plato, Epicurus, and Lucretius, have clearly affirmed, that cold and heat, odours and colours, were no other than sensations, excited in our minds, by the different operations of the bodies surrounding us, and acting on our senses. And it is easy to show, that Aristotle himself was of this opinion, “that sensible qualities exist in the mind ;“ though by the obscure manner in which he opens himself, he hath given occasion to believe that he thought otherwise. There are only the schoolmen, who have positively affirmed, that sensible qualities exist in bodies as in minds; that there is in luminous bodies, for example, the very same thing that is in us when we view light. And as the philosophy of the schools had for some ages taken possession of men’s minds, when Descartes, and after him, Mallebranche, arose in opposition to the common prejudices, taking pains to draw the herd of philosophers out of the gross errors wherein they found them involved; it was not perceived, that in this they did nothing but renew the very same truths, which had been taught by Democritus, Plato, Aristippus, and Sextus Empiricus, supporting them likewise by the very same arguments, though sometimes farther extended.

Hence all the honour has been ascribed to these moderns, as if the error they attacked had been that of all ages; nobody designing to search any deeper, whether in reality, it was so or not. For had they given any attention to what the ancients had advanced, or consulted their writings, they would soon have found that some of them, not only stripped body of every power of exciting opinions in us, but even sometimes called in question its very existence. Yet this indolence in ascertaining the origin of our improvements, was not entirely universal. Gassendi had published a tract upon sensible qualities, and given also an abridgement of the Pyrrhonic philosophy respecting this subject, before ever Descartes attempted it; so that even among the moderns themselves, Descartes is not the first who clearly distinguished between the properties of spirit and body. And as to the ancients, a brief narrative of what Descartes and Mallebranche have said, compared with what those ancients taught, will quickly put the reader in a condition of deciding to whom that discovery ought to be attributed.

2.Descartes begins with remarking, that every one is accustomed from his infancy, to look upon whatever he perceives by his senses as existing out of his mind ; and having an entire resemblance to the perceptions which he finds there. Observing the colour of any object, for instance, we think we see something without ourselves, and residing in the objects, exactly resembling our idea of it; and, we acquire such a habit of judging in this manner, that we never entertain any doubt. This is the case of all our sensations; we seldom imagine that they exist only in the mind, but rather in our hand or foot, or some other part of our body. There is nothing

however more certain, than that the pain which we feel in our foot, is nothing but what the mind perceives as there ; in the same manner as the light we see as it were in the sun, is an idea raised by it in our minds. In the same manner we say, we perceive colours, or discern odours in objects; when these sensations arise in us from something or other in those objects. Such are the misconceptions of our infant state, from which we can hardly rescue ourselves even in advanced life.

3.Mallebranche seized this idea of Descartes, and more fully opened it. In his celebrated work, the research into truth, he begins with discovering that the source of our error is in the abuse of our liberty, and the precipitation with which we form judgment; insomuch, that our senses could not impose on us, were it not for our rashness, For example, when we see light, it is certain we do so; when we feel heat, there is no mistake in imagining we do; but we deceive ourselves when we fancy, that the heat and odours we perceive are external to the mind that feels them. He then combats the errors arising from our way of judging; and having stripped the body of its sensible qualities, instructs us how mind and body co-operate to produce our sensations, and how we accompany them with false judgments. He blames those who always judge of objects by the sensations they excite and by an appeal to their own feelings; for the feelings of all men being different, though things themselves continue the same, they must judge variously as they are affected, but ought not to ascribe the diversity of affections to the objects themselves.

4.Were we to bring into review all the ancients have taught on this subject, we should be surprised at the clearness with which they have explained themselves, and at a loss to account how opinions came to be taken for new, which had been already illustrated in their writings, with such force and precision. It cannot so much as be said, that the moderns have given a new turn to these opinions; for they not only reason upon the same principles, but employ the very same comparisons in proof of them.

5. Democritus was the first who disarrayed body of its sensible qualities. That great man, who admitted only of atoms and space as the principles of things. differed from all who had preceded him in that opinion, in that he affirmed, atoms were void of qualities ; and in this he was followed by Epicurus. He derived qualities from the different order and disposition of the atoms among themselves, as well from their diversity of figure; which, according to him, was the cause of all the various changes and modifications in nature; some of them being round, others angular, some straight, some pointed, some crooked, &c. “ Thus the first elements of things having in them neither whiteness nor blackness, sweetness, nor bitterness, heat nor cold, nor any other quality ; it follows, that colour, for example, exists Only in our perception of it; as also, that bitterness, and sweetness, which exist only in being perceived, are the consequences of the different manners in which we ourselves are affected by the bodies surrounding us, there being nothing in its own nature yellow, or white, or red, sweet or bitter."

6. Sextus Empiricus, explaining the doctrine of Democritus, says, “that sensible qualities,” according to that philosopher, “have nothing of reality but in the opinion of those who are differently affected by them, according to the different dispositions of their organs ; and that from this difference of disposition arise the perceptions of sweet and bitter, heat and cold ; and also, that we do not deceive ourselves in affirming that we feel such impressions ; but in concluding that exterior objects, must have in them something analagous to our feelings.”

7. Protagoras, the disciple of Democritus, says, that in man is contained the rule or measure of every thing ; that the whole existence of external things consists in the impression we perceive in ourselves; insomuch that what is imperceptible, has not the consequences of his system; for admitting, with his master, the perpetual mutability of matter, which occasioned a constant change in things; he then added, that whatsoever we see, apprehend, or touch, are just as they appear; and that the only true rule or criterion of things, was in the perception men had of them. I leave the reader to judge, whether Protagora's manner of thinking might not have transmitted to Berkely the idea of a system, which he with so much subtilty hath maintained "that there is nothing in external objects, but what the sensible qualities existing in our minds induce us to imagine, and of course that they have no other manner of existence; there being no other substratum for them, than the minds by which they are perceived: not as modes or qualities belonging to themselves, but as objects of perception to whatever is percipient."

8.We should think we were listening to the two modern philosophers, when we hear Aristippus exhorting men "to be upon their guard with respect to the reports of sense, because it does not always yield just information; for we do not perceive exterior objects as they are in themselves but only as they affect us. We know not of what colour or smell they may be, these being only affections in ourselves. It is not the objects themselves that we are enabled to comprehend, but are confined to judge of them only by the impressions they make upon us; and the wrong judgments we form of them in this respect, is the cause of all our errors. Hence, when we perceive a tower which appears round, or an oar which seems crooked in the water; we may say that our senses intimate so and so, but ought not to affirm, that the distant tower is really round, or the oar in the water crooked: it is enough, in such a case, to say, that we receive the impression of ,roundness from the tower, and of crookedness from the oar; but it is neither necessary nor proper to affirm, that the tower is really round, or the oar broken; for a square tower may appear round at a distance, and a straight stick always seems crooked in the water."

9.Aristippus says farther, "there is not in man any faculty that can judge of the truth of things, any farther than that men have given common names to their own apprehensions. Thus every body talks of whiteness and sweetness, but they have no common faculty to which they can with certainty refer impressions of this kind. Every one judges by his own apprehensions, and nobody can affirm that the sensation which he feels when he sees a white object, is the same with what his neighbour experiences in regard to the same object; and because the powers of apprehension are not entirely the same in all, it is temerity in us to assert, that what appears in such or such a manner to one, must needs do so to every body else: for one may be so constituted, that the objects which offer themselves to his eye may appear white, while to those of a man differently constituted they seem yellow; as is manifest in those who have the jaundice, or any other natural diversity of discernment, and who by reason of the different contexture of their organs, are incapable of receiving from the same things, the same impressions that others do. Thus he who has large eyes, will see objects in a different magnitude from him whose eyes are little; and he who bath blue eyes, discerns them under different colours from him who hath gray."

10. Plato, following Protagoras, clearly distinguishes between sensible qualities, and the objects which cause-them. He observes, that the same wind appears cold to one, and hot to another; to one soft, and to another rough: but "that we ought not thence to conclude, that the wind is in itself hot and cold at the same time ; but to say with Protagoras, that he who is hot, feels it hot," &c.

11. I come now to Epicurus, whose doctrine is explained with the greatest exactness by Plutarch, but above all by Diogenes Laertius. This philosopher, admitting the principles of Democritus, hath thence deduced the most natural consequences : “that atoms are all of the same nature, and differ only in figure, magnitude, and weight, and that in the constitution of every thing, they bear some affinity to its principal properties, such as roundness, bulk, &c. For colour, says he, cold and heat, and the other sensible qualities, are not inherent in the atoms, but the result of their assemblage : and the difference between them flows from the diversity of their size, figure, and arrangement: insomuch, that any number of atoms in one disposition, creates one Sort of sensation ; and in another, another: but their own primary nature remains always the same, because being solid and uncompounded, no parts transpire, otherwise nature would not be in the main fixed and stable ; and it is from the permanency of the properties essential to atoms of matter, that the different sensations arise, which the same. objects produce in animals of different species, and in men of different constitutions ; for each have in the organs of sight, hearing, and. the ether senses, an innumerable multitude of pores differently sized and situated; these are variously adapted and proportioned for the reception of the small corpuscles, which easily insinuate themselves into some, and with difficulty into others, (according to the analogy between them and the pores, and the variety of contexture in the parts) and of course must produce different impressions.”

12. So that the senses do not deceive us, for they are not judges of the nature of things; but serve only to inform us of the connexion and relation between the bodies surrounding us and our own, in subserviency to our happiness in this life: “whence it is obvious, that our sensations are always true, though the judgments we many times form respecting their objects are sometimes false :“ as must always be the case, whenever we alter those objects themselves which are the exterior causes of our sensations, by either adding something foreign to them or retrenching from them, what is properly their own. "If any think they are imposed upon by the different appearances which result from one and the same object; as, for example, when a body seen at a distance appears of one colour, and when nigh of another; it is themselves who are guilty of the deception, in imagining that the one appearance is true, and the other illusory; for in that, they form a false judgment, not rightly considering the nature of things ; whereas, they ought, on the contrary, to have concluded that both colours were true, though different, occasioned by the change of situations in which they were viewed, which produced two sensations not the same, but equally true.

Whence it also happens, that it is not the sound in the brass that is beaten, nor the voice itself of a person who sings, that are the objects of our perception, but only that which acts upon our ear; for one and the same thing cannot be in two different places at once. And as no man says, that his judgment is imposed upon, because a sound strikes him more feebly at a distance, than when he hath approached the place whence it comes: neither can we say, that our sight illudes us, when at a distance, a tower appears small and round, which upon our approach to it, would be found large and square: for the representative size of the object is in exact proportion to that of the angle formed by it in the eye, which varies according to the difference of the distance. In a word, the use of the senses is to represent objects to us under certain appearances; but not at all to judge what they are in themselves: and hence our sensations are always true; error being only the result of our judgment.”

13.1 have been the more large on this subject, because it is one of the most proper to prove the truth of my proposition, “that the moderns have often enriched themselves with the spoils of the

ancients, without having done them the honour of any acknowledgement.” With reason have we praised Descartes and Mallebranche, for having treated this matter with so much penetration. But they have scarcely advanced any thing but what had been said before by those ancient philosophers, whom I have been quoting.

Chapter 07 - Of Animated Nature

Chapter 7 - Of Animated Nature

1.THE ancients, says Mr. Buffon, understood much better, and made a greater progress in the natural history of animals and minerals than we have done. They abounded more in real observations; and we ought to have made much better advantage of their illustrations and remarks. Yet he does not often support his sentiment by their authority: hence one might be led to believe, that he did not himself perceive the analogy which every where reigns between his system, and that of the ancients. Let the reader himself determine of it, upon perusing what I have to offer. Meanwhile, it is but right to observe, that it cannot be concluded from Mr. Buffon's not supporting himself by the authority of the ancients, that he was not acquainted with their sentiments, and still much less, that having studied them, he did not discern the conformity between theirs and his own. And I make this observation with the less repugnance, because I do not hereby detract from the reputation of that able writer, who will always possess the merit of having, with the greatest sagacity, apprehended the principles of the Greek philosophers, and revived their reasonings; the greatest part of which had been ravaged by the injuries of time.

2. I cannot but look upon the restorer of the system of any great man, the frame of which only shows itself in a few remaining fragments, as upon an able sculptor, who, from the broken bust of Phidias, or any other famous ancient, is capable, by the strength of his own genius, and the skill he has in his art, exactly to judge by that single piece, of the proportions which ought to take place in every. member, so as to form and unite them together in so just a manner, that his statute shall be as perfect as the other. The merit of such a modern artist, doubtless, deserves great praise; but the glory of the ancient one will still be superior, because the idea of the proportions of the adjusted members, was taken from that of those in the broken bust. It is easy to apply this comparison to modern philosophers, of whom the most eminent, so far from seeking to avoid the charge of having borrowed their opinions from the ancients, have often been the first to own it; of which Descartes, and the principal Newtonians, furnish us with striking examples.

3.Diogenus Laertius, Plutarch and Aristotle inform us, that Anax agoras thought bodies were composed of similar or homogeneous particles; that those bodies, however, admitted a certain quantity of small particles that were heterogeneous, or of another kind; but that to constitute any body of a particular species, it sufficed that it was composed of a great number of small particles, similar and constitutive of that species. Different bodies were masses of particles similar among themselves; dissimilar however, relatively to those of any other body or to the mass of small particles, belonging to a different species. They believed, for example, that blood Was formed of many particles, each of which had blood in it; that a bone was formed of many small bones, which from their extreme littleness evaded our view. Likewise according to this philosopher, nothing was properly liable to birth or. to death; generations of every kind, being no other than an assemblage of small particles, constituent of the kind; and the destruction of a body being no other, than the disunion of many small bodies of the same sort, which always preserving a natural tendency to

reunite, produce again by their conjunction with other similar particles, other bodies of the same species.

Vegetation and nutrition were but means employed by nature for the continuation of beings: thus, the different juices of the earth, being composed of a collection of innumerable small particles intermixed, constituting the different parts of a tree or flower, take according to the law of nature, different arrangements; and by the motion originally impressed upon them, proceed, till arriving at the places designed and proper for them, they collect themselves and halt to form all the different parts of that tree or flower: in the same manner as many small imperceptible leaves go to the formation of the leaves we see; many little parts of the fruits of different kinds, to the composition of those which we eat; and so of the rest. The case was the same, according to that philosopher, with respect to the nutrition of animals. The bread we eat, and the other aliments we take, turn themselves according to this system, into hair, veins; arteries, nerves and all the other parts of our bodies; because there are in those ailments, the constituent parts of blood, nerves, bones, hair, &c. which uniting with one another, make themselves by their coalition perceptible, which they were not before, because of their infinite smallness.

4.Empedocles hath acknowledged the same with respect to animal nutrition, which be says, forms itself out of the substance of aliments proper and accommodated to the animal nature. He also taught, that matter had in it a living, principle, a subtile active fire, which put all in motion; and which Mr. de Buffon calls by another name, organized matter, always active; or, animated organic matter. And this matter, according to Empedocles, was distributed through the four elements among which it had an uniting force to bind them, and a separating, to put them asunder, for the small parts either mutually embraced, or repelled one another; whence nothing in reality perished, “but every thing was in perpetual vicissitude.” Whence it follows, according to the system of Empedocles, as well as that of Anaxagoras, nothing had either life or death, properly so called, but that the essence of things consisted in that active principle, whence they arose, and into which they all reduced themselves at last. He bad also a sentiment respecting generation, which Mr. de Buffon bath followed, expressing it in the very same terms ; where he says, that the seminal juices of the two sexes contain all the small parts analogous to the body of an animal, and necessary to its production.

5.Plotinus, following the idea of Empedocles, and investigating the reason of this sympathy in nature, discovered it to proceed from such a harmony and assimilation of the parts, as bound them together when they met, or repelled them when they were dissimilar; he says. that it is the variety of these assimilations that concur to the formation of an animal; and calls that binding or dissolving force, the magic of the universe: and his able interpreter, Marsilius Ficinus, explaining the sense of that passage, says, that the different parts of every animal, have an attractive virtue in them, by means of which they assimilate such parts of the aliment as best agree with them.

6.I come now to the system of Mr. de Buffon. He thinks with Anaxagoras, that there is in nature a common matter to animals and vegetables, which serves for the nutrition and expansion of all that lives or vegetates; and with Plotinus, that this matter contributes to their nutrition and expansion, in being assimilated to each part of an animal or vegetative body, and entering into their inmost pores. This nutritive and productive matter, is universally spread through all, and composed of organic particles, ever active, tending towards organization, and of themselves assuming a variety

of forms according to their situations; so that with Anaxagoras, he thinks there is no pre-existent seed, involving infinite numbers of the same kind, one within another: but an ever active organic matter, always ready so to adapt itself, as to assimilate, and render other things conformable to that wherein it resides : the species of animals and vegetables can never therefore exhaust themselves: but as long as an individual subsists, the species will be renewed. It is as extensive now, as it was at the beginning and all will subsist till they are annihilated by the Creator. It follows from these principles, that generation and corruption are only a differ. ent association or disjunction of similar parts, which after the dissolution of an animal or vegetable body, serve to reproduce another, of the species: provided, according to Mr. de Buffon, that those small constituent parts meet in a place proper for the expansion of them selves, so as to unclose what ought thence to result for the generation of an animal, or that they pass through the interior mould of an animal or vegetable, and assimilate themselves to the different parts in intimately adhering to them; and it is in this last respect only, that any difference subsists between the opinions of the ancients last mentioned, and the theory of Mr. de Buffon. He thinks that the similar and organic parts do not become specific, till after they have assimilated themselves to the different parts of the bodies, into whose composition they enter ; whereas Anaxagoras believed them always specific, and did not think that they had need to enter the inside of the parts in order to assimilate.

