A SURVEY OF THE WISDOM OF GOD IN THE *CREATION*: OR, A COMPENDIUM OF NATURAL PHILOSOPHY:

IN FIVE VOLUMES.

THE THIRD EDITION, ENLARGED.

BY *JOHN WESLEY*, A. M.

VOL. V.

These are thy glorious Works, Parent of Good,
Almighty! Thine this universal Frame,
Thus wond'rous fair! Thyself how wond'rous then!

MILTON.

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PART the FIFTH.

CONTINUED.

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. *Dutens*' "Enquiry into the ori-"gin of the diſcoveries attributed to the Moderns." I am ſurprized 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 had 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."

The AUTHOR's PREFACE.

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 of 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 moderns 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 now behold them in. Many ſecrets of nature, not to be penetrated

netrated 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 re-iterated efforts of *Ramus*, *Bacon*, *Newton*, and many others.

I willingly therefore give up to the partizans 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.

CHAP. I.

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, and doubt not but the reader will perceive not only probable hints, but demonſtrative evidence, that the antients clearly taught what we now diſpute their having had any knowledge of.

2. It is remarkable with regard to medicine, that none of the ſciences 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 to the more evident proofs of this 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

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 communi-" cate one with the other, and run into one ano-" ther; 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 cir-" cle 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 " heat;" he adds, "that they are 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 mo-" tion." He compares 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 the 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; *for 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 Pollux*, 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." *Apuleius* 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 afterwards 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 par-"ticularly to the left ventricle of that viſcus. "The cordiac artery expands and contracts itſelf "with very much force, but always with great "regularity and harmony of motion. In its ex-"panſion it draws in the moſt ſubtle parts of the "blood

" 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 *Harvey* 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 in 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 proper to carry life every where. He
" maintains, that this conveyance and manner of
" preparing the blood in the lungs, is evident
" from the junction of the veins with the arteries

" in this viſcus. And he concludes with ſaying, that " the heart having received the blood thus pre- " pared by the lungs, ſends it forth again by the " artery of its left ventricle, called the aorta, " which diſtributes it into all parts of the body." " *Andreas Ceſalpinus*, who lived likewiſe in the " ſixteenth century, hath two paſſages which com- " pleatly contain all that we know about the cir- " culation of the blood." He explains at length " how the blood guſhing from the right ventri- " cle 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 afterwards " 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 *Harvey*, 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

and thought to have been discovered by *Fallopius* of *Modena*, who died in the year 1562. We find them described as follows, by *Ruffus* of *Ephesus*. " *Herophilus*, says he, imagined that females had " no seminal vessels; but in examining the womb " of a beast, I found arising from the ovaries " certain ducts, which entwisted into each other, " were entirely varicous, and at their farther ex- " tremity 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 struc- " ture with those in males called the *varicous pa-* " *rastatæ*.

CHAP. II.

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 part of a memoir, which he imparted to his friend Mr. *Wotton*.

2. "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 who "do know nothing of them, nor have ever "read them; and who give the ſtrongeſt proofs "of their own ignorance and pride, in the man-"ner 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-in-"troduced the inventions of the ancients, and "ſet them in a better light, than in any impor-"tant 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 the men of the earlieſt times, and by that "means ſooner acquired a degree of perfection,

"than

" than the other branches of medicine: or that
" the moſt part of thoſe who afterwards aſſumed
" the profeſſion, were mere empirics, and igno-
" rant 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 reflect how few the number
" of good writers are upon this ſubject, in compa-
" riſon 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 ren-
" ders the reading of them more uſeful than thoſe
" of the moderns, is that they are more exact in
" deſcribing the ſymptoms and indications of diſ-
" orders, and more juſt and preciſe than the
" moderns, in diſtinguiſhing the different ſpecies
" of ulcers and tumors. If our age has retrenched
" ſome ſuperfluities of practice, as it muſt be
" owned it has; yet it cannot be ſhewn that theſe
" methods came from the ancients. It is much
" more probable, that they were in a great mea-
" ſure introduced by the ignorant profeſſors of a
" later date. There is no doubt but 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 part, 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 tranſ-
" mitted it to us. What I have ſaid, is inconteſ-
" tible: and for proof of it, I appeal to every
" courſe

" courſe of ſurgery that has been publiſhed by the " moſt celebrated among the moderns, all of " which appear to be but tranſcripts of one ano- " ther, excepting thoſe of greateſt note which " are taken from the ancients. Among all the " writers of ſyſtems, few deny the pre-eminence " to *Fabricius ab Aquapendente*, a man of exqui- " ſite 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 excel- " lent 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 exami- " nation into this would diſcover many more, and " of greater utility, either omitted or diſcontinued, " than of new, which we have introduced; pro- " vided their enquiry were entered upon with an " impartial and unprejudiced mind.

3. " To begin with the operation for the ſtone, " there is nobody doubts but they have a right to " claim that as their own. *Celſus* and many " others have given us exact deſcriptions of it; " though, it muſt be 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

" Tapping likewiſe is in all reſpects an invention
" of theirs. Laryngotomy, or the opening of the
" larynx in the quinſey, 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 ptery-
" gion 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
" practiſe 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 *Frederic Ruyſch*,
" that celebrated anatomiſt of *Holland*. The ex-
" tirpation 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 lacrymalis, a
" cure ſo nice and difficult, is preciſely that of
" the antients, with the addition that *Fabricius*
" made of the cannula for applying the cautery.

5. " As to the real cauſtic, which makes a
" conſiderable article in ſurgery, although *Co-*
" *teus*, *Fienus*, and *Severinus*, have written am-
" ply on that ſubject; yet it is evident from a
" ſingle

" ſingle aphoriſm of *Hippocrates*, 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 an-
" cients, as is manifeſt from the works of *Celſus*
" and *Paulus Eginetus*; and whoevér is conver-
" ſant 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 de-
" ſcription of its cure has not been omitted by
" the ancients. They were entirely well ac-
" quainted with all kind of fractures and luxations,
" and the means of remedying them; as well as
" with all the ſorts of ſutures in uſe among 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 *Cœlius Aurelianus* have ſaid of
" them, allowing withal that they ſeem not to
" have known our method of placing and con-
" tinuing them.

6. " Nor ought I to omit what is ſo manifeſt,
" that nobody will deny it, that all ſorts of am-
" putations, as of limbs, breaſts, &c. were per-
" formed among them as frequently, and with as
" great

" great ſucceſs as we can pretend to. As to the " art of bandaging, ſo very important and neceſ- " ſary, though much neglected at preſent, 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 per- " fection, 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 writ on this ſubject. And although " the moderns claim an advantage over the an- " cients, in regard to the variety of their inſtru- " ments, it is nevertheleſs evident, that they " were ignorant and deſtitute of none that were " neceſſary; nay, it is highly probable, from " what *Oribaſius* 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 proper- " ties of thoſe we now uſe; and as to general me- " thods 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 ſub- " ject.

7. " It would require more leiſure and ability " than I have, concludes Mr. *Bernard*, to enter " into a detail of more particulars, and ſhew " what hath been invented, ſet aſide, or loſt in " different ages. What I have already advanced " ſufficiently makes it appear, that we ought to " talk

" 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 judg-* " *ment 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 an-* " *cients, whoſe writings are ſo neceſſary to throw* " *light upon every part of ſcience.* And in ano- " ther place he ſays, *I have always ſhewn a par-* " *ticular regard to the opinions and maxims of* " *the moderns, yet never without paying due ho-* " *mage to antiquity, to which we are indebted for* " *the very prime foundations of our art.*"

CHAP.

CHAP. III.

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 fœtus are incloſed 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 afterwards unfolds its parts: this is the ſentiment of *Harvey*, *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 animalcula, 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

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 her operations, and particularly in the production of plants and animals. Now if this ſyſtem deſervedly confers glory on the inventer of it, it is but juſt that he ſhould have it who is beſt intitled to it; and he to whom it appears primarily due is without doubt *Empedocles*, and next to him *Hippocrates*, *Ariſtotle*, and *Macrobius*.

4. *Plutarch* relating the different opinions of philoſophers, as to the generation of animals and production of plants, ſays, that *Empedocles* thought they were all of them at firſt irregular and imperfect, but acquired afterwards 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 their particular ſeeds or eggs. This is the very ſame which *Ariſtotle* intented to indicate as the doctrine of *Empedocles*, when he introduces him as ſaying, "That whatever was born, was born of a parti-"cular 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 adjoin-

ing

ing 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 prodigious 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 fœtus six days old, comparing it *to a raw egg without the shell, round and full of a red transparent liquor*. In another place, he shews "how the same thing happens "in the generation of an infant, as in the pro- "duction of a plant." He says, "that nature is "always the same, acting uniformly in the gene- "rating of men, and of plants, and of every "thing else."

7. *Aristotle*, with still more precision, describes the egg containing the fœtus—He says, "that all "animals engender and conceive first a kind of "egg, containing a liquor enveloped in a mem- "brane or thin skin, resembling that of an egg- "shell. This, in another place, he plainly calls "an egg; out of one part of which," he says, "the fœtus 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

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 *Harvey*, which derives all generation from eggs. We have already ſeen that this latter opinion ſprung from *Hippocrates*, *Ariſtotle*, &c. And the other, of the exiſtence of ſpermatic vermiculi, is as clearly taught by *Plato*, *Hippocrates*, *Ariſtotle*, and 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 hath ſpoken of certain worms, which aſſume at length the human form; but no author tranſmitted to us, hath 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*,

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 he 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 generating of man the exterior parts of the fœtus 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 con-

contribute to the generation of what has no exiſtence, *But he maintains, that every thing increaſes as much as it can, from the loweſt to the higheſt degree of magnitude.* Theſe principles he afterwards applies to human generation. He ſays, that *the larger 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 conſequence 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,

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 fœtus, the ſubſtance of the egg its nouriſhment, and the membranes of it its wrappers.

14. *Plato* hath 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 afterwards ſpring forth 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 him teaching, that "the human form before birth was compriſed in "the ſeed, where all the members of the body "were concentered and ſhrouded up in a little "indiſcernible place." Which *Tertullian* hath expreſſed in few words, when he ſays, *the ſeed had 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 mo-

derns, 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 ſeperated 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.

CHAP.

CHAP. IV.

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 ragina, the germ to the ovary, and the pericarpium, or fecundated ovary, to the womb.

2. *Linnæus* has the honour of having compleated 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, the 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 or 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 afterwards 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.

Mr. *de Tournefort*, who could not be ignorant of what had been advanced by *Millington*, *Grew*, *Malphigi*, 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 be 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 almoſt, 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 ſhew, the ancients knew the ſexual ſyſtem of plants. This is what only appears confuſedly 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 fœtus, they produce ſeed, which is the fruit of their generative faculty. And on this account *Empedocles* called plants *oviparous*; for the ſeed, or "egg," ſaid he, "is the fruit of the genera-" tive faculty, one part of which ſerves to form " the plant, and the other to nouriſh the germ " and root; and in animals of different ſexes, " we ſee that nature, when they would procreate, " impels them to unite, and like plants to be-" come one; that from this combination of two, " there may ſpring up another animal."

9. As

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 that 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." "Naturaliſts," 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, "*the females of which never propagate, but 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.*

CHAP. V.

Of the CHYMISTRY of the ANCIENTS.

1. IF we will be guided by the greateſt number of etymologiſts, there needs no deep reſearch to demonſtrate the antiquity of Chymiſtry. 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 χημεῖα, *Chemia*, *ſive Chamia*, the ſcience of *Cham*. In the 105th pſalm, *Egypt* is called, "The Land of *Cham*." According to *Bockhart*, the *Coptes* ſtill call themſelves *Chemi*, 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 Chymiſts, 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.

2. The firſt inſtance that occurs for aſcertaining the antiquity of the ſcience, is of a very remote date. Nobody, I think, will doubt, but *Tubal Cain*, and thoſe who with him found out the way of working in braſs and iron, muſt have been able chymiſts. It was impoſſible to work upon theſe metals, without knowing the art of digging them

them out of the mine, of excavating them, and of refining and separating them from the ore, all which are chymical operations, and must have been at first invented by those who excelled in the art, however afterwards 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 shew 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 fire.

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 *Hesperides*, 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 broke 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 intirely impracticable to most of the Chymists of our days, and owned by *Boerhaave* 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 Chymiſts 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 Chymiſtry, could *Moſes* have diſſolved the golden calf, and that too without applying corroſives, which would have poiſoned all who had afterwards 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. *Frederic* the Third, King of *Denmark*, curious to put this operation in practice, engaged ſome able chymiſts to attempt it. After many trials they at laſt ſucceeded, but it was in following the method of *Moſes*, by firſt reducing the gold into ſmall parts by means of fire, and then pounding it in a mortar (along with water,) till it was ſo far diſſolved, as 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 theſe monuments that ſtill ſubſiſt, remains a ſecret to us; though it be paſt all doubt, that they prepared it in a chymical 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 chymiſtry to a degree of perfection attained but

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 Chymistry. All the essays to restore this art, have proved ineffectual, nor have the re-iterated 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 Bils*, 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 fall within the verge of Chymistry: 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 shews 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.

5. It would be eaſy to make a more extenſive enumeration of the particulars of the chymical 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 filled 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 dipt it for a moment in a caldron full of boiling liquor, proper for the purpoſe: and drew 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 dipt, 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 Chymiſtry 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 pidgeon's neck, reflected, on whatever ſide they were viewed, a variety of colours, repreſenting

ing thoſe of the precious ſtone called *Obſidianum*, which ſome commentators have imagined to be the Cats-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 chymiſtry. 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. Chymiſtry 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 Chymiſtry; 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 miniſtring to *Telemachus* 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 cyrenaic or ammoniac, ſo called from being found in the environs of the Temple of *Jupiter Ammon*. They made

made uſe of the litharge of ſilver, the ruſt of iron, and calcined alum, in the cure of ulcers, cuts, boils, defluxions 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 unguents 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, verdigreaſe, and burnt antimony; all which they made uſe of in their plaiſters, 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 chymiſtry of the Ancients, muſt ſuffice upon this occaſion; the *Greeks* and *Romans* preſenting a field too vaſt to be comprized in a tract of this kind. *Hippocrates* eſpecially, the cotemporary and friend of *Democritus*, was remarkably aſſiduous in the cultivation of Chymiſtry. 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 Chymiſtry. *Galen* knew

that

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* hath 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 Chymiſtry, 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 ſhews that this branch of chymiſtry derived from the *Greek* language the name of its principal inſtrument, the Alembic. The word ἄμβιξ *ambix*, according to *Athenæus*, 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 *al* to 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

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 *Panopolis*, 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 chymiſtry; 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, chymiſts 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*. *Varro* 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

cellent remedy. In ſhort, *Hippocrates*, *Celſus*, *Dioſcorides*, and eſpecially *Galen*, often recommend the medical uſe of ſal alcali; and their writings are filled with paſſages, which ſhew that they all underſtood it. To the mixture of acids and alcali it was, that *Plato* aſcribed 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 Chymiſtry, is the experiment with which *Cleopatra* 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, in 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 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

of it. They are *Pliny*, *Petronius*, *Ibn 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 artizan 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 recompence 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

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 *Petronius*. *John of Saliſbury* and *Iſidorus* relate this ſame fact in the ſame way.

As to the *Arabian Ibn Abd Alhokin*, 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 chymical compoſition, well-known, formed of ſilver diſſolved in acid ſpirits, which is called *cornu lunæ*, 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 he 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 hath formed many bodies, having

ing 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, in ſo far as it depends upon chymiſtry, 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 chymiſtry; of the former of which many inſtances occur in the works of *Pliny* and others.

12. Having ſpoken of the chymiſtry of the *Egyptians*, and of that of the *Greeks* and *Romans*, who derived their inſtructions from thoſe firſt maſters; it would not be pardonable to omit mentioning *Democritus*, 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 *Diogenes Laertius*, *Strabo*, *Clemens Alexandrinus*, *Euſebius*, and *Syneſius*. *Vitruvius* tells us, that he wrote many books on natural

tural 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 commentator *Servius*, *Hyginus*, *Euſtathius*, *La Cerda*, *Valerius Flaccus*, and many other authors ſpeaks in ſuch a manner of *Salmoneus's* 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 ſurprize 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

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 high at 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 Græcus*, whoſe work in manuſcript is in the royal library at *Paris*, intitled, *Liber Ignium*. Doctor *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

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 pack-thread; 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 incloſed 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 9th 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 alledged 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

which ſtill remain, and are daily before our eyes, of the ſuperiority of the ancients in many parts of chymiſtry, 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*.

CHAP.

CHAP. VI.

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 ſhew, 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; no body 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 abridgment 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

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 errors is in the abuſe of our liberty, and the precipitation with which we form judgments; 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 the 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 ſurprized 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 as 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 ſtreight, ſome pointed, ſome crooked, &c. "Thus the firſt elements of things having "in them neither whiteneſs nor blackneſs, ſweet-

"neſs

" neſs nor bitterneſs, heat nor cold, nor any " other quality; it follows, that colour, for ex- " ample, 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 ex-* " *terior objects, muſt have in them ſomething ana-* " *logous 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 no exiſtence.* He alſo carried farther, than ever *Democritus* did, 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

reader to judge, whether *Protagoras*'s manner of thinking might not have tranſmitted to *Berkeley* the idea of a ſyſtem, which he with ſo much ſubtilty hath maintained; " that there is nothing " in external objects, but what the ſenſible qua- " lities exiſting in our minds induce us to ima- " gine, 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 per- " ception 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 ap- " pears 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 diſ- " tant 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 round- " neſs from the tower, and of crookedneſs from " the oar; but it is neither neceſſary, nor proper

" to

" to affirm, that the tower is really round, or the " oar broken; for a ſquare tower may appear " round at a diſtance, and a ſtreight 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 ſweet- " neſs, but they have no common faculty to " which they can with certainty refer impreſſions " of this kind. Every one judges by his own ap- " prehenſions, and nobody can affirm that the " ſenſation which he feels when he ſees a white " object, is the ſame with what his neighbour ex- " periences in regard to the ſame object; and " becauſe the powers of apprehenſion are not in- " tirely 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 diffe- " rently conſtituted they ſeem yellow; as is ma- " niſeſt 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 ob- " jects in a different magnitude from him whoſe " eyes are little; and he who hath blue eyes, " diſcerns them under different colours from him " who hath grey."