7.Another principle of Mr. de Buffon is, that when the nutritive matter abounds more than sufficient for the nourishment and expansion of an animal or vegetable body, it is remitted through all parts of the body, into one or more reservoirs, in form of a liquor, which is the semen of the two sexes, which mingled together, contributes to the' formation of a foetus, which becomes male or female in proportion as the seed of the male or female abounds more or less in the organic assemblages; and resembles father or mother, according to the different combinations of the two seeds. One finds all the origin of this idea in Pythagoras, Aristotle, Hippocrates.

8.It would be to stray from my subject, were I to treat of the merit of one or other of these systems. My scope will be sufficiently attained, if I make the analogy of them appear. It seems to me, that both of them are the productions of very fine geniuses; that of Anaxagoras is more intricate, and not supported by the exact experiments, which sustain that of Mr. de Buffon; it were to be wished, therefore, that the Greek philosopher had discovered the principles traced out by the modern; but the advantage the one had of making use of a microscope, ought not to turn to, the disadvantage of the other; yet hereafter, we shall see, that the ancients, in this respect, did not long remain behind.

There is another system, which is no less ingenious than this, and of which we find equal traces among the ancients.

Chapter 08 - Nature Active And Animated

CHAPTER VIII NATURE ACTIVE AND ANIMATED

1.After a long course of microscopic observations, Mr. Need. ham hath remarked, that they all contributed to make appear, that animal and vegetative substances are originally the same; that they reciprocally turn into one another, by a very easy change ; that they decompound themselves into an infinite number of zoophytes, which separating, produce all the different species of common microscopic animals, which after a certain time become immoveable, separating themselves again, and producing other zoophytes, or animals of an inferior species; that the spermatic animalcules have the same property of separating themselves, and in their decomposition of producing still smaller animals, till at last the)' become so very small, that they entirely escape notice. The author of these observations believes, that it is probable besides, that every animal or vegetable substance advances as much as it can to its dissolution, to return by degrees to the principles common to all bodies, and which are of a general nature.

2.The author then insinuates, that in their decomposition, bodies so subtilize themselves, that the resistance continually diminishes, and the active moving force proportionally augments; that after having passed the line of spontaneity, the movement diminishes quicker or slower, till it becomes purely oscillatary ; and of course, matter ought to be considered as continually passing from one state to another, and constituting elements more and more active.

3.A little afterward, he hesitates not to affirm, that in proportion as the matter decompounds itself, it becomes more subtile, and that the swiftness of those bodies increases in proportion to their littleness. He says, that every combination of matter reduces itself at last to such simple parts, as those are of resistance and motion ; that resistance and motive activity, are the effect of simple energies; and in short, that a number of beings, simple and unextended, may contribute to give us an idea of an extended combination of them, divisible and substantial. lie says afterward, that the principles of matter are substances in which all essence, existence, and action, terminate in their last resort, and “that there are active principles in the universe, which are naturally productive of motion." In short, he concludes with saying, that matter, carried to its first principles, is no longer an unactive mass, “but becomes at length, activity itself, endowed with the powers of repulsion, motion, and life, and that every particle of it partakes of sensations : and in another place he says, that there is a perceivable life in every particle; and in short, that there is “a real, active force in matter."*

4. IF we compare this system with that of the ancients, we shall easily discover a striking conformity. Pythagoras and Plato taught, that all nature was animated, and that “matter had in itself a principle of motion and rest, tht held it always in action ; which is no other, according to the system of Mr. Needham, than active, combined with repelling force.

5. The Pythagoreans believed, that the world was animated ; that there was a principle of vitality infused through the whole of nature, which extended itself not only through the animal kingdom,

but through the vegetable, by a succession constant and perpetual; they acknowledged a productive force, an active principle through matter, which penetrated all, and put all in motion, and which was the soul of the world, or the force impressed by God on nature.

6.And it is this which Mr. Needham calls the active principles through the universe, which of themselves produce motion, or the perceptive vitality in every particle; that motive, or repulsive activity, which Plato also joined to matters as an active principle, which held all from the beginning, in an irregular and indetermined movement ; and which, from the foundation of the world, was regulated by God, and directed according to his eternal laws ; and that great philosopher positively says, that God has not created matter inert and inactive; but hath only prevented it from being blindly agitated.

7. Mr. Needham indeed says, that every natural combination can, at last. resolve itself into its natural principles, endowed with resistance and motion; and that a number of simple and indivisible principles might concur to give us an idea of extended combinations of them, divisible and substantial: yet Plato long before had clearly distinguished, with philosophers of his own times, the matter of which bodies are composed. from the bodies themselves. He remarked an essential difference between that matter, which enters into the composition of all bodies, and the bodies themselves. And Stoboeus, explaining Plato's sentiments, agrees, that matter is corporeal, but at the same time warns us not to confound it with the bodies themselves because, says he, it is destitute of the essential qualities of body ; such as figures, weight, lightness, &c. although it contains in it an aptitude to motion, divisibility, and the reception of different forms. And another great Grecian philosopher hath also said, almost in the same terms with Mr. Needham, that the ideas of force, impenetrability and weight concur to give us an idea of bodies.

*Though this doctrine may be considered as absurd, yet here we are not left destitute of facts, which are capable of assisting our judgment, and directing our research to a sentiment at once rational and conclusive. It will not be called in question by the boldest metaphysician, that there is such a principle, property or quality, (call it what we will,) in being, as vitality, and that it is capable of acting upon, and organizing gross matter: and consequently, that there is a susceptibility, or capacity pervading all matter, and by prosecuting a review of the facts presented to our contemplation on the grand theatre of being, we should at length attain to the conclusion, that it pleased the Creator of worlds so to construct them, and that they should consist in d a proportions of vitality, and susceptibility: and that he has in his wisdom ordained a mutual and invincible attraction between the vital and susceptible powers of universal being. So that one could not exist without a proportion of the other: and there are many circumstances to favour the idea, that on the variety and preponderance of these proportions, depends in an extensive degree. the variety and diversity of organized being.

8.Pythagoras, Plato, and Aristotle, held a sentiment respecting generation, to which that of Mr. Needham's evidently refers: this author says, that the first source of vegetation, or its primitive bud, is formed all at once, and specifically determined : that it is the first thing in motion, that it commences vegetation, and that afterward heat concurs to assist its expansive force. Now, is it not this which the ancient Philosophers meant, when they said, that the seminal force was incorporeal, and acted upon bodies as much is spirit did And Democritus and Straho have explained themselves hereupon with still more dignity, when they call its energy spiritual, and

convertive of bodies into itself.

Chapter 09 - Of Thunder and Earthquakes; Of the Virtue of Tile Magnet; Of the Ebbing and Flowing ...

Chapter 9 - Of Thunder and Earthquakes; Of the Virtue of Tile Magnet; Of the Ebbing and Flowing of the Sea; And of the Source of Rivers

1.I go on to some articles of natural philosophy, where I shall endeavour to show the conformity there is between the ancients, and some of our most celebrated philosophers. It is evident, that the causes of thunder, earthquakes, the attractive force of the loadstone, the ebbing and flowing of the sea, and the return of rivers to their source were not hid from the former: nor was it their fault, that the sentiments they so long ago held on these subjects, were either not adopted, or not till very lately. It ought not to be objected here, that the diversity of opinions among them was not so great, that it was difficult to determine which to choose: unless at the same time, it be acknowledged, that the same holds true with respect to the equal variety that reigns at present among us. It is not long ago, that two or three different sets of notions were raised up against those of Sir Isaac Newton, respecting colours, but that did not impede the triumph of his system, nor strip him of the glory of having proposed, what, beyond all others, was most just and solid.

2.The moderns are divided into two opinions as to what occasions thunder; some of them assigning the cause of it to inflamed exhalations, rending the clouds wherein they are confined; others ascribing it to the shock that happens between two or more clouds, when those that are higher and more condensed, fall upon those that are lower, with so much force as suddenly to expel the Intermediate air, which vigorously expanding itself, in order to occupy its former space, puts all the exterior air in commotion, producing those reiterated claps which we call thunder. I stop not to examine a third theory, which makes the matter productive of thunder, the same with that which is the cause of electricity; for though it be the most probable of any, yet the truth of it is still contested.

3.Of those two sentiments of the ancients, which have been adopt ed by our moderns, the latter belongs to Aristotle, who says, that thunder is caused by a dry exhalation, which falling upon a humid cloud, and violently endeavouring to force a passage for itself, produces the peals which we hear. And Anaxagoras refers it to the same cause. All the other passages, which occur in such abundance among the ancients, respecting the formation of thunder, evidently con-thin the reasonings of the Newtonians, and sometimes join together the two sentiments which divide the moderns.

4.Leucippus held, that thunder proceeded from a fiery exhalation, which enclosed in a cloud, burst it asunder, and forced its way through. Democritus asserts, that it is the effect of a mingled collection of various volatile particles, which impel downwards the cloud which contains them, till by the rapidity of their motion, they set themselves and it on fire. Seneca ascribes it to a dry sulphureous exhalation arising out of the earth, which he calls the aliment of lightning; and which, becoming more and more subtilized in its ascent, at last takes fire in the air, and produces a

violent eruption.

5.The Stoics distinguish two things in thunder, the lightning and the noise. According to them, thunder was occasioned by the shock of clouds ; and lightning was the combustion of the volatile parts of the cloud, set on. fire by the shock: and Chrysippus taught, that lightning was the result of clouds being set on fire by winds, which dashed them one against another; and that thunder was the noise produced by that re-encounter: he added, that these effects were coincident ; our perception of the lightning before the thunder-clap, being entirely owing to our sight being quicker than our hearing.

6.There is but one opinion respecting the cause of earthquakes, which deserves any notice; and it is that of the Cartesians, Newtonians, and all our other able naturalists, They ascribe it to the earth's being filled with cavities of a vast extent, containing in them an immense quantity of thick exhalations, of a fuliginous substance, resembling the smoke of an extinguished candle, which being easily inflammable, arid by their agitation catching fire, rarely and heat the central condensed air of the cavern to such a degree, that finding no vent to issue it, it bursts its enclosements ; and in doing this, shakes the earth all around with dreadful percussions, producing all the other effects which naturally follow.

7. The same reason is given by Aristotle and Seneca, in assigning the cause of such dreadful events. The former, after refuting those who ascribed earthquakes to the earth itself, or the water it contains, subjoins his own opinion, "that they were occasioned by the efforts of the internal air in dislodging itself from the bowels of the earth ;" and he observes, that "on the approach of an earthquake, the weather is generally serene, because that sort of air which occasions commotions in the atmosphere, is at that time pent up in the entrails of the earth."

8.Seneca is still more precise ; we might take him for a naturalist of the present times. He supposes, that "the earth hides in its bosom many subterraneous fires which uniting their flames, necessarily put into fervid motion the congregated vapours of its cells, which finding no immediate outlet, exert their utmost powers, till at last they force a way through whatever opposes them." He says also, that if the vapours be too weak to burst the barriers which retain them, all their efforts end in weak shocks, and hollow murmurs, without any fatal consequence..

9.Of all the solutions that ever were attempted to be given of the ebbing and flowing of the sea, the most simple and ingenious, is, that of Kepler and Sir Isaac Newton. It is founded on this hypothesis, that the moon attracts the waters of the sea, diminishing the weight of all those parts of it over whose zenith it comes, and increasing the weight of the collateral parts, so that the parts directly opposite to the moon, and under it in the same hemisphere, must become more elevated than the rest. According to this system, the action of the sun concurs with that of the moon, in occasioning the tides; which are higher or lower respectively, according to the situation of those two luminaries, which, when in conjunction, act in concert, raising the tides to the greatest height; and when in opposition, produce nearly the same effect, in swelling the waters of the opposite hemispheres: but when in quadrature, suspend each other's force, so as to act only by the difference of their powers: and thus the tides vary, according to the different positions of those luminaries.

*would be more philosophical to say, the moon attracts the atmosphere, and the waters naturally conform themselves to its figure, or to its various degree! of pressure. See Note to page 451, vol. I.

10.Pliny's account agrees with this. That great naturalist. maintained, " that the sun and moon had a reciprocal share in causing the tides ;" and after a course of observations for many years, remarks that the moon acted most forcibly upon the waters, when it nearest to the earth, but that the effect was not immediately perceived by us, but at such an interval as may well take place between the actions of celestial causes, and the discernible result of them on earth. He remarked also, that the waters, which are naturally inert, do swell up immediately upon the conjunction of the sun and moon; but having gradually admitted the impulse, and begun to raise themselves continue in that elevation, even after the conjunction is over.

11.There are few things which have more engaged the attention of naturalists, and with less success, than the wonderful properties the loadstone. At all times men have hazarded a variety of conjectures, to account for the curious effects of it. Almost all have agreed in assigning this as a principal reason, that there are corpuscles of a peculiar form and energy, that continually circulate around and through, the loadstone, and a vortex of the same matter, circulating around and through the earth. Upon these suppositions, the modern philosophers have advanced, that the loadstone hath two poles, similar to those of the earth ; and that the magnetic matter which issues at one of the poles, and circulates around to enter at the other, occasions that hath pulse which brings iron to the loadstone, whose, small corpuscles have an analogy to the pores of iron, fitting them to lay hold of it, but not of other bodies. This is almost all that hath been reasonably advanced with respect to the virtue of the magnet, and all this the ancients had said before.

12.This impulsive force, which joins iron to the loadstone, and other things to amber, was known to Plato ; though he would not call it attraction, as allowing no such cause in nature. This philosopher called the magnet, the stone of Hercules, because it subdued iron, which conquers every thing. Lucretius also knew what caused this property in the loadstone, and without doubt furnished Descartes with his explanation. He admitted, that there was a "vortex of corpuscles, or magnetic matter, which continually circulating around the load-stone, repelled the intervening air betwixt itself and the iron. The air thus repelled, the intervening space," says that philosopher,." became a vacuum ; and the iron, finding no resistance, approached with an impulsive force, pushed on by the air behind it." Plutarch likewise is of the same opinion. He says, "amber attracts none of those things that are brought to it, any more than the loadstone. That stone emits a matter, which reflects the circumambient air, and thereby forms a void. That expelled air puts in motion the air before it, which making a circle returns to the void space, driving before it, towards the loadstone, the iron which it meets in its way." He then proposes a difficulty, " why the vortex which circulates round the loadstone, does not make its way to wood or stone, as well as iron " He answers, like Descartes, that the pores of iron have an analogy to the particles of the vortex circulating about the loadstone, which yields them such access as they can find in no other bodies, whose pores are differently formed.

13. It is scarce credible, that the real cause of electricity was known to the ancients, though there be indications of it in the work of Timoeus Locrensis, concerning the soul of the world, a respectable monument of ancient philosophy. It is true, that modern naturalists themselves are divided on this point, not indeed with respect to the general cause of electricity, hut with regard to

the causes of the different directions of the electric matter. They do not indeed say wherein the essence of this matter consists; they only define it by its properties, and explain it by its effects; yet all own, that it is “a very subtile fluid,” residing around electric bodies, which upon being put into motion by the friction of those bodies, or any other cause, forcibly rushes into them, carrying along with it all the minute things contained in its vortex, and producing all the other effects of electricity which we perceive : now this is precisely what Tioemus says of it, in giving the reason of amber’s attracting bodies ; “ this happens,” says he, “ because there issues from the amber a subtile matter, by which it draws other bodies to itself.”

14.The moderns are also divided in their sentiments, how it comes to pass, that rivers continually flowing into the sea, do not swell its mass of waters, so as to make it overflow its banks. One of the chief solutions of this difficulty is, that rivers return again to their source by subterraneons passages, which nature hath formed for that purpose; there being between the sea and the springs of rivers, a circulation analogous to that of blood in the human body. This explanation of the origin of rivers, and the comparison respecting their circulation, is taken from Seneca: who accounts not only for their not overflowing the bed of the ocean, by the secret passages formed for them by nature to reconduct them to their springs; but assigns this reason why, at their springs, they retain nothing of that brackishness, which they carried with them from the sea; because, says he, they are completely filtrated in that extensive circuit they make under ground, through winding paths of all dimensions, and through layers of every soil ; so that they must needs return to their source, as pure and sweet as they departed thence.

Chapter 10 - Of Ether. And the Weight and Elasticity of the Air

Chapter 10 - Of Ether. And the Weight and Elasticity of the Air

1. THE moderns understand by ether, a very rare fluid beyond the atmosphere, and penetrating it, infinitely more subtile than the air we respire, of an immense extent, filling all the Spaces where the celestial bodies roll, yet making no sensible resistance to their motions. The existence of such a fluid is generally acknowledge, although many authors, even among the moderns, differ about its nature; some supposing it to be a sort of air, much purer than that which invests our globe; others maintaining, that it is a substance approaching to that of the celestial fire, which emanates from the sun and other stars; others make it generically different from all other matter, and its parts finer than those of light; alledging, that the exceeding tenuity of its parts, render it capable of that vast expansive force, which is the source of all that pressure and dilatation whence most of the phenomena in nature arise; for, by the extreme subtlety of its parts, it intimately penetrates all bodies, and exerts its energy every where.

2.But, whatever be the sentiments now entertained with respect to the existence and nature of ether, we find the origin of them all in what the ancients have said on this subject. The Stoics first of all taught, there was a subtile and active fire, which diffused itself through, and pervaded the whole universe; that by the energy of this ethereal substance, to which they gave the name of ether, all the parts of nature were produced, sustained, preserved, and linked together: for it embraced every thing, and in it the celestial bodies perform their revolutions.