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

"other

" other 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 dif- " ficulty 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 ano- " ther; it is themſelves who are guilty of the " deception, in imagining that the one appear- " ance 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 ſenſa-

" tions not the ſame, but yet equally true. " Whence it alſo happens. that it is not the " ſound in the braſs that is beaten, or 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 can- " not 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 ap- " proach 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 of " what they are in themſelves; and hence our " ſenſations are always true, error being only " the reſult of our judgment.

13. I 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 acknowledgment.* 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.

CHAP.

CHAP. VII.

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. Mean while 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

ſhews itſelf in a few remaining fragments, as upon an able ſculptor, who from a 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 peice, 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 ſtatue 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. *Diogenes Laertius*, *Plutarch*, and *Ariſtotle* informs us, that *Anaxagoras* 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,

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 re-unite, 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 deſtined 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 aliments, 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*

4. *Empedocles* hath acknowledged the ſame with reſpect to animal nutrition, which he 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 ſubtle 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 had alſo a ſentiment reſpecting generation, which Mr. *de Buffon* hath 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,

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 different aſſociation or diſjunction of ſimilar parts, which after the diſſolution of an animal or vegetable body, ſerve to reproduce another of the ſpecies : provided, accord-

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ing to Mr. *de Buffon*, that thoſe ſmall conſtituent parts meet in a place proper for the expanſion of themſelves, ſo as to unclooſe 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 fœtus, 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 alſo the origin of this idea, in *Pythagoras*, *Ariſtotle*, and *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

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.

CHAP.

CHAP. VIII.

NATURE ACTIVE AND ANIMATED.

1. AFTER a long courſe of microſcopic obſervations, Mr. *Needham* 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 they 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*

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 afterwards, he heſitates not to affirm, that in proportion as the matter decompounds itſelf, it becomes more ſubtle, 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. He ſays afterwards, 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.

* Abſurd to the laſt degree.

formity. *Pythagoras* and *Plato* taught, that all nature was animated, and that *matter had in itself a principle of motion* and reſt, that 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 matter 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

ſible principles might concur to give us an idea of extended combinations of them, diviſible, and ſubſtantial: yet *Plato* long before had clearly diſtinguiſhed, with the 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 *Stobæus*, 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 figure, 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.

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 afterwards 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 as ſpirit did? And *Democritus* and *Strabo* have explained themſelves hereupon with ſtill more dignity, when they call its energy ſpiritual, and convertive of bodies into itſelf.

CHAP.

CHAP. IX.

Of THUNDER, *and* EARTHQUAKES; *of the Virtue of the 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 ſhew 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 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 aſ-

ſigning

ſigning 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 adopted 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 contain 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 incloſed 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

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* diſtinguiſhed 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 intirely owing to our ſight's 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 ſuliginous ſubſtance, reſembling the ſmoke of an extinguiſhed candle, which being eaſily inflammable, and by their agitation catching fire, rarify and heat the central and condenſed air of the cavern to ſuch a degree, that finding no vent to iſſue at, it burſts its incloſements; and in doing this, ſhakes the earth all around with dreadful

percuſſions,

percuſſions, producing all the other effects which naturally follow.

7. This 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 others 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.

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, remarked that the moon acted "moſt forcibly upon the waters, when it was "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 "action of celeſtial cauſes, and the diſcernible "reſult of them on earth." He remarked alſo that the waters, which are naturally inert, do not 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

11. There are few things which have more engaged the attention of naturaliſts, and with leſs ſucceſs, than the wonderful properties of 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 impulſe 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 antients 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 cor-
" puſcles, or magnetic matter, which continually
" circulating around the loadſtone, 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 circum-ambient 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 around " 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 diffe-* " *rently 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 *Timæus 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, but 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*

very ſubtle 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 *Timæus* ſays of it, in giving the reaſon of amber's attracting bodies; this happens, ſays he, *becauſe there iſſues from the amber a ſubtle 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 ſubterraneous 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 re-conduct 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 compleatly 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.

CHAP. X.

Of Ether, and of 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 ſubtle 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 acknowledged, 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 phænomena in nature ariſe; for, by the extreme ſubtilty 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

ancients have ſaid on this ſubject. The *Stoics* firſt of all taught, there was a ſubtil 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 performed 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 ſubtle and active fire. And *Ariſtotle* himſelf, in another place, underſtands by ether, a *fifth element, pure and unalterable, of an active and vital nature, but intirely 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*, and *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 regarded 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 *Stobæus* quote him as teaching that the *Air in its weight is between that of Fire, and of Earth*; and he 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 *Aſclepiades* 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 wind-guns, which we look upon as a modern contrivance. *Philo* of *Byzantium*,

zantium 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 impreſſed*; and affirms, that *it has the property of condenſing itſelf, and forcing its way through all obſtacles that oppoſe its paſſage.*

6. The notions moſt generally received reſpecting Fire, and its properties, are clearly to be found in *Plato*, *Stobæus*, *Ariſtotle*, and *Lucretius*; the firſt of whom ſays, that Fire is generated of motion, it being the effect of the action 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.

CHAP. XI.

NEWTON's *Theory of Colours, indicated by* PYTHAGORAS *and* PLATO.

1. THAT 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 for ever 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 ſolely from the different modifications of reflected Light*; or, as a modern author, in explaining 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 of colours, aſcribe it to a mixture*

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 ſtreight 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: he hath entered into a detail of the compoſition of colours, and enquired *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 ſhews, that he had 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 others.* And he afterwards 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 eulogium are theſe words in the mouth of ſuch a philoſopher as *Plato*, and how 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 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;

greſſive; 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 ſubtle matter upon the organs of ſight. This ſubtle 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 ſubtle, pure, and homogeneous matter; and *Philoponus*, explaining the manner 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 ſubtle matter, to the ſtring itſelf; and the inſtantaneous action of the one,

one, to the movement of the other. *Simplicius*, in his commentary upon this paſſage of *Ariſtotle*, expreſsly employs the motion of a ſtick, to intimate how Light, acted upon by 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 to have been firſt of all made uſe of by *Chryſippus*.

CHAP.

CHAP. XII.

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 of 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 hath been atteſted by *Diodorus Siculus*, *Lucian*, *Dion*, *Zonaras*, *Galen*, *Anthemius*, *Euſtathius*, *Tzetzes*, and others. Nay, ſome have even pretended to demonſtrate by the rules of *Catroptrics* 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.

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*'s 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 168 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, intitled *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 *Archimedes* muſt have been poſſeſſed of, to enable him to ſet fire to the *Roman* fleet. He begins with this enquiry, " How in any given

" 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 *Archimedes* 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 afterwards advances farther in this enquiry, 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 ſhewn, " 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 at 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 " circum-ambient air, reciprocally augmenting " and increaſing the heat; whence" continues he, " it neceſſarily reſults, that by a proper number " of plain mirrors duly diſpoſed, the ſun's rays " might

" might be reflected in ſuch quantity into a com-
" mon focus at a bow-ſhot diſtance, as to ſet all
" in flames around it.

5. " As to the manner of putting this in prac-
tice" he ſays, " it might be done by employing
" many hands to hold 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,
" he 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 to-
" gether, 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 multiplying compound mirrors of this
" kind, and giving them all the ſame direction,
" there muſt thence infallibly reſult, to whatever
" degree of intenſeneſs, the conflagration required
" at the place given."

6. " The better to ſucceed in this enterprize,
" there ſhould be in readineſs" he adds, " a con-
" ſiderable 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 ma-
" chine of the divine *Archimedes*, never ſpeak of
" it as of one compound mirror, but as a combi-
" nation of many." So large and accurate a deſ-
cription is more than ſufficient to demonſtrate the
poſſibility

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.* *Zonaras* 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 wherein *Proclus* effected this, was by launching upon the enemies' veſſels, from the ſurface of reflecting mirrors, ſuch a quantity of flame, as reduced them to aſhes.

7. *Euſtathius*, in his commentary upon the *Iliad*, ſays, that *Archimedes, by a catroptic 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 *Archimides* 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

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 ſhewed 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*'s 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 for ever of his debts. He replies, that *he thought of making uſe of a burning glaſs, which he had 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 be 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 chryſtal, 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.

CHAP.

CHAP. XIII.

Of universal Gravity, and centripetal and centrifugal Force.

Laws of the Movement of the Planets, according to their Diſtance from the common Center.

1. IT is here the moderns flatter themſelves they have a remarkable advantage, imagining, that they were the firſt who diſcovered the principal of univerſal gravitation, which they look upon as a truth unknown to the ancients. It is however eaſy to make it appear, that they have done nothing but trod in the paths of thoſe antients. It is true, 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 find 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

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*'s 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 intimate a law, or power, which ſeparated the parts of matter, in order to join itſelf to them, and to which nothing was wanting but the name of attraction. One ſees alſo, that by the name diſcord, he 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. *Timæus*, 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 *Timæus* 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 that perpendicular motion, which has a tendency to the center of the univerſe, that is, gravity; and what in

in this caſe coincides with it, a lateral impulſe, rendering the whole circular. And *Diogenes Laertius*, 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 afterwards 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 terreſtrial bodies have this tendency, and which collects into one the parts conſtituting the ſun and moon, and retains them in their ſpheres.* He afterwards applies theſe particular phænomena 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 connections one towards another. He illuſtrates this general connection, *by inſtancing what happens to our moon in its revolution round the earth, comparing it to a ſtone in a ſling, which*

is

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 centers; 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 center, 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 center, 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 center, 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, re-unite at the common center of gravity, and coaleſce 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 center of the earth. Their ideas were more philoſophic; *that this power was diffuſed through every*

every particle of the terreſtrial globe, and compounded of the various energy reſiding in each.

9. It remains to enquire, 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 proportion; 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 difference 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 *Maclaurin*, 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 he had a better

better opportunity of entering into the ideas of that great man, hath explained them better than any one beſides. *Pliny*, *Macrobius*, 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* hath 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 *Maclaurin*, 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 lat-"ter, or the force whereby it is extended, is "quadruple to that of the former; *and the gra-"vity of one planet, is quadruple to that of any "other, which is at double the diſtance.* In ge-"neral, to bring a muſical ſtring into uniſon with "one of the ſame kind, ſhorter than itſelf, its "tenſion ought to be increaſed in 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*

" *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 foun- " dation for the reports, that *Pythagoras* drew " his doctrine of harmony from the ſpheres."

12. Before I finiſh this chapter, I 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 diſcernible 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 de- " gree of velocity, ſo as perpetually and equally " to remain in it, without firſt paſſing through " all the inferior degrees of celerity or retarda- " tion; concludes thence, that God, after having " created the celeſtial bodies, determining to aſ- " ſign 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 " afterwards changed the perpendicular into a " circular direction, that being the only courſe " that can preſerve itſelf uniform, and make a " body without ceaſing keep at an equal diſtance

" from its proper center." 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.

CHAP.

CHAP. XIV.

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, and 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 center, 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*, *Philolaüs*, *Nicetas* of *Syracuſe*, *Plato*, *Ariſtarchus*, and many others among the ancients, have in a thouſand places expreſſed this opinion; and *Diogenes Laertius*, *Plutarch*, and *Stobæus*, have with great preciſion tranſmitted to us their ideas. And that this ſyſtem was no ſooner univerſally received, ought intirely 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 center 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 afterwards lays itſelf on its back, and, by means of its feet, whirls that ball round in a circle.

4. Some impute this opinion to *Philolaüs*, 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

for *Euſebius* expreſly affirms, that he was the firſt who put *Pythagoras*'s ſyſtem into writing. *Philolaüs* added, that the earth moved in an oblique circle; by which, no doubt, he meant the zodiac.

5. *Ariſtarchus* of *Samos*, 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 cen-"ter 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 *Cleanthes* accuſed *Ariſtarchus* of impiety, in troubling the repoſe of *Veſta*, and all the Larian gods; when, in giving an account of the phœnomena 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 hath 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 center; but put the earth there, contrary to the order of nature. Nor is it at all ſtrange, that *Plato* ſhould re-aſſume an opinion which he had early imbibed in the ſchools of the two celebrated *Pythagoreans*, *Archytas* of *Tarentum*,

rentum, and *Timeus* the *Locrian*; as we ſee in St. *Jerom*'s Chriſtian Apology againſt *Ruſinus*; 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 there 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

appears ſtill in 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 in the zenith, or elſewhere, change their ſituation with reſpect to us.

CHAP. XV.

Of the REVOLUTION OF THE PLANETS *about their own axis.*

1. HOW uſeful an aid the invention of Teleſcopes hath 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 center; 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 hath 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

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 *Ecphantus*, 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 center. 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 center, 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 center.*

3. *Cicero* aſcribes the ſame notion to *Nicetas* of *Syracuſe*, and quotes *Theophraſtus* to warrant what he advances; this is he whom *Diogenes 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

ſentiment of *Anaxagoras* and of *Empedocles*, who thence accounted not only for the mildneſs of its ſplendor, 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 and 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 be 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 aërial 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

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 hath 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 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 author, 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, valleys, &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 he 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 ſhew by a croud of paſſages, that this opinion was very common among the ancient philoſophers;

ſophers; but I ſhall content myſelf with adding a remarkable paſſage of *Stobæus*, 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, alledging, that there were emboſomed 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 opake 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 *Xenophanes* 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

that there exiſted there, neither clouds, nor rains, nor winds; and of courſe neither plants nor animals. Now, this is the very reaſon alledged 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 intirely different from thoſe of ours, and by their conſtitution fitted to ſuch a clime, and ſuch an 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.

CHAP.

CHAP. XVI.

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 ideas 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 enquiry 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 that trace of white, which we now obſerve there. The *Peripatetics* have aſſerted, after *Ariſtotle*, that it was formed of exhalations, ſuſpended high in air. I eaſily admit, that there were miſtakes; but all were not miſtaken in their conjectures. *Democritus*, without the aid of a teleſcope, preceded *Galileo* in remarking, that *what we call the Milky Way, contained in it an innumerable quantity of fixed ſtars, the mixture of whoſe diſtant rays occaſioned the whiteneſs which we thus 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

derns 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 Fontenelle.*

4. And this notion of a Plurality of Worlds, was generally inculcated by the *Greek* 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 in- "numerable, though not abſolutely infinite multi- "tude 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 this opinion, which paſſed from the *Ionic* to the *Italic* ſect; who held, that every ſtar was a world, containing

containing in itſelf a ſun and planets, all fixed in that immenſe ſpace, which they called Ether.

7. *Heraclides*, 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. *Origen*, in his *Philoſophumena*, treats amply of the opinion of *Democritus*, 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* alſo held this opinion, as did likewiſe *Alcinoüs*, the *Platonic*, and *Lewis Cælius 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

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 how it came to be admitted as cer- "tain, that there were no other wandering stars, "or planets, but those observed by the *Chaldeans*. "As for his part, he thought that their number "was more considerable than was vulgarly given "out, though they had hitherto escaped our no- "tice." 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 handed 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.

CHAP.

CHAP. XVII.

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 phænomena. 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, by recalling and fixing our attention upon what had formerly been advanced by the *Chaldeans*, *Egyptians*, *Anaxagoras*, *Democritus*, *Pythagoras*, *Hippocrates* of *Chios*, *Seneca*, *Apollonius 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 of 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*

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 collected obſervations very ancient and very exact, fully informing them of the ſeveral motions, orbits, and ſtations of the planets; adding alſo, that they could foretel earthquakes, inundations, *and the return of comets*.

3. *Ariſtotle*, in laying down the opinion of *Anaxagoras* and *Democritus*, 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*

Ariſtotle falls into, in endeavouring to explain *Pythagoras*'s 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 *Chios*, and *Æſchylus*, in confirmation of this opinion.

4. *Stobæus* preſents us with *Pythagoras*'s 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 afterwards reaſons upon this with equal elegance and ſolidity. " Why ſhould we be aſtoniſhed," ſays he, " that " comets, which are ſo rare a ſpectable 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 the 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 to us obſcure, " will one day or other, in the courſe of ages, " and through the induſtry of our deſcendants, " become

" become manifeſtly clear; but a ſmall number " of years, paſſed between ſtudy and the indul- " gence of paſſion, will not avail for reſearches " ſo important, as thoſe which propoſe to them- " ſelves the comprehenſion of natures ſo re- " mote."

6. Upon a review of the ſeveral paſſages which we have juſt now cited, it muſt 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.

CHAP.

CHAP. XVIII.