3.Aristotle, explaining Pythagoras’s opinion of ether, ascribes the same also to Anaxagoras, saying, that he looked upon the most remote spaces of the universe, as filled with a substance, called ether by the philosophers of his time, but which he himself understood to be a subtile and active tire. And Aristotle himself, in another place, understands by ether, a fifth element, pure and unalterable, of an active and vital nature, but entirely different from air and fire.

4.Pythagoras, according to Diogenes Laertius, and Hierocles, affirmed, that the air which invests our earth, is impure and mixed; but that the air which is above, is pure, healthful, and all of a piece. He calls it free ether, emancipated from all gross matter, a celestial substance that penetrated at will the pores of all bodies; just like that of the Newtonians, which fills all space, without giving any obstruction to the stars in their courses. And Empedocles, one of the most celebrated disciples of Pythagoras, is quoted by Plutarch, St. Clemens Alexandrinus, as admitting an ethereal substance, which filled all space, and contained in it all the bodies of the Universe.. Likewise Plato, speaking of air, distinguishes it into two kinds, the one gross and filled with vapours, which is what we breathe; the other more refined, called ether, in which the celestial bodies are immerged, and where they roll.

5.The nature of air was no less known among the ancients, than that of ether. They regard it as a general menstruum, containing all the volatile parts of every thing in nature, which being variously agitated, and differently combined in its embrace, produced all that multiplicity of ferments,

meteors, tempests, and all the other changes in it, which we experience. They were acquainted too with its weight, though the experiments transmitted to us relative to this are but few. Aristotle appears to have observed this quality in it, for he speaks of a vessel filled with air, as weighing more than one quite empty. Plutarch and Stobceus quote him as teaching that the air in its weight is between that of fire, and of earth; and be himself', treating of respiration, reports the opinion of Empedocles, who ascribes the cause of it to the weight of the air, which by its pressure insinuates itself with force into the lungs. Plutarch expresses in the very same terms the sentiments of Asciepiades on this subject, representing him among other things, as saying, that the external air by its weight, opened its way with force into the breast. There is still extant a treatise of Heron of Alexandria, wherein he constantly applies the elasticity of the air, to produce such effects, as cannot but convince us, that he perfectly understood that property of it. And what will appear still more surprising, is, that Ctesibius, upon the principle of the air's elasticity, invented windguns, which we look upon as a modern contrivance. Philo of byzantium gives us a very full and exact description of that curious machine, planned upon the property of the air's being capable of condensation, and so constructed, as to manage and direct the force of that element, in such a manner, as to carry stones with rapidity to the greatest distance. Seneca also knew its weight, spring, and elasticity; for he describes the constant effort it makes to expand itself, when it is impresssed; and affirms, that it has the property of condensing itself, and forcing its way through all obstacles that oppose its passage.

6.The notions generally received respecting fire, and its properties, are clearly to be found in Plato, Stoboeus, Aristotle, and Lucretius; the first of whom says, that fire is generated of motion, it being the effect of the act and friction of the small particles of bodies. Aristotle speaks of some philosophers of his time, who taught, that flame was nothing else, but small corpuscular parts, continually succeeding one another in rapid motion ; that fire was composed of pyramidical particles whose sharp angles stung us in entering our pores, and melted metals, by discovering their parts, which is what Descartes hath repeated from him. Demonax affirms, that fire hath weight. Lucretius does the same; adding, that the reason of its always appearing to tend upwards, is owing to a foreign cause; to wit, the pressure of the air, which buoys its flame up, and makes it seem to mount.

Chapter 11 - Newtons Theory of Colours, Indicated by Pythagoras and Plato

Chapter 11 - Newton’s Theory of Colours, Indicated by Pythagoras and Plato

1. THAT the wonderful theory, whereby is investigated and distinguished from one another, all that variety of colours, which enters into the composition of that uniform appearance, light, might of itself suffice to establish forever the glory of Sir Isaac Newton, and be an eternal monument of the extraordinary sagacity of that great man. That discovery seems. by its importance, to have been reserved for an age when philosophy had arrived at its fullest maturity ; and yet it is to be found among some of the eminent men of the first antiquity, whose genius had no occasion for the experience of many ages to form it, as is strikingly evident from their having given birth to the sciences. Of this number are Pythagoras and Plato. The former of whom, and. his disciples after him, entertained sufficiently just conceptions of the formation of colours. They taught that they resulted from the differ-. ent modifications of reflected light; or as a modern author, in explain. ing the sentiments of the Pythagoreans, expresses it, light reflecting itself with more or less vivacity, forms by that means our different. sensations of colour. Those same philosophers of the Pythagoric school, in assigning the reason of the difference in colours, ascribe it to a mixture of the elements of light ; and divesting the atoms, or small particles of light, of all manner of colour, impute every sensation of that kind to the motions excited in our organs of sight. The disciples of Plato contributed not a little to the advancement of optics, by the important discovery they made, that light emits itself in straight lines, and that the angle of incidence is always equal to the angle of reflection.

2.Plato also seems to have apprehended the Newtonian system of colours; for he calls them the effect of light transmitted from bodies, the small particles of which were adapted to the organs of sight. Now is not this precisely the same with what Sir Isaac teaches, “that the different sensations of each particular colour are excited in us by the difference of size in those small particles of light which form the several rays; those small particles occasioning different images of colour, as the vibration is more or less lively with which they strike our sense” The same philosopher hath gone further: lie bath entered into a detail of the composition of colours, and inquired into the visible effects that must arise from a mixture of the different rays of which light itself is composed. And what he advances a little farther on, that it was not in the power of man exactly to determine what the proportion of this mixture should be in certain colours, sufficiently shows, that lie bad an idea of this theory, though he judged it almost impossible to unfold it; which makes him add, that “should any one arrive at the knowledge of this proportion, he ought not to hazard the discovery of it, since it would be impossible to demonstrate it by clear and convincing proofs ;“ and yet he thought “certain rules might be laid down” respecting this subject “if in following and imitating nature, we could arrive at the art of forming a diversity of colours, by the combined intermixture of colours.” And he afterward adds, what may be regarded as the noblest eulogium that ever was made on Sir Isaac Newton: “yea, should ever any one,” exclaims that fine genius of antiquity, “attempt by

curious research to account for this admirable mechanism, he will, in doing so, but manifest how entirely ignorant he is of the difference between Divine and human power. It is true, God can intermingle those things one with another, and then sever them at his pleasure, because he is, at the same time, all-knowing and all. powerful; but there is no man now exists, nor ever will perhaps, who shall ever be able to accomplish things so very difficult." What an eulogimn are these words in the mouth of such a philosopher as Plato, and bow glorious is he who hath successfully accomplished what appeared impracticable to that prince of philosophers! And what elevation of genius, what piercing penetration into the most intimate secrets of nature, displays itself in what we have just now recited from Plato, concerning the nature and theory of colours, at a time when philosophy was but yet in its infancy.

3.Although the system of Descartes, respecting the propagation of light in an instant, is scarcely admitted at present by the most part of philosophers, nor has been ever since Messrs. Cassini and Romer discovered that its motion was progressive; yet as that system was for a long while in vogue, and the whole honour of the invention of it ascribed to Descartes, it will not be amiss, in a few words, to make appear, that he drew the idea of it from Aristotle and his commentators. The opinion of the modern philosophers is, that light is nothing else but the action of a subtile matter upon the organs of sight. This subtile matter is supposed to fill all that space which lies between the sun and us; and that particle of it, which is next to the sun, receiving thence an impulse, must instantaneously communicate it to all the rest which lie between the sun and the organ of sight. To render this the more evident, Descartes introduces the comparison of a stick; which, by reason of the continuity of its parts, cannot in any degree be moved lengthways at one end, without instantaneously being put into the same degree of motion at the other end.

4.Whoever will be at the pains attentively to read what Aristotle hath written concerning light, without having recourse to the ridiculous interpretations that have been put upon his words, will clearly discern, that he was far from being so unacquainted with the truth in this case, as is generally thought. He defines it to be the action of a subtile, pure, and homogeneous matter; and Philoponus explaining the mariner in which this action was performed, makes use of the instance of a long string, which being pulled at one end, will instantaneously be moved at the other. In that very place, he resembles the sun, to the man who pulls the string; the subtile matter, to the string itself; and the instantaneous action of the one, to the movement of the other. Simphicius, in his commentary upon this passage of Aristotle, expressly employs the motion of a stick, to imitate how light, acted upon the sun, may instantaneously impress the organs of sight. The comparison of a stick, to convey an idea of the celerity with which light may communicate itself, seems first of all to have been made use of by Chrysippus.

Chapter 12 - Of Burning Glasses

Chapter 12 - Of Burning Glasses

1.The fertile genius of Archimedes, illustriously appears, not only in those works of his which have been handed down to us, but also in the admirable descriptions which the authors of his time have given us of his discoveries in mathematics and mechanics. Some o the inventions of this great man have appeared so far to surpass human ability and imagination, that some celebrated philosophers have called them in question, and even gone so far as to pretend to demonstrate their impossibility. I intend in this chapter, to examine into the subject of the burning glasses, employed by Archimedes, to set fire to the Roman fleet, at the siege of Syracuse. Kepler, Naudeus and Descartes, have treated it as a mere fable, though the reality of it bath been attested by Diodorus Siculus, Lucian, Dion, Zonaras, Galen, Anthemius, Eustathias, Tzetzes and others. Nay, some have even pretended to demonstrate by the rules of catoptrics, the impossibility of it, notwithstanding the asseveration of such respectable authors, who ought to have prevented them from rejecting so lightly, a fact so well supported.

2.Yet all have not been involved in this mistake. Father Kircher attentively observing the description which Tzetzes gives of the burning glasses of Archimedes, resolved to prove the possibility of this; and having by means of a number of plain mirrors, collected the sun’s rays into one focus, he so augmented the solar heat, that at last by increasing the number of mirrors, he could produce the most intense degree of it.

3.Tzetzes’ description of the glass Archimedes made use of, is indeed proper to raise such an idea as Kircher entertained. That author says, Archimedes set fire to Marcellus’ navy, by means of a burning glass, composed of small, square mirrors, moving every way upon hinges; which, when placed in the sun’s rays, directed them upon the Roman fleet, so as to reduce it to ashes, at the distance of a bow-shot. It is probable, Mr. de Buffon availed himself of this description, in constructing his burning glass, composed of one hundred and sixty-eight little plain mirrors, which produced so considerable a heat as to set wood in flames at the distance of two hundred and nine feet; melt lead, at that of one hundred and twenty; and silver, at that of fifty.

4.Another testimony occurs, which leaves not the least doubt in this case. Anthemius, of Tralles, in Lydia, a celebrated architect, able sculptor, and learned mathematician, who in the emperor Justinian’s time, built the church of St. Sophia, at Constantinople, wrote a small treatise in Greek, which is extant only in manuscript, entitled, “Mechanical Paradoxes.” That work, among other things, has a chapter respecting burning glasses, where we meet with the most complete description of the requisites that Archimides must have been possessed of, to enable him to set lire to the Roman fleet. He begins with this inquiry, "How in any given place at a bow-shot’s distance, a conflagration may be raised by means of the sun’s rays “ And immediately lays it down as a first principle. “The situation of the place must be such, that the rays of the sun may be reflected upon it in an oblique, or even opposite direction, to that in which they came from the sun itself.” And he adds, “that the assigned distance being so considerable, it might appear at first

impossible to effect this, by means of the reflection of the sun's rays; but as the glory Archimides had gained by thus setting fire to the Roman vessels, was a fact universally agreed in, he thought it reasonable to admit the possibility of it, upon the principle he had laid down."

He afterward advances farther in this inquiry, establishing certain necessary propositions in order to come at a solution of it. "To find out therefore, in what position a plain mirror should be placed, to carry the sun's rays by reflection to a given point, he demonstrates that the angle of incidence is equal to the angle of reflection; and having shown, that in so just a position of the glass, the sun's rays might be reflected to the given place, he observes, that by means of a number of glasses, reflecting the rays into the same focus, there must arise the given place, the conflagration required, for inflaming heat is the result of thus concentrating the sun's rays; and that when a body is thus set on fire, it kindles the air around it, so that it comes to be acted upon by the two forces at once; that of the sun, and that of the circumambient air, reciprocally augmenting and increasing the heat ;" whence continues lie, "it necessarily results, that by a proper number of plain mirrors duly disposed, the sun's rays might be reflected in such quantity into a common focus at a bow shot distance as to set all in flames around it."

5. "As to the manner of putting this in practice," he says "it might be done by employing many bands to bold the mirrors in the described position; but to avoid the confusion that might thence arise, twenty-four mirrors at least, being requisite to communicate flame at such a distance, lie fixes upon another method, that of a plain hexagon mirror, accommodated on every side by lesser ones, adhering to it by means of plates, bands, or hinges, connecting them mutually together, so as to be moved or fixed at pleasure in any direction. Thus having adapted the large or middle mirror to the rays of the sun, so as to point them to the given place, it will be easy in the same manner to dispose the rest, so that all the rays together may meet in the same focus : and multiply compound mirrors of this kind, and giving them all the same direction, there must thence infallibly result, to whatever degree or intenses, the conflagration required at the place given."

6. "The better to succeed in this enterprise, there should be in. readiness," he adds, "a considerable number of these compound mirrors to act all at once, from four at least to seven." He concludes his dissertation with observing, "that all the authors who mention the burning machine of the divine Archimedes, never speak of it as one compound mirror, but as a combination of many." So large and accurate a description is more than sufficient to demonstrate the possibility of a fact, so well attested in history, and by such a number of authors, that it would be the highest arrogance to refuse our suffrage to such invincible testimony. Vitellion, who lived about the 13th century, speaks of a work of Anthemius of Tralles, who had composed a burning glass, consisting of twenty-four mirrors, which conveying the rays of the sun into a common focus, produced an extraordinary degree of heat. And Lucian, speaking of Archimedes, says,. "that at the siege of Syracuse, he reduced by a singular contrivance, the Roman ships to ashes." And Galen, "that with burning glasses, he fired the ships of the enemies of Syracuse." Zonoras also speaks of Archimedes' glasses, in mentioning those of Proclus, who, he says, "burnt the fleet of Vitellius, at the siege of Constantinople, in imitation of Archimedes, who set fire to the Roman fleet at the siege of Syracuse." He intimates, that the manner in which Proclus effected was by launching upon the enemies' vessels, from the surface of reflecting mirrors, such a quantity of flame, as reduced them to ashes.

7.Eustathias, in his commentary upon the Iliad, says, that “Archimedes, by a catoptric machine, burnt the Roman fleet, at a bow shot’s distance." Insomuch, that there is scarcely any fact in history, warranted by more authentic testimony; so that it would be difficult not to surrender to such evidence, even although we could not comprehend how it were possible for Archimedes to have constructed such glasses: but now that the experiment of father Kircher, and Mr. de Buffon, have made it apparent, that nothing is more easy in the execution, than what some gentlemen have denied the possibility of; what ought they to think of the genius of that man, whose inventions even by their own accounts, surpass the conception of the most celebrated mathematicians of our days, who think they have done something very extraordinary, when they have showed themselves capable of imitating in some degree the sketches of those great masters, of whom, however, they are very unwilling to be thought the disciples!

8.Again, it appears that the ancients were acquainted with refracting burning glasses; for we find in Aristophanes’ comedy of the clouds, a passage which clearly treats of the effects of those glasses. The author introduces Socrates as examining Strepsiades, about the method he had discovered for getting clear forever of his debts. He replies, that” he thought of making use of a burning glass, which he bad hitherto used in kindling his fire; for,” says he,” should they bring a writ against me, I’ll immediately place my glass in the sun, at some little distance from the writ, and set it on fire.” Where we see he speaks of a glass which burned at a distance, and which could he no other than a convex glass. Pliny and Lactantius have also spoken of glasses that burnt by refraction. The former calls them balls or globes of glass, or crystal, which exposed to the sun, transmit a heat sufficient to set fire to cloth, or corrode away the dead flesh of those patients who stand in need of caustics; and the latter, after Clemens Alexandrinus, takes notice, that fire may be kindled, by interposing glasses filled with water, between the sun and the object, so as to transmit the rays to it.

Chapter 13 - Of Universal Gravity, and Centripetal and Centrifugal Force

Chapter 13 - Of Universal Gravity, and Centripetal and Centrifugal Force Laws of the movement of the planets, according to their distance from the common centre.

1. IT is here the moderns flatter themselves they have a remark able advantage, imagining, that they were the first who discovered the principle of universal gravitation, which they look upon as a truth known to the ancients. It is however easy to make it appear, that they have done nothing but trod in the paths of those ancients. It the moderns have demonstrated the laws of this universal gravitation, and explained them with clearness and precision; but this is all they have done in this respect, and have added nothing.

2.With the least attention to the knowledge of the ancients, we that they were not unacquainted with universal gravitation; and knew besides, that the circular motion, by which the planets describe their course, is the result of the combination of two moving forces, a rectilinear and a perpendicular, which, united together, form a curve. They knew the reason why these two movements, or contrary forces, retain the planets in their orbs; and have explained themselves on this head, just as the moderns do, excepting only the terms of centripetal and centrifugal; instead of which, however, they used what was altogether equivalent. They also knew the inequality of the course of the planets, ascribing it to' the variety of their weights reciprocally considered, and of their proportional distances.

3. I will not expatiate upon Empedocles' system, in which some have thought the foundation of Newton's was to be found; imagining, that under the name of love, he intended to initiate a law, or power, which separated the parts of matter, in order to join himself to them, and to which nothing was wanting but the name of attraction. One sees also, that by the name discords be intended to describe another force, which obliged the same parts to recede from one another, and which Newton calls a repelling force. But I leave Empedocles, and pass on' to passages more deserving notice. -

4.The Pythagoreans and Platonics, treating of the creation of the world, perceived the necessity of admitting the force of two powers, viz, projection and gravity, in order to account for the revolution of the planets. Timoeus, speaking of the soul of the world, which puts all nature in motion, says, that God "hath endowed it with two powers, which, in combination, act according to certain numeric proportions." Plato, who hath followed Timoeus, in his natural philosophy, clearly asserts, that God had impressed upon the planets" a motion which was the most proper for them ; which could be nothing else than the perpendicular motion, which has a tendency to the Centre of the universe, that is, gravity ; and what in this case coincides with it, a lateral impulse, rendering the whole circular. And Diogenes Laer alluding in all likelihood to this passage of Plato, says, that at the beginning, the bodies of the universe were agitated tumultuously, and with a disorderly movement, but that God afterward regulated their course, by laws natural and proportional.

5.Anaxagoras cited by Diogenes Laertius, being asked what it was that retained the heavenly bodies in their orbit, notwithstanding their gravity ; answered, that" the rapidity of their course preserved them in their stations ; and should the celerity of their motions abate," the equilibrium of the world being broke, the whole machine would fall to ruin.

6.Plutarch, who knew almost all the shining truths of astronomy, took notice also of the reciprocal energy, which causes the planets to gravitate towards one another; and in explaining what it was that made bodies tend towards the earth, he attributes it "to a reciprocal attraction, whereby all terrestial bodies have this tendency, and which collects into one the parts constituting the sun and moon, and retains them in their spheres. He afterward applies these particular phenomena to others more general; and " from what happens in our globe, deduces, according to the same principle, whatever must thence happen respectively in each celestial body ;" and then considers them in their relative connexions one towards another. He illustrates this general connexion, "by instancing what happens to our moon in its revolution round the earth, comparing it to a stone in a sling, which is impressed by two powers at once; that of projection, which would carry it away, were it not retained by the embrace of the sling; which like the central force, keeps it from wandering, whilst the combination of the two moves it in a circle. In another place, he speaks "of an inherent power in bodies ; that is, in the earth and other planets; of attracting to themselves whatever is within their reach." It is impossible, not to perceive in all these passages, a plain reference to the centripetal force, which binds the planets to their proper or common centres; and to the centrifugal, which makes them roll in circles at a distance.

7.We have seen that the ancients attribute to the celestial bodies, a tendency towards one common centre, and a reciprocal attractive power. Lucretius well perceived this truth, though he deduced' from it a very strange consequence, that the universe had no common centre, but that infinite space was filled with an infinity of worlds like ours; for, says he, if the celestial bodies were all of them carried towards one common centre, and not restrained from that tendency by some exterior active force, they must needs soon diverge towards one another, by virtue of their attractive power, and like bodies tumbling from on high, reunite at the common centre of gravity, and into one infinite, inactive mass.

8.It appears also, that the ancients knew, as well as the moderns the cause of gravitation, which attracted all things, did not reside solely in the centre of the earth. Their ideas were more philosophic; "That this power was diffused through every particle of the terrestrial globe, and compounded of the various energy residing in each."

9.It remains to inquire, whether the ancients knew the law by which gravity acts upon the celestial bodies; that it was in an inverse proportion of their quantity of matter, and the square of their distance. Certain it is, that the ancients were not ignorant, that the planets, in their courses observed a constant and invariable pro portion; and that they had different opinions respecting this proportion. Some sought for it in the difference of the quantity of matter contained in the masses, of which they were composed; and others, in the differences of their distances. Lucretius, after Democritus and Aristotle, thought that " the gravity of bodies was in proportion to the quantity of matter of which they were composed ;" and the ablest Newtonians, even such as ought to be the most interested to preserve to their master the glory of having first discovered those truths, which are 'the principal ornaments of his system, have been the first to point at the sources whence they

seem to have been drawn. It is true the penetration and sagacity of a Newton, a Gregory, and a Maclauren, were requisite to discover, in the few fragments now remaining, the inverse' law respecting the squares of the distances, a doctrine which Pythagoras had taught ; but it is no less true, that it was contained in those writings. This the Newtonians acknowledge, and are the first to avail themselves of the authority of Pythagoras, to give weight to their system.

10.Plutarch, of all the philosophers who have spoken of Pythagoras, is he, who, as be had a better opportunity of entering into the ideas of that great man, bath explained them better than any one besides. Pliny, Macrobrius, and Censorinus, have also spoken of the harmony which Pythagoras observed to reign in the course of the planets. Plutarch makes him say, it is probable that the bodies of the planets, their distances, the intervals between their spheres, and the celerity of their courses and revolutions, are not only proportionable among themselves, but to the whole of the universe. And Gregory bath been led to declare, it was evident to any attentive mind, that this great man understood, that the gravitation of the planets towards the sun, was in a reciprocal ratio of their distance from that luminary; and that illustrious modern, followed herein by Naclaurin, makes that ancient philosopher speak thus:

11. " A musical string," says Pythagoras, "yields the very same tone with any other of twice its length, because the tension of the latter, or the force whereby it is extended, is quadruple to that of the former "and the gravity of one planet, is quadruple to that of any other which is at double the distance." in general, to bring a musical string into unison with one of the same kind, shorter than itself, its tension ought to be increased to Proportion as the square of its length exceeds that of the other ; " and that the gravity of any planet, may become equal to that of any other nearer the sun, it ought to be increased in proportion as the square of its distance exceeds that of the other." If, therefore, we should suppose musical strings stretched from the sun to each of the planets, it would be necessary," in order to bring them all to unison, "to augment or diminish their tensions, in the very same proportion as would be requisite to render the planets themselves equal in gravity." And this, in all likelihood, gave foundation for the reports, that Pythagoras drew his doctrine of harmony from the spheres.

12.Before I finish this chapter, 1 must not neglect to insert a passage of Galileo's, wherein he acknowledges, that he owes to Plato his first idea of the method of determining, how the different degrees of velocity, ought to produce that uniformity of motion discernable in the revolutions of the heavenly bodies. His account is, "Plato being of opinion, that no moveable thing could pass from a state of rest' to any determinate degree of velocity, so as perpetually and equally to remain in it, without first passing through all the inferior degrees of celerity or retardation; concludes thence, that God, after having created the celestial bodies, determining to assign to each a particular degree of celerity, in which they should always move, impressed upon them, when he drew them from a state of rest, such a force as made them run through their assigned spaces, in that natural and direct way wherein we see the bodies around us pass from rest into motion, by a continual and successive acceleration. And he adds, that having brought them to that degree of motion wherein he intended they should perpetually remain ; he afterward changed the perpendicular into a circular direction, that being the only course that can preserve itself uniform, and make a body without ceasing to keep at an equal distance from its proper centre." This acknowledgment of Galileo is the more remarkable, as it comes from an inventive genius, who least of any owes his eminence to the aid of the ancients ; for it is the disposition of noble minds to arrogate to

themselves as little as possible any merit, but what they have the utmost claim to. Thus do Galileo and Newton, the greatest of all modern philosophers, set an example which will never be imitated but by those of their own class.

Chapter 14 - Of the Copernican System; The Motion of the Earth about the Sun; And the Antipodes

Chapter 14 - Of the Copernican System; The Motion of the Earth about the Sun; And the Antipodes

1.THERE are other truths taught by the ancients long ago, at last adopted by the moderns; after having undergone a not uncommon fate, that of being rejected and condemned with disdain. That the earth moves about the sun, and that there are antipodes, are particulars known long ago, though received almost every where at first with contempt or ridicule; nay, they have sometimes proved dangerous to those who held them; yet both these doctrines are now so well established, that they meet with general approbation. And thus, for two ages past, have we gone on to re-introduce the most celebrated of the ancient opinions; still affecting, however, not to know that we are in any manner indebted to those who first held them.

2.The most reasonable in itself, and what agrees best with the most accurate observations, is that system of the world proposed by Copernicus, who places the sun in the centre, the fixed stars at the circumference, and the earth and other planets in the intervening space; and who ascribes to the earth not only a diurnal motion around its axis, but an annual round the sun. This system is entirely simple, and best explains all the appearances of the planets, and their situations, whether processional, stationary, or retrograde; but it is matter of surprise, how a system so fully and distinctly inculcated by the ancients, should derive its name from a modern philosopher. Pythagoras, Philolaus, Nicetas of Syracuse, Plato, Aristarchus, and many others among the ancients, have in a thousand places expressed this opinion; and Diogenes Laertius, Plutarch, and Stobceus, have with great precision transmitted to us their ideas. And that this system was no sooner universally received, ought entirely to be ascribed to the force of prejudice; which, deciding every thing by appearances, prefers sense to reason, and abandons whatever is not conformable to the judgment of the former.

3.Pythagoras thought the earth was a moveable body, ‘and so far from being the centre of the world, performed its revolutions around the region of fire, that is the sun, and thereby formed day and night. It is said he obtained this knowledge among the Egyptians, who represented the sun emblematically by a beetle, because that insect keeps itself six months under ground, and six above; or, rather because having formed its dung into a ball, it afterward lays itself on its back, and, by means of its feet, whirls that ball round in a circle.

4. Some impute this opinion to Philolaus, the disciple of Pythagoras; but it is evident, he had the merit only of being the publisher of it, and several other opinions belonging to that school; for Eusebius expressly affirms, that he was the first who put Pythagoras’ system into writing. Philolaus added, that the earth moved in an oblique circle; by which no doubt, he meant the zodiac.

5.Aristarchus, of Samoa, who lived about three centuries before Jesus Christ, was one of the principal defenders of the doctrine of the earth’s motion. Archimedes, in his book, “de Arenario,”

informs us, “that Aristarchus, writing on this subject against some of the philosophers of his own age, placed the sun immoveable in the centre of an orbit, described by the earth in its circuit. And Sextus Empiricus, also cites him as one of the principal supporters of this opinion. There is, also, a passage in Plutarch, whereby it appears, that Clean-thes accused Aristarchus of impiety, in troubling the repose of Vesta, and all the Larian gods; when, in giving an account of the phenomena of the planets in their courses, he taught that heaven, or the firmament of the fixed stars, was immoveable: and that the earth moved in an oblique circle, revolving at the same time around its own axis.

6.Theophrastus, as quoted by Plutarch, says, in his history of astronomy, which bath not reached our times, “that Plato when, advanced in years, gave up the error he had been in, of making the sun turn round the earth ; and lamented, that he had not placed it in the centre; but put the earth there, contrary to the order of nature. Nor is at all strange, that Plato should reassume an opinion which he bad early imbibed in the schools of the two celebrated Pythagoreans, Archytas of Tarentum, and Timeus the Locrian; as we see in St. Jerome’s christian apology against Rufinus: and in Cicero, we see that Heraclides of Pontus, who was a Pythagorean, taught the same doctrine.

7. That the earth is round and inhabited on all sides, and of course that they are antipodes, or those whose feet are directly opposite to ours, is one of the most ancient doctrines inculcated by philosophy. Diogenes Laertius says, that Plato was the first, who called the inhabitants of the earth opposite to us, antipodes. He does not mean, that Plato was the first who taught this opinion, but only the first who made use of the term antipodes; for, in another place, he mentions Pythagoras as the first who taught it. There is also a passage in Plutarch, whereby it appears, that it was a point of controversy in his time : and Lucretius and Pliny, who oppose this notion, as well as St. Augustine, all serve as witnesses that it must have prevailed in their time.

8.I make no mention of the condemnation of bishop Virgilius by pope Zachary, for having taught this doctrine, because it is a mistake: the pope, in that letter of his to St. Boniface, speaks only of those who maintained, that there was another world besides this of ours, another sun, another moon, and so on.

9.As to the proofs which the ancients brought of the sphericity of the earth, they were the very same that the moderns make use of Pliny on this subject observes, that the land which retires out of sight to persons on the deck of a ship, appears still view to those who are upon the mast ; and thence concludes that the earth is round Aristotle drew this consequence not only from the shadow of the earth’s being circular on the disk of the moon in the time of an eclipse, but also from this circumstance, that in travelling south we discover other stars, and that those which we saw before, whether is the zenith, or elsewhere, change their situation with respect to us.

Chapter 15 - Of the Revolution of the Planets about Their Own Axis

Chapter 15 - Of the Revolution of the Planets about Their Own Axis

1.HOW useful an aid the invention of telescopes bath been to the astronomical observations of the moderns, is particularly evident from their discovery, that the planets revolve on their axis; a discovery founded on the periodical revolution of the spots observed on their disks: so that every planet performs two revolutions, by the one of which it is carried with others about a common centre; and by the other moves upon its axis round its own. But all that the moderns have advanced in this respect, serves only to confirm to the ancients the glory of being the first discoverers. The moderns are in this to the ancients, as the French Philosophers are to Sir Isaac Newton, all whose Labours and travels in visiting the poles and equator to determine the figure of the earth, serve only to confirm what Sir Isaac had thought of it, without so much as stirring from his closet. in the same manner, we have proved, that most of our experiments have served, and do still contribute to confirm and support the conjectures of the ancients; although it bath often happened, that those very conjectures of theirs, which are now so generally received as true, have formerly been as generally decried. Of this we have had instances in the preceding chapter, and the present will exhibit another not less remarkable.

2.Whatever were the arguments upon which the ancients founded their theory, certain it is, they clearly apprehended, that the planets revolved upon their own axis.. Heraclides of Pontus, and Exphantus, two celebrated Pythagoreans, intimated this truth long ago, and made use of a very apt comparison to convey their idea, saying, that the earth turned from west to east, just as a wheel does upon its axis or centre. And Plato extended this observation from the earth to the other planets; for, according to Atticus, the Platonic, who explains his opinion, “to that general motion which makes the planets describe a circular course, he added another resulting from their spherical shape, which made each of them move about its own centre, whilst they performed the general revolution of their course.” Plotinus also ascribes this sentiment to Plato, for speaking of him, he says, that besides the grand circular course observed by all the stars in general, he thought “they each performed another about their own centre.”

3.Cicero ascribes the same notion to Nicetas of Syracuse, and quotes Theophrastus to warrant what he advances ; this is he whom Diogcnus Laertius names Hycetas, whose opinion was, that the celerity of the earth’s motion about its own axis, and otherwise, was the only cause of the apparent revolutions of the heavenly bodies.

4.Our secondary planet, the moon, gave the ancients an opportunity of displaying their penetration. They early discovered, that it had no light of its own, but shone with that which it reflected from the sun. This, after Thales, was the sentiments of Anaxagoras and of Empedocles, who thence accounted not only for the mildness of its splendour, but the imperceptibility of its heat; which our experiments confirm: for with all the aid of burning glasses, we have never yet found it practicable to produce the least effect of heat from any combination of its rays.

5.The observations made by the moderns, tend to persuade us, that the moon has an atmosphere, though very rare. In a total eclipse of the sun, there appears about the disk of the moon, a glimmering radiance, parallel to its circumference, which becomes more arid more extenuated or rare, as it diverges from it. This, perhaps, is no other than an effect proceeding from such a fluid as air; which by reason of its weight and elasticity, is rather more dense at bottom than at top. With a telescope we easily discern in the moon, parts more elevated and more bright than others, which are judged to the mountains. We discern also other parts lower and less bright, which seem to be vallies lying between those mountains. And there are other parts, which reflecting less light, and presenting one uniform, smooth surface, are supposed to be large pieces of water. If the moon then has its collections of water, its atmosphere, its mountains and its vallies ; it is thence inferred, that there may also be rain there, and snow, and all the other aerial commotions natural to such a situation, and our idea of the wisdom and power of God intimates to us, that he may have placed creatures there to inhabit it ; rather than that all this display of his skill should be a mere waste.

6.The ancients, who had not the aid of telescopes, supplied the defect of that instrument by a vivacity of' penetration; for, without the means that we have, they have deduced all those consequences that are admitted by the moderns: and discovered long before by the mental eye, whatever bath since been presented to corporeal sight through the medium of telescopes.

7. We see by some fragments of theirs, in how sublime a manner and worthy of the majesty of the deity, they entered into the views of that Supreme Being, in his destination of the planets, and that multitude of stars placed by him in the firmament. They looked upon them as so many suns, about which rolled planets of their own, such as those of our solar system. Nay they went farther, maintaining that those planets contained inhabitants, whose natures they presume not to describe, though they suppose them to yield to those' of ours, neither in beauty nor in dignity. Orpheus is the most ancient whose Opinion on this subject hath come down to us. Proclus presents us with three verses of that ancient philosopher, wherein he positively asserts, that the moon was another earth, having in it mountains, vallies, &c.

8. Pythagoras, who followed Orpheus in many of his opinions, taught likewise, that the moon was an earth like ours, replete with animals, whose nature he presumed not to describe, though be was persuaded, they were of a more noble and elegant kind than ours, and not liable to the same infirmities.

9.It were easy here to multiply quotations, and show, by a cro!d of passages, that this opinion was very common among the ancient philosophers ; but I shall content myself with adding a remarkable passage of Stoboeus, wherein he gives us Democritus's opinion about the nature of the moon, and the cause of those spots which we see upon its disk. That great philosopher imagined, that those spots were no other than shades, formed by the excessive height of the lunar, mountains, which intercepted the light from the lower parts of that planet, where the vallies formed themselves into what appeared to us. as shades or spots. Plutarch went farther, alleging, that there were ernbosomed in the moon, vast seas and profound caverns. These, his conjectures, are built upon the same foundation with those of the moderns: for, says he, "those deep and extensive shades which appear upon the disk of that planet, must be occasioned by the vast seas it contains, which are incapable of reflecting so vivid a light, as the more solid and opaque parts; or by caverns extremely wide and deep, wherein the rays of the sun are absorbed, whence those

shades and that obscurity which we call the spots of the moon.” And Zenophanes said, that those immense cavities were inhabited by another race of men, who lived there, just as we do upon earth.