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 aſtronony, 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 careſully 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 this effect, he ſays; "The advantages "recommending the ſtudy of aſtronomy to the "people of the eaſt were many. The ſereníty of "their weather; the largeneſs and correctneſs "of the inſtruments they made uſe of, much ex-

" ceeding 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 ſhew in how many " reſpects the *Arabian* aſtronomers detected the " deficiency of *Ptolemy*, and the pains they took " to correct him; how carefully they meaſured " time by water-clocks, ſand-glaſſes, immenſe " ſolar dials, and even what perhaps will ſur- " priſe you, *the vibrations of the pendulum*; and " with what aſſiduity and accuracy they con- " ducted 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 now employ it.

3. The diſcovery of the refraction of light, is of more antient 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

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 *Ptolemy*, 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 which 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 come upon the horizon. *Alhazen* tells us of a method whereby we may aſſure ourſelves of 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 phænomenon. 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*, enquiring 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, not " 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 re- " fraction and augment the diſperſion of the rays, " whereby

" whereby the object muſt needs be magnified to
" our eye." " Though," ſays he afterwards,
" there has been aſſigned by *Ptolomy* 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 over head,
" 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, and 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 overhead; 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. " *Anaxagoras* and *Democritus*," ſays he, " were inſtructed by *Agatarchus* the
" diſciple of *Eſchylus*. 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, yet they " could not but know at ſight the edifices, and " other proſpects which offered themſelves in the " perſpective ſcenes they drew for the decoration " 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 ex- " cellent painter, applied himſelf much to the " ſtudy of geometry, and maintained that, *with-* " *out 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 drawings, or hiſtory of painting, makes it appear that he knew this ſcience; and

and in the deſcription he gives of *Menatius*'s 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 vertex of 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. *de Montucla* has 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 quite at a loss to conceive where he 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 not 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 unobscured? But of all this there is not one word in *Aristotle*. Mr. *de Montucla* afterwards 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 assumed the resemblance of the luminous 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 intire 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 translation 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*

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 luminous 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 intire neglect of them, or from not rightly underſtanding them.

CHAP. XIX.

Of the many DISCOVERIES *of the* ANCIENTS *in* MATHEMATICS, *&c.*

1. A Large book might be compoſed, were we but curſorily to mention all 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 principal of them, 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 of, who predicted eclipſes; pointed out *the advantages that muſt ariſe 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 did no leſs ſervice to geometry than aſtronomy. He inſtructed in that ſcience the *Egyptians* themſelves, to whom he went to be taught. He ſhewed them how *to meaſure the pyramids by the length of their ſhades, and to determine the meaſure of inacceſſible heights 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 contract*

tract right-angled. He discovered respecting the isosceles triangle, that the angles at its base 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 many other valuable truths, too long to be narrated. We owe to *Anaximander*, the successor of *Thales*, the *invention of 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 musick, 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 in 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 proportioned 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 plain 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 *Eudoxus*, *Archytus*, and *Menechmus*. To him alſo is aſcribed *the ſolution of the problem concerning the triſection 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 360 years before *Jeſus Chriſt*, we owe the invention of algebra. That the ancients laid the firſt foundations of algebra, is a thing out of doubt, and ſhewn by the celebrated *Wallis* in his hiſtory of that ſcience. He makes no queſtion but algebra was known to the

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 *Savilian* library, which treats of this ſcience, and bears the name of *Apollonius*. 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 *Paris*, and who was without " all doubt an excellent geometrician, never " could reflect, but with aſtoniſhment, on the " demonſtrations of *Archimedes* concerning the " properties of the ſpiral line, and could not conceive how that great man hit upon the applying " the tangent of that line to the commenſuration of the

" 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 that state of perfection which it hath now attained. Now, according to this able geometrician, the method of investigating *infinite series* 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.

troduced 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 the ſpace incloſed 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 afterwards, by an analytic 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*. *He 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 phaſis 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

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* reprehends *Rohault* as lying 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 *Timæus Locrenſis*, who lived before *Plato*, taught this very aſtronomical truth in clear terms.

CHAP.

CHAP. XX.

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 he 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*

true principles of ſtatics and hydroſtatics? What a proof of his ſagacity did he give in diſcovering the quantity of ſilver, that was mixed with the gold, in the crown of King *Hiero*; whilſt he 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 therefore the crown in water and in air, and two maſſes, the one of gold, 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 rendered *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 baliſtæ, 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

niſhment of every one, ſhook them with ſuch violence, as either to break them in pieces, or ſink them to the bottom.

3. The ſuperior knowledge he had in ſciences, and his confidence in the powers of mechaniſm, prompted him once to ſay to King *Hiero*, 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 galley, of twenty banks of oars, containing ſpacious apartments, gardens, walks, ponds, and all other conveniences 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 pullies; 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 ſuch 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. 'Tis with difficulty we can conceive, how they reared thoſe bulky towers, an 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

beat down walls; in the middle a draw-bridge, 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, harraſſed 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 Cæſar*, 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 enterprizing genius of the antients, and the vigour wherewith they put their deſigns in execution. The invention of *pumps* by *Cteſibius*, and that of *water-clocks*, *cranes*, *antomatical 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 ſhall find equally inconteſtable evidences of greatneſs of genius among the antients, 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 *Palmyra* and *Balbec*.* *Italy* is filled with monuments, and the ruins

* 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.

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; whoſe ſides were adorned with gardens of a prodigious extent, which aroſe in terraſſes 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 terraſſes; 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 have not ventured to aſſign the meaſure of it: others put it at a thouſand paces.

7. *Ecbatane*, the capital of *Media*, was of immenſe magnificence, being eight leagues in circumference, and ſurrounded with ſeven walls 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 i s ancient grandeur.

8. The

8. The lake *Mocris* is likewiſe a ſtriking proof of the vaſt undertakings of the ancients. All hiſtorians agree in giving it above an hundred and fifty leagues in circuit: yet was it intirely 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 ſolidity, ſo far 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 ſubſiſt 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*

bylon and *Media*, be cut out into a ſtatue of herſelf, which was ſeventeen ſtadia high; that is, near two miles: and around it were an 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 an 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 incloſed. 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 *Alcantara*, 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

each of which measures above an hundred feet from one pier to the other; and it's 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, an hundred and fifty feet high, sixty in circumference, and distant one from another an 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 conveniences 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 mirrours and pier-glasses? But what will now shock the general prejudices 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 phengites, the talcum, &c. whilst the poor were under a necessity of being exposed to all the severities 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.

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 *Myrmecides*, 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 it's 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 he inclosed in the rind of a grain of corn.

12. It is natural here to enquire, 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 a square, or even optic glasses, were to the sight. *Plutarch* speaks of mathematical instruments, which *Archimedes* made use of, to manifest to the eye the largeness of the sun; which may be meant of telescopes. *Aulus Gellius* 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 it's 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 intirely 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 needleſs taſk, to undertake to ſhew, that the ancients have the pre-eminence 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

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, Æneid, 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 hath been laid before the reader, and which comprehends in it almost the whole circle of our knowledge. Of the remaining admirable monuments, which shew 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 Niobé of *Praxiteles**, and the famous statue of *Laocoon*†, still to be seen at *Rome*, are and ever will be models of beauty and true sublime in sculpture; where much more

* Some ascribe this piece to *Scopas*, the contemporary of *Phidias*, and who reached the times of *Praxiteles*. It is still in being, and to be seen at *Rome*.

† The joint labour of *Agesander*, *Polydorus*, and *Athenodorus* of *Rhodes*, who, according to *Maffeus*, lived all of them about the eighty-eighth Olympiad; it is in the Belvidere at *Rome*.

is to be admired, than comes within the comprehenſion of the eye. The Venus de medicis*, 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 Belvidere¶, the maimed Hercules of the ſame place, and the Equerry in the action of breaking a horſe on mount Quirinal**, are all 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 a ſilver medal of *Alexander the Great*, on the reverſe of which there is Jupiter ſitting on his throne, finiſhed with the fineſt ſtrokes of art; not a feature, even the ſmalleſt, but ſeems to declare his divinity. The ſtones engraved by *Pyrgoteles*, who had an excluſive privilege of engraving *Alexander*'s head, as *Lyſippus* had of making his

* The workmanſhip of *Cleomenes*, the Athenian, ſtill to be ſeen in the Farneſian palace at *Florence*.

† Aſcribed to *Polycletus*, who made the Coloſſal ſtatues of *Juno* in gold and ivory at *Argos*, which no longer exiſts.

‡ The work of *Glycon*, ſtill remaining in the Farneſian palace at *Florence*.

‖ Done by *Cteſilas*, or *Cteſias*, in the gallery of the Capitol.

§ By *Agaſias* of *Epheſus*.

¶ By the ſame. Theſe two laſt were at *Antium*, 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 ſtill, at *Conſtantinople*, in the beginning of the thirteenth century; together with the beautiful Cnidan Venus, the handy 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*.

his ſtatue, and *Apelles* of painting him; thoſe *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 eminent pieces of ſculpture and engraving, ſo carefully ſought after by the curious, and with ſo much reaſon admired by connoiſſeurs, render 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 reliques, and ſo much 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 landſkape with figures, both of the utmoſt beauty. There are alſo a ſacrificial piece, conſiſting of three figures,§ and an Oedipus, and a ſphynx; which all of them formerly

* In the palace of Barbarini.
† In the gallery of the college of St. Ignatius.
§ In the poſſeſſion of Cardinal Alexander Albani.

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 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 fine 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 thoſe 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 *Zenxis* 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

‡ In the Villa Albieri.
‖ Theſe two are, perhaps, the performances of Parrhaſius.

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 *Tivoli*. It represents a bason 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 afterwards 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 diciples, 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.

Till his time muſic was ſo vague and uncertain, that it required an extraordinary effort of genius to reduce it to method and order. He preciſely determined the proportions which ſounds bears one to another, and regulated harmony upon mathematical principles. But he 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. Ariſtoxenes, the diſciple of Ariſtotle thought, on the contrary, that this ſubject, came intirely within the verge of hearing, and that the ear was the only judge of ſounds. He therefore regulated the order, the uniſon and break in tones, ſolely by the judgment of the ear; and his ſyſtem prevailed for ſome time in *Greece*. *Olympus* a *Phrygian*, came ſoon after to *Athens*, who invented a ſtringed inſtrument which gave the ſemi-tones, whereby he introduced ſo many new graces into muſic, as gave it intirely another air. He joined *Ariſtoxenes*, appealing for the merit of his ſyſtem to the deciſion of the ear. At length the famous *Ptolemy* ap-

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 *Pythagoreans* 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 agreable to it, merely becauſe the proportions of it did not correſpond with their arbitrary rules. And he charged the partizans of *Ariſtoxenes* with an 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. He 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 no 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 afterwards made. The ancients have the whole merit of having laid down the firſt exact principles of muſic; and the writings of the *Pythagoreans*, of *Ariſtoxenes*, *Euclid*, *Ariſtides*, *Nicomachus*, *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 of noting their tunes, which

among them was called the paraſemantic, or ſemeiotic, performed by means of intire letters either contracted, or reverſed, placed upon a line parallel to the words, and ſerving for the direction, the one of the voice, 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 *Meſſina*, in the library of the Jeſuits, wherein he found the hymns noted, juſt as in the manner of *Aretin*.

18. As to the effects, which muſic produced, and the manner of performing it, ſo far were the ancients from falling 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 to the latter, though it be alledged, that their inſtruments were not ſo compleat 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, and too apt to relax the mind. In *Anacreon*'s time, it had already obtained forty ſtrings. *Ptolomy* and *Porphyry* deſcribe inſtruments reſembling the lute and theorbo, having a handle with keys belonging to it, and the ſtrings extended from the handle ove a concave body of wood. There is to be ſeen at *Rome* an ancient ſtatue of *Orpheus*, with a muſical

musical bow in his right hand, and a kind of violin in his left. In the commentaries of *Philostratus* 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 num- "ber of pieces, consisting each of so many differ- "ent parts, connected together by such a quanti- "ty 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 toge- "ther 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 base bears such a symphany 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

ing 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 baſe, the " higher notes, and the intermediate, the ſoft " accents of women, and the tones of men, in- " termingled with the ſound of flutes, which, " however ſeparately diſtinct, form altogether but " one harmony of ſound, in which each bears 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 baſe 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 practiſe 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 baſe and 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

fectly 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, thro' all the different tones, from the base 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 base 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 base 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 intirely 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. I 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

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 be remarked, that thoſe, who gave this advice, were but houſhold ſervants. Profane hiſtory ſupports us in this reflection, by a great number of inſtances of the ſame kind. *Aulus Gellius* and *Athenæus* 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 *Eurydice* 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 alledged, 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

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. The work indeed referred to is now lost. Another purpose, to which the 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 heard of the wonderful influenee, 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 *Lacedemon* by the lyre of *Terpander*;

gander; and *Boetius* of rioters diſperſed 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 their 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 coarſer ſort, which knows no other refinement, than that of the whole and the demi-note, 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

* *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.

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*, *Æolic*; 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.

The 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 had 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 authorized by *Aristotle*, *Democritus*, and many other philosophers of antiquity, *Mallebranche*, observing his system accused not only of being false, but of being impious, immediately had recourse to the authority of St. *Augustin*. And some *Newtonians*, upon seeing that attraction was by

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 recourſe to the authority of the ancients; others, upon being attacked, have fled 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 belonged 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* hath 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*, *Parmenides*, *Plato*, and St. *Auguſtin*; but when he ſaw himſelf warmly attacked

tacked 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 diſtinguiſhed the properties of the mind from thoſe of the body, and demonſtrated, 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 *Leucippus*, *Democritus*, *Plato*, *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 ground work of his ſyſtem, which has always been thought to be new, though it appears to be almoſt intirely the ſame with that of *Anaxagoras*, *Empedocles*, and *Plotinus*. 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 *Caſſendi* 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*,

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*, *Ariſtotle*, *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 in 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 and elaſticity. *Leucippus*, *Chryſippus*, *Ariſtophanes*, and the ſtoics, had fully accounted for

for thunder and earthquakes. *Pytheas*, and *Seleucus* of *Erythrea*, preceded *Descartes* in explaining the cause of the ebbing and flowing of the sea; and *Pliny*, before 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, 1600 years ago, the varicous paraflatæ, called by us the Fallopian tubes. And by the sentiment of an able surgeon of the present age, we have shewn, 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 gun-powder, and a thousand other chymical preparations, with which we have proved the ancients to have been acquainted, leave not the least doubt of their skill in chymistry. We have seen, that the sentiment of *Harvey*, *Steno*, and *Redi*, 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 *Leuwenhoek*, 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 assign to *Morland*, *Grew*, *Vaillant*, and *Linnæus*, 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

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 its cauſe, their attempts to ſquare the circle, their diſcovery of the fundamental propoſitions of geometry, and above all that of algebra, and the preceſſion 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 painting, 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 preceeded us, directed, or ſurpaſſed us.

8. Now, if it hath been demonſtrated, that the writings of thoſe great maſters contain the greateſt

eſt part of what is to be known, and 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 intirely 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 either 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 aſcertain 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

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 he, "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 ſtill 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 a-new, to put their inventions into uſe, and make their knowledge ours."

WHEN

WHEN I firſt read over the preceding Treatiſe, I had little thought or deſign of making ſo large an Extract from it. But I afterwards 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, 2. That it might ſerve for a kind of recapitulation of the preceding ſchemes. 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 in 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 an ocean both of Knowledge and Love!

LONDON, Nov. 16, 1777.

APPENDIX.

BEFORE I conclude, it ſeems highly neceſſary to inlarge a little on ſome particulars, which were before but ſlightly mentioned.

One of theſe is the *Human Underſtanding*, which was juſt mentioned in the 4th Chapter of the Firſt Part. On this important head I now intend to ſpeak particularly; chiefly on the plan of the pious and learned Dr. *Brown*, late Biſhop of *Cork* in *Ireland*.

It is needful, firſt, to trace out the *bounds* and *extent* of human underſtanding. Theſe bounds being fixt, we are next to conſider, how the mind

dilates itſelf beyond them; how it ſupplies the want of direct ideas, by raiſing up ſecondary images in itſelf: inſomuch that things, otherwiſe imperceptible, grow familiar and eaſy; and we meditate and diſcourſe even on thoſe beings, whereof we have not the leaſt direct perception.

CHAP. I.

SECT. I.

Of the Ideas of Senſation.

OUR ſenſes are the only ſource of thoſe ideas, upon which all our knowledge is founded. Without ideas of ſome ſort or other we could have no knowledge, and without our ſenſes we could have no ideas. But theſe being once tranſmitted to the memory, the ſoul, which till then was ſtill and unactive, being ſupplied with materials to work upon, begins to exert her operations.

Before we ſpeak of the properties of ideas of ſenſation, it is proper to obſerve three things: 1. That

That it is not neceſſary to decide, whether ſenſitive perception be performed, by an impreſſion of the object upon the ſenſe, or by an operation of the ſenſe upon the object. It is certain, that either way of ſenſitive perception neceſſarily requires the preſence of the object, and an immediate action, either of the organ upon this, or of this upon the organ: conſequent upon which is a ſort of repreſentation of the object to the mind. This is the caſe of all external objects, which have left any repreſentation of themſelves with us by our ſenſes: which repreſentation being tranſmitted by the ſenſes to the memory, is properly termed an *Idea*.

If any one aſks, what an idea is, let him look upon a tree, and then immediately ſhutting his eyes, try if he retains any reſemblance of what he ſaw; and that is an idea. Thus it is, that all the variety of the viſible creation is let in upon our minds through the ſenſes, as all the parts of a delightful and ſpacious landſkip are contracted, and conveyed into a dark chamber, through an artificial eye in the wall, and ſo become conſpicuous and diſtinguiſhed in miniature.