10.Yet it appears from one place in Plutarch, that in his time, as well as of late, it was disputed by many, whether the moon yielded any exhalations or vapours for the production of rain and the other meteors. He took part with those who held the negative, being persuaded that the moon must be so intensely heated by the never ceasing action of the sun’s rays upon it that all its humidity must be dried up, so as to render it incapable of furnishing new vapours; whence he concludes, that there existed there, neither clouds, nor rains, nor winds; and of course, neither plants nor animals. Now, this is the very reason alleged by such of the moderns as oppose the notion of the moon’s being inhabited; whereas, the only necessary consequence is, that the inhabitants of that planet must be entirely different from those of ours, and by their constitution fitted to such a clime, and such a habitation. But, however this be; it appears from this passage, that the opinion here mentioned, had partizans even in Plutarch’s time, who were no less fertile than we are in conjectures to support it.

Chapter 16 - The Milky Way; Solar Systems, or a Plurality of Worlds

Chapter 16 - The Milky Way; Solar Systems, or a Plurality of Worlds

1.THAT lucid, whitish zone, which is seen in the firmament among the fixed stars, must have for a long while attracted the attention of the ancients, and occasioned them to advance a great many conjectures about the reason of it, and among the various opinions respecting it, many without doubt, must to us appear groundless, since one only can be true. But this kind of deficiency is what will befal genius in every age, however bright, and especially those who appeared in remote ages. A course of centuries so familiarizes the discovery of any truth, after it hath gained the general consent, that we are astonished, men of real ability, should ever have hesitated about things which we have known from our infancy; and we never give ourselves the trouble to think, that the day perhaps shall come when the idea of Locke and Leibnits, and those of the Newtonians, respecting attraction, and of our other naturalists upon other subjects, will be regarded by posterity, as things so obvious, that they will be amazed, how such great men could for any time resist such evidence. Should any one of us appear to them to have discerned the truth, in those points which are at present in debate, how many of us will seem to have advanced nothing but reveries: and it will be happy, if, among such a variety of opinions, some be found to be true; for it is no inconsiderable thing among men, when at great intervals, some one or other arises among them, who, with sure steps, so advances as to keep clear of those devious paths wherein others. had wandered. This' hath frequently happened among the moderns, and so it also did among the ancients. Truth often beamed through the obscurity in which their knowledge was enveloped. Many erred in their conjectures, whilst only one or two discovered the right course, and pointed it out to others; so we, of this age, direct our views by the beams of those geniuses who have illuminated it.

2.The milky way and fixed stars, have been an object of inquiry to many philosophers. As to the former of these, the Pythagoreans held that it had once been the sun's path. and that he had left in it a trace of white, which we now observe there. The Peripatics have asserted, after Aristotle, that it was formed of exhalations, pended high in air. I easily admit, that there were mistakes but all were not mistaken in their conjectures. Democritus, of a telescope, preceded Galileo in remarking, "that what we call the milky way, contained in it an innumerable quantity of fixed star mixture of whose distant rays occasioned the whiteness which we denominate :" or to express it in Plutarch's words, "it was the united brightness of an immense number of stars. -

3.The ancients were no less clear in their conceptions of the nature of the fixed stars than we are; for it is but a short while ago. that the moderns adopted the ideas of those great masters on this subject after having rejected them during many ages. It would be reckoned an absurdity in philosophy at present, to doubt of those stars being suns like ours, each respectively having planets of their own which revolve around them, and form various solar systems, more or less resembling that of ours. All philosophers at present admit of this theory; and even less philosophic minds, begin to render this conception familiar to them, thanks to the elegant work of Mr. de Fonte

nelle.

4.And this notion of a plurality of worlds, was generally inculcated by the Grecian philosophers. Plutarch, after having given an account of it, says, " that he was so far from finding fault with it, that he thought it highly probable there had been, and were, like this of ours an innumerable, though not absolute infinite multitude of worlds; wherein were, as well as here, land and water, invested by sky."

5.Anaximenes was one of the first who taught this doctrine. He believed, that the stars were immense masses of fire, around which certain terrestrial globes, imperceptible to us, accomplished their periodic revolutions. It is evident, that by these terrestrial globes, turning round those masses of fire, he meant planets, such as ours, subordinate to their own sun, and forming along with him a solar system.

6.Anaximenes agreed with Thales in his opinion which passed from the Ionic to the Italic sect : who held that every star was a world, containing in itself a sun and planets, all fixed in that immense space which they call ether.

7.Heaclides and all the Pythagoreans taught the same, that "every star was a world, or solar system, having, like this of ours, its sun and planets invested with an atmosphere of air, and moving in the fluid ether, by which they were sustained." This opinion seems to have been of still more ancient origin. We find traces of it in the verses of Orpheus, who lived in the time of the Trojan war, and taught that there was a plurality of worlds ; a doctrine which Epicurus also looked upon as very probable.

8.Origin, in his Philosophumena, treats amply of the opinion of Hernocritus, saying, "that he taught, that there was an innumerable multitude of worlds, of unequal size, and differing in the number of their planets; that some of them were as large as ours, and placed at unequal distances; that some were inhabited by animals, which he could not take upon him to describe ; and that some had neither animals nor plants, nor any thing like what appeared among us." For that truly philosophic genius discerned, that the different nature of those spheres required inhabitants of very different kinds.

9.It appears, that Aristotle who held this opinion, as did likewise Alcinous, the Platonic, and Lewis Coelus de Rovigo, ascribes it to Plotinus; who held besides, that the earth, compared to the rest of the universe, was one of the meanest globes in it.

10. It was certainly in consequence of such an idea, that Phavorinus struck out into that remarkable conjecture of his, of the existence of other planets, besides those known to us. He was astonished bow it came to be admitted as certain, that there were no other wandering stars or planets, but those observed by the Chaldeans. As for his part, be thought that their number was more considerable than was vulgarly given out, though they had hitherto escaped our notice. Here in all likelihood he alludes to the reality of those satellites, which have since become manifest by means of the telescope. It required singular penetration to be capable of forming this supposition, and of having, as it were, predicted this discovery. Seneca makes mention of a similar notion of Democritus: who, in a treatise which he wrote concerning the planets, of which only the title has been banded down to us, supposes that there were many more of them, than had yet come within our view; though he says nothing either of their names or magnitude.

Chapter 17 - Of Comets

Chapter 17 - Of Comets

1.There is no extravagance of fancy, how wild soever, but what hath been hazarded in different ages to account for the nature of comets, and the irregularity of their course. Even in the last age Kepler and Hevelius advanced conjectures entirely extravagant, respecting the cause of these phenomena. Mr. Cassini, and after him Sir Isaac Newton, have at length given certainty to the opinions of the philosophers in this respect, by observations and calculations most just and accurate; or to speak with more propriety, upon recalling and fixing our attention upon what had formerly been advanced by the Chaldean Egyptians, Anaxagoras, Democritue, Pythagoras, Hippocrates Seneca, Appolonius, Myndius, and Artemidorus. For in treating of the nature of these stars, their definitions of them, the reasons they assign for the rareness of their appearance, and the apologies they make for not having yet formed a more exact theory, are all in the very terms that Seneca had already used. With respect to the time of that philosopher, we have formerly taken notice, that the collecting together the observations anciently made by the returns of comets was not sufficient to establish the theory of them; because, their appearances were so very rare, that there had not been an opportunity of making a proper number of observations, to determine whether their course was regular or not; but that the Greeks, who had some time before observed this, were applying themselves to researches of this kind.

2.Seneca, in the same place acquaints us, that the Chaldeans looked upon comets as planetary bodies; and Diodorus Siculus, in his history, giving an account of the extent of knowledge among the Egyptians, praises them for the application with which they studied the stars and their courses: where he remarks, that they had collect ed observations very ancient and very exact, fully informing them of the several motions, orbits and stations of the planets; adding also, that they could foretell earthquakes, inundations and the return of comets.

3.Aristotle, in laying down the opinion of Anaxagoras and Demo critus, says of the first, that he apprehended comets to be an assemblage of many wandering stars; which, by their approximation, and the mutual blending of their rays, rendered themselves visible to us. This notion was far from being philosophical, yet was it preferable to that of some great moderns, such as Kepler and Hevelius. who would have it, that they were formed out of air, as fishes are out of water.Pythagoras, who approached very near to the times of Anaxagoras, taught. according to Aristotle’s account, an opinion worthy- of the most enlightened age; for he looked upon comets as stars, which circulated regularly, though elliptically about the sun, and which appeared- to us only in particular parts of their orbit, and at considerable distances of time; and the error which Aristotle falls into, in endeavouring- to explain Pythagoras’ sentiment, by a comparison referring to the planet Mercury, ought not to be imputed to the Pythagoric-school. Aristotle relates also, the testimonies of Hippocrates of Chois, and Aeschylus, in confirmation of this opinion.

4.Stoboeus presents us with Pythagoras’ sentiment in the very terms of Aristotle, though somewhat more clearly; for he says they imagined the comets to be wandering planets, which

appeared only at certain times during their course.

5.Upon the whole, Seneca, more than any other, hath discussed this subject like a true philosopher. in his seventh book of natural questions, he relates all the different opinions respecting comets, and seems to prefer that of Artemidorus, who imagined, “that there was an immense number of them, but that their orbits were so situated, that so far from being always within view, they could only be seen at one of the extremities.” He afterward reasons upon this with equal elegance and solidity. “Why should we be astonished, says he, that comets, which are so rare a spectacle in the world, have not yet come under certain rules: or that we have not hitherto been able to determine, where begins or ends the course of planets, as ancient as universe, and whose returns are at such distant intervals The time will come, cries he, that posterity will be amazed at our ignorance in. things so very evident; for what now appears so obscure, will one day or other, in the course of ages, and through the industry of our descendants, become manifestly clear; but a small number of years, passed between study and the indulgence of passion, will not avail for researches so important, as those which propose to themselves the compression of nature so remote.”

6.Upon a review of the several passages which we have just now cited, it must now be admitted, that the moderns have said nothing solid with regard to comets, but what is to be found in the writings of the ancients: except what later observations have furnished them with, which Seneca judged to be so necessary, and which only can be the effect of a long succession of ages.

Chapter 18 - Of the Refraction of Light, and Astronomical Refraction; And of Perspective

Chapter 18 - Of the Refraction of Light, and Astronomical Refraction; And of Perspective

1.THE Arabians applied themselves with much assiduity to the study of the sciences, and the situation of their climate led them to prefer astronomy, which they cultivated very early. There are a considerable quantity of their writings in our large repositories for books, which have never yet come under our notice, having still remained in manuscript in their original language: so great has been our neglect of them for some ages. Yet those who have been at the pains curiously to ransack those manuscripts, have been well rewarded for their trouble, by the acquisition they have thence made of many new and original ideas, and the information they have received of various inventions and discoveries, useful and entertaining. A learned gentleman at Oxford, who carefully examined the Arabian manuscripts in the famous library of that university, gives his sanction to this in a manner that should engage others to imitate his example in such researches. Among other motives naturally tending to produce the effect, he says, “the advantages recommending the study of astronomy to the people of the east were many. The serenity of their weather; the largeness and correctness of the instruments they made use of much exceeding what the moderns would be willing to believe; the multitude of their observations and writings, being six times more than what have been composed by Greeks and Latins; and, in short the number of powerful princes, who, in a manner becoming their own magnificence, aided them with protection. One letter is not sufficient, says he, to show in how many respects the Arabian astronomers detected the deficiency of Ptolomy, and the pains they took correct him; how carefully they measured time by water-clucks, sandglasses, immense solar dials, and even what perhaps will surpris you. the vibrations of the pendulum; and with what assiduity and accurately they conducted themselves in those nice attempts, which do so much honour to human genius in the taking the distances of the stars, and the measure of the earth.”

2.Hence it is manifest that the vibration of the pendulum was employed by the ancient Arabians, long before the epocha we ordinarily assign for its first discovery; and the use it was applied to, was, exactly to measure time, the very purpose for which we employ it.

3.The discovery of the refraction of light, is of more ancient origin than is generally imagined; for the cause of it appears to have’ been known to Ptolomy. According to Roger Bacon’s account, that great philosopher and geometrician gave the same explanation of that phenomenon, which Descartes has done since; for he says, that a ray, passing from a more rare into a more dense medium, becomes more perpendicular. Ptolomy, wrote a treatise on optics, which was extant in Bacon’s time; and Alhazen seems not only to have known that treatise of Ptolomy, but to have drawn thence whatever is truly estimated in what he advances about the refraction of light, astronomical refraction, and the cause of the extraordinary size of planets when they appear on the horizon. This last point, discussed with so much warmth between Mallebranche and Regis, had already been adjusted by Ptolomy.

4.Ptolomy, and after him Alhazen, said, that “when a ray of light passes from a more rare, into a more dense medium, it changes its direction when it arrives upon the surface of the latter, describing a line which intersects the angle made by that of its first direction, and a perpendicular falling upon it from the more dense medium.” Bacon adds, after Ptolomy, that the angle formed by the coincidence of those two lines, is not always equally divided by the refracted ray; because in proportion to the greater or less density of the medium, the ray is more or less refracted, or obliged to decline from its first direction.” In this he approaches very near to the reason assigned by Sir Isaac Newton, who deducing the cause of refraction, from the attraction made upon the ray of light by the bodies surrounding it says, “ that mediums are more or less attractive in proportion to their density.”

5.Ptolomy, acquainted with the principle of the refraction of light, could not fail to conclude, that this was the cause also of what was called astronomic refraction, or of the appearance of planets upon the horizon before they came there; having recourse therefore to this principle, he accounted for those appearances from the difference there was between the medium of air, and that of ether winch lay beyond it; so that the rays of light coming from the planet, and entering into the denser medium of our atmosphere, must of course be so attracted as to change their direction, and by that means bring the star to our view, before it really came upon the horizon. Alhazen tells us of a method whereby we may assure ourselves of this truth by observation. He bids us “take an armillary sphere, and upon it measure the distance of any star from the pole, when it passes nearest its zenith under the meridian, and when it appears on the horizon. This last, he says, will be its smallest distance.” He then makes it appear, that refraction is the cause of this phenomenon. Yet Alhazen advances nothing but what he derived from Ptolomy ; and neither one nor other of them have applied this important discovery in astronomy. so as to deduce from it, that the apparent elevation of the stars, when near the horizon, necessarily requires to be corrected.

6.Roger Bacon, inquiring into the cause of that difference of magnitude in stars when seen on the horizon, from what they have when viewed over head, says, in the first place, that it may proceed from this: “that the rays coming from the star are made to diverge from each other, riot only by passing from the rare medium of ether into the denser one of our surrounding air, but also by the interposition of clouds and vapours arising out of’ the earth, which repeat the refraction and augment the dispersion of the rays, whereby the object must needs be magnified to our eye." “Though, says he afterward there has been assigned by Ptolemy and Alhazen, another cause for this; these authors thought that the reason of a star’s appearing larger at its rising or setting than when viewed overhead arose from this: that when the star is over head, there are no immediate objects perceived between it and us, so that we judge it nearer to us, arid are not surprised at its littleness ; but when a star is viewed on the horizon, it lies then so low, that all we can see upon earth. interposes between it and us, which making it appear at a greater distance, we imagine it larger than it is. For the same reason the sun and moon, when appearing upon the horizon, seem to be at a greater distance, by reason of the interposition of those objects, which are upon the surface of our earth, than when they are over head; and consequently, there will arise in our minds an idea of their largeness, augmented by that of their distance, and this of course must make it appear larger to us when viewed on the horizon, than when seen in the zenith.

7.Most of the learned deny the ancients the advantage of having known the rules of perspective, or of having put them in practice although Vitruvius makes mention of the principles of Democritus

and Anaxagoras respecting that science. in a manner that plainly shows they were not ignorant of them. “Anazagoras and Democritus," says he, “were instructed by Agatarchus the disciple of They both of them taught the rules of drawing, so as to imitate from any point of view the prospect that lay in sight, by making the lines in their draught, issuing from the point of view there, exactly resemble the radiation of those in nature; insomuch that, however ignorant any one might be of the rules whereby this was performed, could not but know at sight the edifices, and other prospects which offered themselves in the perspective scenes they drew for the deco ration of the theatre; where, though all the objects were represented on a plain surface, yet they swelled out, or retired from the sight, just as objects do endowed with all dimensions.” Again, he says, “that the painter Apatarius drew a scene for the theatre at Tralles, which was wonderfully pleasing to the eye, on account that the artist had so well managed the lights and shades, that the architecture appeared in reality to have all its projections.”

Plato, in two or three places of his dialogues, speaks in such a manner of the effects of perspective, as makes it evident that he was acquainted with its principles. Pliny says, “that Pamphilus, who was an excellent painter, applied himself much to the study of geometry, and maintained, that, without its aid, it was impossible ever to arrive at perfection in that art ;“ which holds certainly true with respect to perspective. And a little farther he uses an expression, which can allude to nothing-but perspective; when he says, “that Apelles fell short of Asclepiodorus, in the art of laying down distances in his paintings.” Lucian, in his dialogue of Zeuxis, speaks of the effects of perspective in pictures. Philostratus, in his preface to his drawing, or history of painting, makes it appear that he knew this science; and in the description be gives of Menoetuis’ picture of the siege of Thebes, he places full in sight the happy effects of perspective when studied’ with care. There he extols the genius of this painter, who, in representing the walls of the place invested, and scaled by soldiers, placed some of them full in view, others to be seen only as far as the knee, others only at- half length, and others whose heads only, or helmets, were seen, till the whole ended in the points of the spears of those who were not seen at all ; and he adds, that all this was the effect of perspective, which’ deceives the eye by means of the flexure of its lines which gradually approaching one another as they seem to recede from view, proportionally diminish the enclosed objects, and make them appear to retire.