Nor, 2. Is it material, whether the ideas of ſenſible objects are true images of their real natures; or whether the objects be only the occaſions of producing thoſe ideas, by virtue of an ar-

bitrary law of God, That such a thought in the soul shall follow such a motion in the body. For whatever impression sensible objects occasion in us, this we call their idea; it being the only perception of them we are capable of, and the only way we now have of knowing them. And such a way it is, as answers all the ends of knowledge in this life, and lays a ground-work sufficient for all that knowledge, which is necessary in order to another.

The third thing proper to be mentioned is, that, to prevent confusion, the word *idea* is, in all that follows, confined to the images we have of sensible objects, and the various alterations of them by the understanding. And taking the word in this sense, the mind has no idea of her own operations. For these are originally within us themselves, and so are known by inward consciousness; not as outward things are, by any similitude of them, conveyed through the senses to the memory.

SECT. II.

Of the Idea of Spirits.

WHEN we observe such effects among material things, as we know cannot proceed from any inherent power in them, we necessarily infer,

infer, There are ſome other beings not material, which have the power of producing thoſe effects: though, as theſe beings are imperceptible to our ſenſes, we have no idea of them.

It has been ſaid indeed, that we have as clear an idea of *ſpirit*, as we have of *body*: and to prove this, it is ſaid farther, that we conceive *thinking*, as clearly as we do *extenſion*. But what if we did? A pure ſpirit, if we ſpeak ſtrictly, does not *think* at all. Thinking is the property of an *imbodied ſpirit*, as requiring the concurrence of material organs, and being accordingly ever performed to more or leſs advantage, as theſe are better or worſe diſpoſed. They are ſoon relaxed by the labour of thought and attention, and muſt be conſtantly wound up anew by reſt or ſleep. A diſtemper puts the whole machine out of frame, and turns our ſober thinking into madneſs. And if the veſſels of the brain are intirely obſtructed, as in an apoplexy, we think not at all. How then can we imagine, that a pure ſpirit *thinks*? It *knows* indeed; but we cannot tell how: to be ſure, not by playing upon a ſet of material ſprings, exquiſitely wrought up into a curious contexture for that purpoſe.

It is becauſe we have no idea of a ſpirit, that we are naturally led to expreſs it by a negative; to call it an immaterial ſubſtance, or ſomething

that is not matter; ſomething that is not any thing that we know; which forces us to conceive and expreſs it in this imperfect manner.

Yet it has been affirmed farther, that we have as clear an idea of God himſelf, as we have of man; and that we are as ignorant of the eſſence of a man, as we are of the eſſence of God? Do we not then know, that it is eſſential to man to be finite? And have we not a diſtinct idea of Finiteneſs? But who has any idea of Infinity, the eſſential attribute of God? 'Tis plain, we have not: and therefore we expreſs it by a negative, "Without bound."

Properly ſpeaking, we have no idea of God. We come to our knowledge of his very exiſtence, not from any idea of him, but from our reaſoning upon the works of the viſible creation. And hence, for want of a ſimple and direct idea, we form an indirect and very complex notion of him.

This we do in the beſt manner we can, by removing from him all the imperfections of the creatures, and attributing to him all their perfections, eſpecially thoſe of our own minds. Yet in truth even theſe cannot be ſuppoſed to be in God, as they are in us. And therefore we are ſaid to aſcribe them to him only in the *abſtract:* which is ſaying in other words, that they are of a different

ſpecies

ſpecies in the Creator, from what they are in the creature.

Accordingly, that there are incomprehenſible perfections in God, anſwerable to knowledge and power in man, whereof theſe are only the faint, though true, reſemblances, is natural and eaſy to conceive. But the conceiving his power as an ability to change things infinitely, his knowledge as only infinite thinking; the multiplying and inlarging our own perfections in number or degree only, to the utmoſt ſtretch of our capacity, and attributing them ſo inlarged to God, is no more than raiſing up an unwieldy idol of our own imagination, without any foundation in nature.

The ſum is this. We have no idea of God, as he is in himſelf. For want of one, we frame the beſt conception we can, by putting together the perfections of the creatures, particularly thoſe we obſerve in ourſelves, to ſtand for his perfections: not groſly inferring, That God is, in effect, ſuch an one as ourſelves; but concluding, that our greateſt excellencies are the apteſt repreſentations of his incomprehenſible perfections, though theſe infinitely tranſcend the moſt exalted of what are in any created beings, and are far above, out of the reach of all human imagination. So true it is, that, though it may be juſtly affirmed, we can have no knowledge *without* ideas, yet it is moſt

unjuſt and abſurd to infer thence, that we can have no knowledge *beyond* them.

SECT. III.

The Properties of Ideas of Senſation.

SINCE then the *ideas of ſenſation* are the foundation, and rough materials, of all even our moſt abſtracted knowledge, (out of which every man raiſes a ſuperſtructure, according to the different turn of thoſe organs, that are more immediately ſubſervient to the operations of the underſtanding, and the different ways in which he employs thoſe operations;) it will be convenient to ſay ſomething concerning the properties of theſe ideas.

Their firſt property is, that they are *original*. We receive them from our firſt coming into the world, without any immediate concurrence of the underſtanding, antecedently to any of its operations. The ſoul, till theſe are received, is wholly unactive, and cannot ſo much as form one thought. Theſe ideas are, in reſpect of our ſubſequent notions, like the firſt particles of matter in reſpect of the things compounded of them. They run through infinite changes, as the mind work

works upon them; yet in themſelves remain unchangeable. And as our compound notions are made out of theſe, ſo are they all ultimately reſolvible into them.

Ideas of ſenſation are by this property diſtinguiſhed,

1. From ſuch ideas, as are ſuppoſed to be innate, and antecedent to the impreſſion of any outward object.

That we have no ſuch ideas, ſufficiently appears even from hence, That we have no occaſion for them. We have no occaſion for innate ideas of ſenſible objects, becauſe there is an obvious way of obtaining them by the ſenſes. And as to our knowledge of ſpiritual things, as it cannot be accounted for by innate ideas, ſo it eaſily may be accounted for without them. The riſe and whole extent of this knowledge is eaſily accounted for, from the ideas we have of ſenſible objects, the neceſſary conſequence we draw from their exiſtence, to the exiſtence of things not ſenſible, and from that manner of conceiving theſe, which we naturally fall into, by the help and mediation of ſuch things, as are within our preſent ſphere.

2. From ſuch ideas as are ſuppoſed to be acquired by, and ſeated in the underſtanding, to be the ground-work of our knowledge of ſpiritual things, as others are of our knowledge of things

material. Now, if there were any ſuch ideas, we muſt acquire them one of theſe ways: either,

Firſt, By the preſence of the object itſelf, and its immediate impreſſion on ſome faculty diſpoſed to receive and retain the impreſſion. But every one may be conſcious, that immaterial objects were never ſo preſent to any faculty of his mind, as to imprint and leave upon it any juſt and real ſimilitude or reſemblance of themſelves. Or,

Secondly, Theſe ideas muſt proceed from the immediate power of God. That he *can* impregnate the mind with them, is certain. But how is it proved, that he *does?* If ever he does, it is by an extraordinary, ſupernatural act. Whereas we are now ſpeaking what our perceptions are, in the ordinary way of nature. Or,

Thirdly, The mind has a power of raiſing up to itſelf ideas of things, whereof it can have no actual view, of objects which have no communication with any of our faculties. But if it cannot form one idea of any material object, without the actual preſence of it, much leſs can it frame ideas of immaterial objects, without their immediate preſence.

Perhaps the power of raiſing up to itſelf ideas, without the preſence or impreſſion of any object, is the privilege of the Divine Mind, anſwerable to that of creation. But the power of our mind in the

the little world, is much the ſame with that of the whole man in the greater. It is as impoſſible for it to raiſe up to itſelf any new idea, independent of all ſenſation, as it is for a man to add one particle to the common maſs of matter.

A ſecond property of an idea of ſenſation is, that it is *ſimple:* by which I mean, that it is an appearance, which cannot be reſolved into more than one of the ſame kind.

Simple ideas are generally confined within too narrow a compaſs. For not only thoſe of ſounds, ſmells, taſtes, colours, and tangible qualities, are ſimple, but the ideas of all ſingle bodies. All that ſtrikes the ſenſe at once, is to be accounted a ſimple idea. For you cannot divide the idea you have of any one body, into the idea of more bodies than one; though it may be ſubdivided into the ideas of the ſeveral parts of that body.

By this property, ideas of ſenſation are diſtinguiſhed,

1. From the various alterations and combinations of them made by the mind. The mind cannot indeed deſtroy any of theſe ideas, any more than it could create them. But it alters, inlarges or diminiſhes them: it ſeparates and tranſpoſes them; and thus is furniſhed with a new ſet of ideas from within, as well as with ſimple ones from without.

2. From

2. From thoſe notions, which the underſtanding forms out of ſimple and complex ideas, conſidered together with the various operations of the underſtanding upon them. Such is the notion we form of moſt virtues and vices: each of which is apprehended by ideas of ſenſation, and the action of the mind upon them put together into one complex conception.

A third property of ideas of ſenſation is, that they are *direct* and *immediate*. Theſe original, ſimple ideas neceſſarily preſuppoſe the preſence of the object, and its actual impreſſion on the ſenſe: whence follows a direct and immediate repreſentation of it, without the intervention of any thing elſe. Thus we could not have had the idea of a tree, if the eye had not actually ſeen it; nor of a trumpet's ſound, if ſome of the undulating air had not actually ſtruck upon the ear.

By this property, ideas of ſenſation are diſtinguiſhed,

1. From the ideas we have of thoſe objects of the ſame kind, which we never actually perceived. Thus the idea of a man we have ſeen, is put for a man we never ſaw: having no way of conceiving a man that was never preſent, but by ſubſtituting for him the idea of one that was.

2. From all conceptions of things, which are purely

purely metaphorical. There are two ſorts of metaphor, human and divine.

Divine metaphor is the ſubſtituting our ideas of ſenſation, which are direct and immediate, with the words belonging to them, for the things of heaven, of which we have no direct idea, or immediate conception: as when God's knowledge is expreſſed by *his eyes being in every place*, his power, by a *ſtrong hand*.

Divine and human metaphor agree in this, That the words, figuratively transferred from one thing to another, do not agree with the things to which they are transferred, in any part of their literal ſenſe. So hands and eyes, when applied to God, are not ſpoke in any part of their literal ſignification: as neither is the word *ſmiling*, when applied to the verdure of a field.

They differ in this, That in human metaphor the things, for which the figurative words are ſubſtituted, may be as immediately and directly known, as the ideas placed in their ſtead. But in divine metaphor, only the ſubſtituted ideas are direct and immediate. We have no direct or immediate conception of the things they are ſubſtituted for.

3. From all conceptions of things, which are purely analogical. Divine analogy is the ſubſtituting

ſtituting words, that expreſs our ideas, for heavenly things, whereof we have no ideas. Thus far it agrees with metaphor: but here lies the eſſential difference. Metaphorical words are ſpoke of heavenly things, in no part of their proper ſenſe: analogical, in ſome part of it, though not the whole. So the word *hand* is ſpoken of God metaphorically: for he has no hand of any ſort whatever. The word *power* is ſpoken of him analogically: for he has ſome ſort of power, though of a quite different ſort from ours.

The true nature of our preſent knowledge of divine things, is by the apoſtle very aptly deſcribed by our *ſeeing in a glaſs darkly*, or *in a mirror, in an obſcure repreſentation*. To ſhew the aptitude and ſignificancy of which expreſſions, I ſhall obſerve two things:

1. That a glaſs exhibits to us nothing of the ſubſtance of the thing repreſented in it: the ſimilitude therein having no more of the eſſence of the thing itſelf, than a mere ſhadow. Yet we cannot ſay, but there is a real likeneſs of the ſubſtance in the airy form. There is ſuch a proportion between them, that the idea of a face we never ſaw, but in a glaſs, is a juſt one, and may well be ſubſtituted for the face itſelf, of which it gives ſome real knowledge.

Thus

Thus as to thoſe conceptions, which ſtand in our minds to repreſent ſpiritual things, though the things they ſtand for are of quite another ſort, and though theſe ſubſtitutes are no more in reſpect of them, than a fleeting appearance in the glaſs is to the man repreſented by it; yet there may be ſuch a proportion between them, as to make our conceptions of natural things juſt repreſentations of things ſupernatural. So that the knowledge we have of them is true, and our reaſonings upon them ſubſtantial, as long as they are kept within the due compaſs of thoſe repreſentations. For then it is, that men run into abſurdity, concerning ſpiritual things, when, not content with this analogical knowledge, they argue from things natural to the intrinſic nature of the ſupernatural, and ſuppoſe, that what is affirmed of theſe repreſentations only, is literally true of the things they repreſent.

The ſecond thing I would obſerve concerning this phraſe is, That in all inſtances we uſe the ſame expreſſions, by which we expreſs the things themſelves, for their appearances in the glaſs. And indeed juſtly: for though there is nothing of the real nature of the objects, in thoſe appearances, yet, ſeeing there is ſuch a proportion between them, the ſame words aptly ſerve for both. So we ſay, We ſee a man in the glaſs, or the ſun

or

or moon in the water, when we ſee only an appearance, which has nothing of the real nature of a man, or the ſun or moon. And there is ſuch a proportion between the object and its appearance, as would give us ſome idea of it, though we had never ſeen it, but in a glaſs, or in the water.

By what has been already ſaid, analogy in general may be eaſily diſtinguiſhed from metaphor. But becauſe the diſtinction between this and divine analogy is of ſo great importance, I ſhall ſet the difference between theſe two in a clearer and oppoſite light.

Metaphor expreſſes an imaginary, analogy a real correſpondence: metaphor is no more than an alluſion; analogy, a ſubſtitution of ideas and conceptions. The intention of metaphor is only, to expreſs more emphatically ſomething known more exactly before: the intention of analogy, to inform us of ſomething, which we could not have known without it. Metaphor uſes ideas of ſenſation to expreſs things, whereto they have no real reſemblance: analogy ſubſtitutes our notions and complex conceptions for things, with which they have a real correſpondence. To conclude. Words applied metaphorically are not underſtood in any part of their proper ſenſe: analogical words are underſtood in a part, though not the whole of their literal meaning.

CHAP.

CHAP. II.

SECT. I.

Of the pure Intellect and its Operations.

HAVING hitherto conſidered the ideas of ſenſation as the only materials the mind of man has to work upon, I come to treat of the mind itſelf, or the *Pure Intellect*. I do not mean by this, the immaterial part of us, nor yet the moſt refined and exquiſite parts of the body, which are immediately ſubſervient to its nobler operations: but both of theſe operating together in eſſential union.

Our preſent knowledge is gradually performed, by the concurrent motion of ſome bodily part within us; which is the cauſe of that wearineſs we feel, after long-continued thinking. We ſhould never be tired with this, if the pure ſpirit could reaſon independently of all material organs. But experience ſhews us, the caſe is otherwiſe: we find it a labour to the brain, and feel ourſelves as much wearied with intenſe thought, as with hard bodily labour: having premiſed this of them in general, I proceed to conſider the particular operations

operations of the intellect, which presuppose sensation, and contain the whole process and utmost extent of human understanding.

The first of these is a simple view or survey of the ideas of sensation, just as they lie in the memory. This the Logicians have rightly termed *Simple apprehension*; but they generally confound it with pure sensation, whereas it is easy to observe these essential Differences between them. 1. In simple apprehension the mind is often active, in sensation always passive: 2. Simple apprehension presupposes sensation, and is always subsequent to it: 3. By sensation the mind receives ideas; by simple apprehension she surveys those already received.

The second operation of the intellect on the ideas of sensation is *judgment*. This may be divided into several species; the most considerable of which are these that follow.

1. The *separating* our ideas from each other, and ranging them under distinct heads.

2. The *comparing* them with each other, and observing their agreements or disagreements.

3. The *enlarging* or *diminishing them*. So we can enlarge the idea we have of a tree, to any size, even to reach the clouds; or diminish it in

our

our thoughts, till we reduce it to what it was in its firſt principle or ſeed.

4. The *dividing* or *compounding* them. So we divide any ſimple idea into its ſeveral parts, or compound the ideas of ſeveral houſes, to make up that of a city. All theſe ſpecies of judging are peculiar to men, and enjoyed by brutes in any degree.

Another act of the intellect, generally reduced to judgment, is *abſtraction*. This ſome ſuppoſe to be performed, by drawing the mind off from all ideas of ſenſation, from all compoſitions of them, and from all complex notions, in order to form ideas of incorporeal beings. But it may be doubted, whether this be practicable in our preſent ſtate.

The true abſtraction ſeems to conſiſt, not in orming ideas independent on ſenſation, but in ſubſtituting the only notions we have, which are natural, eaſy, and familiar, to repreſent thoſe ſupernatural things, of which otherwiſe we can have no notion; in transferring our thoughts from the literal propriety of the words, by which we expreſs them, to that analogical ſignification, whereby they are, as it were, ſpiritualized. This ſeems to be the only abſtraction we are capable of, with regard to things ſpiritual. And this is ſo far from being independent on ſenſation, and the operations

tions of the intellect, that we can no otherwise think or speak of such objects, than in these worldly and human symbols; and that, if we abstract from these, we abstract from all thought of heavenly beings, and can have neither names nor ideas for them.

What has been hitherto said of the operations of the intellect, relates only to ideas of sensation. Therefore it is proper to observe here, that the same operations are likewise exercised upon all our alterations and compositions of them. When the memory is once furnished with those voluntary alterations and combinations of simple ideas, the mind has the same full power over them, as over the ground-work of them; namely, that of simple apprehension, and of judgment in all its branches. And the same arbitrary sway it has over all the complex notions and conceptions, which are formed out of those simple or complex ideas, considered together with the operations of the intellect upon them.

Before we close this head of judgment, it is worth while to take particular notice of that species of one of its branches, comparing, which is distinct from all the rest, and is commonly called *relation*. This is that act of the mind, whereby it considers the dependencies of things on each other. I shall dwell on it no longer, than is necessary

ceſſary to ſhew the procedure of the underſtanding, in attaining knowledge.

Firſt, When we conſider the relations of ſenſible objects to each other, as they are in their own nature, without any reſpect which they bear to our underſtanding, hence opens a ſpacious field of knowledge; that of natural cauſes and effects, of the manner wherein natural things act upon, or ſuffer from, each other: in ſhort, of their influencing one another numberleſs ways: and this is Natural Philoſophy.

Secondly, From our ideas of ſenſation, we infer the exiſtence of thoſe outward objects, that occaſion them in us. And from the exiſtence of theſe we infer a Firſt Cauſe of all things, eternal, and neceſſarily exiſting. Hence again we have the knowledge of the relation he bears to us, as our Creator and our Preſerver. From theſe relations flow all the duties of piety; ſuch as love, reverence, praiſe, and prayer.

Again. When we conſider the relation we bear to our fellow-creatures, of the ſame nature and degree in this world, hence we come to be ſenſible of our obligations to juſtice and humanity. And when we diſtinguiſh theſe by particular, nearer relations, ſuch as parent or child, ſervant or maſter, hence we deduce all the duties neceſ-

ſary

ſary to the well-being of the whole kind, and of every individual.

Laſtly, When we conſider the relation we bear to ourſelves, the regard every man ought to have for his own happineſs; hence we may infer all thoſe duties, that naturally tend to promote the good either of our body or mind. And all comprehended under this ſecond head, is properly natural religion. For the ſanction of this, and to ſhew the tendency of its precepts to our future happineſs, the underſtanding proceeds thus. From the unequal diſtribution of rewards to thoſe, who obſerve them, and of puniſhments to thoſe, who tranſgreſs them in this life, ſo evidently inconſiſtent with the goodneſs and juſtice of an All-perfect Being, we infer the neceſſity of future rewards and puniſhments, and conſequently the immortality of human ſouls.

SECT. II.

Of the different Kinds of Knowledge and Evidence.

IT being a matter of the utmoſt conſequence to the right procedure of the intellect, to ſtate the ſeveral kinds of knowledge, as well as the degrees of it in each kind, which can admit of any

any, I ſhall obſerve, that there are three kinds of knowledge, and as many kinds of evidence, on which they are built.

The firſt is that we have from our ſenſes, which conſiſts in an intellectual view of the ideas tranſmitted through them to the memory. This is a knowledge direct, immediate, and intuitive, and carries in it the higheſt certainty. Conſequently, it admits of no proof from reaſon: for all ſuch proof has leſs of perſpicuity and certainty, than that which it already contains in its own nature. This is a knowledge, which admits of no degrees of evidence: for all ſenſation is in itſelf equally certain, and the evidence of all the ſenſes is equally clear, with reſpect to their proper objects. When the ſenſation is regular and perfect, the aſſent of the intellect neceſſarily follows all at once; though in a manner quite different from demonſtration, which extorts it by intermediate proof. Not that it yields to the cleareſt demonſtration, when the organ is rightly diſpoſed, and exerciſed upon it's proper object, at a juſt diſtance, and in a due medium. Againſt ſenſitive knowledge reaſon can never interpoſe, unleſs there is a ſuſpicion of failure in the act of ſenſation. Nor does it enquire then, whether the evidence of ſenſe be true; but whether it be truly the evidence of ſenſe. So that to argue

againſt the evidence of ſenſe, is to oppoſe the evidence of reaſon, to what in its nature admits of no reaſoning at all.

And highly neceſſary it was, that this evidence of ſenſe ſhould be ſo immediate, clear, and undoubted, becauſe it is the foundation of all knowledge, human and divine. If then the truth of this admitted of any doubt, or were capable of any proof, we ſhould wander about in endleſs ſcepticiſm, without the leaſt certainty in any thing. For no proof for it could be more evident, than that which it was brought to prove, and would therefore itſelf require another proof; and ſo on, with endleſs confuſion.

A ſecond kind of knowledge is that we have from ſelf-conſciouſneſs. We come to the knowledge of things without us, by the mediation of their ideas; but we are immediately conſcious of what paſſes in our own minds, without the intervention of any idea. Thus we have a knowledge of all the faculties of our ſoul, very different from ſenſitive knowledge; though we have no degree of it antecedent to the exerciſe of thoſe faculties upon the ideas of ſenſation: as we ſhould have had no knowledge of our bodily motions, if the parts had not been actually moved.

Though this kind of knowledge be more complex, it is equally certain with that we have from ſenſation.

ſenſation. The aſſent as neceſſarily follows upon conſciouſneſs: indeed it falls in with it. The conſciouſneſs itſelf is the very aſſent; nor can they be diſtinguiſhed even in thought. When this internal ſenſation is truly natural, we are never deceived in this article of knowledge. And this alſo is ſo clear and diſtinct, that it admits of no proof from reaſon. So that neither can this, any more than the former, be called *demonſtration*: ſince, like that, it is ſo immediate and intimate to us, that nothing can increaſe its evidence. And for a man to *argue* away any inſtances of this knowledge, or to deny their certainty, is no leſs abſurd, than to contradict the clear perceptions of external ſenſe. Only it is to be obſerved, that all here ſaid of this knowledge, is ſaid of the firſt, immediate, internal perceptions; not of any farther obſervations, made upon them by the intellect, or of any deductions afterwards drawn concerning them.

Theſe two kinds of knowledge are immediate, and conſequently a ſort of intuition: entirely different from which is

The third kind of knowledge, *reaſoning*, which is mediate, and wholly acquired by deduction, by the exerciſe of that one operation of the mind, illation or conſequence. This we may ſubdivide into different ſpecies, according to the different

manner of the intellect's procedure, in making its deductions.

The firſt ſpecies is *ſcience* or *demonſtration*, which appears cleareſt in the ſyllogiſtic form; by applying a common meaſure to two extremes, which have an *infallible connexion* with it. So that the concluſion follows by an abſolute certainty, and compels the aſſent. And the knowledge is as infallible, as the direct, clear perception of ſenſation, or conſciouſneſs.

The ſecond ſpecies of it is *moral certainty*, the utmoſt degree of which is neareſt to demonſtration. This knowledge is acquired by proofs, that have only an *undoubted* connexion with the two extremes. The force of this every plain underſtanding perceives; and it rarely requires the ſyllogyſtic form, unleſs for the confuting perverſe oppoſers. The arguments for it are deduced from all kinds of knowledge: but ſtill the aſſent is free; and the will has a great ſhare in promoting or hindering it. And hence it comes, that there is room for paſſion and prejudice of all ſorts, to interpoſe and bias the intellect.

We ought not therefore to call the evidence of moral truths, by the name of demonſtration. It is true, both mathematical and moral truths are founded on the ſtrongeſt proofs. Yet they admit not

not of the ſame ſort of proof, nor indeed are they capable of it.

Becauſe it is ſo great a diſadvantage both to natural and revealed religion, to have moral certainty confounded with mathematical, I ſhall diſtinguiſh the different natures of them more fully, under two different propoſitions.

Mathematical Certainty.	Moral Certainty.
As in this propoſition, The three angles of a right-lined triangle are equal to two right ones.	As in this propoſition, There is a God.
1. Here there is the utmoſt degree of mathematical certainty: the evidence is infallible, and the conſequence follows by a natural neceſſity.	1. Here there is the utmoſt degree of moral certainty: the evidence is indubitable, and the conſequence follows by a moral neceſſity.
2. The demonſtrative evidence of this, when underſtood, compels and extorts aſſent.	2. The moral evidence of this, when underſtood, demands and requires aſſent.

3. In this point of knowledge, no concurrence of the will is requiſite. The intellect aſſents without it, and no prejudice or paſſion can ſo interpoſe, as to influence its judgment.

4. This ſort of knowing admits of no degrees of certainty, and there can be no proof of it, but of one kind.

5. One demonſtrative argument makes the utmoſt mathematical certainty, which excludes all poſſibility of falſhood.

6. This takes place in things natural and material, ſuch as quantity, figure, and extenſion; ideas of which we have from direct and

3. In this point of knowledge, the concurrence of the will is requiſite. The intellect cannot aſſent without it. Any prejudice or paſſion may ſo interpoſe, as entirely to alter its judgment.

4. This ſort of knowledge admits of many degrees of certainty, and draws its proofs from all kinds of knowledge.

5. Many arguments concur to make the utmoſt moral certainty, which excludes all probability, though not poſſibility, of falſhood.

6. This takes place in things ſupernatural and ſpiritual, ſuch as God and his attributes; of which we have no idea from direct and immediate

immediate ſenſation.

7. Our reaſonings on this ſide are about ſimple ideas, concerning which there is a general conſent.

immediate ſenſation, but only from analogy.

7. Our reaſonings on this ſide are about complex notions and conceptions, concerning which men extremely diſagree.

From the very different, and even oppoſite nature of moral certainty, and that which is ſtrictly mathematical, it muſt appear,

1. That there is as little room for the latter in natural religion, as in revealed. To ſhew this clearly, I have inſtanced in the fundamental truth of both; which, though founded upon the utmoſt moral evidence, ſo as to render a diſſent from it inexcuſable, yet appears not to be ſtrictly demonſtrable. Indeed, were there one demonſtrative argument for it, all others would be entirely needleſs.

2. That natural religion includes faith, founded on moral evidence. When, upon full proof to our underſtanding, we aſſent to this, There is a God, then the hearty concurrence of the will compleats that aſſent into faith. Faith therefore is altogether as neceſſary in natural religion, as in revealed. For though we have a moral certainty

for the exiſtence of a Deity, which ſo far is knowledge only; yet ſtill becauſe the intrinſic nature of God is utterly incomprehenſible, and can be no immediate object of human underſtanding, men muſt give the aſſent of the intellect here, together with the conſent of the will, to the truth of things as myſterious, as any in all revealed religion; and which they are obliged to conceive by the ſame analogy, by which we conceive all the myſteries of chriſtianity.

3. That evangelical faith is no precarious or implicit aſſent, but founded on the utmoſt evidence we are capable of receiving, for a truth of that nature. To ſee this clearly, we muſt well diſtinguiſh two things:

Firſt, The aſſent of the underſtanding to a propoſition upon moral evidence, which is thus far merely knowledge. Here we are to fix our foot, and join iſſue with all ranks of unbelievers; the ground of whoſe condemnation will be, that they wilfully with-held their aſſent from the truths of revelation, when they had the ſame evidence, which would have fully convinced them in matters merely human.

Secondly, A conſent of the will, following the aſſent of the intellect. The whole proceſs of the mind, in obtaining ſuch a faith, is performed in this manner. 1. A propoſition being offered

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to us, the will conſents to weigh the evidence for it. 2. The intellect weighs it, and if the moral evidence be full, aſſents to it. Thus it commences a point of knowledge, and on a ſecond conſent of the will, a point of faith.

But it is worth obſerving, that there can be no immediate aſſent, to any thing inconceivable or incomprehenſible. To explain this by a few inſtances. "There is a God." When, upon full evidence, we aſſent to this, what is intelligible in that propoſition, is the immediate object of our knowledge. The incomprehenſible nature and attributes of God are only the remote and mediate objects of it.

Again. "This is my beloved Son." We aſſent to this, as a perfectly intelligible propoſition, on full evidence that it was ſpoke from heaven; being aſſured, that Chriſt, not in any unintelligible manner, but according to the plain ſenſe of the words, is as really and truly the Son of God, as one man is the ſon of another.

He who believes thus far, without any reſpect to what is incomprehenſible in that propoſition, namely, the ſupernatural generation, and the ineffable manner of it, has an evangelical faith.

But what then, you will ſay, becomes of the myſteries of the goſpel? They are all laid up ſafe, out of our reach, to be the immediate ob-

jects of our knowledge, when we come to see face to face.

From hence it appears, that christian faith is not an implicit assent to things unintelligible and unconceivable: since nothing, that is incomprehensible, can come into any question between us and unbelievers. We can have no controversy, but about what is perfectly understood, as far as it is so; and concerning the moral evidence, upon which propositions, as clear as any in human language, are founded. Our controversies turn wholly upon what is clear. As to what is incomprehensible in any proposition, it can be no immediate, direct object, either of knowledge or of faith.

The third species of knowledge, which we have from reason, is *opinion*. This *Plato* well defines a medium between knowledge and ignorance. It is a sort of knowledge, loosely speaking, inferior to any of the foregoing, but approaching nearest to that founded on moral evidence. Only whereas moral certainty, in its highest degree, leaves but a bare *possibility* of the thing's being otherwise; all opinion leaves room, more or less, for *doubt*, yea, for some fear of its being otherwise. But as for all the degrees between the highest moral certainty on one hand, and the lowest probability on the other, these two

sorts.

ſorts of knowledge run into each other, and are not eaſily to be diſtinguiſhed.

This may be illuſtrated by a parallel, drawn from common mechaniſm. While you are offering the reaſons, for and againſt any morally-certain or probable propoſition, imagine yourſelf throwing them into the ſcales, and weighing them in a balance. If the balance inclines not at all to either ſide, there is no ſort of knowledge, but downright *ignorance:* the reaſons on each ſide deſtroy each other, ſo that the intellect cannot aſſent to either. And if there be any deciſion, it is the arbitrary impoſition and precarious act of the will. If, either from its natural weakneſs, or for want of improvement, the intellect cannot find out reaſons, ſo that each ſcale preponderates in its turn, then it is a ſtate of *doubt*. If one ſcale preponderates but a little, and continues at a ſtay, ſo that the difference is barely diſcernible, it is then only a *conjecture*. But if this preponderancy is very plain, though there is weight enough on the other ſide, to keep the ſcale ſtill pendent, then it is properly *probability* or *opinion*. When, laſtly, the arguments are ſo ſtrong that one of the ſcales weighs to the ground, then it is *moral certainty*, and there is no reaſonable cauſe for any farther ſcrutiny. The propoſition then concludes as *ſurely*, though not ſo *neceſſarily*,

as *demonſtration*; which admits of no weight whatever to be thrown into the oppoſite ſcale.

Of probability in general it may be obſerved,

1. That, while we are weighing a probable propoſition, there are two latent cauſes of deceit; the one in the intellect itſelf, which holds the balance; for if a man is ignorant or weak, ſo as not to diſcern the proper reaſons, he may be impoſed upon by falſe weights: the other in the will, when, inſtead of plain reaſon, a man throws his pride, or paſſion, or prejudice, into the ſcales. And theſe will, by the inviſible turn of a falſe balance, outweigh the ſtrongeſt arguments.

2. That the higher degrees of probability, in matters of religion, demand our aſſent. So they do in all other things. Where the difference is not great, between the oppoſite ſides of a queſtion, men ever cloſe with the greateſt appearance of truth, and that in things of the greateſt moment. Nay, the main conduct of human life is governed by the higheſt probability: ſo that, in many inſtances, it would be downright madneſs, not to be determined by it. Yet,

3. Mere probability is not a ſufficient ground for religious faith. This muſt be built on certain knowledge, which opinion, properly ſpeaking, is not. Indeed the word is vulgarly taken for any aſſent, whether formed on probability, or moral certainty.

certainty. And ſo, it is commonly ſaid, "A man is of ſuch an opinion," with regard to the very fundamentals of Chriſtianity. But this looſe way of ſpeaking ought never to be uſed, ſeeing it has a tendency to betray unwary men, into a favourable judgment of ſuch principles, as are deſtructive of all religion.

The fourth ſpecies of knowledge, which we have from reaſoning, (if it be not rather a particular ſpecies of moral certainty) is an aſſent upon *teſtimony:* to make which truly knowledge, there muſt be a concurrence of our own reaſon in the following particulars:

1. Our own reaſon muſt judge of the ſubject-matter of the information, whether it be made in intelligible words. For no man can be informed, of what he cannot underſtand: there can be no revelation to us, concerning the intrinſic nature of things, that are incomprehenſible to us. And accordingly, no part of the Chriſtian revelation, concerning God and things ſupernatural, reaches farther than their *exiſtence*, and that lively analogy, under which they are repreſented; which is as plain, and obvious, and intelligible, as any thing in common life.

2. Our reaſon muſt convince us, that the matter of the information is poſſible, that it implies no contradiction. And if the information relates

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to things supernatural, this is a fundamental rule, to deduce no contradiction, but from what is plain and intelligible in every proposition. Whence it follows, that such absurdities and contradictions, as arise from a comparison of what is plain and intelligible, with what is incomprehensible, in respect of their intrinsic natures, are all groundless and imaginary.

3. Our reason must judge concerning the ability and integrity of the informer. Information or testimony may be divided into human and divine. To human testimony we assent only so far, as it appears agreeable to truth. Yet this assent is very extensive, and makes up the greatest part of human knowledge. It takes in all we have of the history of mankind, all the accounts of whatever we have not seen ourselves. And we acquiesce in all this, not as probable only, but as so much real knowledge; being an assent, which is founded on such evidence, as often amounts to a moral certainty.