8. Aristotle was the first who proposed the famous problem respecting the roundness of that image of the sun, which is formed by his rays passing through a small puncture, even though the hole itself be square or triangular. Marolle, resolved this about the middle of the fifteenth century, by demonstrating that this puncture is the vortex 0f two cones of light, the one of which has the sun itself for its base, and the other the refracted image. Upon this, Mr. de Montucla ascribes to him the whole honour of the solution of this optical problem, formerly indeed proposed by Aristotle, but which that ancient philosopher, says he, “according to his wonted way, had but badly accounted for.” It is with regret that I find myself obliged to animadvert upon some very material mistakes, into which Mr. deMontuclahas slipt, whose judgment I so much revere on other occasions. For first of all, from his manner of quoting this problem of Aristotle, it appears that he neither consulted the Greek text, nor even the Latin version that accompanies it: insomuch, that I am at a loss to conceive where be came by this problem of Aristotle, as he produces it; and still more where he met with this obscure solution of it, which he imputes to that ancient philosopher.

Aristotle’s only inquiry is, “why the sun, in transmitting his beams through a square puncture, does hot form a rectilineal figure “ And Mr. de Montucla, instead of this, makes him substitute quite another question, respecting the sun in a partial eclipse: Why his rays, in passing through such a puncture, should produce a figure exactly resembling that part of his disk, which remains yet obscured But of all this, there is not one word in Aristotle. Mr. de Montucla afterward affirms, that this question, the proper solution of which had till then been despaired of by naturalists, reduced them all to the necessity of saying with Aristotle, that “light naturally threw itself into a round form, or resumed the resemblance of the luminious body, as soon as ever it had surmounted the obstacle which put it under constraint.” Now this again is what Aristotle says nothing at all of. He gives two solutions of his own problem: the first of which is certainly the foundation, if not the entire substance of what Mr. de Montucla calls the discovery of Marolle. To enable the reader to decide whether I have wronged Mr. de Montucla, I present him with a literal ranslation of a passage of Aristotle’s, containing in it his first solution of this problem. “ Why is it that the sun, in passing through a square puncture, forms itself into an orbicular, and not into a rectilineal figure, as when it shines through a grate Is it not because the efflux of its rays, through the puncture, converges it into a cone whose base is the luminious circle ” This may serve to confirm, what I have formerly ventured to assert, that we but seldom do justice enough to the ancients, either through our entire neglect of them or from not rightly understanding them.

Chapter 19 - Of the Many Discoveries of the Ancients in Mathematics, &c

Chapter 19 - Of the Many Discoveries of the Ancients in Mathematics, &c

1. A LARGE book might be composed, were we but cursorily to mention al the important discoveries in geometry, mathematics and philosophy, for which we are indebted to the ancients. Wherefore, not to swell this volume, we shall just point at the principle of this without insisting at length, because it is generally acknowledged that they owe their origin to those philosophers of antiquity.

2. All the learned agree, that Thales was the first we know who predicted eclipses; pointed out the advantages that must all from a due observation of the little bear, or polar star; taught that the earth was round, and the ecliptic in an oblique position. He had no less service to geometry than astronomy. He instructed in that science the Egyptions themselves, to who he went to be taught. He showed them how to measure the pyramids by the length and distances, by the proportion of the sides of a triangle. He demonstrated the various properties of the circle; particularly that whereby it appears that all triangles which have the diameter for their base, the subtending angle of which touches the circumference are in that point of contact right angled. He discovered respecting the isosceles triangle, that the angles at its vase were equal; and was the first who found out, that in right lines cutting one another, the opposite angles are equal,. In short, he taught a great may other valuable truths, too long to be narrated. We owe to Anaximander, the successor of Thales, the invention fo the armillary sphere, and of sun dials; he was likewise the first who drew a geographical map.

3. Pythagoras has already afforded to us many instances of his profound knowledge in all the sciences. There are few philosophers, even among the ancients, who had so much sagacity and depth of genius, He was the first who gave sure and fundamental precepts, with respect to music, which he fixed upon by a reach of discernment that was extraordinary. Struck by the difference of sounds which issued from the hammers of a forge, but came into unison at the fourth, and fifth, and eighth percussions; he concluded that this must proceed, from the difference of weight of the hammers; he had them weighed, and found that he had conjectured right. Upon this he wound up some musical strings, in number equal to the hammers, and of a length proportional to their weight; and found, that at the same intervals, they corresponded with the hammers in sound. It was upon the same principle that he devised the monochord; an instrument consisting of one string, yet capable of easily determining the various relations of sound. He also made many fine discoveries in geometry, among others, that-property of a right angled triangle, that the square of the hypothenuse, or side subtending the right angle, is equal to the squares of the two other sides. And he gave the first sketch of the doctrine of isoperimeters, in demonstrating, that of all plane figures, the circle is the largest; and of all solids, the sphere.

4. Plato likewise applied himself to the study of mathematics; and we owe to him many fine discoveries in that science. He it was, who first introduced the analytic method, or that geometric analysis which enables us to find the truth we are in quest of, out of the proposition itself which we want to resolve. He it was, who at length solved the famous problem, respecting the duplication of the cube, on account of which so much honour is paid, by all the philosophers of his school, to Euxodes, Archydes and Menechinus; To him also, is ascribed the solution of the problem concerning the tri section of an angle; and the discovery of the conic sections. Pappus. hath given us the summary of a great many analytic works. In the preface to his seventh book, we meet with this principle of Guldinus, “that whatever figure arises from the circumvolution of another, is produced by the revolution of the latter about its centre of gravity.”

5.Geometry is indebted to Hipparchus for the first elements of plain and spherical trigonometry; and to Diophantes, who lived three hundred and sixty years before Jesus Christ, we owe the invention of algebra. That the ancients laid the first foundation of algebra, is a thing out of doubt, as shown by the celebrated Wallis, in his history of that science. He makes no question but algebra was known to the ancients, and that they thence drew those long and difficult demonstrations which we meet with in their works. He supports his opinion by the testimonies of Schoten, Oughtred and Barrow; and makes mention of a manuscript in the Savillian library, which treats of this science, and bears the name of Appollonius. But he thinks the ancients carefully concealed a method, which furnished them with so many beautiful and difficult demonstrations; and that they chose rather to prove their propositions by reasonings ad absurdum, than to hazard the -discovery of that method, which brought them more directly to the result of what they demonstrated.

One to whom algebra is much indebted, Leibnits, forms the same judgment. Speaking of the higher operations of it, he says, “in perusing the arithmetic of Diophantes, and the geometrical books of Apollonius and Pappus, we cannot doubt, but the ancients had some knowledge of it. Vietus extended it still further, in expressing by those general characters, not only unknown numbers and proportions, but such as are known ; doing that by figures, which Euclid does by reasoning. And Descartes hath extended it to geometry, in marking by equations the proportions of lines. Yet, even since the discovery of our modern algebra, Mr. Bouillaud, whom I was acquainted with at who was without all doubt, an excellent geometrician, never reflect, but with astonishment, on the demonstrations of Archimedes concerning the properties of the spiral line, and could not how that great man hit upon the applying the tangent of- that line to the commensuration of the circulation of the circle.” Nunes is of the same opinion with the former ; and in his history of Algebra, regrets that the ancients concealed from US, a method which they-themselves used; and says, “that we are not to think that the greater part of the propositions of Euclid and Archimedes, were founded by those great men in that way of reasoning, in which they have thought proper to transmit them to us.”

6.This method of theirs, which resembled our algebra, sometimes however, discovers itself in their researches. We meet with traces of it sufficiently strong in the thirteenth book of Euclid; especially, if we make use of the Greek text, or the old Latin translation. And although Wallis imagines, that they may belong to some other scholiasts; yet the antiquity of the science itself will still be the same. Some indeed make it mount much higher, who, led by the authority of some able mathematicians among the ancients, assign the first invention of it to Plato. Whoever desires to

enter into a more exact examination of this, will find in Wallis a guide and monitor, whose authority may be acquiesced in, he having set this matter in the-clearest light, as well as made the first and noblest efforts in our time, to raise algebra to the state of perfection which it bath now attained.

Now, according to this able geometrician, the method of investigating infinite serieses took its rise from his arithmetic of infinites, published in 1656; and he himself acknowledges, that both of them are founded on the method of exhaustions, used by the ancients. He farther says, “that the method of indivisibles introduced ;by cavallieri, is no other than an abridgment of that of exhaustions, though somewhat more obscure.” He observes, that the lines and surfaces, whose proportion and contents are inquired into, and ascertained by Cavallieri, differ in nothing from the inscribed and circumscribed triangles, whose approaches Archimedes brought so near, that the difference of space enclosed between them, and that which they approached, and about which they were drawn, to wit, the -contents of the circle, might become less than any assignable quantity: and this he proves afterward, by an analytical exposition of both. I may however remark, that from the time of Diophantes, algebra made but small progress, till that of Vietus, who restored and perfected it, and was the first who marked the known quantities by the letters of the alphabet.

7.Besides the discoveries made in astronomy by the ancients, which we have been reading, there are a great many others, which I cannot bring into view, in that full manner they deserve. Yet I cannot omit mentioning here one important observation of Aristarchus. was the first who suggested a method of measuring the distance of the sun from the earth, by means of the half section of the moon’s disk, or that basis of it wherein it appears to us when it is in its quadratures.

8. Hipparchus was the first who calculated tables of the motion of the sun and moon, and composed a catalogue of the fixed stars. He was also the first, who, from the observation of eclipses, determined the longitude of places upon earth : but what above all does immortal honour to his genius is, that he laid the first foundations for the discovery of the precession of the equinoxes. Mr. Bayle reprebends Rohault as laying under a mistake, when he says that, “Hipparchus knew nothing of the peculiar motion of the fixed stars from west to east, which is the cause of their varying the longitude.”— Yea, and Timoeus Locrensis, who lived before Plato, taught this very astronomical truth in clear terms.’

Chapter 20 - Of Archimedes; Of the Mechanics and Architecture of the Ancients; And of Microscopes...

Chapter 20 - Of Archimedes; Of the Mechanics and Architecture of the Ancients; And of Microscopes. Of Sculpture, Painting, and the Origin of Music

1.ARCHIMEDES alone would afford sufficient matter for a volume, in giving a detail of the marvellous discoveries of a genius so profound and fertile in invention. We have seen, that some of his discoveries appeared so much above the reach of men, that many of - the learned of our days found it more easy to call them in doubt, than even to imagine the means, whereby be had acquired them. We are again going to produce proofs of the fecundity of genius belonging to this celebrated man. Leibnits did justice to the genius of Archimedes, when he said, that if we were better acquainted with the admirable productions of that great man, we would throw away much less of our applause on the discoveries of eminent moderns.

2.Wallis calls him a man of admirable sagacity, who laid the foundation of almost all those inventions, which our age glories in having brought to perfection. In reality, what a glorious light hath he diffused over the mathematics, in his attempt to square the circle, and in discovering the square of the parabola, the properties of spiral lines, the proportion of the sphere to the cylinder, and the true principles of statics and hydrostatics! What a proof of his sagacity did he give in discovering the quantity of silver, that was mixed gold in the crown of king Hiero; whilst be reasoned upon that principle, that all bodies immerged in water, lose just so much of their weight, as a quantity of water equal to them in bulk weighs ! Hence he drew this consequence, that gold being more compact -must lose less of its weight, and silver more; and that a mingled mass of both must lose in proportion to the quantities mingled. Weighing there... fore, the crown in water and in air, and two masses, the one of gold,. and the other of silver, equal in weight to the crown; he thence determined what each lost of their weight, and so resolved the problem.

He likewise invented a perpetual screw, valuable on account- of its being capable to overcome any resistance; and the screw that still goes by his name, used in elevating of water. He, of himself alone, defended the city of Syracuse, by opposing to the efforts of a Roman general, the resources he found in his own genius. By means -of many various warlike machines, all of his own construction, he tendered Syracuse inaccessible to the enemy. Sometimes he hurled upon their land forces, stones of such an enormous size, as crushed whole bodies of them at once, and put the whole army into confusion. And when they retired from the walls, he still found means to annoy them; for with his balistae, he overwhelmed them with arrows innumerable, and beams of a prodigious weight. If their vessels approached the fort, he seized them by the prows with grapples of iron, which he let down upon them from the walls; and rearing them up in the air, to the great astonishment of every one, shook them with such violence, as either to break them in pieces, or sink them to the bottom.

3.Superior knowledge he had in sciences, and his confidence in the powers of mechanism, prompted him once to say to king Hero, who was his patron, admirer, and friend, “give me where to stand, and I will move the earth.” And when the king, amazed at what he said, seemed to be in hesitation, he gave him a striking proof of his skill, in launching, singly by himself, a ship of a prodigious weight. He built likewise for the king an immense gallery, of twenty banks of oars, containing spacious apartments, gardens, walks, ponds, and all other conveniencies, suitable to the dignity of a great king. He constructed also a sphere, representing all the motions of the stars, which Cicero esteemed one of the inventions, that did the highest honour to human genius. He perfected the manner of augmenting the mechanic powers, by the multiplication of wheels and pulleys; and, in short, carried mechanics so far, that the works he produced surpass imagination.

4.Nor was Archimedes the only one, who succeeded in mechanics. The immense machines, and of astonishing force, as were those which the ancients adapted to the purpose of war, are a proof, they came nothing behind us in this respect. It is with difficulty we can conceive, how they reared those bulky towers, a hundred and fifty-two feet in -height, and sixty in compass, ascending by many stories, having at bottom a battering-ram, a machine of strength sufficient to beat down walls; in the middle a drawbridge, to be let down upon the wall of the city attacked, in order to open a passage into the town for the assailants; and at the top a body of men, who, being placed above the besieged, harassed them without running any risk. An ancient historian has transmitted to us an action of an engineer at Alexandria, which deserves to have a place here. In defending that city, when it was attacked by Julius Caesar, he, by means of wheels and other machines, drew from the sea a prodigious quantity of water, which he turned upon the adversary, to their extreme annoyance. Indeed, the art of war gave occasion for a great number of instances of this kind, which cannot but excite in us the highest idea of the enterprising genius of the ancients, and the vigour wherewith they put their designs in execution. The invention of pumps by Ctesibus, and that of water-clocks, cranes, anatomical figures, and wind-machines by Heron, and the other discoveries of the Grecian geometricians, are so very numerous, that it would exceed the limits of a chapter, even to mention them.

5.Should we pass to other considerations, we should find equally incontestable evidences of greatness of genius among the ancients, in the difficult and indeed astonishing experiments in which they so successfully engaged. Egypt and Palestine still present us with proofs of this, the one in its pyramids, the other in the ruins of Palmyra and Balbec.* Italy is filled with monuments and the ruins of monuments, which aid us in comprehending the former magnificence of that people. And ancient Rome even now attracts much more of our admiration, than the modern.

6.The greatest cities of Europe give but a faint idea of that grandeur, which all historians unanimously ascribe to the famous city of Babylon; which, being fifteen leagues in circumference, was encompassed with walls two hundred feet in height, and fifty in breadth ;t whose sides were adorned with gardens of a prodigious extent, which arose in terraces one above another, to the very summit of the walls. And for the watering of those gardens, they had contrived machines, which raised the water of the Euphrates to the very highest of these terraces; a height equalling that, to which the water is carried by the machine at Marly. The tower of Belus, arising out of the middle of a temple, was of so vast a height, that some ancient authors not ventured to assign the measure of it: others put it at a thousand paces.

* It is proper to remark, that the temples and immense palaces of Palmyra, whose magnificence surpasses all other buildings in the world, appear to have been built at the time, when architecture was in its decline.

One celebrated historian states the walls surrounding this famous city, to be 350 feet high, and 87 feet thick, so that eight carriages could pass abreast upon them; their circumference is stated, by the same historian, to be sixty English miles; they formed an exact square, each side being fifteen miles in length.

7.Ecbatane, the capital of Media, was of immense magnificent being eight leagues in circumference, and surrounded with seven in form of an amphitheatre; the battlements of which were of various colours, white, black, scarlet, blue, and orange; but all of them covered with silver or with gold. Persepolis was also a city, which all historians speak of as one of the most ancient and noble of Asia, There remain the ruins of one of its palaces, which measured six hundred paces in front, and still displays the relics of its ancient grandeur.

8.The lake Mocris is likewise a striking proof of the vast under takings of the ancients. All historians agree in giving it above a hundred and fifty leagues in circuit: yet was it entirely the work of one Egyptian king, who caused that immense compass of ground to be hollowed, to receive the waters of the Nile, when it overflowed more than ordinary, and to serve as a reservoir for watering Egypt by means of its canals, when the overflowing of the river was not of height sufficient to enrich the country. Out of the midst of this lake arose two pyramids, of about six hundred feet in height.