As to Divine information or revelation, reason, knowing it to be divine, is already convinced, that it exceeds all human certainty. The only thing, therefore, which it is to be convinced of here, is

4. That the revelation is Divine, or that the Scripture

Scripture is of Divine authority. In order to this, we may obſerve,

Firſt, That, as God has made men the immediate inſtruments of all thoſe revelations, ſo evangelical faith muſt be partly founded on human teſtimony. By men were both the Old and New Teſtament wrote: and, if we conſider them abſtracted from their Divine authority, they muſt be allowed to be of equal credibility, at leaſt, with all other ancient writings. Though we ſhould ſuppoſe them to be upon the foot of mere human teſtimony, yet would our knowledge of them be, at leaſt, of equal certainty, with that founded on any profane hiſtory. Now, if to this human, we add ſuch Divine teſtimony, as cannot be pretended for any other writings in the world, as the miracles of Chriſt and his apoſtles; the concurrent completion of all the prophecies, from the beginning of the world, in him alone; the ſcriptures being the only book in the world, that gives us any account of the whole ſeries of God's diſpenſations toward man, from the creation for four thouſand years; the great exaltation of natural religion, viſible in every part of it; and, laſtly, the providential care, ſo manifeſt in every age, for tranſmitting down ſeveral books, written at ſuch great diſtances of time one from another, and all of them from us; their being at this

this day so void of any material error, that in the infinite various readings, which have been carefully collected, there cannot be found one contrariety in any fundamental point of faith or practice: if these things, I say, are throughly considered, they give the Scriptures such a certainty, as no writing merely human can have, and are the greatest evidence for the truth of them, which they are capable of receiving, without a continued, daily repetition of miracles. We may observe,

Secondly, That, as God has made men the immediate instruments of all his revelations, so he hath condescended to make use of human language, as well as of our natural ideas and conceptions, for the clear and easy representation of things supernatural, and otherwise incomprehensible. Indeed the intrinsic nature of heavenly things could no otherwise have been revealed to us; seeing we had neither capacity to apprehend, nor language to express it. Or had it been miraculously revealed to a particular man, yet it would not have been possible for him to utter it. This made it necessary to adapt all the Divine revelations to our natural way of thinking and speaking. And accordingly we are not obliged to believe any doctrine, which is not plain and intelligible. All in Scripture, beyond this, is no

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immediate object of our faith, but belongs to another world; and we are at present to believe no more of it, than that it is incomprehensible.

Nothing therefore is more absurd, than the objections of unbelievers against the Christian mysteries, as unintelligible; since Christianity requires our assent to nothing, but what is plain and intelligible in every proposition. Let every man first have a full conviction of the truth of each proposition in the gospel, as far only as it is plain and intelligible, and let him believe as far as he understands. Let him firmly believe, there is but one God, the object of any divine worship whatever; and think and speak of him under that plain, Scriptural distinction, of Father, Son, and Holy Ghost; leaving the incomprehensible nature of that union and distinction, to the great Author of our faith himself. Let him believe Christ to be the only-begotten Son of God, in the obvious import of those words, and leave the manner of that inconceivable generation, to the veracity of God. Let him believe, that Christ did as truly make an atonement to God for us, as one man atones for another to a third person; and leave the unintelligible part of that divine operation, for the subject of future praise and contemplation. Let men, I say, believe as far as they thus clearly understand, without perplexing

ing themſelves or others with what is incomprehenſible; and then they fulfil the whole purpoſe of God in all his revelations.

By thus carefully diſtinguiſhing the ſeveral kinds of knowledge and evidence, what endleſs confuſion may be prevented, in religious controverſies? Moſt of theſe have ariſen, from ſuppoſing theſe heads of knowledge to differ in degree only, not in kind; and from confounding the different kinds of evidence, peculiar to each of them; from men's inſiſting upon the evidence proper to one kind of knowledge, for that of another, which will not admit of it; from oppoſing to each other the different kinds of knowledge, which can never interfere or claſh with each other; and, laſtly, from not diſtinguiſhing between a blind, implicit aſſent to the teſtimony of another, and that faith, which implies a full, rational conviction of the truth of what is believed.

SECT. III.

Of the Improvement of Knowledge by Revelation.

WE have now brought the mind of man, by ſeveral ſteps, to the utmoſt knowledge, it can reach by its own faculties. Whatever

ever is beyond that contained under the foregoing heads, is communicated to it from heaven.

When we obſerve, 1. The more particular and full diſcoveries of thoſe relations we had ſome knowledge of, by the light of nature,* and, 2. Thoſe relations we bear to God, and God to us, which are intirely new, and undiſcoverable by the light of nature; this knowledge includes the foundation and ſubſtance of all revealed religion.

As to the firſt. When to that general knowledge we have by the light of nature, of God, as the Creator of all things, it is revealed, That he *ſpoke them* into being, and created them *by his Word*; that he made man in partiaular *out of the earth*, and breathed into him a principle of an higher kind; that he was created in innocence, and *in the image of God*; and that from him all mankind deſcended.

Again. When to the general relation of his Providence over us, it is more particularly revealed, That he *upholdeth all things by the Word of his power*; that *in Him we live, move, and have our being*; that *not a ſparrow falls to the ground without Him*; nay, that *the hairs of our head are all*

* I believe all "the light of nature," ſo called, to flow from preventing Grace.

all numbered; and, laſtly, when his relation to us, as a Judge, is rendered more full and expreſs by theſe particulars, that *the eyes of the Lord are in every place, beholding the evil and the good*; that *He ſhall bring every work into judgment, with every ſecret thing, whether it be good or evil*; that *He hath appointed a day, in which He will judge the world*; and that, in order to this univerſal judgment, there ſhall be a reſurrection of the dead, both of the juſt and of the unjuſt.

Again. When it is revealed, That *there is but one God*; in oppoſition to the multitude of heathen deities; that this God *is a Spirit*, that *there is none good but* He; that He *only is wiſe*, and his wiſdom is infinite; that He is Almighty, hath all power, is *above all, the only Potentate, King of kings*, and *Lord of lords*; that He is the *Moſt High, the Lord of hoſts*, who *only hath immortality:* theſe and ſuch like equally expreſs declarations, concerning the One God, are evident improvements of that knowledge, which we have by the light of nature.

Theſe expreſſions are all plain and intelligible, ſo that, when we uſe them, we know what we ſay. But as to the following expreſſions, concerning the One God, That he is "God of himſelf, Root, Principle, and Original;" that he is a "Pure Act, ſimple, undivided, Self-exiſtent, abſo-

abſolutely ſupreme;" together with the words, "Subordinate, co-ordinate," and, above all, his metaphyſical "Subſtance and eſſence:" theſe are not the language of revelation, eſpecially when uſed to explain the Unity of God; but affected terms, invented by men, to expreſs their ſeveral ſentiments of that Unity.

Can we ſufficiently lament the miſchief, which has been done by the rumbling of theſe, and ſuch like ſounding words, through whole volumes; to the confounding both the writer and the reader, and perplexing that great article of our faith, the Trinity; which, as it lies in the Scripture, is, ſo far as we are to believe it, the plaineſt thing in the world? All this pompous affectation of being more knowing in the Chriſtian myſteries, than the Scriptures can make men, tends only to propagate abſurd and inconſiſtent notions, which a plain rational man would be aſhamed of. Such as theſe,

That the Son of God was produced by an external act of the Father's power, but was not made or created:

That there are Three Perſons truly Divine; One of them the true God, the Second, truly God, the Third, no God at all.

That we may and muſt pay divine worſhip to Two

Two Gods, and divine honour to a Third Perſon, who is no God:

That by the term *Trinity* we muſt mean, a Trinity of Two Gods, and a Divine Perſon, but no God.

Theſe and many ſuch poſitions are either expreſly, or by plain conſequence, contained in ſome of our modern ſyſtems of religion, and are ſet down here, not as they are a total ſubverſion of the Chriſtian faith, but as they are a bold and arbitrary impoſition on the common ſenſe and reaſon of mankind.

The relation we bear to God as our Creator, which was partly diſcovered by the light of nature, is made nearer yet, and more dear and engaging, by that entirely new diſtinction in the One God, revealed to us under the different characters of Father, Son, and Holy Ghoſt, and by the unſpeakable bleſſings we derive, from their ſeveral offices and operations.

This diſtinction, utterly incomprehenſible in itſelf, could never have been known to men, but by revelation. Nor could we have conceived it in any degree, had it not been diſcovered to us, under the ſemblance of ſuch relations, as are familiar among men: as that of a Father and a Son, and the Spirit of a man, which is in him. And, if we admit this diſtinction at all, we muſt hold it

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to be ſo really founded in the Divine Nature, that we cannot think or ſpeak of it any otherwiſe, than as a perſonal diſtinction. For the Father, Son, and Holy Ghoſt, are, in reſpect of one another, thus diſtinguiſhed through the whole language of revelation: and, in reſpect of mankind, they are ever diſtinguiſhed by ſuch different operations, as we diſtinguiſh human perſons by. So that whatever is denoted by Father, Son, and Spirit, we muſt either flatly reject the Scriptures, or elſe always ſpeak and think of thoſe Three, as we do of three human perſons.

That Chriſt, the Second Perſon, had a being, before he was born of a virgin, is ſo evident from Revelation, that we can make no ſenſe or coherence of Scripture, without allowing it: and there can be no other purpoſe, in revealing all things concerning him, under the character of a Son, and only-begotten Son, but to convince us, that he has all the natural, eſſential attributes of his Father; that, as an human ſon poſſeſſes the entire human nature, ſo the Son of God poſſeſſes the entire Divine Nature.

That the Holy Spirit, who is in Scripture diſtinguiſhed from the Father and the Son, is a diſtinct Perſon from both, is plain from the commiſſion given the apoſtles to baptize, *in the Name of the Father, and of the Son, and of the Holy Ghoſt.*

Ghoſt. This form, if each of theſe be not a diſtinct Perſon, ſufficiently tends to confound mankind. If the Holy Ghoſt be not a diſtinct Perſon, but only a Power of the Father, then the ſenſe of it runs thus, " Go and baptize in the Name of the Father, and of the Son, and of the Father again." Therefore to ſay, the Third Perſon, here mentioned, is a mere Name, and imports only the Power of the Father, is not only charging God with laying a ſnare to deceive us, but denying his commiſſion to be common ſenſe.

That the Holy Spirit is God, is evident from Revelation, which every where diſtinguiſhes him by this peculiar character of Holy. For abſolute holineſs is the peculiar attribute of the abſolutely ſupreme God: and He being every where called " The Holy Spirit," by way of excellency, and diſtinction from all created ſpirits, that epithet muſt imply an original, intrinſic, and eſſential holineſs in Him. Eſpecially if we obſerve, that this is his conſtant, diſtinguiſhing character, not only where he is mentioned with relation to us, but alſo where he is named, together with the Father and the Son. Inſomuch that He alone is expreſly ſtiled Holy, wherever the Three Perſons are expreſly named together in Scripture.

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The word *Holy* in thoſe places cannot be added, in oppoſition to the Father and the Son; nor as excluſive of them; becauſe they are both abſolutely holy, as well as the Spirit: ſo that they naturally lead us into a belief, that his is the ſame holineſs with that of the Father and the Son, namely, the intrinſic holineſs of Jehovah, the Moſt High, the Supreme God. To this if we add, that He is called, "*The Spirit of holineſs, the Spirit of glory, the Eternal Spirit,*" and very often, *The Spirit of God*; as particularly at the baptiſm of Chriſt, where he was perſonally diſtinguiſhed from the Father, even in a viſible appearance. We muſt have our reaſon ſtrangely amuſed by ſubtlety and criticiſm, and be turned quite out of the plain way of thinking, before we can underſtand theſe revelations to mean any thing elſe, than that he is God, equal with the Father.

The ſum is this. Since both reaſon and Revelation ſhew, there is but one God, we can own and worſhip but one. And ſince that one God is ſet forth to us in Scripture, under three diſtinct relations, and accordingly repreſented by diſtinct perſonal names, and characters, and operations, and offices: therefore we worſhip but one God, with this diſtinction of his own making, not of ours.

It is said, *Thou ſhalt worſhip the Lord thy God, and Him only ſhalt thou ſerve:* by which all Divine worſhip is utterly cut off from the Son and Holy Ghoſt, unleſs they are one with the Lord our God. Again, it is written, *The Lord thy God is one Lord,* whom we are to *love with all our heart, mind, ſoul, and ſtrength.* But if ſo, all Divine love is cut off from the Son and Holy Ghoſt, unleſs they are that one Lord our God, who is a jealous God, and will by no means ſuffer any part of his worſhip to be paid to any other.

According to this plain and natural way of thinking, as we are baptized by one and the ſame ſolemn act of worſhip, *In the name of the Father, and of the Son, and of the Holy Ghoſt:* ſo we ever after adore them, without any degrees or inequality of worſhip; which, indeed, as it is truly Divine, can admit of no degrees or inequality. Whereas they, who argue for an inequality in the Divine Perſons, and for an inferiority of nature in the Son and Holy Ghoſt to the Father, neceſſarily involve themſelves and all their adherents in endleſs uncertainty and confuſion. For they can never ſettle the different kinds and degrees of that *lower Divine worſhip,* (a contradiction in the very terms) which is to be paid to the Son and the Holy Ghoſt. They can never diſtinguiſh it with ſuch exactneſs, that it ſhall neither

ther be the worſhip due to the Supreme God, nor that honour, which is to be paid to mere creatures, and varied according to their ſeveral dignities.

But to make it yet more clear, that the mind of man cannot, without abſurdity, have any other conception of the Son and Holy Ghoſt, than as being incomprehenſible, one abſolutely Supreme God with the Father, and one joint Object of all Chriſtian worſhip; let us collect the two ſeemingly-inconſiſtent doctrines, into oppoſite propoſitions.

There is no other God, but one.

Thou ſhalt worſhip the Lord thy God, and Him only ſhalt thou ſerve.

On this ſide the precepts are expreſs and poſitive, for our believing in one God alone, and for paying Divine worſhip to Him only They are full and peremptory, againſt addreſſing ourſelves religiouſly

Let all the Angels of God worſhip Him.

Baptize all nations in the name of the Father, and of the Son, and of the Holy Ghoſt.

On this ſide, the precepts are equally expreſs and poſitive, for our believing the Son and the Holy Ghoſt to be God, and for the whole intelligent creation to pay Divine worſhip to the Son in par-

giouſly to any other, than that one Supreme God, who is a jealous God, and will not ſuffer any degree of Divine worſhip to be directed to any other. Nor can we frame any other notion of idolatry, than the addreſſing ourſelves either in body or mind, by way of religious worſhip, to any other being, than to the Supreme God.

particular. They are likewiſe full and peremptory for our addreſſing ourſelves in one of the moſt ſolemn acts of Divine worſhip, jointly to the Father, Son, and Holy Ghoſt. And as we are initiated into Chriſtianity by this act, ſo we are ever after bleſſed in the name of the Three jointly: and all this, without the leaſt direct or indirect mention, or intimation, of any inequality in their natures, or of any diſtinction in their worſhip.

Now both theſe precepts are expreſs Scripture, and therefore equally objects of our faith; it being evident, that here is no contradiction in terms, and that the ſeeming contradiction is with regard to a Unity and diſtinction, for the direct apprehenſion of which, there is no capacity in the mind of man. The wiſdom of God has left it for

us

us to believe them both, and to reconcile them according to the beſt of our underſtanding: not by taking upon us to ſhew, how the Divine Nature is One, and how it is Three; but by ſolving the ſeeming oppoſition, in a way moſt obvious to a plain capacity; that is, by concluding, ſince there is but one God, who alone is to be worſhipped, and ſince the Son and Holy Ghoſt are both called God in Scripture, and expreſly commanded to be worſhipped; therefore they are One with the Moſt High God, though how they are One, we cannot comprehend.

Thus has the Goſpel-revelation improved the knowledge of mankind, in theſe important points. And it has no leſs improved our knowledge, in the grand article of future rewards and puniſhments.

As to rewards, 1. Whereas all, that was before expected in the other world, was ſenſual pleaſures for the body, and pleaſing contemplation for the ſoul. Now we learn the joys of heaven to be of a ſort, whereof nature can give us no conception: we ſhall be as the angels of God in heaven.

2. The reſurrection of the ſame body, is a point entirely new, of which Chriſt's riſing with the ſame body aſſures us. That this body will be *changed*, is likewiſe intirely new; that this

change ſhall be effected in a moment; that the dead in Chriſt ſhall riſe firſt; that their change ſhall be into the likeneſs of Chriſt's glorious body: all which particulars are beyond whatever could have been ſuggeſted, by the mere underſtanding of man.

Another inſtance of Revelation, intirely new with reſpect to theſe rewards, is, that of living for ever in the immediate preſence of God, the Fountain of all happineſs. We are now informed, that we *ſhall ſee God, as He is, face to face, in whoſe preſence is fulneſs of joy*; that we *ſhall be where he is*, ſhall *behold his glory*, and ſhall ſhine forth as the ſun in the kingdom of our Father. This is a ſtrain, no imagination, merely human, could ever reach or aſpire to. We may add, that whatever the wiſeſt heathens ſpoke of future rewards, was only from faint conjecture: whereas now we have the plain, and expreſs, and repeated promiſe of God for them.

As to future puniſhments, we learn from Revelation alone,

1. That they are both for ſoul and body, which are diſtinguiſhed by *the worm that dieth not*, and *the fire that is not quenched*. And accordingly we are bid to *fear Him, who is able to deſtroy both body and ſoul in hell*.