9.The other pyramids of Egypt, in their largeness and splidity, so fir surpass whatever we know of edifices, that we should be- ready to doubt of the reality of their having ever existed, did they not still exist to this day. Mr. De Chezele, of the academy of sciences, who travelled into Egypt in the last century, to measure them, assigns to one of the sides of the base of the highest pyramid, a length of six hundred and sixty feet, which reduced to its perpendicular altitude, makes four hundred and sixty-six feet. The free-stones, of which it is composed, are each of them thirty feet long; so that we cannot imagine, how the Egyptians found means to rear such heavy masses to so prodigious a height. The Colossus of Rhodes was another of the marvellous productions of the ancients. To give an idea of its excessive bigness, it need only be observed, that the fingers of it were as large as statues, and very few were able with out-stretched arms to encompass the thumb. Pliny and Diodorus Siculus relate, that Semiramis made the mountain Bagistan, between Babylon and Media, be cut out into a statue of herself, which was seventeen stadia high; that is, near two miles: and around it were a hundred other statues, of proportionable size, though less large. And Plutarch speaks of a very great undertaking, which one Stesicrates proposed to Alexander; viz. to make a statue of him out of mount Athos, which would have been a hundred and fifty miles in circumference, and about ten in height. His design was to make him hold in his left hand a city, large enough to contain ten thousand inhabitants ; and in the other an urn, out of which should flow a -river, poured by him into the sea. See also the same Plutarch, vol. 1. p. 705. But Nitruvius gives to this statuary the name of Dinocrates.

10.In short, what shall we say of the other structures of the ancients, which still remain to be spoken of- Of their cement, which in hardness equalled even marble itself; of the firmness of their highways, some of which were paved with large blocks of black marble; and of their bridges, some

of which still subsist, irrefragable monuments of the greatness of their conceptions The bridge at Gard, three leagues from Nimes, is one of them. It serves at once as a bridge and an aqueduct. It goes across the river Gardon, and joins together the two mountains, between which it is enclosed. It comprehends three stories ; the third is the aqueduct, which conveys the waters of the Eure into a great reservoir, which supplies the amphitheatre and city of Nimes. The bridge of Aleantara, upon the Tagus, is still a work fit to raise in us a great idea of the Roman magnificence: it is six hundred and seventy feet long, and contains six arches, each of which measures above a hundred feet from one pier to the other; and its height from the surface of the water is two hundred feet. The broken remains of Trajan's bridge over the Danube are still to be seen; which had twenty piers of free stone, some of which are still standing, a hundred and fifty feet high, sixty in circumference, and distant one from another a hundred and seventy.

I should never end were I to enumerate all the admirable monuments left us by the ancients: the slight sketch here given of them will more than suffice to answer my purpose. As to the ornaments and conveniencies of their buildings, among many I shall mention but one, that of their using glass in their windows, and in the inside of their apartments, just in the same manner as we do. Seneca and Pliny inform us, that they decorated their rooms with glasses; and do not we the same, in the use of mirrors and pier-glasses But what will now shock the general prejudice is, that they should know how to glaze their windows, so as to enjoy the benefit of light, without being injured by the air; yet this they did very early. Before they discovered this manner of applying glass, which is so delightful and so commodious, the rich made use of transparent stones in their windows, such as the agate, the alabaster, the phengistes, the talcum, &c. whilst the poor were under the necessity of being exposed to all the seventies of wind and weather.

11.If we admire the ancients in those monuments which remain to us, of the greatness of their undertakings, we shall have no less reason for wonder, in contemplating the dexterity and skill of their artists in works of a quite different kind. Their works in miniature are well deserving of notice. Archytas, who was contemporary with Plato, is famous in antiquity for the artful structure of his wooden pigeon. which imitated the flight and motions of a living one. Cicero, according to Pliny's report, saw the whole Iliad of Homer written in so fine a character, that it could be contained in a nut-shell. And Elian speaks of one Myrmesides, a Milesian, and of Callicrates, a Lacedemonian; the first of whom made an ivory chariot, so small and so delicately framed, that a fly with its wing could cover it; and a little ivory ship of the same dimensions: the second formed ants and other little animals out of ivory, which were so extremely small, that their component parts were scarcely to be distinguished. He says also in the same place, that one of those artists wrote a distich in golden letters, which be enclosed in the rind of a grain of corn.

12.It is natural here to inquire, whether in such undertakings as our best artists cannot accomplish, without the assistance of microscopes, the ancients had not any such aid; and the result of this research will be, that they had several ways of helping the sight, of strengthening it. and of magnifying small objects Jamblichus says of Pythagoras, that he applied himself to find out instruments as efficacious to aid the hearing as a rule, or square, or even optic glasses, were to the sight. Plutarch speaks of mathematical instruments, which Archimedes make use of, to manifest to the eye the largeness of the sun; which may be meant of telescopes. Aulus Geflius, having spoken of mirrors, that multiplied objects, makes mention of those which inverted them; and these of course must be concave or convex glasses.-

Pliny says that in his time artificers made use of emeralds to assist their sight, in works that required a nice eye; and, to prevent us from thinking that it was on account of its green colour only that they had recourse to it, he adds, that they were made concave, the better to collect the visual rays; and that Nero made use of them in viewing the combats of the gladiators. In short, Seneca is very full and clear upon this head, when he says, that the smallest characters in writing, even such as almost entirely escape the naked eye, may easily be brought to view, by means of a little glass ball filled with water, which had all the effect of a microscope, in rendering them large and clear: and indeed this was the very sort of microscope, that Mr. Gray made use of in his observations. To all this add the burning-glasses made mention -of before, which were in reality magnifying-glasses: nor could this property of them remain unobserved.

13.It would be a needles task to undertake to show, that the ancients have the preeminence over the moderns in architecture, engraving, sculpture, medicine, poetry, eloquence, and history, The moderns themselves will not contest this with them: on the contrary, the height of their ambition is, to imitate them in those branches of science. And indeed what poets have we to produce, fit to be compared with Homer. Horace, and Virgil; what orators equal to Demosthenes and Cicero; what historians to match Thucidides, Xenophon, Tacitus, and Titus Livius; what physicians, such as Hippocrates and Galen; what sculptors like Phidias, Polycletus, and Praxiteles; what architects to rear edifices similar to those, whose very ruins are still the object of our admiration Till we have those, whom we can place in competition with the ancients in these respects, it will become our modesty to yield to them the superiority.

14.‘Tis worth notice, that the merit of the ancients is generally most controverted by those, who are least acquainted with them. There are very few of those who rail at antiquity qualified to relish the original beauties of the Iliad, Aeneid, and other immortal performances, of the authors just enumerated. There are fewer still, who are capable at one view to take in all that variety of science, which bath been laid before the reader, and which comprehends in it almost the whole circle of our knowledge. Of the remaining admirable monuments, which show to what perfection the ancients carried the arts of sculpture and design, how few have taken any due notice; and of those, how very few have been able to judge of their- real value True it is, that time and the hands of barbarians have destroyed the better part of them; yet still enough is left to prove the excellence of what hath perished, and to justify encomiums bestowed on them by historians. The group of figures in the Niobe of Praxiteles,* and the famous statue of Lacoon, still to be seen at Rome, are, and ever will be models of beauty and true sublime in sculpture; where much more is to be admired, then comes within the comprehension of the eye. The Venus de Medicisa the Hercules stifling Antacus, that other Hercules, who rests upon his club. the dying Gladiator, and that other in the vineyard of Borghese, the Apollo of the Belviderejf the maimed Hercules of the same place, and the Equerry in the action of braking a horse on mount Quirinal, are all

* Some ascribe this piece to Scopas, the cotemporary of Phidia, and who reached the times of Praxiteles. It is still in being, and to be seen at Rome. The joint labour of Agesander, Folydorus and Athenodorus, of Rhodes: who, according to Maffeus, lived all of them about the eighty-eighth Olympiad; it is in the Belvidere at Rome. The workmanship of Cleomenes, the Athenian, still to be seen in the Farnesian palace at Florence.

Ascribed to Polycletus, who made the Colossial statues of Juno in gold and ivory, at Argos, which no longer exist. The work of Glycon, still remaining in the Farnesian palace at Florence Done by Ctesilas, or Ctesias, in the gallery of the capitol. By Agathias, of Ephus. By the same. These two last were at Antiuin, now Nettuno.

Ascribed by some to Phidias, by others to Praxiteles. Those who assign it to the latter imagine it to be that of Alexander breaking Bucephalus. But if it was done by the former, it must be another subject, that sculptor having flourished. about a century before. It is thought that nothing of this is now remaining His Olympian Jupiter was an object of admiration for many ages, and continued of them monuments. which loudly proclaim the just pretensions of the ancients to a superiority in those arts. These pretensions are still further supported by their remaining medals, the precious stones of their engraving and their cameos. There is still to be seen medal of Alexander the Great, on the reverse of which there- is sitting on his throne, finished with the finest strokes of art; not a feature, even the smallest, but seems to declare his divinity: stones engraved by Pyrgoteles, who had an exclusive privilege engraving Alexander's head, as Lysippus had of making his statue, and Apelles of painting him; those of Dioscorides, who engraved the heads on the seals of Augustus; the celebrated Medusa, Diomedes, Cupid, and other performances of Solon; in short, all the other nent pieces of sculpture and engraving, so carefully sought the curious, and with so much reason admired by connoisseurs, under it needless for me to enlarge on the praises of artists sufficiently -renowned, by being the authors of works so lasting and so precious

15.As to painting, so few and so scanty are the relics, and so more injured by time, than the statues and other remains of sculpture in bronze and marble, that to form a proper judgment of the merit of the ancients in it appears at first very difficult. Yet if due attention be paid to what of that kind has been discovered at Rome, and more lately in the ruins of Herculaneum, we shall be obliged to admit the -justice of that applause, which the painters of antiquity received from their contemporaries; an applause confirmed by all we -have had occasion to observe of their excellency in sculpture. The ancient paintings in freses, still to be seen at Rome, are, a reclining Venus,at full length,* and seven other pieces, taken out of a vault at the foot of mount Palatine; among which are a satyr drinking out of a horn-, and a landscape with figures, both of the utmost beauty. There--are also a sacrificial piece, consisting of three figures and an Oedipus, and a sphinx; which all of them formerly belonged to the tomb of Ovid. These are specimens from which, without temerity, we may form a very advantageous judgment of the ability of the masters who executed them; but those discovered at Herculaneum; disclose beyond all others, a happiness of design and boldness of expression, that could proceed only from the hands of the most accomplished artist. The picture of Theseus vanquishing the Minotaur, that of the birth of still at Constantinople, in the beginning of the thirteenth century; together with the beautiful Caidan Venus, the happy work of Praxiteles, and the statue of Opportunity, by Lysippus. It is probable, these fine remains were destroyed at the taking of the city by Baldwin.

* In the Palace of Barbirini. In the gallery of the college of St. Ignatus. In the possession of Cardinal Alexander Albani. In the Villa Altieri.

Telephus, that of Chiron and Achilles,* and that of Pan and Olympe, present innumerable beauties to all who have discernment, and strike most the eye of the more intelligent beholder. If indeed we examine the countenance of Achilles in the original picture itself and not in the imperfect

impression published of it, we shall perceive in it something inimitably just and line in its air, energy and expression; every thing contributes to display the young hero's ardour for glory ; and he looks with such eagerness and impatience on his master as if he wanted but an opportunity to acquire it- at all hazards. There were found also, among the ruins of that city, four capital pictures, wherein beauty of design seems to vie with the most skilful management of the pencil. They appear to be -of an earlier date than these we have spoken of, which belong to the first century ; a period when painting, as Pliny informs us, was in its decline. What then are we to think of the paintings of Zeuxis and Apelles, when even this art itself, in its very decline, was capable of exhibiting such productions as these, which however justly exciting our praise, seem to have been but of an inferior kind, when compared to the noble performance of those great masters This accounts for the silence observed by Pliny,- and the other historians, in relation to them.

16.Another kind of work, of affinity to painting, and which deserves to find a place here, is the mosaic, which the Romans made use of in paving their apartments. One of the most beautiful monuments of that kind, and elegantly described by Pliny, was found some years ago in the ruins of Adrian's famous country seat at Tivile. It represents a basin of water, with four pigeons around the brim of it, one of which is drinking, and in that attitude its shadow appears in the water. Pliny in the same place says, that on the same pavement, the breaking up of an entertainment was so naturally represented, that you would have thought you really saw the scattered fragments.

17.Music is as ancient as the world. It seems to have been born with man, to accompany him in his painful career, to sweeten his labours, and charm away his cares. This was its first employment. It was afterward consecrated to divine service, and having thus risen in its dignity, became of principal account among the people, in accompanying the traditional narratives, relative to the characters and' exploits of their ancestors. Hence it came to be the first science wherein their children were instructed. Music, and poetry its ally, accompanied all their studies. They even deified those, who first distinguished themselves in it: Apollo was of this number. Orpheus, Amphion, and Linus, for their eminent talents in this art, were accounted more than men. Philosophers applied themselves to it; Pythagoras, Socrates, and Plato, recommend it as worthy of being cultivated, not only by their disciples, but by the best regulated states. The Grecians, and particularly the Arcadians, enacted the study of it by law. regarding it as indispensably necessary to the common, welfare. A science so generally cultivated, should have arrived at perfection very early; yet did it continue in a state of imbecility and without principles till the times of Pythagoras. We have seen before in what manner this great man first determined its fundamental rules.

* These two are, perhaps, the performances of Parrhasius.

Till his time, music was so vague and uncertain that it required as extraordinary effort of genius to reduce it to method and order. He precisely determined the proportions which sounds bear one to other, and regulated harmony upon mathematical principles. let the precision of his mind carry him too far, in subjecting music to the judgment of reason alone, and admitting no pauses or rests, but such as had an arithmetical or geometric proportion in them. texenes, the disciple of Aristotle, thought, on the contrary, that this subject came entirely within the verge of hearing, and that the ear was the only judge of sounds. He therefore regulated the order, the umson and break in tones, solely by the judgment of the earth his system prevailed for some time in Greece. Olympus, a Phrygian. came soon after to Athens, who invented a stringed instrument which, gave the

semitones, whereby he introduced so many new graces into music, as gave it entirely another air. He joined Aristoxenes, appealing for the merit of his system to the decision of the ear. At length. the famous Ptolomy appeared, and with superior spirit equally disclaimed the partiality of both sides.

He took a middle course, asserting that sense and reason had a joint right to judge of sounds. He accused the Pytbagoreans of fallacy in their speculations, with respect to proportions; as well as of folly in so disregarding the decisions of the ear, as to refuse it that kind of harmony which was agreeable to it, merely because the proportions of it did not correspond with their arbitrary rules. And he charged the partisans of Aristoxenes with absurd neglect of reasoning, in that though they were convinced of the difference of grave and acute tones, and of the proportions subsisting between them; and that those. proportions invariably depended: upon the several lengths of the musical chords; yet they never took the trouble of considering this, so as to enter into the reason of it. Be therefore determined in deciding upon the principles of harmony, to make use not only of reason but also of the ear, as being of aid to one another; and in consequence of this, laid down a sure method for finding out the proportions of sounds. Had the ancients done more with respect to music, than made the discoveries already taken notice of, that science must be infinitely more indebted to them, than it possibly could be to those who succeeded them, for what additions they have afterward made. The' ancients have the whole. merit of having laid down the first exact principles of music; and the writings of the Pythaoreans, of Aristoxenes, Euclid, Aristides, Nicoma chus, Plutarch, and many others, even such of them as still remain, contain in them every theory of music yet known. They knew, as well as we, the art or noting their tunes, which among them was called the parasemantic, or semeiotic, performed by means of entire letters, either contracted or reversel, placed upon a line parallel to the words and serving for the direction, the one of the voice, and the other of the instrument ; and the scale itself, of which Guy Aretin, is the supposed inventor, is no other than the ancient one of the Greeks a little enlarged, and what Guy may have taken from a Greek manuscript, written above eight hundred years ago. which Kircher says he saw at Mesina in the library of the Jesuits, wherein he found the hymns noted, just as in 'he manner of Aretin.

18.As to the effects which music produced, and the manner of performing it, so far were the ancients from filing short of the moderns in these respects, that as to the former, after reducing the accounts we have of it to the most rigid conformity to truth, they still appear therein to have gone far beyond us: and as the latter, though it be alleged, that their instruments were not so complete as ours, and that they knew not, nor put in practice those divisions in harmony which enter into our concerts; yet this seems to be a groundless objection. The lyre, for instance, was certainly a very harmonious instrument, and in Plato's time was so constructed, and so full of variety, that he regarded it as dangerous, arid too apt to relax the mind. In Anacreon's time it had already obtained forty strings, Ptolomy and orphyry described instruments resembling the lute and theorby, having a handle with keys belonging to it, and the strings extended from the handle over a concave body of woods There is to be seen at Rome an ancient statue of Orpheus, with a musical bow in his right hand, and a kind of violin in his left. In the commentaries of Philostrastus by Vigenere, is a medal of Nero with a violin upon it. In the passages referred to below, it plainly appears, that the flute was carried to so high a degree of perfection by the ancients, that there were various kinds of them, and so different in sound, as to be wonderfully adapted to express all manner of subjects. And in

Tertullian we meet with a very full description of an hydraulic organ, invented by Archimedes, which was so far from being inferior in any respect to ours, that it plainly exceeded them in its mechanism, as being made to play by water. “ Behold,” says Tertullian, “ that astonishing and admirable hydraulic organ of Archimedes, composed of such a number of pieces, consisting each of so many different parts, connected together by such a quantity of joints, and containing such a variety of pipes for the imitation of voices conveyed in such a multitude of sounds, modulated into such a diversity of tones, breathed from so immense a combination of flutes; and yet all taken together constitute but one single instrument.”

19.Should we for the present confine our views only to harmony or the consenting notes in music, we shall find that the ancients were by no means ignorant of it. Many respectable authors have cursorily treated of it. Macrobius speaks of five notes, among which the bass bears such a symphony with those above it, that however different they’ be among themselves, they come to the ear as if they altogether composed but one sound. Ptolomy, speaking of the monochord, calls it a mighty simple instrument, as having neither unison, accompanyment, variety, nor complication of sounds. Seneca, in one of his letters, says to his friend, “ Don’t you observe how many different voices a band of music is composed of! There you have the bass,” the higher notes, and the intermediate, the soft accents of and the stories of men, intermingled with the sound of flutes, however separately distinct, form altogether but one harmony of sound, in which each hears a share.”

Plato sufficiently makes it appear, that he knew what harmony was, when he says, that music is a very proper study for youth, and should employ three years’ of their time ; but that it was improper to put them upon playing alternately in concert, it being enough for them. if they could accompany their voice with the lyre. And the reason he gives for it is, that the accompanyment of various instruments, the bass with those of a higher key, and the variety, and even opposition of symphonies, where music is played in divisions, can only embarrass the minds of youth. True it is, the ancients did not much practice compound music; but that proceeded only from their not liking it. For Aristotle, after asking, why one instrument, accompanied only by a single voice, gave more delight than that very voice would do with a greater number, replies, that the multitude of instruments only obstructed the sound of the song, and hindered it from being heard.

Yet the same author in another place expressly says, that music, by the combination of the bass arid higher tones, and of notes long and short, and of a variety, of voices, arises in perfect harmony. And in the following chapter, speaking of the revolutions of the several planets, as perfectly harmonizing with one another, they being all of them conducted by the same principle, he draws a comparison from music to illustrate his sentiments. “Just as in a chorus,” says he, “of men and women, where all the variety of voices, through all the different tones, from the bass to the higher notes, being under the guidance and direction of a musician, perfectly correspond with one another, and form a full harmony.” Aurelius Cassiodorus defines symphony to be the art of so adjusting the bass to the higher notes, and them to it, through all the voices and instruments, whether they be wind or stringed instruments, that thence an agreeable harmony may result And Horace speaks expressly of the bass and higher tones, and the harmony resulting from their concurrence. All these testimonies therefore uniting in favour of the harmony of the ancients, ought not to leave us the least doubt respecting this branch of their knowledge. We have seen the reason why they did not much use harmony in concert. One fine voice alone, accompanied with

one instrument, regulated entirely by it, pleased them better than mere music without voices, and made a more lively impression on their feeling minds. And this is what even we ourselves every day experience.

20.1 come now to consider the effects, which the ancient music produced, and begin with observing, that it is not at all probable they would unanimously consent to impose upon posterity, in matters delivered with such an air of truth. There is scarcely any thing in history better supported. To begin with sacred story. We find there, that the ministers of Saul bid him send for a player upon an instrument, to relieve him of his malady. The consequence of this was, that David came, and administered the expected relief. And to be convinced, that there was nothing supernatural in this, but that music was at that time a known specific in such maladies as Saul complained of, it need only to be remarked, that those, who gave this, advice, were but household servants. Profane history supports us in this reflection, by a great number of instances of the same kind. Aulus Gellius and Athenaeus make mention of many cures performed among the Thebans by music, and cite Theophrastus as to what happened in his time. Galen, a very grave author, and whose authority is of the greatest weight in subjects of this kind, speaks very seriously of this custom. And Aristotle, Appollonius, Dipscolus, Capella. and many others, speak of singing as a nostrum in many maladies. There is a passage in Tzetzes, which gives rise to a conjecture, that may very naturally accompany these facts. He says, that Orpheus recalled Euridice from the gates of death, by the charms of his lyre. Now to take this literally, one might presume from it, that Eurydice had been bit by a tarantula instead of a serpent, as historians give out, and that Orpheus having recovered her by means of music, as is practised in Italy even at this day, in process of time there was founded on this the well known allegory of his descent into hell. But if, in opposition to this, it be alleged, that there are no tarantulas in Thrace, which is what I cannot take upon me to affirm, the objection is easily evaded by admitting with historians, that she was really bit by a serpent, observing withal, that she might still be cured of that bite by means of music. Theophrastus, among other writers, is quoted by Aulus Gellius, as an ocular evidence of the medical effects of music, in the case of persons bit by serpents or vipers, he work indeed referred to is now lost. Another purpose, to which e ancients applied their music was to alleviate the rigour of their punishments; and in this they displayed their humanity. The Americans entertain the same idea of the power of music, having recourse to it to allay the severity of their toils. Plutarch reports of Antigenidas, that he so roused the spirit of Alexander, by playing on the flute, that in a transport of heroism the prince immediately started up from table, and flew to his arms. Every body hath hear of' the wonderful influence which the music of the famous Timotheus had over the mind of that prince, when touching his lyre. he so inflamed him with rage, that drawing his sabre he suddenly slew one of his guests; which Timotheus no sooner perceived, than, altering the air from the Phrygian to a softer measure, he stripped him of his fury, becalmed his passion, and infused into him the tenderest feelings of grief and compunction for what he had done. Jamblicus relates' like extraordinary effects of the lyres of Pythagoras and Empedocles The painter Theon dextrously availed himself of this force of music, when going to make a public exhibition of a piece he had finished wherein a soldier was represented as just ready to assail the enemy, he first of all warmed the spirit of the company by a warlike air, and when he found them sufficiently animated, uncovered the picture, which struck the whole assembly with admiration. Plutarch informs us of a sedition quelled at Lacedernon by the lyre of Terpander; and' Boetius of rioters dispered by the musician Damon.

21.To conclude this inquiry respecting the merit of the ancients in music, I shall make but two observations. The first is, that their airs in delicacy very much surpassed ours, and that it is in this respect principally, that we may be said to have lost their music. Of these three kinds of music, the diatonic, chromatic, and the enharmonic, there exists now only the first* and second. The difficulty there was to find voices and hands proper to execute the enharmonic kind, brought it first into neglect, and then into oblivion : insomuch that all now remaining of the ancient music is that of coarser sort, which" knows no other refinement, than that of the whole and the deminote, instead of these finer kinds, which carried on the division of a note into threes and fours. Doubtless the prevalency of that system, which referred the determination of sounds to the judgment of the ear, occasioned the rejection of the enharmonic species, which was too fine for the decision of the ear, and sprung entirely from the Pythagoric system. But this by no means ought to hinder us from acknowledging the excellency of that music above the modern, in the extreme delicacy of its tones. The second observation is, that the variety of manner, in which the ancient music was performed, placed it in a rank of dignity, superior to ours. Our modes are but of two kinds, the flat and the sharp: whereas the ancients modified theirs' into five, the principal of which were the Ionic, the Lydian, the Phrygian, the Doric, the Aeolic each adapted to express and excite different passions ; and by that means, especially, to produce such effects as we have just now taken notice of, not only from the authentic manner in which they have been recorded, but from the very state and condition in which music at that time was.

*Dutens, is mistaken in saying, first, that only the first, viz, the diatonic kind now remains; and secondly, that this divides the tones into semitones; which certainly is done by the chromatic, and not the diatonic scale.

Chapter 21 - CONCLUSION

Chapter 21 - CONCLUSION

1.We have seen in how many truths of the greatest importance the ancients preceded the moderns, or at least pointed out, or prepared the way for their discoveries. It appears also, that the latter have not always bad the disinterestedness to own, that the former guided them in attaining their ends. And here it may not be amiss to remark, that those very philosophers, when their opinions were attacked, or when they dreaded they might be so, recurred to the authority of those great men, to put envy and calumny to silence. Descartes, Mallebranche, and some Newtonians, are instances of this.

2.The first of these, at the conclusion of his principles of philosophy, advertises the reader, that he had advanced nothing but what had been authorised by Aristotle, Democritus, and many other philosophers of antiquity. Mallebranche, observing his system accused not only of being false, but of being impious, immediately bad recourse to the authority of St. Augustin. And some Newtonians, upon seeing that attraction was by many regarded as a mere whim, set about proving, that the ancients owned and taught it; trusting by this to open a reception for it. Some, to conciliate the favour of the public, have had resource to the authority of the ancients ; others, upon being attacked, have tied to them for succour and protection. Others again, distrusting their own ability to support what they advanced, have rather chosen to abdicate the glory of invention, than give up their favourite ideas a prey to their adversaries ; and have therefore, to put them out of reach, placed their origin at a vast distance. Nor are there wanting those, who seeing themselves secure of success, in hazarding certain opinions, have ventured to pass them under their own names, though they belong to others ; and observing, that they were not reclaimed to their real authors by the public, have silently gloried in their borrowed lustre; many conscious that they had no right, and some., though few in number, thinking that they had.

3.What little we have taken notice of respecting the conduct of Descartes, Locke, and Mallebranche, is sufficient to authorize what we here advance. Descartes bath not specified the authors, from whom in particular he derived his thoughts. He only says in general that the greatest philosophers of antiquity have thought as he has done. Locke hath passed for an original, though his principles be the same with those of Aristotle, and his distinctions just such as were employed by the stoics. Mallebranche did not at first avow,' that his opinion was the same with that of the Chaldeans, Permenides, Plato, and St. Augustin ; but when he saw himself warmly attacked by his adversaries, against the philosophical part of them, he held up the buckler of Plato, whilst he fled to St. Augustin for shelter against the divines. The glory of having been the first, who clearly distinguisheth: the properties of the mind from those of the body, and demonstratad, that sensible qualities had their existence in the mind of the percipient, and not in the object perceived, hath been wrongfully ascribed to Descartes ; since we have seen, that he was preceded in all these' respects by Lencippus, Democritus, Flato, Strato, Aristippus, Plutarch, and Sextus Empiricus.

4.Leibnits hath not only revived the doctrine of Pythagoras; but employed the very same arguments, which the Pythagoreans made use of to demonstrate the necessity of admitting the existence of simple and uncompounded things, anterior to those that were compounded, and as being the foundation of the existence of body itself. Mr. de Buffon hath sometimes quoted Aristotle and Hippocrates, but never when there was any inquiry about the groundwork of his system, which has always been thought to be new, though it appears to be almost entirely: the same with that of Anaxagoras, Empedocles, and Piotinus. According to the system of Pythagoras, Plato and Epicurus, the production of every thing in nature was ascribed to the concurrent force of simple and active principles, long before Mr. Needham thought of it. The philosophy of Gassendi and the Newtonians, is no other than that of Moschus, Leucippus, Democritus, and Epicurus. The acceleration.. of motion was known to, Aristotle, and the best manner of accounting" for it is that which he makes use of. Lucretius observed long before Galileo, that bodies the most unequal in weight, such as gold and down, must descend with equal velocity in a vacuum.

Universal gravity attractive, centripetal, and centrifugal force, were clearly indicated by Anaxagoras, Plato, Airstotle, Plutarch, and Lucretius. We have' also seen, that, without the aid of telescopes, Democritus and Phavorinus entertained very just ideas of the milky way, and predicated the discovery of the satellites ; that a plurality of worlds, and the doctrine of vortices, were clearly and with precision taught by the ancients; and that Plato had a notion of the theory of colours. We have seen, that two thousand years before Copernicus, Pythagoras had proposed the same system; and that Plato, Aristarchus, and many others, had admitted it; as they did, also, without difficulty. the doctrine of antipodes, which though very reasonable in itself, had so much difficulty is gaining a reception among us. The revolution of the planets about their own axis was known also in the schools of Pythagoras and Plato. There was nothing left to the moderns to say new, respecting the return of comets, their nature, and their orbits. The Chaldeans, Egyptians, Pythagoras, Democritus, Hippocrates of Chios, Artemidorus, and Seneca, had already fully settled the theory of them ; though the moderns, it is true, demonstrated more clearly some parts of it. The mountains, valleys, and inhabitants of the moon, had been suggested and supposed by Orpheus, Pythagoras, Anaxagoras, and Democritus.

5.Aristotle knew the weight of the air; Seneca its spring anti elasticity. Lucippius, Chrysippus, Aristophanes, and the stoics, had fully accounted for thunder and earthquakes. Pytheas, and Seleucus of Erytherea, preceded Descartes in explaining the cause of the ebbing and flowing of the sea ; and PlinAcibre Sir Isaac Newton had made mention, in that case, of the combined forces of sun and moon.

6.We have also seen, that Hippocrates and Plato knew the circulation of the blood, and that Rufus described, sixteen hundred years ago, the various parastatae, called by, us the Fallopian tubes. And by the sentiment of an able surgeon of the present age, we have shown, that there were as great advances made in that art a thousand years ago, as there are at present. The art of working metals, of rendering gold potable, glass ductile and malleable ; that of distillation, of painting upon glass, of making gunpowder, and a thousand other chemical preparations, with which we have proved the ancients to have been acquainted, leave not the least doubt of their skill in chemistry. We have seen, that the sentiment of Harvey. Steno, and B.hedi, respecting generation by eggs, was only a renewal of what had been taught by Hippocrates, Empedocles, Aristotle, and Macrobius ; and the system of Hartsoeker, and Leuwenhoeck, with respect to spermatic

animalcula, is found in Aristotle, Hippocrates, Plato, Lactantius, and Plutarch. And the sexual system of plants, the merit of discovering which we chiefly assigned to Morland, Grew, Vaillant, and Linnacus, was accurately expounded by Empedocles, Theophrastus, Pliny, and Diodorus Siculus.

7.Though we did not employ much time in our survey of mathematics and geometry, yet we made it appear, that the noblest discoveries in those sciences were made by the ancients. All the English geometricians agree with Leibnits and Wolf in acknowledging, that, notwithstanding all the attempts made by the ablest geometricians in these last ages, Euclid's method still remains the most accurate and perfect. We observed, that the most difficult problems in those sciences were solved by Thales, Pythagoras, Plato, Archimedes, and Apollonius. We have seen, that their mechanical contrivances were carried to such a pitch, as to surpass even the conception of the most learned among us. Archimedes's burning-glasses furnished us with an instance of this. Their application of the equal vibration of the pendulum, their knowledge of the refraction of light, and their attempts to square the circle, their discovery of the fundamental propositions of geometry, and above all that of algebra, and the pre cession of the equinoxes, afford convincing proofs of the depth and acuteness of the genius of the ancients. We have also made it appear, that microscopes were not unknown to them; and that in the arts of pointing, sculpture, and the science of music, they not only equalled, but even surpassed us. In laying before the" eyes. of the reader, a sketch of the admirable works of the ancients in architecture, and in the art of war, we have likewise given proofs, that they were no less able in the arts, than in the sciences; insomuch that there is no part of knowledge in which they have not: either preceded us, directed, or surpassed us.

8.Now, if it hath been demonstrated, that the writings of those great masters contain the greatest part of what is to be known, that the most celebrated discoveries of the moderns have thence derived their origin; is it not very reasonable, that we should rather go to the fountain head of science, than to confine ourselves entirely to the little streams that issue from it ! But in recommending the study of the ancients, I am far from thinking that the moderns are to be neglected. I apprehend, on the contrary, that it is of great use attentively to consider their labours in order to remark what they have added to the knowledge of the ancients by their experiments; for without doubt there may be daily added something to our knowledge. This makes it necessary attentively to compare the ancients and moderns together; for in these last many things may be found, which have ever been omitted, or but obscurely treated of in the former. Nay, farther, the labours of the moderns may serve to replace, as it were, some of those treatises of the ancients, which have been lost, and of which there now remain only the titles, to give us an idea of the greatness of our loss. Another advantage, which may arise from this comparison, is, to sustain us in our reflections; for where the ancients, and moderns agree, it is natural, that their joint consent should determine our judgment in such or such a point. And even when they differ, the diversity of their reasonings may tend to throw light on the mind.

9.Free from partiality towards either, we ought to think, that whatever efforts have been made to bring our knowledge to perfection, there will remain something still to be done in that respect, by us and our posterity. There is no man sufficient of himself to establish or perfect any one art or science. Having received from our ancestors the product of all their meditations and researches, we ought daily to add what we can to it, and by that means contribute all in our power to the

increase and perfection of knowledge. Let us put on the disposition of Seneca, who expresses himself on ‘this subject with his usual eloquence. "I ‘hold in great veneration says be, “the inventions of the wise, and the inventors themselves. This is an inheritance, which every one may and ought to lay claim to. To me they have been transmitted; for me they have been found out. But let us in this,” continues he, “act like good managers ; let us improve what we have received, and convey this heritage to our descendants, in better condition than it came to us. Much remains for us to do; much will remain for those who come after us. A thousand years hence, there will stilt be occasion, and still opportunity, to add something to the common stock. But had every thing’ been found out by...the ancients, there would still this remain to be done anew, to put their inventions into use, and make their knowledge When I first read over the preceding treatise, I bad had little though or design of making so large an extract from it. But I afterward considered, 1. That this might be a means of making that valuable work more extensively known, (as men of learning would naturally desire to see and examine the proofs at large ;) and, That it might serve for a kind of recapitulation of the preceding volumes. Such a recapitulation as, on the one hand, could not be unentertaining to the sensible reader; and on the other, might repress the vanity which is apt to arise in our minds, when we imagine we have made new discoveries Alas! how little new has been discovered, even by Gassendi, Mallebranche, Mr. Locke, or Sir Isaac Newton! How plain is it, that is philosophy, as well as the course of human affairs, “ there is nothing new under the sun !" The more we consider this, the more we shall be convinced of the inconceivable littleness of human knowledge. But although with our utmost efforts, we can know so small a part of the things that surround us, yet we can know, and that with the greatest certainty, our’ whole duty to Him that made them. And what can we reasonably desire more For “this is the whole of man,” (which is the literal rendering of Solomon’s words) his whole business, his whole happiness, In this our infant state we cannot know much: but we may love much. Let us secure this point, and we shall soon be swallowed up in the ocean both of Knowledge and Love!

London, November 16, 1777.