2. That

2. That the ſoul will be *puniſhed with everlaſting deſtruction, from the preſence of the Lord.* That the chief of all miſery, in another life, would be, excluſion from the ſight of God, was never thought of by the wiſeſt heathens, who placed all happineſs in themſelves.

3. That the body will be puniſhed by fire, than which we have not any Revelation more expreſs and poſitive. And as it is an inſtance of the great goodneſs of God, that the joys of heaven are repreſented, figuratively, as exceeding the utmoſt of our conceptions; ſo it is an argument of his ſtrict juſtice, that the pains of hell are more literally foretold.

4. The eternity of theſe puniſhments is revealed, as plainly as words can expreſs it. Not that the puniſhments denounced are mere arbitrary ſanctions, like thoſe annexed to human laws. But thoſe denunciations are withal ſo many previous warnings of the inevitable conſequence, the natural tendency of ſin to miſery. So that an unrepenting ſinner cannot be otherwiſe than miſerable, in another life, by a neceſſity of nature: ſince there never can be any alteration of his condition, without ſuch a change of the whole man, as would put the natural and ſettled order of the creation out of courſe.

With respect to these rewards and punishments, we have these farther revelations: that the very *Day is appointed by God, in which He will judge the world in righteousness, by the Man, whom He hath ordained*; that He hath committed all judgment to the Son; and that all mankind must come upon their tryal at once. The glorious pomp and majesty of his appearance, the awful solemnity of the whole procedure, nay, the very words of the sentence, both on the just, and on the unjust, are discovered to us. It is farther revealed, that in this day of God, while He descendeth with ten thousands of his Angels, *the heavens, being on fire, shall be dissolved, and the elements shall melt with fervent heat.* These are *the terrors of the Lord*, which are sufficient to make the stout-hearted tremble, and are such motives to all holiness of heart, and holiness of conversation, as nothing but infidelity, or wilful want of consideration, can render ineffectual.

HAVING now, as my leisure and abilities permitted, taken a Survey of the Wisdom of God in the Creation; before I conclude, it may

may not be improper to add ſomething, in anſwer to thoſe on the one hand, who imagine all enquiries of this kind to be vain, fruitleſs labour; and thoſe on the other, who ſpend more time therein, than is conſiſtent either with religion or reaſon.

I do this chiefly in the words of that great ornament of his profeſſion, the Lord Chief Juſtice, *Hale*. He ſuppoſes *the good ſteward* giving in his account, at the laſt day, thus to ſpeak. (Happy is he, who can adopt his words, in ſpeaking to the Judge of all!)

1. I have not looked upon thy works inconſiderately, and paſſed them over as ordinary things. But I have ſtudiouſly and diligently ſearched into them, as things of great eminence and wonder; and have eſteemed it part of the duty, which the wiſe God of nature requires of the children of men, who, for that very end, expoſed theſe his works to the view of his intelligent creatures, and gave us not only eyes to behold, but reaſon, in ſome meaſure, to underſtand them. Therefore I have ſtrictly obſerved the frame of the world, and its ſeveral parts, the motion, order, and Divine œconomy of them. I have ſearched into their quality, cauſes, and operations; and have diſcovered as great, if not greater matter of

admiration therein, than in the beauty, which at firſt view they preſented to my ſenſe.

2. And this obſervation did not reſt in the bare peruſal of the works themſelves, or in the ſearching out, ſo far as that could be done, their immediate natural cauſes. But I traced their being, dependence, and government, unto Thee, the Firſt Cauſe of all. And by this tracing of things to their Original, I was led to a demonſtrative conviction, that there is a God, who is the Great Cauſe, both of their being and motions: yea, that there is but one God; that He is Moſt Powerful, Moſt Wiſe, knowing all things, governing all things, ſupporting all things. Upon theſe convictions, I was ſtrengthened in the belief of thy holy Word, which had ſo great a congruity with theſe truths.

3. And, upon theſe convictions, I did learn the more to honour, reverence, and admire Thee; and to worſhip, ſerve, and obey Thee; to walk humbly, and ſincerely, and lawfully, before Thee, as being preſent with me, and beholding me; to love and adore Thee, as the Fountain of all being and good. When I looked upon the glory and uſefulneſs of the ſun, I admired the God that made it, chalked out its motions

tions, placed it in that due distance from the earth, for its use and conveniency. When I looked upon the stars, those huge and wonderful balls of light, placed at that immense distance from the inferior bodies, and one from another, their multitude and motion; I admired the wisdom and power of that God, whose hand spans the heavens, and has fixed every thing in its place. Nay, when I looked upon the poor little herbs, that arise out of the earth, and considered the secret spark of life, which is in every one of them, that attracts, increaseth, groweth, produces seed, preserves them and their kinds; the various virtues, that are in them, for the food, medicine, and delight, of the more perfect creatures; my mind was sweetly carried up, to the adoration and praise of that God, whose wisdom, and power, and influence, and government, are seen in these footsteps of his goodness.

So that take all the wisest and ablest men, the most powerful, and the most knowing, under heaven, they cannot all equal the wisdom and power, that are seen in a blade of grass. Nay, they cannot so much as trace out, or clearly and distinctly decypher, the great varieties in the production, growth, and process, of its short, yet wonderful, continuance. Insomuch that there is scarce any thing upon earth, be it ever

ſo inconſiderable, but yields me inſcriptions of the power and wiſdom of its Maker written upon it.

4. In the contemplation of thy great works of the heavens, theſe goodly, beautiful, and numerous bodies, ſo full of glory and light, I could not but make that natural reflection, *Lord, what is man, that thou art mindful of him, or the ſon of man, that thou regardeſt him?* It is true, man, conſidered in himſelf, is a creature full of wonder; but compared with theſe goodly creatures, he ſeems but an inconſiderable thing. I learned hereby, to be humbled to the duſt, and to adore thy condeſcenſion, that thou art pleaſed from heaven, the dwelling-place of thy Majeſty, to take care of ſuch a worm as man, ſinful man!

5. In the contemplating thy power and wiſdom, in creating and governing the world, I have learned ſubmiſſion to thy will, as being the will of that moſt wiſe God, that by his wiſdom not only created at firſt, but ſtill governs, all things. I have learned to depend upon thy Providence, who, though I am but a worm in compariſon of thy heavenly works, yet am an excellent creature in compariſon of the ravens, and the herbs of the field. Yet thoſe he feeds, and

and theſe he cloaths: and ſhall he not much more cloathe and feed *me?* Thus I have, in ſome meaſure, improved the talent of thy works, to trace out thy Majeſty, and my own duty.

Now is it a vain or fruitleſs labour, thus to ſurvey the wonderful works of God? And yet it is certain, we may run to exceſs, even in enquiries of this nature. We may ſpend far more time and pains therein, than is conſiſtent either with religion or reaſon. Have we not a curious inſtance of this in the writings of a late eminent philoſopher; at the ſame time, a divine by profeſſion, and rector of a conſiderable pariſh. "During the whole time," ſays he, "that I have reſided here, I have not been able, by all my induſtry, to diſcover any more than fifty-three ſpecies [of *butterflies!*] in this neighbourhood. But I verily believe, if God ſpares my life a few years longer, I ſhall be able to find ſeveral more!" Was it not pity, but his life ſhould have been ſpared fifty years, for ſo excellent a purpoſe?

To thoſe, who lean on this extreme, I would recommend a few more reflections, extracted from the ſame maſterly writer.

1. My learning of natural cauſes and effects, and of arts and ſciences, I have not eſteemed to be

be the chief, or the beſt furniture of my mind; but have accounted them droſs in compariſon of the knowledge of Thee, and thy Chriſt, and him crucified. In acquiring them, I have always taken care, 1. That I might not too prodigally beſtow my time upon them, to the prejudice of that time and pains, which were moſt profitably beſtowed, on the acquiring of more excellent knowledge, and the greater concernments of my everlaſting happineſs.

2. I carried along with me, in all my ſtudies of this kind, the great deſign of improving them, and the knowledge acquired by them, to the honour of thy name, and the greater diſcovery of thy wiſdom, power, and truth; and ſo tranſlated my ſecular learning, into an improvement of Divine knowledge. And had I not ever preſerved that deſign, in my acquirement of natural knowledge, I ſhould have accounted all the time miſ-ſpent, which had been employed therein. For I ever thought it unworthy of a man, who had an everlaſting ſoul, to furniſh it with ſuch learning, as either would die with the body, and ſo become unuſeful for his everlaſting ſtate; or that, in the next moment after death, would be attained without labour.

3. My

3. My knowledge did not heighten my opinion of myſelf: for the more I knew, the more I knew my own ignorance. I was more and more convinced, that I was very ignorant, even in what I thought I knew. And I found an infinite latitude of things, which I did not know at all. Yea, the farther I waded into knowledge, the deeper ſtill I found it. And it was with me, juſt as it is with a child, that thinks, if he could but come to ſuch a field, or climb to the top of ſuch an hill, he ſhould be able to touch the ſky. But no ſooner is he come thither, than he finds it as far off, as it was before. Juſt ſo, while my mind was purſuing knowledge, I found the object ſtill as far before me as it was, if not much farther; and could no more attain the full and exact knowledge of any one ſubject, than the hinder wheel of a chariot can overtake the former. Though I knew much, that others were ignorant of, yet ſtill I found there was much more, whereof I was ignorant, than what I knew, even in the compaſs of the moſt inconſiderable ſubject. And as my very knowledge taught me humility, in the ſenſe of my own ignorance, ſo it taught me the narrowneſs of my underſtanding, which could take in things only by little and little. It taught me, that thy wiſdom was unſearchable, and paſt finding out: yea, and that thy works, though

though they are but finite in themſelves, and neceſſarily ſhort of the infinite Wiſdom that contrived them, are yet ſo wonderful, as fully to confirm the obſervation of the wiſe man, *No man can find out the work, that Thou makeſt, from the beginning to the end.* If a man were to ſpend his whole life, in the ſtudy of a poor fly, he would ſtill leave much more undiſcovered, than the moſt ſingular wit ever attained.

4. It taught me alſo, with the wiſe man, (when I looked back on what I had attained) to write Vanity and Vexation, upon all my ſecular knowledge and learning. That little I knew, was not attained without much labour, nor yet free from much uncertainty. And the great remainder, which I knew not, rendered that I knew, poor and inconſiderable.

5. Hence I did moſt evidently conclude, that the perfection of my underſtanding was not to be found; as neither my happineſs, in this kind of knowledge; in a knowledge thus ſenſibly mixed with ignorance, in the things I ſeemed to know, mingled with pain and diſſatisfaction, in reſpect of the things I knew not. And the more I knew, the more impatient my mind was, to know what it knew not. My knowledge did rather inlarge

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my desire of knowing than satisfy it. The most intemperate sensual appetite, was more capable of being satisfied by what it enjoyed, than my intellectual appetite was, of being satisfied with the things I knew. The inlarging my understanding with knowledge, did but enlarge the desire I had to know. So that the answer which was returned to Job, upon his inquisition after wisdom, *The depth saith, it is not in me; and the sea saith, it is not in me.* The same account, all my several kinds of knowledge gave, when I enquired for satisfaction in them. My metaphysics, when I had pursued great volumes of it, it was so mercurial, I could hardly hold it: and yet so endless, that the more I read, or thought of it, the more I might. Natural Philosophy, almost in every branch was full of uncertainty. Much of it was grounded on suppositions impossible to be experimented. The latter philosophers censured the former, and departed from them. The latest despised and rejected both, as equally ignorant. The subject to be treated of, was as vast, as the visible or tangible universe. And yet every individual thing was so complicated, that if all the rest were omitted, this alone had more lines concentered in it, than any one age could sift to the bottom. Yet any one lost, or not exactly scanned, left all the rest precarious and uncertain. And what could we expect

to

to know, while we know not ourſelves, not even our own bodies? Yet none could ever do this: the diſquiſition concerning any one part of the human body, the brain. the eye, the blood, the nerves, utterly perplexed the moſt exact ſcrutators. But ſuppoſe it were otherwiſe: ſuppoſe we could attain a full knowledge of Philoſophy, that we could maſter every branch thereof, yet three unhappineſſes attend it:

Firſt, That moſt parts of it are of little uſe; they are only known, that they may be known. That which is of ordinary uſe, is ſoon attained, and by ordinary capacities: the reſt were little better than laborious trifles, curious impertinencies.

Secondly, That they ſerve only for this life: a ſeparated ſoul, or a ſpiritualized body will not be concerned in them.

But admit they ſhould, yet Thirdly, a greater meaſure of ſuch knowledge will be attained, in one hour after our diſſolution, than the toilſome expence of an age in this life would produce. What a deal of pains is taken here, concerning the motion of the ſun or earth: concerning the habitableneſs of the moon, and other primary or ſecondary planets: concerning the nature, the magnitude, and the diſtance of the fixed ſtars: concerning the various influences of the heavenly bodies, in their oppoſitions, conjunctions, Aſpects? When once the

the immortal has taken its flight through the ſtories of the heavens, in one moment all theſe will be known diſtinctly and evidently. All our doubts will be reſolved, and our ſouls filled with light, without any mixture of darkneſs.

Upon all theſe conſiderations I concluded, that my intellectual power, and the exerciſe of it in this life, was given for a certain, uſeful and becoming object, even to *know thee, the only true* GOD, *and* JESUS CHRIST *whom thou haſt ſent.*

In many parts of the preceding tract, I have occaſionally touched on the littleneſs of human knowledge. Perhaps a few more obſervations on this important head, may not be unacceptable to the ſerious reader. I propoſe them barely as hints, which may be purſued at large, by men of reflection and leiſure.

To begin (where we ended before) with the things which are at the greateſt diſtance from us. How far does the univerſe extend, and where are the *limits* of it? Where did the Creator "ſtay "his rapid wheels?" Where "fix the golden com- "paſſes? Certainly himſelf alone is without bounds, but all his works are finite. Therefore he muſt have ſaid at ſome point of ſpace,

"Be

" Be theſe thy bounds;
This be thy juſt circumference, O world!"

But where, who can tell? Only the *morning-ſtars* who then *ſang together*, *the ſons of* GOD, who then *ſhouted for joy*. All beyond the region of the fixed ſtars is utterly hid from the children of men.

And what do we know of the *fixed ſtars?* A great deal one would imagine: ſince, like the Moſt High, we too *tell* their *number*, yea, and *call them all by their names!* Thoſe at leaſt which appear to the naked eye, both in the northern and ſouthern hemiſphere. But what are theſe, in compariſon of thoſe which our glaſſes diſcover, even in an inconſiderable part of the firmament? What are one or two and twenty hundred, to thoſe which we diſcover in the *Milky way* alone? How many are there then in the whole expanſe, in the boundleſs field of ether? But to what *end* do they ſerve? To illuminate worlds? To impart light and heat to their ſeveral choirs of planets? Or (as the ingenious Mr. Hutchinſon ſuppoſes) to gild the extremities of the ſolar ſphere, which, according to him is the only inhabited part of the univerſe: and to miniſter in ſome unknown way, to the perpetual circulation of light and ſpirit?

For

For our ſakes only that great man apprehends the *Comets* alſo to run their amazing circuits! But what are Comets? Planets not fully formed? Or planets deſtroyed by a conflagration? Or bodies of an wholly different nature, of which therefore we can form no idea? How eaſy is it to form a thouſand conjectures: how hard to determine any thing concerning them? Can their huge *revolutions* be even tolerably accounted for, by the principles of gravitation and projection? Has not Dr. Rogers overturned the very foundation of this faſhionable hypotheſis? What then brings them back, when they have travelled ſo immenſely far beyond the ſphere of the ſolar attraction? And what whirls them on, when by the laws of gravitation, they would immediately drop into the ſolar fire?

What is the *Sun* itſelf? It is undoubtedly the moſt glorious of all the inanimate creatures. And its *uſe* we know. God made it *to rule the day.* It is

"Of this great world both eye and ſoul."

But who knows of what *ſubſtance* it is compoſed? Or even, whether it be fluid or ſolid? What are thoſe ſpots on his ſurface, that are continually changing

changing? What are thoſe that always appear in the ſame place? What is its real magnitude? Which ſhall we embrace, amidſt the immenſe variety of opinions? Mr. Whiſton indeed ſays, that eminent aſtronomers are nearly agreed upon this head. But they cannot agree concerning his magnitude, till they agree concerning his *diſtance*. And how far are they from this? The generality of them believe, that he is near an hundred millions of miles from the earth. Others ſuppoſe it to be twenty, ſome twelve millions: and laſt comes Dr. Rogers, and brings a clear and full *demonſtration*, ſo he terms it, that they are not three millions from each other. What an unbounded field for *conjecture* is here? But what foundation for real *knowledge*?

Juſt as much do we know of the feebly ſhining bodies that move regularly round the ſun: of *Jupiter*, *Saturn*, and other *Planets*. Their *revolutions* we are acquainted with. But who is able to this day, regularly to demonſtrate, either their *magnitude* or their *diſtance*? Unleſs he will prove as is the uſual way, the magnitude from the diſtance, and the diſtance from the magnitude; And what are *Jupiter's Belts*? Can any man tell? What is Saturn's *Ring*? The honeſt ploughman knows as well as the deepeſt philoſopher. How

many

many *fatellits, ſecondary planets*, move round Jupiter or Saturn? Are we ſure even of their number? How much leſs of their nature, ſize, motions, or diſtances from the primary? But what wonder we are ſo ignorant concerning Saturn's *Moons*, when we know ſo little of *our own?* For although ſome men of genius have not only diſcovered

" Rivers and mountains on her ſpotty globe."

but have travelled over the whole hemiſphere which is obverted to us, (and why is the ſame hemiſphere always obverted? What reaſon can be aſſigned, why we do not ſee the other hemiſphere in his turn?) have marked out all her ſeas and continents, with the utmoſt exactneſs: yea, and carried ſelenography to ſo great perfection, as to give us a compleat map of the moon: yet do others (and not without reaſon) doubt, Whether ſhe has any atmoſphere. And if ſhe has not any ſhe can have no rain or dews, nor conſequently either ſeas or rivers. So that after all, we have nothing more than mere conjectures, concerning the neareſt of all the *heavenly bodies.*

What is it that contains them all in their orbits? And what is the principle of their *motions?*

By

By what created Power, what outward or inward force, are they thrown forward to such a point, and then brought back again to a determinate distance from the central fire? Dr. Rogers has evidently demonstrated, that no conjunction of the centrifugal and centripetal force, can possibly account for this, or ever cause any body to move in an ellipses. Will *light* moving outward, and returning inward in the form of *spirit*, account for them? Nay, if they take away some, they plunge us into other difficulties, no less considerable. So that there is reason to fear, that even the *Newtonian*, yea, and *Hutchinsonian* system, however plausible and ingenious, and whatever advantage they may have in several particulars, are yet no more capable of solid convincing proof, than the *Ptolemaic* or *Cartesian*.

But let us come to things that are nearer home, and see what knowledge we have of them. And how much do we know of that wonderful body, that enables us to see and know all things around us? I mean *Light*. How is it communicated to us? Does it flow in a lucid river, in a continued stream from the orb of the sun to the earth? Or does the sun impel those particles only, which are contiguous to his orb, which impel others, so on and on, to the extremity of his system? Again,

Are

Are the particles of light, naturally and *essentially lucid?* Or only by accident, when they are collected? Or when put into motion? Yet again, does light *gravitate* or not? Does it *attract* other bodies, or *repel* them? Is it the strongest, or the only repellent in nature, and what communicates that power to all repellents in nature? Is this power the same with elasticity, or wherein does it differ therefrom? Is light subject to the *general laws*, which obtain in all other matter? Or is it a body *sui generis*, altogether different from all other bodies? Is it the same, or how does it differ from *Ether?* Sir Isaac Newton's *subtle matter?* What is *Ether?* Wherein does it differ from the *electric fluid?* Who can explain (and demonstrate the truth of his explanation) the phænomena of electricity? Why do some substances *conduct* the electric matter, and others arrest its course? Why do a globe of glass and another of sulphur just counter-act each other? Why is the coated phial capable of being charged just to such a point, and no farther? *O Crux Philosophorum!* Superabundant proof of the shortness of human *knowledge!*

But let us consider what is not of so subtle a nature, nor therefore so liable to elude our enquiries. Surely we understand the *Air* we breathe, and which encompasses us on every side.

By its *elaſticity* it ſeems to be the grand mover and general ſpring of all ſublunary nature. But is elaſticity eſſential to air, and conſequently inſeparable from it? Not ſo. It has been lately proved, by numberleſs experiments, that it may be *fixed*, diveſted of its elaſticity, and *generated* or reſtored to it anew. Therefore elaſticity is not eſſential to air, any more than fluidity is to water. Is it then elaſtic any otherwiſe than as it joined to another body? As every particle of air, is in its ordinary ſtate, attached to a particle of ether or electric fire? Does it not derive its whole elaſticity from this, (perhaps the only true, eſſential elaſtic in nature?) And conſequently, when ſeparated from this, loſe all its elaſtic force? For want of which it is then effete, and will neither ſuſtain flame, nor the life of animals.

By what powers do the dew, the rain, the other vapours riſe and fall in the air? Can we account for all the phœnomena of them, upon the common principles? And can we demonſtrate that this is the true, the moſt rational way of accounting for them? Or ſhall we ſay, with a late ingenious writer, that thoſe principles are utterly inſufficient? And that they cannot be accounted for at all, but upon the principles of electricity?

Do

Do we throughly underſtand the nature and properties of the *Atmoſphere* that ſurrounds us? That immenſe congeries, not only of air and vapours, whether of a watry or inflammable nature, but likewiſe of effluvia of every kind, which are continually ſteaming out from ſolid as well as fluid bodies, in all parts of the terraqueous globe? Do all our inſtruments, with all the improvements of them, ſuffice to give us a thorough knowledge of its conſtituent parts? Do they inform us of their innumerable combinations and changes, with the remote and immediate cauſes of them? Very far from it; and yet it is not a barely curious knowledge, but uſeful in the higheſt degree: ſeeing for want of it, not only various diſeaſes, but often death itſelf enſues.

Let us deſcend to what is of a ſtill more firm and a ſtable nature, and ſubject to the ſcrutiny of all our ſenſes: namely the *Earth* we tread upon, and which God hath peculiarly given to the children of men. Do the children of men underſtand this? Of what parts then is it compoſed? I ſpeak now of its internal parts, in compariſon of which the ſurface is next to nothing. Many arguments induce us to believe that the earth is between ſeven and eight thouſand miles in diameter. How much of this do we know? Perhaps

ſome cavities, natural or artificial, which have been examined by men, deſcend one, or even two miles beneath its ſurface. But what lies beneath theſe? Beneath the region of foſſils, of ſtones, metals and minerals? Theſe being only a thin exterior cruſt. Whereof conſiſt the inner parts of the globe? Of a *Nucleus*, (as an eminent man ſuppoſes, in order to account for the variation of the needle) and a luminous medium interpoſed, between that and the outer ſhell? Or is there a central *Fire*, a grand reſervoir, which ſupplies all the burning mountains: as well as miniſters to the ripening of gems and metals, if not of vegetables alſo? Or is the great deep ſtill contained in the bowels of the earth, a central abyſs of waters? Who hath ſeen? Who can tell? Who can give any ſolid ſatisfaction to a rational enquirer?

But what wonder if we are ignorant of its internal nature? For how many parts are there on the *ſurface* of the globe, which after all the diſcoveries of later ages, are ſtill utterly unknown to us? How very little do we know of the polar regions, either in Europe or Aſia? In Aſia particularly, where all but the ſea-coaſt, is mere *terra incognita?* How little do we know of the inland parts either of Africa or America? Either of the ſoil, the climate, the fruits, the animals, or the human

human inhabitants. So far are we from having any proper knowledge of these, that we can scarce form any rational conjecture about them.

And who knows what is contained in the broad *Sea*, in the abyss that covers so large a part of the globe? Many indeed *go down to the sea in ships, and occupy their business in the great waters.* But what know they, of what is contained therein: either of its animal-inhabitants, its productions of the vegetable kind, or those of a mineral or metallic nature? Most of its chambers are inaccessible to man, so that how they are furnished, we know not. Leviathan may *take his pastime therein:* but they are not designed for the children of men.

But let us come nearer home. How little do we know even of the furniture of the dry land? Survey those things which fall directly under our notice, even the most simple *Stones*, *Metals*, *Minerals*. How exceeding imperfectly are we acquainted, with their nature and properties? What is there in the inward constitution of *Metals*, which distinguishes them from all other fossils? From stones in particular? "Why they are heavier." True; but what makes them heavier? I doubt whether Solomon himself was able to

aſſign the reaſon. What is the original, internal difference between *Gold* and *Silver*, or between *Tin* and *Lead?* 'Tis all myſtery to the ſons of men. And yet vain man would be wiſe!

" If all the men in the world, ſays the great Mr. Boyle, were to ſpend their whole life in the ſearch, they would not be able to find out all the properties of that ſingle mineral, *Antimony*." And if all men could know ſo little of one thing, how little can one man know of all?

Let us proceed to the higher parts of the creation. Obſerve the *vegetable* kingdom. And here alſo whatever diſplays the wiſdom of the Creator, diſcovers the ignorance of his creature. Who can clearly determine even that fundamental queſtion, concerning the general nature of vegetables. Does the ſap perform a regular circulation through their veſſels or not? How plauſible arguments have been brought, both on the one ſide and the other? Who knows the ſeveral *ſpecies* of vegetables, from the cedar of Lebanon to the hyſſop on the wall? Or rather, (if we would deſcend from the higheſt to the loweſt) to the innumerable grove of plants which appear in the form of mouldineſs; or thoſe more innumerable (if the expreſſion may be allowed) which do not appear to the naked

naked eye at all? Who is able to diſcover the proper ſpecific difference, between any one kind of plant and another? Or the peculiar internal conformation and diſpoſition of their component particles? Yea, what man upon earth thoroughly underſtands the nature and properties of any one plant under heaven?

Aſcend we higher ſtill from plants to *Animals*. But here we are ſtopped in the mid-way. Under which of theſe ſhall we place the innumerable tribes of microſcopic *Animals*, ſo called? Are they *real* Animals in the common ſenſe of the word? Or are they Animals, in quite another ſenſe? Eſſentially different from all other ſpecies of Animals in the univerſe: as neither requiring any food to ſuſtain them, nor generating or being generated? Are they no animals at all, (according to the ſuppoſition of a late ingenious writer,) but merely inanimate particles of matter, in a ſtate of fermentation? So much may be ſaid for each of theſe opinions, that it is not eaſy to fix upon any of them.

If they are Animals of a peculiar kind, which neither generate, nor are generated, they ſpread a veil over one conſiderable branch of human ignorance. For how totally ignorant are the moſt ſagacious of men, touching the whole affair of

Generation? I do not say of the generation of insects and fishes: The countless fry,

" That by unnumber'd millions multiply."

But let us come to that of the most perfect animals, yea, of man himself. *In* the *book* of the Creator indeed, *were all our members written; which day by day were fashioned, when as yet there were none of them.* But by what rule were they fashioned? In what manner? By what degrees from the moment of impregnation? Who can explain

" How the dim speck of entity began,
To extend its recent form, and swell to man?"

By what means was the first *motion* communicated to the *punctum saliens?* When and how was the immortal spirit added to the mass of senseless clay? There is no need of descending to particulars: for 'tis mystery all! And after all our researches, we can only say, *I am fearfully and wonderfully made!*

But is there any such thing as *equivocal generation*, whether of plants or animals? It is impossible any thing can appear more absurd to the eye of

of reaſon? Was there ever an inſtance, ſince the world began, that an houſe grew *of itſelf?* Nay, ſo much as a bed, a table, a chair, or the ſmalleſt piece of houſhold furniture? And yet how trifling and inartificial is the conſtruction of theſe to that of the meaneſt plant or animal? What is the workmanſhip of *Whitehall* or *Weſtminſter-Abbey*, to that of a tree or a fly? And yet on the other hand, if we deny ſpontaneous generation, what difficulties ſurround us? If we can give a plauſible account of the propagation of miſſelto on trees, and a few of the plants growing on the tops of houſes, or on the walls of churches and towers, yet how many more confound all our ſagacity? And how many animals are diſcovered in ſuch places as no animal of that kind ever frequented?

With regard to the loweſt claſs of animals, *Inſects*, almoſt innumerable are the diſcoveries which have been made within few years, particularly by the ingenious and indefatigable Mr. Reaumur: but how inconſiderable is all this, in compariſon of that which ſtill remains undiſcovered? How many *ſpecies*, how many entire genera of theſe, are we totally unacquainted with? How many millions by their extreme minuteneſs elude our moſt careful enquiries? And the minuter

parts of larger animals, escape our utmost diligence? So that all we can attain to is an imperfect knowledge of what is obvious in their composition.

Have we a more perfect knowledge of *fishes* than of Insects? How many of the inhabitants of the waters, are intirely concealed from human view, by the element wherein they live? It is not permitted to the sons of men, to *walk through the paths of the sea*, nor consequently to trace out their several kinds or species with any exactness. But it is highly probable these are far more numerous, than the species of land-animals: as the distance between the smallest and the largest of sea-animals, is so immensely greater; from the *Minow*, for instance, (though this is far from being the least) to the *Norwegian Whale*: to say nothing of Bishop Pontoppidan's *Craken* and *Sea-serpent*, which I doubt never existed but in his own imagination. And with regard to the species we are acquainted with, how little is it that we know? Only a few of their general properties: enough to satisfy our need, but not our curiosity.

We are something better acquainted with the inhabitants of the air; *Birds* being more accessible to us: yet upon the whole, we are very far from

from being perfectly acquainted with them. Of many we know little more than the outward ſhape. We know a few of the obvious properties of others, but the inward, ſpecific difference of very few. And we have a thorough adequate knowledge of none.

" However, we have a more extenſive knowledge of *Beaſts*, many of which are our domeſtic companions." Certainly we have. And yet a thouſand queſtions may be aſked even concerning theſe, which we are in no wiſe able to anſwer. To touch only on two or three general heads. Do they *reaſon*, or do they not? Whence ariſe the different *qualities* and *tempers*, not only in different kinds and ſpecies; but even in the individuals of one ſpecies, as in dogs, cats, and horſes? Are they *mere machines?* If we aſſert they are, it inevitably follows, that they neither *ſee*, nor *hear*, nor *ſmell*, nor *feel*. For of this mere machines are utterly incapable. Much leſs can they *know* or *remember* any thing, or *move* any otherwiſe than they are impelled. But all this, as numberleſs experiments ſhew, is quite contrary to matter of fact. On the other hand if they are not mere machines, if they have either ſenſation, or knowledge, or memory, or a principle of ſelf-motion, then they are not mere matter; they have

in them an immateral principle. But of what kind? Will it die with the body, or not? Is it mortal or immortal? Here again we are got into an unknown path. We cannot order our ſpeech by reaſon of darkneſs.

But although we know ſo little either of the things that are above us, of thoſe that are beneath us, or of thoſe that ſurround us on every ſide, yet it is to be hoped, we know *ourſelves*: and of all, this is the moſt uſeful, the moſt neceſſary knowledge. But do we truly know ourſelves? Do we know the moſt excellent part of ourſelves, our own *ſoul?* That it is a ſpirit, we know. But what is a ſpirit? Here again we are at a full ſtop. And *where is* the ſoul *lodged?* In the pineal gland? The whole brain? In the heart? The blood? In any ſingle part of the body? Or, is it (if any one can underſtand thoſe terms) All in all, and all in every part. How is it *united to* the body? What is the ſecret chain, what the bands that couple them together? Can the wiſeſt of men give a ſatisfactory anſwer, even to theſe few plain queſtions?

As to the *body*, we glory in having attained abundantly more knowledge than the ancients. By our glaſſes we have diſcovered very many things,

things, which we ſuppoſe they were wholly unacquainted with. But have we diſcovered, why we perſpire three parts in four leſs, when we ſweat, than when we do not? What a total miſtake is it then to ſuppoſe ſweat is only an increaſe of inſenſible perſpiration! Have we diſcovered, why one part of mankind have black ſkins, and the other white? It is not owing to the climate: for both black men and white are born in the ſame latitude. And have not negroes the ſame fleſh and blood with us? But what is *fleſh?* That of the muſcles in particular? Are the fibres out of which it is woven, of a determinate ſize? So that when you have divided them into ſmaller and ſmaller, to a certain point, you come to thoſe of the ſmalleſt kind? Or are they reſolvible (at leaſt in their own nature) into ſmaller and ſmaller *in infinitum?* How does a *muſcle act?* If you ſay, by being inflated, and conſequently ſhortened: I aſk again, But what is it inflated with? If with blood, how and whence comes that blood? And what becomes of that blood, whither does it go, the moment the muſcle is relaxed? What is *blood?* Of how many ſorts of particles does it eſſentially conſiſt? Of red globules and ſerum? But in the famous inſtance, the man bled at the noſe, till what was diſcharged had no redneſs left. By what force is the circulation

lation of the blood performed? Can any one suppose the force of the heart, is sufficient to overcome the resistance of all the arteries? Are the *nerves* pervious or solid? How do they act? By vibration or transmission of the animal spirits? What are the animal spirits? If they have any being, are they of the nature of blood or ether? What is *sleep?* Wherein does it consist? We do not enquire, What are the effects of it (Cessation of voluntary motion and so on) but what is the thing itself, the cause of these effects? What is *Dreaming?* By what criterion can we distinguish dreams from waking thoughts? I mean, by what means may a dreaming person then know that he is in a dream? What is (the *Consanguineus Somni*) *Death? When* do we die? You say, "When the soul leaves the body." This cannot be denied. But my question is, When does the soul leave the body? When we cease to breathe, according to the maxim, *Nullus Spiritus, nulla vita?* This will not hold; for many have revived after respiration was utterly ceased. When the circulation of the blood stops? Nay, neither will this hold; for many have recovered after the pulse was quite gone. When the vital warmth ceases, and the juices lose their fluidity? Even this is not a certain mark. For some have revived after the body was quite cold and stiff: a case not uncommon.

uncommon in *Sweden*. By what token then can we ſurely know? It ſeems, none ſuch can be found. God knows when the Spirit returns to him. And the ſpirit itſelf: but none that dwells in a body.

What cauſe have we then to adore the wiſdom of God, who has ſo exactly proportioned our knowledge to our ſtate? We may know whatever is needful for life or godlineſs, whatever is neceſſary either for our preſent or eternal happineſs. But how little beſide can the moſt penetrating genius know with any certainty? Such pains, ſo to ſpeak, hath God taken to *hide pride from man!* And to bound his thoughts within that channel of knowledge, wherein he already finds eternal life.

FINIS.

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